CICS Transaction Server for z/OS
Version 4 Release 2

Java Applications in CICS

SC34-7174-02

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Note

Before using this information and the product it supports, read the information in “Notices” on page 391.

This edition applies to Version 4 Release 2 of CICS Transaction Server for z/OS (product number 5655-S97) and to all subsequent releases and modifications until otherwise indicated in new editions.

Contents

Preface

This manual documents intended Programming Interfaces that allow the customer to write programs to obtain the services of Version 4 Release 2.

What this information is about

This information tells you how to develop and use Java applications and enterprise beans in CICS®.

Who should read this information

This information is intended for:

- Experienced Java application programmers who may have little experience of CICS, and no great need to know more about CICS than is necessary to develop and run Java programs.
- Experienced CICS users and system programmers, who need to know about CICS requirements for Java support.

Changes in CICS Transaction Server for z/OS, Version 4 Release 2

For information about changes that have been made in this release, please refer to *What's New* in the information center, or the following publications:

- *CICS Transaction Server for z/OS What's New*
- *CICS Transaction Server for z/OS Upgrading from CICS TS Version 4.1*
- *CICS Transaction Server for z/OS Upgrading from CICS TS Version 3.2*
- *CICS Transaction Server for z/OS Upgrading from CICS TS Version 3.1*

Any technical changes that are made to the text after release are indicated by a vertical bar (|) to the left of each new or changed line of information.

Chapter 1. Java support in CICS

CICS provides the tools and runtime environment to develop and run Java enterprise applications in a Java Virtual Machine (JVM) that is under the control of a CICS region. Java applications can interact with CICS services and applications written in other languages.

Java on z/OS® provides comprehensive support for running Java applications. CICS uses the IBM® 64-bit SDK for z/OS, Java Technology Edition, Version 6.0.1. The SDK contains a Java Runtime Environment that supports the full set of Java APIs and a set of development tools. To encourage the adoption of Java on z/OS, a special processor is available in certain System z® hardware. This processor is called the IBM System z Application Assist Processor (zAAP) and can provide additional processor capacity to run eligible Java workloads at a reduced cost. CICS can exploit this capability in its Java workloads. You can find more information about Java on the z/OS platform and download the 64-bit version of the SDK at http://www.ibm.com/servers/eserver/zseries/software/java/.

CICS provides an Eclipse-based tool and two runtime environments for Java applications:

CICS Explorer® SDK

The CICS Explorer SDK is a freely available download for Eclipse-based Integrated Development Environments (IDEs). The SDK provides support for developing and deploying applications that comply with the OSGi Service Platform specification. The OSGi Service Platform provides a mechanism for developing applications using a component model and deploying those applications into a framework as OSGi bundles. An *OSGi bundle* is the unit of deployment for an application component and contains version control information, dependencies, and application code. The main benefit of OSGi is that you can create applications from reusable components that are accessed only though well-defined interfaces called *OSGi services*. You can also manage the life cycle and dependencies of Java applications in a granular way.

The CICS Explorer SDK supports developing Java applications for any supported release of CICS. The SDK includes the Java CICS (JCICS) library of classes to access CICS services and examples to get started with developing applications for CICS. You can also use the tool to convert existing Java applications to OSGi.

JVM server

The JVM server is the strategic runtime environment for Java applications in CICS. A JVM server can handle multiple concurrent requests from different Java applications in a single JVM. It reduces the number of JVMs that are required to run Java applications in a CICS region. To use a JVM server, Java applications must be threadsafe and must comply with the OSGi specification. Use this runtime environment for all Java applications where possible. It is the preferred method for running Java workloads in a CICS region and provides the following benefits:

- You can run more than one Java application in a JVM server, simplifying the operations of running and managing JVMs in a CICS region.

- You can run eligible Java workloads on zAAPs, reducing the cost of transactions.
- You can run different types of work in a JVM server, including threadsafe Java programs and web services.
- You can manage the life cycle of applications in the OSGi framework without restarting the JVM server.
- You can more easily port Java applications that are packaged using OSGi between CICS and other platforms.

Pooled JVMs
The pooled JVM is a runtime environment where each Java program uses its own JVM. JVM programs running concurrently are isolated from each other. When a Java program has finished using the JVM, the JVM can be reused by a subsequent program. Use this runtime environment for existing Java applications that are not threadsafe. Pooled JVMs are stable and will be removed in a future release of CICS. Where possible, convert your existing Java applications to run in a JVM server.

The OSGi Service Platform

The OSGi Service Platform provides a mechanism for developing applications by using a component model and deploying those applications into an OSGi framework. The OSGi architecture is separated into a number of layers that provide benefits to creating and managing Java applications.

The OSGi framework is at the core of the OSGi Service Platform specification. CICS uses the Equinox version 3.6.1 implementation of the OSGi framework, which supports version 4 of the OSGi Service Platform specification. The OSGi framework is initialized when a JVM server starts. Using OSGi for Java applications provides the following major benefits:

- Your Java applications are more portable, easier to re-engineer, and more adaptable to changing requirements.
- You can follow the Plain Old Java Object (POJO) programming model, giving you the option of deploying an application as a set of OSGi bundles with dynamic life cycles.
- You can more easily manage and administer application bundle dependencies and versions.

The OSGi architecture has the following layers:

- Modules layer
- Life cycle layer
- Services layer

Modules layer

The unit of deployment is an OSGi bundle. The modules layer is where the OSGi framework processes the modular aspects of a bundle. The metadata that enables the OSGi framework to do this processing is provided in a bundle manifest file.

One key advantage of OSGi is its class loader model, which uses the metadata in the manifest file. There is no global class path in OSGi. When bundles are installed into the OSGi framework, their metadata is processed by the module layer and their declared external dependencies are reconciled against the exports and version information declared by other installed modules. The OSGi framework works out all the dependencies and calculates the independent required class path for each bundle. This approach resolves the shortcomings of plain Java class loading by ensuring that the following requirements are met:

- Each bundle provides visibility only to Java packages that it explicitly exports.
- Each bundle declares its package dependencies explicitly.
- Packages can be exported at specific versions, and imported at specific versions or from a specific range of versions.
- Multiple versions of a package can be available concurrently to different clients.

Life cycle layer

The bundle life cycle management layer in OSGi enables bundles to be dynamically installed, started, stopped, and uninstalled, independently from the life cycle of the JVM. The life cycle layer ensures that bundles are started only if all their dependencies are resolved, reducing the occurrence of ClassNotFoundException exceptions at run time. If there are unresolved dependencies, the OSGi framework reports the problem and does not start the bundle.

Each bundle can provide a bundle activator class, which is identified in the bundle manifest, that the framework calls on to start and stop events.

Services layer

The services layer in OSGi intrinsically supports a service-oriented architecture through its non-durable service registry component. Bundles publish services to the service registry, and other bundles can discover these services from the service registry. These services are the primary means of collaboration between bundles. An OSGi service is a Plain Old Java Object (POJO), published to the service registry under one or more Java interface names, with optional metadata stored as custom properties (name/value pairs). A discovering bundle can look up a service in the service registry by an interface name, and can potentially filter the services that are being looked up based on the custom properties.

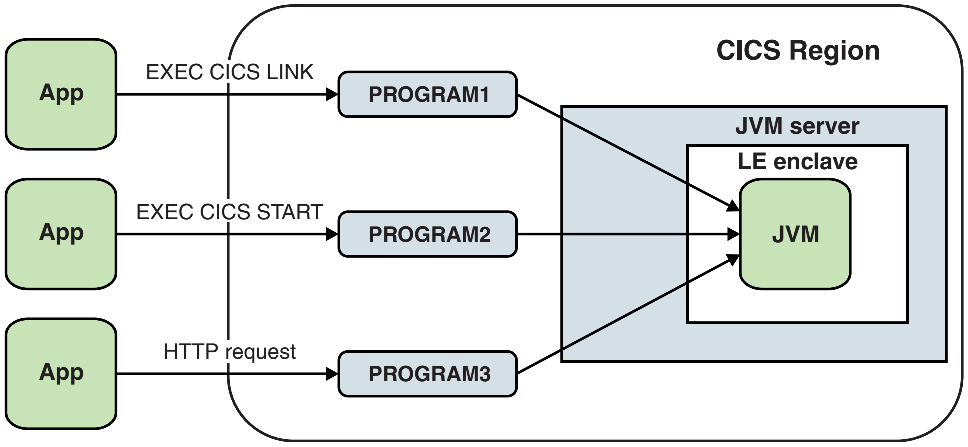
Services are fully dynamic and typically have the same life cycle as the bundle that provides them.

JVM server runtime environment

A *JVM server* is a runtime environment that can handle multiple concurrent requests for different Java applications in a single 64-bit JVM. You can use a JVM server to run threadsafe Java applications in an OSGi framework and process web service requests in the Axis2 web services engine.

A JVM server is represented by the JVMSERVER resource. When you enable a JVMSERVER resource, CICS requests storage from MVS™, sets up a Language Environment® enclave, and launches the 64-bit JVM in the enclave. CICS uses a JVM profile that is specified on the JVMSERVER resource to create the JVM with the correct options. In this profile, you can add native libraries to access WebSphere® MQ from Java applications and specify JVM options. Java on z/OS efficiently manages the JVM memory and garbage collection, so you do not have to set these options in the profile.

One of the advantages of using JVM servers is that you can run multiple requests for different applications in the same JVM. In the following diagram, three applications are calling three Java programs in a CICS region concurrently using different access methods. Each Java program runs in the same JVM server.



Java applications

To run a Java application in a JVM server, it must be threadsafe and packaged as one or more OSGi bundles in a CICS bundle. The JVM server implements an OSGi framework in which you can run OSGi bundles and services. The OSGi framework registers the services and manages the dependencies and versions between the bundles. OSGi handles all the class path management in the framework, so you can add, update, and remove Java applications without stopping and restarting the JVM server.

The unit of deployment for a Java application that is packaged using OSGi is a CICS bundle. A CICS bundle must be available in a directory in zFS that contains the OSGi bundles. The BUNDLE resource represents the application to CICS and you can use it to manage the life cycle of the application. The CICS Explorer SDK provides support for deploying OSGi bundles in a CICS bundle project to zFS.

To access the Java application from outside the OSGi framework, use a PROGRAM resource to identify the JVM server in which the application is running and the name of the OSGi service. The OSGi service points to the CICS main class.

For more information about using the OSGi framework in a JVM server, see "Java applications that comply with OSGi" on page 21.

Web services

You can use a JVM server to run the SOAP processing for web service requester and provider applications. If a pipeline uses Axis2, a Java-based SOAP engine, the SOAP processing occurs in a JVM server. The advantage of using a JVM server for web services is that you can offload the work to a zAAP processor.

For more information about using a JVM server for web services, see "Java web services" on page 17.

TP and T8 TCBs

CICS uses the open transaction environment (OTE) to run JVM server work. Each task runs as a thread in the JVM server and is attached using a T8 TCB. The JVM server also has a parent TCB called TP. The TP TCB is created when the JVM server is initialized and runs on a system thread. The system thread provides access to inquire on the state of the JVM server, to collect statistics information, and to stop the JVM server.

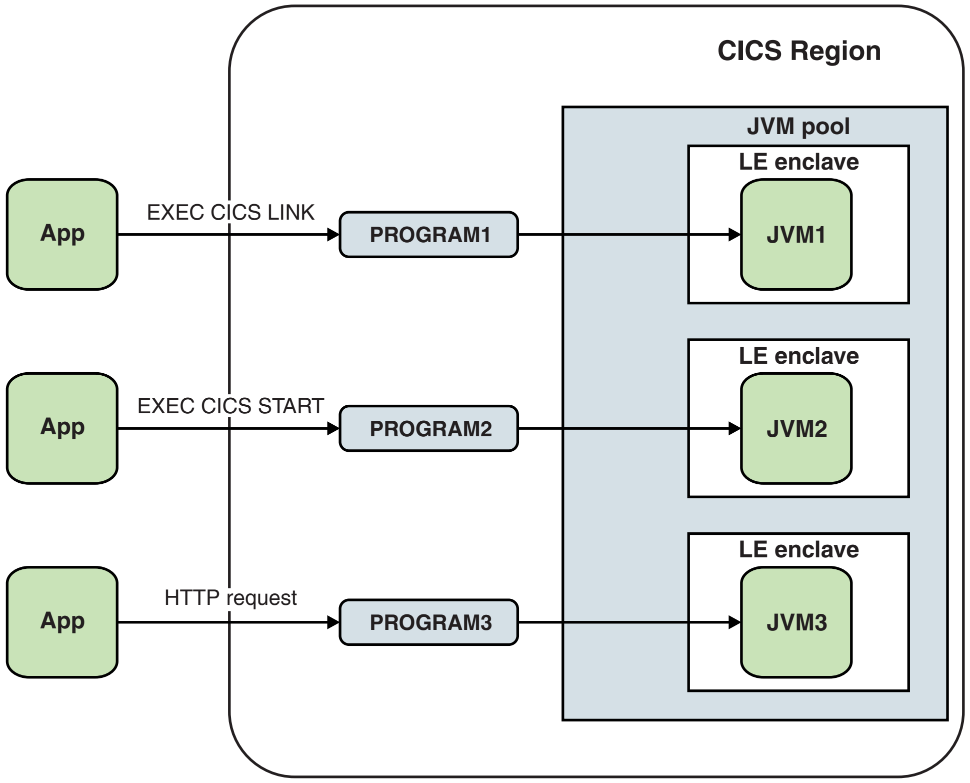
Every task is attached to a thread in the JVM using a T8 TCB. You can control how many T8 TCBs are available to the JVM server by setting the THREADLIMIT attribute on the JVMSERVER resource. The T8 TCBs that are created for the JVM server exist in a virtual pool and cannot be reused by another JVM server running in the same CICS region. The maximum number of T8 TCBs that can exist in a CICS region across all JVM servers is 1024 and the maximum for a particular JVM server is 256.

Pooled JVMs

A *pooled JVM* is a JVM that can handle only one request at a time from a CICS task. The pool of these JVMs can handle multiple tasks concurrently, meaning that you must have many JVMs to handle Java workloads. CICS uses the open transaction environment (OTE) to run pooled JVMs and you can manage the number of JVMs that CICS can create in the region.

A pooled JVM runs one Java program only to ensure that every transaction involving the JVM is isolated from every other concurrent transaction involving a JVM. Therefore you must have a number of JVMs available to handle Java programs concurrently. For all new Java workloads, use the JVM server runtime environment. In a JVM server, you can run multiple Java programs concurrently using a single JVM.

In the following diagram, three applications are calling three Java programs in a CICS region concurrently using different access methods. Each request must run in a separate JVM and enclave.



JVM reuse

When a Java program has finished, a pooled JVM can be reassigned to another Java program. The JVM profile determines the characteristics of a JVM and whether it can be reused or not. If a JVM is reusable it is called a *continuous JVM*. If a JVM is not reusable it is called a *single-use JVM*. If you must use pooled JVMs, use continuous JVMs to improve performance. You can also use the shared class cache with continuous JVMs to reduce storage requirements and improve the startup time for the JVMs.

Continuous JVMs can be reused many times. The application code that runs in the next Java program or transaction is not automatically isolated from the actions of the previous program invocation; that is, serial isolation is not automatic. You must ensure that your Java application programs do not change the state of a continuous JVM in undesirable ways, or leave any unwanted state in the JVM.

A continuous JVM maintains the content of its storage heaps between one program invocation and the next. Static or dynamic state persists in the storage heaps of continuous JVMs, and threads that are not quiesced persist, along with their related storage. All application classes that have been loaded into the JVM are kept intact. The application can choose to clean up any unwanted items and retain any desirable items.

The PROGRAM resource for the Java program determines the appropriate execution key and JVM profile for the JVM that the program uses. You can define different JVM profiles that meet the requirements of your Java programs.

When CICS receives a request to run a Java program, it must either create a suitable JVM or assign an existing JVM that is not currently being used. To create a suitable JVM, CICS requests storage from MVS, sets up a Language Environment enclave, and launches the JVM in the enclave. CICS uses the JVM profile specified on the PROGRAM resource to create the JVM with the correct classes and options.

Limit for JVMs in the JVM pool

Each pooled JVM runs on an MVS TCB, which is allocated from a pool of J8 and J9 open TCBs. This pool of open TCBs is called the JVM pool. JVMs can be in one of two execution keys: user key or CICS key. JVMs that are in user key run on a J9 TCB. JVMs that are in CICS key run on a J8 TCB. Statistics are collected separately for each of the modes, so you can see what proportions of each mode are in the JVM pool. The JVM profile and execution key are independent of each other, so two JVMs could have the same profile but different execution keys.

The total number of TCBs that can be created for JVMs is limited by the MAXJVMTCBS system initialization parameter. This parameter limits the number of JVMs that you can have in the JVM pool in your CICS region.

Each JVM runs in its own Language Environment enclave, and uses MVS storage. For this reason, you must choose a **MAXJVMTCBS** limit for your CICS region that takes into account not just the processor time used by the JVMs, but also the amount of MVS storage that is used by each JVM and the storage available to the region. If you set a **MAXJVMTCBS** limit that is too high, CICS might attempt to create too many JVMs for the available MVS storage, resulting in an MVS storage constraint.

JVM profiles

JVM profiles are text files that contain Java launcher options and system properties, which determine the characteristics of JVMs. You can edit JVM profiles using any standard text editor.

A JVM profile lists the options that are used by the CICS launcher for Java. Some of the options are specific to CICS and others are standard for the JVM runtime environment. For example, the JVM profile controls the initial size of the storage heap and how far it can expand. The profile can also define the destinations for messages and dump output produced by the JVM.

The JVM profile also specifies the class paths. Class paths contain the directories that the JVM searches for the application classes and resources that are required for your applications.

When CICS receives a request to run a Java program, the name of the JVM profile is passed to the Java launcher. The Java program runs in a JVM, which was created using the options in the JVM profile and the JVM properties file, if one is specified.

CICS uses JVM profiles that are in the z/OS UNIX System Services directory specified by the JVMPROFILEDIR system initialization parameter. This directory must have the correct permissions for CICS to read the JVM profiles.

Sample JVM profiles

CICS supplies four sample JVM profiles to help you configure your Java environment. They are customized during the CICS installation process. These files are used by CICS as defaults or for system programs.

You can copy the samples and customize them for your own applications. The CICS-supplied sample JVM profiles are in the directory `/usr/lpp/cicsts/cicsts42/JVMProfiles` on z/OS UNIX. Copy the samples from the installation directory to the directory that you specified in the **JVMPROFILEDIR** system initialization parameter. The sample JVM profiles in the installation location are overwritten if you apply an APAR that includes changes to these files. To avoid losing your modifications, always copy the samples to a different location before adding your own application classes or changing any options.

The sample JVM profiles include the symbol &JAVA_HOME for the variable part of the name of the installation directory for Java. During the installation of CICS, this symbol is substituted with your own value. The base library path and base class path for the JVM, which are not visible in the JVM profile, are built automatically using these directories. The default value is `java/` for the &JAVA_HOME symbol.

The following table summarizes the key characteristics of each sample JVM profile.

Table 1. CICS-supplied sample JVM profiles

JVM profile	Characteristics
DFHJVMAX	The DFHJVMAX profile is the supplied sample profile for an Axis2 JVM server. The JVM profile is specified on the JVMSERVER resource. CICS uses the DFHJVMAX profile to initialize the JVM server.Do not specify this profile in PROGRAM resources for your own applications. Instead, specify the name of the JVMSERVER resource in the PROGRAM resource.

Table 1. CICS-supplied sample JVM profiles (continued)

JVM profile	Characteristics
DFHOSGI	The DFHOSGI profile is the supplied sample profile for an OSGi JVM server. The JVM profile is specified on the JVMSERVER resource. CICS uses the DFHJVMAX profile to initialize the JVM server.Do not specify this profile in PROGRAM resources for your own applications. Instead, specify the name of the JVMSERVER resource in the PROGRAM resource.
DFHJVMPR	The DFHJVMPR profile is the default for pooled JVMs if no JVM profile is specified in the PROGRAM resource of a Java program. Pooled JVMs created with the profile DFHJVMPR use the shared class cache because the profile specifies CLASSCACHE=YES.
DFHJVMCD (reserved for the use of CICS)	CICS-supplied system programs have their own JVM profile, DFHJVMCD, for pooled JVMs. System programs are independent of any changes that you make to the default JVM profile, DFHJVMPR. In particular, the PROGRAM resource for the default request processor program, DFJIIRP, specifies DFHJVMCD. Pooled JVMs created with the profile DFHJVMCD do not use the shared class cache because the profile specifies CLASSCACHE=NO. You can change the default value.Do not specify this profile in PROGRAM resources that you set up for your own Java applications. However, you must make sure that it is set up correctly for your CICS region. CICS uses DFHJVMCD to initialize and terminate the shared class cache in addition to using it for CICS-supplied system programs.

Structure of a JVM

JVMs that run under CICS use a set of classes and class paths that are defined in JVM profiles and use 64-bit storage. Each JVM runs in a Language Environment enclave that you can tune to make the most efficient use of MVS storage.

For further information about Version 6.0.1 of the IBM 64-bit SDK for z/OS, Java Technology Edition, see the *IBM 64-bit SDK for z/OS, Java Technology Edition, Version 6.0.1 SDK and Runtime Environment User Guide*. The document is available to download from www.ibm.com/servers/eserver/zseries/software/java/javaintr.html.

Classes and class paths in JVMs

Three types of classes and native libraries are used by a JVM running under CICS.

- The z/OS JVM code, which provides the base services in the JVM. These classes are *system classes* and *standard extension classes*, which are known collectively as *primordial classes*.
- Native C dynamic link library (DLL) files that are used by the JVM. These files have the extension `.so` in z/OS UNIX. Some libraries are required for the JVM to run, and additional native libraries can be loaded by application code or services. For example, the additional native libraries might include the DLL files to use the DB2® JDBC drivers.
- The Java classes for the applications that run in the JVM. These classes are known as *application classes*. This group includes classes that are part of user-written applications. It also includes some classes supplied by IBM or by another vendor to provide services that access resources, such as the JCICS interfaces classes, JDBC and JNDI, which are not included in the standard JVM

setup for CICS. When application classes have been loaded, they are kept across JVM reuses so that they can be used by other transactions.

The JVM understands the purpose of each of these items and determines how the class or native library is loaded by the JVM, and where it is stored.

The class paths for a JVM are defined by options in the JVM profile, and are optionally in referenced JVM properties files.

The class paths on which classes or native libraries can be included are as follows:

- The *library path* is for all the native C dynamic link library (DLL) files that are used by the JVM, including the files required to run the JVM and additional native libraries loaded by application code or services. Only one copy of each DLL file is loaded, and all the JVMs share it, but each JVM has its own copy of the static data area for the DLL.

  The base library path for the JVM is built automatically using the directories specified by the **USSHOME** system initialization parameter and the **JAVA_HOME** option in the JVM profile. The base library path is not visible in the JVM profile. It includes all the DLL files required to run the JVM and the native libraries used by CICS. You can extend the library path using the **LIBPATH_SUFFIX** option or the **LIBPATH_PREFIX** option. **LIBPATH_SUFFIX** adds items to the end of the library path, after the IBM-supplied libraries. **LIBPATH_PREFIX** adds items to the beginning, which are loaded in place of the IBM-supplied libraries if they have the same name. You might have to do this for problem determination purposes.

  Compile and link with the LP64 option any DLL files that you include on the library path . The DLL files supplied on the base library path and the DLL files used by services such as the DB2 JDBC drivers are built with the LP64 option.

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  The *standard class path* is for all application classes that run in pooled JVMs or a JVM server that is not configured for OSGi. All Java `.class` and `.jar` files are placed on the standard class path. You can add classes to the standard class path using the **CLASSPATH_SUFFIX** option in the JVM profile or the **CLASSPATH_PREFIX** option.

  CICS also builds a base class path for the JVM automatically, using the `/lib` subdirectories of the directories specified by the **USSHOME** system initialization parameter. This class path contains the JAR files supplied by CICS and by the JVM. It is not visible in the JVM profile.

  For JVM servers that are configured to support OSGi, you must not set a class path for your application classes. The OSGi framework automatically determines the class path for applications by using the information in the OSGi bundle that contains the application.

You do not have to include the system classes and standard extension classes (the primordial classes) on a class path, because they are already included on the boot class path in the JVM.

Storage heap in JVMs

The runtime storage in JVMs for IBM 64-bit SDK for z/OS, Java Technology Edition Version 6.0.1 is managed by a single 64-bit storage heap.

The heap for each JVM is allocated from 64-bit storage in the Language Environment enclave for the JVM. The size of each heap is determined by options in the JVM profile.

The single storage heap is known as the *heap*, or sometimes as the *garbage-collected heap*. Its initial storage allocation is set by the **-Xms** option in a JVM profile, and its maximum size is set by the **-Xmx** option.

You can tune the size of a heap to achieve optimum performance for your JVMs. See "Tuning JVM server heap and garbage collection" on page 159 and "Tuning pooled JVM heaps and garbage collection" on page 166.

Where JVMs are constructed

When a JVM is required, the CICS launcher program for JVMs requests storage from MVS, sets up a Language Environment enclave, and launches the JVM in the Language Environment enclave. Each JVM is constructed in its own Language Environment enclave, to ensure isolation between JVMs running in parallel.

The Language Environment enclave is created using the Language Environment preinitialization module, CELQPIPI, and the JVM runs as a z/OS UNIX process. The JVM therefore uses MVS Language Environment services rather than CICS Language Environment services. The storage used for a JVM is MVS 64-bit storage, obtained by calls to MVS Language Environment services. This storage resides in the CICS address space, but is not included in the CICS dynamic storage areas (DSAs).

The Language Environment enclave for a JVM can expand, depending on the storage requirements of the JVM. The Language Environment runtime options used by CICS for a Language Environment enclave control the initial size of, and incremental additions to, the Language Environment enclave heap storage.

You can tune the runtime options that CICS uses for a Language Environment enclave, so that the amount of storage CICS requests for the enclave is as close as possible to the amount of storage specified by your JVM profiles. You can therefore make the most efficient use of MVS storage. For more information about tuning storage, see "Language Environment enclave storage for JVMs" on page 170.

Execution keys for JVMs

A Java program must use a JVM that is running in the correct execution key. Pooled JVMs can run in one of two execution keys: user key or CICS key. JVM servers run only in CICS key.

Execution keys for JVM servers

JVM servers run in CICS key only. To use a JVM server, the PROGRAM resource for the Java program must have the EXECKEY attribute set to `CICS`. CICS uses a T8 TCB to run the JVM and obtains MVS storage in CICS key.

Execution keys for pooled JVMs

When you set the EXECKEY attribute on the PROGRAM resource for a Java program to `USER`, CICS gives the program a pooled JVM that is in user key. CICS uses a J9 TCB to run the JVM and obtains MVS storage in user key. When you set the EXECKEY attribute to `CICS`, CICS gives the program a JVM that is in CICS key. CICS uses a J8 TCB to run the JVM and obtains MVS storage in CICS key.

Running applications in user key extends CICS storage protection, so if your Java programs are using a pooled JVM run in user key where possible. However, if a

Java program is part of a transaction that specifies **TASKDATAKEY**(CICS), the program must use a JVM that is running in CICS key.

You do not have to make any other changes if you change the EXECKEY attribute for a Java PROGRAM resource. CICS can use the same JVM profile to create JVMs in both execution keys. A single CICS task can include Java programs running in CICS key and Java programs running in user key. However, a JVM can be reused only by programs that specify the same execution key and JVM profile on the PROGRAM resources. If most of your JVMs are created in the same execution key, CICS has more opportunities for giving a program an existing JVM to reuse, rather than creating a new JVM.

JVMs and the z/OS shared library region

The shared library region is a z/OS feature that enables address spaces to share dynamic link library (DLL) files.

This feature enables your CICS regions to share the DLLs that are needed for JVMs, rather than each region having to load them individually. This can greatly reduce the amount of real storage used by MVS, and the time it takes for the regions to load the files.

The storage that is reserved for the shared library region is allocated in each CICS region when the first JVM is started in the region. The amount of storage that is allocated is controlled by the **SHRLIBRGNSIZE** parameter in z/OS. For more information about tuning the amount of storage that is allocated for the shared library region, see “Tuning the z/OS shared library region” on page 177.

Shared class cache

The IBM SDK for z/OS provides a class-sharing facility for JVMs, where multiple JVMs can share a single cache of class files that have already been loaded. CICS supports this facility for pooled JVMs and JVM servers in different ways.

The shared class cache contains all the classes that are required by the JVMs that use the shared class cache. All the application classes required by your Java programs are placed on the standard class path in your JVM profiles, and they are all eligible to be loaded into the shared class cache. In some exceptional scenarios, some classes might not be eligible to be loaded into the shared class cache.

The shared class cache does not store the following items:

- Native C dynamic link library (DLL) files that are specified on the library path in JVM profiles. A single copy of each DLL file is used by all the JVMs that require it.
- Working data for applications (objects and variables). Working data is stored in the individual JVMs.
- Compiled classes produced by just-in-time (JIT) compilation. Compiled classes are stored in individual JVMs, not in the shared class cache, because the compilation process can vary for different workloads.

The shared class cache updates its contents automatically if you change any application classes or JAR files, or add new items to the class paths in your JVM profiles, and restart the appropriate JVMs. The shared class cache is persistent across warm and emergency CICS starts, except in some circumstances such as an IPL of z/OS, so there is no startup cost to the first JVM in the CICS region at those times.

In Java 6.0.1, you can have multiple shared class caches available for use at the same time. CICS does not provide interfaces to manage multiple class caches, but you can use multiple class caches with JVM servers. Pooled JVMs cannot use multiple class caches, but CICS does provide interfaces to manage a single class cache in a region for pooled JVMs.

Class cache for JVM servers

If you want to use class caches with JVM servers, you can use the support provided by Java 6 directly. This support is described in Class data sharing between JVMs. JVM servers do not use the support for class caches that is provided in CICS. For example, you cannot enable or disable a class cache for JVM servers using SPI or CEMT commands.

Class cache for pooled JVMs

Pooled JVMs that use the shared class cache start up more quickly and have lower storage requirements than JVMs that do not. The overall cost of class loading is also reduced when pooled JVMs use the shared class cache. When a new JVM that shares the class cache is initialized, it uses the preinstalled classes instead of reading them from the file system. A JVM that shares the class cache still owns all the working data (objects and variables) for the applications that run in it to maintain the isolation between the Java applications being processed in the system.

CICS uses the CICS-supplied sample profile DFHJVMCD to initialize and terminate the shared class cache for pooled JVMs. DFHJVMCD must always be available and configured for use in your CICS region, but you do not have to make any additional changes to it for use with the shared class cache.

CICS provides interfaces to manage one active shared class cache in each region. A region might also contain old shared class caches that are being phased out. You can manage the shared class cache and monitor its status using CICS commands.

The shared class cache is named `CICS_sharedcc_`*`APPLID_n`*, where *APPLID* is the APPLID of the CICS region, and *n* is a generation number starting at zero. The generation number is used to differentiate the name of the new shared class cache.

CICS uses one or more JM TCBs, a type of open TCB, for shared class cache management functions. JM TCBs do not count towards the **MAXJVMTCBS** limit for the JVM pool.

The JVMCCSIZE system initialization parameter specifies the initial size of the shared class cache. The JVMCCSTART system initialization parameter controls the startup behavior of the shared class cache at CICS region initialization.

Chapter 2. Java planning

If you are planning how to use Java in your enterprise, the examples in this section provide guidance on the various strategic options that are available for CICS applications.

You can use Java in CICS in various ways:

Use JCA to connect external Java applications to CICS

You can use the Java EE Connector Architecture (JCA) to connect existing CICS applications to external Java applications by using CICS Transaction Gateway. This product in the CICS family provides support for connecting Java applications in application servers, such as WebSphere Application Server, to CICS by using resource adapters that implement the JCA technology.

The CICS applications can be written in any of the supported high-level programming languages.

Use Java web services

You can create Java web services to work with service providers and service requesters in a heterogeneous environment, connecting to the Internet over HTTP or WebSphere MQ. Java web services run in a JVM server and the SOAP processing is performed by the Axis2 web services engine. You can choose to process existing web services in Axis2, where the provider or requester application is written in any of the supported high-level programming languages, including Java. You can also use standard Java APIs to create Java web services that can handle XML or work with structured data.

Java workloads that run in a JVM server are eligible to run on an IBM System z Application Assist Processor (zAAP).

Use OSGi to create Java applications

You can create modular and reusable Java applications that comply with the OSGi Service Platform. These applications are easier to port between CICS and other platforms and OSGi provides granularity around managing dependencies and versions.

You can use the Java CICS (JCICS) API to write applications that access CICS services, such as reading from files or temporary storage queues. Java applications can link to other CICS applications and access data in DB2 and IMS™. Java applications can run in JVM servers or pooled JVMs. The strategic environment for running Java applications is the JVM server, so plan to use this environment for all Java applications. Java workloads that run in a JVM server are eligible to run on a zAAP.

As part of your planning, you must also decide how to route your Java workloads and scale your CICS regions accordingly.

Accessing CICS applications from CICS Transaction Gateway

CICS Transaction Gateway provides resource adapters to connect Java client programs to existing CICS applications.

You can use the CICS TG resource adapters to reuse your CICS applications in new Java applications. Frequently, new Java applications can be developed more quickly and reliably by reusing existing Java or non-Java CICS applications. Typically, the Java client application is network-based and the CICS program is written in a language such as COBOL.

The J2EE Connector Architecture (JCA)

The Java 2 Platform Enterprise Edition (J2EE) Connector Architecture defines a standard means of connecting a J2EE-compliant platform to a heterogeneous Enterprise Information System (EIS) such as CICS. Java applications interact with resource adapters by using the Common Client Interface (CCI), which is an open standard defined by the JCA.

The J2EE connector architecture enables an EIS vendor to provide a standard resource adapter for its EIS. A resource adapter is the middle tier between a Java application and an EIS and connects the Java application to the EIS.

The CICS Transaction Gateway implements the JCA by providing J2EE CICS resource adapters that support the Common Client Interface.

Accessing CICS programs from external Java programs

From the network, a Java client application can use any of the following methods to call a CICS TS program:

`The CICS Transaction Gateway API`
The CICS Transaction Gateway API provides, among other things, the following facilities:

The External Call Interface
An external application can use the External Call Interface (ECI) to call a program in a CICS region. To be eligible, the CICS program must be made available to other CICS programs through an **`EXEC CICS LINK`** command. It can have a COMMAREA interface or, when an IPIC connection is used, the program can use a channel and containers to transfer data.

CICS programs that are called by an ECI request must follow the rules for distributed program link (DPL) requests. For information about DPL requests, see Distributed Program Link (DPL) in CICS Application Programming.

The External Presentation Interface
An external application can use the External Presentation Interface (EPI) to call a 3270-based CICS application program and use its output. The client application can install and delete virtual IBM 3270 terminals in the CICS region. The definitions used by the EPI are processed by CICS as remote 3270 terminal definitions and therefore support automatic transaction initiation requests (ATI).

The External Security Interface
An external application can use the External Security Interface (ESI) to perform certain security functions. For example, the application can access information about user IDs held in the CICS external security manager (ESM) and set the default security credentials for a server connection.

`The ECI resource adapters`

The ECI resource adapters provide a high-level CCI interface to the External Call Interface that applications can use to link to CICS applications and pass data in COMMAREAs or containers. The resource adapters can be deployed into a J2EE application server, such as WebSphere Application Server, so that J2EE enterprise applications can access CICS. When the JCA is used, connection pooling, security, and transaction context are managed by the J2EE application server instead of the application.

For z/OS, two ECI resource adapters are supplied in CICS Transaction Gateway:

- Adapter `cicseciXA.rar` that supports two-phase commit
- Adapter `cicseci.rar` that supports single-phase commit only

The ECI resource adapters also support the following additional features:

Support for IPIC connections

You can use IPIC connections to access CICS over TCP/IP when the region is CICS TS for z/OS, Version 3.2 or later. Unlike EXCI, APPC, and ECI over TCP/IP, this type of connection supports containers and SSL authentication. The IPIC connection is represented by an IPCONN resource in CICS.

You cannot install static IPCONN resources to external Java clients: these connections are always automatically installed. See Writing a program to control autoinstall of IPIC connections in the Customization Guide.

Channels and containers

Channels and containers provide applications with a way to transfer data in CICS that is larger than 32 KB. For more information about channels and containers, see Enhanced inter-program data transfer using channels in CICS Application Programming.

Secure Sockets Layer (SSL) authentication

Secure Sockets Layer (SSL) authentication. SSL is supported on IPIC connections between CICS Transaction Gateway and CICS. For information about using SSL authentication, see Configuring CICS to use SSL in the RACF Security Guide.

`The EPI resource adapter`

The EPI resource adapter provides a high-level CCI interface to the External Presentation Interface that can be used to install terminals and run 3270-based transactions in a CICS region. There is no support for Automatic Transaction Initiation (ATI). The resource adapter can be deployed into a J2EE application server so that J2EE enterprise applications to access CICS. When the JCA is used, connection pooling, security, and transaction context are managed by the J2EE application server instead of the application.

Examples of using the CICS resource adapters

The scenario shown in Figure 1 on page 16 is an example of a *three-tier configuration*. A Java application uses the ECI resource adapter to link to a program in the CICS region. The connection between the client application and the CICS region is occurring through an intermediate system. Because the client application is not running on the same host as CICS Transaction Gateway, the daemon listens and communicates with the client. On z/OS, CICS Transaction Gateway uses the External CICS Interface (EXCI) or the IPIC driver to pass requests to CICS. These requests are processed by CICS as ECI calls.

The diagram also shows a Java servlet that also uses the ECI resource adapter to connect to a server program. This configuration is an example of a *two-tier configuration*, where a direct connection exists between the client application and the CICS region through the ECI Adapter. Because the servlet is running on the same host as CICS TG, it uses the local protocol to communicate.

CICS Transaction Gateway on z/OS supports the External Call Interface but not the External Presentation Interface. The ECI and the ECI resource adapter are supported, but not the EPI or the EPI resource adapter. Only Java client programs are supported. ECI calls can be made over EXCI or IPIC connections to the CICS region.

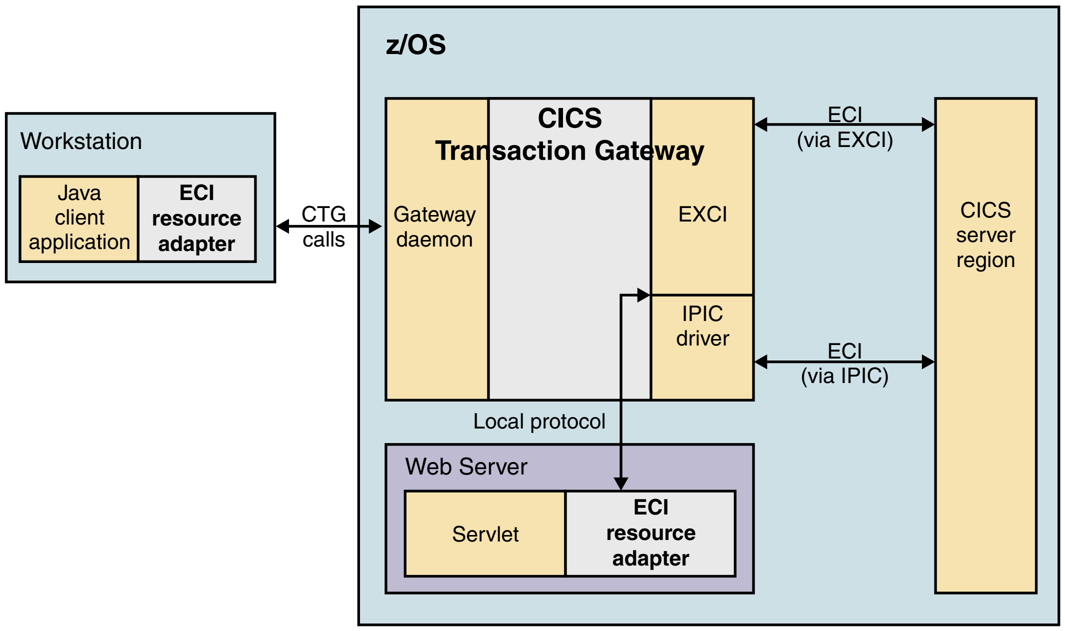


Figure 1. Java clients connect to a CICS program by using the ECI resource adapter

A variation is shown in Figure 2 on page 17. In this example, CICS Transaction Gateway runs on a Windows server. CICS Transaction Gateway on Windows and Linux supports both the ECI and ECI resource adapter and the EPI and EPI resource adapter. The Java client can access 3270-based CICS programs, in addition to CICS programs that use a suitable COMMAREA or containers.

ECI calls can be made to CICS over APPC, TCP62, ECI over TCP/IP, or IPIC connections. EPI calls are supported only on APPC connections.

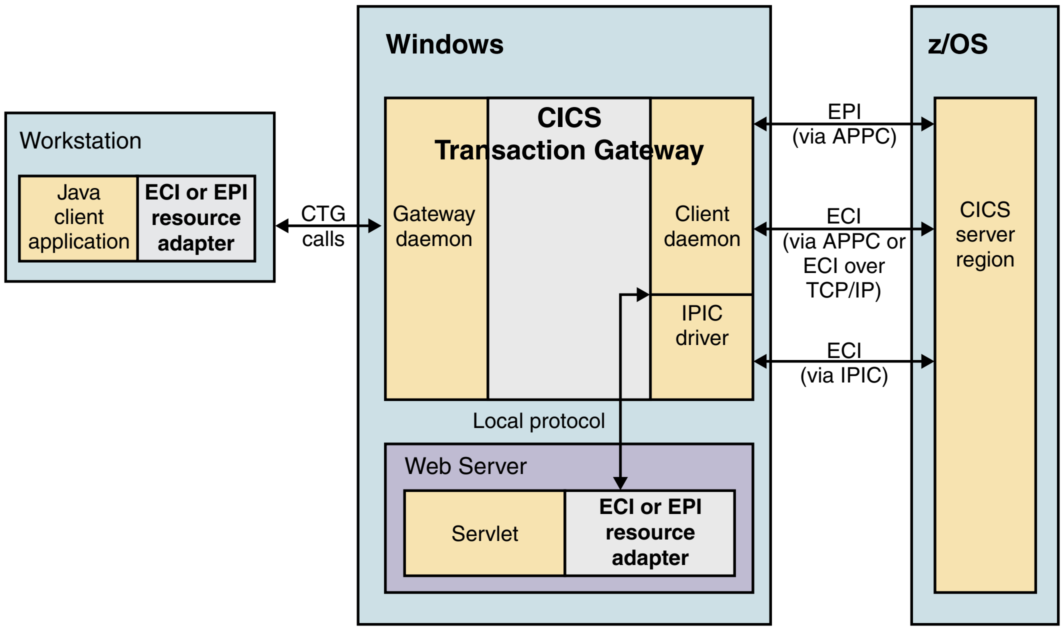


Figure 2. Java clients connect to a CICS program from outside CICS

To use CICS programs in this way, the Java developer requires some knowledge of developing CICS applications.

CICS Transaction Gateway

Programming Guide

Scenarios

Programming Reference

IBM Redbooks®

Developing Connector Applications for CICS

Java Connectors for CICS Featuring the J2EE Connector Architecture

Java web services

CICS includes the Axis2 technology to run Java web services. Axis2 is an open source web services engine from the Apache foundation and is provided with CICS to process SOAP messages in a Java environment.

Axis2 is a Java-based implementation of a web services SOAP engine that supports a number of the web services specifications. It also provides a programming model that describes how to create Java applications that can run in Axis2. Axis2 is provided with CICS to process web services in a Java environment. Although Axis2 response times are slightly slower than the non-Java equivalent, this type of Java workload is eligible for running on a zAAP.

The JVM server supports running Axis2 to process inbound and outbound SOAP messages in a Java-based SOAP pipeline, without changing any of your existing web services. However, you can also create a web service from a Java application and run it in the same JVM server. By deploying the application to the Axis2 repository of the JVM server, both the Java application and SOAP processing are eligible for running on a zAAP.

You might want to use Java web services for one of the following reasons:

- You have experience of Axis2 web services on other platforms and want to create web services in CICS.
- You want to use standard Java APIs to create Java data bindings that integrate with Axis2.
- You have complicated WSDL documents that are difficult to handle with the CICS web services assistants.
- You want to run the handling of the web service application on a zAAP.

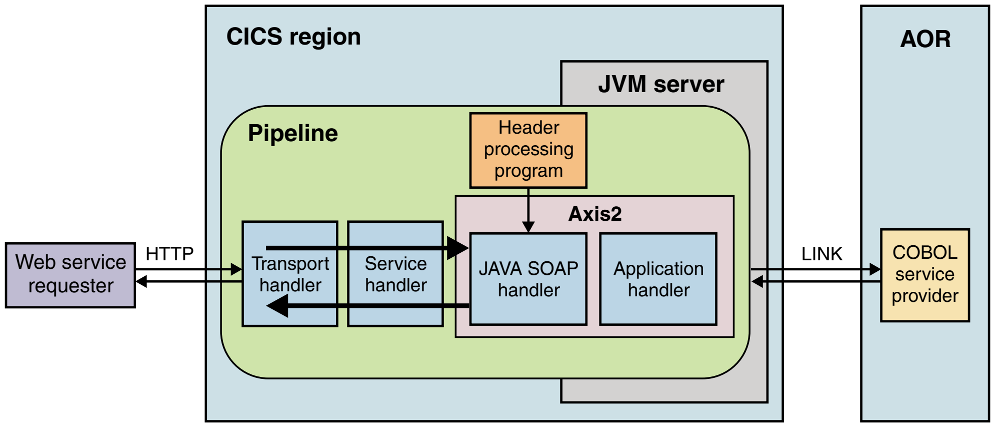
The following examples describe how you can use Java with web services.

Process SOAP messages in a JVM server

The majority of SOAP processing that occurs in the web services pipeline is performed by the SOAP handler and application handler. You can optionally run this SOAP processing in a JVM server and use zAAP to run the work. You can continue to use web service applications that are written in COBOL, C, C++, or PL/I.

If you have existing web services, you can update the configuration of your pipelines to use a JVM server. You do not have to make any changes to the web services. If the pipeline uses a SOAP header processing program, it is best to rewrite the program in Java by using the Axis2 programming model. The header processing program can share the Java objects with Axis2 without doing any further data conversion. If you have a header processing program in COBOL for example, the data must be converted from Java into COBOL and back again, which can slow down the performance of the SOAP processing.

The scenario shown in the following diagram is an example of a COBOL application that is a web service provider. The request is processed in a pipeline that is configured to support Java. The SOAP handler and application handler are Java programs that are processed by Axis2 and run in a JVM server. The application handler converts the data from XML to COBOL and links to the application.



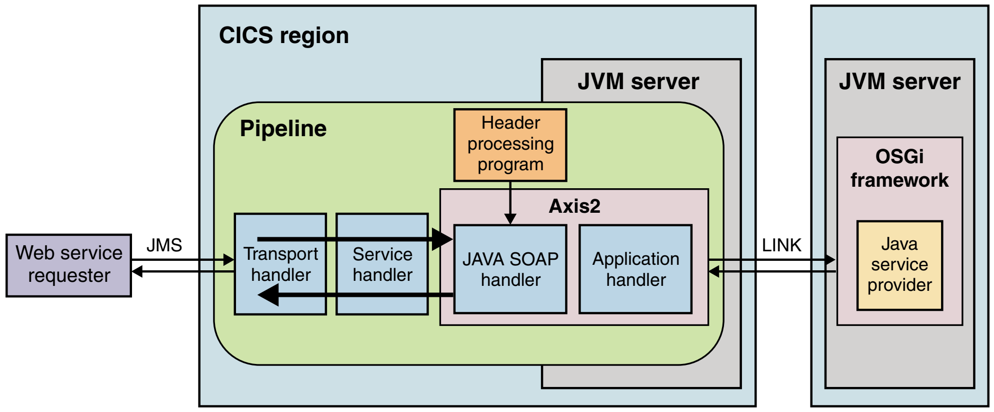
When you are planning your environment, ensure that you use a set of dedicated regions for your JVM servers. In this example, the COBOL application runs in an application-owning region (AOR) that is separate from the CICS region where the JVM server runs. You can use workload management to balance the workloads, for example on the **EXEC CICS LINK** from the application handler or on the inbound request from the web service requester.

Write a Java application that uses output from the CICS web services assistant

You can write a Java application that interprets the language structures and uses the data bindings generated by the CICS web services assistant. The web services assistant can produce language structures from WSDL or WSDL from language structures. The assistant also produces a web service binding that describes how to convert the data between XML and the target language during SOAP processing.

If you use the assistant to generate a language structure, you can use JZOS or J2C to work with the language structures to generate Java classes. These tools provide a way for Java developers to interact with other CICS applications. In this example, you can use these tools to write a Java application that can handle an inbound SOAP message after CICS has converted the data from XML. For more information, see "Interacting with structured data from Java" on page 46.

The scenario shown in the following diagram is an example of a Java application that is a web service provider. The SOAP processing is handled by Axis2 in a JVM server. The application handler links to the Java application, which is packaged and deployed as one or more OSGi bundles and runs in a JVM server.



The advantage of this approach is that because the data bindings were generated by the web services assistant, the web service is represented in CICS by the WEBSERVICE resource. You can use statistics, resource management, and other facilities in CICS to manage the web service. The disadvantage is that the Java developer must work with language structures for a programming language that might be unfamiliar.

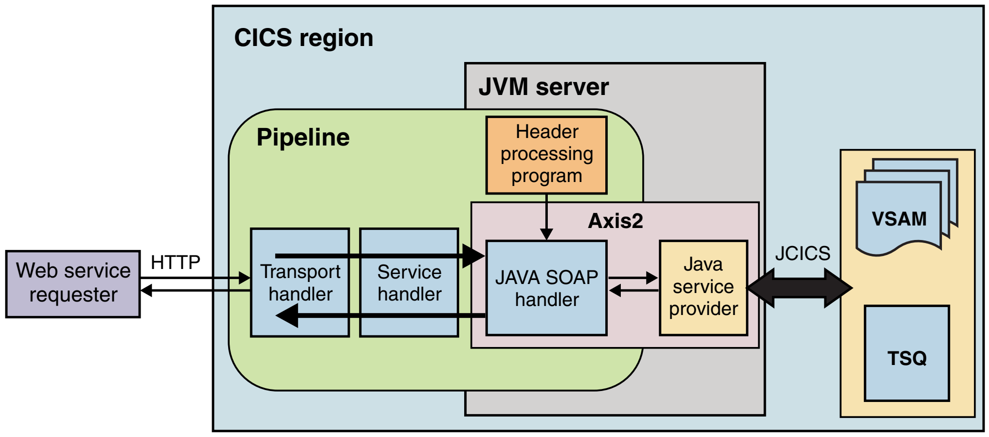
When you are planning your environment for this type of application, use a separate JVM server to run the application:

- You can more effectively manage and tune the JVM servers for the different workloads.
- You can use workload management on the inbound requests and **EXEC CICS LINK** to balance workloads and scale the environment.
- You can take advantage of the OSGi support in CICS to manage the Java application.

Write a Java application that uses Java data bindings

You can write a Java application that generates and parses the XML for SOAP messages. The Java 6 API provides standard Java libraries to work with XML; for example, you can use the Java Architecture for XML Binding (JAXB) to create the Java data bindings, and the Java API for XML Web Services (JAX-WS) libraries to generate and parse the XML. If you use these libraries, the application can run in Axis2 in the same JVM server as the SOAP pipeline processing.

The scenario shown in the following diagram is an example of a Java application that is a web service provider and is processed by the Axis2 SOAP engine in a JVM server.



The Java application uses Java data bindings and interacts with the Java SOAP handler, so there is no application handler. In this example, the web service requester uses HTTP to connect to the CICS region, but you can also use JMS. The Java application uses JCICS to access CICS services, in this example VSAM files and a temporary storage queue.

The advantage of this approach is that the Java developer uses familiar technologies to create the application. Also, the Java developer can work with complex WSDL documents that the web services assistant cannot process to produce a binding. However, this approach has some limitations:

- You cannot use WS-Security for this type of application, so if you want to use security, use SSL to secure the connection.
- No context switch for the user ID occurs in the pipeline processing. To change the user ID on the request, use a URIMAP resource.
- Because you are not using the web service binding from the web services assistant, there is no WEBSERVICE resource.
- If the application is a web service requester, the pipeline processing is bypassed. So you do not get the qualities of service that are available in the pipeline.

If you implement workload management in your CICS regions, you must plan how to route this type of workload. Because the Java application runs in the same JVM server as the SOAP processing, CICS does not provide a routing opportunity. However, you can implement a distributed program link in the JAX-WS application to another program if routing is required.

Java applications that comply with OSGi

CICS includes the Equinox implementation of the OSGi framework to run Java applications that comply with the OSGi specification in a JVM server.

The OSGi Service Platform specification, as described in "The OSGi Service Platform" on page 2, provides a framework for running and managing modular and dynamic Java applications. The default configuration of a JVM server includes the Equinox implementation of an OSGi framework. Java applications that are deployed into the OSGi framework of a JVM server benefit from the advantages of using OSGi and the qualities of service that are inherent in running applications in CICS.

You might want to use Java applications for any of the following reasons:

- You want to create Java workloads that can run on a zAAP to reduce the cost of transactions.
- You have experience of writing Java applications that use OSGi on other platforms and want to create Java applications in CICS.
- You want to provide Java applications as a set of modular components that can be reused and updated independently, without affecting the availability of applications and the JVM in which they are running.

To effectively develop, deploy, and manage Java applications that comply with OSGi, you must use the CICS Explorer SDK and the CICS Explorer:

- The CICS Explorer SDK enhances an existing Eclipse Integrated Development Environment (IDE) to provide the tools and support to help Java developers create and deploy Java applications in CICS. Use this tool to convert existing Java applications to OSGi bundles.
- The CICS Explorer is an Eclipse-based systems management tool that provides system administrators with views for OSGi bundles, OSGi services, and the JVM servers in which they run. Use this tool to enable and disable Java applications, check the status of OSGi bundles and services in the framework, and get some preliminary statistics on the performance of the JVM server.

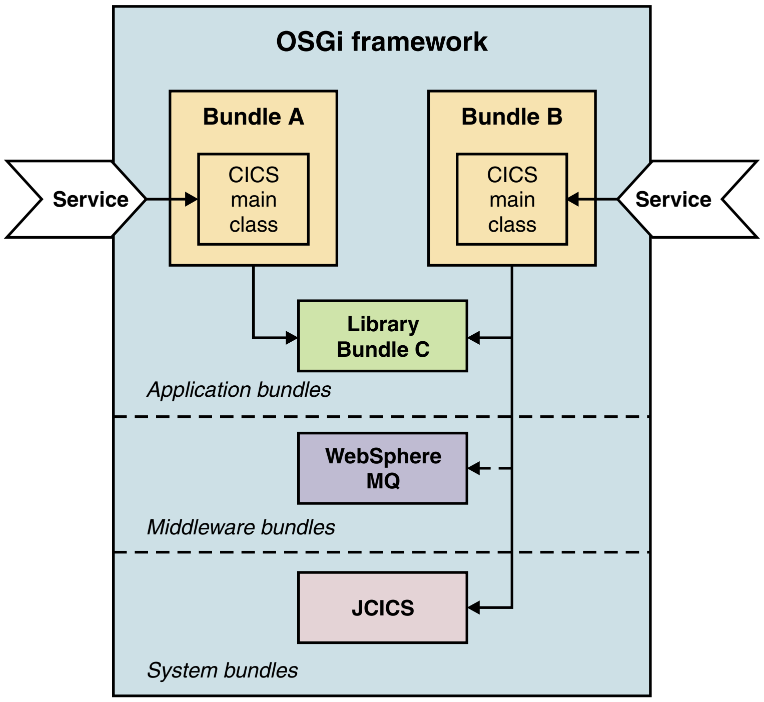
Any Java developer or systems administrator who wants to work with OSGi requires access to these freely available tools.

The following examples describe how you can run Java applications that use OSGi in CICS.

Run multiple Java applications in the same JVM server

The JVM server can handle multiple requests in the same JVM concurrently. Therefore you can call the same application multiple times concurrently or run more than one application in the same JVM server.

When you have decided how to split your applications between JVM servers, you can plan how to use the OSGi model to componentize your applications into a set of OSGi bundles. You must also decide what supporting OSGi bundles are required in the framework to provide services to your applications. The OSGi framework can contain different types of OSGi bundle, as shown in the following diagram:



Application bundles

An application bundle is an OSGi bundle that contains application code. OSGi bundles can be self-contained or have dependencies on other bundles in the framework. These dependencies are managed by the framework, so that an OSGi bundle that has an unresolved dependency cannot run in the framework. To make the application accessible outside the framework in CICS, an OSGi bundle must declare a CICS main class as its OSGi service. If a PROGRAM resource points to the CICS main class, other applications outside the OSGi framework can access the Java application. If you have an OSGi bundle that contains common libraries for one or more applications, a Java developer might decide not to declare a CICS main class. This OSGi bundle is available only to other OSGi bundles in the framework.

The deployment unit for a Java application is a CICS bundle. A CICS bundle can contain any number of OSGi bundles and can be deployed to one or more JVM servers. You can add, update, and remove application bundles independently from managing the JVM server.

Middleware bundles

A middleware bundle is an OSGi bundle that contains classes to implement system services, such as connecting to WebSphere MQ. Another example might be an OSGi bundle that contains native code and must be loaded only once in the OSGi framework. A middleware bundle is managed with the life cycle of the JVM server, rather than the applications that use its classes. Middleware bundles are specified in the JVM profile of the JVM server and are loaded by CICS when the JVM server starts up.

System bundles

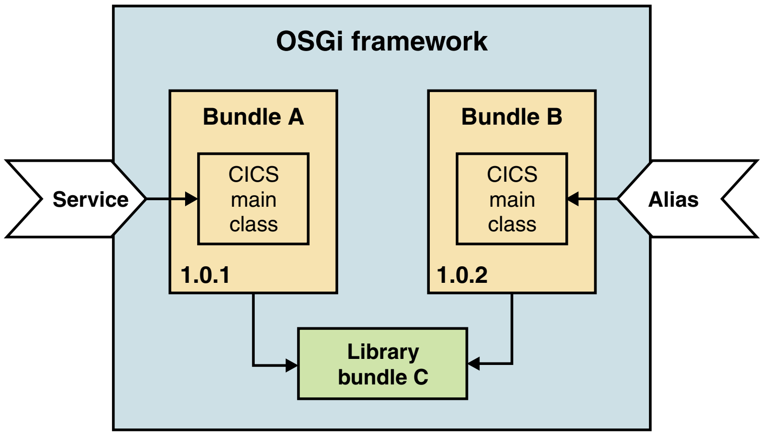
A system bundle is an OSGi bundle that manages the interaction between CICS and the OSGi framework to provide key services to the applications. The primary example is the JCICS OSGi bundles, which provide access to CICS services and resources.

To simplify the management of your Java applications, follow these best practices:

- Deploy tightly coupled OSGi bundles that comprise an application in the same CICS bundle. Tightly coupled bundles export classes directly from each other without using OSGi services. Deploy these OSGi bundles together in a CICS bundle to update and manage them together.
- Avoid creating dependencies between applications. Instead, create a common library in a separate OSGi bundle and manage it in its own CICS bundle. You can update the library separately from the applications.
- Follow OSGi best practices by using versions when creating dependencies between bundles. Using a range of versions mean that an application can tolerate compatible updates to bundles that it depends on.
- Set up a naming convention for the JVM servers and agree the convention between the system programmers and Java developers.

Run multiple versions of the same Java application in a JVM server

The OSGi framework supports running multiple versions of an OSGi bundle in a framework, so you can phase in updates to the application without interrupting its availability. However, you cannot have multiple versions of the same OSGi service in the framework. If different versions of the OSGi bundle have the same CICS main class, you can use an alias to override the duplicate service. The alias is specified with the declaration of the CICS main class and registered in the OSGi framework as the OSGi service for the updated version of the bundle. Specify the alias on another PROGRAM resource to make the application available.



Chapter 3. Developing Java applications for CICS

You can write Java application programs that use CICS services and run under CICS control. Using the CICS Explorer SDK, you can develop applications that use the JCICS class library to access CICS resources and interact with programs that are written in other languages. You can also connect to your Java programs using various protocols and technologies, such as web services or CICS Transaction Gateway.

CICS provides tools and the runtime environment to support Java applications. The CICS Explorer SDK is an eclipse-based tool that provides support for developing and deploying Java applications in CICS. It contains the JCICS class libraries to develop applications that access CICS resources and services; for example, you can access VSAM files, transient data queues, and temporary storage. You can also use JCICS to link to CICS applications that are written in other languages, such as COBOL and C.

The CICS Explorer SDK provides other features, such as packaging applications to comply with the OSGi specification and providing a target environment to ensure that you use only the classes that are supported in a specific release of CICS. JCICS samples are also included to help you get started if you are new to developing Java applications for CICS.

What you need to know about CICS

CICS is a transaction processing subsystem that provides services for a user to run applications by request, at the same time as many other users are submitting requests to run the same applications, using the same files and programs. CICS manages the sharing of resources, integrity of data, and prioritization of execution, while maintaining fast response times.

A CICS application is a collection of related programs that together perform a business operation, such as processing a product order or preparing a company payroll. CICS applications run under CICS control, using CICS services and interfaces to access programs and files.

You run CICS applications by submitting a *transaction* request. The term transaction has a special meaning in CICS; See “CICS transactions” for an explanation of the difference between the CICS usage and the more common industry usage. Execution of the transaction consists of running one or more application programs that implement the required function.

To develop Java applications for CICS, you have to understand the relationship between CICS programs, transactions, and tasks. These terms are used throughout CICS documentation and appear in many programming commands. You also have to understand how CICS handles Java applications in the runtime environment.

CICS transactions

A transaction is a piece of processing initiated by a single request.

The request is typically made by a user at a terminal. However, it could be made from a Web page, from a remote workstation program, or from an application in another CICS region; or it might be triggered automatically at a predefined time. The Overview: CICS and HTTP in the Internet Guide and the External interfaces overview in the External Interfaces Guide describe different ways of running CICS transactions.

A single transaction consists of one or more *application programs* that, when run, carry out the processing needed.

However, the term *transaction* is used in CICS to mean both a single event and all other transactions of the same type. You describe each transaction type to CICS with a TRANSACTION resource definition. This definition gives the transaction type a name (the transaction identifier, or TRANSID) and tells CICS several things about the work to be done, such as which program to invoke first, and what kind of authentication is required throughout the execution of the transaction.

You run a transaction by submitting its TRANSID to CICS. CICS uses the information recorded in the TRANSACTION definition to establish the correct execution environment, and starts the first program.

The term *transaction* is now used extensively in the IT industry to describe a *unit of recovery* or what CICS calls a *unit of work*. This is typically a complete logical operation that is recoverable; it can be committed or backed out as an entirety as a result of a programmed command or of a system failure. In many cases, the scope of a CICS transaction is also a single unit of work, but you should be aware of the difference in meaning when reading CICS documentation.

CICS tasks

A task is single instance of the execution of a transaction.

This word, *task*, has a specific meaning in CICS. When CICS receives a request to run a transaction, it starts a new task that is associated with this *one instance* of the execution of the transaction type. That is, a CICS task is one execution of a transaction, with its own private set of data, usually on behalf of a specific user. You can also consider a task as a *thread*. Tasks are *dispatched* by CICS according to their priority and readiness. When the transaction completes, the task is terminated.

CICS application programs

In Java programs, you can use the Java class library for CICS (JCICS) to access CICS services and link to application programs that are written in other languages.

CICS application programs can be written in COBOL, C, C++ , Java, PL/I, or assembler languages. Most of the processing logic is expressed in standard language statements, but to request CICS services, applications use the provided application programming interfaces. COBOL, C, C++, PL/I, or assembler programs can use the **EXEC CICS** application programming interface or the C++ class library. Java programs use the JCICS class library. JCICS is described in "The Java class library for CICS (JCICS)" on page 47.

CICS services

Java programs can access the following CICS services through the JCICS programming interface: Data management, communications, unit-of-work, program, and diagnostic services.

CICS services managers usually have the word control in their title; for example, “terminal control” and “program control”. These terms are used extensively in CICS information.

Data management services

CICS provides the following data management services:

- Record-level sharing, with integrity, in accessing Virtual Storage Access Method (VSAM) data sets. CICS logs activity to support data backout (for transaction or system failure) and forward recovery (for media failure). CICS file control manages the VSAM data.

  CICS also implements two proprietary file structures, and provides commands to manipulate them:

  Temporary storage

  Temporary storage (TS) is a means of making data readily available to multiple transactions. Data is kept in queues, which are created as required by programs. Queues can be accessed sequentially or by item number.

  Temporary storage queues can reside in main memory, or can be written to a storage device.

  A temporary storage queue can be thought of as a named scratchpad.

  Transient data

  Transient data (TD) is also available to multiple transactions, and is kept in queues. However, unlike TS queues, TD queues must be predefined and can be read only sequentially. Each item is removed from the queue when it is read.

  Transient data queues are always written to a data set. You can define a transient data queue so that writing a specific number of items to it acts as a trigger to start a specific transaction. For example, the triggered transaction might process the queue.
- Access to data in other databases (including DB2), through interfaces with database products.

Communications services

CICS provides commands that give access to a wide range of terminals (displays, printers, and workstations) by using SNA and TCP/IP protocols. CICS terminal control provides management of SNA and TCP/IP networks.

You can write programs that use Advanced Program-to-Program Communication (APPC) commands to start and communicate with other programs in remote systems, using SNA protocols. CICS APPC implements the peer-to-peer distributed application model.

CICS also provides an Object Request Broker (ORB) to implement the inbound and outbound IIOP protocols defined by the Common Object Request Broker Architecture (CORBA). The ORB supports requests to execute Java stateless objects and enterprise beans.

The following CICS proprietary communications services are provided:

Function shipping
: Program requests to access resources (files, queues, and programs) that are defined as existing on remote CICS regions are automatically routed by CICS to the owning region.

Distributed program link (DPL)
: Program-link requests for a program defined as existing on a remote CICS region are automatically routed to the owning region. CICS provides commands to maintain the integrity of the distributed application.

Asynchronous processing
: CICS provides commands to allow a program to start another transaction in the same, or in a remote, CICS region and optionally pass data to it. The new transaction is scheduled independently, in a new task. This function is similar to the *fork* operation provided by other software products.

Transaction routing
: Requests to run transactions that are defined as existing on remote CICS regions are automatically routed to the owning region. Responses to the user are routed back to the region that received the request.

Unit of work services

When CICS creates a new task to run a transaction, a new unit of work (UOW) is started automatically. (Thus CICS does not provide a BEGIN command, because one is not required.) CICS transactions are always executed in-transaction.

CICS provides a SYNCPOINT command to commit or roll back recoverable work done. When the sync point completes, CICS automatically starts another unit of work. If you terminate your program without issuing a SYNCPOINT command, CICS takes an implicit sync point and attempts to commit the transaction.

The scope of the commit includes all CICS resources that have been defined as recoverable, and any other resource managers that have registered an interest through interfaces provided by CICS.

If you write enterprise beans using transaction services provided by commands defined by the Java Transaction Service (JTS), these commands (including BEGIN) are mapped by CICS to its unit of work services.

Program services

CICS provides commands that enable a program to link or transfer control to another program, and return.

Diagnostic services

CICS provides commands that you can use to trace programs and produce dumps.

|

Java runtime environment in CICS

| CICS provides two runtime environments for running Java applications.
| Threadsafe applications can use a JVM server. Applications that are not threadsafe
| have to use pooled JVMs.

JVM servers

The JVM server is a runtime environment that can run tasks in a single JVM. This environment is preferred for running Java applications, because it reduces the virtual storage required for each Java task and allows CICS to run many tasks concurrently.

CICS tasks run in parallel as threads in the same JVM server process. Not only is the JVM shared by all CICS tasks, which might be running multiple applications concurrently, all static data and static classes are also shared. So to use a JVM server in CICS, a Java application must be threadsafe. Each thread runs under a T8 TCB and can access CICS services using the JCICS API.

You can write application code to start a new thread or call a library that starts a thread. However, these threads cannot access CICS services. Any attempt to access CICS services from an application-spawned thread results in a Java bm.exception. If you want to create threads in your application, ensure that they do not run beyond the lifetime of the CICS task that runs the application. When the system programmer disables the JVM server, CICS waits for all current threads running on T8 TCBs to finish in the JVM. However, any threads created by an application itself are terminated.

Because static data is shared by all threads running in the JVM server, you can create OSGi bundle activator classes to initialize static data and leave it in the right state when the JVM shuts down. A JVM server runs until the system programmer disables it, for example to add an application or fix a problem. By providing bundle activator classes, you can ensure that the state is correctly set for your applications. CICS has a timeout that specifies how long to wait for these classes to complete before continuing to start or stop the JVM server. You cannot use JCICS in startup and termination classes.

Do not use the System.exit() method in your applications. This method causes both the JVM server and CICS to shut down, affecting the state and availability of your applications.

Pooled JVMs

A pooled JVM can handle only one request for a Java application at a time, therefore many more JVMs are required in a CICS region. A pooled JVM is isolated, so a Java application does not have to be threadsafe. However, pooled JVMs are typically reused many times, potentially by different applications, so it is important to maintain transaction isolation and the state of data.

The main thread under which a JVM starts is called the Initial Process Thread (IPT). CICS ensures that the public static main method in any Java program runs under the IPT in a pooled JVM. If you want to create threads in your application, they must not attempt to access CICS services and must not run beyond the lifetime of the CICS task that starts the threads. If user threads continue to run after the IPT has returned control to CICS, these threads can damage isolation for the JVM when it is reused by another application, and can cause problems when CICS attempts to stop the JVM.

Installing the CICS Explorer SDK

The CICS Explorer SDK is freely available to download from the IBM website to install in an Eclipse Integrated Development Environment (IDE).

Before you begin

You must have the required software installed on your workstation, including an Eclipse IDE at the correct version. The list of supported operating systems and required software are described on the CICS Explorer website.

About this task

The CICS Explorer SDK is an Eclipse-based framework for developing extensions to the CICS Explorer. It also provides support for developing Java applications to run in any supported release of CICS. It provides support for JCICS and packaging applications to comply with the OSGi specifications.

Procedure

1. If you do not have an Eclipse IDE installed, go to the Eclipse website. Download and install an IDE. You must install an Eclipse IDE at version 3.6.2 or higher.
2. To download the CICS Explorer SDK, go to the CICS Explorer website.
3. Select the **Download site** link and enter your IBM ID and password.
4. Select CICS Explorer from the list and click **Continue**.
5. Read and accept the license.
6. Select the CICS Explorer SDK from the list to download the compressed file to a directory on your workstation.
7. Open the Eclipse IDE and click **Help** > **Install new software**.
8. Click **Add**. In the "Add site" dialog box, click **Archive**.
9. Browse to the downloaded file and click **Open**.
10. Select the check box next to IBM CICS Explorer SDK and click **Next**.
11. Accept the license and click **Finish** to install the CICS Explorer SDK.

Results

The CICS Explorer SDK is installed in your Eclipse IDE. You might need to accept a security warning and restart your IDE to pick up the new software.

What to do next

You can work with the CICS samples provided by the CICS Explorer SDK to become familiar with the Java support. For more information, see “Getting started with the JCICS examples.”

Getting started with the JCICS examples

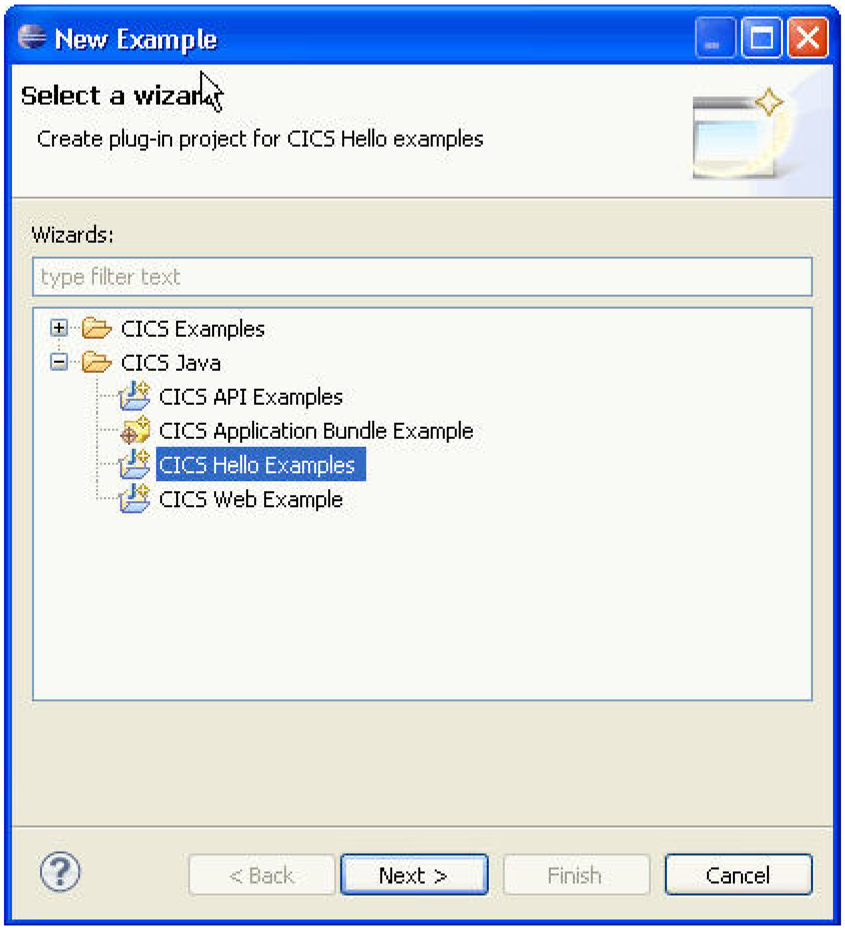
The CICS Explorer SDK contains the JCICS examples to help you start developing Java applications for CICS.

About this task

The JCICS examples are packaged as a set of OSGi bundles that you can import into an Eclipse plug-in project to view the Java source code. You can also use the context help to look up the Javadoc explanations for the methods that are used in the code.

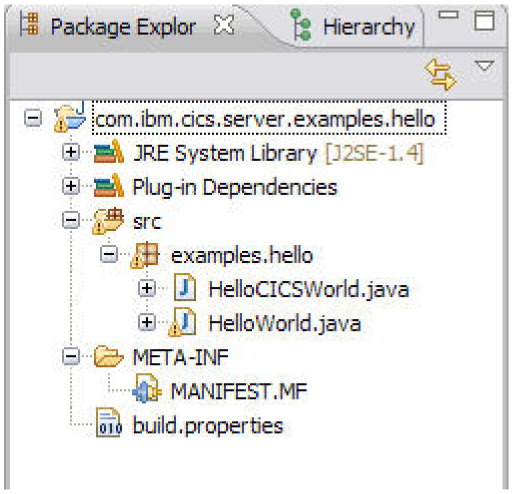
Procedure

1. In the Eclipse IDE, open the Java perspective.
2. To create a new example plug-in project, open the New Example wizard using one of the following choices:
   - In the Eclipse menu bar, click **File** > **New** > **Example**.
   - Click the down arrow on the **New Wizard** icon and click **Example**.
   - In the Project Explorer view, right-click and click **New** > **Example**.
3. In the **CICS Java** folder, select **CICS Hello Examples** and click **Next**.



   - The CICS API examples demonstrate how to use transient data queues, temporary storage queues, and channels and COMMAREAs in Java programs.
   - The CICS application bundle example demonstrates how to create a CICS bundle to deploy to CICS.
   - The CICS hello examples demonstrate two ways to do a simple Hello World test in CICS.
   - The CICS web example demonstrates how to use classes to interact with a web browser.
4. In the **Project name** field enter a name for the new project. By default, Eclipse creates a name that is the folder location of the examples in the workspace, followed by the example name. For example, the default project name for the Hello World example is `com.ibm.cics.server.examples.hello`.
5. Click **Finish**. Eclipse creates the plug-in project containing the JCICS Hello World example as an OSGi bundle.

6. Expand the project in the Package Explorer view.



- The **Plug-in Dependencies** folder contains the dependencies for the OSGi bundle. In this example, the bundle has a dependency on the OSGi bundle that contains JCICS. This information is also captured in the manifest of the project.
- The **src** folder contains the Java source for the examples. You can browse the source files to see the JCICS classes that are used and use the context help to look up a particular class. You can also open the Javadoc view to see the API details for the selected content, for example a method or class.
- The **META-INF** folder contains the manifest for the project. The manifest contains the OSGi headers to describe the OSGi bundle.

7. Create plug-in projects for the CICS API and CICS Web examples by using the New Example wizard. You can view the Java source to understand how the JCICS classes are used for working with programs and web applications.

Results

You have created three plug-in projects in Eclipse for the JCICS examples. These projects contain OSGi bundle packaging information, including plug-in dependencies and target Java environments.

What to do next

To run Java applications in CICS, you have to deploy the Java application in a CICS bundle project to zFS. You can try the deployment process using the JCICS examples, as described in “Deploying the JCICS examples.”

Deploying the JCICS examples

You can use the example CICS bundle in the CICS Explorer SDK to deploy the JCICS examples to a CICS region.

Before you begin

You must have created the JCICS example projects, as described in “Getting started with the JCICS examples” on page 30.

About this task

CICS loads and runs Java applications from zFS, so you must deploy your compiled applications to a suitable directory in zFS. You can create a suitable directory in zFS using the z/OS perspective in CICS Explorer. CICS must have read and execute access to the directory.

The CICS Explorer SDK provides support for deploying Java applications in a CICS bundle project to zFS. A CICS bundle project groups a set of OSGi bundles together that are logically deployed and managed as a single unit. You can use the example CICS bundle project to deploy the JCICS examples to a CICS region.

Procedure

1. In the Eclipse IDE, open the Java perspective.
2. Open the New Example wizard using one of the following choices:
   - In the Eclipse menu bar, click **File** > **New** > **Example**.
   - Click the down arrow on the **New Wizard** icon and click **Example**.
   - In the Project Explorer view, right-click and click **New** > **Example**.
3. In the **CICS Java** folder, select **CICS Application Bundle Example** and click **Next**.
4. In the **Project name** field enter a name for the new project. By default, Eclipse creates a name that is the folder location of the examples in the workspace, followed by the example name. For example, the default project name for the CICS bundle is `com.ibm.cics.server.examples`.
5. Click **Finish**. Eclipse creates the CICS bundle project that contains a manifest and three resources. These resources reference the three OSGi bundles.
6. Open the `web.osgibundle` file to check its contents. This file is in XML format and contains the symbolic name and version of the OSGi bundle. It also contains the name of a sample JVM server. The JVM server is the runtime environment for Java applications in CICS. When you create your own applications, you must provide the name of the target JVM server in this file.
7. Deploy the CICS bundle to zFS:
   a. Right-click the CICS bundle project and select **Export to z/OS UNIX File System**.
   b. Enter your FTP credentials if required. You might need to create a connection to a target host machine if you have not previously set up a connection.
   c. Browse to a directory where you want to deploy the CICS bundle and click **Finish**.

   The CICS bundle is deployed in the specified directory.
8. Open the CICS SM perspective. In the CICSplex Explorer view, select the CICS region where you want to run the JCICS example programs.
9. Install the JVMSERVER resource, DFH$JVMS, which is in the sample group DFH$OSGI. The resource creates a sample JVM server in the CICS region that contains an OSGi framework. This resource name matches the name of the JVM server that was specified in the manifest of the CICS bundle. You can check the status of the JVM server by clicking **Operations** > **Java** > **JVM Servers**.
10. Open the Bundle Definitions view by clicking **Definitions** > **Bundle Definitions**. This view lists all the bundle definitions for the CICS region.

11. In the Resource Group Definitions view, select the supplied DFH$OSGI group. If this view is not open, select **Window** > **Show view** to open it in the Eclipse perspective. The Bundle Definitions view is filtered to display the DFH$OSGB resource definition.
12. Copy the resource definition to a new group to edit the attributes:
    a. Right-click on DFH$OSGB and select **Copy**.
    b. Right-click anywhere in the Resource Group Definitions view and select **Paste**.
    c. Enter a new group name and click **OK**.
13. Edit the BUNDLE resource definition in the new group to change the bundle directory to match the location of the deployed CICS bundle.
14. Right-click the definition to install the BUNDLE resource. You can check the BUNDLE installed in the ENABLED state by clicking **Operations** > **Bundles**. You can also check the list of OSGi bundles by clicking **Operations** > **Java** > **OSGi Bundles**.
15. To run the examples in a JVM server, install the DFH$OSGI sample group in the CICS region. This group contains the resource definitions for all the samples. The sample BUNDLE and JVMSERVER resources are not installed because you have already created resources of the same name. When you install the group, CICS creates the resources that are required to run the examples.

Results

You have successfully deployed the example CICS bundle to zFS and created the CICS resources that are required to run the JCICS examples.

What to do next

You can run the JCICS examples, as described in "Running the JCICS examples."

Running the JCICS examples

CICS provides a number of JCICS examples that you can run in CICS. You can either run the examples in a JVM server, the preferred environment for running Java applications, or you can run them in a pooled JVM.

Before you begin

The JCICS examples must be deployed in a zFS directory to which the CICS region has read and execute access.

Procedure

1. Ensure that the CICS region is correctly configured:
   - If you want to run the examples in a JVM server, the DFH$OSGI group must be installed in the CICS region. In particular, the DFH$JVMS resource must be enabled in the CICS region. This resource is the supplied sample JVM server and uses the default DFHOSGI profile. The BUNDLE resource containing the OSGi bundles for the JCICS examples must also be enabled.
   - If you want to run the examples in a pooled JVM, the DFH$JVM group must be installed in the CICS region. Edit the default JVM profile DFHJVMPR to

add the class path `/usshome/samples/dfjcics` to the `CLASSPATH_SUFFIX` option, where *usshome* is the value of the **USSHOME** system initialization parameter.

2. Follow the appropriate procedure to run each sample.

Running the Hello World examples

You can run two “Hello World” examples: HelloWorld and HelloCICSWorld. The HelloWorld example uses only Java services and HelloCICSWorld demonstrates the use of the JCICS TerminalPrincipalFacility class.

Before you begin

Ensure the CICS region is configured, as described in “Running the JCICS examples” on page 34.

About this task

The programs are started by sample CICS transactions. The examples use the following Java classes and CICS programs:

Example	Transaction	Program	Java class
HelloWorld	JHE1	DFJ$JHE1	`HelloWorld`
		DFH$JSAM (C program)	N/A
HelloCICSWorld	JHE2	DFJ$JHE2	`HelloCICSWorld`

DFH$JSAM is a standard CICS program that could be written in any of the CICS-supported languages. If, for example, you do not have a C compiler, you could write a COBOL version of DFH$JSAM and use it in place of the supplied C version. Alternatively, you can bypass DFH$JSAM altogether by changing the JHE1 TRANSACTION definition to run program DFJ$JHE1. However, if you change the definition, the Java program does not write anything to the terminal; so your only indication that the application has run successfully is the message in the `stdout` file.

Procedure

- Enter the JHE1 transaction in a terminal to run the standard Java application. You receive the following messages from JHE1: The following message is returned to your terminal:
  ```
  SAMPLE *COMPLETED*, SEE STOUT
  ```
  The following entry is written to the `stdout` file:
  ```
  Hello from a regular Java application
  ```
- Enter the JHE2 transaction in a terminal to run the JCICS application. You receive the following message from JHE2 on your terminal:
  ```
  Hello from a Java CICS application
  ```

Results

You have successfully run the Hello World examples.

What to do next

You can run the other examples to try out different services that are available to Java programs in CICS.

Running the program control examples

You can run the channel and COMMAREA examples to understand how CICS processes channels and containers or COMMAREAs. Programs can use either method to pass data, but containers are not limited to 32 KB.

Before you begin

Ensure the CICS region is configured, as described in “Running the JCICS examples” on page 34.

About this task

The examples demonstrate how to use the JCICS `Program` class to pass a channel and container or COMMAREA to another program. The COMMAREA example also shows you how to convert ASCII characters in the Java code to and from the equivalent EBCDIC used by the native CICS program.

The programs are started by sample CICS transactions. The examples use the following Java classes and CICS programs:

Example	**Transaction**	**Program**	**Java class**
Channel	JPC3	DFJ$JPC3	`ProgramControl.ClassThree`
		DFJ$JPC4	`ProgramControl.ClassFour`
		DFH$LCCC (C language)	N/A
COMMAREA	JPC1	DFJ$JPC1	`ProgramControl.ClassOne`
		DFJ$JPC2	`ProgramControl.ClassTwo`
		DFH$LCCA (C language)	N/A

DFH$LCCA and DFH$LCCC are standard CICS programs that can be written in any of the supported high-level languages. If you do not have a C compiler, you can write COBOL versions of DFH$LCCA and DFH$LCCC and use them in place of the supplied C versions.

Procedure

- To run the channel example:
  1. Enter the JPC3 transaction in a terminal. You receive the following messages on `Task.out` (usually your terminal):
     ```
     Entering ProgramControlClassThree.main()
     About to link to C program
     Leaving ProgramControlClassThree.main()
     ```
  2. Clear the screen. The following messages are displayed:
     ```
     Entering ProgramControlClassFour.main()
     ProgramControlClassFour invoked with Container "IntData         "
     ProgramControlClassFour invoked with Container "StringData      "
     ProgramControlClassFour invoked with Container "Response        "
     Leaving ProgramControlClassFour.main()
     ```

The messages that list the containers might appear in a different order.

The following processing is taking place in CICS:

1. The transaction runs the main Java class that is defined in the PROGRAM resource DFJ$JPC3. The Java program constructs a Channel object with two containers, and links to the C program, DFH$LCCC.
2. DFH$LCCC processes the containers, creates a new response container, and returns.
3. The Java program checks the data in the response container and schedules a pseudoconversational transaction to be started, passing the Channel object to the started transaction.
4. The started transaction runs another Java class that is defined in the PROGRAM resource DFJ$JPC4. This Java program browses the `Channel` using a `ContainerIterator` object and displays the name of each container it finds.

- To run the COMMAREA example:
  1. Enter the JPC1 CICS transaction to run the example. You receive the following messages on `Task.out` (usually your terminal):
     ```
     Entering ProgramControlClassOne.main()
     About to link to C program
     Leaving ProgramControlClassOne.main()
     ```
  2. Clear the screen. The following messages are displayed:
     ```
     Entering ProgramControlClassTwo.main()
     data received correctly
     Leaving ProgramControlClassTwo.main()
     ```

The following processing is taking place in CICS:

1. The transaction runs the main Java class that is defined in the PROGRAM resource DFJ$JPC1. The Java program constructs a COMMAREA and links to the C program, DFH$LCCA.
2. The C program processes the COMMAREA, updates it, and returns to the Java program.
3. The Java program checks the data in the COMMAREA and schedules a pseudoconversational transaction to be started, passing the started transaction the changed data in its COMMAREA.
4. The started transaction runs another main Java class that is defined in the PROGRAM resource DFJ$JPC2. This Java program reads the COMMAREA and validates it again.

Running the TDQ example

You can run the transient data queue example to understand how Java programs can interact with transient data. Programs can read and write transient data that is stored in sequential queues.

Before you begin

Ensure the CICS region is configured, as described in “Running the JCICS examples” on page 34.

About this task

This example demonstrates how to use the JCICS TDQ class. The example uses the following Java class and program:

Transaction	Program	Java class
JTD1	DFJ$JTD1	`TDQ.ClassOne`

Procedure

Enter the JTD1 transaction in a terminal to run the example. You receive the following messages on `Task.out`:

```
Entering examples.TDQ.ClassOne.main()
Entering writeFixedData()
Leaving writeFixedData()
Entering writeFixedData()
Leaving writeFixedData()
Entering readFixedData()
Leaving readFixedData()
Entering readFixedDataConditional()
Leaving readFixedDataConditional()
Leaving examples.TDQ.ClassOne.main()
```

Results

CICS performs the following processing:

1. The transaction runs the main Java class that is defined in the PROGRAM resource DFJ$JTD1.
2. The Java program writes some data to a transient data queue, reads it, and then deletes the queue.

Running the TSQ example

You can run the temporary storage example to understand how Java programs can interact with temporary storage queues. A temporary storage queue is a queue of data items that can be read and reread in any sequence. The queue is created by a task and persists until the same task or another task deletes it.

Before you begin

Ensure the CICS region is configured, as described in “Running the JCICS examples” on page 34.

About this task

This example demonstrates how to use the JCICS TSQ class and how to build a class as a dynamic link library (DLL) that can be shared with other Java programs. This example uses the following Java classes and programs:

Transaction	Program	Java class
JTS1	DFJ$JTS1	`TSQ.ClassOne`
	DFJ$JTSC	`TSQ.Common`

Procedure

Enter the JTS1 CICS transaction to run the example. You receive the following messages on `Task.out`:

```
Entering TSQ.ClassOne.main()
Entering TSQ_Common.writeFixedData()
Leaving TSQ_Common.writeFixedData()
```

```
Entering TSQ_Common.serializeObject()
Leaving TSQ_Common.serializeObject()
Entering TSQ_Common.updateFixedData()
Leaving TSQ_Common.updateFixedData()
Entering TSQ_Common.writeConditionalFixedData()
Leaving TSQ_Common.writeConditionalFixedData()
Entering TSQ_Common.updateConditionalFixedData()
Leaving TSQ_Common.updateConditionalFixedData()
Entering TSQ_Common.readFixedData()
Leaving TSQ_Common.readFixedData()
Entering TSQ_Common.deserializeObject()
Leaving TSQ_Common.deserializeObject()
Entering TSQ_Common.readFixedConditionalData()
Number of items returned is 3
Leaving TSQ_Common.readFixedConditionalData()
Entering TSQ_Common.deleteQueue()
Leaving TSQ_Common.deleteQueue()
Leaving TSQ.ClassOne.main()
```

Results

The following processing is taking place in CICS:

1. The transaction runs the main Java class that is defined in the PROGRAM resource DFJ$JTS1. The Java program links to another common Java program that is defined in the PROGRAM resource DFJ$JTSC.
2. The common Java program writes to an auxiliary temporary storage queue, updates the queue, deletes the queue, and returns.

Running the web example

You can run the web example to understand how Java programs can use CICS web support to interact with web browsers.

Before you begin

Ensure the CICS region is configured, as described in “Running the JCICS examples” on page 34. Before you run the web sample, follow the instructions in Configuring CICS web support components in the Internet Guide. Use the sample programs DFH$WB1A (Assembler) or DFH$WB1C (C) to confirm that CICS web support is configured correctly.

About this task

This example demonstrates how to use the JCICS web and document classes. You access this example application from a web browser. The example obtains information about the inbound client request, the HTTP headers, and the TCP/IP characteristics of the transaction. This information is written to the standard output stream `System.out` and inserted into a response document. Information about the document is also obtained and written to `System.out` and inserted into the response document. The response document is then sent to the client.

The example uses the following Java class and program:

Program	**Java class**
DFJ$JWB1	Web.Sample1

Procedure

1. Start your web browser and enter a URL that connects to CICS with the absolute path `/CICS/CWBA/DFJ$JWB1`. CICS returns the following response document to the web browser:

```
Web Sample1

Inbound Client Request Information:

Method: GET

Version: HTTP/1.1

Path: /cics/cwba/jcicxsa1

Request Type: HTTPYES

Query String: null

HTTP headers:

Value for HTTP header User-Agent is 'Mozilla/4.75 €en€ (WinNT; U)'

Browse of HTTP Headers started

Name: Host Value: winmvs2d.hursley.ibm.com:27361

Name: Connection Value: Keep-Alive, TE

Name: Accept Value: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, image/png,
      */*

Name: Accept-Encoding Value: gzip

Name: Accept-Language Value: en

Name: Accept-Charset Value: iso-8859-1,*,utf-8

Name: Cookie Value: PBC_NLSP=en_US

Name: TE Value: chunked

Name: Via Value: HTTP/1.0 sp15ce18.hursley.ibm.com (IBM-PROXY-WTE-US)

Name: User-Agent Value: Mozilla/4.75 €en€ (WinNT; U)

Browse of HTTP Headers completed

TCPIP Information:

Client Name: sp15ce18.hursley.ibm.com

Server Name: winmvs2d.hursley.ibm.com

Client Address: 9.20.136.28

ClientAddrNu: 9.20.136.28

Server Address: 9.20.101.8

ServerAddrNu: 9.20.101.8

Clientauth: NO

SSL: NO

TcpipService: HTTPNSSL
```

```
PortNumber: 27361

Document Information:

Doctoken: 33 92 112 0 0 0 0 1 64 64 64 64 64 64 64 64

Docsize: 2762
```

2. Check the standard output stream in zFS. The example writes information messages to the standard output stream `System.out` and error messages to the standard output stream `System.err`. Here is an example of the output written to the `System.out` output stream:

```
Sample1 started
Method: GET (3)
Version: HTTP/1.1 (8)
Path: /cics/cwba/jcicxsa1 (19)
Request Type: HTTPYES
Value for HTTP header User-Agent is 'Mozilla/4.75  en  (WinNT; U)'
HTTP headers:
Name: Host (4)
Value: winmvs2d.hursley.ibm.com:27361 (30)
Name: Connection (10)
Value: Keep-Alive, TE (14)
Name: Accept (6)
Value: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, image/png, */* (67)
Name: Accept-Encoding (15)
Value: gzip (4)
Name: Accept-Language (15)
Value: en (2)
Name: Accept-Charset (14)
Value: iso-8859-1,*,utf-8 (18)
Name: Cookie (6)
Value: PBC_NLSP=en_US (14)
Name: TE (2)
Value: chunked (7)
Name: Via (3)
Value: HTTP/1.0 sp15ce18.hursley.ibm.com (IBM-PROXY-WTE-US) (52)
Name: User-Agent (10)
Value: Mozilla/4.75  en  (WinNT; U) (28)
Client Name: sp15ce18.hursley.ibm.com (24)
Server Name: winmvs2d.hursley.ibm.com (24)
Client Address: 9.20.136.28 (11)
ClientAddrNu: 9.20.136.28
Server Address: 9.20.101.8 (10)
ServerAddrNu: 9.20.101.8
Clientauth: NO
SSL: NO
TcpipService: HTTPNSSL
PortNumber: 27361
Doctoken: Doctoken: 33 92 112 0 0 0 0 1 64 64 64 64 64 64 64 64
Docsize: 2762
Sample1 complete
```

Developing applications using the CICS Explorer SDK

The CICS Explorer Software Development Kit (SDK) provides an environment for developing and deploying Java applications in CICS, including support for OSGi.

About this task

You can use the SDK to create new applications or repackage existing Java applications to comply with the OSGi specification. The OSGi Service Platform provides a mechanism for developing applications using a component model and deploying those applications into a framework as OSGi bundles. An *OSGi bundle* is the unit of deployment for an application and contains version control information, dependencies, and application code. The main benefit of OSGi is that you can create applications from reusable components that are accessed only through well-defined interfaces called *OSGi services*. You can also manage the life cycle and dependencies of Java applications in a granular way. For information about developing applications with OSGi, see the OSGi Alliance website.

You can use the SDK to develop a Java application to run in any supported release of CICS. Different releases of CICS support different versions of Java, and the JCICS API has also been extended in later releases to support additional features of CICS. To avoid using the wrong classes, the SDK provides a feature to set up a target platform. You can define which release of CICS you are developing for and the SDK automatically hides the Java classes that you cannot use.

See the *CICS Java Developer Guide* in the SDK help for full details on how you can perform each of the following steps to develop and deploy applications.

Procedure

1. Set up a target platform for your Java development. The target platform ensures you use only the Java classes that are appropriate for the target release of CICS in your application development.
2. Create a plug-in project for your Java application development.
3. Develop your Java application using best practices. If you are new to developing Java applications for CICS, you can use the JCICS examples provided with the CICS Explorer SDK to get started. To use JCICS in a Java application, you must import the com.ibm.cics.server package.
4. Deploy your Java application in a CICS bundle to zFS. CICS bundles can contain one or more OSGi bundles and are the unit of deployment for your application in CICS. If you are running the Java application in a JVM server, you must know the name of the JVMSERVER resource in which you want to deploy the application.

Results

You have successfully developed and deployed your application in a CICS bundle using the CICS Explorer SDK.

What to do next

Create a CICS BUNDLE resource to install the OSGi bundles in a JVM server. If you cannot create resources in the CICS region, the system programmer can create the BUNDLE resource. You must tell the system programmer where the bundle directory is located in zFS and the name of the target JVM server. For details, see "Installing OSGi bundles in a JVM server" on page 84.

Migrating applications using the CICS Explorer SDK

If you have existing applications running in pooled JVMs and you want to run them in a JVM server, you can use the CICS Explorer SDK to repackage the applications as OSGi bundles.

About this task

You can use three methods to repackage an existing Java application. Each method is explained in full detail in the SDK help and is summarized in the following procedure.

Procedure

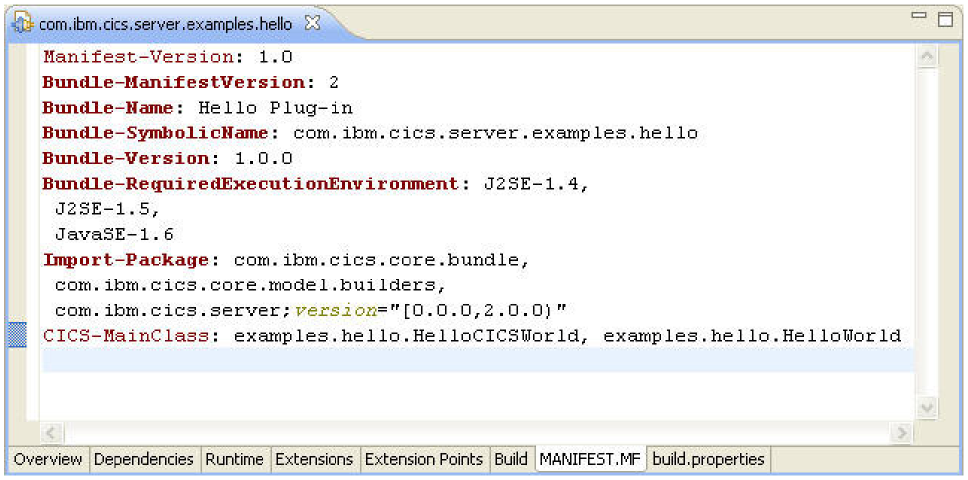
1. Check that the Java application is threadsafe. Because the JVM server is a multithreaded runtime environment, it is important that any Java application running in that environment is threadsafe.
2. Check that the Java application does not use the System.exit() Java method. If this method is used, the JVM server and CICS both shut down.
3. Package the Java application as one or more OSGi bundles. You can use three methods to package the application:

   Conversion
   : If you already have an Eclipse Java project for the Java application, you can convert the project to an OSGi plug-in project. This method is the preferred best practice. The OSGi bundle can run in a pooled JVM environment and a JVM server.

   Injection
   : Create an OSGi plug-in project and import the contents of the existing JAR file. This method is useful when the application is already threadsafe and no refactoring or recompiling is required. The OSGi bundle can run in a pooled JVM environment and a JVM server.

   Wrapping
   : Create an OSGi plug-in project and import an existing binary JAR file. This method is useful in situations where there are licensing restrictions or where the binary file cannot be extracted. However, an OSGi bundle that contains a JAR file is not supported in a pooled JVM environment.
4. For each of these methods, add the CICS-MainClass declaration to the project manifest.

   The following screen capture shows an example manifest file for the CICS Hello examples. The example application contains two classes: HelloCICSWorld and HelloWorld, and these are declared in the manifest file in the CICS-MainClass declaration. You must add a CICS-MainClass declaration for each class used in your application.



```
Manifest-Version: 1.0
Bundle-ManifestVersion: 2
Bundle-Name: Hello Plug-in
Bundle-SymbolicName: com.ibm.cics.server.examples.hello
Bundle-Version: 1.0.0
Bundle-RequiredExecutionEnvironment: J2SE-1.4,
 J2SE-1.5,
 JavaSE-1.6
Import-Package: com.ibm.cics.core.bundle,
 com.ibm.cics.core.model.builders,
 com.ibm.cics.server;version="[0.0.0,2.0.0)"
CICS-MainClass: examples.hello.HelloCICSWorld, examples.hello.HelloWorld
```

5. Deploy the OSGi bundles in a CICS bundle to zFS. You must specify the target JVMSERVER resource in the plug-in resource file of the CICS bundle.

Results

You have a threadsafe application that is packaged as one or more OSGi bundles and is deployed as a CICS bundle in zFS.

What to do next

The system programmer can create the resources that are required to run the application in a JVM server, as described in "Moving applications to a JVM server" on page 127.

Best practices for developing Java applications in CICS

When you are designing and developing Java applications to run in CICS, ensure that the application does not leave any unwanted state in the JVM or change the state of the JVM in undesirable ways. You can use CICS services to help control the state of the JVM.

Although JVM servers and pooled JVMs operate in different ways, any Java application that you develop can follow the same best practices to work correctly in both runtime environments.

Protect the state of a JVM

If your application changes the state of the JVM, ensure that the application also resets to the original state. For example, an application might reset the default time zone, and do calculations based on this time zone. Other applications that use the same JVM use the new default time zone, which might not be appropriate.

- If an application runs in a pooled JVM, it is isolated from other applications. However, pooled JVMs are serially reused and the changes made by one application can affect other applications that run in the same JVM afterwards.
- If an application runs in a JVM server, it is not isolated from other applications that might also be running in the same JVM under different threads. Any changes that an application makes to the JVM affects the other applications.

  Do not use System.exit() methods in your applications. Using System.exit() methods causes both the JVM server and CICS to shut down and can affect the state of your applications.

Control static state in a JVM

Do not leave any unwanted state in a JVM. State is passed on to subsequent applications using the same pooled JVM and in a JVM server state is shared between all running applications.

An application must reinitialize its own static storage, if it depends on the state of a changeable class field. The values of static variables persist in the JVM for all application and system classes, including classes that might affect the application but are not used explicitly by the application and values used in static initializers.

In most cases, static variables are used to avoid reinitialization of storage, and allowing them to persist can improve performance. If the application requires that the value of these variables is reset, the application must reset the value itself. Try to identify and eliminate any changeable class fields and static initializers that have not been included deliberately as part of the application design.

Define a class field as private and final whenever possible. A native method can write to a final class field, and a non-private method can obtain the object referenced by the class field and can change the state of the object or array.

You can use the ability to pass on state to your advantage in designing your Java applications if you want information to persist from one program invocation to the next. Static state and object instances that are referenced through static state persist in the JVM, so it is permissible for applications to create persistent items that might be of use to future executions of the same application in the same JVM.

For example, an operation reads DB2 information to construct a complex data structure; this might be an expensive operation that you do not want to repeat more times than absolutely necessary. The complex data structure can be stored in application static storage and be accessible to later executions of the application in the same JVM, thus avoiding unnecessary initialization. If objects are anchored in static storage, that is, in the static class fields, they are never be candidates for garbage collection.

- In a JVM server, static state persists for all applications until the JVM server is disabled by the system programmer. You can provide OSGi bundle activator classes to maintain the state of objects across restarts of the JVM server. These classes cannot contain JCICS calls.
- In a pooled JVM, there is no guarantee that subsequent invocations of an application will run in the same JVM. Your application must not rely on the presence of the persistent items that you create in the JVM. The application can check for their presence in order to avoid unnecessary initialization, but it must be prepared to initialize them if they are not found in the present JVM.

Close DB2 connections, sockets, and other task lifetime system resources after use

If your application is running in a pooled JVM, it must close the connection after it has accessed DB2. If the application does not close the connection, a subsequent execution of the same application fails to open the connection. If your application is running in a JVM server, it is possible to have multiple connections to DB2 from different applications. Therefore, when a task has finished with DB2, it is best practice but not required to close the connection, because the connection is deleted when the task has completed.

If you start threads in an application to manage sockets using the java.net package, the application must manage the connections and close them. Sockets created using the java.net classes use the native sockets capability in the JVM, rather than the CICS sockets domain. CICS is not able to manage or monitor any communications that are performed using these sockets.

The same applies to any other task lifetime system resources used by the application, which must be released after use.

Test applications for possible threadsafe issues

Always write threadsafe Java applications. You can use the CICS JVM Application Isolation Utility to audit the use of static variables in your Java applications. The utility inspects Java bytecodes and reports on the static variables used by each class. You can use this information to help you check your source code. Make sure that the application is resetting the static variable correctly in each case.

If a Java application works correctly on its first use in a given JVM, but does not behave correctly on subsequent uses, the problem is likely to be due to threadsafety issues. In this case, use the CICS JVM Application Isolation Utility as part of your problem determination work to help identify the cause of the problem.

Interacting with structured data from Java

CICS Java programs often interact with data that was originally designed for use with other programming languages. For example, a Java program might link to a COBOL program using a COMMAREA defined in a COBOL copybook, or read a record from a VSAM file where the data is defined using a C++ header file. You can use an importer to interact with these forms of structured data.

Importing application data into Java using JZOS and J2C

CICS supports copybook importers so that you can use structured data from other programming languages in Java. Supported importers are provided by JZOS tools and by Rational, using the Java EE Connector Architecture (JCA), also known as the J2EE Connector architecture (J2C).

The importers map the data types contained in the source program so that your application can access individual fields in data structures. You can use the JZOS or Rational J2C tools to interact with data to produce a Java class, so that you can pass data between Java and other programs in CICS.

CICS supports Java artifacts from the following importers:

- Data binding beans from the J2C tools in Rational® Application Developer (RAD) and Rational Developer for System z
- Records from the IBM JZOS Batch Toolkit for z/OS SDK

The IBM Redbook, Java Application Development for CICS uses an example application called the Heritage Trader application, which manipulates an existing COBOL application. Information is provided on the following topics:

- Instructions for installing JZOS and J2C
- Migrating the COBOL application to JCICS
- Creating a Java data binding class for J2C
- Generating a wrapper class with JZOS
- Example implementations for web, file, and DB2 access using the JCICS API

J2C requirements

You can create J2EE Connector artifacts that you can use to create enterprise applications. The RAD J2C wizard helps you create a class or set of classes that map to COBOL and other application program data structures.

You require RAD on a Windows or Linux workstation to use the Rational J2C importer.

JZOS requirements

The IBM JZOS Batch Toolkit for z/OS SDK is a set of tools that provide Java batch capabilities on z/OS. JZOS includes a launcher for running Java applications directly as batch jobs or started tasks, and a set of Java methods that make access to traditional z/OS data and key system services directly available from Java applications.

JZOS supports automatic generation of record classes from COBOL copybooks and Assembler DSECTs.

The JZOS download includes the *JZOS COBOL Record Generator User's Guide* and the *JZOS Assembler Record Generator User's Guide* in PDF format.

IBM Redbooks

- Java Application Development for CICS
- Java Connectors for CICS Featuring the J2EE Connector Architecture
- Java Stand-alone Applications on z/OS Volume 2

J2C information

- RAD: Connecting to enterprise information systems (EIS)
- RAD: COBOL Importer overview
- CICS Transaction Gateway Programming Guide

JZOS information

- JZOS Java Launcher and Toolkit Overview
- JZOS Batch Launcher and Toolkit Installation and User Guide

Java programming using JCICS

You can write Java applications that use the CICS Java class library (JCICS) to access CICS services. JCICS is the Java equivalent of the **EXEC CICS** application programming interface (API) that is provided for other CICS supported languages, such as COBOL.

Using JCICS, you can write Java applications that access CICS resources and integrate with programs written in other languages. Most of the functions of the **EXEC CICS** API are supported. The library is supplied in the `com.ibm.cics.server.jar` file with CICS and with the CICS Explorer SDK.

The Java class library for CICS (JCICS)

The Java class library for CICS (JCICS) supports most of the functions of the **EXEC CICS** API commands.

The JCICS classes are fully documented in Javadoc that is generated from the class definitions. The Javadoc is available at JCICS Class Reference.

JavaBeans

Some of the classes in JCICS can be used as JavaBeans, which means that they can be customized in an application development tool such as Eclipse, serialized, and manipulated using the JavaBeans API.

The following JavaBeans are available in JCICS:

- Program
- ESDS
- KSDS
- RRDS
- TDQ
- TSQ
- AttachInitiator
- EnterRequest

These beans do not define any events; they consist of properties and methods. They can be instantiated at run time in one of three ways:
- By calling the new method for the class itself. This method is preferred.
- By calling Beans.instantiate() for the name of the class, with property values set manually.
- By calling Beans.instantiate() of a `.ser` file, with property values set at design time.

If either of the first two options are chosen, the property values, including the name of the CICS resource, must be set by invoking the appropriate set methods at run time.

Library structure

Each JCICS library component falls into one of four categories: Interfaces, Classes, Exceptions, or Errors.

`Interfaces`
Some interfaces are provided to define sets of constants. For example, the TerminalSendBits interface provides a set of constants that can be used to construct a `java.util.BitSet`.

`Classes`
The supplied classes provide most of the JCICS function. The `API` class is an abstract class that provides common initialization for every class that corresponds to a part of the CICS API, except for ABENDs and exceptions. For example, the `Task` class provides a set of methods and variables that correspond to a CICS task.

`Errors and Exceptions`
The Java language defines both exceptions and errors as subclasses of the class `Throwable`. JCICS defines `CicsError` as a subclass of `Error`. `CicsError` is the superclass for all the other CICS error classes, which are used for severe errors.

JCICS defines `CicsException` as a subclass of `Exception`. `CicsException` is the superclass for all the CICS exception classes (including the `CicsConditionException` classes such as `InvalidQueueIdException`, which represents the CICS QIDERR condition).

See “Error handling and abnormal termination” on page 52 for further information.

CICS resources

CICS resources, such as programs or temporary storage queues, are represented by instances of the appropriate Java class, identified by the values of various properties such as the name of the resource.

Resources must be defined to CICS using the CICS Explorer, CEDA transaction, or CICSPlex® SM BAS. See the *CICS Resource Definition Guide* or the *CICSPlex System Manager Concepts and Planning* manual for information about defining CICS resources. It is possible to use implicit remote access by defining a resource locally to point to a remote resource.

Arguments for passing data

You can pass data between programs using channels and containers, or by using a communication area (COMMAREA).

If you use a COMMAREA, you are limited to passing 32 KB at a time. If you use a channel and containers, you can pass more than 32 KB between programs. The COMMAREA or channel, and any other parameters, are passed as arguments to the appropriate methods.

Many of the methods are overloaded; that is, they have different versions that take either a different number of arguments or arguments of a different type. There might be one method that has no arguments, or the minimum mandatory arguments, and another that has all of the arguments. For example, the `Program` class includes the following different link() methods in the :

`link()`
This method does a simple LINK without using a COMMAREA to pass data, nor any other options.

`link(com.ibm.cics.server.CommAreaHolder)`
This method does a simple LINK, using a COMMAREA to pass data but without any other options.

`link(com.ibm.cics.server.CommAreaHolder, int)`
This method does a distributed LINK, using a COMMAREA to pass data and a DATALENGTH value to specify the length of the data within the COMMAREA.

`link(com.ibm.record.IByteBuffer)`
This method does a LINK using an object that implements the IByteBuffer interface of the Java Record Framework supplied with VisualAge for Java.

`link(com.ibm.cics.server.Channel)`
This method does a LINK using a channel to pass data in one or more containers.

Serializable classes

Serializable classes are JCICS classes that can survive a Passive/Activate cycle

The following list shows the serializable classes:

- AddressResource
- AttachInitiator
- CommAreaHolder
- EnterRequest
- ESDS
- File
- KeyedFile
- KSDS
- NameResource
- Program

- RemotableResource
- Resource
- RRDS
- StartRequest
- SynchronizationResource
- SyncLevel
- TDQ
- TSQ
- TSQType

System.out and System.err

For each Java-related CICS task, CICS automatically creates two Java `PrintWriters` classes that can be used as standard out and standard error streams. The standard out and standard error streams are public fields in the `Task` class called `out` and `err`.

If a CICS task is being driven from a terminal (the terminal is called a *principal facility* in this case), CICS maps the standard out and standard error streams to the task's terminal.

If the task does not have a terminal as its principal facility, the standard out and standard error streams are sent to System.out and System.err. System.out and System.err are mapped to the CICS transient data queues CESO and CESE, respectively. Your CICS system programmer creates these queues, and others used for CICS messages, during CICS installation. You can access and print or display these message queues using utility programs such as the DFH$TDWT sample program. DFH$TDWT is in CICSTS42.CICS.SDFHLOAD.

Threads

Only the initial thread in the JVM can access the JCICS API. You can create other threads, but you must route all requests to the JCICS API through the initial thread. In a JVM server environment, multiple initial threads can access the JCICS API using the same JVM.

Additionally, you must ensure that all threads other than the initial thread have terminated before doing any of the following actions:
- link()
- xctl()
- setNextTransaction(), setNextCOMMAREA()
- commit(), rollback()
- returning an `AbendException`

JCICS services reference

Many of the options and services available to non-Java programs through the **`EXEC CICS`** API are available to Java programs through JCICS.

CICS exception handling in Java programs

CICS ABENDs and exceptions are integrated into the Java exception-handling architecture to handle problems that occur in CICS.

All regular CICS ABENDs are mapped to a single Java exception, `AbendException`, whereas each CICS condition is mapped to a separate Java exception. This leads to an ABEND-handling model in Java that is similar to the other programming languages; a single handler is given control for every ABEND, and the handler must query the particular ABEND and then decide what to do.

If the exception representing a condition is caught by CICS itself, it is turned into an ABEND.

Java exception-handling is fully integrated with the ABEND and condition-handling in other languages, so that ABENDs can propagate between Java and non-Java programs, in the standard language-independent way. A condition is mapped to an ABEND before it leaves the program that caused or detected the condition.

However, there are several differences to the abend-handling model for other programming languages, resulting from the nature of the Java exception-handling architecture and the implementation of some of the technology underlying the Java API:

- ABENDs that cannot be handled in other programming languages can be caught in Java programs. These ABENDs typically occur during sync point processing. To avoid these ABENDs interrupting Java applications, they are mapped to an extension of an unchecked exception; therefore they do not have to be declared or caught.
- Several internal CICS events, such as program termination, are also mapped to Java exceptions and can therefore be caught by a Java application. Again, to avoid interrupting the normal case, these events are mapped to extensions of an unchecked exception and do not have to be caught or declared.

Three class hierarchies of exceptions relate to CICS:

1. CicsError, which extends java.lang.Error and is the base for AbendError and UnknownCicsError.
2. CicsRuntimeException, which extends java.lang.RuntimeException and is in turn extended by:

   `AbendException`
   Represents a normal CICS ABEND.

   `EndOfProgramException`
   Indicates that a linked-to program has terminated normally.

   `TransferOfControlException`
   Indicates that a program has used an xctl() method, the equivalent of the CICS XCTL command.
3. CicsException, which extends java.lang.Exception and has the subclass:

   `CicsConditionException.`
   The base class for all CICS conditions.

CICS error-handling commands:

CICS condition handling is integrated into the Java exception architecture as described above. The way that the equivalent "**`EXEC CICS`**" command is supported in Java is described below:

`HANDLE ABEND`
To handle an ABEND generated by a program in any CICS-supported language, use a Java try-catch statement, with AbendException appearing in a catch clause.

HANDLE CONDITION
To handle a specific condition, such as PGMIDERR, use a catch clause that names the appropriate exception—in this case InvalidProgramException. Alternatively, use a catch clause naming CicsConditionException, if all CICS conditions are to be caught.

IGNORE CONDITION
This command is not relevant in Java applications.

POP HANDLE and PUSH HANDLE
These commands are not relevant in Java applications. The Java exceptions used to represent CICS ABENDs and conditions are caught by any catch block in scope.

CICS conditions:

The condition-handling model in Java is different from other CICS programming languages.

In COBOL, you can define an exception-handling label for each condition. If that condition occurs during the processing of a CICS command, control transfers to the label.

In C and C++, you cannot define an exception-handling label for a condition; to detect a condition, the RESP field in the EIB must be checked after each CICS command.

In Java, any condition returned by a CICS command is mapped into a Java exception. You can include all CICS commands in a try-catch block and do specific processing for each condition, or have a single null catch clause if the particular exception is not relevant. Alternatively, you can let the condition propagate, to be handled by a catch clause at a larger scope.

See "JCICS exception mapping" on page 68 for a description of the relationship between CICS conditions and Java exceptions.

Error handling and abnormal termination

To initiate an ABEND from a Java program, you must invoke one of the Task.abend(), or Task.forceAbend() methods.

Methods	JCICS class	EXEC CICS commands
abend(), forceAbend()	Task	ABEND

ABEND
To initiate an ABEND from a Java program, invoke one of the Task.abend() methods. This causes an abend condition to be set in CICS and an AbendException to be thrown. If the AbendException is not caught within a higher level of the application object, or handled by an ABEND-handler registered in the calling program (if any), CICS terminates and rolls back the transaction.

The different abend() methods are:

- abend(String *abcode*), which causes an ABEND with the ABEND code *abcode*.
- abend(String *abcode*, boolean *dump*), which causes an ABEND with the ABEND code *abcode*. If the **dump** parameter is false, no dump is taken.
- abend(), which causes an ABEND with no ABEND code and no dump.

ABEND CANCEL

To initiate an ABEND that cannot be handled, invoke one of the Task.forceAbend() methods. As described above, this causes an AbendCancelException to be thrown which can be caught in Java programs. If you do so, you must re-throw the exception to complete **ABEND_CANCEL** processing, so that, when control returns to CICS, CICS will terminate and roll back the transaction. Only catch the AbendCancelException for notification purposes and then re-throw it.

The different forceAbend() methods are:

- forceAbend(String *abcode*), which causes an **ABEND CANCEL** with the ABEND code *abcode*.
- forceAbend(String *abcode*, boolean *dump*), which causes an **ABEND CANCEL** with the ABEND code *abcode*. If the **dump** parameter is false, no dump is taken.
- forceAbend(), which causes an **ABEND CANCEL** with no ABEND code and no dump.

APPC mapped conversations

APPC unmapped conversation support is not available from the JCICS API.

APPC mapped conversations:

Methods	JCICS class	EXEC CICS Commands
initiate()	AttachInitiator	ALLOCATE, CONNECT PROCESS
converse()	Conversation	CONVERSE
get*() methods	Conversation	EXTRACT ATTRIBUTES
get*() methods	Conversation	EXTRACT PROCESS
free()	Conversation	FREE
issueAbend()	Conversation	ISSUE ABEND
issueConfirmation()	Conversation	ISSUE CONFIRMATION
issueError()	Conversation	ISSUE ERROR
issuePrepare()	Conversation	ISSUE PREPARE
issueSignal()	Conversation	ISSUE SIGNAL
receive()	Conversation	RECEIVE
send()	Conversation	SEND
flush()	Conversation	WAIT CONVID

Basic Mapping Support (BMS)

Basic mapping support (BMS) is an application programming interface between CICS programs and terminal devices. JCICS provides support for some of the BMS application programming interface.

Methods	JCICS class	EXEC CICS Commands
sendControl()	TerminalPrincipalFacility	SEND CONTROL
sendText()	TerminalPrincipalFacility	SEND Text
	Not supported	SEND MAP, RECEIVE MAP

Channels and containers

Containers are named blocks of data designed for passing information between programs. Containers are grouped in sets called *channels*. You can use channel and container-related JCICS commands when writing CICS enterprise beans. However, CICS does not support the transmission of channels over IIOP request streams.

For introductory information about channels and containers, and guidance about using channels in non-Java applications, see Enhanced inter-program data transfer using channels in CICS Application Programming.

| For information about tools that allow Java programs to access existing CICS
| application data, see Interacting with structured data from Java in Java
| Applications in CICS.

Note: CICS does not support the transmission of channels over IIOP request streams and you cannot, for example, pass a channel to an enterprise bean on a remote region.

Table 2 lists the classes and methods that implement JCICS support for channels and containers.

Table 2. JCICS support for channels and containers

Methods	JCICS class	`EXEC CICS` Commands
containerIterator()	Channel	STARTBROWSE CONTAINER
createContainer()	Channel	
deleteContainer()	Channel	DELETE CONTAINER CHANNEL
getContainer()	Channel	
getName()	Channel	
delete()	Container	DELETE CONTAINER CHANNEL
get(), getLength()	Container	GET CONTAINER CHANNEL [NODATA]
getName()	Container	
put()	Container	PUT CONTAINER CHANNEL
getOwner()	ContainerIterator	
hasNext()	ContainerIterator	
next()	ContainerIterator	GETNEXT CONTAINER BROWSETOKEN
remove()	ContainerIterator	
link()	Program	LINK
xctl()	Program	XCTL
setNextChannel()	TerminalPrincipalFacility	RETURN CHANNEL
issue()	StartRequest	START CHANNEL
createChannel()	Task	
getCurrentChannel()	Task	ASSIGN CHANNEL
containerIterator()	Task	STARTBROWSE CONTAINER

The CICS condition CHANNELERR results in a ChannelErrorException being thrown; the CONTAINERERR CICS condition results in a ContainerErrorException; the CCSIDERR CICS condition results in a CCSIDErrorException.

Creating channels and containers in JCICS:

To create a channel, use the createChannel() method of the Task class.

For example:

```
Task t=Task.getTask();
Channel custData = t.createChannel("Customer_Data");
```

The string supplied to the createChannel method is the name by which the Channel object is known to CICS. (The name is padded with spaces to 16 characters, to conform to CICS naming conventions.)

To create a new container in the channel, use the Channel's createContainer() method. For example:

```
Container custRec = custData.createContainer("Customer_Record");
```

The string supplied to the createContainer() method is the name by which the Container object is known to CICS. (The name is padded with spaces to 16 characters, if necessary, to conform to CICS naming conventions.) If a container of the same name already exists in this channel, a ContainerErrorException is thrown.

Putting data into a container:

To put data into a Container object, use the Container.put() method.

To put data into a Container object, use the Container.put() method. Data can be added to a container as a byte array or a string. For example:

```
String custNo = "00054321";
byte[] custRecIn = custNo.getBytes();
custRec.put(custRecIn);
```

Or :

```
custRec.put("00054321");
```

Passing a channel to another program or task:

To pass a channel on a program-link or transfer program control (XCTL) call, use the link() and xctl() methods of the Program class, respectively.

```
programX.link(custData);
```

```
programY.xctl(custData);
```

To set the next channel on a program-return call, use the setNextChannel() method of the TerminalPrincipalFacility class:

```
terminalPF.setNextChannel(custData);
```

To pass a channel on a START request, use the issue method of the StartRequest class:

```
startrequest.issue(custData);
```

Receiving the current channel:

It is not necessary for a program to receive its current channel explicitly. However, a program can get its current channel from the current task.

If a program gets the current channel from the current task, the task can extract containers by name:

```
Task t = Task.getTask();
Channel custData = t.getCurrentChannel();
if (custData != null) {
    Container custRec = custData.getContainer("Customer_Record");
} else {
    System.out.println("There is no Current Channel");
}
```

Getting data from a container:

Use the Container.get() method to read the data in a container into a byte array.

```
byte[] custInfo = custRec.get();
```

Browsing the current channel:

A JCICS program that is passed a channel can access all of the `Container` objects without receiving the channel explicitly.

To do this, it uses a `ContainerIterator` object. (The `ContainerIterator` class implements the java.util.Iterator interface.) When a Task object is instantiated from the current task, its containerIterator() method returns an Iterator for the current channel, or null if there is no current channel. For example:

```
Task t = Task.getTask();
ContainerIterator ci = t.containerIterator();
While (ci.hasNext()) {
    Container custData = ci.next();
    // Process the container...
}
```

A JCICS example:

This example shows an excerpt of a Java class called Payroll that calls a COBOL server program named `PAYR`. The Payroll class uses the JCICS com.ibm.cics.server.Channel and com.ibm.cics.server.Container classes to do the same things that a non-Java client program would use **`EXEC CICS`** commands to do.

```
import com.ibm.cics.server.*;
public class Payroll {
     ...
     Task t=Task.getTask();

     // create the payroll_2004 channel
     Channel payroll_2004 = t.createChannel("payroll-2004");

     // create the employee container
     Container employee = payroll_2004.createContainer("employee");

     // put the employee name into the container
     employee.put("John Doe");

     // create the wage container
     Container wage = payroll_2004.createContainer("wage");

     // put the wage into the container
     wage.put("2000");

     // Link to the PAYROLL program, passing the payroll_2004 channel
     Program p = new Program();
     p.setName("PAYR");
     p.link(payroll_2004);

     // Get the status container which has been returned
     Container status = payroll_2004.getContainer("status");

     // Get the status information
     byte[] payrollStatus = status.get();
     ...
}
```

Figure 3. Java class that uses the JCICS com.ibm.cics.server.Channel and com.ibm.cics.server.Container classes to pass a channel to a COBOL server program

Diagnostic services

The JCICS application programming interface has support for these CICS trace and dump commands.

Methods	JCICS class	`EXEC CICS` Commands
	Not supported	DUMP
enterTrace()	EnterRequest	ENTER
enableTrace(), disableTrace()	Region, Task	TRACE

Document services

This section describes JCICS support for the commands in the DOCUMENT application programming interface.

Class `Document` maps to the **`EXEC CICS DOCUMENT`** API. Constructors for class `DocumentLocation` map to the AT and TO keywords of the **`EXEC CICS DOCUMENT`** API. Setters and getters for class SymbolList map to the SYMBOLLIST, LENGTH, DELIMITER, and UNESCAPE keywords of the **`EXEC CICS DOCUMENT`** API.

Methods	JCICS class	`EXEC CICS` Commands
create*()	Document	DOCUMENT CREATE
append*()	Document	DOCUMENT INSERT
insert*()	Document	DOCUMENT INSERT

Methods	JCICS class	`EXEC CICS` Commands
addSymbol()	Document	DOCUMENT SET
setSymbolList()	Document	DOCUMENT SET
retrieve*()	Document	DOCUMENT RETRIEVE
get*()	Document	DOCUMENT

Environment services

CICS environment services provide access to CICS data areas, parameters, and resource attributes that are relevant to an application program.

The **EXEC CICS** commands and options that have equivalent JCICS support are:
- ADDRESS
- ASSIGN
- INQUIRE SYSTEM
- INQUIRE TASK
- INQUIRE TERMINAL/NETNAME

ADDRESS:

The following support is provided for the **ADDRESS** API command options.

For complete information about the **EXEC CICS ADDRESS** command, see ADDRESS in CICS Application Programming.

ACEE The Access Control Environment Element (ACEE) is created by an external security manager when a CICS user signs on. This option not supported in JCICS.

COMMAREA
A COMMAREA contains user data that is passed with a command. The COMMAREA pointer is passed automatically to the linked program by the **CommAreaHolder** argument . See "Arguments for passing data" on page 49 for more information.

CWA The Common Work Area (CWA) contains global user data, sharable between tasks.

EIB The contains information about the CICS command last executed. Access to EIB values is provided by methods on the appropriate objects. For example,

eibtrnid
is returned by the getTransactionName() method of the Task class.

eibaid is returned by the getAIDbyte() method of the TerminalPrincipalFacility class.

eibcposn
is returned by the getRow() and getColumn() methods of the Cursor class.

TCTUA
The Terminal Control Table User Area (TCTUA) contains user data associated with the terminal that is driving the CICS transaction (the principal facility). This area is used to pass information between application programs, but only if the same terminal is associated with the

application programs involved. The contents of the TCTUA can be obtained using the getTCTUA() method of the TerminalPrincipalFacility class.

TWA The Transaction Work Area (TWA) contains user data that is associated with the CICS task. This area is used to pass information between application programs, but only if they are in the same task. A copy of the TWA can be obtained using the getTWA() method of the Task class.

ASSIGN:

The following support is provided for the **ASSIGN** API command options.

For detailed information about this command, see ASSIGN in CICS Application Programming.

Methods	JCICS class
getABCODE()	AbendException
getAPPLID()	Region
getCurrentChannel()	Task
getCWA()	Region
getName()	TerminalPrincipalFacility or ConversationPrincipalFacility
getFCI()	Task
getNetName()	TerminalPrincipalFacility or ConversationPrincipalFacility
getPrinSysid()	TerminalPrincipalFacility or ConversationPrincipalFacility
getProgramName()	Task
getQNAME()	Task
getSTARTCODE()	Task
getSysid()	Region
getTCTUA()	TerminalPrincipalFacility
getTERMCODE()	TerminalPrincipalFacility
getTWA()	Task
getUSERID(), Task.getUSERID()	Task, TerminalPrincipalFacility or ConversationPrincipalFacility

No other ASSIGN options are supported.

INQUIRE SYSTEM:

Support is provided for the **INQUIRE SYSTEM** SPI options.

Methods	JCICS class
getAPPLID()	Region
getSYSID()	Region

No other **INQUIRE SYSTEM** options are supported.

INQUIRE TASK:

The following support is provided for the **INQUIRE TASK** API command options.

Methods	JCICS class
getSTARTCODE()	Task
getTransactionName()	Task
getUSERID()	Task

FACILITY
You can find the name of the task's principal facility by calling the getName() method on the task's principal facility, which can in turn be found by calling the getPrincipalFacility() method on the current Task object.

FACILITYTYPE
You can determine the type of facility by using the Java instanceof operator to check the class of the returned object reference.

No other INQUIRE TASK options are supported.

INQUIRE TERMINAL and INQUIRE NETNAME:

The following support is provided for **INQUIRE TERMINAL** and **INQUIRE NETNAME** SPI options.

Methods	JCICS class
getUSERID()	Terminal, ConversationalPrincipalFacility
Terminal.getUser()	Terminal, ConversationalPrincipalFacility

You can also find the USERID value by calling the getUSERID() method on the current Task object, or on the object representing the task's principal facility

No other **INQUIRE TERMINAL** or **INQUIRE NETNAME** options are supported.

File services

JCICS provides classes and methods that map to the **EXEC CICS** API commands for each type of CICS file and index.

For information about tools that allow Java programs to access existing CICS application data, see Interacting with structured data from Java in Java Applications in CICS.

CICS supports the following types of files:

- Key Sequenced Data Sets (KSDS)
- Entry Sequenced Data Sets (ESDS)
- Relative Record Data Sets (RRDS)

KSDS and ESDS files can have alternative (or secondary) indexes. CICS does not support access to an RRDS file through a secondary index. Secondary indexes are treated by CICS as though they were separate KSDS files in their own right, which means they have separate FD entries.

There are a few differences between accessing KSDS, ESDS (primary index), and ESDS (secondary index) files, which means that you cannot always use a common interface.

Records can be read, updated, deleted, and browsed in all types of file, with the exception that records cannot be deleted from an ESDS file.

See VSAM data sets: KSDS, ESDS, RRDS for more information about data sets.

Java commands that read data support only the equivalent of the SET option on **EXEC CICS** commands. The data returned is automatically copied from CICS storage to a Java object.

The Java interfaces relating to File Control are in five categories:

File The superclass for the other file classes; contains methods common to all file classes.

KeyedFile
Contains the interfaces common to a KSDS file accessed using the primary index, a KSDS file accessed using a secondary index, and an ESDS file accessed using a secondary index.

KSDS Contains the interface specific to KSDS files.

ESDS Contains the interface specific to ESDS files accessed through Relative Byte Address (RBA, its primary index) or Extended Relative Byte Address (XRBA). To use XRBA instead of RBA, issue the setXRBA(true) method.

RRDS Contains the interface specific to RRDS files accessed through Relative Record Number (RRN, its primary index).

For each file, there are two objects that can be operated on; the File object and the FileBrowse object. The File object represents the file itself and can be used with methods to perform the following API operations:

- DELETE
- READ
- REWRITE
- UNLOCK
- WRITE
- STARTBR

A File object is created by the user application explicitly starting the required file class. The FileBrowse object represents a browse operation on a file. There can be more than one active browse against a specific file at any time, each browse being distinguished by a REQID. Methods can be instantiated for a FileBrowse object to perform the following API operations:

- ENDBR
- READNEXT
- READPREV
- RESETBR

A FileBrowse object is not instantiated explicitly by the user application; it is created and returned to the user class by the methods that perform the STARTBR operation.

The following tables show how the JCICS classes and methods map to the **`EXEC CICS`** API commands for each type of CICS file and index. In these tables, the JCICS classes and methods are shown in the form `class.method()`. For example, KeyedFile.read() references the read() method in the KeyedFile class.

The first table shows the classes and methods for keyed files:

Table 3. Classes and methods for keyed files

KSDS primary or secondary index class and method	**ESDS secondary index class and method**	**CICS File API command**
KeyedFile.read()	KeyedFile.read()	**`READ`**
KeyedFile.readForUpdate()	KeyedFile.readForUpdate()	**`READ UPDATE`**
KeyedFile.readGeneric()	KeyedFile.readGeneric()	**`READ GENERIC`**
KeyedFile.rewrite()	KeyedFile.rewrite()	**`REWRITE`**
KSDS.write()	KSDS.write()	**`WRITE`**
KSDS.delete()		**`DELETE`**
KSDS.deleteGeneric()		**`DELETE GENERIC`**
File.unlock()	File.unlock()	**`UNLOCK`**
KeyedFile.startBrowse()	KeyedFile.startBrowse()	**`START BROWSE`**
KeyedFile.startGenericBrowse()	KeyedFile.startGenericBrowse()	**`START BROWSE GENERIC`**
KeyedFileBrowse.next()	KeyedFileBrowse.next()	**`READNEXT`**
KeyedFileBrowse.previous()	KeyedFileBrowse.previous()	**`READPREV`**
KeyedFileBrowse.reset()	KeyedFileBrowse.reset()	**`RESET BROWSE`**
FileBrowse.end()	FileBrowse.end()	**`END BROWSE`**

This table shows the classes and methods for non-keyed files. ESDS and RRDS are accessed by their primary indexes:

ESDS primary index class and method	**RRDS primary index class and method**	**CICS File API command**
ESDS.read()	RRDS.read()	**`READ`**
ESDS.readForUpdate()	RRDS.readForUpdate()	**`READ UPDATE`**
ESDS.rewrite()	RRDS.rewrite()	**`REWRITE`**
ESDS.write()	RRDS.write()	**`WRITE`**
	RRDS.delete()	**`DELETE`**
File.unlock()	File.unlock()	**`UNLOCK`**
ESDS.startBrowse()	RRDS.startBrowse()	**`START BROWSE`**
ESDS_Browse.next()	RRDS_Browse.next()	**`READNEXT`**
ESDS_Browse.previous()	RRDS_Browse.previous()	**`READPREV`**
ESDS_Browse.reset()	RRDS_Browse.reset()	**`RESET BROWSE`**
FileBrowse.end()	FileBrowse.end()	**`END BROWSE`**
ESDS.setXRBA()		

Data to be written to a file must be in a Java byte array.

Data is read from a file into a RecordHolder object; the storage is provided by CICS and is released automatically at the end of the program.

You do not need to specify the **`KEYLENGTH`** value on any File method; the length used is the actual length of the key passed. When a FileBrowse object is created, it contains the length of the key specified on the startBrowse method, and this length is passed to CICS on subsequent browse requests against that object.

You do not need to provide a **REQID** for a browse operation; each browse object contains a unique REQID which is automatically used for all subsequent browse requests against that browse object.

HTTP and TCP/IP services

Getters in classes `HttpHeader`, `NameValueData`, and `FormField` return HTTP headers, name and value pairs, and form field values for the appropriate API commands.

Methods	**JCICS class**	**`EXEC CICS` Commands**
get*()	CertificateInfo	EXTRACT CERTIFICATE / EXTRACT TCPIP
get*()	HttpRequest	EXTRACT WEB
getHeader()	HttpRequest	WEB READ HTTPHEADER
getFormField()	HttpRequest	WEB READ FORMFIELD
getContent()	HttpRequest	WEB RECEIVE
getQueryParm()	HttpRequest	WEB READ QUERYPARM
startBrowseHeader()	HttpRequest	WEB STARTBROWSE HTTPHEADER
getNextHeader()	HttpRequest	WEB READNEXT HTTPHEADER
endBrowseHeader()	HttpRequest	WEB ENDBROWSE HTTPHEADER
startBrowseFormField()	HttpRequest	WEB STARTBROWSE FORMFIELD
getNextFormField()	HttpRequest	WEB READNEXT FORMFIELD
endBrowseFormField()	HttpRequest	WEB ENDBROWSE FORMFIELD
startBrowseQueryParm()	HttpRequest	WEB STARTBROWSE QUERYPARM
getNextQueryParm()	HttpRequest	WEB READNEXT QUERYPARM
endBrowseQueryParm()	HttpRequest	WEB ENDBROWSE QUERYPARM
writeHeader()	HttpResponse	WEB WRITE
getDocument()	HttpResponse	WEB RETRIEVE
getCurrentDocument()	HttpResponse	WEB RETRIEVE
sendDocument()	HttpResponse	WEB SEND

Note: Use the method get HttpRequestInstance() to obtain the HttpRequest object.

Each incoming HTTP request processed by CICS Web support includes an HTTP header. If the request uses the POST HTTP verb it also includes document data. Each response HTTP request generated by CICS Web support includes an HTTP header and document data.

To process this JCICS provides the following Web and TCP/IP services:

HTTP Header
You can examine the HTTP header using the HttpRequest class. With

HTTP in GET mode, if a client has filled in an HTTP form and selected the submit button, the query string is submitted.

SSL CICS Web support provides the TcpipRequest class, which is extended by HttpRequest to obtain more information about which client submitted the request as well as basic information on the SSL support. If an SSL certificate is provided, you can use the CertificateInfo class to examine it in detail.

Documents

If a document is published to the server (HTTP POST), it is provided as a CICS document. You can access it by calling the getDocument() method on the HttpRequest class. See "Document services" on page 57 for more information about processing existing documents.

To serve the HTTP client web content resulting from a request, the server programmer needs to create a CICS document using the Document Services API and call the sendDocument() method.

For more information on CICS Web support see Internet overview in the Internet Guide. For more information on the JCICS Web classes see the *JCICS Class Reference*.

Program services

JCICS supports the CICS program control commands; LINK, RETURN, XCTL, and SUSPEND.

| For information about tools that allow Java programs to access existing CICS
| application data, see Interacting with structured data from Java in Java
| Applications in CICS.

Table 4 lists the methods and JCICS classes that map to CICS program control commands.

Table 4. Relationship between methods, JCICS classes and CICS commands

Methods	JCICS class	EXEC CICS Commands
link()	Program	LINK
setNextTransaction(), setNextCOMMAREA(), setNextChannel()	TerminalPrincipalFacility	RETURN
xctl()	Program	XCTL
	Not supported	SUSPEND

LINK and XCTL

You can transfer control to another program that is defined to CICS using the link() and xctl() methods. The target program can be in any language supported by CICS.

If you use the xctl() method, a TransferOfControlException is thrown to the issuing program, even if it completes successfully.

RETURN

Only the pseudoconversational aspects of this command are supported. It is not necessary to make a CICS call to return; the application can terminate as normal. The pseudoconversational functions are supported by methods in the TerminalPrincipalFacility class: setNextTransaction() is equivalent to using the TRANSID option of RETURN; setNextCOMMAREA() is equivalent to using the COMMAREA option; while setNextChannel() is equivalent to using the

CHANNEL option. These methods can be invoked at any time during the running of the program, and take effect when the program terminates.

Note: The length of the COMMAREA provided is used as the LENGTH value for CICS. This value should not exceed 32,500 bytes if the COMMAREA is to be passed between any two CICS servers (for any combination of product/version/release). This limit allows for the 32,500 byte COMMAREA and space for headers.

Scheduling services

JCICS provides support for the CICS scheduling services, which let you retrieve data stored for a task, cancel interval control requests, and start a task at a specified time.

Methods	JCICS class	EXEC CICS Commands
cancel()	StartRequest	CANCEL
retrieve()	Task	RETRIEVE
issue()	StartRequest	START

To define what is to be retrieved by the Task.retrieve() method, use a java.util.BitSet object. The com.ibm.cics.server.RetrieveBits class defines the bits which can be set in the BitSet object; they are:

- RetrieveBits.DATA
- RetrieveBits.RTRANSID
- RetrieveBits.RTERMID
- RetrieveBits.QUEUE

These correspond to the options on the **EXEC CICS** RETRIEVE command.

The Task.retrieve() method retrieves up to four different pieces of information in a single invocation, depending on the settings of the RetrieveBits. The DATA, RTRANSID, RTERMID and QUEUE data are placed in a RetrievedData object, which is held in a RetrievedDataHolder object. The following example retrieves the data and transid:

```
BitSet bs = new BitSet();
bs.set(RetrieveBits.DATA, true);
bs.set(RetrieveBits.RTRANSID, true);
RetrievedDataHolder rdh = new RetrievedDataHolder();
t.retrieve(bs, rdh);
byte[] inData = rdh.value.data;
String transid = rdh.value.transId;
```

Serialization services

JCICS provides support for the CICS serialization services, which let you schedule the use of a resource by a task.

Methods	JCICS class	EXEC CICS Commands
dequeue()	SynchronizationResource	DEQ
enqueue(), tryEnqueue()	SynchronizationResource	ENQ

Storage services

No support is provided for explicit storage management using CICS services (such as **EXEC CICS** GETMAIN). You should find that the standard Java storage management facilities are sufficient to meet the needs for task-private storage.

Sharing of data between tasks must be accomplished using CICS resources.

Names are generally represented as Java strings or byte arrays; you must ensure that these are of the necessary length.

Temporary storage queue services

JCICS supports the CICS temporary storage commands; DELETEQ TS, READQ TS, and WRITEQ TS.

Interaction between JCICS methods and `EXEC CICS` commands

| For information about tools that allow Java programs to access existing CICS
| application data, see Interacting with structured data from Java in Java
| Applications in CICS.

Table 5 lists the methods and JCICS classes that map to CICS temporary storage commands.

Table 5. Relationship between methods, JCICS classes and CICS commands

Methods	JCICS class	`EXEC CICS` Commands
delete()	TSQ	DELETEQ TS
readItem(), readNextItem()	TSQ	READQ TS
writeItem(), rewriteItem() writeItemConditional() rewriteItemConditional()	TSQ	WRITEQ TS

`DELETEQ TS`
: You can delete a temporary storage queue (TSQ) using the delete() method in the TSQ class.

`READQ TS`
: The CICS INTO option is not supported in Java programs. You can read a specific item from a TSQ using the readItem() and readNextItem() methods in the TSQ class. These methods take an ItemHolder object as one of their arguments, which will contain the data read in a byte array. The storage for this byte array is created by CICS and is garbage-collected at the end of the program.

`WRITEQ TS`
: You must provide data to be written to a temporary storage queue in a Java byte array. The writeItem() and rewriteItem() methods suspend if a NOSPACE condition is detected, and wait until space is available to write the data to the queue. The writeItemConditional() and rewriteItemConditional() methods do not suspend in the case of a NOSPACE condition, but return the condition immediately to the application as a NoSpaceException.

Terminal services

JCICS provides support for these CICS terminal services commands.

Methods	JCICS class	`EXEC CICS` Commands
converse()	TerminalPrincipalFacility	CONVERSE
	Not supported	HANDLE AID
receive()	TerminaPrincipalFacility	RECEIVE

Methods	JCICS class	EXEC CICS Commands
send()	TerminaPrincipalFacility	SEND
	Not supported	WAIT TERMINAL

If a task has a terminal as a principal facility, CICS automatically creates two Java PrintWriters that can be used as standard output and standard error streams. They are mapped to the task's terminal. The two streams, called `out` and `err`, are public files in the Task object and can be used just like System.out and System.err.

Data to be sent to a terminal must be provided in a Java byte array. Data is read from the terminal into a DataHolder object. CICS provides the storage for the returned data and it will be deallocated when the program ends.

Transient data queue services

JCICS supports the CICS transient data commands, DELETEQ TD, READQ TD, and WRITEQ TD. All options are supported except the INTO option.

Interaction between JCICS methods and EXEC CICS commands

| For information about tools that allow Java programs to access existing CICS
| application data, see Interacting with structured data from Java in Java
| Applications in CICS.

Table 6 lists the methods and JCICS classes that map to CICS transient data commands.

Table 6. Relationship between methods, JCICS classes and CICS commands

Methods	JCICS class	EXEC CICS Commands
delete()	TDQ	DELETEQ TD
readData(), readDataConditional()	TDQ	READQ TD
writeData()	TDQ	WRITEQ TD

DELETEQ TD
You can delete a transient data queue (TDQ) using the delete() method in the TDQ class.

READQ TD
The CICS INTO option is not supported in Java programs. You can read from a TDQ using the readData() or the readDataConditional() method in the TDQ class. These methods take as a parameter an instance of a DataHolder object that will contain the data read in a byte array. The storage for this byte array is created by CICS and is garbage-collected at the end of the program.

The readDataConditional() method drives the CICS NOSUSPEND logic. If a QBUSY condition is detected, it is returned to the application immediately as a QueueBusyException.

The readData() method suspends if it attempts to access a record in use by another task and there are no more committed records.

WRITEQ TD
You must provide data to be written to a TDQ in a Java byte array.

Unit of work (UOW) services

JCICS provides support for the CICS SYNCPOINT service.

Table 7. Relationship between JCICS and EXEC CICS commands for UOW services

Methods	JCICS class	EXEC CICS Commands
commit(), rollback()	Task	SYNCPOINT

Web services

JCICS supports all the API commands that are available for working with web services in an application.

Methods	JCICS class	EXEC CICS commands
invoke()	WebService	INVOKE WEBSERVICE
create()	SoapFault	SOAPFAULT CREATE
addFaultString()	SoapFault	SOAPFAULT ADD FAULTSTRING
addSubCode()	SoapFault	SOAPFAULT ADD SUBCODESTR
delete()	SoapFault	SOAPFAULT DELETE
create()	WSAEpr	WSAEPR CREATE
delete()	WSAContext	WSACONTEXT DELETE
set*()	WSAContext	WSACONTEXT BUILD
get*()	WSAContext	WSACONTEXT GET

The following example shows how you might use JCICS to create a web service request:

```
Channel requesterChannel = Task.getTask().createChannel("TestRequester");
                    Container appData = requesterChannel.createContainer("DFHWS-DATA");
                    byte[] exampleData = "ExampleData".getBytes();
                    appData.put(exampleData);

                    WebService requester = new WebService();
                    requester.setName("MyWebservice");
                    requester.invoke(requesterChannel, "myOperationName");

                    byte[] response = appData.get();
```

To handle the application data that is sent and received in a web service request, you can use a tool such as JZOS to generate classes for you if you are working with structured data. For more information, see "Interacting with structured data from Java" on page 46. You can also use Java to generate and consume XML directly.

JCICS exception mapping

In Java, a condition returned by a CICS command is mapped into a Java exception.

Table 8. Java exception mapping

CICS condition	Java Exception	CICS condition	Java Exception
ALLOCERR	AllocationErrorException	CBIDERR	InvalidControlBlockIdException
CCSIDERR	CCSIDErrorException	CHANNELERR	ChannelErrorException
CONTAINERERR	ContainerErrorException	DISABLED	FileDisabledException

Table 8. Java exception mapping (continued)

CICS condition	Java Exception	CICS condition	Java Exception
DSIDERR	FileNotFoundException	DSSTAT	DestinationStatusChangeException
DUPKEY	DuplicateKeyException	DUPREC	DuplicateRecordException
END	EndException	ENDDATA	EndOfDataException
ENDFILE	EndOfFileException	ENDINPT	EndOfInputIndicatorException
ENQBUSY	ResourceUnavailableException	ENVDEFERR	InvalidRetrieveOptionException
EOC	EndOfChainIndicatorException	EODS	EndOfDataSetIndicatorException
EOF	EndOfFileIndicatorException	ERROR	ErrorException
EXPIRED	TimeExpiredException	FILENOTFOUND	FileNotFoundException
FUNCERR	FunctionErrorException	IGREQID	InvalidREQIDPrefixException
IGREQCD	InvalidDirectionException	ILLOGIC	LogicException
INBFMH	InboundFMHException	INVERRTERM	InvalidErrorTerminalException
INVEXITREQ	InvalidExitRequestException	INVLDC	InvalidLDCException
INVMPSZ	InvalidMapSizeException	INVPARTNSET	InvalidPartitionSetException
INVPARTN	InvalidPartitionException	INVREQ	InvalidRequestException
INVTSREQ	InvalidTSRequestException	IOERR	IOErrorException
ISCINVREQ	ISCInvalidRequestException	ITEMERR	ItemErrorException
JIDERR	InvalidJournalIdException	LENGERR	LengthErrorException
MAPERROR	MapErrorException	MAPFAIL	MapFailureException
NAMEERROR	NameErrorException	NODEIDERR	InvalidNodeIdException
NOJBUFSP	NoJournalBufferSpaceException	NONVAL	NotValidException
NOPASSBKRD	NoPassbookReadException	NOPASSBKWR	NoPassbookWriteException
NOSPACE	NoSpaceException	NOSPOOL	NoSpoolException
NOSTART	StartFailedException	NOSTG	NoStorageException
NOTALLOC	NotAllocatedException	NOTAUTH	NotAuthorisedException
NOTFND	RecordNotFoundException	NOTOPEN	NotOpenException
OPENERR	DumpOpenErrorException	OVERFLOW	MapPageOverflowException
PARTNFAIL	PartitionFailureException	PGMIDERR	InvalidProgramIdException
QBUSY	QueueBusyException	QIDERR	InvalidQueueIdException
QZERO	QueueZeroException	RDATT	ReadAttentionException
RETPAGE	ReturnedPageException	ROLLEDBACK	RolledBackException
RTEFAIL	RouteFailedException	RTESOME	RoutePartiallyFailedException
SELNERR	DestinationSelectionErrorException	SESSBUSY	SessionBusyException
SESSIONERR	SessionErrorException	SIGNAL	InboundSignalException
SPOLBUSY	SpoolBusyException	SPOLERR	SpoolErrorException
STRELERR	STRELERRException	SUPPRESSED	SuppressedException
SYMBOLERR	SymbolErrorException	SYSBUSY	SystemBusyException
SYSIDERR	InvalidSystemIdException	TASKIDERR	InvalidTaskIdException
TCIDERR	TCIDERRException	TEMPLATERR	TemplateErrorException
TERMERR	TerminalException	TERMIDERR	InvalidTerminalIdException
TOKENERR	TokenErrorException		

Table 8. Java exception mapping (continued)

CICS condition	Java Exception	CICS condition	Java Exception
TRANSIDERR	InvalidTransactionIdException	TSIOERR	TSIOErrorException
UNEXPIN	UnexpectedInformationException	USERIDERR	InvalidUserIdException
WRBRK	WriteBreakException	WRONGSTAT	WrongStatusException

Note: `NonHttpDataException` is thrown by `getContent()` if the CICS command WEB RECEIVE indicates that the data received is a non-HTTP message (by setting TYPE=HTTPNO).

Using JCICS

You use the classes from the JCICS library like normal Java classes. Your applications declare a reference of the required type and a new instance of a class is created using the `new` operator.

About this task

You name CICS resources using the setName method to supply the name of the underlying CICS resource. After you create the resource, you can manipulate objects using standard Java constructs. You can call methods of the declared objects in the usual way. Full details of the methods supported for each class are available in the supplied Javadoc.

Do not use finalizers in CICS Java programs. For an explanation of why finalizers are not recommended, see the Java Diagnostics Guide.

Do not end CICS Java programs by issuing a System.exit() call. When Java applications run in CICS, the public static void main() method is called through the use of another Java program called the Java wrapper. When you use the wrapper CICS initializes the environment for Java applications and, more importantly, cleans up any processes that are used during the life of the application. Terminating the JVM, even with a clean return code of 0, prevents this cleanup process from running, and might lead to data inconsistency. Using System.exit() when the application is running in a JVM server terminates the JVM server and quiesces CICS immediately.

Procedure

1. Write the main method. CICS attempts to pass control to the method with a signature of main(CommAreaHolder) in the class specified by the JVMCLASS attribute of the PROGRAM resource. If this method is not found, CICS tries to invoke method main(String[]).
2. To create an object using JCICS, follow these steps:
   a. Declare a reference:
      ```
      TSQ tsq;
      ```
   b. Use the new operator to create an object:
      ```
      tsq = new TSQ()
      ```
   c. Use the setName method to give the object a name:
      ```
      tsq.setName("JCICSTSQ");
      ```
3. Use the object to interact with CICS.

Example

This example shows how to create a TSQ object, invoke the delete method on the temporary storage queue object you have just created, and catch the thrown exception if the queue is empty.

```
// Define a package name for the program
package unit_test;

// Import the JCICS package
import com.ibm.cics.server.*;

// Declare a class for a CICS application
public class JCICSTSQ
{

    // The main method is called when the application runs
    public static void main(CommAreaHolder cah)
    {

         try
         {
             // Create and name a Temporary Storage queue object
             TSQ tsq = new TSQ();
             tsq.setName("JCICSTSQ");

             // Delete the queue if it exists
             try
             {
                   tsq.delete();
             }
             catch(InvalidQueueIdException e)
             {
                  // Absorb QIDERR
                  System.out.println("QIDERR ignored!");
             }

             // Write an item to the queue
             String transaction = Task.getTask().getTransactionName();
             String message = "Transaction name is - " + transaction;
             tsq.writeItem(message.getBytes());

         }
         catch(Throwable t)
         {
             System.out.println("Unexpected Throwable: " + t.toString());
         }

         // Return from the application
         return;
    }
}
```

Java restrictions

When you are developing Java applications, you must adhere to certain restrictions to avoid problems when the application is running in CICS.

Java applications that run in CICS are subject to the following restrictions:

- You cannot use the System.exit() method in your Java application. If you use this method, the application abnormally ends. The JVM server and CICS also shut down.
- You cannot use JCICS API calls in the activator classes of OSGi bundles.

- Start and stop methods in bundle activators must return in a reasonable amount of time.

Accessing data from Java applications

You can write Java applications that can access and update data in DB2 and VSAM. Alternatively, you can link to programs in other languages to access DB2, VSAM, and IMS.

You can use any of the following techniques when writing a Java application to access data in CICS. The CICS recovery manager maintains data integrity.

Accessing relational data

You can write a Java application to access relational data in DB2 using any of the following methods:

- A **JCICS LINK** command, or the CCI Connector for CICS TS, to link to a program that uses Structured Query Language (SQL) commands to access the data.
- Where a suitable driver is available, use Java Data Base Connectivity (JDBC) or Structured Query Language for Java (SQLJ) calls to access the data directly. Suitable JDBC drivers are available for DB2. For more information about using JDBC and SQLJ application programming interfaces, see Using JDBC and SQLJ to access DB2 data from Java programs in the DB2 Guide.
- JavaBeans that use JDBC or SQLJ as the underlying access mechanism. You can use any suitable Java integrated development environment (IDE) to develop such JavaBeans.
- Entity beans. CICS does not support entity beans running under CICS but does support access to entity beans running on other EJB servers. A CICS enterprise bean could, for example, use an entity bean running on WebSphere Application Server to access DB2 on z/OS.

Accessing DL/I data

To access DL/I data in IMS, your Java application must use a **JCICS LINK** command to link to an intermediate program that issues EXEC DLI commands to access the data.

Accessing VSAM data

To access VSAM data, a Java application can use either of the following methods:

- The JCICS file control classes to access VSAM directly.
- A **JCICS LINK** command, or the CCI Connector for CICS TS, to link to a program that issues CICS file control commands to access the data.

Connectivity from Java applications in CICS

Java programs in the CICS environment can open TCP/IP sockets and communicate with external processes. You can use Java programs as a gateway to connect to other enterprise applications that might not be available to CICS programs in other languages. For example, you can write a Java program to communicate with a remote servlet or database.

In some cases, this connectivity is integrated with CICS to provide enterprise qualities of service, such as distributed transactions and identity propagation. In other cases, you can use connectivity without distributed transactions and other services provided by CICS. Depending on the type of connectivity you require, third party vendor products might be available which enable connectivity with enterprise applications that are not natively supported by CICS.

Generally, JVMs in the CICS environment are similar in capability to batch mode JVMs. A batch mode JVM runs as a stand-alone process outside the CICS environment, and is typically started from a UNIX System Services command line or with a JCL job. Most applications that can work in a batch mode JVM can also run in a JVM in CICS to the same extent. For example, if you write a batch mode Java application to communicate with a non-IBM database using a third-party JDBC driver, then the same application is likely to work in a JVM in CICS. If you want to use vendor supplied code such as non-IBM JDBC drivers in a JVM in CICS, consult with your vendor to determine whether they support their code running in a JVM in CICS.

Some batch mode applications might behave in a different way when hosted in a JVM in CICS, because of the way in which CICS reuses JVMs. Any data stored in static variables persists across uses of the JVM. For more information about Java application behavior in CICS, see "Java runtime environment in CICS" on page 28.

Batch mode applications that run in a JVM in the CICS environment do not usually exploit the capabilities of CICS. For example, if a Java program in CICS updates records in a non-IBM database using a third-party JDBC driver, CICS is not aware of this activity, and does not attempt to include the updates in the current CICS transaction.

Chapter 4. Setting up Java support

Perform the basic setup tasks to support Java in your CICS region.

Before you begin

The Java components that are required for CICS are set up during the installation of the product. You must ensure that the Java components are installed correctly using the information in Verifying your Java components installation in the Installation Guide.

Procedure

1. Set the JVMPROFILEDIR system initialization parameter to a suitable directory in z/OS UNIX where you want to store the JVM profiles used by the CICS region. For details, see “Setting the location for the JVM profiles.”
2. Ensure your CICS region has enough memory to run Java applications. For details, see “Setting the memory limits for Java” on page 76.
3. Give your CICS region permission to access the resources held in z/OS UNIX, including your JVM profiles, directories, and files that are required to create JVMs. For details, see “Giving CICS regions access to z/OS UNIX directories and files” on page 77.

Results

You have set up your CICS region to support Java.

What to do next

If you are upgrading existing Java applications, follow the guidance in Upgrading. To create a JVM server or pooled JVM to run Java workloads, see Chapter 5, “Enabling applications to use a JVM,” on page 81.

Setting the location for the JVM profiles

CICS loads the JVM profiles from the z/OS UNIX directory that is specified by the **JVMPROFILEDIR** system initialization parameter. You must change the value of the **JVMPROFILEDIR** parameter to a new location and copy the supplied sample JVM profiles into this directory so that you can use them to verify your installation.

Before you begin

The USSHOME system initialization parameter must specify the root directory for CICS files on z/OS UNIX.

About this task

The CICS-supplied sample JVM profiles are customized for your system during the CICS installation process, so you can use them immediately to verify your installation. You can customize copies of these files for your own Java applications.

The settings that are suitable for use in JVM profiles can change from one CICS release to another, so for ease of problem determination, use the CICS-supplied samples as the basis for all profiles. Check the upgrading information to find out what options are new or changed in the JVM profiles.

Procedure

1. Set the JVMPROFILEDIR system initialization parameter to the location on z/OS UNIX where you want to store the JVM profiles used by the CICS region. The value that you specify can be up to 240 characters long.

   The supplied setting for the **JVMPROFILEDIR** system initialization parameter is `/usr/lpp/cicsts/cicsts42/JVMProfiles`, which is the installation location for the sample JVM profiles. This directory is not a safe place to store your customized JVM profiles, because you risk losing your changes if the sample JVM profiles are overwritten when program maintenance is applied. So you must always change **JVMPROFILEDIR** to specify a different z/OS UNIX directory where you can store your JVM profiles. Choose a directory where you can give appropriate permissions to the users who must customize the JVM profiles.
2. Copy the CICS-supplied sample JVM profiles, DFHJVMPR, DFHJVMAX, DFHOSGI, and DFHJVMCD, from their installation location to the z/OS UNIX directory. The DFHJVMCD profile, although not strictly a sample JVM profile, is required for internal CICS Java transactions, and for managing the shared class cache.

   When you install CICS, the CICS-supplied sample JVM profiles are placed in the `/usr/lpp/cicsts/cicsts42/JVMProfiles` directory. The `/usr/lpp/cicsts/cicsts42` directory is the installation directory for CICS files on z/OS UNIX. This directory is specified by the **USSDIR** parameter in the DFHISTAR installation job.

Setting the memory limits for Java

Java applications require more memory than programs written in other languages. You must ensure that CICS and Java have enough storage and memory available to run Java applications.

About this task

Java uses storage below the 16 MB line, 31-bit storage, and 64-bit storage. The storage required for the JVM heap comes from the CICS region storage in MVS and not EDSA.

Procedure

1. Ensure that the z/OS **MEMLIMIT** parameter is set to a suitable value. This parameter limits the amount of 64-bit storage that the CICS address space can use. CICS uses the 64-bit version of Java and you must ensure that **MEMLIMIT** is set to a large enough value for this and the other CICS facilities that use 64-bit storage.

   See the following topics:
   - "Calculating storage requirements for pooled JVMs" on page 165
   - "Calculating storage requirements for JVM servers" on page 158
   - Estimating, checking, and setting MEMLIMIT in the Performance Guide
2. Ensure that the **REGION** parameter on the start up job stream is large enough for Java to run. Each JVM require some storage below the 16 MB line to run applications, including just-in-time compiled code, and working storage to pass parameters to CICS.

Giving CICS regions access to z/OS UNIX directories and files

CICS requires access to directories and files in z/OS UNIX. During installation, each of your CICS regions is assigned a z/OS UNIX user identifier (UID). The regions are connected to a RACF group that is assigned a z/OS UNIX group identifier (GID). Use the UID and GID to grant permission for the CICS region to access the directories and files in z/OS UNIX.

Before you begin

Ensure that you are either a superuser on z/OS UNIX, or the owner of the directories and files. The owner of directories and files is initially set as the UID of the system programmer who installs the product. The owner of the directories and files must be connected to the RACF group that was assigned a GID during installation. The owner can have that RACF group as their default group (DLFTGRP) or can be connected to it as one of their supplementary groups.

About this task

z/OS UNIX System Services treats each CICS region as a UNIX user. You can grant user permissions to access z/OS UNIX directories and files in different ways. For example, you can give the appropriate group permissions for the directory or file to the RACF group to which your CICS regions connect. This option might be best for a production environment and is explained in the following steps.

Procedure

1. Identify the directories and files in z/OS UNIX to which your CICS regions require access.

Default directories	**Permission**	**Description**
`/usr/lpp/java/J6.0.1_64/bin`	read and execute	IBM 64-bit SDK for z/OS, Java Technology Edition directories
`/usr/lpp/java/J6.0.1_64/bin/j9vm`	read and execute	IBM 64-bit SDK for z/OS, Java Technology Edition directories
`/usr/lpp/cicsts/cicsts42`	read and execute	The installation directory for CICS files on z/OS UNIX. Files in this directory include sample profiles and CICS-supplied JAR files.
`/u/`*`CICS region userid`*	read, write, and execute	The working directory for the CICS region. This directory contains input, output, and messages from the JVMs.
`/usr/lpp/cicsts/cicsts42/JVMProfiles/`	read and execute	Directory that contains the JVM profiles for the CICS region, as specified in the **JVMPROFILEDIR** system initialization parameter.

2. List the directories and files to show the permissions. Go to the directory where you want to start, and issue the following UNIX command:

```
ls -la
```

If this command is issued in the z/OS UNIX System Services shell environment when the current directory is the home directory of `CICSHT##`, you might see a list such as the following example:

```
/u/cicsht##:>ls -la
total 256
drwxr-xr-x   2 CICSHT## CICSTS42     8192 Mar 15  2008 .
drwx------   4 CICSHT## CICSTS42     8192 Jul  4 16:14 ..
-rw-------   1 CICSHT## CICSTS42     2976 Dec  5  2010 Snap0001.trc
-rw-r--r--   1 CICSHT## CICSTS42     1626 Jul 16 11:15 dfhjvmerr
-rw-r--r--   1 CICSHT## CICSTS42        0 Mar 15  2010 dfhjvmin
-rw-r--r--   1 CICSHT## CICSTS42      458 Oct  9 14:28 dfhjvmout
/u/cicsht##:>
```

3. If you are using the group permissions to give access, check that the group permissions for each of the directories and files give the level of access that CICS requires for the resource. Permissions are indicated, in three sets, by the characters `r`, `w`, `x` and `-`. These characters represent read, write, execute, and none, and are shown in the left column of the command line, starting with the second character. The first set are the owner permissions, the second set are the group permissions, and the third set are other permissions. In the previous example, the owner has read and write permissions to `dfhjvmerr`, `dfhjvmin`, and `dfhjvmout`, but the group and all others have only read permissions.
4. If you want to change the group permissions for a resource, use the UNIX command `chmod`. The following example sets the group permissions for the named directory and its subdirectories and files to read, write, and execute. `-R` applies permissions recursively to all subdirectories and files:

   ```
   chmod -R g=rwx directory
   ```

   The following example sets the group permissions for the named file to read and execute:

   ```
   chmod g+rx filename
   ```

   The following example turns off the write permission for the group on two named files:

   ```
   chmod g-w filename filename
   ```

   In all these examples, `g` designates group permissions. If you want to correct other permissions, `u` designates user (owner) permissions, and `o` designates other permissions.
5. Assign the group permissions for each resource to the RACF group that you chose for your CICS regions to access z/OS UNIX. You must assign group permissions for each directory and its subdirectories, and for the files in them. Enter the following UNIX command:

   ```
   chgrp -R GID directory
   ```

   GID is the numeric GID of the RACF group and *directory* is the full path of a directory to which you want to assign the CICS regions permissions. For example, to assign the group permissions for the `/usr/lpp/cicsts/cicsts42` directory, use the following command:

   ```
   chgrp -R GID /usr/lpp/cicsts/cicsts42
   ```

   Because your CICS region user IDs are connected to the RACF group, the CICS regions have the appropriate permissions for all these directories and files.

Results

You have ensured that CICS has the appropriate permissions to access the directories and files in z/OS UNIX to run Java applications.

When you change the CICS facility that you are setting up, such as moving files or creating new files, remember to repeat this procedure to ensure that your CICS regions have permission to access the new or moved files.

What to do next

Verify that your Java support is set up correctly using the sample programs and profiles.

Chapter 5. Enabling applications to use a JVM

Just as for non-Java applications, CICS requires that you define the resources required to run a Java program in a JVM. You must also define where to find the classes for the application.

You can run standard Java applications in a pooled JVM or a JVM server by creating a PROGRAM resource. Use a pooled JVM only if your application is not threadsafe. Otherwise use a JVM server for your Java applications.

CORBA stateless objects and enterprise beans do not have their own PROGRAM resources, but use the profile specified by the request processor program. CORBA stateless objects and enterprise beans can run only in a pooled JVM.

Setting up a JVM server

To run Java applications or Axis2 in a JVM server, you must set up the CICS resources and create a JVM profile that passes options to the JVM.

About this task

A JVM server can handle multiple concurrent requests for different Java applications in a single JVM. The JVMSERVER resource represents the JVM server in CICS. The resource defines the JVM profile that specifies options for the JVM, the program that provides values to the Language Environment enclave, and the thread limit. A JVM server can run different types of workload:

- You can configure the JVM server to run applications that are packaged as OSGi bundles.
- You can configure the JVM server to run SOAP processing for Web services using the Axis2 SOAP engine.

A JVM server cannot run both types of workload, so a JVM profile is supplied for each type of workload. Any changes that you make to these profiles apply to all JVM servers that use it. The DFHOSGI JVM profile contains the options to run an OSGi framework in the JVM server. When you customize the DFHOSGI profile, make sure that the changes are suitable for all the Java applications that use the JVM server. The DFHJVMAX JVM profile contains the options to run Axis2 in the JVM server.

Procedure

1. Create a JVM profile for the JVM server. You can copy the appropriate supplied profile, DFHJVMAX or DFHOSGI, from the installation directory to the directory that is specified by the **JVMPROFILEDIR** system initialization parameter. The profile you copy requires no further changes, but you can edit the options as appropriate for your environment. If you change the name of the profile, it must be 1 - 8 characters in length.

   Tip: You can use the z/OS perspective in CICS Explorer to copy the profiles between directories.
2. Optional: Open the JVM profile and edit the options if required. Only a subset of options are supported in a JVM server, so use the list of options in "JVM profiles: options and samples" on page 96 as a guide. Each parameter or

property is specified on a separate line, and the parameter or property value is delimited by the end of the line. Follow the coding rules in “Rules for coding JVM profiles” on page 99.

Do not specify the class path options in the DFHOSGI profile. The OSGi framework determines where the classes for each application are located. You can make the following changes:

a. Use the `LIBPATH_SUFFIX` option to specify any directories containing native C dynamic link library (DLL) files that are required by the JVM server. Middleware and tooling supplied by IBM or by vendors might require DLL files to be added to the library path; for example, DLL files are required to use the DB2 JDBC drivers.
b. For OSGi only, use the `OSGI_BUNDLES` option to specify middleware bundles that you want to run in the OSGi framework. Middleware bundles are a type of OSGi bundle that contain classes to implement system services, such as connecting to WebSphere MQ.
c. For OSGi only, use the `OSGI_FRAMEWORK_TIMEOUT` option to specify how many seconds CICS waits for the OSGi framework to initialize or shut down before timing out. The default value is 60 seconds. If the framework takes longer than the specified time, the JVM server fails to initialize or shut down correctly.
d. Change the destination for messages, trace, and output from the JVM. You can change the name and location of the `dfhjvmtrc`, `stdin`, `stdout`, and `stderr` files and Java memory dumps. To avoid interleaving output, use the &JVMSERVER; symbol to make these files unique to each JVM server.

3. Save your changes to the JVM profile. The JVM profile must be saved in EBCDIC.
4. Create a JVMSERVER resource for the JVM server.
   a. Specify the name of the JVM profile that you created.
   b. Specify the thread limit for the JVM server. The number of threads that are required depend on the workload that you want to run in the JVM server. To start with, you can accept the default value and then tune the environment. You can set up to 256 threads in a JVM server.
   c. Optional: Specify the program that supplies the Language Environment options for the enclave if different to DFHAXRO. CICS provides a default set of values that is already compiled in the DFHAXRO program. You can tune the enclave by providing your own options if required. For more information, see “Using DFHAXRO to modify the enclave of a JVM server” on page 173.

Results

When you enable the JVMSERVER resource, CICS creates a Language Environment enclave and passes the options from the JVM profile to the JVM server. Depending on the options in the profile, the JVM server is configured to run an OSGi framework or Axis2:

- If the JVM server supports OSGi, the JVM starts up and the OSGi framework resolves any OSGi middleware bundles.
- If the JVM server supports Axis2, the JVM starts up and loads the Axis2 JAR files.

When the JVM server completes startup successfully, the JVMSERVER resource installs in the ENABLED state.

If an error occurs, for example CICS is unable to find or read the JVM profile, the JVM server fails to initialize. The JVMSERVER resource installs in the DISABLED state and CICS issues error messages to the system log.

What to do next

For a JVM server that is configured to support OSGi, you can install OSGi bundles in the framework, as described in "Installing OSGi bundles in a JVM server" on page 84. For a JVM server that is configured to support Axis2, you can configure CICS to run Web service requests in the JVM server, as described in the *CICS Web Services Guide*.

Setting up a JVM server for DB2

If you want to access DB2 from Java applications that are running in a JVM server, you must add options to the JVM profile.

Before you begin

To use the JVM server with DB2, you must have the latest version of the IBM Data Server Driver for JDBC and SQLJ. For more information about what APARs are required, see the system requirements at http://www-01.ibm.com/support/docview.wss?uid=swg27020857.

About this task

DB2 provides OSGi bundle versions of the IBM Data Server Driver for JDBC and SQLJ. You must install the appropriate DB2 middleware bundle in the OSGi framework so that applications can access DB2.

Procedure

1. Open the JVM server profile for the appropriate JVM server. You can use the z/OS perspective in the CICS Explorer to open, edit, and save the JVM profiles.
2. Add the location of the `lib` directory for the appropriate DB2 driver to the `LIBPATH_SUFFIX` option.
3. Optional: If you previously used the OSGi bundle supplied with CICS to access DB2, remove these references from the profile:
   a. Remove the `com.ibm.cics.db2.jcc.jar` bundle from the `OSGI_BUNDLES` option.
   b. Remove the JVM system property **`-Dcom.ibm.cics.db2.jcc.jdbc.home`**.
4. Add either the DB2 JDBC 3.0 or the JDBC 4.0 middleware bundle, together with the DB2 licence bundle, to the `OSGI_BUNDLES` option. You can specify only one version of the JDBC bundle in the framework.
5. Save your changes.
6. If you are updating an existing JVM server, disable and enable the JVMSERVER resource. Otherwise, create a JVMSERVER resource. CICS starts the OSGi framework and installs the middleware bundle.

Example

The following excerpt shows an example JVM profile with the required options to use DB2 Version 9.1 and the JDBC 4.0 bundle:

```
#*******************************************************************
#
#                          Required parameters
#                          -------------------
#
# When using a JVM server, the set of CICS options that are supported
JAVA_HOME=/usr/lpp/java/J6.0.1_64
WORK_DIR=.
LIBPATH_SUFFIX=/usr/lpp/db2910/lib
...
#*******************************************************************
#
#                    JVM server specific parameters
#                    ------------------------------
#
OSGI_BUNDLES=/usr/lpp/db2910/classes/db2jcc4.jar,\
             /usr/lpp/db2910/classes/db2jcc_license_cisuz.jar
OSGI_FRAMEWORK_TIMEOUT=60
#
#*******************************************************************
#
#                              JVM options
#                              -----------
# The following option sets the Garbage collection Policy.
#
-Xgcpolicy:gencon
#
#*******************************************************************
#
#                 Setting user JVM system properties
#                 ----------------------------------
#
# -Dcom.ibm.cics.some.property=some_value
#
#*******************************************************************
#
#              Unix System Services Environment Variables
#              ------------------------------------------
#
JAVA_DUMP_OPTS="ONANYSIGNAL(JAVADUMP,SYSDUMP),ONINTERRUPT(NONE)"
#
#
```

Installing OSGi bundles in a JVM server

To deploy a Java application in a JVM server, you must install the OSGi bundles for the application in the OSGi framework of the target JVM server.

Before you begin

A CICS bundle that contains the OSGi bundles for the application must be deployed to zFS. The target JVM server must be running in the CICS region.

About this task

A CICS bundle can contain one or more OSGi bundles and services. Because the CICS bundle is the unit of deployment, all the OSGi bundles and services are managed together as part of the BUNDLE resource. The OSGi framework also manages the life cycle of the OSGi bundles and services, including the management of dependencies and versioning.

As a best practice, ensure that all OSGi bundles that comprise a Java application are deployed in the same CICS bundle. Using this method, you can manage the application as a single entity by using the BUNDLE resource. If there are dependencies between OSGi bundles, deploy them in the same CICS bundle. When you install the CICS BUNDLE resource, CICS ensures that all the dependencies between the OSGi bundles are resolved.

If you have dependencies on an OSGi bundle that contains a library of common code, the best practice is to create a separate CICS bundle for the library. In this case, it is important to install the CICS BUNDLE resource containing the library first. If you install the Java application before the CICS bundles that it depends on, the OSGi framework is unable to resolve the dependencies of the Java application.

Procedure

1. Check the target JVM server in the CICS bundle to ensure that a JVM server of that name exists in the CICS region.
2. Create a BUNDLE resource that specifies the directory of the bundle in zFS:
   a. Click **Definitions** > **Bundle Definitions** in the CICS Explorer menu bar to open the Bundles Definitions view.
   b. Right-click anywhere in the view and click **New** to open the New Bundle Definition wizard. Enter the details for the BUNDLE resource in the wizard fields.
   c. Install the BUNDLE resource. You can either install the resource in an enabled or disabled state:
      - If you install the resource in a DISABLED state, CICS installs the OSGi bundles in the framework and resolves the dependencies, but does not attempt to start the bundles.
      - If you install the resource in an ENABLED state, CICS installs the OSGi bundles, resolves the dependencies, and starts the OSGi bundles. If the OSGi bundle contains a lazy bundle activator, the OSGi framework does not attempt to start the bundle until it is first called by another OSGi bundle.
3. Optional: Enable the BUNDLE resource to start the OSGi bundles in the framework if the resource is not already in an ENABLED state.
4. Click **Operations** > **Bundles** in the CICS Explorer menu bar to open the Bundles view. Check the state of the BUNDLE resource.
   - If the BUNDLE resource is in an ENABLED state, CICS was able to install all the resources in the bundle successfully.
   - If the BUNDLE resource is in a DISABLED state, CICS was unable to install one or more resources in the bundle.

   If the BUNDLE resource failed to install in the enabled state, check the bundle parts for the BUNDLE resource. If any of the bundle parts are in the UNUSABLE state, CICS was unable to create the OSGi bundles. Typically, this state indicates that there is a problem with the CICS bundle in zFS. You must discard the BUNDLE resource, fix the problem, and then install the BUNDLE resource again.
5. Click **Operations** > **Java** > **OSGi Bundles** in the CICS Explorer menu bar to open the OSGI Bundles view. Check the state of the installed OSGi bundles and services in the OSGi framework. The following table summarizes the states:

BUNDLE	BUNDLEPART	OSGIBUNDLE	OSGISERVICE
ENABLED	ENABLING	INSTALLED	N/A
	ENABLED	STARTING	N/A
		ACTIVE	ACTIVE
			INACTIVE
DISABLED	DISABLING	STOPPING	N/A
	DISABLED	RESOLVED	N/A
	UNUSABLE	N/A	N/A

- If the OSGi bundle is in the STARTING state, the bundle activator has been called but not yet returned. If the OSGi bundle has a lazy activation policy, the bundle remains in this state until it is called in the OSGi framework.
- If the OSGi bundles and OSGi services are active, the Java application is ready.
- If the OSGi service is inactive, CICS detected that an OSGi service with that name already exists in the OSGi framework.

Results

The BUNDLE is enabled, the OSGi bundles are successfully installed in the OSGi framework, and any OSGi services are active. The OSGi bundles and services are available to other bundles in the framework.

What to do next

You can make the Java application available to other CICS applications outside the OSGi framework.

Calling a Java application in a JVM server

To call a Java application that is running in a JVM server from another CICS application, you must use an OSGi service that is active in the OSGi framework.

About this task

An OSGi service is a well-defined interface that is registered in the OSGi framework for an OSGi bundle. Other OSGi bundles and remote applications use the OSGi service to call application code that is packaged in the OSGi bundle. An OSGi bundle can have more than one OSGi service.

The OSGi framework manages the invocations of services for OSGi bundles that are installed in the same framework. To call a Java application from a CICS application that is outside the OSGi framework, use the appropriate OSGi service for the OSGi bundle.

Procedure

1. Determine the symbolic name of the active OSGi service that you want to use in the OSGi framework. Click **Operations** > **Java** > **OSGi Services** in CICS Explorer to list the OSGi services that are active.
2. Create a PROGRAM resource to represent the OSGi service to other CICS applications:

   a. In the JVM attribute, specify `YES` to indicate that the program is a Java program.
   b. In the JVMCLASS attribute, specify the symbolic name of the OSGi service. This value is case sensitive.
   c. In the JVMSERVER attribute, specify the name of the JVMSERVER resource in which the OSGi service is running.
3. You can call the Java application in various ways:
   - Use a 3270 or **EXEC CICS START** request that specifies a transaction identifier. Create a TRANSACTION resource that defines the PROGRAM resource for the OSGi service.
   - Use an **EXEC CICS LINK** request, an ECI call, or an EXCI call. Name the PROGRAM resource for the OSGi service when coding the request.
   - Use an entry in a program list table (PLT). Name the PROGRAM resource for the OSGi service.

Results

You have created a PROGRAM resource to make an OSGi bundle available to other CICS applications. When the OSGi service is called, CICS runs the request in the target JVM server. If the OSGi service is registered as active, the Java program runs successfully. If the OSGi service is not registered or is inactive, an error is returned to the calling program.

Enabling a Java security manager

By default, Java applications have no security restrictions placed on activities requested of the Java API. To use Java security to protect a Java application from performing potentially unsafe actions, you can enable a security manager for the JVM in which the application runs.

About this task

The security manager enforces a security policy, which is a set of permissions (system access privileges) that are assigned to code sources. A default policy file is supplied with the Java platform. However, to enable Java applications to run successfully in CICS when Java security is active, you must specify an additional policy file that gives CICS the permissions it requires to run the application.

You must specify this additional policy file for each kind of JVM that has a security manager enabled. CICS provides some examples that you can use to create your own policies.

Procedure

- For applications that run in the OSGi framework of a JVM server:
  1. Create a plug-in project in the CICS Explorer SDK and select the supplied OSGi security agent example. This example creates an OSGi middleware bundle called `com.ibm.cics.server.examples.security` in your project that contains a security profile. This profile applies to all OSGi bundles in the framework in which it is installed.
  2. In the project, select the `example.permissions` file to edit the permissions for your security policy. This file contains permissions that are specific to running applications in a JVM server, including a check to ensure that applications do not use the System.exit() method.

3. Deploy the OSGi bundle to a suitable directory in zFS. CICS must have read and execute access to this directory.
4. Create a policy file to give all permissions to the Java launcher. An example policy called `all.policy` is provided in the plug-in project. It is not included in the middleware bundle, but you can copy it to a suitable directory in zFS. The policy file contains the following permissions:

   ```
   grant {
   permission java.security.AllPermission;
   };
   ```
5. Edit the JVM profile for the JVM server to add the OSGi bundle to the `OSGI_BUNDLES` option before any other bundles:

   ```
   OSGI_BUNDLES=/u/bundles/com.ibm.cics.server.examples.security_1.0.0.jar,/usr/lpp/cicsts42/lib/c
   ```
6. Add the following Java environment variable to the JVM profile to enable security in the OSGi framework:

   ```
   org.osgi.framework.security=osgi
   ```
7. Add the following Java security system property to the JVM profile to specify the security policy:

   ```
   -Djava.security.policy=/u/policies/all.policy
   ```
8. Save your changes and enable the JVMSERVER resource to install the middleware bundle in the JVM server.

- For applications that run in a pooled JVM, use the `dfhjejbpl.policy` file to implement your security policy.
  1. Create a policy file for your application in the `/usr/lpp/java/J6.0.1_64/lib/security/`, where `java/J6.0.1_64` is the location for the IBM 64-bit SDK for z/OS, Java Technology Edition.

     The security manager always uses the default policy file `java.policy` that is provided in this directory. If you want an application to use JDBC or SQLJ, create a policy file to grant permissions to the JDBC driver. You must use the JDBC 2.0 driver with Java security.
  2. Enable the security manager by adding the **`-Djava.security.manager`** system property to the JVM profile. Use one of the following formats:
     – `-Djava.security.manager=default`
     – `-Djava.security.manager=""`
     – `-Djava.security.manager=`
  3. Specify your policy files by adding the **`-Djava.security.policy`** system property to the JVM profile. The security manager uses any policies set on this property in addition to the default security policy.

Results

When the Java application is called, the JVM determines the code source for the class and consults the security policy before granting the class the appropriate permissions.

Setting up pooled JVMs

The pooled JVM environment is required to run Enterprise Java Beans, CORBA, and non-threadsafe Java applications. You must set up the supplied JVM profiles and CICS resources. You can optionally run the Hello World sample to check your environment is set up correctly.

About this task

Procedure

1. Copy the supplied samples DFHJVMPR and DFHJVMCD from their installation location to the z/OS UNIX directory that is specified in the **JVMPROFILEDIR** system initialization parameter. Working with copies of the suppled profiles ensures that you do not lose your changes if the profiles are updated when maintenance is applied.
   - DFHJVMPR is the supplied profile for the pooled JVM.
   - DFHJVMCD is the supplied profile for system programs and the shared class cache.
2. Customize the JVM profiles to edit the options that configure the JVM when it starts. For example, you change the amount of storage that is available and apply security settings. The options are explained in "JVM profiles: options and samples" on page 96.
3. Optional: Check your pooled JVM environment setup using the JCICS HelloWorld sample.
4. Create the CICS resources and JVM profile to enable an application, Enterprise Java Bean, or CORBA, to use a pooled JVM. You can use the customized default profile, DFHJVMPR, or you can create your own profile.

Results

The environment is configured and you have created the CICS resources to run a Java application in a pooled JVM.

Customizing DFHJVMCD

The JVM profile DFHJVMCD is reserved for use by CICS-supplied system programs, in particular the default request processor program, DFJIIRP, used by the CICS-supplied CIRP request processor transaction. CICS also uses DFHJVMCD to initialize and terminate the shared class cache for pooled JVMs.

Before you begin

DFHJVMCD must be set up correctly for your CICS region, but customize it only when required. DFHJVMCD can have an associated JVM properties file, but this is optional.

Make sure that you are working with a copy of DFHJVMCD in the z/OS UNIX directory that you specified on the **JVMPROFILEDIR** system initialization parameter, and not with the original file in its installation location.

About this task

The options that you can change are indicated in the text of DFHJVMCD. Do not make any other changes to the files.

For detailed information about the options in DFHJVMCD that you can change, and the purpose of changing them, see "Options for JVMs in a CICS environment" on page 101, and "JVM system properties" on page 109.

Procedure

1. Open DFHJVMCD in a standard text editor.

2. If you have a shared class cache in your CICS region, you can specify that any pooled JVMs created with the profile DFHJVMCD use the shared class cache. Change the CLASSCACHE option to CLASSCACHE=YES. The default, CLASSCACHE=NO, means that they are stand-alone JVMs.
3. Change the value for the JAVA_HOME option if it does not match your installation directory for the IBM 64-bit SDK for z/OS, Java Technology Edition on z/OS UNIX.
4. To change the working directory on z/OS UNIX that is used by JVMs with the DFHJVMCD profile, change the WORK_DIR option to specify your preferred directory.
5. To change the names of the z/OS UNIX files to be used for `stderr`, `stdin`, and `stdout`, change the STDERR, STDIN, and STDOUT options.
6. To use an output redirection class to intercept and redirect output and messages from the JVM, use the USEROUTPUTCLASS option to specify the name of the class. Do not use this option in a production environment.
7. To tune the heap size for JVMs with the DFHJVMCD profile, to fit better with the needs of your applications, change the **`-Xms`** or **`-Xmx`** options.
8. If you have applications that use JDBC, add the relevant DB2 libraries and files as specified in the sample profile DFHJVMPR to the LIBPATH_SUFFIX and CLASSPATH_SUFFIX options in DFHJVMCD.
9. Enable the Java security policy mechanism (the **`-Djava.security.policy`** system property) if required by your installation.
10. Save the changes to the profile. Confirm that your customized copy of DFHJVMCD is in the z/OS UNIX directory that you specified on the **`JVMPROFILEDIR`** system initialization parameter.

What to do next

Do not specify DFHJVMCD in PROGRAM resources that you set up for your own applications. You might want to make similar customization changes to a copy of the other CICS-supplied sample JVM profile, DFHJVMPR, for use by your applications.

Customizing DFHJVMPR

DFHJVMPR is the default JVM profile for pooled JVMs. Any changes that you make to this profile apply to all pooled JVMs where the PROGRAM resource does not specify another JVM profile.

Before you begin

Before you begin, make sure that you are working with the copy of the supplied sample JVM profile and not the original file in its installation location.

About this task

When you customize the DFHJVMPR profile, make sure that the changes are suitable for all the Java applications that use the profile. If you want to add options for a Java application that do not apply to your other applications, create a JVM profile based on DFHJVMPR with a different name.

Procedure

1. Open the JVM profile in a standard text editor and edit the options. Use the lists of options in "JVM profiles: options and samples" on page 96. Each

parameter or property is specified on a separate line, and the parameter or property value is delimited by the end of the line. Follow the coding rules in "Rules for coding JVM profiles" on page 99.

You might want to change these key options for pooled JVMs:

- Enable Java security by adding a security manager and policy to the profile. The Java security policy mechanism protects Java applications from performing unsafe actions. You can add security to the profile using the **`-Djava.security.manager`** and **`-Djava.security.policy`** system properties. For more information, see "Enabling a Java security manager" on page 87.
- Change the **`-Xmx`** option in the JVM profile to adjust the amount of storage available for the application. This option changes the size of the heap in the JVM. The default value is 16 MB, but if you have large Java applications, you might want to increase this value.
- Change the timeout threshold for the JVM, using the `IDLE_TIMEOUT` option in the JVM profile. The default is that an inactive JVM becomes eligible for automatic termination by CICS after 30 minutes. If you prefer to keep unused JVMs available for a longer period, you can specify a timeout threshold of up to 7 days or set the JVM to never time out.
- Change the destination for messages and output from the JVM. You can change the name and location of the `stdin`, `stdout`, and `stderr` files and Java dumps, and use symbols to make these files unique to each JVM. During application development, you can redirect messages from JVM internals and output from Java applications using the `USEROUTPUTCLASS` option in the JVM profile. "Controlling the location for JVM stdout, stderr and dump output" on page 182 tells you more about the changes that you can make.

2. Optional: If your Java applications require access to DB2 data using JDBC, use the **`-Djdbc.drivers`** system property. For more information, see Using JDBC and SQLJ to access DB2 data from Java programs in the DB2 Guide.
3. Save the customized JVM profile in the z/OS UNIX directory that is specified by the **`JVMPROFILEDIR`** system initialization parameter for your CICS region. CICS loads the JVM profiles from this directory.
4. Confirm that CICS has read and write access on z/OS UNIX for your JVM profile and the directory containing it.
5. If you have JVMs running that are using the DFHJVMPR profile, phase out the JVM pool for the profile. All the existing JVMs that are using DFHJVMPR are stopped and started. The new JVMs use the latest version of the JVM profile.

Results

You have customized the sample JVM profile for pooled JVMs and ensured that CICS has the correct access to the profile in the z/OS UNIX directory.

What to do next

You can set up applications to use the customized JVM profile and add the classes for the application to the class path. See "Enabling an application to use a pooled JVM" on page 94.

Creating your own JVM profiles

You can create a JVM profile with a different file name for a specific application, or if you want to avoid making updates to the customized sample profiles.

Before you begin

You must have copies of the supplied sample profiles in the z/OS UNIX directory that is specified by the **JVMPROFILEDIR** system initialization parameter for your CICS region. CICS must have read and execute access to this directory.

About this task

To minimize administration, always copy and rename the appropriate sample profile. If your Java application is going to run in a JVM server, use the DFHOSGI profile as the basis for your modifications. If your Java application is going to run in a pooled JVM, use the DFHJVMPR profile as the basis for your modifications.

Procedure

1. Copy and rename the appropriate sample JVM profile. Do not give the JVM profile a name beginning with DFH, because these characters are reserved for use by CICS. The names of JVM profiles are case-sensitive. For more information about naming profiles, see “JVM profiles” on page 7.
2. Edit the JVM profile in a standard text editor, using the lists of options in “JVM profiles: options and samples” on page 96. Some options are specific to JVM servers and others are specific to pooled JVMs.

   Each parameter or property is specified on a separate line, and the parameter or property value is delimited by the end of the line. Follow the coding rules in “Rules for coding JVM profiles” on page 99.
3. If you want to enable Java security, specify the security options and set up one or more security policy files to define security properties for the JVM. For details, see “Enabling a Java security manager” on page 87.
4. Save your JVM profile in the z/OS UNIX directory that is specified by the **JVMPROFILEDIR** system initialization parameter for your CICS region. CICS loads the JVM profiles from this directory.
5. Ensure that CICS has read access on z/OS UNIX for your JVM profile. See “Giving CICS regions access to z/OS UNIX directories and files” on page 77.

Results

You have created a JVM profile that conforms to the naming conventions and contains the correct options for your Java application and the intended runtime environment.

What to do next

Set up the application to use the JVM profile, including creating the CICS resources. You can set up a JVM server, as described in “Setting up a JVM server” on page 81, or a pooled JVM, as described in “Enabling an application to use a pooled JVM” on page 94.

Checking your pooled JVM setup with the examples

Set up and run the "Hello World" and "Hello CICS World" example programs to verify that your pooled JVM environment is correctly set up in your CICS region.

Before you begin

Before running the example programs, make sure that you have completed the other setup tasks described in Chapter 4, “Setting up Java support,” on page 75.

About this task

The Java examples are provided in the CICS Explorer SDK to help application developers get started with developing Java applications in CICS. The Java source and build files are also provided in z/OS UNIX during CICS installation if you want to run the examples to verify that the pooled JVM environment is correctly set up.

To set up and run the supplied programs, you must define environment variables in z/OS UNIX. You can define the variables in a profile for z/OS UNIX by using the **`export`** command, or you can enter the **`export`** command manually when you log in to z/OS UNIX.

Procedure

1. PATH is the z/OS UNIX System Services search path. Define the PATH environment variable:
   ```
   /usr/lpp/java/J6.0.1_64/bin
   ```
   The path locates where IBM 64-bit SDK for z/OS, Java Technology Edition is installed on z/OS UNIX. You can use the **`export`** command to add the path as follows:
   ```
   export PATH=/usr/lpp/java/J6.0.1_64/bin:$PATH
   ```
2. CICS_HOME is the installation directory for CICS Transaction Server for z/OS files in z/OS UNIX System Services. Define the CICS_HOME environment variable as follows:
   ```
   /usr/lpp/cicsts/cicspath
   ```
   The value of *cicspath* is defined by the **`USSDIR`** installation parameter when you installed CICS TS. `cicsts42` is the default. You can use the export command to set the directory prefix as follows:
   ```
   export CICS_HOME=/usr/lpp/cicsts/cicsts42
   ```
   The `$CICS_HOME/samples/dfjcics` directory contains the makefiles.

   The `$CICS_HOME/samples/dfjcics/examples` directory contains the Java source.
3. JAVA_HOME specifies the path to the IBM 64-bit SDK for z/OS, Java Technology Edition subdirectories. Define the JAVA_HOME environment variable as follows:
   ```
   /usr/lpp/java/java_location/
   ```
   The *java_location* is where the IBM 64-bit SDK for z/OS, Java Technology Edition is installed on z/OS UNIX. The default value is `java/J6.0.1_64/`.
4. Build the Java examples:
   a. In the `samples/dfjcics` directory, type `make jvm` to build all the examples. The makefiles call `javac` and store the output files in the *`$CICS_HOME`*`/samples/dfjcics/examples/`*`sample_name`* z/OS UNIX directory, where `sample_name` is the name of the example program.
   b. Compile and translate the supplied C programs that are in SDFHSAMP:
      - DFH$LCCA
      - DFH$JSAM
      - DFH$LCCC

      These programs are linked by the Program Control and one of the "Hello World" Java example programs. DFH$LCCA and DFH$JSAM are standard CICS programs that could be written in any of the languages supported by

   CICS. If you do not have a C compiler, you can write COBOL versions of the supplied programs and use them in place of the supplied C versions.
   c. Link the programs into DFHRPL or a dynamic library concatenation.
5. Add the string `/usr/lpp/cicsts/cicsts42/samples/dfjcics` to the `CLASSPATH_SUFFIX` option in the default JVM profile DFHJVMPR. `/usr/lpp/cicsts/cicsts42` is the value of the **`USSHOME`** system initialization parameter.
6. Run the Hello World examples by following the steps outlined in "Running the Hello World examples" on page 35.

Results

The Hello World examples ran successfully.

What to do next

You can enable Java applications to run using pooled JVMs.

Enabling an application to use a pooled JVM

To enable a Java application to use a pooled JVM, you must set up the CICS resources to run a Java program in a JVM. You must also define where to find the classes for the application.

About this task

Use a pooled JVM when you want to run an application that is not threadsafe in a single JVM.

Procedure

1. Select or create an appropriate JVM profile for the Java application. You can copy the supplied sample DFHJVMPR. All JVM profiles are located in the z/OS UNIX directory that is specified by the **`JVMPROFILEDIR`** system initialization parameter.
2. Edit the JVM profile to add the classes and libraries that are required by your application. You can use any standard text editor. Use a colon as the separator between paths. To include line breaks, use a backslash and a blank (`\ `).
   a. Place the application classes on the standard class path. The standard class path is defined by the **`CLASSPATH_SUFFIX`** option. Do not specify the name of the class itself or the name of the package in the JVM profile. The options in the JVM profile specify the path to the class.
   b. If your classes are not in a package, include all the subdirectories on the class path.
   c. If your classes or packages are in JAR files, include the name of the JAR file on the class path.

   For details on rules for coding class paths and other items in a JVM profile, see "Rules for coding JVM profiles" on page 99.
3. Add any native C dynamic link library (DLL) files that are required by the application to the **`LIBPATH_SUFFIX`** option in the JVM profile.

   Middleware and tooling supplied by IBM or by vendors might require DLL files to be added to the library path; for example, DLL files are required to use the DB2 JDBC drivers. You might also have native code associated with a class that you have written.

4. Save your JVM profile in the directory specified by the **JVMPROFILEDIR** system initialization parameter.
5. Create a PROGRAM resource and set the appropriate Java attributes. When you enter values for the attributes, ensure that you use the correct case for the JVM class and the JVM profile.
   a. In the EXECKEY attribute, specify the execution key for the Java program. The default value for this attribute is USER and is suitable for most Java programs because it improves storage protection. However, if the program is part of a transaction that specifies TASKDATAKEY(CICS), the program must run in CICS key.
   b. In the JVM attribute, specify YES to indicate that the program is a Java program.
   c. In the JVMCLASS attribute, specify the name of the main class in the Java program. If the program has been built as a package, specify the fully qualified name, which is the Java class name qualified by the package name, with a period (.) used as a separator.

      For example, the package example.HelloWorld contains the class HelloCICSWorld; in this case, the fully qualified class name is example.HelloWorld.HelloCICSWorld. If the program has not been built as a package, specify the class name with no qualifiers.
   d. In the JVMPROFILE attribute, specify the name of the profile that you edited to include your application classes.

Results

Your JVM profile and PROGRAM resource are available in the CICS region to support running the Java application. When an application makes a request to run a Java program, it can make the request in various ways:
- A 3270 or **EXEC CICS START** request that specifies a transaction identifier.
- An **EXEC CICS LINK** request, or an ECI or EXCI call that names the Java program directly.
- An entry in a program list table (PLT).

For **EXEC CICS LINK** requests or ECI or EXCI calls, and for entries in a program list table, CICS is given the name of the PROGRAM resource directly. However, for 3270 or START requests, CICS determines the PROGRAM resource by using the transaction identifier.

What to do next

If the JVM profile specifies that the JVM uses the shared class cache, you must ensure that the class cache is started or enabled to autostart for the Java application to run. "Starting the shared class cache" on page 142 tells you how to start the shared class cache or enable autostart.

Enabling CORBA or enterprise bean applications to use a JVM

To enable a CORBA application or enterprise bean to use a pooled JVM, you must update the JVM profile and class path for the application.

About this task

CORBA stateless objects and enterprise beans do not have their own PROGRAM resources. A method request for an enterprise bean or CORBA stateless object involves a JVM, because the request processor that handles it executes in a JVM. A request processor is a program that manages the execution of an IIOP request, including calling the container to process the method. When CICS receives the method request, it compares it to a REQUESTMODEL resource, finds the one that best matches the request, and uses the transaction identifier from that request model to determine the PROGRAM resource.

Sometimes, IIOP requests are processed using an existing request processor transaction that already has a JVM assigned to it. CICS only looks at the transaction identifier in any matching request model when a new request processor transaction is required.

Procedure

1. Identify the JVM profile for the request processor program that handles the CORBA stateless object or enterprise bean. The JVM profile is specified on the PROGRAM resource for the request processor program. The default request processor program is DFHJIIRP and the default JVM profile for this program is DFHJVMCD.
2. For CORBA stateless objects only, add the JAR file for the application to the CLASSPATH_SUFFIX option in the JVM profile for the request processor program. Use a colon as the separator between paths that you specify on a class path. To include line breaks, use a backslash and a blank: `(\ )`.

   You do not have to add the deployed JAR (DJAR) files for your enterprise beans to the class path.
3. If your enterprise beans or CORBA application use any classes, such as classes for utilities that are not included in the JAR file, include these classes on the class path that is used by the JVM for the request processor program.

Results

Your JVM profile and class paths are available in the CICS region to support running the Java application.

JVM profiles: options and samples

CICS provides sample JVM profiles that contain a selection of options for IBM JVMs that are used in a CICS environment. Some of these options are specific to the CICS environment and are not used for JVMs in other environments. Other options are standard or nonstandard Java options, which can be used for IBM JVMs in any environment.

You can specify any JVM option or system property in a JVM profile, and it is passed to the JVM. The JVM profiles for JVM servers and pooled JVMs are different, so some options you can specify only for one type of Java environment.

You can set system properties in a JVM properties file. However, JVM properties files are supported only for pooled JVMs, and sample properties files are not provided with CICS.

No central repository of all options and system properties for the JVM exists. Here are some sources of information that you can use:

- The documentation for the IBM 64-bit SDK for z/OS, Java Technology Edition, Version 6.

- The *IBM SDK Java Technology Edition Version 6 Supplement*, that is available at http://www-03.ibm.com/systems/z/os/zos/tools/java/products/sdk601_64.html. This document contains information specific to IBM 64-bit SDK for z/OS, Java Technology Edition, Version 6.0.1.
- The Java Diagnostics Guide. This guide documents system properties that are used for JVM trace and problem determination.

The Java class libraries include other system properties, and applications might have their own system properties. The IBM Java documentation is the primary source of information and the CICS documentation is a secondary source of information.

The summary table, Table 9, lists the options that are used in the sample JVM profiles, and which options apply to JVM servers and pooled JVMs. The table also includes some further options that you might use to complete tasks described in the CICS documentation. The table indicates the default for each option if it is not specified in the sample JVM profiles.

Table 9. JVM options reference table for JVMs in a CICS environment

Option	Default	JVM server	Pooled JVM	Comments
JVM type				
CLASSCACHE	NO	Not supported	Supported	YES makes JVM use shared class cache, NO does not
REUSE	YES	Not supported	Supported	YES makes continuous JVM, NO makes single-use JVM
Directories				
JAVA_HOME	None	Supported	Supported	Required, sample profiles include this directory
WORK_DIR	/tmp	Supported	Supported	
Paths				
CLASSPATH_PREFIX	None	Not supported	Supported	
CLASSPATH_SUFFIX	None	Not supported	Supported	
LIBPATH_PREFIX	None	Supported	Supported	
LIBPATH_SUFFIX	None	Supported	Supported	
OSGI_BUNDLES	None	Supported	Not supported	Set if you want to use middleware bundles in a JVM server
Timeout threshold				
IDLE_TIMEOUT	30 minutes	Not supported	Supported	Applies only to continuous pooled JVM
OSGI_FRAMEWORK_TIMEOUT	60 seconds	Supported	Not supported	
Further settings and facilities for the JVM				
JVMPROPS	None	Not supported	Supported	Set only if you use a JVM properties file
INVOKE_DFHJVMAT	NO	Not supported	Supported	Applies only to single-use pooled JVM

Table 9. JVM options reference table for JVMs in a CICS environment (continued)

Option	Default	JVM server	Pooled JVM	Comments
Storage heap sizes				
-Xms		Supported	Supported	For information about the **-Xms** default value, see the reference information at Default settings for the JVM
-Xmx		Supported	Supported	For information about the **-Xmx** default value, see the reference information at Default settings for the JVM
Garbage collection threshold				
GC_HEAP_THRESHOLD	85%	Not supported	Supported	Applies only to continuous pooled JVM
Output from the JVM				
JVMTRACE	`dfhjvmtrc`	Supported	Not supported	
LEHEAPSTATS	NO	Not supported	Supported	
STDERR	`dfhjvmerr`	Supported	Supported	
STDIN	`dfhjvmin`	Supported	Supported	
STDOUT	`dfhjvmout`	Supported	Supported	
USEROUTPUTCLASS	None	Supported	Supported	Set only in a development environment
Problem determination and application debugging				
JAVA_DUMP_OPTS	YES	Supported	Supported	
-Xdebug	NO	Supported	Supported	
PRINT_JVM_OPTIONS	NO	Supported	Supported	Set YES only temporarily

z/OS UNIX System Services environment variables

In addition to the JVM options and system properties that are used to construct the JVM, you can specify z/OS UNIX System Services environment variables in a JVM profile. Any name and value pair in a JVM profile that is not recognized as a JVM option or system property is treated as a z/OS UNIX System Services environment variable and is exported. z/OS UNIX System Services environment variables specified in a JVM profile apply only to JVMs created with that profile.

The `JAVA_DUMP_OPTS` and `JAVA_DUMP_TDUMP_PATTERN` options in the sample JVM profiles are z/OS UNIX System Services environment variables. Another example is the `TZ` environment variable, which you can specify to change the time zone for the JVM.

z/OS UNIX System Services environment variables can be specified only in a JVM profile.

Rules for coding JVM profiles

You can edit JVM profiles using any standard text editor. Follow these rules when coding your JVM profiles.

- The name of a JVM profile can be up to 8 characters in length. The name of a JVM properties file can be any length, but, for ease of use, it is generally a short name with some similarity to the name of the JVM profile that references it.
- The name of a JVM profile or JVM properties file can be any name that is valid for a file in z/OS UNIX System Services. Do not use a name beginning with DFH, because these characters are reserved for use by CICS.
- Because JVM profiles and JVM properties files are UNIX files, case is important. When you specify the name in CICS, you must enter it using the same combination of uppercase and lowercase characters that is present in the z/OS UNIX file name.
- Do not use quotation marks when specifying values for directories in a JVM profile.
- The CEDA panels accept mixed case input for the JVMPROFILE field irrespective of your terminal UCTRAN setting. However, you must enter the name of a JVM profile in mixed case when you use CEDA from the command line or when you use another CICS transaction. Ensure that your terminal is correctly configured with uppercase translation suppressed. You can use the supplied CEOT transaction to alter the uppercase translation status (UCTRAN) for your own terminal, for the current session only.

Follow these rules when coding JVM options or system properties:

Case sensitivity
All parameter keywords and operands are case-sensitive, and must be specified exactly as shown in "Options for JVMs in a CICS environment" on page 101 and "JVM system properties" on page 109.

Class path separator character
Use the **:** (colon) character to separate the directory paths that you specify on a class path option, such as CLASSPATH_SUFFIX.

Continuation
For JVM options or system properties, the value is delimited by the end of the line in the text file. If a value that you are entering or editing is too long for an editor window, you can break the line to avoid scrolling. To continue on the next line, terminate the current line with the backslash character and a blank continuation character, as in this example:

```
CLASSPATH_SUFFIX=/u/example/pathToJarOrZipFile/jarfile.jar:\
/u/example/pathToRootDirectoryForClasses
```

Comments
To add comments or to comment out an option instead of deleting it, begin each line of the comment with a # symbol. Comment lines are ignored when the file is read by the JVM launcher.

Blank lines are also ignored. You can use blank lines as a separator between options or groups of options.

Character escape sequences
In a property element string, you can code the escape sequences shown in Table 10 on page 100

Table 10. Escape sequences

Escape sequence	Character value
\b	Backspace
\t	Horizontal tab
\n	Newline
\r	Carriage return
\"	Double quotation mark
\'	Single quotation mark
\\	Backslash
\xxx	The character corresponding to the octal value *xxx*, where *xxx* is between values 000 - 377
\uxxxx	The Unicode character with encoding *xxxx*, where *xxxx* is 1 - 4 hexadecimal digits. (See note for more information.)

Note: Unicode `\u` escapes are distinct from the other escape types. The Unicode escape sequences are processed before the other escape sequences described in Table 10. A Unicode escape is an alternative way to represent a character that might not be displayable on non-Unicode systems. The character escapes, however, can represent special characters in a way that prevents the usual interpretation of those characters.

Multiple instances of options
You can use each option only once in a JVM profile. If more than one instance of the same option is included in a JVM profile, the value for the last option found is used, and previous values are ignored.

Storage sizes
When specifying storage-related options in a JVM profile, specify storage sizes in multiples of 1024 bytes. Use the letter K to indicate KB, the letter M to indicate MB, and the letter G to indicate GB. For example, to specify 6 291 456 bytes as the initial size of the heap, code **-Xms** in one of the following ways:

```
-Xms6144K
-Xms6M
```

Validation of JVM profile options

CICS carries out a number of checks on key options specified in your JVM profiles whenever you start JVMs. These checks enable the early detection of problems in your JVM setup.

CICS carries out checks relating to the following JVM profile options:

CLASSPATH_PREFIX, CLASSPATH_SUFFIX
For JVM server profiles, CICS checks that these options are not present in the profile. If either option is specified in the profile, the OSGi framework in the JVM server cannot start. The JVMSERVER resource cannot be enabled and CICS issues the DFHSJ0210 error message.

JAVA_HOME
CICS checks the following points for this directory:

- The directory exists in z/OS UNIX.
- CICS has at least read permission to access the directory.

- The JDK_INSTALL_OK file is present in the directory, indicating a completed installation of the IBM 64-bit SDK for z/OS, Java Technology Edition 6.0.1 files in this location.
- The Java release number in the JDK_INSTALL_OK file is a version supported by CICS.

If any problems are found, CICS issues an error message and does not start the JVM.

Deprecated class path options: LIBPATH, CICS_HOME, CLASSPATH, TMPREFIX, and TMSUFFIX
A warning message is issued at JVM startup if you have one or more of these options in a pooled JVM profile. Do not use these options in JVM profiles. The message advises on the correct option to use instead.

OSGI_BUNDLES
For JVM server profiles, CICS checks that the specified JAR files are OSGi bundles. CICS also checks that the middleware bundles are correctly delimited and have the right separators.

Options for JVMs in a CICS environment

The options in a JVM profile are used by CICS, the IBM 64-bit SDK for z/OS, Java Technology Edition, or z/OS UNIX System Services, to start JVMs.

When you specify the options, make sure that you follow the coding rules that are described in "Rules for coding JVM profiles" on page 99. The format of options can vary:

- Some options in a JVM profile take the form of a keyword and value separated by an = sign, for example `LEHEAPSTATS=NO`.
- Some options are specified with the option immediately followed by the value, with no = sign, for example `-Xms16M`.
- Any option that begins with a hyphen (-) is either a Java standard option or a Java nonstandard option, and is passed to the JVM without any parsing by CICS.
- You can specify any z/OS UNIX System Services environment variables in a JVM profile. Any name and value pair in a JVM profile that is not recognized as a JVM option or system property is treated as a z/OS UNIX System Services environment variable and is exported.
- You can specify JVM system properties, which begin with -D, in a JVM profile. They are listed separately in "JVM system properties" on page 109.

For information about the **`-Xmso`**, **`-Xiss`**, and **`-Xss`** JVM options and all the default values, see the reference information at Default settings for the JVM.

Profile symbols

The following symbols can be used in the values of options in a JVM profile, as demonstrated in the sample JVM profiles.

`&APPLID;`
When you use this symbol, the APPLID of the CICS region is substituted at run time. In this way, you can use the same profile or properties file for all regions, and still have region-specific working directories or output destinations. The APPLID is always in uppercase. You can use the symbol on the `WORK_DIR`, `STDOUT`, `STDERR`, and `JAVA_DUMP_TDUMP_PATTERN` options.

&DATE;
When you use this symbol, the symbol is replaced with the current date in the format *Dyymmdd* at run time. You can specify the &DATE; symbol for any type of output from the JVM, including the `WORK_DIR`, `STDOUT`, `STDERR`, and `JAVA_DUMP_TDUMP_PATTERN` options.

&JVM_NUM;
When you use this symbol, the unique number of the pooled JVM is substituted at run time. Use this symbol to create unique output or dump files for each JVM. You can use the symbol on the `WORK_DIR`, STDOUT, `STDERR`, and `JAVA_DUMP_TDUMP_PATTERN` options. CICS might modify the JVM number to conform to MVS data set naming standards for the TDUMPs.

This symbol does not apply to JVM servers.

&JVMSERVER;
When you use this symbol, the name of JVMSERVER resource is substituted at run time. Use this symbol to create unique output or dump files for each JVM server.

This symbol does not apply to pooled JVMs.

&TIME;
When you use this symbol, the symbol is replaced with the current time in the format *Thhmmss* at run time. You can specify the &TIME; symbol for any type of output from the JVM including the `WORK_DIR`, `STDOUT`, `STDERR`, and `JAVA_DUMP_TDUMP_PATTERN` options.

List of JVM options

In the list of options that follows, all options apply to both JVM servers and pooled JVMs unless explicitly stated. Any default value indicated for an option is the value that CICS uses when the option is not specified in a JVM profile. Some or all of the sample JVM profiles might specify a value that is different from the default value.

CLASSCACHE={YES,NO}
Specifies whether this JVM is to use the shared class cache. The default value is NO.

This option does not apply to JVM servers.

CLASSPATH_PREFIX, CLASSPATH_SUFFIX=*class_pathnames*
The standard class path specifies directory paths, Java archive files, and compressed files to be searched by a pooled JVM for application classes and resources. You can specify entries on separate lines by using a \ (backslash) at the end of each line that is to be continued.

CLASSPATH_PREFIX adds class path entries to the beginning of the standard class path, and CLASSPATH_SUFFIX adds them to the end of the standard class path.

With Version 6.0.1 of the SDK, all application classes are placed on the standard class path. For pooled JVMs, all application classes are eligible to be loaded into the shared class cache.

Use the `CLASSPATH_PREFIX` option with care. Classes in `CLASSPATH_PREFIX` take precedence over classes of the same name supplied by CICS and the Java run time and the wrong classes might be loaded.

CICS builds a base class path for a JVM by using the `/lib` subdirectories of the directories specified by the **USSHOME** system initialization parameter and the

JAVA_HOME option in the JVM profile. This base class path contains the Java archive files supplied by CICS and by the JVM. It is not visible in the JVM profile. You do not specify these files again in the class paths in the JVM profile.

If you set either option in the profile of a JVM server, the OSGi framework does not start.

DISPLAY_JAVA_VERSION=
If this option is set to YES, whenever a JVM is started by an application CICS writes message DFHSJ0901 to the MSGUSER log, showing the version and build of the IBM Software Developer Kit for z/OS, Java Technology Edition that is in use.

GC_HEAP_THRESHOLD=
Specifies the heap utilization limit for the JVM heap. When this percentage of the storage in the active part of the heap is used, CICS schedules a garbage collection. CICS checks heap utilization after every Java program execution. If the limit is reached, the garbage collection transaction CJGC is scheduled to run in the JVM immediately after the current use of the JVM ends.

The default heap utilization limit is 85 (85%). The minimum is 50. The maximum if you want CICS to schedule garbage collections is 99. If you specify a heap utilization limit of 100, CICS never schedules garbage collections, and all garbage collections result from allocation failures while applications are running.

This option does not apply to JVM servers or a single-use pooled JVM.

IDLE_TIMEOUT={30|*number*}
Specifies the timeout threshold, in minutes, for pooled JVMs with this JVM profile. If a pooled JVM is inactive for the specified amount of time, it becomes eligible for automatic termination. The next time CICS checks on the idle JVMs, if the JVM is still inactive, the JVM and its J8 or J9 TCB might be destroyed. CICS does not immediately stop all the JVMs that have timed out; they are stopped progressively over time.

The default timeout threshold is 30 minutes, and the maximum is 10,080 minutes (seven days). You can also specify a timeout threshold of zero, so that JVMs with that profile are never stopped automatically because of inactivity. JVMs with a timeout threshold of zero might be stopped if they are selected for stealing or mismatching, or if MVS storage becomes constrained. If you specify an unacceptable value, CICS uses the default instead.

This option does not apply to JVM servers or to a single-use pooled JVM.

INVOKE_DFHJVMAT={NO|YES}
Specifies whether the user replaceable module, DFHJVMAT, is called before creating a JVM. DFHJVMAT can be used only for single-use pooled JVMs; that is, where the option REUSE=NO is specified in the JVM profile.

This option does not apply to JVM servers or to a continuous pooled JVM.

JAVA_DUMP_OPTS=
A z/OS UNIX System Services environment variable. Specifies a set of Java dump options that are used to obtain diagnostic information for an abend in the JVM. See the information about Java dump options in Dump agent environment variables.

JAVA_DUMP_TDUMP_PATTERN=
A z/OS UNIX System Services environment variable that specifies the file name to be used for transaction dumps (TDUMPs) from the JVM. Java

TDUMPs are written to a data set destination in the event of a JVM abend. You can use the symbols &APPLID; (CICS region APPLID) and &JVM_NUM; (unique JVM number) in this value, as shown in the supplied sample JVM profiles, to create unique dump file names for each JVM.

When you use the &JVM_NUM; symbol here, CICS might modify the JVM number to conform to MVS data set naming standards. The number is formatted as an 8-digit hexadecimal value. If the first character is numeric, it must be changed: 0 is changed to G, 1 is changed to H, and so on, through 9 which is changed to P.

`JAVA_HOME=/usr/lpp/java/J6.0.1_64/`
Specifies the installation location for IBM 64-bit SDK for z/OS, Java Technology Edition in z/OS UNIX. This location contains subdirectories and Java archive files required for Java support.

The supplied sample JVM profiles contain a path that was generated by the **JAVADIR** parameter in the DFHISTAR CICS installation job. The default for the **JAVADIR** parameter is `java/J6.0.1_64/`, which is the default installation location for the IBM 64-bit SDK for z/OS, Java Technology Edition. This value produces a `JAVA_HOME` setting in the JVM profiles of `/usr/lpp/java/J6.0.1_64/`.

`JAVA_PIPELINE={YES,NO}`
Adds the required Java archive files to the class path so that a JVM server can support web services processing in Java-based SOAP pipelines. The default value is NO. If you set this value, the JVM server is configured to support Axis2 instead of OSGi.

This option does not apply to pooled JVMs.

`JVMPROPS=`*`path/file_name`*
Specifies the path and name of an optional JVM properties file, which is a z/OS UNIX file that can be used to contain system properties for this JVM. For more information about what you can specify in a JVM properties file, see “JVM system properties” on page 109.

This option does not apply to JVM servers.

`JVMTRACE={`*`applid.jvmserver.`***`dfhjvmtrc|`***`file_name`***`}`**
Specifies the name of the z/OS UNIX file to which Java tracing is written during the startup and termination of a JVM server. If no value is specified, the trace is written to the file *`applid.jvmserver.`*`dfhjvmtrc`. CICS automatically creates unique output files for each JVM server using the &APPLID; and &JVMSERVER; symbols. This file is created in the directory specified by the `WORK_DIR` option.

This option does not apply to pooled JVMs.

`LEHEAPSTATS={YES|NO}`
Specifies whether statistics are to be collected for the amount of Language Environment heap storage that is used by the JVM. The default value is NO. The statistics are reported as the field "Peak Language Environment heap storage used" in the JVM Profile statistics. Collecting these statistics affects the performance of the JVM, so you must specify LEHEAPSTATS=YES only while you are tuning the heap sizes for your JVMs. For more information, see . In a production environment, specify LEHEAPSTATS=NO.

This option does not apply to JVM servers.

`LIBPATH_PREFIX, LIBPATH_SUFFIX=`*`pathnames`*
Specifies directory paths to be searched for native C dynamic link library

(DLL) files that are used by the JVM, and that have the extension `.so` in z/OS UNIX, including files required to run the JVM and additional native libraries loaded by application code or services.

The base library path for the JVM is built automatically using the directories specified by the **USSHOME** system initialization parameter and the `JAVA_HOME` option in the JVM profile. The base library path is not visible in the JVM profile. It includes all the DLL files required to run the JVM and the native libraries used by CICS.

You can extend the library path using the `LIBPATH_SUFFIX` option. This option adds directories to the end of the library path, after the base library path. Use this option to specify directories containing any additional native libraries that are used by your applications or by any services that are not included in the standard JVM setup for CICS. For example, the additional native libraries might include the DLL files that are required to use the DB2 JDBC drivers.

The `LIBPATH_PREFIX` option adds directories to the beginning of the library path, before the base library path. Use this option with care, because, if DLL files in the specified directories have the same name as DLL files on the base library path, they are loaded in place of the supplied files.

Any DLL files that you include on the library path for use by your applications must be compiled and linked with the XPLink option for optimum performance. The DLL files supplied on the base library path and the DLL files used by services such as the DB2 JDBC drivers are built with the XPLink option.

OSGI_BUNDLES=*pathnames*
Specifies the directory path for middleware bundles that are enabled in the OSGi framework of a JVM server. These OSGi bundles contain classes to implement system functions in the framework, such as connecting to WebSphere MQ. If you specify more than one OSGi bundle, use commas to separate them.

This option does not apply to pooled JVMs.

OSGI_FRAMEWORK_TIMEOUT=60|*number*
Specifies the number of seconds that CICS waits for the OSGi framework to initialize or shut down before timing out. You can set a value from 1 to 60000 seconds. The default value is 60 seconds. If the OSGi framework takes longer to start than the specified number of seconds, the JVM server fails to initialize and a DFHSJ0215 message is issued by CICS. Error messages are also written to the JVM server log files in zFS. If the OSGi framework takes longer to shut down than the specified number of seconds, the JVM server fails to shut down normally.

This option does not apply to pooled JVMs.

PRINT_JVM_OPTIONS={YES|NO}
If this option is set to YES, whenever a JVM is started all the options passed to the JVM at startup are printed to SYSPRINT. The output is produced every time a JVM is started with this option in its profile. You can use this option to check the contents of the class paths for a particular JVM profile, including the base library path and the base class path built by CICS, which are not visible in the JVM profile.

REUSE={YES|NO}
Specifies whether a pooled JVM is reusable or not reusable:

- REUSE=YES, which is the default, creates a JVM that is reused many times by Java applications. This type of pooled JVM is known as a continuous JVM.
- REUSE=NO creates a JVM that is not reused, but instead is destroyed after a single Java program has run in it. This type of pooled JVM is known as a single-use JVM.

This option does not apply to JVM servers.

STDERR={dfhjvmerr|*file_name*} [-generate]
Specifies the name of the z/OS UNIX file to be used for `stderr`. If the file does not exist, it is created in the directory specified by the `WORK_DIR` option. If the file exists, output is appended to the end of the file. When the JVM stops, if the `stderr` file is empty and it has been created for the specific JVM, it is deleted. Otherwise, the file is kept.

- For pooled JVMs, the default name is `dfhjvmerr`. For a fixed file name, the output from multiple JVMs is appended to the named file, and the output is interleaved. To create unique output files for each JVM, either use the &JVM_NUM; and &APPLID; symbols in your file name, as demonstrated in the sample JVM profiles, or specify the **-generate** option. The **-generate** option appends the unique JVM number, the APPLID of the CICS region, and additional identifying information to the file name. **-generate** must be preceded by one blank.
- For JVM servers, the file name is *applid.jvmserver.*`dfhjvmerr`. CICS automatically creates unique output files for each JVM server using the &APPLID; and &JVMSERVER; symbols.

If you specify the `USEROUTPUTCLASS` option on a JVM profile, the Java class named on that option handles the System.err requests instead. The z/OS UNIX file named by the `STDERR` option might still be used if the class named by the `USEROUTPUTCLASS` option cannot write data to its intended destination, as is the case when you use the supplied sample class com.ibm.cics.samples.SJMergedStream. You can also use the file if output is directed to it for any other reason by a class named by the `USEROUTPUTCLASS` option.

STDIN={dfhjvmin|*file_name*}
Specifies the name of the z/OS UNIX file to be used for `stdin`. If the file does not exist, it is created in the directory specified by the `WORK_DIR` option.

STDOUT={dfhjvmout|*file_name*} [-generate]
Specifies the name of the z/OS UNIX file that is to be used for output to the `stdout` file. If the file does not exist, it is created in the directory specified by the `WORK_DIR` option. If the file exists, output is appended to the end of the file. When the JVM stops, if the `stdout` file is empty and it has been generated for the specific JVM, it is deleted. Otherwise, the file is kept.

- For pooled JVMs, the default name is `dfhjvmout`. For a fixed file name, the output from multiple JVMs is appended to the named file, and the output is interleaved. To create unique output files for each JVM, either use the &JVM_NUM; and &APPLID; symbols in your file name, as demonstrated in the sample JVM profiles, or specify the **-generate** option.
- For JVM servers, the file name is *applid.jvmserver.*`dfhjvmout`. CICS automatically creates unique output files for each JVM server using the &APPLID; and &JVMSERVER; symbols.

If you specify the `USEROUTPUTCLASS` option in a JVM profile, the Java class named on that option handles the System.out requests instead. The z/OS UNIX file named by the `STDOUT` option might still be used if the class named by the USEROUTPUTCLASS option cannot write data to its intended destination; for example, when you use the sample class com.ibm.cics.samples.SJMergedStream. You can also use the file if output is directed to it for any other reason by a class named by the USEROUTPUTCLASS option.

USEROUTPUTCLASS={*classname*}
Specifies the fully qualified name of a Java class that intercepts the output from the JVM and messages from JVM internals. You can use this Java class to redirect the output and messages from your JVMs, and you can add time stamps and headers to the output records. If the Java class cannot write data to its intended destination, the files named in the STDOUT and STDERR options might still be used.

Specifying the USEROUTPUTCLASS option has a negative effect on the performance of JVMs. For best performance in a production environment, do not use this option. However, this option can be useful to application developers who are using the same CICS region because the JVM output can be directed to an identifiable destination.

For more information about this class and the supplied samples, see "Controlling the location for JVM stdout, stderr and dump output" on page 182.

WORK_DIR={.|*directory_name*}
Specifies the working directory on z/OS UNIX that the CICS region uses for Java-related activities. The CICS JVM interface uses this directory when creating the stdin , stdout, and stderr files. A period (.) is defined in the supplied JVM profiles, indicating that the home directory of the CICS region user ID (that is, the z/OS UNIX directory /u/*CICS region userid*) is to be used as the working directory. This directory can be created during CICS installation. If the CICS region user ID does not have this home directory, or if WORK_DIR is omitted, /tmp is used as the z/OS UNIX directory name.

Relative working subdirectory
For pooled JVMs only, you can create a relative subdirectory in this z/OS UNIX directory to hold the output files, by specifying the subdirectory name after the period. For example, if you specify:

```
WORK_DIR=./javaoutput
```

the output files from all the JVMs in that CICS region are created in the subdirectory javaoutput in the home directory of the CICS region user ID.

Absolute working directory
For pooled JVMs and JVM servers, you can specify an absolute path to the working directory. If you do not want to use the home directory as the working directory for Java-related activities, or if your CICS regions are sharing the same z/OS user identifier (UID) and so have the same home directory, you can create a different working directory for each CICS region. You specify a directory name that uses the &APPLID; symbol, for which CICS substitutes the actual CICS region APPLID. So you can have a unique working directory for each region, even if all the CICS regions share the same set of JVM profiles. For example, if you specify:

```
WORK_DIR=/u/&APPLID;/javaoutput
```

each CICS region using that JVM profile has its own working directory. Ensure that you have created all the relevant directories on z/OS UNIX and given the CICS regions read, write, and execute access to them.

You can also specify a fixed name for the working directory, again ensuring that you have created the relevant directory on z/OS UNIX and given the CICS regions the correct access. When you use a fixed name for the working directory, the output files from all the JVMs in the CICS regions that share the JVM profile are created in that directory. If you have also used fixed file names for your output files, the output from all the JVMs in those CICS regions is appended to the same z/OS UNIX files. To avoid appending to the same files, use the &JVM_NUM; symbol and the &APPLID; symbols with the appropriate JVM profile options to produce unique output and dump files for each JVM in each CICS region.

Do not define your working directories in the CICS directory on z/OS UNIX, which is the home directory for CICS files as defined by the **`USSHOME`** system initialization parameter.

You can also use the option `USEROUTPUTCLASS` to name a Java class that intercepts, redirects, and formats the `stderr` and `stdout` output from a JVM. The supplied sample classes for output redirection use the directory specified by `WORK_DIR` in some circumstances.

`-generate`

Specify this option to uniquely identify the `stdout` (JVM output) and `stderr` (JVM error messages) files on z/OS UNIX. This option must be specified on the `STDOUT` and `STDERR` options after the file name. For example, you can specify `STDOUT=dfhjvmout -generate`.

The **-generate** option appends the unique JVM number (as with the &JVM_NUM; symbol), the CICS region APPLID (as with the &APPLID; symbol), and some additional qualifiers, to the file name that you have specified for the `STDOUT` or `STDERR` option.

For example, a typical `stdout` file created with the **-generate** option might have the following name:

```
dfhjvmout.IYK2ZIK1.0067240142.06004165342.txt
```

where:

- `dfhjvmout` is the fixed part of the file name
- `IYK2ZIK1` is the APPLID of the CICS region
- `0067240142` is the unique JVM number
- `06004165342` is the time stamp showing when the JVM was created
- `.txt` is the file suffix

When you use the **-generate** option, the &APPLID; and &JVM_NUM; symbols are not required in the file name, because **-generate** supplies these pieces of information automatically.

Because the **-generate** option includes the JVM number, the resulting output file is unique to the JVM and can be matched with the JVM number identified from the **`INQUIRE JVM`** command. Because it includes the CICS region APPLID, it is also unique across multiple CICS regions.

This option does not apply to JVM servers.

-Xdebug
Specifies whether debugging support is to be enabled in the JVM.

For more information, see “Debugging a Java application” on page 190. See also the Java Platform Debugger Architecture (JPDA) information available at the Oracle Technology Network Java website.

To ensure a clean end to the debug session for pooled JVMs, specify REUSE=NO when debugging support is enabled.

-Xms
Specifies the initial size of the heap. Specify storage sizes in multiples of 1024 bytes. Use the letter K to indicate KB, the letter M to indicate MB, and the letter G to indicate GB. For example, to specify 6,291,456 bytes as the initial size of the heap, code **-Xms** in one of the following ways:

```
-Xms6144K
-Xms6M
```

Specify *size* as a number of KB or MB. For information about the default value, see Default settings for the JVM.

-Xmx
Specifies the maximum size of the heap. This fixed amount of storage is allocated by the JVM during JVM initialization.

Specify *size* as a number of KB or MB.

-Xshareclasses
Specify this option to enable class data sharing in a shared class cache. The JVM connects to an existing cache or creates a cache if one does not exist. You can have multiple caches and you can specify the correct cache by adding a suboption to the **-Xshareclasses** option. For details, see Class data sharing between JVMs.

This option does not apply to pooled JVMs.

JVM system properties

System properties contain information to configure the JVM and its environment. Some system properties are particularly relevant for JVMs in a CICS environment.

Specify JVM system properties in the JVM profile. For pooled JVMs, you can also set these options in a JVM properties file to share the same options between different profiles. To reference the file, use the JVMPROPS option in each JVM profile. CICS passes all the system properties in a JVM profile or JVM properties file to the JVM unchanged.

If you use JVM properties files, ensure that the files are secure, with update authority restricted to system administrators, if they are used to define sensitive JVM configuration options, such as the security policy file.

The JVM can support a much wider range of system properties than those documented here. “JVM profiles: options and samples” on page 96 lists some recommended sources of information about system properties.

The list below includes a selection of relevant system properties and describes how you can use them in a CICS environment. The system properties that begin with **-Dcom.ibm.cics** are specific to the IBM JVM in a CICS environment. Those that begin with **-Dcom.ibm** (without **.cics**) or with **-Djava** are used more widely. Specify each system property according to the coding rules described in “Rules for coding JVM profiles” on page 99.

-Dcom.ibm.cics.datasource.path=
Specifies the name and subContext of a CICS-compatible DataSource that you have deployed to generate JDBC connections for Java applications in CICS that access DB2. For more information, see Acquiring a connection using the DataSource interface in the DB2 Guide.

-Dcom.ibm.cics.ejs.nameserver=
Specifies the URL and TCP/IP port number of the name server that you use for JNDI references.

- For an LDAP name server, specify something like this:
  ```
  -Dcom.ibm.cics.ejs.nameserver=ldap://myldserv.example.com:389
  ```
  `myldserv.example.com` is the URL of the name server and `389` is the port number on which it is configured to listen. Your LDAP administrator can supply the correct URL and port number.
- For a standard COS Naming Directory Server, specify something like:
  ```
  -Dcom.ibm.cics.ejs.nameserver=iiop://mycsserv.example.com:900
  ```
  The relevant administrator in your organization can supply the correct name and port number.

  If you are using the COS Naming Directory Server supplied with WebSphere Application Server, specify something like this:
```
-Dcom.ibm.cics.ejs.nameserver=iiop://mycsserv.example.com:2809/domain/legacyRoot
```
  In WebSphere Application Server, the following conditions apply:
  - The default TCP/IP port used by the COS Naming Directory Server is 2809.
  - CICS objects must be published to a specially architected location in the WebSphere naming structure called `domain/legacyRoot`. CICS publishes objects to a context defined by the JNDIPREFIX option of the CORBASERVER definition, where the JNDI prefix is a relative path. If you do not specify the `/domain/legacyRoot` path from the root node of the name space, CICS tries to publish objects to the JNDI prefix location relative to the root node itself. With the COS Naming Directory Server supplied with WebSphere Application Server, this attempt fails.

If you are using a COS naming service, and you have chosen to specify it in **-Djava.naming.provider.url**, do not specify it again here.

-Dcom.ibm.cics.ejs.loadjndiproperties=
Sets up a file called `jndi.properties` to contain JNDI nameserver configuration properties that are common across a set of CICS regions. By default, CICS does not attempt to locate a `jndi.properties` file. Include the following system property to cause CICS to load `jndi.properties` for this JVM:
```
-Dcom.ibm.cics.ejs.loadjndiproperties=true
```
Place the directory containing the `jndi.properties` file on the standard class path in the JVM profile, in all the relevant JVM profiles, for all the regions that you want to share the same nameserver settings.

-Dcom.ibm.cics.iiop.CSIv2Enabled=true
Enables CICS support for the Common Secure Interoperability Version 2 (CSIv2) protocol for identity assertion. To activate this support, specify this

system property in all of the JVM profiles or JVM properties files used in the CICS region. This support is required if a CICS CorbaServer has to support asserted identity authentication for IIOP messages sent from WebSphere Application Server for z/OS.

`-Dcom.ibm.cics.soap.validation.local.CCSID=`
Specifies the local code page to use when validating SOAP messages if validation is enabled for a CICS WEBSERVICE resource. If you do not specify a local CCSID, the default USS code page for your installation is assumed when validating the SOAP message.

`-Dcom.ibm.websphere.naming.jndicache.cacheobject={populated |none}`
Turns the JNDI cache on or off. The JNDI cache stores the results of JNDI lookups in local storage, so that, if an application does the same lookup twice, perhaps in different tasks, the results are already available. The cache has the following characteristics:

- It is JVM-specific. That is, there is a separate cache for each JVM.
- It works only with an IBM JNDI name server.
- It stores only object references and not other things, such as DataSources.

populated
The JNDI cache is active.

none The JNDI cache is not used.

`-Dcom.ibm.websphere.naming.jndicache.maxcachelife={20 vmins}`
Specifies, in minutes, the "time to live" of the JNDI cache. If the cache is accessed after this time is exceeded, the entire cache is flushed of its contents.

See also the **-Dcom.ibm.websphere.naming.jndicache.cacheobject** property.

`-Dcom.ibm.ws.naming.ldap.containerdn=`
Specifies the Container Distinguished Name for the LDAP name server. For example:

```
-Dcom.ibm.ws.naming.ldap.containerdn=ibm-wsnTree=t1,o=WASNaming,c=us
```

Your LDAP administrator can supply the correct value for your installation.

The Container Distinguished Name is the root of the system name space.

This property is not required if you specify a COS naming service.

`-Dcom.ibm.ws.naming.ldap.noderootrdn=`
Specifies the Noderoot Relative Distinguished Name for the LDAP name server. For example:

```
-Dcom.ibm.ws.naming.ldap.noderootrdn=ibm-wsnName=legacyroot,
ibm-wsnName=PLEX2,ibm-wsnName=domainRoots
```

Your LDAP administrator can supply the correct value.

This property is not required if you specify a COS naming service.

`-Dfile.encoding=`
Specifies the encoding.

`-Djava.naming.security.authentication=`
Specifies the type of security authentication in use for naming operations. You might need this property if you are using an LDAP name server.

CICS must have write access into the LDAP name space. If the LDAP service is set up securely, the following three properties are required: authentication, credentials, and principal. If the LDAP service is set up so that any user can write to it, these three properties are not needed. Your LDAP administrator can tell you whether you need to include these properties in your JVM profile or optional JVM properties file.

The only value for this property that is supported by CICS is **simple**. Specifying **-Djava.naming.security.authentication=simple** indicates that the LDAP name server is running in secure mode.

Important:

If you do specify this property, you must also specify **-Djava.naming.security.principal** and **-Djava.naming.security.credentials**.

Because these properties specify the user ID and password that CICS requires to access the secure LDAP service, give particular attention to the file permissions controlling access to all the files containing these system properties.

-Djava.naming.security.credentials=
Specifies the password required for the **principal**, which is described in java.naming.security.principal, to access to the LDAP name server.

This property is required if you specified **-Djava.naming.security.authentication=simple**. Your LDAP administrator provides the value that you specify. For example:

```
-Djava.naming.security.credentials=secret
```

.

-Djava.naming.security.principal=
Specifies the **principal** required for access to the LDAP name server.

This property is required if you specified **-Djava.naming.security.authentication=simple**. Your LDAP administrator provides the value that you specify. For example, **-Djava.naming.security.principal=cn=CICSUser,c=uk** .

-Djava.security.manager={default| "" | |*other_security_manager*}
Specifies the Java security manager to be enabled for the JVM. To enable the default Java security manager, include this system property in one of the following formats:

- `-Djava.security.manager=default`
- `-Djava.security.manager=""`
- `-Djava.security.manager=`

All these statements enable the default security manager. If you do not include the **-Djava.security.manager** system property in your JVM profile, the JVM runs without Java security enabled. To disable Java security for a JVM, comment out this system property.

-Djava.security.policy=
Describes the location of additional policy files that you want the security manager to use to determine the security policy for the JVM. A default policy file is provided with the JVM in `/usr/lpp/java/J6.0.1_64/lib/security/java.policy`, where the `java/J6.0.1_64` subdirectory names are the default values when you install the IBM 64-bit SDK for z/OS, Java Technology Edition. The default security manager always uses this default policy file to determine the security policy for the JVM, and you can use the **-Djava.security.policy**

system property to specify any additional policy files that you want the security manager to take into account as well as the default policy file.

To enable CICS Java applications to run successfully when Java security is active, specify, as a minimum, an additional policy file that gives CICS the permissions it requires to run the application.

For information on enabling Java security, see “Enabling a Java security manager” on page 87.

-Djdbc.drivers=

Specifies one or more 64-bit JDBC drivers. Setting the driver names as a system property is an alternative to the Java application itself loading the drivers using the **Class.forName("driver_name");** command. Separate each driver name in a list by a : (colon).

To specify the DB2-supplied JDBC drivers, set the system property:

```
-Djdbc.drivers=com.ibm.db2os390.sqlj.jdbc.DB2SQLJDriver
```

This common name works for all levels of the JDBC driver supplied by DB2, including the DB2 Universal JDBC Driver.

You must use the 64-bit version of the JDBC drivers. For more information about JDBC, see Using JDBC and SQLJ to access DB2 data from Java programs in the DB2 Guide.

DFHJVMAX, JVM profile for the JVM server

The JVM profile DFHJVMAX is a CICS-supplied JVM profile that is used by an Axis2 JVM server. Make sure that DFHJVMAX is set up correctly for your CICS region.

JVM options in DFHJVMAX JVM profile

```
######################################################################
# JVM profile: DFHJVMAX                                              #
#                                                                    #
#   This sample CICS JVM profile is for an Axis2 JVM server.         #
#                                                                    #
######################################################################
#
#                          Symbol Substitution
#                          -------------------
#
# The following substitutions are supported:
#   &APPLID;     => The applid of the CICS region.
#   &JVMSERVER;  => The name of the JVMSERVER resource.
#   &DATE;       => Date the JVMSERVER is enabled.  Dyymmdd
#   &TIME;       => Time the JVMSERVER is enabled.  Thhmmss
#
# Using substitutions means that you can use the same profile
# for multiple regions and still have unique working directories
# and output destinations for each region.
#
# With this substitution
#     ENV_VAR=myvar.&APPLID;.&JVMSERVER;.data
# becomes
#     ENV_VAR=myvar.ABCDEF.JSERVER1.data
# for a JVMSERVER resource with the name JSERVER1 in a CICS region with
# applid ABCDEF.
#
#*********************************************************************
#
#                          Required parameters
#                          -------------------
```

```
#
# The set of supported CICS options for JVM servers
# differs from those used with JVM pools.
#
# JAVA_HOME specifies the location of the Java directory.
#
JAVA_HOME=/usr/lpp///&JAVA_HOME///
#
# Set the current working directory. If this environment variable is
# set, a change to the specified directory is issued before the JVM
# is initialized, and the STDIN, STDOUT and STDERR streams are
# allocated to this directory.
#
# If you do not specify this option, the current working directory is
# left unchanged and the STDIN, STDOUT and STDERR streams are allocated
# to the /tmp directory.
#
WORK_DIR=.
#
# Specify any directories that contain DLLs required at run time. For
# example, to use the IBM DB2 Driver for JDBC and SQLJ, add the
# directory containing the native DLLs to the LIBPATH_SUFFIX option.
# See the "Application Programming Guide and Reference for Java" relevant
# to the level of DB2 being used.
#
#LIBPATH_SUFFIX=
#
#*********************************************************************
#
#                    JVM server specific parameters
#                    ------------------------------
#
# Use the JAVA_PIPELINE option to configure the JVM Server
# to support Java-based SOAP pipelines.
#
JAVA_PIPELINE=YES
#
#*********************************************************************
#
#                         Output redirection
#                         ------------------
#
# STDOUT, STDERR, STDIN, and JVMTRACE are allocated with file names
# beginning with &APPLID;.&JVMSERVER;. You can specify different file
# names using the STDOUT, STDERR, STDIN, and JVMTRACE environment
# variables.
#
# The default file name for JVMTRACE is dfhjvmtrc.
# To send the output to somewhere other than a file, specify a user
# output redirection class. CICS provides a sample that demonstrates
# this capability. JVMTRACE cannot be redirected.
#
#USEROUTPUTCLASS=com.ibm.cics.samples.SJMergedStream
#
#*********************************************************************
#
#                             JVM options
#                             -----------
#
# See "IBM SDK for z/OS platforms, Java Technology Edition, SDK Guide"
# or "IBM Developer Kit and Runtime Environment, Java Technology
# Edition, Diagnostics Guide" for information on all JVM options.
#
# JVM options which print output and then exit must not be specified
# because they will cause the creation of the JVM to fail. These
# options include: -version, -help, -?, -assert and -X.
#
```

```
# Use the following options to tune the JVM.
# -Xms    Initial Java heap size, for example -Xms64M
# -Xmx    Maximum Java heap size, for example -Xmx512M
# -Xmso   Initial stack size for native threads (default -Xmso256KB)
# -Xiss   Initial stack size for Java threads (default -Xiss128KB)
# -Xss    Maximum stack size for Java threads (default -Xss256KB)
#
#
# Omit these values from the profile to accept the JVM defaults,
# unless you have performed workload analysis and can provide
# tuned values from a stable workload.
#
# The -Xgcthreads option sets the maximum number of helper threads
# allowed for garbage collection. If you do not specify this option,
# the default is set to (the number of CPUs - 1).
#
# -Xgcthreads4
#
# The following option sets the Garbage collection Policy.
#
-Xgcpolicy:gencon
#
#*********************************************************************
#
#                Setting user JVM system properties
#                ----------------------------------
#
# Specify JVM system properties for a JVM server if required.
# Properties are key name and value pairs that
# contain basic information about the JVM and its environment. They are
# always prefixed with -D. For example:
#
# -Dcom.ibm.cics.some.property=some_value
#
#*********************************************************************
#
#             Unix System Services Environment Variables
#             ------------------------------------------
#
# Java Dump Options. See "IBM Developer Kit and Runtime Environment,
# Java Technology Edition Diagnostics Guide" or "IBM SDK for z/OS
# platforms, Java Technology Edition, SDK Guide" for information on all
# Java runtime options.
#
JAVA_DUMP_OPTS="ONANYSIGNAL(JAVADUMP,SYSDUMP),ONINTERRUPT(NONE)"
#
# Specify where JVM dumps are written to
#
#JAVA_DUMP_TDUMP_PATTERN=DUMP.&APPLID;.&JVMSERVER;.&DATE;.&TIME;
#
# Specify the local time zone
#
#TZ=CET-1CEST,M3.5.0,M10.5.0
#
```

DFHOSGI, JVM profile for the JVM server

The JVM profile DFHOSGI is a CICS-supplied JVM profile that is used by an OSGi JVM server. Make sure that DFHOSGI is set up correctly for your CICS region.

JVM options in DFHOSGI JVM profile

```
######################################################################
# JVM profile: DFHOSGI                                               #
#                                                                    #
#   This sample CICS JVM profile is for a JVM server.                #
#                                                                    #
```

```
#######################################################################
#
#                          Symbol Substitution
#                          -------------------
#
# The following substitutions are supported:
#   &APPLID;     => The applid of the CICS region.
#   &JVMSERVER;  => The name of the JVMSERVER resource.
#   &DATE;       => Date the JVMSERVER is enabled.  Dyymmdd
#   &TIME;       => Time the JVMSERVER is enabled.  Thhmmss
#
# Using substitutions means that you can use the same profile
# for multiple regions and still have unique working directories
# and output destinations for each region.
#
# With this substitution
#     ENV_VAR=myvar.&APPLID;.&JVMSERVER;.data
# becomes
#     ENV_VAR=myvar.ABCDEF.JSERVER1.data
# for a JVMSERVER resource with the name JSERVER1 in a CICS region with
# applid ABCDEF.
#
# Note: The continuation character for use with JVMProfiles is '\'.
#*********************************************************************
#
#                          Required parameters
#                          -------------------
#
# The set of supported CICS options for JVM servers
# differs from those used with JVM pools.
#
# JAVA_HOME specifies the location of the Java directory.
#
JAVA_HOME=/usr/lpp///&JAVA_HOME///
#
# Set the current working directory. If this environment variable is
# set, a change to the specified directory is issued before the JVM
# is initialized, and the STDIN, STDOUT and STDERR streams are
# allocated to this directory.
#
# If you do not specify this option, the current working directory is
# left unchanged and the STDIN, STDOUT and STDERR streams are allocated
# to the /tmp directory.
#
WORK_DIR=.

# Specify any directories that contain DLLs required at run time. For
# example, to use the IBM DB2 Driver for JDBC and SQLJ, add the
# directory containing the native DLLs to the LIBPATH_SUFFIX option.
# See the "Application Programming Guide and Reference for Java" relevant
# to the level of DB2 being used.
#
#LIBPATH_SUFFIX=
#
#*********************************************************************
#
#                     JVM server specific parameters
#                     ------------------------------
#
# Use the OSGI_BUNDLES option to specify a list of middleware
# bundles that are installed and activated in the OSGi framework
# when the JVM is initialized.
# The list of bundles must be comma separated. The continuation
# character is '\'.
#
#OSGI_BUNDLES=/u/example/pathToBundleDirectory/B1.jar,\
#             /u/example/pathToBundleDirectory/B2.jar
```

```
#
# This option is used to specify, in seconds, how long the OSGi
# framework initialization, termination, and middleware bundles
# initialization are allowed to run before being timed out.
# The specified value must be in the range 1-60000. If it falls
# outside of this range then it will default to 60. If the
# initialization exceeds the limit, the JVMserver fails to initialize.
#
#OSGI_FRAMEWORK_TIMEOUT=60
#
#********************************************************************
#
#                          Output redirection
#                          ------------------
#
# STDOUT, STDERR, STDIN, and JVMTRACE are allocated with file names
# beginning with &APPLID;.&JVMSERVER;. You can specify different file
# names using the STDOUT, STDERR, STDIN, and JVMTRACE environment
# variables.
#
# The default file name for JVMTRACE is dfhjvmtrc.
# To send the output to somewhere other than a file, specify a user
# output redirection class. CICS provides a sample that demonstrates
# this capability. JVMTRACE cannot be redirected.
#
#USEROUTPUTCLASS=com.ibm.cics.samples.SJMergedStream
#
#********************************************************************
#
#                              JVM options
#                              -----------
#
# See "IBM SDK for z/OS platforms, Java Technology Edition, SDK Guide"
# or "IBM Developer Kit and Runtime Environment, Java Technology
# Edition, Diagnostics Guide" for information on all JVM options.
#
# JVM options which print output and then exit must not be specified
# because they will cause the creation of the JVM to fail. These
# options include: -version, -help, -?, -assert and -X.
#
# Use the following options to tune the JVM.
# -Xms    Initial Java heap size, for example -Xms64M
# -Xmx    Maximum Java heap size, for example -Xmx512M
# -Xmso   Initial stack size for native threads (default -Xmso256KB)
# -Xiss   Initial stack size for Java threads (default -Xiss128KB)
# -Xss    Maximum stack size for Java threads (default -Xss256KB)
#
# Omit these values from the profile to accept the JVM defaults,
# unless you have performed workload analysis and can provide
# tuned values from a stable workload.
#
# The -Xgcthreads option sets the maximum number of helper threads
# allowed for garbage collection. If you do not specify this option,
# the default is set to (the number of CPUs - 1).
#
# -Xgcthreads4
#
# The following option sets the Garbage collection Policy.
#
-Xgcpolicy:gencon
#
#********************************************************************
#
#                 Setting user JVM system properties
#                 ----------------------------------
#
# Specify JVM system properties for a JVM server if required.
# Properties are key name and value pairs that
# contain basic information about the JVM and its environment. They are
# always prefixed with -D. For example:
#
# -Dcom.ibm.cics.some.property=some_value
#
#*******************************************************************
#
#              Unix System Services Environment Variables
#              -----------------------------------------
#
# Java Dump Options. See "IBM Developer Kit and Runtime Environment,
# Java Technology Edition Diagnostics Guide" or "IBM SDK for z/OS
# platforms, Java Technology Edition, SDK Guide" for information on all
# Java runtime options.
#
JAVA_DUMP_OPTS="ONANYSIGNAL(JAVADUMP,SYSDUMP),ONINTERRUPT(NONE)"
#
# Specify where JVM dumps are written to
#
#JAVA_DUMP_TDUMP_PATTERN=DUMP.&APPLID;.&JVMSERVER;.&DATE;.&TIME;
#
# Specify the local time zone
#
#TZ=CET-1CEST,M3.5.0,M10.5.0
#
```

DFHJVMPR, JVM profile for a pooled JVM

The JVM profile DFHJVMPR is a sample JVM profile for pooled JVMs that use the shared class cache. The file is used as the default if you do not specify a JVM profile or a JVM server in the PROGRAM resource for the Java program.

JVM options in DFHJVMPR JVM profile

```
#############################################################
# JVMProfile: DFHJVMPR
#############################################################
#
# This is a sample CICS JVM Profile for JVMs that use the
# Shared Class Cache. This profile is the default profile
# for use with all CICS PROGRAMs defined with JVM(YES)
# unless specified otherwise.
#
######
#
# Symbol Substitution:
#
# If you use any of the following variable symbols in any of
# the variables below, they will be replaced with appropriate
# values. The variable symbols may be specified in upper or
# lower case.
#
#  Symbol       Replacement value
#  ------       -----------------
#
# &APPLID;      The APPLID of the CICS region
# &JVM_NUM;     The Unix Systems Services Process ID (pid)
#               of the JVM. This is guaranteed to be unique
# &DATE;        The current date in the format Dyymmdd
# &TIME;        The current time in the format Thhmmss
#
# With this substitution, for example
#      STDERR=dfhjvmerr.&APPLID;.&JVM_NUM;.&DATE;.&TIME;
# becomes
#      STDERR=dfhjvmerr.ABCDEF.0084214386.D081220.T135323
```

```
#
######
#
# ********* CICS-specific parameters ***********
#
JAVA_HOME=/usr/lpp/java/J6.0.1_64
WORK_DIR=.
REUSE=YES
CLASSCACHE=YES
#
# A JVM Properties file can optionally be used by supplying its
# full path and file name on the JVMPROPS option.
# See "Java Applications in CICS" for more information on JVM
# Properties Files.
#
# JVMPROPS=/u/example/pathToProperties/myJVMProps.data
#
STDIN=dfhjvmin
STDOUT=dfhjvmout
STDERR=dfhjvmerr
#
DISPLAY_JAVA_VERSION=NO
# Percentage of heap full which will trigger a scheduled GC
GC_HEAP_THRESHOLD=85
# Timeout value in minutes after which a JVM and its TCB become
# eligible for termination
IDLE_TIMEOUT=30
#
# Specify any directories containing DLLs needed at runtime.
# For example, to use the IBM DB2 Driver for JDBC and SQLJ,
# add the directory containing the native DLLs to the
# LIBPATH_SUFFIX. See the DB2 Application and Programming
# Guide for Java relevant to the level of DB2 being used.
#
#LIBPATH_PREFIX=
#LIBPATH_SUFFIX=
#
# Specify any directories containing application Java classes
# and jar files. (Uncomment the lines below if needed)
#
#CLASSPATH_SUFFIX=/u/example/pathToJarOrZipFile/jarfile.jar:\
#                 /u/example/pathToRootDirectoryForClasses
#
# Uncomment the line below to use the specified output redirection
# class.
#
#USEROUTPUTCLASS=com.ibm.cics.samples.SJMergedStream
#
######
#
# ********* Unix System Services Environment Variables ***********
#
# Java Dump Options. See "IBM Developer Kit and Runtime Environment,
# Java Technology Edition, Diagnostics Guide" for information on all
# Java runtime options.
JAVA_DUMP_OPTS="ONANYSIGNAL(JAVADUMP,CEEDUMP,SYSDUMP),ONINTERRUPT(NONE)"
#
# Specify where JVM dumps should be written to
#JAVA_DUMP_TDUMP_PATTERN=DUMP.JVM.TDUMP.&APPLID;.&JVM_NUM;.LATEST
#
# Specify the local timezone
#TZ=CET-1CEST,M3.5.0,M10.5.0
#
######
#
# ********* JVM options **************
#
```

```
-Xms16M
-Xmx16M
-Xmso128K
-Xiss64K
-Xss256K
```

DFHJVMCD, JVM profile reserved for CICS-supplied system programs

The JVM profile DFHJVMCD is a CICS-supplied JVM profile that is reserved for use by CICS-supplied system programs, in particular the default request processor program DFJIIRP, which is used by the CICS-supplied CIRP request processor transaction. CICS also uses DFHJVMCD to initialize and stop the shared class cache. Make sure that DFHJVMCD is set up correctly for your CICS region, but customize it only if required.

"Customizing DFHJVMCD" on page 89 has instructions for customizing the options in this JVM profile.

JVM options in DFHJVMCD JVM profile

```
#############################################################
# JVMProfile: DFHJVMCD
#############################################################
#
# This is the CICS JVM Profile for use by CICS programs.
# It must have a valid value for JAVA_HOME.
# It must always be available in the directory specified by
# the JVMPROFILEDIR SIT parameter.
#
######
#
# Symbol Substitution:
#
# If you use any of the following variable symbols in any of
# the variables below, they will be replaced with appropriate
# values. The variable symbols may be specified in upper or
# lower case.
#
#  Symbol       Replacement value
#  ------       -----------------
#
# &APPLID;      The APPLID of the CICS region
# &JVM_NUM;     The Unix Systems Services Process ID (pid)
#               of the JVM. This is guaranteed to be unique
# &DATE;        The current date in the format Dyymmdd
# &TIME;        The current time in the format Thhmmss
#
# With this substitution, for example
#     STDERR=dfhjvmerr.&APPLID;.&JVM_NUM;.&DATE;.&TIME;
# becomes
#     STDERR=dfhjvmerr.ABCDEF.0084214386.D081220.T135323
#
######
#
# ********* CICS-specific parameters ***********
#
JAVA_HOME=/usr/lpp/java/J6.0.1_64
WORK_DIR=.
REUSE=YES
CLASSCACHE=NO
#
STDIN=dfhjvmin
STDOUT=dfhjvmout
STDERR=dfhjvmerr
```

```
######
#
# ********* Unix System Services Environment Variables ***********
#
# Java Dump Options. See "IBM Developer Kit and Runtime Environment,
# Java Technology Edition, Diagnostics Guide" for information on all
# Java runtime options.
JAVA_DUMP_OPTS="ONANYSIGNAL(JAVADUMP,CEEDUMP,SYSDUMP),ONINTERRUPT(NONE)"
#
# Specify where JVM dumps should be written to
#JAVA_DUMP_TDUMP_PATTERN=DUMP.JVM.TDUMP.&APPLID;.%JVM_NUM;.LATEST
#
# Specify the local timezone
#TZ=CET-1CEST,M3.5.0,M10.5.0
#
######
#
# ********* JVM options **************
#
-Xms16M
-Xmx16M
-Xmso128K
-Xiss64K
-Xss256K
```

Chapter 6. Managing Java applications

After you have enabled your Java applications, you can monitor the CICS region to understand how the applications are performing. You can also tune the JVM and Language Environment enclave to optimize the performance of the application.

About this task

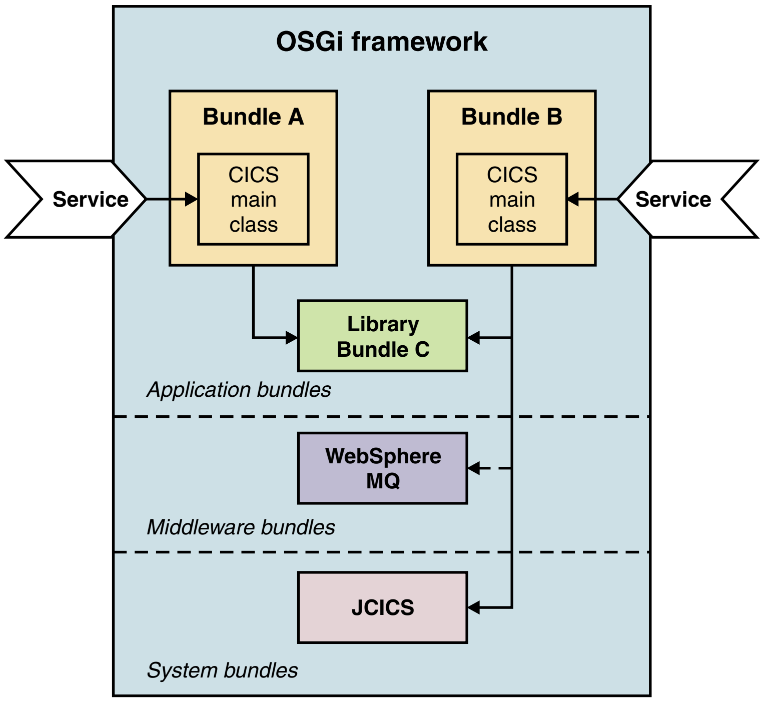
You can use statistics and monitoring to gather information about how the Java applications are performing in the CICS region. In particular, you can check how the JVMs are performing. After you gather the information, you can make changes to a JVM or a Language Environment enclave to improve performance. You can also disable or move applications between CICS regions to balance Java workloads more effectively.

Updating OSGi bundles in a JVM server

The process for updating OSGi bundles in the OSGi framework depends on the type of bundle and its dependencies. You can update OSGi bundles for applications without restarting the JVM server. However, updating a middleware bundle requires a restart of the JVM server.

About this task

In a typical JVM server, the OSGi framework contains a mixture of OSGi bundles as shown in the following diagram.



Bundle A and Bundle B are separate Java applications that are packaged as OSGi bundles in separate CICS bundles. Both applications have a dependency on a common library that is packaged in Bundle C. Bundle C is separately managed and updated. In addition, Bundle B has a dependency on a WebSphere MQ middleware bundle and the JCICS system bundle.

Bundle A and B can both be independently updated without affecting any of the other bundles in the framework. However, updating Bundle C can affect both the bundles that depend on it. Any exported packages in Bundle C remain in memory in the OSGi framework, so to pick up changes in Bundle C, Bundles A and B also have to be updated in the framework.

Middleware bundles contain framework services and are managed with the life cycle of the JVM server. For example, you might have native code that you want to load once in the framework or you might want to add a driver to access another product such as WebSphere MQ.

System bundles are provided by CICS to manage the interaction with the OSGi framework. These bundles are serviced by IBM as part of the product. An example of a system bundle is the `com.ibm.cics.server.jar` file, which provides most of the JCICS API to access CICS services.

Updating OSGi bundles

If a Java developer provides an updated version of a CICS bundle, you can either completely replace the CICS bundle or you can phase in a new version and then remove the old version.

Before you begin

An updated CICS bundle that contains the new version of an OSGi bundle must be present in zFS.

About this task

To phase in a new version and have both bundles running in the framework at the same time, the OSGi service must have an alias specified. If no alias is specified, the service is listed as inactive in the framework because it is considered a duplicate of the service that is already running.

Procedure

- To replace the existing OSGi bundle:
  1. Disable and discard the BUNDLE resource for the CICS bundle that you want to update. The OSGi bundles and services that are part of that CICS bundle are removed from the OSGi framework.
  2. Optional: Edit the BUNDLE resource definition if the updated CICS bundle is deployed in a different directory.
  3. Install the BUNDLE resource definition to pick up the changed OSGi bundle. The OSGi bundles and services in the CICS bundle are installed in the OSGi framework.
  4. Check the status of the OSGi bundles and services in the **Operations** > **Java** views in CICS Explorer.
- To create a new version of the OSGi bundle in the framework at the same time as the existing deployed bundle:

1. Create a BUNDLE resource to pick up the changed CICS bundle. The OSGi bundles and services in the CICS bundle are installed in the OSGi framework. The OSGi service is in the inactive state, unless an alias is specified in the bundle manifest.
2. Check the status of the OSGi bundles and services in the **Operations** > **Java** views in CICS Explorer. Two versions of the OSGi bundle are listed in the OSGi bundles view. The OSGi service for the bundle is in the inactive state, unless an alias is specified. If an alias is specified, both OSGi services are active.
3. Disable the BUNDLE resource that points to the old version of the OSGi bundle. CICS removes the OSGi service associated with the bundle and sets the OSGi bundle to the resolved state. As a result, the OSGi service for the changed OSGi bundle moves from inactive to active state.
4. If there is an alias for the OSGi service, you can specify the alias in a PROGRAM resource to call the updated application from outside the JVM server.

Results

The symbolic version of the OSGi bundle has increased, indicating that the Java code has been updated. The updated OSGi bundle is available in the OSGi framework and can be called from outside the JVM server.

Updating bundles that contain common libraries

OSGi bundles that contain common libraries for use by other OSGi bundles have to be updated in a specific order.

Before you begin

An updated CICS bundle that contains the new version of the OSGi bundle must be present in zFS. It is best practice to manage common libraries in a separate CICS bundle, so that you can manage the life cycle of these libraries separately from the applications that depend on them.

About this task

Typically an OSGi bundle specifies a range of supported versions in a dependency on another OSGi bundle. Using a range provides more flexibility to make compatible changes in the framework. When you are updating bundles that contain common libraries, the version number of the OSGi bundle increases. However, the running applications are already using a version of the bundle that satisfies the dependencies. To pick up the latest version of the library, you have to refresh the OSGi bundles for the applications. It is therefore possible to update specific applications to use different versions of the library and leave other applications running on an older version.

When you update an OSGi bundle that contains common libraries, you can completely replace the CICS bundle. However, if classes have not been loaded in the library, the dependent bundles might receive errors. You can phase in a new version of the library and run it in the framework alongside the original version. As long as the OSGi bundles have different version numbers, the OSGi framework can run both bundles concurrently.

Procedure

1. Create a BUNDLE resource that points to the new version of the OSGi bundle. CICS creates the new version of the OSGi bundle in the OSGi framework. The existing OSGi bundles continue to use the previous version of the library.
2. Check the OSGi Bundles view in the CICS Explorer. The list shows two entries for the same OSGi bundle symbolic name with different versions running in the framework.
3. To pick up the new version of the library in a dependent Java application:
   a. Disable and discard the BUNDLE resource for the Java application. Alternatively, you can get the Java developer to update the version information for the OSGi bundle and deploy a new version of the CICS bundle to maintain the availability of the application.
   b. Install the BUNDLE resource. When the OSGi bundle is loaded in the framework, it picks up the latest version of the common libraries.
4. Check the status of the BUNDLE resource in the Bundles view of the CICS Explorer.

Results

You have updated an OSGi bundle that contains common libraries and updated a Java application to use the latest version of the libraries.

Updating OSGi middleware bundles

If you want to update the middleware bundles that are running in an OSGi framework, you must stop and restart the JVM server.

About this task

OSGi middleware bundles are installed in the OSGi framework during the initialization of the JVM server. If you want to update a middleware bundle, for example to apply a patch or use a new version, you must stop and restart the JVM server to pick up the changed bundle.

Procedure

1. Ensure that the new version of the middleware bundle is in a directory on zFS to which CICS has read and execute access. CICS also requires read access to the files.
2. If the zFS directory or file name is different to the values specified in the JVM profile, edit the OSGI_BUNDLES option in the JVM profile for the JVM server. JVM profiles are in the zFS directory specified by the **JVMPROFILEDIR** system initialization parameter.
3. Disable the JVMSERVER resource to shut down the JVM server. Disabling the JVMSERVER also disables any BUNDLE resources that contain OSGi bundles that are installed in that JVM server.
4. Enable the JVMSERVER resource to start the JVM server with the updated JVM profile. The JVM server starts up and installs the new version of the middleware bundle in the OSGi framework. CICS also enables the BUNDLE resources that were disabled and installs the OSGi bundles and services in the updated framework.

Results

The OSGi framework contains the updated middleware bundles and the OSGi bundles and services for Java applications that were installed before you shut down the JVM server.

Removing OSGi bundles from a JVM server

If you want to remove OSGi bundles from the JVM server, use the CICS Explorer to disable and discard the BUNDLE resource.

About this task

The BUNDLE resource provides life-cycle management for the collection of OSGi bundles and OSGi services that are defined in the CICS bundle. Removing OSGi bundles from the OSGi framework does not automatically affect the state of other installed OSGi bundles and services. If you remove a bundle that is a prerequisite for another bundle, the state of the dependent bundle does not change until you explicitly refresh that bundle.

Procedure

1. Click **Operations** > **Java** > **OSGi Bundles** to find out which BUNDLE resource contains the OSGi bundle.
2. Click **Operations** > **Bundles** to disable the BUNDLE resource. CICS disables each resource that is defined in the CICS bundle. For OSGi bundles and services, CICS sends a request to the OSGi framework in the JVM server to unregister any OSGi services and moves the OSGi bundles into a resolved state. Any in-flight transactions complete, but any new links to the OSGi service from CICS applications return with an error.
3. Discard the BUNDLE resource. CICS sends a request to the OSGi framework to remove the OSGi bundles from the JVM server.

Results

You have removed the OSGi bundles and services from the OSGi framework.

What to do next

If you have PROGRAM resources pointing to OSGi services that are no longer in the OSGi framework, you might want to disable and discard the PROGRAM resources.

Moving applications to a JVM server

If you are running Java applications in pooled JVMs, you can move them to run in a JVM server. Because a JVM server can handle multiple requests for Java applications in the same JVM, you can reduce the number of JVMs that are required to run the same workload.

Before you begin

Ensure that the application is threadsafe and is packaged as one or more OSGi bundles. The OSGi bundles must be deployed in a CICS bundle to zFS and specify the correct target JVMSERVER resource.

The Java developer can use the CICS Explorer SDK to repackage a Java application using OSGi, as described in “Migrating applications using the CICS Explorer SDK” on page 42.

About this task

You can either use an existing JVM server or create a JVM server for your application. Do not move an application to a JVM server where the thread limit and usage are already high, because you might introduce locking contentions in the JVM server.

Procedure

1. Create or update a JVM server:
   - If you decide to create a JVM server, see “Setting up a JVM server” on page 81. Many of the settings in a JVM profile for a pooled JVM do not apply to JVM servers. The only option that you might want to copy from the pooled JVM profile to the DFHOSGI profile is the `LIBPATH_SUFFIX` option.
   - If you use an existing JVM server, you might have to increase the THREADLIMIT attribute on the JVMSERVER resource to handle the additional application or update the options in the JVM server profile. If you change the JVM profile, restart the JVM server to pick up the changes.
2. Create a BUNDLE resource that points to the deployed bundle in zFS. When you install the BUNDLE resource, CICS loads the OSGi bundles into the OSGi framework in the JVM server. The OSGi framework resolves the OSGi bundles and registers the OSGi services. Use the CICS Explorer to check that the BUNDLE resource is enabled. You can also use the OSGi Bundles and OSGi Services views to check the state of the OSGi bundles and services.
3. Update the PROGRAM resource for the application:
   a. Ensure that the EXECKEY attribute is set to CICS. All JVM server work runs in CICS key.
   b. Remove the JVM profile name and enter the name of the JVMSERVER resource.
   c. Ensure that the JVMCLASS attribute matches the OSGi service of the Java application.
   d. Reinstall the PROGRAM resource for the application.

   The PROGRAM resource uses the OSGi service to make an OSGi bundle available to other CICS applications outside the JVM server.

Results

When the Java application is called, it runs in the JVM server.

What to do next

You can use the JVM server view in the CICS Explorer and CICS statistics to monitor the JVM server. If the performance is not optimal, adjust the thread limit.

Managing the thread limit of JVM servers

JVM servers are limited in the number of threads that they can use to run Java applications. The CICS region also has a limit on the number of threads, because each thread uses a T8 TCB. You can adjust the thread limit using CICS statistics to balance the number of JVM servers in the region against the performance of the applications running in each JVM server.

About this task

Each JVM server can have a maximum of 256 threads to run Java applications. In a CICS region you can have a maximum of 1024 threads. If you have many JVM servers running in the CICS region, you cannot set the maximum value for every JVM server. If you set the maximum value on four JVM servers, you cannot enable any other JVMSERVER resources in the CICS region. You can adjust the thread limit of each JVM server to balance the number of JVM servers in the CICS region against the performance of the Java applications.

The thread limit is set on the JVMSERVER resource, so set an initial value and use CICS statistics to adjust the number of threads when you are testing your Java workloads.

Procedure

1. Enable the JVMSERVER resources and run your Java application workload.
2. Collect JVMSERVER resource statistics using an appropriate statistics interval. You can use the **Operations** > **Java** > **JVM Servers** view in CICS Explorer, or you can use the DFH0STAT statistics program.
3. Check how many times and how long a task waited for a thread. The “JVMSERVER thread limit waits” and “JVMSERVER thread limit wait time” fields contain this information.
   - If the values in these fields are high and many tasks are suspended with the JVMTHRD wait, the JVM server does not have enough threads available. Increasing the number of threads can increase the processor usage, so check you have enough MVS resource available.
   - If the values in these fields are low and the peak number of tasks is below the maximum number of threads available, you can free up threads for other JVM servers by reducing the thread limit.
4. To check the availability of MVS resource, use the dispatcher TCB pool and TCB mode statistics to assess the T8 TCB usage across the CICS region. Each thread in a JVM server uses a T8 TCB and you are limited to 1024 in a region. T8 TCBs cannot be shared between JVM servers, although all TCBs are in a THRD TCB pool. If the number of waiting TCBs and processor usage is low, it indicates there is enough MVS resource available.
5. To adjust the number of threads that can run in the JVM server, change the THREADLIMIT attribute on the JVMSERVER resource.
6. Run the Java application workload again and use the statistics to check that the number of waiting tasks has reduced.

What to do next

To tune the performance of your JVM servers, see “Improving JVM server performance” on page 156.

OSGi bundle recovery on a CICS restart

When you restart a CICS region that contains OSGi bundles, CICS recovers the BUNDLE resources and installs the OSGi bundles into the framework of the JVM server.

OSGi bundles that are packaged in CICS bundles are not stored in the CSD. The BUNDLE resource itself is stored in the catalog, so that on a restart of the CICS region, the OSGi bundles are dynamically re-created when the BUNDLE resource is restored.

On a cold, warm, or emergency restart of CICS, the JVM server is started asynchronously to BUNDLE resource recovery. The JVM server must be fully available to successfully restore an OSGi bundle on a CICS restart. Therefore, although the BUNDLE resources are recovered during the last phase of CICS startup, the OSGi bundles are installed only when the JVM server has completed its startup.

BUNDLE resources and the OSGi bundles that they contain are installed in the correct order to ensure that the dependencies between both CICS bundles and OSGi bundles are resolved in the framework. If CICS fails to install an OSGi bundle, the BUNDLE resource installs in a disabled state. You can use the IBM CICS Explorer to view the state of BUNDLE resources, OSGi bundles, and OSGi services.

Updating Java applications in pooled JVMs

If you change Java applications that run in pooled JVMs, you must stop and restart the JVMs that run those applications to load the changed resources. You also have to stop and restart the pooled JVMs if you make any changes to the resources or files on the class path.

Before you begin

The updated Java application must be compiled, packaged, and deployed to the z/OS UNIX file system.

About this task

You can add Java application classes to the class paths for a JVM, or you can change the names of files. When JVMs are running, they do not recognize changes to the JVM profiles, so you must stop and restart the JVM to pick up the changes to the application.

Procedure

1. Optional: Edit the JVM profile for the application to add the new or changed classes to the class path. If you have changed the contents of a class or JAR file but kept the same name you do not have to perform this step.
2. Restart the JVM to pick up the application changes. Phase out the JVM pool for each JVM profile that lists the changed file. Other JVMs that do not run this application can continue to run. If requests are waiting for JVMs with the profiles that you phased out, CICS starts new JVMs. The shared class cache updates automatically when the JVM loads the changed classes, so you do not have to restart it.

Results

CICS creates a pooled JVM using the updated version of the JVM profile and loads the new or changed classes.

Writing Java classes to redirect JVM stdout and stderr output

Use the `USEROUTPUTCLASS` option in a JVM profile to name a Java class that intercepts the stdout and stderr output from the JVM. You can update this class to specify your choice of time stamps and record headers, and to redirect the output.

CICS supplies sample Java classes, com.ibm.cics.samples.SJMergedStream and com.ibm.cics.samples.SJTaskStream, that you can use for this purpose. Sample source is provided for both these classes, in the directory `/usr/lpp/cicsts/cicsts42/samples/com.ibm.cics.samples`. The `/usr/lpp/cicsts/cicsts42` directory is the install directory for CICS files on z/OS UNIX. This directory is specified by the **`USSDIR`** parameter in the DFHISTAR install job. The sample classes are also shipped as a class file, `com.ibm.cics.samples.jar`, which is in the directory `/usr/lpp/cicsts/cicsts42/lib`. You can modify these classes, or write your own classes based on the samples.

"Controlling the location for JVM stdout, stderr and dump output" on page 182 has information about:
- The types of output from JVMs that are and are not intercepted by the class named by the `USEROUTPUTCLASS` option. The class that you use must be able to deal with all the types of output that it might intercept.
- The behavior of the supplied sample classes. The com.ibm.cics.samples.SJMergedStream class creates two merged log files for JVM output and for error messages, with a header on each record containing APPLID, date, time, transaction ID, task number, and program name. The log files are created using transient data queues, if they are available; or z/OS UNIX files, if the transient data queues are not available, or cannot be used by the Java application. The com.ibm.cics.samples.SJTaskStream class directs the output from a single task to z/OS UNIX files, adding time stamps and headers, to provide output streams that are specific to a single task.

For a pooled JVM to use an output redirection class that you have modified or written, the class must be present in a directory on an appropriate class path in the JVM profile or properties file. The directory containing the JAR file for the sample output redirection class is automatically included on an appropriate class path, and you do not need to specify it explicitly in the JVM profile. If you supply your own class, you must add the directory to the standard class path.

For a JVM server to use an output redirection class, you must create an OSGi bundle that contains your output redirection class. You must ensure that the bundle activator registers an instance of your class as a service in the framework and sets the property `com.ibm.cics.server.outputredirectionplugin.name=`*`class_name`*. You can use the constant `com.ibm.cics.server.Constants.CICS_USER_OUTPUT_CLASSNAME_PROPERTY` to get the property name. The following code excerpt shows how you might register your service in the bundle activator:

```
Properties serviceProperties = new Properties();
    serviceProperties.put(Constants.CICS_USER_OUTPUT_CLASSNAME_PROPERTY, MyOwnStreamPlugin.class.getName());
    context.registerService(OutputRedirectionPlugin.class.getName(), new MyOwnStreamPlugin(), serviceProperties);
```

| You can either add the OSGi bundle to the `OSGI_BUNDLES` option in the JVM profile
| or ensure that the bundle is installed in the framework when the first task is run.
| Whichever method you use, you must still specify the class in the `USEROUTPUTCLASS`
| option.

If you decide to write your own classes, you need to know about:

- The OutputRedirectionPlugin interface
- Possible destinations for output
- Handling output redirection errors and internal errors

The output redirection interface

CICS supplies an interface called com.ibm.cics.server.OutputRedirectionPlugin in `com.ibm.cics.server.jar`, which can be implemented by classes that intercept the stdout and stderr output from the JVM. The supplied samples implement this interface.

The following sample classes are provided:

- A superclass com.ibm.cics.samples.SJStream that implements this interface
- The subclasses com.ibm.cics.samples.SJMergedStream and com.ibm.cics.samples.SJTaskStream, which are the classes named in the JVM profile

Like the sample classes, ensure that your class implements the interface OutputRedirectionPlugin directly, or extends a class that implements the interface. You can either inherit from the superclass com.ibm.cics.samples.SJStream, or implement a class structure with the same interface. Using either method, your class must extend java.io.OutputStream.

The initRedirect() method receives a set of parameters that are used by the output redirection class or classes. The following code shows the interface:

```
package com.ibm.cics.server;

import java.io.*;

public interface OutputRedirectionPlugin {

  public boolean initRedirect( String inDest,
                               PrintStream inPS,
                               String inApplid,
                               String inProgramName,
                               Integer inTaskNumber,
                               String inTransid
                              );
  }
```

The superclass com.ibm.cics.samples.SJStream contains the common components of com.ibm.cics.samples.SJMergedStream and com.ibm.cics.samples.SJTaskStream. It contains an initRedirect() method that returns `false`, which effectively disables output redirection unless this method is overridden by another method in a subclass. It does not implement a writeRecord() method, and such a method must be provided by any subclass to control the output redirection process. You can use this method in your own class structure. The initialization of output redirection can also be performed using a constructor, rather than the initRedirect() method.

The **`inPS`** parameter contains either the original System.out print stream or the original System.err print stream of the JVM. You can write logging to either of these underlying logging destinations. You must not call the close() method on either of these print streams because they remain closed permanently and are not available for further use.

Possible destinations for output

The CICS-supplied sample classes direct output from JVMs to a directory that is specific to a CICS region; the directory name is created using the applid associated with the CICS region. When you write your own classes, if you prefer, you can send output from several CICS regions to the same z/OS UNIX directory or file.

For example, you might want to create a single file containing the output associated with a particular application that runs in several different CICS regions.

Java applications executing on threads other than the initial process thread (IPT) are not able to make CICS requests. For these applications, the output from the JVM is intercepted by the class you have specified for USEROUTPUTCLASS, but it cannot be redirected using CICS facilities (such as transient data queues). You can direct output from these applications to z/OS UNIX files, as the supplied sample classes do. For Java applications that are executing on the IPT, you can use CICS facilities, such as transient data queues, to redirect the output.

Handling output redirection errors and internal errors

If your classes use CICS facilities to redirect output, they should include appropriate exception handling to deal with errors in using these facilities.

For example, if you are writing to the transient data queues CSJO and CSJE, and using the CICS-supplied definitions for these queues, the following exceptions might be thrown by TDQ.writeData:
- IOErrorException
- LengthErrorException
- NoSpaceException
- NotOpenException

If your classes direct output to z/OS UNIX files, they should include appropriate exception handling to deal with errors that occur when writing to z/OS UNIX. The most common cause of these errors is a security exception.

The Java programs that will run in JVMs that name your classes on the USEROUTPUTCLASS options should include appropriate exception handling to deal with any exceptions that might be thrown by your classes. The CICS-supplied sample classes handle exceptions internally, by using a Try/Catch block to catch all throwable exceptions, and then writing one or more error messages to report the problem. When an error is detected while redirecting an output message, these error messages are written to `System.err`, making them available for redirection. However, if an error is found while redirecting an error message, then the messages which report this problem are written to the file indicated by the STDERR option in the JVM profile used by the JVM that is servicing the request. Because the sample classes trap all errors in this way, this means that the calling programs do not need to handle any exceptions thrown by the output redirection class. You can use this method to avoid making changes to your calling programs. Be careful that you do not send the output redirection class into a loop by attempting to redirect the error message issued by the class to the destination which has failed.

Managing pooled JVMs

CICS performs many tasks to manage pooled JVMs, including creating and reusing JVMs. You can monitor pooled JVMs and the shared class cache, and adjust the Java environment to optimize performance.

You can start and stop JVMs in the JVM pool or disable the pool in the CICS region. You can also adjust the options in the JVM profiles, for example changing the timeout threshold to determine how long CICS waits before removing inactive JVMs from the pool.

CICS provides statistics and monitoring information about how pooled JVMs perform in the CICS region. You can use this information to help you tune the Java environment to optimize performance. For more information about achieving optimum performance, see Chapter 7, "Improving Java performance," on page 151.

How CICS allocates pooled JVMs to applications

When an application runs a Java program that runs using a pooled JVM, CICS first tries to find a suitable JVM that is available for reuse in the JVM pool. If a suitable JVM, with the correct JVM profile and execution key, is not available, CICS either creates a new JVM if possible, or uses its selection mechanism to decide on an alternative course of action.

An application can reuse an available pooled JVM if the JVM was created using the JVM profile and the execution key (USER or CICS) that are specified in the PROGRAM resource for the Java program. If a suitable JVM is available, CICS assigns the JVM to the request.

If a suitable JVM, with the correct JVM profile and execution key, is not available, and the limit set by the **MAXJVMTCBS** system initialization parameter has not yet been reached, and MVS storage is not severely constrained, CICS creates a new JVM for the Java program. The new JVM has the correct profile and execution key for the program.

If CICS cannot find a suitable JVM, and a new JVM cannot be created because the **MAXJVMTCBS** limit has been reached, or because MVS storage is severely constrained and CICS is acting as though the **MAXJVMTCBS** limit had been reached, then CICS must decide on the best way to provide the application with a JVM. This involves assessing the need of the application for a JVM, against the need for different types of JVM in the CICS region. CICS can fulfil an application's request for a JVM in one of the following ways:

- Taking a free JVM that has the right execution key but the wrong profile for the request, destroying the JVM, and re-creating the JVM on the TCB of the old JVM, with the correct profile. This is called a *mismatch*.
- Destroying a free JVM and its TCB that are in the wrong execution key, and replacing it with a JVM and TCB in the correct execution key. This situation is known as a *steal*, or *stealing*, as the TCB has been "stolen" from one TCB mode (J8 or J9) to another TCB mode.

Both a mismatch and a steal are expensive, so before taking one of these courses of action, CICS tries to decide if it is worthwhile. In terms of the need for different types of JVM in the CICS region, it might be more economical for overall system performance for CICS to make the application wait until a suitable JVM is available, and to keep the free JVMs for requests that can benefit more from them. CICS has a selection mechanism to make this decision.

Figure 4 shows this process happening.

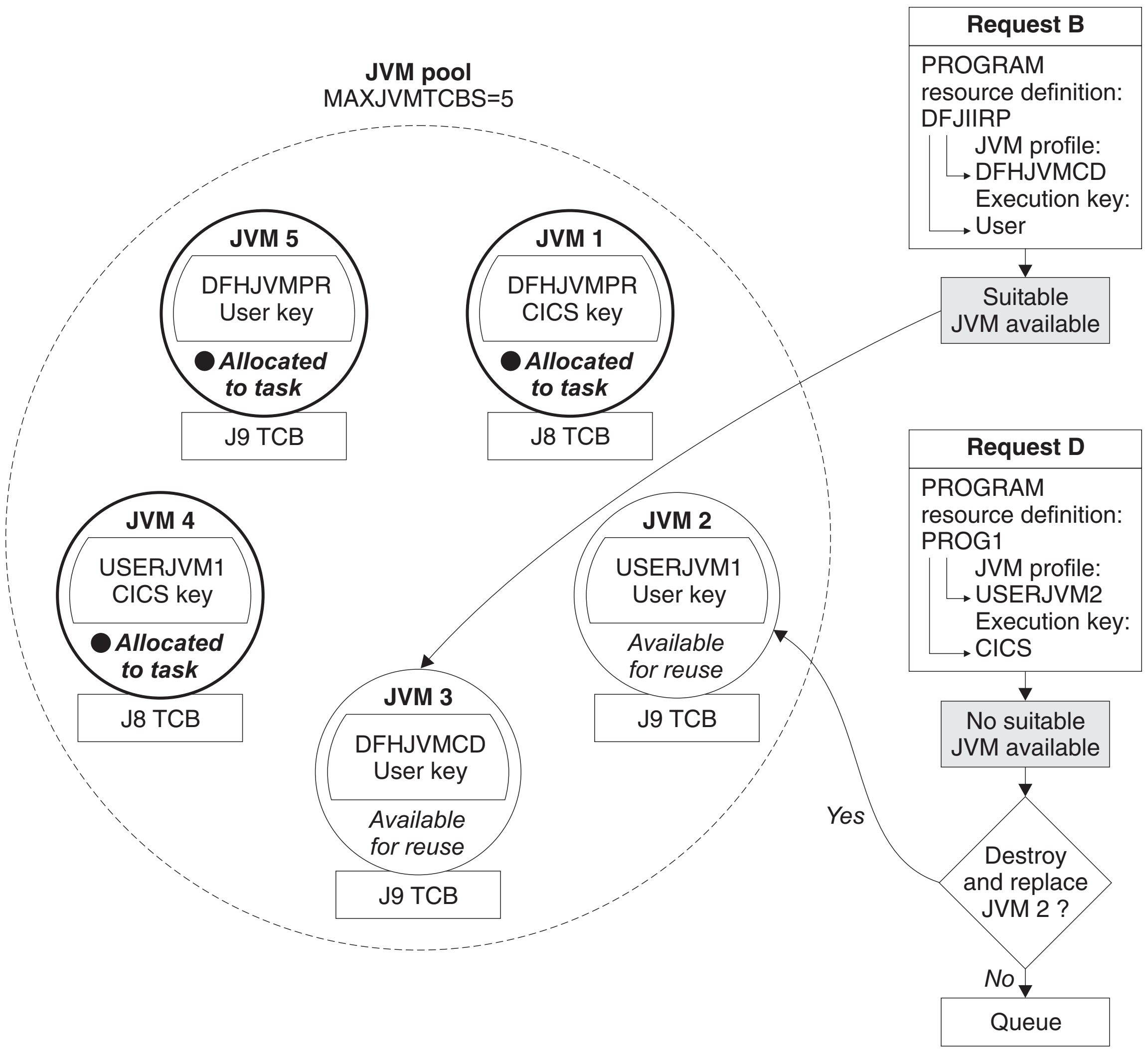


Figure 4. Dealing with requests for JVMs: example

Request B specifies the PROGRAM resource definition for the default request processor program DFJIIRP, which names the JVM profile DFHJVMCD, and the execution key USER. CICS checks the JVM pool and finds that JVM 3 has the correct JVM profile and execution key to match the request, and it is available for reuse. CICS assigns JVM 3 to Request B.

Request D specifies the PROGRAM resource definition for PROG1, which names the JVM profile USERJVM2, and the execution key CICS. CICS checks the JVM pool. There is a free JVM, JVM 2, but it has the wrong profile and execution key for Request D. As the **MAXJVMTCBS** limit has been reached, CICS cannot create a new JVM for Request D. So CICS must use the selection mechanism to decide if it should destroy JVM 2 and its TCB, and replace it with a JVM and TCB that matches Request D; or if it should make Request D wait, and keep JVM 2 for a request that can benefit more from it. If Request D is made to wait, it is queued along with any other requests that are waiting for a JVM.

CICS makes its decision to assign a JVM to an application in two stages:

- It takes one set of actions to deal with incoming requests for a JVM

- It takes another set of actions when it has a queue of requests waiting for a JVM.

How CICS deals with incoming requests for a JVM

To deal with incoming requests for a JVM, CICS takes the actions summarized here.

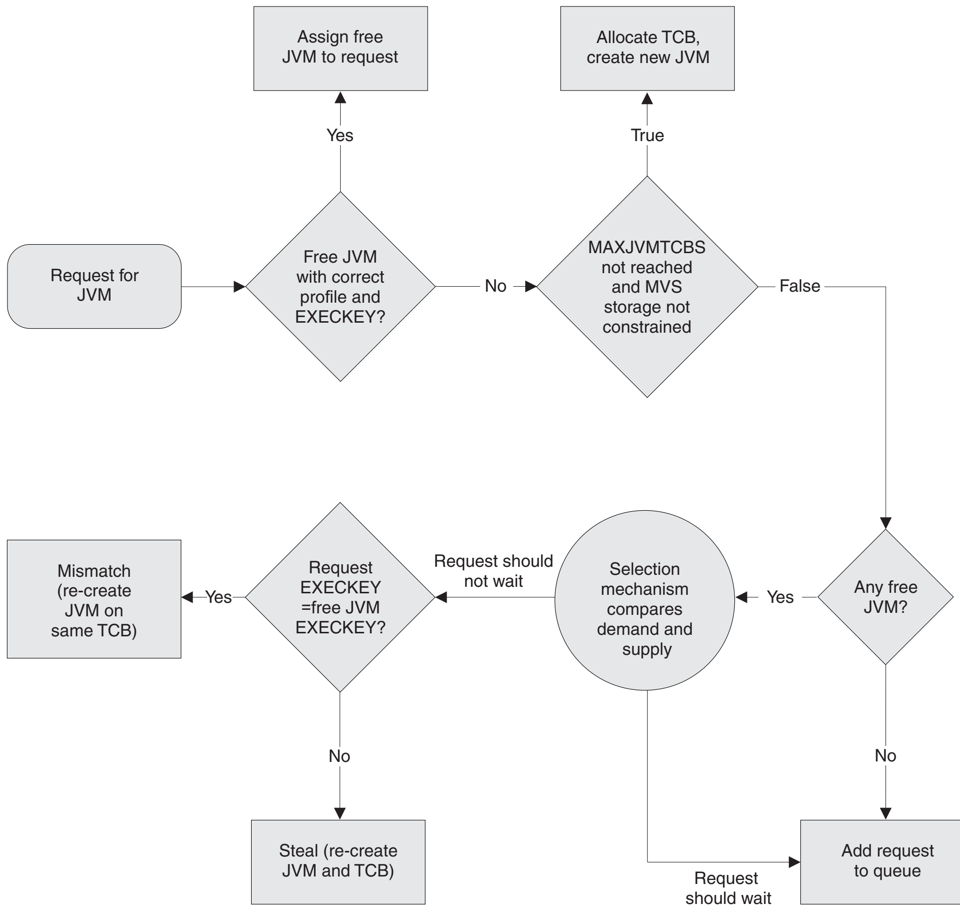

Assign free JVM to request
Allocate TCB, create new JVM
Yes
True
Request for JVM
Free JVM with correct profile and EXECKEY?
No
MAXJVMTCBS not reached and MVS storage not constrained
False
Mismatch (re-create JVM on same TCB)
Yes
Request EXECKEY =free JVM EXECKEY?
Request should not wait
Selection mechanism compares demand and supply
Yes
Any free JVM?
No
No
Steal (re-create JVM and TCB)
Request should wait
Add request to queue

Figure 5. Dealing with incoming requests for JVMs

1. When CICS receives a request for a JVM, and a JVM of the correct profile and execution key is free, CICS assigns the JVM to the incoming request.
2. If CICS receives a request for a JVM when either:
   - there are no free JVMs
   - there are free JVMs, but they are not of the correct profile and execution key for the request

   and CICS **is** able to create more JVMs (because the **MAXJVMTCBS** limit has not been reached and MVS storage is not severely constrained), then a TCB is allocated and a new JVM is created for the request.
3. If CICS receives a request when there are free JVMs, but they are not of the correct profile and execution key, and CICS is **not** able to create more JVMs (because the **MAXJVMTCBS** limit has been reached or MVS storage is severely constrained), the selection mechanism is used. The selection mechanism decides whether the request should wait for a suitable JVM, or whether it should receive one of the free JVMs.

   a. If the request receives one of the free JVMs, there will be either a mismatch or a steal, and the JVM and possibly the TCB will need to be re-initialized, so the selection mechanism avoids this where it makes sense to do so. If the selection mechanism does decide that the request should receive one of the free JVMs, CICS checks whether the execution key specified by the request matches the execution key of the JVM. If the execution key does not match, the JVM and its TCB are destroyed and reinitialized (a steal). If the execution key does match, and only the JVM profile is incorrect, the JVM is reinitialized on the same TCB (a mismatch).
   b. If the selection mechanism decides that the request should wait rather than receiving one of the free JVMs, the request is placed on the queue to wait for a suitable JVM to become free.
4. If CICS receives a request when there are no free JVMs, and CICS **is not** able to create more JVMs (because the **MAXJVMTCBS** limit has been reached or MVS storage is severely constrained), the request is placed on the queue to wait for a JVM to become free.

How CICS deals with a queue of requests waiting for a JVM

When CICS has a queue of requests waiting for a JVM, it takes these actions.

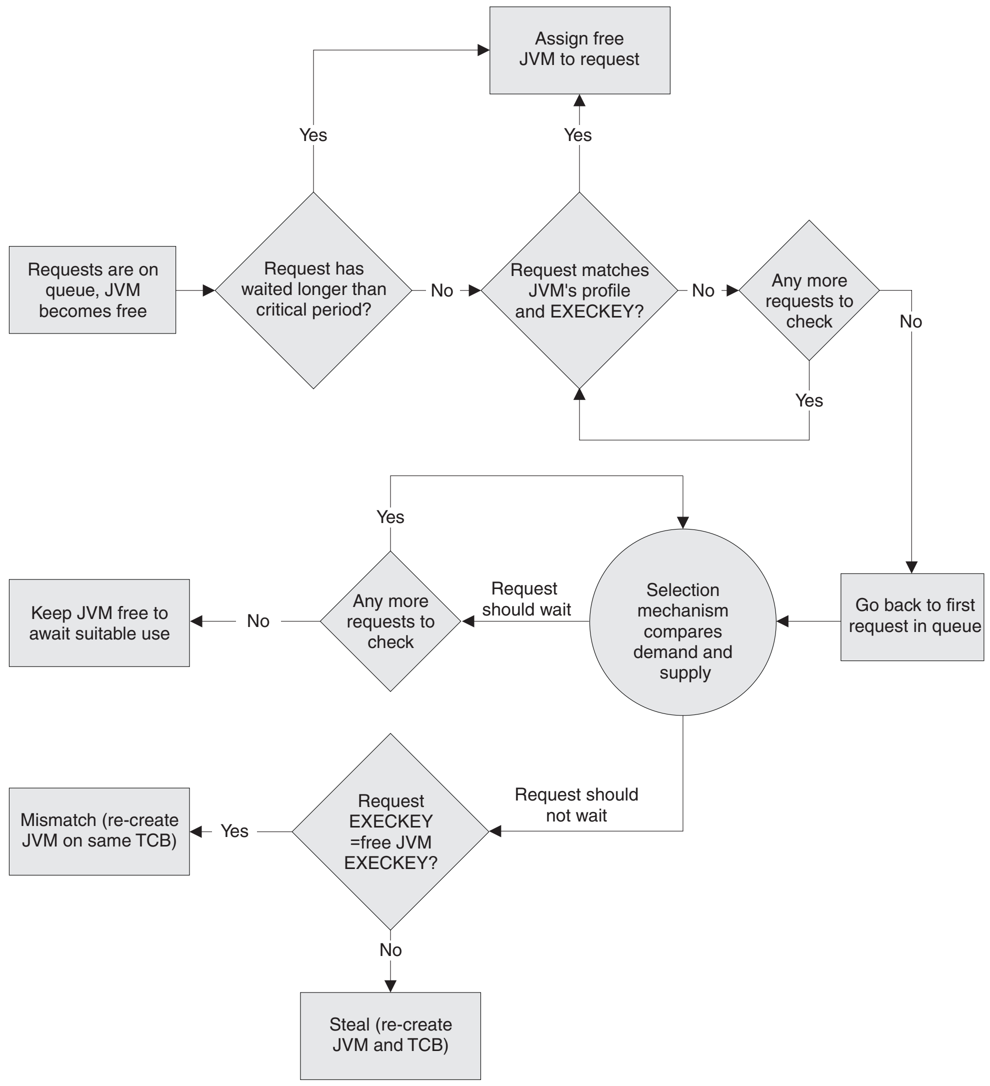

Assign free JVM to request
Yes
Yes
Requests are on queue, JVM becomes free
Request has waited longer than critical period?
No
Request matches JVM's profile and EXECKEY?
No
Any more requests to check
No
Yes
Yes
Keep JVM free to await suitable use
No
Any more requests to check
Request should wait
Selection mechanism compares demand and supply
Go back to first request in queue
Mismatch (re-create JVM on same TCB)
Yes
Request EXECKEY =free JVM EXECKEY?
Request should not wait
No
Steal (re-create JVM and TCB)

Figure 6. Dealing with a queue of requests waiting for a JVM

1. If any request that is waiting for a JVM to become free has been waiting longer than a critical period (which CICS determines), CICS gives it the next available JVM, whatever the profile and execution key of the JVM. This applies both to requests that have been placed on the queue because no JVMs are free, and requests that have been placed on the queue because the free JVMs have the wrong profile or execution key. There will be either a mismatch or a steal, and the JVM and possibly the TCB are likely to be re-initialized (unless the request is in a queue and the next free JVM happens to have the correct profile and execution key), but the action is worth taking, as the request should not wait any longer.
2. If requests are queueing and a JVM becomes free, but no requests have been waiting longer than the critical period, CICS scans through the queue to find the longest-waiting request that requires a JVM with that profile and execution key. It gives the free JVM to the longest-waiting request that specifies the

correct profile and execution key. So in this situation, the JVM does not need to be re-initialized, and a mismatch or steal is avoided.

3. If CICS cannot find a request that matches the profile and execution key of the free JVM, it scans through the queue again and uses the selection mechanism to look for a request where it will be an advantage to destroy and re-initialize the free JVM, and re-initialize it as a JVM with the profile and execution key that the request needs. A mismatch or a steal occurs, but the selection mechanism ensures that it occurs for a deserving request.
4. If CICS does not find a request in the queue where it will be an advantage to destroy and re-initialize the free JVM, the JVM is kept free to await a more appropriate use. For example, CICS might receive a request that needs a JVM with the profile and execution key of the free JVM; or the first request in the queue might wait longer than the critical period, and so be given the free JVM; or CICS might receive a request where it is an advantage to destroy and re-initialize the free JVM.

The selection mechanism

The selection mechanism is used when CICS needs to know if an incoming request should wait for a more suitable JVM, or when CICS has a queue of requests that do not match a free JVM, and needs to know if one of them deserves to take, destroy and re-initialize the JVM.

In these situations, the mechanism looks at the complete picture of the need for different types of JVM in the CICS region. It compares the demand for, and supply of, JVMs with each profile and execution key, by looking at:

- The historical data relating to recent requests for each type of JVM (the demand).
- The number of each type of JVM in the pool, and the time for which tasks kept these JVMs (the supply).

The selection mechanism uses this data to work out whether a given request should wait for a JVM of the correct profile and execution key, or whether it should be given a free JVM. The same answer is valid for a request that is waiting in a queue for a JVM to become free, or for a request that is made when there are free JVMs but they are not of the correct profile or execution key. In both cases, a request is made to wait if the data indicates that the demand for the type of JVM (that is, a JVM with that profile and execution key) which the request wants, is generally *lower* than the supply, and so it is not worth destroying and re-creating the free JVM as a JVM of that type. When the selection mechanism is examining a queue of requests, it continues down the queue until it reaches a request where the data indicates that the demand for the type of JVM that the request wants is generally *higher* than the supply. For this request, the selection mechanism decides that because JVMs of that type are needed in the CICS region, it is worth destroying and re-creating the free JVM as a JVM of that type, and assigns the free JVM to the request. If the free JVM had the wrong profile but the correct execution key, this is a mismatch, and the JVM is re-initialized. If the free JVM had the wrong execution key, this is a steal, and both the TCB and JVM are destroyed and re-created. So although the overhead of re-initializing the JVM, and if necessary re-creating the TCB, has still been incurred, the selection mechanism has ensured that the new JVM and TCB are of a type that is likely to be used in the future.

Under certain circumstances, there could be an unusually large number of requests for JVMs that have been waiting longer than the critical period. For example, this could happen when a system dump has just been taken, which delays all processing. In this case, rather than abandon matching and give each of the waiting requests the next available JVM, as would normally happen when a request has been waiting longer than the critical period, CICS temporarily increases the critical period value for the JVM pool. This enables it to perform matching for the waiting requests, and avoids incurring abnormal overhead. Once the situation has passed, CICS lowers the critical period value again.

Manually starting and terminating JVMs and disabling the JVM pool

CICS starts up JVMs in response to the requirements of applications, and reduces the number of available JVMs automatically if the workload does not require them. You can also control the JVM pool using CICS commands; you can start up and terminate JVMs, and disable the JVM pool temporarily. This manual control lets you implement changes to JVM profiles or suspend activity in the JVM pool. You can also use it to create JVMs in advance of application requests.

CICS normally manages the startup and termination of JVMs in order to achieve a balanced level of capacity in the JVM pool to meet the demand from applications. CICS has sophisticated mechanisms to manage the number and type of JVMs in the pool, particularly when there is a need to optimize the performance of complex workloads at times of peak demand.

You might want to start up or terminate JVMs manually in certain situations:

- You need to update JVMs if you make changes to your JVM profiles or JVM properties files while CICS is running, including adding new classes or JAR files to class paths.
- If your Java workload is regular, predictable, and involves a limited number of different JVM profiles, you could consider starting up JVMs in advance of the demand from applications, so that they are ready for use as soon as they are required.

Starting JVMs using CICS commands

To start up JVMs manually, use the **EXEC CICS** or **CEMT PERFORM JVMPOOL** command. You need to specify the number of JVMs to be started, and the JVM profile and execution key that is to be used for them.

The number that you specify, added to the number of JVMs that already exist in the JVM pool, must not exceed the **MAXJVMTCBS** limit for the CICS region. You can check this by issuing the **EXEC CICS** or **CEMT INQUIRE DISPATCHER** command. **MAXJVMTCBS** shows the limit, and ACTJVMTCBS shows the number of JVMs that currently exist.

CICS does not start all the JVMs at once, but schedules the starts over a short period of time. Each JVM is available for use by an application as soon as it has been started. If a JVM is not used by an application, then like any other idle JVM, it becomes eligible for automatic termination at the timeout threshold that you have specified in the JVM profile.

If you have just terminated JVMs in order to implement changes to JVM profiles, and application activity in the CICS region is low, you can use the **PERFORM JVMPOOL** command to start a JVM of the type where you applied the changes. This enables you to confirm, without waiting for an application request, that the JVM is able to start with the changed profile, and that the classes specified on your class paths can be loaded.

If the Java workload in your CICS region is regular and predictable, you might want to use the manual startup facility to create a JVM pool that anticipates the needs of your applications, rather than allowing CICS to do this in response to demand. This strategy might reduce the delay time for applications in periods when workload is increasing.

By configuring the timeout threshold (which defaults to 30 minutes), and starting up JVMs in advance of need, you could structure a JVM pool that always has enough capacity available for your requirements. For example, you could start up a sufficient number of JVMs to handle your peak workloads, with their timeout thresholds set so that they are only eligible for automatic termination after 24 hours of idleness. (You might want to set up a task that starts the appropriate number of JVMs when the CICS region is started.) With a JVM pool like this, CICS would not terminate the JVMs automatically at times of the day when the workload is reduced. They would only be terminated if the system was idle for an extended period, or if your workload reduced over the long term.

When you start up JVMs manually with a particular JVM profile, they are eligible for mismatching or stealing in the same way as JVMs started by CICS. Mismatching and stealing change the JVM profile or user key, so the JVM can no longer be used by the applications for which you originally started it up. Mismatching and stealing also involve restarting the JVM, which can negate any benefit you experience from starting the JVMs in advance. The possibility of mismatching and stealing increases with the number of different JVM profiles in the CICS region, so if you want to structure a JVM pool manually, the benefit is likely to be greatest if your applications use only one or a small number of JVM profiles.

Terminating JVMs

To terminate JVMs, use the CEMT or **EXEC CICS PERFORM JVMPOOL** command. You can choose to terminate all the JVMs in the JVM pool, or you can specify a JVM profile to terminate only the JVMs with that profile.

You need to terminate JVMs to implement changes to JVM profiles or to add new application classes. Changes to existing classes on the standard class path do not require termination of the JVMs. The standard class path, is the recommended choice for stand-alone JVMs, but if you are in the process of migrating from resettable to continuous JVMs, you might still have classes on the shareable application class path in stand-alone JVMs.

The **PERFORM JVMPOOL** command does not terminate the shared class cache. The shared class cache updates itself automatically when classes are changed or new classes are added, so you do not need to terminate it in this situation.

To minimize disruption to your applications, try to terminate only those JVM profiles where you have made changes to the JVM profile, its associated JVM properties file, or the applications that use it. Terminating a subset of the JVM pool is more efficient than terminating the whole JVM pool. Make sure that you do terminate all the JVMs affected by your changes. For example, a shared Java class which you have changed might be listed on the class path in more than one JVM profile. In certain unusual circumstances, an application class might be used by JVMs with more than one profile, but this might not be obvious from the JVM profiles. This might be an issue, for example, if you use custom classloaders, or instantiate classes through reflection, or have enterprise beans which call other enterprise beans. If you are not sure whether an application class is used by JVMs with more than one profile, you might prefer to be safe and terminate the whole JVM pool.

CICS starts up new JVMs as soon as it receives requests from applications for each type of JVM. If you prefer, you can start JVMs manually using the **PERFORM JVMPOOL** command. If you have made any changes to the JVM profiles, the new JVMs use the changed options. If you have made any changes to your Java applications, the new JVMs load the new or changed classes.

Disabling the JVM pool

To suspend all activity in the JVM pool, use the **EXEC CICS** or **CEMT SET JVMPOOL** command to set the status to DISABLED. In this state, the JVM pool cannot service new requests.

When you disable the JVM pool, the JVMs in it are retained, but new Java programs cannot use them until you enable the JVM pool again. Java programs that are already using a JVM are allowed to finish running. To re-enable the JVM pool, use the **EXEC CICS** or **CEMT SET JVMPOOL** command to set the status to ENABLED.

Starting the shared class cache

By default, the shared class cache starts automatically as soon as CICS receives a request to run a Java application in a pooled JVM whose profile requires the use of the shared class cache. If at any time you stop the shared class cache and want to restart it again, you can either enable autostart or use CICS commands.

About this task

The JVMCCSTART system initialization parameter controls the normal startup behavior of the shared class cache. The default setting is AUTO, where the shared class cache starts as soon as a pooled JVM requires it. If a shared class cache is active when the CICS region shuts down on a warm or emergency start, it usually persists except in some circumstances such as an IPL of z/OS.

Procedure

1. Ensure that the value of the **JVMCCSTART** system initialization parameter is set to AUTO or YES. The class cache starts when the first pooled JVM requires it.
2. To restart the shared class cache while CICS is running, use one of the following methods:
   - To restart the shared class cache immediately, use the **CEMT PERFORM CLASSCACHE START** command (or the equivalent **EXEC CICS** command). If you want to enable autostart, use the AUTOSTARTST option on the command. You can use the CACHESIZE option on this command if you want to change the size of the shared class cache.
   - To set the shared class cache to start when it is required by a JVM, use the **CEMT SET CLASSCACHE AUTOSTARTST** command (or the equivalent **EXEC CICS** command) to enable autostart while CICS is running.

Results

The shared class cache is restarted when CICS receives a request to run a Java application in a pooled JVM that requires the shared class cache. Subsequent warm or emergency CICS starts use this setting for autostart, unless you have specified the **JVMCCSTART** system initialization parameter as an override at startup.

Adjusting the size of the shared class cache

When the shared class cache starts, the amount of storage in the cache is fixed. The default size is 24 MB. When the storage in the shared class cache becomes full, the classes that are already present in it can still be used, but no new classes can be added to it. In this situation, you must increase the size of the shared class cache.

About this task

CICS provides commands and parameters to help you control the size of the shared class cache for pooled JVMs. If you are using class caches with JVM servers, you cannot use these commands and must use the support provided by Java. For more information about the Java shared classes utility, see Java Diagnostics Guide.

The size of the shared class cache must be sufficient to contain all the classes for your applications, as specified on the standard class path for all the pooled JVMs that use the shared class cache. The shared class cache does not distinguish between shareable and nonshareable application classes and it does not contain JIT-compiled code.

Procedure

1. Either estimate the storage required for your application classes, or for better results, run the applications in a test environment to identify the total space required in the shared class cache:
   a. Run each application repeatedly in a test environment, using the shared class cache.
   b. While you are running the application, monitor the amount of free space in the shared class cache. Use the **INQUIRE CLASSCACHE** command to report on the size of the shared class cache and amount of free storage in the shared class cache by specifying the CACHESIZE and CACHEFREE options.

      You can obtain further shared class cache statistics by running the following command in a z/OS UNIX System Services shell:

      ```
      java -Xshareclasses:name=CICS_sharedcc_APPLID_n,printStats
      ```

      where *APPLID* is the z/OS Communications Server APPLID of the CICS system, and *n* is the current generation number for the shared class cache.
   c. Run the application until the amount of free space has stabilized.
   d. Repeat this process for each application that uses the shared class cache.
   e. Add the amount of storage used by each application, and add on a suitable safety margin to account for any future application changes.

   The total gives you an approximate size for the shared class cache.
2. Use the **PERFORM CLASSCACHE RELOAD** command to create a new shared class cache. You can specify the size for the new shared class cache by using the CACHESIZE option on the command. This command causes the least disruption to pooled JVMs that are using the shared class cache.
3. Optional: Change the value for the JVMCCSIZE system initialization parameter. This parameter specifies the initial size of the shared class cache and is used on cold and initial restarts of CICS.

Results

When you specify a new size for the shared class cache while CICS is running, subsequent CICS warm and emergency restarts use the new value. CICS initial or cold restarts use the value from the **JVMCCSIZE** system initialization parameter.

Terminating the shared class cache

You can use CICS to terminate the shared class cache that is used by pooled JVMs and prevent it from restarting. You can also terminate any pooled JVMs that are using it.

About this task

When you terminate the shared class cache and autostart is enabled, a new shared class cache is created as soon as a pooled JVM requests its use. If you want to terminate the shared class cache without restarting it, you must disable the autostart.

If you terminate the shared class cache and it is not restarted, pooled JVMs that use the shared class cache cannot run.

When you change the autostart status of the shared class cache while CICS is running, subsequent CICS warm restarts use the most recent setting that you made. If the CICS region starts as INITIAL or COLD, or the **JVMCCSTART** system initialization parameter is specified as an override at startup, the setting from the system initialization parameter is used.

Procedure

1. Check the status of autostart on the shared class cache. You can use the JVM class cache operations view in the CICS Explorer or the **INQUIRE CLASSCACHE** command.
2. If you do not want the shared class cache to restart when you terminate it, disable autostart. You can disable autostart for the shared class cache in three ways:
   - Before you enter the command to terminate the shared class cache, use the **SET CLASSCACHE AUTOSTARTST** command to disable autostart.
   - When you enter the **PERFORM CLASSCACHE** command to terminate the shared class cache, use the AUTOSTARTST option to disable autostart.
   - To disable autostart for the next CICS execution, set the **JVMCCSTART** system initialization parameter to NO. This setting always prevents autostart on an initial or cold start of CICS. If the shared class cache is active when the region shuts down, it persists across a warm or emergency start, even if you specify **JVMCCSTART** as an override.
3. Terminate the shared class cache and any pooled JVMs that are using it. You can use the JVM class cache operations view or the **PERFORM CLASSCACHE** command. You can purge or force purge the JVMs, or leave them to finish running their current Java programs before they are deleted. JVMs that are not using the shared class cache are not affected by this command.
4. Repeat the **PERFORM CLASSCACHE** command to attempt to purge the tasks that are using the pooled JVMs, if you do not want to restart the shared class cache and the pooled JVMs that are using it remain active for too long. Only repeat the command if autostart for the shared class cache is disabled. The command operates on both the most recent shared class cache and any old shared class caches in the region that still have JVMs using them. If autostart is enabled,

and you repeat the command to terminate the shared class cache, the command might terminate the new shared class cache that has been started by the autostart facility.

Results

The class cache for the pooled JVMs is successfully terminated.

Monitoring the shared class cache

You can use CICS commands to report on the status of the shared class cache for pooled JVMs and for each JVM in the pool.

Procedure

- To report on the status of the shared class cache for pooled JVMs, use the **CEMT INQUIRE CLASSCACHE** command (or the equivalent **EXEC CICS** command). The command tells you if the shared class is being initialized (STARTING), ready for use (STARTED), being reloaded (RELOADING), or not active (STOPPED). The command also tells you information such as the status of autostart, the size of the shared class cache, and the amount of free space in the cache. The command also reports any old shared class caches in the CICS region that are being phased out.
- To report on the status of the JVMs in the JVM pool, use the **CEMT INQUIRE JVM** command (or the equivalent **EXEC CICS** command). The command tells you about a specified JVM or about each JVM in the pool, indicating the task to which it is allocated, whether its execution key is USER or CICS, and whether or not it is using the shared class cache.

Monitoring the JVM pool

You can use the **CEMT INQUIRE JVMPOOL** command (or the equivalent **EXEC CICS** command) to find out information about the JVM pool.

The command tells you about:
- The number of JVMs in the pool.
- The number of those JVMs that have been marked for deletion, but are still being used by a task.
- Whether the JVM pool is enabled or disabled (that is, whether it can service new requests or not).
- What trace options apply for the JVMs in the pool (this option is only available on the **EXEC CICS** version of the command).

Monitoring JVMs in the JVM pool

You can use the **EXEC CICS INQUIRE JVM** command or the **CEMT INQUIRE JVM** command to identify and report the status of each JVM in the JVM pool. You can also monitor the activity in the JVM pool using the CICS statistics.

Using the **EXEC CICS INQUIRE JVM** command, you can inquire on a specific JVM, or you can browse through all the JVMs in the JVM pool. Using the CEMT INQUIRE JVM command, you can list all the JVMs in the JVM pool, or inquire on all JVMs in a specified state.

The commands tell you about:
- The JVM profile and execution key of the JVMs in the pool.

- Which of the JVMs in the pool use the shared class cache.
- The age of each JVM.
- The task to which a JVM is allocated, and the time it has been allocated to the task.
- JVMs that are being phased out as a result of a **CEMT SET JVMPOOL PHASEOUT**, **PURGE** or **FORCEPURGE** command, or a **CEMT PERFORM CLASSCACHE PHASEOUT**, **PURGE** or **FORCEPURGE** command (or the equivalent **EXEC CICS** commands).

You can also monitor the activity in the JVM pool using the CICS statistics. Use the **EXEC CICS COLLECT STATISTICS** command, or the **CEMT PERFORM STATISTICS** command, with the relevant options to collect these statistics. Some useful statistics are the JVM pool statistics (JVMPOOL option), the TCB Mode statistics (DISPATCHER option), the JVM profile statistics (JVMPROFILE option), and the JVM program statistics (JVMPROGRAM option). These statistics can tell you, among other things:

- How many JVMs of a particular profile, on a particular TCB mode, are in the JVM pool (from the JVM profile statistics).
- How many requests were made for a JVM of a particular profile, on a particular TCB mode (from the JVM profile statistics).
- How many times a request for a JVM had to wait because there was no JVM available with an execution key and profile matching the request (from the TCB pool statistics for the JVM pool). This includes both requests that were eventually assigned a suitable JVM, and requests to which CICS decided to assign a mismatching or stolen JVM, rather than make them wait any longer. This figure can also include serialization waits, that is, time spent waiting to obtain any required locks.
- How long these requests spent waiting (from the TCB pool statistics for the JVM pool).
- How many times a request for a JVM was assigned a JVM that had the wrong profile or the wrong execution key (from the JVM profile statistics). These incidents of mismatching and stealing are broken down by JVM profile, so you can see if a particular profile is causing excess stealing activity.

Monitoring pooled JVM profile usage

You can use the **EXEC CICS INQUIRE JVMPROFILE** command in browse mode to find out what JVM profiles have been used for pooled JVMs since the CICS region started. You can also collect CICS statistics for JVM profiles.

INQUIRE JVMPROFILE finds JVM profiles that have been used during the lifetime of the CICS region. The command returns each JVM profile name, as used in a PROGRAM resource, and the full path name of the z/OS UNIX file for that JVM profile. The command also tells you whether JVMs with that profile use the shared class cache.

You can collect statistics for JVM profiles by using the **EXEC CICS COLLECT STATISTICS** command or the **CEMT PERFORM STATISTICS** command. For both commands, specify the JVMPROFILE option. The statistics are broken down by JVM profile and execution key, and they show, among other things:

- The number of requests made by applications for JVMs of this profile
- The total, current and peak number of JVMs of this profile that were in the JVM pool
- The number of pooled JVMs of this profile that were destroyed because CICS was short on storage

- The incidence of TCB stealing by, and from, JVMs of this profile
- The Language Environment heap storage and JVM heap storage used by JVMs of this profile

JVM server and pooled JVM statistics in the Performance Guide has more information about JVM statistics, and tells you how to find the full listings and reports for these statistics.

Monitoring programs in pooled JVMs

You can use the **EXEC CICS COLLECT STATISTICS** command or the **CEMT PERFORM STATISTICS** command to collect statistics on Java programs that run in a pooled JVM. For both commands, specify the JVMPROGRAM option

CICS does not collect statistics for these programs when a **COLLECT** or **PERFORM STATISTICS PROGRAM** command is issued, because the JVM programs are not loaded by CICS.

For each program, the statistics show the following details:

- The JVM profile that the program requires, as specified in the JVMPROFILE attribute of the PROGRAM resource
- The execution key that the program requires, either CICS key or user key, as specified in the EXECKEY attribute of the PROGRAM resource
- The main class in the program, as specified in the JVMCLASS attribute of the PROGRAM resource
- The number of times that the program has been used

For more information about JVM statistics, see JVM server and pooled JVM statistics in the Performance Guide.

Using DFHJVMAT to modify options in a JVM profile

DFHJVMAT is a user-replaceable program that you can use to override the options specified in a JVM profile for single-use pooled JVMs. Normally, a JVM profile provides sufficient flexibility to configure a JVM as required. Use DFHJVMAT only if you must tailor the JVM in a way that cannot be achieved by specifying options in the JVM profile.

You can also use DFHJVMAT to override the JVMCLASS attribute on a CICS PROGRAM resource. This attribute specifies the main class in the Java program that is to execute in the JVM. If you use the PROGRAM resource, the limit for the JVMCLASS attribute is 255 characters, but you can use DFHJVMAT to specify a class name longer than 255 characters.

You can call DFHJVMAT by specifying INVOKE_DFHJVMAT=YES as an option on the JVM profile that you want to override.

Important

You can only call DFHJVMAT for a single-use pooled JVM, that is, a JVM with a JVM profile that specifies the option REUSE=NO. With single-use JVMs, when the task using the JVM terminates, CICS does not attempt to make the JVM available for reuse for another task.

You cannot call DFHJVMAT for a continuous pooled JVM or a JVM server. If you specify INVOKE_DFHJVMAT=YES for either type of JVM, INVOKE_DFHJVMAT=YES is ignored and DFHJVMAT is not called.

The values specified in the JVM profile are available to DFHJVMAT as z/OS UNIX System Services environment variables, which you can modify before the JVM is created.

Note: The values of the STDERR and STDOUT parameters, which can be interpreted by CICS to generate task-specific names, are passed to DFHJVMAT before interpretation.

DFHJVMAT uses the C/C++ `getenv` and `setenv` functions to change the environment variables that correspond to the options in the JVM profile. For example, you can use the following command to replace the CLASSPATH_SUFFIX environment variable with the specified value:

```
setenv(ecp_suffix, cp_suffix_val,1)
```

where:

```
char *ecp_suffix = "CLASSPATH_SUFFIX";
char *cp_suffix_val ="/u/jtest1/Java/test:.";
```

The `setenv` function has no effect on the CICS PROGRAM resource and remains in effect only for the lifetime of the JVM.

The CICS-supplied DFHJVMAT:
- Issues `getenv` requests for each variable.
- Issues a `printf` to destination `stdout`, to record the setting of each variable.
- Contains (within comments) some sample code that demonstrates how to use the `setenv` command to the supplied names for **stdout** and **stderr** to make unique output and error files for each CICS task.

If you write your own program to tailor options in the JVM profile based on the supplied version, the name must be DFHJVMAT, and the program must be written in C. You can use EXEC CICS commands in DFHJVMAT but these commands might increase the processing time. DFHJVMAT must be written to threadsafe standards and defined with CONCURRENCY(THREADSAFE) in its PROGRAM resource, because multiple invocations of this module might run in parallel.

Options in the JVM profile that are available to DFHJVMAT

The JVM profile options listed in this topic are made available to DFHJVMAT. The options are read from the specified JVM profile and created as environment variables using Language Environment services.

In most cases, the full descriptions of these options are in "JVM profiles: options and samples" on page 96. Before modifying any of these options using DFHJVMAT, read the full description of the option.

Some of the options are no longer documented in the CICS documentation, and information about these can be found in the documentation for the IBM 64-bit SDK for z/OS, Java Technology Edition and other Java documentation.

Note:
1. Except where explicitly stated as being for information only, you can reset the values of these variables.
2. All environment variables and values are case sensitive and must be set as shown.
3. CICS ignores any values that it does not recognize as a valid option.

4. For the options beginning with `X`:
   - Some of these options are no longer documented in the CICS documentation. However, they are still valid options and available to DFHJVMAT.
   - These options should now begin with `-X` when specified in a JVM profile. However, the hyphen is not included in the environment variables used by DFHJVMAT, which still begin with `X`.

Table 11. JVM profile options available to DFHJVMAT

Option	**Specifies**
CLASSPATH_PREFIX, CLASSPATH_SUFFIX	Prefix and suffix to standard class path
INVOKE_DFHJVMAT	For information only
JAVA_DUMP_OPTS	Set of Java dump options to obtain diagnostics for an abend in the JVM
JAVA_HOME	Path to IBM 64-bit SDK for z/OS, Java Technology Edition subdirectories and JAR files
JVMPROPS	Path and name of the JVM properties file
LIBPATH_PREFIX, LIBPATH_SUFFIX	Prefix and suffix to library path
STDERR	Name of z/OS UNIX file for **stderr** output from the JVM
STDIN	Name of z/OS UNIX file for **stdin**
STDOUT	Name of z/OS UNIX file for **stdout** output from the JVM
USEROUTPUTCLASS	Name of a Java class that intercepts and redirects the **stdout** and **stderr** output from the JVM.
VERBOSE	Level of information messages from the JVM
WORK_DIR	Working directory for CICS region on z/OS UNIX
`Xcheck`	Perform additional checks
`Xdebug`	Enable debugging support
`Xmaxe`, `Xmaxf`, `Xmine`, `Xminf`	Maximum and minimum heap expansion sizes and free heap percentage sizes for the heap
`Xms`	Initial size of the heap
`Xmx`	Maximum size of the heap
`Xnoagent`	Disable the old `sun.tools.debug` agent (if `Xdebug` specified)
`Xnoclassgc`	Disable class garbage collection
`Xoss`	Maximum Java stack size for any thread
`Xrs`	Reduces the use of operating system signals by the JVM
`Xrun`*`dllname`*	Loads the specified dynamic link library (DLL) and passes it the specified options
`Xss`	Size of stack for each new Java thread
`Xverify`	Level of verification to perform on classes loaded

Two additional fields not found in a standard JVM profile are passed to DFHJVMAT, as follows:

`CICS_PROGRAM`
Specifies the name of the CICS program (1-8 characters) associated with the

Java class to be run. This name is established at runtime; it is passed to DFHJVMAT for information only and cannot be changed. Any changes are ignored by CICS.

CICS_PROGRAM_CLASS
: Specifies the CICS user application class name, and is obtained from the program resource definition. This is defined by the JVMCLASS attribute on the CICS PROGRAM resource definition. As an alternative to using DFHJVMAT to override this attribute, you can use the **SET PROGRAM** command to modify the JVMCLASS attribute on the PROGRAM resource before control is passed to the JVM. If you use the PROGRAM resource, the limit for the JVMCLASS attribute is 255 characters, but you can use DFHJVMAT to specify a class name longer than 255 characters.

Chapter 7. Improving Java performance

You can take a number of actions to improve the performance of both Java applications and the JVMs in which they run.

About this task

No matter how well CICS is tuned, if an application is written inefficiently it will always perform poorly compared to well written applications. For example, if you change your applications to generate less garbage, you can make significant savings on garbage collection costs. If less garbage is produced then less time is spent in garbage collection. To improve performance, always ensure that your Java applications are written efficiently, as well as tuning the Java environment.

Procedure

1. Determine the performance goals for your Java workload. Some of the most common goals include minimizing processor usage or application response times. After you have decided the goal, you can tune the Java environment accordingly.
2. Analyze your Java applications to ensure they are running efficiently and do not generate too much garbage. IBM has tools that can help you to analyze Java applications to improve the efficiency and performance of particular methods and the application as a whole.
3. Tune the JVM server or pooled JVMs. You can use statistics and IBM tools to analyze the storage settings, garbage collection, task waits, and other information to tune the performance of the JVM.
4. Tune the Language Environment enclave in which a JVM runs. JVMs use MVS storage, obtained by calls to MVS Language Environment services. You can modify the runtime options for Language Environment to tune the storage that is allocated by MVS.
5. Optional: If you use the z/OS shared library region to share DLLs between JVMs in different CICS regions, you can tune the storage settings.

Determining performance goals for your Java workload

Tuning CICS JVMs to achieve the best overall performance for a given application workload involves several different factors. You must decide what the desired performance characteristics of your Java workload are. When you establish these characteristics, you can determine what parameters to change and how to change them.

The following performance goals for Java workloads are most common:

Minimum overall processor usage
: This goal prioritizes the most efficient use of the available processor resource. If a workload is tuned to achieve this goal, the total use of the processor across the entire workload is minimized, but individual tasks might experience high processor consumption. Tuning for the minimum overall processor usage involves specifying large storage heap sizes for your JVMs to minimize the number of garbage collections.

Minimum application response times

This goal prioritizes ensuring that an application task returns to the caller as rapidly as possible. This goal might be especially relevant if there are Service Level Agreements to be achieved. If a workload is tuned to achieve this goal, applications respond consistently and quickly, though a higher processor usage might occur for garbage collections. Tuning for minimum application response times involves keeping the heap size small and possibly using the gencon garbage collection policy.

Minimum JVM storage heap size

This goal prioritizes reducing the amount of storage used by JVMs. JVMs use 64-bit storage so it is possible to run many pooled JVMs and JVM servers in a CICS region. If pooled JVMs use a smaller storage heap, it might be possible to run more of them in the CICS region. However, choosing this goal might increase processor costs. Tuning JVMs to minimize the storage heap size results in a greater frequency of garbage collection events.

Other factors can affect the response times of your applications. The most significant of these is the Just In Time (JIT) compiler. The JIT compiler optimizes your application code dynamically at run time and provides many benefits, but it requires a certain amount of processor resource to do this.

Analyzing Java applications using IBM Health Center

To improve the performance of a Java application, you can use IBM Health Center to analyze the application. This tool provides recommendations to help you improve the performance and efficiency of your application.

About this task

IBM Health Center is available in the IBM Support Assistant Workbench. These free tools are available to download from IBM as described in the Getting Started guide. Try to run the application in a JVM on its own. If you are running a mixed workload in a JVM server, it might be more difficult to analyze a particular application.

Procedure

1. Add the required connection options to the JVM profile of the JVM server. The IBM Health Center documentation describes what options you must add to connect to the JVM from the tool.
2. Start up IBM Health Center and connect it to your running JVM. IBM Health Center reports JVM activity in real time so wait a few moments for it to monitor the JVM.
3. Select the **Profiling** link to profile the application. You can check the time spent in different methods. Check the methods with the highest usage to look for any potential problems.

   Tip: The **Analysis and Recommendations** tab can identify particular methods that might be good candidates for optimization.
4. Select the **Locking** link to check for locking contentions in the application. If the Java workload is unable to use all the available processor, locking might be the cause. Locking in the application can reduce the amount of parallel threads that can run.

5. Select the **Garbage Collection** link to check the heap usage and garbage collection. The **Garbage Collection** tab can tell you how much heap is being used and how often the JVM pauses to perform garbage collection.
   a. Check the proportion of time spent in garbage collection. This information is presented in the Summary section. If the time spent in garbage collection is more than 2%, you might need to adjust your garbage collection.
   b. Check the pause time for garbage collection. If the pause time is more than 10 milliseconds, the garbage collection might be having an effect on application response times.
   c. Divide the rate of garbage collection by the number of transactions to find out approximately how much garbage is produced by each transaction. If the amount of garbage seems high for the application, you might have to investigate the application further.

What to do next

After you have analyzed the application, you can tune the Java environment for your Java workloads.

Garbage collection and heap expansion

Garbage collection and heap expansion are an essential part of the operation of a JVM. The frequency of garbage collection in a JVM is affected by the amount of garbage, or objects, created by the applications that run in the JVM.

Allocation failures

When a JVM runs out of space in the storage heap and is unable to allocate any more objects (an allocation failure), a garbage collection is triggered. The Garbage Collector cleans up objects in the storage heap that are no longer being referenced by applications and frees some of the space. Garbage collection stops all other processes from running in the JVM for the duration of the garbage collection cycle, so time spent on garbage collection is time that is not being used to run applications. The Java Diagnostics Guide has a detailed explanation of the JVM garbage collection process.

When a garbage collection is triggered by an allocation failure, but the garbage collection does not free enough space, the Garbage Collector expands the storage heap. During heap expansion, the Garbage Collector takes storage from the maximum amount of storage reserved for the heap (the amount specified by the `-Xmx` option), and adds it to the active part of the heap (which began as the size specified by the `-Xms` option). Heap expansion does not increase the amount of storage required for the JVM, because the maximum amount of storage specified by the `-Xmx` option has already been allocated to the JVM at startup. If the value of the `-Xms` option provides sufficient storage in the active part of the heap for your applications, the Garbage Collector does not have to carry out heap expansion at all.

At some point during the lifetime of the JVM, the Garbage Collector stops expanding the storage heap, because the heap has reached a state where the Garbage Collector is satisfied with the frequency of garbage collection and the amount of space freed by the process. The Garbage Collector does not aim to eliminate allocation failures, so some garbage collection can still be triggered by allocation failures after the Garbage Collector has stopped expanding the storage heap. Depending on your performance goals, you might consider this frequency of garbage collection to be excessive.

Garbage collection options

You can use different policies for garbage collection that make trade-offs between throughput of the application and the overall system, and the pause times that are caused by garbage collection. Garbage collection is controlled by the `-Xgcpolicy` option:

`-Xgcpolicy:optthruput`
: This policy delivers high throughput to applications but at the cost of occasional pauses, when garbage collection occurs.

`-Xgcpolicy:gencon`
: This policy helps to minimize the time that is spent in any garbage collection pause. Use this garbage collection policy with JVM servers. You can check which policy is being used by the JVM server by inquiring on the JVMSERVER resource. The JVM server statistics have fields that tell you how many major and minor garbage collection events occur and what processor time is spent on garbage collection.

You can change the garbage collection policy by updating the JVM profile. For details of all the garbage collection options, see Specifying garbage collection policy.

Example 1: An application producing small amounts of garbage

Figure 7 shows the storage heap in a pooled JVM at various stages for the `optthruput` garbage collection policy. The maximum amount of storage reserved for the storage heap is determined by the `-Xmx` option. The active part of the storage heap, determined by the `-Xms` option, is shown shaded.

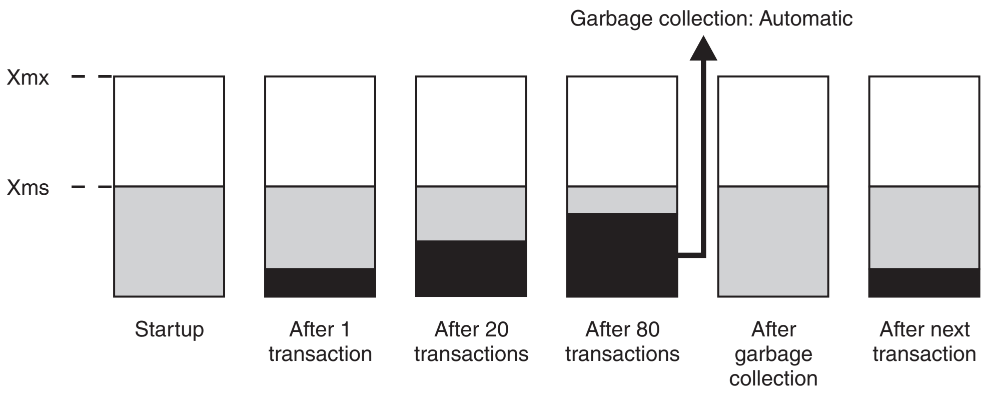


Figure 7. Storage heap in a pooled JVM with small amounts of garbage

At startup, `-Xms` is set to half of `-Xmx`, as with the default settings in the supplied JVM profiles. The heap utilization limit (`GC_HEAP_THRESHOLD` option) is set to the default of 85%.

The first application that runs in the JVM uses a small amount of the storage in the active part of the heap. The storage it uses is shown in black. When the transaction has finished, the objects used by the application are no longer referenced, so they are eligible for garbage collection. They remain in the storage heap until garbage collection occurs.

After 20 transactions have used the JVM, the amount of storage occupied in the active part of the heap has increased. Each transaction has used a small amount of storage, and no garbage collection has taken place yet.

After 80 transactions, the heap utilization limit of 85% has been reached, with 85% of the storage occupied in the active part of the heap. Immediately after the transaction during which the limit is reached, CICS initiates a garbage collection. After the garbage collection, all the objects used by the first 80 transactions have been garbage collected, so the active part of the storage heap is now empty. The next application that runs in the JVM again uses a small amount of storage, and the cycle begins again.

In this example, there are no allocation failures and no heap expansion takes place, because the value of the `-Xms` option is set so that there is sufficient storage in the active part of the heap for the applications. Only the garbage collections requested by CICS at the heap utilization limit are taking place. However, assuming this workload stays constant, the `-Xmx` option is higher than it needs to be. All the storage reserved for the storage heap has been allocated, but half of it is not being used and is wasted.

Example 2: A multithreaded application producing large amounts of garbage

Figure 8 shows the storage heap in a JVM server at various stages for the `gencon` garbage collection policy. Unlike the pooled JVM, a JVM server can run many requests for an application at the same time. Therefore, the application can produce larger amounts of garbage. In a JVM server, the garbage collection is handled automatically by the JVM.

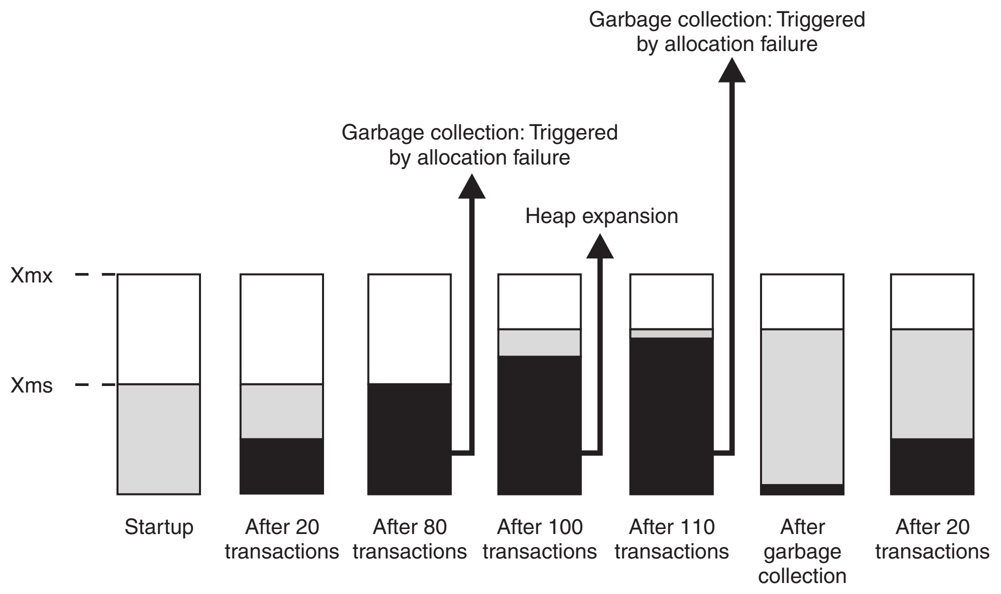


Figure 8. Storage heap in a JVM server with large amounts of garbage

During the first 20 transactions, the active part of the storage heap starts to fill. After 80 transactions, the heap becomes full and an allocation failure occurs, which triggers a minor garbage collection in the JVM. The garbage collection cleans up the short lived objects. However, because application requests are still running, some of the objects are still referenced, so they are not eligible for garbage collection.

After 100 transactions, the Garbage Collector cannot find enough space for all the currently needed objects and it expands the storage heap . Some storage from the maximum amount of storage reserved for the storage heap (the amount specified by the `-Xmx` option) is added to the active part of the heap. The application continues to produce objects, but the heap expansion has now created enough space so that the current transaction can complete.

After 110 transactions, the storage heap is largely occupied. Another allocation failure occurs that triggers a major garbage collection. The JVM cleans up many of the longer lived objects used by previous transactions. After another 20 transactions, the heap starts to fill up again.

When you use the `gencon` policy, many minor garbage collections can occur to manage the heap size before a major garbage collection occurs. You can find out how many garbage collections have occurred, the heap occupancy, and other information by using JVM server statistics.

Improving JVM server performance

To improve the performance of applications that run in a JVM server, you can tune different parts of the environment, including the garbage collection and the size of the heap.

About this task

CICS provides statistics reports on the JVM server, which include details of how long tasks wait for threads, heap sizes, frequency of garbage collection, and processor usage. You can also use additional IBM tools that monitor and analyze the JVM directly to tune JVM servers and help with problem diagnosis. You can use the statistics to check that the JVM is performing efficiently, particularly that the heap sizes are appropriate and garbage collection is optimized.

Procedure

1. Check the amount of processor time that is used by the JVM server. Dispatcher statistics can tell you how much processor time the T8 TCBs are using. JVM server statistics tell you how long the JVM is spending in garbage collection and how many garbage collections occurred. Application response times and processor usage can be adversely affected by the JVM garbage collection.
2. Ensure that you have enough storage available to adjust the heap sizes required by the JVM server.
3. Tune the garbage collection and heap in the JVM. A small heap can lead to very frequent garbage collections, but too large a heap can lead to inefficient use of MVS storage. You can use IBM Health Center to visualize and tune garbage collection and adjust the heap accordingly.

What to do next

For more detailed analysis of memory usage and heap sizes, you can use the Memory Analyzer tool in IBM Support Assistant to analyze Java heap memory using system dump or heap dump snapshots of a Java process.

Examining processor usage by JVM servers

You can use the CICS monitoring facility to monitor the processor time that is used by transactions running in a JVM server. All threads in a JVM server run on T8 TCBs.

About this task

You can use the DFH$MOLS utility to print the SMF records or use a tool such as CICS Performance Analyzer to analyze the SMF records.

Procedure

1. Switch on monitoring in the CICS region to collect the performance class of monitoring data.
2. Check the performance data group DFHTASK. In particular, you can look at the following fields:

Field ID	Field name	Description
283	MAXTTDLY	The elapsed time for which the user task waited to obtain a T8 TCB, because the CICS region reached the limit of available threads. The thread limit is 1024 for each CICS region and each JVM server can have up to 256 threads.
400	T8CPUT	The processor time during which the user task was dispatched by the CICS dispatcher domain on a CICS T8 mode TCB. When a thread is allocated a T8 TCB, that same TCB remains associated with the thread until the processing completes.
401	JVMTHDWT	The elapsed time that the user task waited to obtain a JVM server thread because the CICS system had reached the thread limit for a JVM server in the CICS region.

3. To improve processor usage, reduce or eliminate the use of tracing where possible.
   a. In a production environment, consider running your CICS region with the CICS master system trace flag set off. Having this flag on significantly increases the processor cost of running a Java program. You can set the flag off by initializing CICS with SYSTR=OFF, or by using the CETR transaction.
   b. Ensure that you activate JVM trace only for special transactions. JVM tracing can produce large amounts of output in a very short time, and increases the processor cost. For more information about controlling JVM tracing, see "Diagnostics for Java" on page 180.
4. Do not use the `USEROUTPUTCLASS` option in JVM profiles in a production environment. Specifying this option has a negative effect on the performance of JVMs. The `USEROUTPUTCLASS` option enables developers using the same CICS region to separate JVM output, and direct it to a suitable destination, but it involves the building and invocation of additional class instances.

Calculating storage requirements for JVM servers

To increase the number of JVM servers in a CICS region, you must ensure that enough storage is available to CICS.

About this task

JVMs use storage below the 16 MB line, 31-bit storage, and 64-bit storage. To run a JVM server incurs a one-off storage cost, no matter how many JVMs run in the CICS region. Each JVM server and its Language Environment enclave also require a certain amount of 31-bit and 64-bit storage. The JVM heap sizes are managed by the JVM and CICS uses the default values. You can adjust the heap size if required as part of tuning the environment.

The storage required for the JVM heap comes from the CICS region storage (from MVS storage, not EDSA storage). Larger JVM heaps reduce the number of JVMs that can be present in a CICS region, and increase the region size to support them. However, if the heap size is set too small, excessive garbage collection takes place, which affects performance. You can tune the JVM storage options to achieve the best performance for your Java workloads. The JVM storage options help to determine the processor usage, storage usage, and task response times for Java applications.

Procedure

1. Determine the amount of free storage available below the bar by using the sample statistics program DFH0STAT. The storage reports include the amount of user storage allocated in 31-bit storage and below the 16 MB line.
   - If you have no JVM servers running, subtract the storage that is reserved for the z/OS shared library region from the total amount of free storage in the CICS address space. The storage is controlled by the **SHRLIBRGNSIZE** parameter in MVS and is allocated once when the first JVM is started in the region.
   - If you have JVM servers running, subtract the value of the **SHRLIBRGNSIZE** parameter from the total amount of free storage. Each JVM that is running uses 12 KB of storage below the 16 MB line. The Language Environment enclave for each JVM uses 31-bit storage for the heap and library heap. The amount of allocated 31-bit storage is set by the `HEAP64` and `LIBHEAP64` options in DFHOSGI. You must also subtract these values from the total amount of free storage to work out how much storage is currently available.

   If you want to change the 31-bit storage settings, you can adjust the **SHRLIBRGNSIZE** parameter and the Language Environment options. See “Tuning the z/OS shared library region” on page 177 and “Using DFHAXRO to modify the enclave of a JVM server” on page 173.
2. Calculate how much 64-bit storage is required for each additional JVM server. You can calculate the 64-bit storage requirements for a JVM server by adding up the following storage requirements:
   - The **-Xmx** value. The default value for this parameter is set by the JVM, so check the documentation in the Java information center.
   - The value of the 64-bit storage that is allocated by the `HEAP64` option in DFHAXRO.
   - The value of the 64-bit storage that is allocated by the `LIBHEAP64` option in DFHAXRO.
   - The value of the 64-bit storage that is allocated by the `STACK64` option in DFHAXRO. Multiply this value by the number of threads that are allowed in

the JVM server. To calculate the number of allowed threads, add the THREADLIMIT attribute value on the JVMSERVER resource to the value of the **-Xgcthreads** parameter. This Java option controls the number of garbage collection helper threads in the JVM.

3. Check the **MEMLIMIT** value to determine whether you have enough 64-bit storage available to run additional JVM servers. You must allow for the other CICS facilities that use 64-bit storage.

   The z/OS **MEMLIMIT** parameter limits the amount of 64-bit (above-the-bar) storage for the CICS region. For information about the CICS facilities that use 64-bit storage, and how to check and adjust this parameter, see Estimating, checking, and setting MEMLIMIT in the Performance Guide.

Tuning JVM server heap and garbage collection

Garbage collection in a JVM server is handled by the JVM automatically. You can tune the garbage collection process and heap size to ensure that application response times and processor usage are optimal.

About this task

The garbage collection process affects application response times and processor usage. Garbage collection temporarily stops all work in the JVM and can therefore affect application response times. If you set a small heap size, you can save on memory, but it can lead to more frequent garbage collections and more processor time spent in garbage collection. If you set a heap size that is too large, the JVM makes inefficient use of MVS storage and this can potentially lead to data cache misses and even paging. CICS provides statistics that you can use to analyze the JVM server. You can also use IBM Health Center, which provides the advantage of analyzing the data for you and recommending tuning options.

Procedure

1. Collect JVM server and dispatcher statistics over an appropriate interval. The JVM server statistics can tell you how many major and minor garbage collections take place and the amount of time that the processor spent in garbage collection. The dispatcher statistics can tell you about processor usage for T8 TCBs across the CICS region.
2. Use the dispatcher TCB mode statistics for T8 TCBs to find out how much processor time is spent on JVM server threads. The “Accum CPU Time / TCB” field shows the accumulated processor time taken for all the TCBs that are, or have been, attached in this TCB mode. The “TCB attaches” field shows the number of T8 TCBs that have been used in the statistics interval. Use these numbers to work out approximately how much processor time each T8 TCB has used.
3. Use the JVM server statistics to find the percentage of time that is spent in garbage collection. Divide the time of the statistics interval by how much elapsed time is spent in garbage collection. Aim for less than 2% of processor usage in garbage collection. If the percentage is higher, you can increase the size of the heap so that garbage collection occurs less frequently.
4. Compare the “Current heap size” field with the “GC heap occupancy” field to find out how much live data is being used in the heap. If the heap is large, even after a garbage collection, the pause time for performing garbage collection is longer.

   The optthruput policy uses a single heap that can cause less frequent but longer pause times. The gencon policy splits the heap into two parts, so the

JVM performs minor garbage collection on the nursery and major garbage collection on the full heap. The gencon policy helps to minimize the time that is spent in any garbage collection pause.

If you want to improve application response times, use the gencon policy:

a. Check the statistics for the JVMSERVER resource to find out which policy is being used by the JVM.
b. If the JVM is using optthruput, edit the JVM profile to add the **`-Xgcpolicy`** option. Specify `-Xgcpolicy:gencon`.
c. Disable and enable the JVMSERVER resource to pick up the changes to the JVM profile. You can check the enabled JVMSERVER resource to confirm that your changes have been applied.

5. Divide the heap freed value by the number of transactions that have run in the interval to find out how much garbage per transaction is being collected. You can find out how many transactions have run by looking at the dispatcher statistics for T8 TCBs. Each thread in a JVM server uses a T8 TCB.
6. Optional: To perform more detailed analysis, add the **`-verbose:gc`** option to the JVM profile. The JVM writes garbage collection messages in XML to the file that is specified in the STDERR option in the JVM profile. See verbose:gc logging for examples and explanations of the messages.

   Tip: You can use the file in the Memory Analyzer tool to perform more detailed analysis.

Results

The outcome of your tuning can vary depending on your Java workload, the maintenance level of CICS and of the IBM SDK for z/OS, and other factors. For more detailed information about the storage and garbage collection settings and the tuning possibilities for JVMs, see the Java Diagnostics Guide.

Tuning JVM server startup in a sysplex

If you have problems starting many JVM servers at the same time across CICS regions in a sysplex, you can improve performance by tuning the environment.

About this task

When a JVM server starts, it loads a set of libraries in the `/usr/lpp/cicsts/cicsts42/lib` directory. If you start many JVM servers at the same time, it can take a while for each JVM to load the required libraries. Some JVM servers might time out or take a long time to start up. To reduce the startup time, you can tune the environment.

Procedure

1. Mount zFS in read-only mode to improve the time it takes to access the libraries from different JVM servers in the sysplex.
2. Mount zFS on a different LPAR in the sysplex to provide a local copy of the libraries to a CICS region.
3. Create a shared class cache for the JVM servers to load the libraries once. To use a shared class cache, add the **`-Xshareclasses`** option to the JVM profile of each JVM server. For details on this option, see Class data sharing between JVMs.
4. Increase the timeout value for the OSGi framework. The DFHOSGI JVM profile contains the `OSGI_FRAMEWORK_TIMEOUT` option that specifies the amount of time

that CICS waits for the JVM server to start up and shut down. If the time is exceeded, the JVM server fails to initialize or shut down correctly. The default value is 60 seconds, so increase this value to a more suitable number of seconds for your environment.

Managing your JVM pool for performance

By tuning the settings for the JVM pool, you might be able to decrease the response time for your transactions, by ensuring that processor time is not being wasted during uses of pooled JVMs. You can also ensure that each CICS region that is running Java workloads contains the optimum number of JVMs for the region size, and is therefore making the best use of storage and processor time.

About this task

The number of pooled JVMs that a CICS region can support is governed mainly by the following factors:
- The amount of processor time used by the JVMs.
- The amount of MVS storage required by the JVMs.
- The amount of MVS storage and processor time that are available for the use of the CICS region.

To estimate how many pooled JVMs you require to support the required level of transaction throughput, use the following formula:

```
ETR x Response time = Number of JVMs
```

where:
- ETR is the desired level of transaction throughput
- Response time is the time taken to run your transaction in a JVM

The following procedure is a suggested process to tune your JVM pool.

Procedure

1. Find out how long your transactions are waiting to acquire a JVM. Check the statistics field “Total Max TCB Pool Limit delay time” in the CICS dispatcher TCB pool statistics. This field shows how long your transactions waited to acquire a JVM at those times when the **MAXJVMTCBS** limit had been reached for the JVM pool. You can also use the CICS monitoring data field MAXJTDLY (field ID 277), in performance data group DFHTASK, to check how much time an individual transaction waited to acquire a JVM.
   a. If the delay time seems low, the **MAXJVMTCBS** limit for your JVM pool might not often be reached. The statistics field “Times at Max TCB Pool Limit” in the CICS dispatcher TCB pool statistics shows you how many times the limit was reached. In this situation, it might be possible to reduce the **MAXJVMTCBS** limit, without causing a serious increase in the delay time for your transactions.
   b. If the delay time seems high, divide it by the statistics field “Total Attaches delayed by Max TCB Pool Limit” in the CICS dispatcher TCB pool statistics, to see how long each transaction was made to wait. The field “Average Max TCB Pool Limit delay time” in the summary TCB pool statistics has this information. If your JVM pool is normally at its **MAXJVMTCBS** limit, transactions often wait for at least a short time to acquire a JVM. Increase your **MAXJVMTCBS** limit only if you feel that the delay time for each transaction is excessive.

2. If you have found that the delay time for transactions waiting to acquire a JVM is excessive, check your level of QR TCB use. Calls made by a Java program for CICS services, such as using a JCICS class to access a transient data queue, require a switch to the QR TCB. When the QR TCB reaches a high level of use, adding more JVMs might produce no further increase in the throughput of your CICS system. You can check your level of QR TCB use by looking at the statistics field “Accum CPU Time / TCB” for the QR mode in the CICS dispatcher TCB mode statistics.
3. Examine the amount of processor time that is used by your pooled JVMs on their own J8 and J9 TCBs. Make sure that you have stopped any unnecessary processor usage. For more information, see “Examining processor usage by pooled JVMs.”
4. If you want to increase the number of pooled JVMs, compare the amount of storage required to support a single JVM, with the amount of storage space that is available (or that you can make available) to the CICS region, and calculate the maximum number of JVMs that your CICS region can support. For more information, see “Calculating storage requirements for pooled JVMs” on page 165.
5. Taking your findings about processor usage and storage availability into account, set an appropriate **MAXJVMTCBS** limit for the CICS region. You can change the setting for **MAXJVMTCBS** without restarting CICS, by using the CEMT SET DISPATCHER command.
6. If you receive message DFHSJ0203 and receive a return code of 12 from Language Environment, examine the storage settings for your JVMs. JVMs use 64-bit storage, and the limit for 64-bit storage for the CICS region is controlled by the z/OS **MEMLIMIT** parameter. You can adjust the storage setting, the **MAXJVMTCBS** limit, or both, to decrease the amount of storage that the JVMs are using in the CICS region. For more information, see “Dealing with MVS storage constraints” on page 168.
7. If you find that the incidence of mismatching and stealing in your JVM pool is excessive, you can use some strategies to reduce this number. For more information, see “Dealing with excessive mismatches and steals” on page 169.
8. If your Java workload is regular, predictable, and involves a limited number of different JVM profiles, you can start JVMs manually in advance of the demand from applications. This strategy might reduce the delay time for applications in periods when workload is increasing. For more information, see Manually starting and terminating JVMs and disabling the JVM pool.

Examining processor usage by pooled JVMs

You can use the CICS monitoring facility to monitor the processor time used by a transaction that invokes a JVM program, including the amount of processor time used by the pooled JVM on a J8 or J9 TCB. The CICS monitoring facility also includes the elapsed time spent in the JVM, and the number of JCICS API requests issued by the JVM program.

About this task

As a first step in tuning your JVMs, ensure that they are not using unnecessary processor time. You can use the DFH$MOLS utility to print the SMF records or use a tool such as CICS Performance Analyzer to analyze the SMF records.

Procedure

1. Switch on monitoring in the CICS region to collect the performance class of monitoring data.

2. Check the performance data group DFHTASK and DFHCICS. In particular, you can look at the following fields:

Table 12. JVM-related monitoring data fields

Group	Field ID	Field name	Description
DFHTASK	253	JVMTIME	The total elapsed time spent in the JVM by the user task. This comprises the JVM initialization time, the Java application execution time, and the JVM cleanup time. The fields JVMITIME and JVMRTIME show the initialization and cleanup time respectively.
DFHTASK	254	JVMSUSP	The elapsed time the user task was suspended by the CICS dispatcher while running in the JVM.
DFHTASK	260	J8CPUT	The processor time during which the user task was dispatched by the CICS dispatcher domain on a CICS J8 mode TCB (used for JVMs in CICS key). The field JVMTIME shows the actual elapsed time spent in the JVM.
DFHTASK	267	J9CPUT	The processor time during which the user task was dispatched by the CICS dispatcher domain on a CICS J9 mode TCB (used for JVMs in user key). The field JVMTIME shows the actual elapsed time spent in the JVM.
DFHTASK	273	JVMITIME	The elapsed time spent initializing the JVM environment. The first JVM that is initialized in a CICS region, whatever its type, has a longer initialization time than subsequent JVMs initialized in the region, because of the setup required at this time.
DFHTASK	275	JVMRTIME	The elapsed time spent cleaning up the JVM after use by a Java program. This does not include garbage collections scheduled by CICS, which take place under a separate transaction (CJGC).
DFHTASK	277	MAXJTDLY	The elapsed time in which the user task waited to obtain a CICS JVM TCB (J8 or J9 mode), because the CICS system had reached the limit set by the **MAXJVMTCBS** system initialization parameter, .
DFHCICS	025	CFCAPICT	The number of CICS OO foundation class requests, including the Java API for CICS (JCICS) classes, issued by the user task.

3. To improve processor usage, reduce or eliminate the use of tracing where possible.
   a. In a production environment, consider running your CICS region with the CICS master system trace flag set off. Having this flag on significantly increases the processor cost of running a Java program. You can set the flag off by initializing CICS with SYSTR=OFF, or by using the CETR transaction.

   b. Ensure that you only activate JVM trace for special transactions. JVM tracing can produce large amounts of output in a very short time, and increases the processor cost. "Diagnostics for Java" on page 180 tells you how to control JVM tracing.
4. Do not use the `USEROUTPUTCLASS` option in JVM profiles in a production environment. Specifying this option has a negative effect on the performance of JVMs. The `USEROUTPUTCLASS` option enables developers using the same CICS region to separate JVM output, and direct it to a suitable destination, but it involves the building and invocation of additional class instances. For best performance in a production environment, do not use this option; reserve it for use during application development. The CICS-supplied JVM profiles do not specify the `USEROUTPUTCLASS` option.
5. Look at the different types of pooled JVMs in your CICS region. In particular, check whether you have any single-use JVMs. Single-use JVMs use a large amount of processor time compared to continuous JVMs. If the application is threadsafe, it can run in a JVM server. Otherwise, move the application to run in a continuous pooled JVM.

How different pooled JVMs affect processor usage

Pooled JVMs can be continuous or single-use and continuous JVMs can optionally use the shared class cache. Your choice of pooled JVM can have a significant impact on processor usage.

Continuous JVMs and single-use JVMs

Single-use JVMs have poor performance in terms of processor usage and transaction throughput, compared to continuous JVMs. A new JVM is initialized for each program invocation and destroyed after use, incurring very high processor usage costs.

The time taken to initialize one single-use JVM is slightly lower than the time taken for a continuous JVM that does not use the shared class cache, although it is higher than the time taken to initialize a continuous JVM that does use the shared class cache. However, this initialization occurs every time a program runs in a single-use JVM, which greatly increases the cumulative initialization time and the processor time for each transaction.

Do not use single-use JVMs for running Java applications in a production environment. They are only beneficial for Java applications that were originally designed to run in a single-use JVM, and have not been made suitable for running in a JVM that is intended for reuse. If you are running any Java programs in single-use JVMs, your first action to improve performance is to redesign these Java programs, so that the programs can run in continuous JVMs.

Continuous JVMs might have to be reinitialized from time to time, incurring the initialization cost, in the following situations:

- You have a mix of Java applications in your CICS region which use different JVM profiles, and so mismatches and steals occur.
- You have peaks and troughs in your Java workload, and during times of low workload, some of your JVMs time out because they remain unused for long enough.

You can use strategies to avoid or minimize the impact of these situations, if they occur too frequently in your CICS region.

JVMs that use the shared class cache

JVMs that use the shared class cache have a significantly shorter initialization time because they use preloaded classes that are available in the shared class cache.

In terms of the processor time used for each transaction, some applications perform slightly better in a continuous JVM that uses the shared class cache, and some applications perform slightly better in a continuous JVM that does not use the shared class cache. If the processor time for each transaction is your overriding consideration, and is more important than initialization time, test the application in both types of JVM. If your JVMs have to be reinitialized from time to time, take the lower initialization time for a JVM that uses the shared class cache into account in your assessment.

Calculating storage requirements for pooled JVMs

To increase the number of pooled JVMs in a region, you must ensure that enough storage is available to CICS.

About this task

JVMs use storage below the 16 MB line, 31-bit storage, and 64-bit storage. To run pooled JVMs incurs a one-off storage cost, no matter how many JVMs run in the CICS region. Each pooled JVM and its Language Environment enclave also require a certain amount of 31-bit and 64-bit storage. The default values for the JVM heap sizes are:

Table 13. JVM profile options for heap sizes

Description	Option in the JVM profile	Pooled JVM profile value
Heap: initial storage allocation	`-Xms`	16 MB
Heap: maximum size	`-Xmx`	16 MB

The storage required for the JVM heap comes from the CICS region 64-bit storage above the bar. Larger JVM heaps reduce the number of JVMs that can be present in a CICS region, and increase the **MEMLIMIT** size that is required to support them. However, if the heap size is set too small, excessive garbage collection takes place, which affects performance. The JVM storage options must be tuned in order to achieve the best performance for your Java workloads. The JVM storage options help to determine the processor usage, storage usage, and task response times for Java applications.

Procedure

1. Determine the amount of free storage available below the bar by using the sample statistics program DFH0STAT. The storage reports include the amount of user storage allocated in 31-bit storage and below the 16 MB line.
   - If you have no JVMs running, subtract the storage that is reserved for the z/OS shared library region from the total amount of free storage in the CICS address space. The storage is controlled by the **SHRLIBRGNSIZE** parameter in MVS and is allocated once when the first pooled JVM is started in the region.
   - If you have pooled JVMs running, subtract the value of the **SHRLIBRGNSIZE** parameter from the total amount of free storage. Each JVM that is running uses 12 KB of storage below the 16 MB line. The Language Environment

enclave for each JVM uses 31-bit storage for the heap and library heap. The amount of allocated 31-bit storage is set by the HEAP64 and LIBHEAP64 options in DFHJVMRO. You must also subtract these values to work out how much storage is currently available.

If you want to change the 31-bit storage settings, you can adjust the **SHRLIBRGNSIZE** parameter and the Language Environment options. See "Tuning the z/OS shared library region" on page 177 and "Using DFHJVMRO to modify the enclave for pooled JVMs" on page 176.

2. Calculate how much 64-bit storage is required for each additional pooled JVM. You can calculate the 64-bit storage requirements for a pooled JVM by adding up the following storage requirements:
   - The -Xmx value in the JVM profile.
   - The amount of 64-bit storage that is specified by the HEAP64 option in DFHJVMRO.
   - The amount of 64-bit storage that is specified by the LIBHEAP64 option in DFHJVMRO.
   - The amount of 64-bit storage that is specified by the STACK64 option in DFHJVMRO. Multiply this value by 5 to include the system and application threads that are used by each pooled JVM.

   If your applications use several JVM profiles that specify different heap sizes, you can estimate the average maximum heap.
   a. Collect statistics for the JVM profiles to report the level of activity for each JVM profile and the maximum heap.
   b. The field "Total number of requests for this profile" tells you how many times each type of JVM was requested by an application during your sampling period, which can reflect the proportions of each type of JVM that is typically in the JVM pool. Multiply the total number of requests for each JVM profile, by the storage requirement you have calculated for that profile.
   c. Add the results for all the JVM profiles and divide this figure by the total number of requests for JVMs in the sampling period.
3. Check the **MEMLIMIT** value to determine whether you have enough 64-bit storage available to run additional pooled JVMs. You must allow for the other CICS facilities that use 64-bit storage.

   The z/OS **MEMLIMIT** parameter limits the amount of 64-bit (above-the-bar) storage for the CICS region. For information about the CICS facilities that use 64-bit storage, and how to check and adjust this parameter, see Estimating, checking, and setting MEMLIMIT in the Performance Guide.

Tuning pooled JVM heaps and garbage collection

The garbage collection options that you specify in JVM profiles for pooled JVMs can have a significant influence on the performance of your Java applications. You can use the output from the garbage collection process in the JVM to tune these settings.

About this task

As well as being triggered by allocation failures, garbage collection can be initiated by CICS. CICS initiates garbage collection using a System.gc() call when heap utilization in the active part of the storage heap reaches a specified limit. The default is 85%, meaning that when 85% of the storage in the active part of the storage heap is used, CICS schedules a garbage collection. CICS checks heap utilization after every Java program execution. If the limit has been reached, the garbage collection transaction CJGC is scheduled to run in the JVM immediately after the current use of the JVM ends. Between these garbage collections, however, allocation failures could still occur if a Java program begins to run when heap utilization is below the limit, then uses all the remaining storage in the active part of the heap, and still requires more storage.

The garbage collections scheduled by CICS are carried out as a separate system transaction, CJGC. Garbage collections caused by allocation failures, however, take place while an application is running in the JVM. If garbage collection takes place while an application is running, it delays the application, and it is counted in the CICS statistics for the user transaction.

Procedure

1. Identify the JVM profile for the pooled JVM that you want to tune.
2. Edit the JVM profile:
   a. Depending on your performance goals, you might want to minimize task response times by setting the `GC_HEAP_THRESHOLD` option so that garbage collection is initiated by CICS rather than being caused by allocation failures. If you do not want CICS to initiate garbage collection, you can set `GC_HEAP_THRESHOLD` to 100. All garbage collections result from allocation failures while applications are running.
   b. Specify the option `-verbose:gc`. The JVM outputs garbage collection messages to the file that is specified by the `STDERR` option in the JVM profile (the default name is `dfhjvmerr`). The file is in the z/OS UNIX directory that is specified by the `WORK_DIR` option in the JVM profile. If possible, clear this file of any existing messages (you can delete the file and it will be re-created).
   c. If you want to examine the normal behavior of the JVM with its present heap settings, do not edit the maximum and minimum heap size values. If you are attempting to determine more suitable heap settings for this JVM profile, specify the following values in the JVM profile:

      ```
      -Xmx100M
      -Xms1M
      ```

      The `-Xmx` value is large so that the heap can expand up to the size it requires. The `-Xms` value is small so that the heap begins at a size smaller than required, and expands to the minimum size required to run the Java workload.
3. Set the **MAXJVMTCBS** system initialization parameter to 1. You can do this while CICS is running by using the **CEMT SET DISPATCHER MAXJVMTCBS** command. With the default settings in the CICS-supplied sample JVM profiles, the output from all the JVMs in the CICS region is directed to the same file, so in this situation having only one JVM makes it easier to analyze the behavior of the Garbage Collector. Alternatively, you can change the STDERR option in the JVM profile to specify individual output files for each JVM.
4. Use the **CEMT INQUIRE JVM** command to view the contents of the JVM pool. If any JVMs are displayed, purge the JVM pool by using the **CEMT PERFORM JVMPOOL** command. This ensures that a JVM with the profile that you want to tune is re-created with the `-verbose:gc` option and any new heap settings that you have specified.
5. Using TPNS (Teleprocessing Network Simulator) or another network simulator, run a large number of transactions that are representative of the usual, or intended, workload for a JVM with the profile that you want to tune. As a guide, any single transaction has to run around 1000 times to ensure that most

JIT-compilation is invoked. However, if you know that a transaction is unlikely ever to be run this number of times for a given JVM, run the transaction the maximum expected number of times instead.

6. Locate the file containing the output from garbage collection for analysis. The output is in XML. See verbose:gc logging for examples and explanations of the output, including an allocation failure involving heap expansion and the output from a garbage collection triggered by a System.gc() call.

   Tip: You can use the file in the Memory Analyzer tool to perform more detailed analysis.

   The output from garbage collection shows you the following information:
   - Occurrences of garbage collections that were initiated by CICS when the heap utilization threshold was reached
   - Occurrences of garbage collections that were caused by an allocation failure
   - The amount of free space in the storage heap, in bytes and as a percentage
   - The amount of free space before and after a garbage collection is shown
   - The time taken for each garbage collection, in milliseconds
   - Occurrences of heap expansion
   - The amount by which a storage heap was expanded and the new size of the heap, in bytes

   The total time taken for a garbage collection triggered by a System.gc() call is displayed in the output twice, once excluding and once including the time required to obtain exclusive VM access. You can base your tuning on either of these total times, but make sure you use the same one consistently, and do not add both together.

Results

The outcome of your tuning can vary depending on your Java workload, the maintenance level of CICS and of the IBM SDK for z/OS, and other factors. For more detailed information about the storage and garbage collection settings and the tuning possibilities for JVMs, see the Java Diagnostics Guide.

Dealing with MVS storage constraints

If CICS attempts to create too many pooled JVMs for the available MVS storage, it can result in an MVS storage constraint. The pooled JVM fails to start, CICS issues message DFHSJ0203, and Language Environment fails with a return code of 12.

About this task

JVMs use 64-bit storage, and the amount of 64-bit (above-the-bar) storage for the CICS region is limited by the z/OS **`MEMLIMIT`** parameter. You cannot alter the value of this parameter while CICS is running; you can specify a new value on the next start of the CICS region. Therefore, you might want to adjust other settings in the JVM profiles before changing the **`MEMLIMIT`** parameter.

Procedure

1. Check that the storage heap settings in your JVM profiles are not too high, particularly the `-Xmx` option, which defines the maximum size for the storage heap. The `-Xmx` option for each of the JVM profiles in use in your CICS region is displayed when you collect statistics for JVM profiles. “Tuning pooled JVM heaps and garbage collection” on page 166 tells you how to change these settings.

2. Check whether you have a problem with high peak usage of a particular JVM profile. If so, you can consider using the technique described in “Dealing with excessive mismatches and steals” to limit the number of transactions that request a JVM with that profile. This involves defining the transactions which run JVM programs requiring that JVM profile, in the same transaction class (TRANCLASS), and placing a limit on that transaction class.
3. Calculate the number of JVMs that you want to run in your CICS region and adjust the value of the **MEMLIMIT** parameter. “Calculating storage requirements for pooled JVMs” on page 165 tells you how to do this. You must also adjust the MAXJVMTCBS limit accordingly.

Dealing with excessive mismatches and steals

CICS assigns pooled JVMs to applications, and tries to avoid mismatches and steals wherever it makes sense to do so. However, if there are no suitable JVMs and no space in the JVM pool, CICS can fulfill an application request through a mismatch or steal. You can use the CICS statistics to see if the incidence of mismatches and steals in the JVM pool is greater than you would like. There are some techniques you can use to intervene if required.

About this task

When an application requests a JVM, CICS first tries to find a suitable JVM that is available for reuse in the JVM pool. If a JVM with the correct JVM profile and execution key is unavailable, and the MAXJVMTCBS limit for the JVM pool has not yet been reached, CICS can create a new JVM for the application.

If there are no suitable JVMs and no space in the JVM pool, CICS destroys an available JVM and reinitializes the JVM with the correct profile and execution key. This process is called a *mismatch* if the JVM is destroyed and reinitialized but the TCB is kept and reused, and a *steal* if both the JVM and the TCB are destroyed and replaced. Before allowing a mismatch or a steal, CICS uses its selection mechanism to decide whether it is worthwhile.

Procedure

1. Assess the incidence of mismatches and steals in the JVM pool. In the CICS dispatcher TCB mode statistics, the statistics fields “TCB Mismatches” and “TCB Steals”, for the TCB modes J8 and J9, show the overall incidence of mismatches and steals in the JVM pool. In the CICS statistics for JVM profiles, the field “Number of times this profile stole a TCB” shows the combined incidence of both mismatches and steals for each JVM profile.
2. You cannot specify the number of JVMs with each JVM profile that CICS keeps in the JVM pool. You can indirectly limit the number of JVMs with a particular JVM profile, by limiting the number of transactions that request a JVM with that profile:
   a. Define the transactions which run JVM programs requiring that JVM profile, in the same transaction class (TRANCLASS).
   b. Assign a MAXACTIVE value to the TRANCLASS.

   This value limits the number of concurrent executions of JVM programs requiring that JVM profile, and so limits the maximum number of JVMs with that JVM profile that are in the JVM pool at any one time.
3. As an alternative, you can attempt to reduce the number of different JVM profiles that are used by your CICS region. The fewer the number of JVM

types, the more chance there is of an existing JVM matching an application request, and so the mismatches and steals reduce in number:

a. Check that all your JVM profiles and their associated JVM properties files do specify different options.
b. Investigate whether you can combine compatible options in different JVM profiles to create a single JVM profile. For example, if you found two infrequently used JVM profiles that contained similar options, but one specified a larger storage heap size, you might combine these profiles into a single JVM profile that specified the larger storage heap size. Although some applications might use a larger JVM, the reduction in the incidence of mismatches and steals is more beneficial.

Language Environment enclave storage for JVMs

A JVM runs as a z/OS UNIX System Services process in a Language Environment enclave that is created using the Language Environment preinitialization module, CELQPIPI. You can modify the runtime options for the enclave to tune the storage that is allocated by MVS.

JVMs use MVS Language Environment services rather than CICS Language Environment services. As a result, all storage obtained by the JVM is MVS storage, obtained by calls to MVS Language Environment services. This storage resides within the CICS address space but is not included in the CICS dynamic storage areas (DSAs). All JVMs that run in CICS use 64-bit storage.

The Language Environment enclave for each JVM must contain not only the JVM storage heap, but also a basic amount of storage for each JVM. This basic storage cost represents the amount of storage in the Language Environment enclave that is used for the structure of the JVM. When you calculate the total size of the JVM, the basic storage cost must be added to the storage that is used for the storage heap.

The Language Environment runtime options are set by DFHAXRO and DFHJVMRO. DFHAXRO provides the options for a JVM server and DFHJVMRO provides the options for pooled JVMs. The default values provided by these programs for a JVM enclave are shown in Table 14:

Table 14. Language Environment runtime options used by CICS for the JVM enclave

Language Environment runtime options	JVM server values	Pooled JVM values
Heap storage	`HEAP64(100M,4M,KEEP,4M,512K,KEEP,1K,1K,KEEP)`	`HEAP64(8M,2M,KEEP,512K,512K,KEEP,1K,1K,KEEP)`
Library heap storage	`LIBHEAP64(3M,3M)`	`LIBHEAP64(1M,1M,FREE,16K,4K,FREE,4K,2K,FREE)`
Library routine stack frames that can reside anywhere in storage	`STACK64(1M,1M,32M)`	`STACK64(1M,1M,32M)`
Optional user heap storage management for multithreaded applications	`HEAPPOOLS64(ALIGN)`	N/A
Optional heap storage management for multithreaded applications	`HEAPPOOLS(ALIGN)`	N/A

Table 14. Language Environment runtime options used by CICS for the JVM enclave (continued)

Language Environment runtime options	JVM server values	Pooled JVM values
Amount of storage reserved for the out-of-storage condition and the initial content of storage when allocated and freed	`STORAGE(NONE,NONE,NONE)`	`STORAGE(NONE,NONE,NONE,0K)`

For information about Language Environment runtime options, see *z/OS Language Environment Customization*.

You can override the Language Environment runtime options:

Options for JVM servers

For JVM servers, modify and recompile the sample program DFHAXRO, which is described in "Using DFHAXRO to modify the enclave of a JVM server" on page 173. This program is set on the JVMSERVER resource, so you can use different options the Language Environment enclave for individual JVM servers if required. The default Language Environment storage settings that control the initial size of, and incremental additions to, the Language Environment enclave heap storage can make inefficient use of MVS storage. The storage settings that CICS supplies are more efficient. You can also modify these settings to match more closely with the storage use of your JVMs. Ensure that the heap sizes are set to avoid many segment allocations and frees.

Options for pooled JVMs

For pooled JVMs, use the DFHJVMRO user-replaceable module, which is described in "Using DFHJVMRO to modify the enclave for pooled JVMs" on page 176.

To improve the use of MVS storage, use DFHJVMRO to set the initial allocation for the amount of Language Environment enclave heap storage to a value that approximates to the storage used by your Java applications that run in pooled JVMs, using this as an initial heap size. The settings that you make using DFHJVMRO apply to all the JVMs in your CICS region, so consider the different storage heap sizes and basic storage costs that JVMs with different profiles might have.

The amounts of storage required for a JVM in a Language Environment enclave might require changes to installation exits, IEALIMIT or IEFUSI, which you use to limit the **REGION** and **MEMLIMIT** sizes. A possible approach is to have a Java owning region (JOR), to which all Java program requests are routed. Such a region runs only Java workloads, minimizing the amount of CICS DSA storage required and allowing the maximum amount of MVS storage to be allocated to JVMs.

Identifying Language Environment storage needs for JVM servers

You can identify a suitable value for the initial allocation of Language Environment enclave heap storage in a JVM server by generating storage reports. Generating storage reports increase processor costs, so run them at an appropriate time in a production environment.

About this task

The HEAP64 runtime option in DFHAXRO controls the heap size of the Language Environment enclave for a JVM server. This option includes settings for 64-bit and 31-bit storage. You can use your own program instead of DFHAXRO if preferred. The program must be specified on the JVMSERVER resource.

Procedure

1. Set the RPTO(ON) and RPTS(ON) options in DFHJVMRO. These options are in comments in the supplied source of DFHAXRO. Specifying these options causes Language Environment to report on the storage options and to write a storage report showing the actual storage used.
2. Disable the JVMSERVER resource. The JVM server shuts down and the Language Environment enclave is removed.
3. Enable the JVMSERVER resource. CICS uses the Language Environment runtime options in DFHAXRO to create the enclave for the JVM server. The JVM also starts up.
4. Run your Java workloads in the JVM server to collect data about the storage that is used by the Language Environment enclave.
5. Remove the RPTO(ON) and RPTS(ON) options from DFHAXRO.
6. Disable the JVMSERVER resource to generate the storage reports. The storage reports include a suggestion for the initial Language Environment enclave heap storage. The entry "Suggested initial size" in the 64-bit user heap statistics contains the suggested value and is equal to the total amount of Language Environment enclave heap storage that was used by the JVM server.

Results

The storage reports are saved in an stderr file in z/OS UNIX. The directory depends on whether you have redirected output for the JVM in the JVM profile. If no redirection exists, the file is saved in the working directory for the JVM. If no value is set for WORK_DIR in the profile, the file is saved in the /tmp directory.

Use the information in the storage reports to select a suitable value for the initial Language Environment enclave heap storage in DFHAXRO. Language Environment can make additions to the heap storage, but it cannot remove unwanted storage that is given in the initial allocation. Allocate enough storage to ensure the number of segments allocated and freed are minimal.

You can also use this technique to set the initial size and increment values for the LIBHEAP64 and STACK64 runtime options.

Example

The following example is a storage report from Language Environment:

```
64bit User HEAP statistics:
      Initial size:                                          50M
      Increment size:                                         4M
      Total heap storage used:                          91977408
      Suggested initial size:                                88M
      Successful Get Heap requests:                         2439
      Successful Free Heap requests:                        1619
      Number of segments allocated:                            1
      Number of segments freed:                                0
31bit User HEAP statistics:
      Initial size:                                       524288
```

```
Increment size:                                          524288
Total heap storage used (sugg. initial size):           8440784
Successful Get Heap requests:                              1965
Successful Free Heap requests:                             1904
Number of segments allocated:                                 2
Number of segments freed:                                     0
```

Based on the values for Language Environment enclave heap storage in the example, you can set these values for heap storage in DFHAXRO:

```
HEAP64(88M,4M,KEEP,10M,512K,KEEP,1K,1K,KEEP)
```

Using DFHAXRO to modify the enclave of a JVM server

DFHAXRO is a sample program that provides a default set of runtime options for the Language Environment enclave in which a JVM server runs. For example, it defines storage allocation parameters for the JVM heap and stack. For CICS, the storage settings that are supplied in DFHAXRO are more appropriate than the default Language Environment storage settings.

About this task

You can update the sample program to tune the Language Environment enclave or you can write your own program based on the sample. The program is defined on the JVMSERVER resource and is called during the CELQPIPI preinitialization phase of the Language Environment enclave that is created for a JVM server.

You must write the program in assembler language and it must not be translated with the CICS translator. The options are specified as character strings, comprising a 2-byte string length followed by the runtime option. The maximum length for all Language Environment runtime options is 255 bytes, so use the abbreviated version of each option and restrict your changes to a total of under 200 bytes.

Procedure

1. Copy the DFHAXRO program to a new location to edit the runtime options. If maintenance is applied to your CICS region, you might want to reflect the changes in your program. The source for DFHAXRO is in the CICSTS42.CICS.SDFHSAMP library.
2. Edit the runtime options, using the abbreviation for each option. The *z/OS Language Environment Programming Guide* has complete information about Language Environment runtime options.
   - Keep the size of the list of options to a minimum for quick processing and because CICS adds some options to this list.
   - Use the HEAP64 option to specify the initial heap allocation.
   - The ALL31 option, the POSIX option, and the XPLINK option are forced on by CICS. The ABTERMENC option is set to (ABEND) and the TRAP option is set to (ON,NOSPIE) by CICS.
   - The output produced by the RPTO and RPTS options is written to the CESE transient data queue.
   - Any options that produce output do so at each JVM termination. Consider the volume of output that might be produced and directed to CESE.
3. Use the DFHASMVS procedure to compile the program.

Results

When you enable the JVMSERVER resource, CICS creates the Language Environment enclave using the runtime options that you specified in the DFHAXRO program. CICS checks the length of the runtime options before passing them to Language Environment. If the length is greater than 255 bytes, CICS does not attempt to start the JVM server and writes error messages to CSMT. The values that you specify are not checked by CICS before being passed to Language Environment.

Identifying Language Environment storage needs using JVM statistics

You can use the CICS statistics to see how much Language Environment enclave heap storage is used by your JVMs. The field "Peak Language Environment heap storage used" in the JVM Profile statistics shows the peak (or high watermark) amount of Language Environment enclave heap storage that was used by a JVM with the specified execution key and profile. Collecting this statistic affects the performance of JVMs, so carry out this process at an appropriate time in a production environment.

Procedure

1. Use the **`EXEC CICS INQUIRE JVMPROFILE`** command to identify each of the JVM profiles in use in your CICS region. (There is no CEMT equivalent for this command.)
2. Specify the option LEHEAPSTATS=YES in each of the JVM profiles that you have identified.
3. Purge your JVMs using the CEMT SET JVMPOOL PHASEOUT command (or the equivalent EXEC CICS command), around the time of a statistics reset (either before or immediately afterwards). This ensures that the statistics collected in the next statistics interval are a more accurate reflection of the storage usage for your JVMs. It also ensures that your JVMs will be re-created using the LEHEAPSTATS=YES option.
4. Run a representative sample of the transactions that use your JVMs.
5. Either collect the JVM profile statistics using the EXEC CICS COLLECT STATISTICS JVMPROFILE or CEMT PERFORM STATISTICS JVMPROFILE command, or view the JVM profile statistics that have been collected during the statistics interval.
6. Remove the option LEHEAPSTATS=YES from your JVM profiles, or change it to NO (which is the default).
7. Purge your JVMs using the CEMT SET JVMPOOL PHASEOUT command to ensure that they are re-created with the option LEHEAPSTATS=NO.
8. Examine the field "Peak Language Environment heap storage used" in the JVM Profile statistics for each JVM profile.

Results

Use the value in the "Peak Language Environment heap storage used" field to set as the initial heap size in DFHJVMRO. If the peak amount of storage used varies between JVM profiles, select a suitable value based on the relative usage of each JVM profile. Try to select a value that is close to the storage used by most of your JVMs. Language Environment can make additions to the heap storage, but it cannot remove unwanted storage that is given in the initial allocation.

Identifying Language Environment storage needs using DFHJVMRO

You can identify a suitable value for the initial allocation for the amount of Language Environment enclave heap storage by setting additional runtime options in DFHJVMRO. These options increase processor costs, so use them at an appropriate time in a production environment.

About this task

The `HEAP64` runtime option in DFHJVMRO controls the heap size of the Language Environment enclave. This option includes settings for 64-bit and 31-bit storage.

DFHJVMRO cannot identify the JVM profile to which each storage report applies, so use this procedure for only one JVM profile at a time, by making sure you are using transactions that request only that JVM profile.

Procedure

1. Set the RPTO(ON) and RPTS(ON) options in DFHJVMRO. These options are in comments in the supplied source of DFHJVMRO. Specifying these options causes Language Environment to report on the storage options and to write a storage report showing the actual storage used.
2. Purge any JVMs in your JVM pool to ensure that they are re-created using the RPTO(ON) and RPTS(ON) options. You can use the **Operations** > **Java** > **JVM pools** view in CICS Explorer or use the **`CEMT SET JVMPOOL PHASEOUT`** command
3. Run a representative sample of the transactions that use pooled JVMs with the JVM profile that you want to examine. The JVM profile for a program is named in the PROGRAM resource.
4. Remove the RPTO(ON) and RPTS(ON) options from DFHJVMRO.
5. Purge your JVMs. The storage reports are written when each JVM ends. The storage reports include a suggestion for the initial Language Environment enclave heap storage. The entry “Total heap storage used (sugg. initial size)” contains the suggested value and is equal to the total amount of Language Environment enclave heap storage that was used by the JVM.
6. Examine all the sets of storage reports to check for any variations in the amount of storage used.

Results

Select a suitable value for the initial Language Environment enclave heap storage in DFHJVMRO. Try to select a value that is close to the storage used by most of your JVMs. Language Environment can make additions to the heap storage, but it cannot remove unwanted storage that is given in the initial allocation.

You can also use this technique to set the initial size and increment values for the `LIBHEAP64` and `STACK64` runtime options.

Example

The following example is a storage report from Language Environment:

```
64bit User HEAP statistics:
   Initial size:                                      8M
   Increment size:                                    2M
   Total heap storage used:                    30573536
   Suggested initial size:                           30M
   Successful Get Heap requests:                       24395
   Successful Free Heap requests:                      12416
   Number of segments allocated:                           7
   Number of segments freed:                               0

31bit User HEAP statistics:
   Initial size:                                      524228
   Increment size:                                    524228
   Total heap storage used (sugg. initial size):     1099824
   Successful Get Heap requests:                         599
   Successful Free Heap requests:                        567
   Number of segments allocated:                           2
   Number of segments freed:                               0
```

Based on the values for Language Environment enclave heap storage in the example, you can set these values for heap storage in DFHJVMRO:

```
HEAP64(30M,2M,KEEP,1099824,512K,KEEP,1K,1K,KEEP)
```

Using DFHJVMRO to modify the enclave for pooled JVMs

DFHJVMRO specifies the runtime options that are used to create the Language Environment enclave in which a pooled JVM runs. It defines storage allocation parameters for heap and stack and a number of other options. For CICS, the storage settings that are supplied in DFHJVMRO are more appropriate than the default Language Environment storage settings.

About this task

DFHJVMRO is a user-replaceable module (URM) that is called during the CELQPIPI preinitialization phase of the Language Environment enclave for every pooled JVM. You might want to change the supplied version of the program in the following situations:

- Use the `RPTO` and `RPTS` options to obtain reports on the storage options set, and the actual storage used, for JVMs.
- Set storage heap values for the enclave that are different from the supplied settings. The Java heap is allocated separately from the enclave heap.
- At the request of the IBM service team, set other options to obtain diagnosis information.

You must write the program in assembler language and it must not be translated with the CICS translator. The options are specified as character strings, comprising a 2-byte string length followed by the runtime option. The maximum length for all Language Environment runtime options is 255 bytes, so use the abbreviated version of each option and restrict your changes to a total of under 200 bytes.

Procedure

1. Copy the DFHJVMRO program to a new location to edit the runtime options. If maintenance is applied to your CICS region, you might want to reflect the changes in your program. The source for DFHJVMRO is in the CICSTS42.CICS.SDFHSAMP library.
2. Edit the runtime options, using the abbreviation for each option. The source code for DFHJVMRO contains comments with examples of how to set these options. The *z/OS Language Environment Programming Guide* has complete information about Language Environment runtime options.
   - Keep the size of the list of options to a minimum for quick processing and because CICS adds some options to this list.

- Use the HEAP64 option to specify the initial heap allocation.
- The XPLINK option is forced on by CICS and the ALL31 options is therefore forced on by Language Environment. The POSIX option defaults to ON because of the AMODE(64) option. The ABTERMENC defaults to ABEND and the TRAP option is set to (ON,NOSPIE) by CICS.
- The output produced by the RPTO and RPTS options is written to the CESE transient data queue.
- Any options that produce output do so at each JVM termination. Consider the volume of output that might be produced and directed to CESE.

3. Check that the length of the options does not exceed 200 characters. The maximum length is 255 characters, but CICS adds some options automatically.
4. Use the DFHASMVS procedure to compile the program.

Results

When CICS receives a request to run a Java program, CICS creates the Language Environment enclave for the pooled JVM using the runtime options that you specified in the DFHJVMRO program. CICS checks the length of the runtime options before passing them to Language Environment. If the length is greater than 255 bytes, CICS does not attempt to start the pooled JVM and writes error messages to CSMT. The values that you specify are not checked by CICS before being passed to Language Environment.

Tuning the z/OS shared library region

The shared library region is a z/OS feature that enables address spaces to share dynamic link library (DLL) files. This feature enables your CICS regions to share the DLLs that are needed for JVMs, rather than each region having to load them individually. This can greatly reduce the amount of real storage used by MVS, and the time it takes for the regions to load the files.

The storage that is reserved for the shared library region is allocated in each CICS region when the first JVM is started in the region. The amount of storage that is allocated is controlled by the **SHRLIBRGNSIZE** parameter in z/OS, which is in the BPXPRMxx member of SYS1.PARMLIB. The minimum is 16 MB, and the z/OS default is 64 MB. You can tune the amount of storage that is allocated for the shared library region by investigating how much space you need, bearing in mind that other applications besides CICS might be using the shared library region, and adjusting the **SHRLIBRGNSIZE** parameter accordingly.

If you want to reduce the amount of storage that is allocated for the shared library region, first check that you do not have wasted space in your shared library region. Bring up your normal workload on the z/OS system, then issue the command **D OMVS,L** to display the library statistics. If there is unused space in the shared library region, you can reduce the setting for **SHRLIBRGNSIZE** to remove this space. If CICS is the only user of the shared library region, you can reduce the **SHRLIBRGNSIZE** to the minimum of 16 MB, because the DLLs needed for the JVM only use around 10 MB of the region.

If you find that all the space in the shared library region is being used, but you still want to reduce this storage allocation in your CICS regions, there are three possible courses of action that you can consider:

1. It is possible to set the shared library region size smaller than the amount of storage that you need for the files. When the shared library region is full, files

are loaded into private storage instead, and do not benefit from the sharing facility. If you choose this course of action, you should make sure that you bring up your more important applications first, to ensure that they are able to make use of the shared library region. This course of action is most appropriate if most of the space in the shared library region is being used by non-critical applications.

2. The DLLs that are placed in the shared library region are those marked with the extended attribute +l. You can remove this attribute from some of your files to prevent them going into the shared library region, and so reduce the amount of storage that you need for the shared library region. If you choose this course of action, select files that are less frequently shared, and also try not to select files that have the extension .so. Files with the extension .so, if they are not placed in the shared library region, are shared by means of user shared libraries, and this sharing facility is less efficient than using the shared library region. This course of action is most appropriate if large files that do not have the extension .so are using most of the space in the shared library region.
3. If you remove the extended attribute +l from all the files relating to the CICS JVM, then your CICS regions do not use the shared library region at all, and no storage is allocated for it within the CICS regions. If you choose this course of action, you do not benefit from the shared library region's sharing facility. This course of action is most appropriate if other applications on the z/OS system require a large shared library region, and you do not want to allocate this amount of storage in your CICS regions.

If you choose to remove the extended attribute +l from any of your files, when you replace those files with new versions (for example, during a software upgrade), remember to check that the new versions of the files do not have this attribute.

You can find more information about shared libraries in z/OS UNIX on the z/OS UNIX System Services Web site at http://www.ibm.com/servers/eserver/zseries/zos/unix/perform/sharelib.html.

Chapter 8. Troubleshooting Java applications

If you have a problem with a Java application, you can use the diagnostics provided by CICS and the JVM to determine the cause of the problem.

About this task

CICS provides some statistics, messages, and tracing to help you diagnose problems related to Java. The diagnostic tools and interfaces provided with Java can give you more detailed information about what is happening in the JVM than CICS, because CICS is unaware of many of the activities in a JVM.

You can use freely available tools that perform realtime and offline analysis of a JVM, for example JConsole and IBM Health Center. For full details, see Using diagnostic tools in the *Java Diagnostics Guide*.

Procedure

1. If you are unable to start a JVM server or a pooled JVM, check that the setup of your Java installation is correct. Use the CICS messages and any errors in the `stderr` file for the JVM to determine what might be causing the problem.
   a. Check that the correct version of the Java SDK is installed and that CICS has access to it in z/OS UNIX. CICS supports the IBM 64-bit SDK for z/OS, Java Technology Edition Version 6.0.1.
   b. Check that the **USSHOME** system initialization parameter is set in the CICS region. This parameter specifies the home for files on z/OS UNIX.
   c. Check that the **JVMPROFILEDIR** system initialization parameter is set correctly in the CICS region. This parameter specifies the location of the JVM profiles on z/OS UNIX.
   d. Check that the CICS region has read and execute access to the z/OS UNIX directories that contain the JVM profiles.
   e. Check that the CICS region has write access to the working directory of the JVM. This directory is specified in the `WORK_DIR` option in the JVM profile.
   f. Check that the `JAVA_HOME` option in the JVM profiles points to the directory that contains the Java SDK.
   g. Check that SDFJAUTH is in the STEPLIB concatenation of the CICS startup JCL.
   h. If you are using WebSphere MQ or DB2 DLL files, check that the 64-bit version of these files is available to CICS.
   i. If you have changed DFHAXRO or DFHJVMRO to configure the Language Environment enclave, ensure that the runtime options do not exceed 200 bytes and that the options are valid. CICS does not validate the options that you specify before passing them to Language Environment. Check SYSOUT for any error messages from Language Environment.
2. If your setup is correct, gather diagnostic information to determine what is happening to the application and the JVM.
   a. Add `PRINT_JVM_OPTIONS=YES` to the JVM profile. When you specify this option, all the options passed to the JVM at startup, including the contents of the class paths, are printed to SYSPRINT. The information is produced every time a JVM is started with this option in its profile.

   b. Check the `dfhjvmout` and `dfhjvmerr` files for information and error messages from the JVM. These files are in the directory specified by the `WORK_DIR` option in the JVM profile. The files might have different names if the STDOUT and STDERR options were changed in the JVM profile.
3. If the application is failing or performing poorly, debug the application using a JPDA debugger.
4. If you are getting out-of-memory errors, there might be insufficient 64-bit storage, the application might have a memory leak, or the heap size might be very small.
   a. Use CICS statistics or a tool such as IBM Health Center to monitor the JVM. If the application has a memory leak, the amount of live data that remains after garbage collection gradually increases over time until the heap is exhausted. The JVM server statistics report the size of the heap after the last garbage collection and the maximum and peak size of the heap.
   b. Run the storage reports for Language Environment to find out if there is enough storage available. See "Language Environment enclave storage for JVMs" on page 170.

What to do next

If you cannot fix the cause of the problem, contact IBM support. Make sure that you provide the required information, as listed in the MustGather for reporting Java problems.

Diagnostics for Java

Many of the usual sources of CICS diagnostic information contain information that applies to Java applications. In addition to the information supplied by CICS, there are a number of interfaces specific to the JVM that you can use for problem determination.

CICS diagnostic tools for Java

CICS has statistics and monitoring data that you can collect on running Java applications. When errors occur, transactions abend and messages are written to the appropriate log. See CICS messages and codes overview in Messages and Codes Vol 2 for a list of the abends and messages that apply to the JVM (SJ) domain. Messages related to Java are in the format DFHSJxxxx.

You can also switch on tracing to produce additional diagnostic information. The trace points for the JVM domain are listed in JVM domain trace points in Trace Entries.

When the first JVM is started in a CICS region after initialization, CICS issues message DFHSJ0207, showing the version of Java that is being used.

The Java SDK provides diagnostic tools and interfaces that give you more detailed information about what is happening in the JVM. Messages and diagnostic information from the JVM are written to the `stderr` log file for the JVM. If you encounter a Java problem, always consult this file. For example, if CICS issues a message to indicate that the JVM has abended, the `stderr` log file is the primary source of diagnostic information. "Controlling the location for JVM stdout, stderr and dump output" on page 182 tells you how to control the location of output from the JVM, and how to redirect messages from JVM internals and output from Java applications running in a JVM.

When you develop Java applications for CICS, it is important to consider the requirements for threadsafety and transaction isolation in CICS. If a Java application works correctly on its first use, but does not behave correctly on subsequent uses, then the problem is likely to be due to isolation issues. In this case, use the CICS JVM Application Isolation Utility as part of your problem determination work to help identify the cause of the problem.

OSGi diagnostic files

The OSGi framework produces diagnostic files in zFS that you can use to help troubleshoot problems with OSGi bundles and services in a JVM server:

OSGi cache
: The OSGi cache is in the `*$WORK_DIR*/*applid*/*jvmserver*/configuration/org.eclipse.osgi` directory of the JVM server. *$WORK_DIR* is the working directory of the JVM server, *applid* is the CICS APPLID, and *jvmserver* is the name of the JVMSERVER resource. The OSGi cache contains framework metadata and other information that is required to run the framework. The cache is replaced when the JVM server starts up.

OSGi logs
: If an error occurs in the OSGi framework, an OSGi log is created in the *$WORK_DIR*/*applid*/*jvmserver*/`configuration/` directory of the JVM server. The file extension is `.log`. The OSGi framework continues to write to the log file until it reaches 1000 KB in size. After this, the OSGi framework creates another log file to write out further error messages. You can have up to ten log files in the directory. After the tenth log file is full, the OSGi framework overwrites the oldest log file.

JVM diagnostic tools

The CICS documentation provides information about some of the Java diagnostic tools and interfaces:

- "Activating and managing tracing for JVM servers" on page 187 describes how you can use the component tracing provided by the CETR transaction to trace the life cycle of the JVM server and the tasks running inside it. JVM servers do not use auxiliary or GTF tracing. Instead, the tracing is written to a file on zFS that is uniquely named for each JVM server.
- "Defining and activating tracing for pooled JVMs" on page 188 describes how you can use the internal trace facility of a pooled JVM through the interfaces provided by CICS. The internal trace facility can provide detailed tracing of entry, exit, and event points within the JVM. This information is output as CICS trace.
- "Debugging a Java application" on page 190 describes how you can use a remote debugger to step through the application code for a Java application that is running in a JVM. CICS also provides a set of interception points (or "plugins") in the CICS Java middleware, which allows additional Java programs to be inserted immediately before and after the application Java code is run, for debugging, logging, or other purposes. For more information, see "The CICS JVM plugin mechanism" on page 191.

Many more diagnostic tools and interfaces are available for the JVM. See the Java Diagnostics Guide for information about further facilities that can be used for problem determination for JVMs. The following facilities provide useful diagnostic information:

- The internal trace facility of the JVM can be used directly, without going through the interfaces provided by CICS. The *Diagnostics Guide* has information about the system properties that you can use to control the internal trace facility and to output JVM trace information to various destinations. You can use these system properties to output trace from any method or class within the JVM, and to find the value of any parameters and return types on the method call.
- If you experience memory leaks in the JVM, you can request a heap dump from the JVM. A heap dump generates a dump of all the live objects (objects still in use) that are in the heap of the JVM. You can also analyze memory leaks using the IBM Health Center and Memory Analyzer tools, which are both available with IBM Support Assistant. For more information about Java tools, see IBM Monitoring and Diagnostics Tools for Java.
- The HPROF profiler, that is shipped with the IBM 64-bit SDK for z/OS, Java Technology Edition, provides performance information for applications that run in the JVM, so you can see which parts of a program are using the most memory or processor time.
- The JVM provides interfaces for monitoring, profiling, and RAS (Reliability, Availability, and Serviceability).

With all interfaces, options, or system properties available for the IBM JVM that are not specific to the CICS environment, use the IBM JVM documentation as the primary source of information.

Controlling the location for JVM stdout, stderr and dump output

Output from Java applications running in a JVM is normally written to the z/OS UNIX files that are named by the STDOUT and STDERR options in the JVM profile for the JVM. JAVADUMP files are written to the JVM's working directory on z/OS UNIX, and the more detailed Java TDUMPs are written to the file named by the JAVA_DUMP_TDUMP_PATTERN option. Most of these file names can be customized at runtime to uniquely identify the JVMs that produced them. During application development, you can also redirect the output from the JVM and messages from JVM internals using a Java class.

In the standard setup for a CICS JVM, the file named by the STDOUT option in the JVM profile is used for System.out requests, and the file named by the STDERR option is used for System.err requests. The output files are z/OS UNIX files located in the working directory named by the WORK_DIR option in the JVM profile.

You can specify a fixed file name for the `stdout` and `stderr` files. However, if you use a fixed file name, the output from all the JVMs which were created with that JVM profile is appended to the same file, and the output from different JVMs is interleaved with no record headers. This is not helpful for problem determination.

A better choice is to specify a variable file name for the `stdout` and `stderr` files. When you do this, the files can be made unique to each individual JVM during the lifetime of the CICS region. You can also include additional identifying information.

03 - The unique JVM number differentiates the JVM from any other JVMs in the
03 CICS region. The JVM number used in CICS is the same number that is used to
03 identify the JVM in the z/OS UNIX environment, where it is known as the
03 process id (PID) for the JVM. You can specify this number as part of the file
03 name using the &JVM_NUM; symbol, or using the **-generate** option.

- You can include the CICS region applid in the file name by using the &APPLID; symbol, or the **-generate** option.
- You can include a time stamp in the file name using the **-generate** option.

Other identifying information in file names includes the &DATE; and &TIME; symbols.

&DATE; is replaced by the current date in the form Dyymmdd

&TIME; is replaced by the current time in the format Thhmmss.

The location for JAVADUMP files output from the JVM is the working directory on z/OS UNIX named by the WORK_DIR option in the JVM profile. JAVADUMP files are uniquely identified by a timestamp in their names, and you cannot customize the names for these files.

TDUMPs output from the JVM, which contain more detailed dump output including the JVM's address space, are written to a data set destination. The name of the destination is specified by the JAVA_DUMP_TDUMP_PATTERN option in the JVM profile. You can use the &APPLID;, &DATE; &JVM_NUM;, and &TIME; symbols in this value to make the name unique to the individual JVM, as shown in the CICS-supplied sample JVM profiles. Note that in this context, CICS might have to modify the JVM number to conform to MVS data set naming standards.

The JVM writes information to its `stderr` file when it generates a JAVADUMP or a TDUMP. The Java Diagnostics Guide has more information about the contents of JAVADUMP and TDUMP files.

During application development, you can use the USEROUTPUTCLASS option in a JVM profile to name a Java class that intercepts and redirects the output from the JVM and messages from JVM internals. You can add time stamps and headers to the output records, and identify the output from individual transactions running in the JVM. CICS supplies sample classes which perform these tasks. Specifying this option has a negative effect on the performance of JVMs, so it should not be used in a production environment.

Redirecting JVM stdout and stderr output

During application development, the `USEROUTPUTCLASS` option can be used by developers to separate out their own JVM stdout and stderr output in a CICS region, and direct it to an identifiable destination of their choice. You can use a Java class to redirect the output, and you can add time stamps and headers to the output records. Dump output cannot be intercepted by this method.

Specifying the `USEROUTPUTCLASS` option has a negative effect on the performance of JVMs. For best performance in a production environment, do not use this option.

Output written to System.out() or System.err(), either by an application or by system code, can be redirected by the output redirection class. The z/OS UNIX files named by the `STDOUT` and `STDERR` options in the JVM profile are still used for some messages issued by the JVM, or if the class named by the `USEROUTPUTCLASS` option is unable to write data to its intended destination. You must therefore still specify appropriate file names for these files.

To use the `USEROUTPUTCLASS` option, specify `USEROUTPUTCLASS=[java class]` in a JVM profile, naming the Java class of your choice. The class extends java.io.OutputStream. The supplied sample JVM profiles contain the commented-out option `USEROUTPUTCLASS=com.ibm.cics.samples.SJMergedStream`, which names the supplied sample class. Uncomment this option to use the com.ibm.cics.samples.SJMergedStream class to handle output from JVMs with that profile. CICS also supplies an alternative sample Java class, com.ibm.cics.samples.SJTaskStream.

The source for the supplied user output classes is provided as samples, so you can modify the classes as you want, or write your own classes based on the samples.

For pooled JVMs, the class that you are using must be present in a directory on an appropriate class path in the JVM profile. The supplied sample class is automatically included on an appropriate class path and you do not have to specify it in the JVM profile. If you supply your own output redirection class, add the directory to the standard class path, using the `CLASSPATH_SUFFIX` option, in the JVM profile where you specified the `USEROUTPUTCLASS` option.

For JVM servers, you do not have to specify a class path. However, you must package your output redirection class as an OSGi bundle to run the class in the OSGi framework. For more information, see "Writing Java classes to redirect JVM stdout and stderr output" on page 131.

The CICS-supplied sample classes com.ibm.cics.samples.SJMergedStream and com.ibm.cics.samples.SJTaskStream

For Java applications executing on the initial process thread (IPT), which are able to make CICS requests, the intercepted output from the JVM can be written to a transient data queue, and you can add time stamps, task and transaction identifiers, and program names. This enables you to create a merged log file containing the output from multiple JVMs. You can use this log file to correlate JVM activity with CICS activity. The CICS-supplied sample class, com.ibm.cics.samples.SJMergedStream, is set up to create merged log files like this.

The com.ibm.cics.samples.SJMergedStream class directs output from the JVM to the transient data queues CSJO (for stdout output), and CSJE (for stderr output and internal messages). These transient data queues are supplied in group DFHDCTG, and they are indirected to CSSL, but they can be redefined if necessary.

In particular, note that the length of messages issued by the JVM can vary, and the maximum record length for the CSSL queue (133 bytes) might not be sufficient to contain some of the messages you receive. If this happens, the sample output redirection class issues an error message, and the text of the message might be affected.

If you find that you are receiving messages longer than 133 bytes from the JVM, you should redefine CSJO and CSJE as separate transient data queues. Make them extrapartition destinations, and increase the record length for the queue. You can allocate the queue to a physical data set or to a system output data set. You might find a system output data set more convenient in this case, because you do not then need to close the queue in order to view the output. TDQUEUE resources in the Resource Definition Guide tells you how to define transient data queues. If you redefine CSJO and CSJE, ensure that they are installed as soon as possible during a cold start, in the same way as for transient data queues that are defined in group DFHDCTG.

If the transient data queues CSJO and CSJE cannot be accessed, output is written to the z/OS UNIX files `/`*`work_dir`*`/`*`applid`*`/stdout/CSJO` and `/`*`work_dir`*`/`*`applid`*`/`

`stderr/CSJE`, where *work_dir* is the directory specified on the `WORK_DIR` option in the JVM profile, and *applid* is the APPLID identifier associated with the CICS region. If these files are unavailable, the output is written to the z/OS UNIX files named by the `STDOUT` and `STDERR` options in the JVM profile.

As well as redirecting the output, the class adds a header to each record containing the date, time, APPLID, TRANSID, task number and program name. The result is two merged log files for JVM output and for error messages, in which the source of the output and messages can easily be identified.

For Java applications executing on threads other than the initial process thread (IPT), which are not able to make CICS requests, the output from the JVM cannot be redirected using CICS facilities. The com.ibm.cics.samples.SJMergedStream class still intercepts the output and adds a header to each record. The output is then written to the z/OS UNIX files `/`*`work_dir`*`/`*`applid`*`/stdout/CSJO` and `/`*`work_dir`*`/`*`applid`*`/stderr/CSJE` as described above, or if these files are unavailable, to the z/OS UNIX files named by the `STDOUT` and `STDERR` options in the JVM profile.

As an alternative to creating merged log files for your JVM output, you can direct the output from a single task to z/OS UNIX files, and add time stamps and headers, to provide output streams that are specific to a single task. The CICS-supplied sample class, com.ibm.cics.samples.SJTaskStream is set up to do this. The class directs the output for each task to two z/OS UNIX files, one for stdout output and one for stderr output, that are uniquely named using a task number (in the format `YYYYMMDD.task.`*`tasknumber`*). The z/OS UNIX files are stored in the `stdout` directory for stdout output, or `stderr` directory for stderr output. The process is the same for both Java applications executing on the IPT, and Java applications that are executing on other threads.

When an error is encountered by the supplied sample output redirection classes, one or more error messages are issued reporting this. If the error occurred while processing an output message, then the error messages are directed to System.err, and as such are eligible for redirection. However, if the error occurred while processing an error message, then the new error messages are sent to the file named by the `STDERR` option in the JVM Profile. This avoids a recursive loop in the Java class. The classes do not return exceptions to the calling Java program.

The classes are shipped in the file `com.ibm.cics.samples.jar`, which is in the directory `/usr/lpp/cicsts/cicsts42/lib`, where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OS UNIX. The source for the classes is also provided as samples, so you can modify the classes as you want, or write your own classes based on the samples. For more information, see “Writing Java classes to redirect JVM stdout and stderr output” on page 131.

Control of Java dump options

The JAVA_DUMP_OPTS option in JVM profiles specifies the Java dump options for the JVM.

You can use this option to set your preferred Java dump options.

Information about Java dump options can be found in the Java Diagnostics Guide.

Managing the OSGi log files of JVM servers

The OSGi framework writes errors to a set of log files in the working directory of the JVM server. You can manage the number and size of the log files for each JVM server if the defaults are not appropriate for your environment.

About this task

The OSGi framework writes errors to a log file in the *`$WORK_DIR`*`/`*`applid`*`/`*`jvmserver`*`/configuration` directory on zFS, where *$WORK_DIR* is the working directory of the JVM server, *applid* is the CICS APPLID, and *jvmserver* is the name of the JVMSERVER resource. The OSGi framework continues to write to the log file until it reaches 1000 KB in size. After this, the OSGi framework creates another log file to write out further error messages. You can have up to ten log files in the directory. After the tenth log file is full, the OSGi framework writes over the oldest log file. Each JVM server can therefore have up to 10,000 KB of storage allocated to log files in zFS.

You can add options to the JVM profile to change the number and size of log files that are used by the OSGi framework to reduce or increase the number of files and the storage usage.

Procedure

- To change the maximum number of log files, add the **`eclipse.log.backup.max`** parameter to the JVM profile.
- To change the maximum size of each log file, add the **`eclipse.log.size.max`** parameter to the JVM profile.

Example

The following example shows a JVM profile with the two parameters specified. In this example, the OSGi framework can use up to five log files and each log file has a maximum size of 500 KB.

```
#Parameters to control the number and size of OSGi logs
#
eclipse.log.backup.max=5
eclipse.log.size.max=500
#
#
```

CICS component tracing for JVMs

In addition to the tracing produced by Java, CICS provides some standard trace points in the SJ (JVM) and AP domains for 0, 1, and 2 trace levels. These trace points trace the actions that CICS takes in setting up and managing JVM servers and pooled JVMs.

You can activate the SJ and AP domain trace points at levels 0, 1, and 2 using the CETR transaction. For details of all the standard trace points in the SJ domain, see JVM domain trace points in Trace Entries.

SJ and AP component tracing for JVM servers

The SJ component for JVM servers traces the startup and shutdown of JVM servers. The life-cycle operations of the JVM server are traced to the internal trace table. The life-cycle operations of the JVM launcher, JVM, and OSGi framework are traced to a file in zFS. In addition, the AP component traces the transactions that are running in the JVM server to the same trace file. For example, OSGi framework events are written to the trace file as follows:

- At a trace level of 0, the OSGi framework writes out errors to the trace file.
- At a trace level of 1, the OSGi framework writes out information, warning, and errors to the trace file.
- At a trace level of 2, the OSGi framework writes out debug, information, warning, and errors to the trace file.

If you switch AP component tracing on, the next request that comes in to the OSGi framework is traced.

SJ component tracing for pooled JVMs

SJ domain tracing for pooled JVMs traces the CICS actions associated with starting and managing pooled JVMs:

- At a trace level of 0, CICS traces extraordinary events and errors. Unlike CICS exception trace, which cannot be switched off, the JVM Level 0 trace is usually switched off.
- At a trace level of 1 and 2, you can get deeper levels of JVM tracing. The JVM trace point levels go up to level 9 and provide in-depth component detail. Activating internal JVM tracing at a level also enables tracing for all levels above it. For example, if you activate level 1 tracing for a transaction, you also receive level 0 tracing for that transaction as well.

In addition, you can use additional trace levels to control the internal trace facility of the pooled JVM. To select a level above 2, change the **`JVMxxxxTRACE`** system initialization parameter. For example, you can specify level 5 tracing as **`JVMLEVEL5TRACE`**. If you want to create more complex specifications for JVM tracing that use multiple trace point levels, or if you do not want to use trace point levels at all in your specification, use the **`JVMUSERTRACE`** parameter to create your own trace option string.

Activating and managing tracing for JVM servers

You can activate JVM server tracing by turning on SJ and AP component tracing. Small amounts of trace are written to the internal trace table, but most of the trace is written to a unique file in zFS for each JVM server. This file does not wrap so you must manage its size in zFS.

About this task

JVM server tracing does not use auxiliary or GTF tracing. Instead, the trace is written to a file in zFS that is uniquely named for each JVM server. The default file name has the format `*applid.jvmserver.*dfhjvmtrc` and is created by CICS in the working directory of the JVM when you enable the JVMSERVER resource. You can change the name and location of the trace file in the JVM profile. If you delete or rename the trace file when the JVM server is running, CICS does not re-create the file and the trace is not written to another destination.

Procedure

1. Use the CETR transaction to activate tracing for the JVM server. You can use two components to produce tracing for a JVM server:

- Select the SJ component to trace the actions taken by CICS to start up and stop the JVM server. CICS writes to the trace file in zFS during the startup of the JVM server and to the internal trace table during the shutdown of the JVM server.
- Select the AP component to trace the transactions that are running inside the JVM server. If you select this option, CICS writes to the trace file in zFS.

2. Set the tracing level for the SJ and AP components:
   - SJ and AP level 0 produce tracing for exceptions only, such as errors during the initialization of the JVM server or problems in the OSGi framework.
   - SJ and AP level 1 produce additional tracing information, such as warning and information messages in the OSGi framework.
   - SJ and AP level 2 produce debug tracing information, which provides much more detailed information about the JVM server processing.

   CICS writes out the tracing to the trace file in zFS.
3. View the tracing results in the `*applid.jvmserver.*dfhjvmtrc` file. Each trace entry has a date and time stamp. You can change the name and the location of this trace file by using the `JVMTRACE` profile option.
4. To manage the size of the file, you can delete old entries. If you disable the JVMSERVER resource, you can delete the file or rename the file if you want to retain the information separately. When you enable the JVMSERVER resource, CICS appends trace entries to the trace file if it already exists and creates a file in zFS if a trace file does not exist.

Defining and activating tracing for pooled JVMs

Pooled Java Virtual Machines (JVMs) produce their own trace points. You can control the pooled JVM's internal trace facility through interfaces provided by CICS. The trace points for the pooled JVMs in a CICS environment are output as CICS trace.

About this task

The SJ domain uses trace levels 29–32 to control the JVM's internal trace facility. These levels correspond to the CICS options for pooled JVM Level 0 trace, pooled JVM Level 1 trace, pooled JVM Level 2 trace, and pooled JVM User trace.

The default JVM trace options that are provided in CICS map to the Level 0, Level 1 and Level 2 trace point levels for JVMs. The JVM User trace option can be used to specify deeper levels of tracing or complex trace options.

The JVM trace options are defined using a "free-form" 240–character field. You can specify some or all of the following parameters:
- A trace level.
- A component, which is a JVM subcomponent (a functional area, like a CICS domain).
- A trace point type or group.
- A trace point ID.

You can add further parameters to the CICS specifications for JVM Level 0 trace, JVM Level 1 trace, and JVM Level 2 trace, if you want to include or exclude particular items at the selected trace levels. If you want to specify deeper levels of tracing or complex trace options, use the JVM User trace option to create a trace option string that includes the parameters of your choice. Note that trace point level specifications do not apply to trace points that are explicitly specified by their trace point ID. This means that you can add trace point IDs that are classified at any level to any of the JVM trace options in CICS, and they are supplied when the option is activated, regardless of the trace point levels that are enabled by that trace option.

The information about on tracing Java applications and the JVM in the Java Diagnostics Guide, lists the possible trace levels, components, trace point types, and trace point groups. These tracing parameters depend on the version of the IBM 64-bit SDK for z/OS, Java Technology Edition that you are using, and they can also change during the lifetime of a version, so you must check the appropriate version of the *Diagnostics Guide* for the latest information.

The trace format file supplied with the IBM 64-bit SDK for z/OS, Java Technology Edition lists each JVM trace point with its ID. For Version 6.0.1 the file is called `J9TraceFormat.dat`. You can use this file to identify an individual JVM trace point. This file is subject to change without notice; a version number is included as the first line of the file and is updated if the file is changed. You can find this file in the installation directory of Java.

JVM trace can produce a large amount of output, so you should normally activate JVM trace for special transactions, rather than turning it on globally for all transactions. When you activate trace options for a transaction, CICS passes the trace options to the JVM at the point when the transaction begins to use the JVM. The CICS SJ domain level 2 trace point SJ 052E shows the option string that has been passed to the JVM. The trace options apply only for the duration of the transaction's use of the JVM.

Procedure

- To set default JVM trace options for all JVMs in the CICS region, you can use the CICS system initialization parameters **JVMLEVEL0TRACE**, **JVMLEVEL1TRACE**, **JVMLEVEL2TRACE**, and **JVMUSERTRACE**. You can supply these parameters only at CICS startup; you cannot define them in the DFHSIT macro. You can use the CETR transaction to view and change these options. These parameters do not activate JVM tracing, they only set the default JVM trace options.
- To define or change JVM trace options while CICS is running, use either of these methods:
  1. Use the JVM Trace Options screens in the CETR transaction. You can specify trace option strings, and specify whether each trace level applies for standard tracing, special tracing, or both. For more information, see CETR - trace control in CICS Supplied Transactions.
  2. Use the **EXEC CICS INQUIRE JVMPOOL** and **EXEC CICS SET JVMPOOL** commands. The **INQUIRE JVMPOOL** command displays the JVM trace options you have set for the JVM pool, and the **SET JVMPOOL** command changes them. JVM trace options are not available on the CEMT equivalents for these commands.
- To activate JVM tracing, use any of these methods. Remember to activate JVM trace only for special transactions.
  1. Use the Transaction and Terminal Trace screen in the CETR transaction to switch on special tracing (or if required, standard tracing) for the relevant transactions. For more information, see CETR - trace control in CICS Supplied Transactions.
  2. Use the CICS system initialization parameter **SPCTRSJ** or **STNTRSJ** to activate JVM trace at startup. **SPCTRSJ** applies to special tracing, and **STNTRSJ** applies to standard tracing. Use the **SPCTRSJ** system initialization parameter rather

than the **STNTRSJ** system initialization parameter. Specify level numbers 29–32 to activate the levels of JVM trace that you require. You can supply these parameters only at CICS startup time; you cannot define them in the DFHSIT macro.

3. Use the **EXEC CICS SET TRACETYPE** command to set trace levels 29–32 for the SJ component. Use the `SPECIAL` option rather than the `STANDARD` option.

Results

04 When you activate JVM trace, the results appear as CICS trace points in the SJ
04 (JVM) domain. Each JVM trace point that is generated appears as an instance of a
04 CICS trace point:

- 04 SJ 4D02 is the trace point used for formatted JVM trace information.
- 04 SJ 4D01 is used for any JVM trace points that cannot be formatted by CICS. If
  04 you see this trace point often, check that the trace format file supplied with the
  04 IBM 64-bit SDK for z/OS, Java Technology Edition is present in the `/lib/`
  04 subdirectory of your SDK installation. For Version 6.0.1 it is called
  04 `J9TraceFormat.dat`. CICS requires this file to format the JVM trace points.

04 If the JVM trace facility fails, CICS issues the trace point SJ 4D00.

What to do next

The Java Diagnostics Guide has more detailed information about JVM trace and about problem determination for JVMs.

In addition to the interfaces provided by CICS, you can use the internal trace facility of the JVM directly. JVM system properties are a valid method of setting and activating trace options for JVMs in a CICS environment. The *Diagnostics Guide* has more information about the system properties that you can use to control the internal trace facility.

Debugging a Java application

The JVM in CICS supports the Java Platform Debugger Architecture (JPDA), which is the standard debugging mechanism provided in the Java 2 Platform. This architecture provides a set of APIs that allow the attachment of a remote debugger to a JVM.

About this task

You can use any tool that supports JDPA to debug a Java application running in CICS. For example, you can use the Java Debugger (JDB) that is included with the Java SDK on z/OS. To attach a JPDA remote debugger, you must set some options in the JVM profile.

Do not enable debugging for JVM profiles that specify the CLASSCACHE=YES or the DFHJVMCD profile.

Procedure

1. Add the **-Xdebug** option to the JVM profile to start the JVM in debug mode. If the JVM profile is shared by more than one application, you can use a different JVM profile for debugging.
2. Optional: Add the **-Xrunjdwp** option to specify the details of the connection between the debugger and the JVM. If you set this option to debug a JVM

server, specify `suspend=n`. This option stops CICS from waiting on attaching the debugger to the JVM before completing commands or processing in the region.

Debuggers can have different connection requirements and capabilities, so refer to the documentation provided by the debugger.

3. Attach the debugger to the JVM. If an error occurs during the connection, for example an incorrect TCP/IP host or port value, messages are written to the JVM standard output and standard error streams.
4. Using the debugger, check the initial state of the JVM. For example, check the identity of threads that have started and system classes that are loaded. The JVM suspends execution; the Java application has not yet started.
5. Set a breakpoint at a suitable point in the Java application by specifying the full Java class name and source code line number. Because the application class has not usually loaded at this point, the debugger indicates that activation of this breakpoint is deferred until the class is loaded. Let the JVM run through the CICS middleware code to the application breakpoint, at which point it suspends execution again.
6. Examine the loaded classes and variables and set further breakpoints to step through the code as required.
7. End the debug session. You can let the application run to completion, at which point the connection between the debugger and the CICS JVM closes. Some debuggers support forced termination of the JVM, which results in an abend and error messages on the CICS system console.

The CICS JVM plugin mechanism

In addition to the standard JPDA debug interfaces in the JVM, CICS provides a set of interception points in the CICS Java middleware, which can be useful for developers to debug applications. You can use these interception points (or plugins) to insert additional Java programs immediately before and after the application Java code is run.

Information about the application (for example, class name and method name) is made available to the plugin programs. The plugin programs can also use the JCICS API to obtain information about the application. These interception points can be used in conjunction with the standard JPDA interfaces to provide additional CICS-specific debug facilities. They can also be used for purposes other than debugging, in a similar way to user exit points in CICS.

There are three Java exit points:

- A CICS EJB container plugin that provides methods that are called immediately before and after an EJB method is invoked.
- A CICS CORBA plugin that provides methods that are called before and after a CORBA method is invoked.
- A CICS Java Wrapper plugin that provides methods that are called immediately before and after a Java program is invoked

You can use debug plugins with pooled JVMs. When you use plugin programs to debug a Java application, you must specify the classes on the standard class path for the JVM that the application uses. The standard class path is specified by the `CLASSPATH_SUFFIX` option in the JVM profile. For more information, see “Classes and class paths in JVMs” on page 8. You add classes for plugin programs in the same way as classes for ordinary applications.

The programming interface consists of two Java interfaces.

- **DebugControl** (full name: `com.ibm.cics.server.debug.DebugControl`) defines the method calls that can be made to a user-supplied implementation.
- **Plugin** (full name: `com.ibm.cics.server.debug.Plugin`) provides a general purpose interface for registering the plugin implementation.

These interfaces are supplied in `com.ibm.cics.server.jar`, and documented in Javadoc (see "The Java class library for CICS (JCICS)" on page 47 for more information).

The code fragment in Figure 9 shows an example implementation of the DebugControl interface.

```
public interface DebugControl
{
    // called before an application object method or program main is invoked
    public void startDebug(java.lang.String className,java.lang.String methodName);

    // called after an application object method or program main is invoked
    public void stopDebug(java.lang.String className,java.lang.String methodName);

    // called before an application object is deleted
    public void exitDebug();

}
public interface Plugin
{
    // initaliser, called when plugin is registered
    public void init();
}
```

Figure 9. Definitions of the DebugControl and Plugin interfaces

The code fragment in Figure 10 on page 193 shows an example implementation of the DebugControl and Plugin interfaces.

```
import com.ibm.cics.server.debug.*;

public class SampleCICSDebugPlugin
    implements Plugin, DebugControl
{
    // Implementation of the plugin initialiser
    public void init()
    {
        // This method is called when the CICS Java middleware loads and
        // registers the plugin. It can be used to perform any initialisation
        // required for the debug control implementation.
    }

    // Implementations of the debug control methods
    public void startDebug(java.lang.String className,java.lang.String methodName)
    {
        // This method is called immediately before the application method is
        // invoked. It can be used to start operation of a debugging tool. JCICS
        // calls such as Task.getTask can be used here to obtain further
        // information about the application.
    }

    public void stopDebug(java.lang.String className,java.lang.String methodName)
    {
        // This method is called immediately after the application method is
        // invoked. It can be used to suspend operation of a debugging tool.
    }

    public void exitDebug()
    {
        // This method is called immediately before an application object is
        // deleted. It can be used to terminate operation of a debugging tool.
    }
}
```

Figure 10. Sample implementation of the DebugControl and Plugin interfaces

To activate a debug plugin implementation, set one or more of the following system properties in the JVM properties file for the JVM:

EJB container debug plugin

If you set the following system property, the supplied plugin is registered by Java code in the CICS EJB server layer when the EJB container is initialized.

```
-Dcom.ibm.cics.server.debug.EJBPlugin=<fully qualified classname,
   for example com.ibm.cics.server.debug.SampleCICSDebugPlugin>
```

CORBA debug plugin

If you set the following system property, the supplied plugin is registered by Java code in the CICS ORB when the ORB is initialized.

```
-Dcom.ibm.cics.server.debug.CORBAPlugin=<fully qualified classname,
   for example com.ibm.cics.server.debug.SampleCICSDebugPlugin>
```

CICS Java debug plugin

If you set the following system property, the supplied plugin is registered by additional Java code in the JCICS wrapper when the Java program is run.

```
-Dcom.ibm.cics.server.debug.WrapperPlugin=<fully qualified classname,
   for example com.ibm.cics.server.debug.SampleCICSDebugPlugin>
```

More than one plugin interface can be triggered when a Java application is run. For example, if plugin implementations are registered for all three interfaces, and an enterprise bean method is run, the JCICS wrapper, CORBA, and EJB plugins are triggered in succession.

Chapter 9. Stable Java technologies

CORBA, IIOP, and Enterprise beans are Java technologies that are stable in CICS. Do not use these technologies to develop new applications.

Stateless CORBA objects

From the client perspective, a stateless CORBA object invoked by means of the CICS ORB is just a collection of methods—that is, a stateless object.

Each remote method represents a piece of logic that may make one or more CICS API calls, including program-link calls, to existing CICS programs. CICS stateless CORBA objects execute in a CICS JVM. At the end of the remote method, the state of the object is no longer available.

As with all Java programs that execute in a continuous JVM in CICS, any static state created by a CORBA object is persisted within the JVM for subsequent retrieval in a later task. However, there is no affinity between a CORBA client and a CICS JVM, so there is no certainty that two subsequent CORBA requests that use the same socket will be processed in the same JVM (or even the same CICS region). This means that the availability of previously initialised static state cannot be relied upon.

Every remote method must therefore be passed sufficient information in its parameter list to enable it to complete its work. No information is passed to the server ORB by way of the object reference, except the object type, which is used to find the implementation class. However, the methods of the object may save state in application-managed data storage between invocations. They will need to ensure that sufficient information is passed as parameters to subsequent methods so that the saved state can be retrieved.

A CORBA object can make outbound IIOP calls, including calls to enterprise beans running under the same or under a different CorbaServer. A CORBA object can even pass a reference to itself as a parameter on a remote IIOP method. This is known as a **call back reference**. However, if the target object uses the call back reference to call the first CORBA object, this new request is processed in a new JVM; thus it has no access to any state from the original JVM.

Method invocations may participate in Object Transaction Service (OTS) **distributed transactions**. If a client calls an IIOP application in the scope of an **OTS transaction**, information about the OTS transaction flows as an extra parameter on the IIOP call. If a target stateless CORBA object implements CosTransactions::TransactionalObject, the object is treated as transactional.

Developing stateless CORBA objects

Stateless CORBA objects are Java server applications that communicate with a client application using the IIOP protocol. No state is maintained in object attributes between successive client invocations of remote methods; state is initialized at the start of each remote method call and referenced by explicit parameters.

Note: By a *remote method* we mean a method that may be called from a remote client. That is, a public method that is exposed as part of one of the object's (potentially multiple) remote interfaces, or declared in the IDL for the object; rather than an internal method that cannot be accessed from a remote client.

In the server programming model, each method is a subroutine. The parameters passed allow you to establish temporary state from any existing databases or applications, to perform business logic, to store data in the existing databases or applications, to return results when the subroutine returns, or to throw an exception. The remote methods of a stateless CORBA object—that is, those that may be called by a remote client—may call each other locally or call non-remote methods without the object's temporary state being lost. The temporary state is only discarded at the end of the client-initiated remote method request, when the response to the client's request is sent.

You can develop a stateless CORBA application using either of two different approaches:

1. Use the typical CORBA development style, whereby an application interface is defined in Interface Definition Language (IDL) and then the application is coded to that interface. This approach is described in the sections that follow.
2. Use the typical Java development style, whereby a Java Remote Method Invocation (RMI) application is developed and IDL is optionally generated later. This approach is known as RMI-IIOP. It is described in “Developing an RMI-IIOP stateless CORBA application” on page 204.

To develop a stateless CORBA object using the first (CORBA-style) approach, you need to perform the following steps:

1. Use the Interface Definition Language (IDL) to define the object's interfaces and operations.
2. Run the IDL-to-Java compiler (IDLJ) against the IDL to generate stub and skeleton classes for the object.
3. Write a client application that makes calls to the server using the generated stub class.
4. Write a server application (the stateless CORBA object) that extends the generated base skeleton class.
5. Compile and package the client and server applications.
6. Define CICS resources for the server and add the server application's JAR file to the standard class path in the JVM profile for the JVM that the application uses.

To develop a stateless CORBA object using the second (Java-style) approach, you need to perform the following steps:

1. Write a remote interface for the server application (the stateless CORBA object).
2. Write a client application that makes calls to the server using this remote interface.
3. Write a server application that implements the remote interface.
4. Compile the client and server applications.
5. Run the Java RMI compiler (RMIC) against the remote interface and server application to generate stub and tie classes for the object.
6. Package the client and server applications.

7. Define CICS resources for the server and add the server application's JAR file to the standard class path in the JVM profile for the JVM that the application uses.
8. Optionally, create IDL for the application for use by non-Java CORBA clients.

There are benefits and drawbacks to each of the two approaches. One of the main differences is that the CORBA approach requires the stateless CORBA object to extend a generated base class. Given that Java supports only a single inheritance hierarchy, this means that you cannot make your stateless CORBA object extend a class of your choice. The RMI-IIOP approach allows you to use an inheritance hierarchy of your choice for the stateless CORBA object, because the object only has to implement a specific interface.

The CORBA interface and operation names are mapped to corresponding Java implementations. You can develop server implementations that use the CICS Java classes (JCICS) to access CICS services. See the *JCICS Class Reference* for details of the JCICS classes, and "Java programming using JCICS" on page 47 for an explanation of how to develop server applications using them.

The JCICS classes are fully documented in JAVADOC html that is generated from the class definitions. This is available through the CICS Information Center, in the *JCICS Class Reference*.

Obtaining an interoperable object reference (IOR)

To locate a server object at run-time, the client application requires a reference to it.

This reference is called an **Interoperable Object Reference** (**IOR**). An IOR is a text string encoded in a specific way, such that a client ORB can decode the IOR to locate the remote server object. It contains enough information to allow:

- A request to be directed to the correct server (host, port number)
- An object to be located or created (classname, instance data)

IORs may be returned by server methods, but a factory class is needed to create an initial IOR. CICS uses the CORBA LifeCycle Services' (CosLifeCycle) GenericFactory class for this purpose. A client application can use this GenericFactory to create IORs for each stateless CORBA object needed at runtime. However, the GenericFactory is itself a stateless CORBA object and thus the client application will need *its* IOR before it can create the target object's IOR.

Use the PERFORM CORBASERVER PUBLISH command to publish a stringified IOR for the GenericFactory class. The GenericFactory IOR is then created and stored on the shelf (an z/OS UNIX directory associated with the CorbaServer), and published to the nameserver. The GenericFactory IOR can be used by the client application to create IORs for any stateless CORBA objects that exist for this CorbaServer (and only for this CorbaServer). The IOR is published with the name `genfac.ior`. How the client locates the GenericFactory IOR at runtime is an application architecture decision. The IOR could be retrieved from a well known location in a JNDI namespace, be kept locally on the client machine, or accessed by some other process.

To publish the IOR, you can use the **`CEMT PERFORM CORBASERVER`** command, or you can issue an **`EXEC CICS PERFORM CORBASERVER`** command from a CICS application.

The `genfac.ior` file is written to the CORBASERVER's shelf directory :

`/shelf/applid/corbaserver/`

where:

shelf is the SHELF directory name specified in the CORBASERVER resource definition, defaulting to `/var/cicsts/`

`applid` is the is the APPLID identifier associated with the CICS region

`corbaserver`
is the CORBASERVER resource name

You can download the IOR to your client workstation (in ASCII mode) from the shelf using FTP. Alternatively, your client can use the JNDI interface to obtain the IOR from the nameserver.

Due to the stateless nature of the object, there is seldom any point in a client creating more than one instance of a class. Once a client has created an instance of an object, for example `bankaccountfacilitator`, the same object can be used to access both Mr X's account and Mr Y's account; the account number is an input parameter in every method.

Note: We have called the object in this example a bankaccountfacilitator so that it can perform actions on any account. To have called it a bankaccount might imply that the instance always represented Mr X's account.

Creating the Interface Definition Language (IDL)

If you are using the CORBA development style to create a stateless CORBA object application, your must create an OMG IDL file that contains the definitions of interfaces the server implementation will support.

Note: This section assumes that you're using the CORBA development style to create a stateless CORBA object application (approach 1 in “Developing stateless CORBA objects” on page 195, rather than the RMI-IIOP approach). The RMI-IIOP approach is described in “Developing an RMI-IIOP stateless CORBA application” on page 204.

An OMG IDL file describes the data-types, operations, and objects that the client can use to make a request, and that a server must provide for an implementation of a given object.

For information about writing IDL, see the OMG publication, *Common Object Broker: Architecture and Specification*, obtainable from the OMG Web site at http://www.omg.org/.

You process the IDL definitions with an IDL-to-Java compiler (sometimes called a “parser” or “generator”). You must use a compiler provided by the server environment to generate server-side skeletons and helper classes, and a compiler provided by the client environment to generate client-side stub (sometimes called “proxy”) and helper classes. Skeleton classes appropriate for use with CICS can be created using the IDLJ compiler provided with any IBM Java 2 SDK. If you use a non-IBM IDLJ compiler, the resulting skeleton class may or may not be suitable for use with CICS. If in doubt, you may use the IDLJ compiler that ships with the Java SDK supplied on z/OS that is used by CICS.

The stub or proxy classes produced by the IBM IDL compiler (IDLJ) are appropriate for use with any IBM ORB. If you use a client-side ORB from a different vendor, use the IDL compiler supplied with that ORB. If you use stub classes generated for one vendor's ORB with another vendor's ORB, the results are undefined—the stubs might or might not work.

The proxies and skeletons provide the object-specific information needed for an ORB to distribute a method invocation.

Figure 11 shows how the same IDL file is used to generate different classes used by the client and the server.

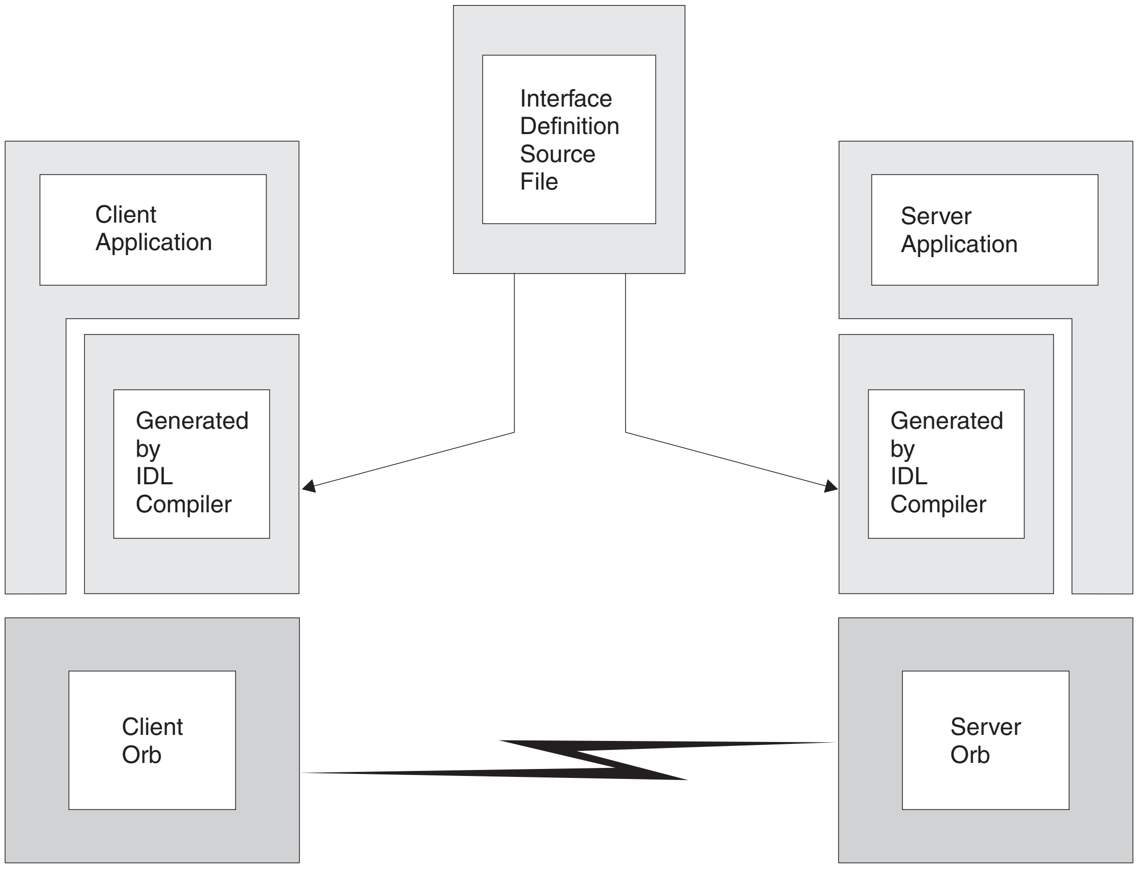

Interface Definition Source File
Client Application
Server Application
Generated by IDL Compiler
Generated by IDL Compiler
Client Orb
Server Orb

Figure 11. IDL and generated code

Developing an IIOP server program

The server program can be developed on any platform that supports Java. For example, an NT workstation, AIX® or the UNIX System Services environment of z/OS.

About this task

Note: This section assumes that you're using the CORBA development style to create a stateless CORBA object application (approach 1 in “Developing stateless CORBA objects” on page 195, rather than the RMI-IIOP approach). The RMI-IIOP approach is described in “Developing an RMI-IIOP stateless CORBA application” on page 204.

The following steps are required:

Procedure

1. Write the IDL definition of the interfaces and operations that form your application.
2. Compile the IDL file to generate CORBA skeleton and helper classes, using the IDL compiler **idlj** command which is part of the Java 2 SDK.

   Note:

   a. You must use an IBM-supplied IDL-to-Java compiler to do this. The IDL-to-Java compiler supplied with the Sun version of the Java 2 SDK may not be 100% compatible with the IBM ORB.
   b. The **idlj** command is not supplied as part of the Java Runtime Environment (JRE); you will need a full SDK installed on your machine before this will work.

   The IDL compiler can be invoked as follows:

   ```
   idlj [options] <idl file>
   ```

   Where `<idl file>` is the name of the file containing the IDL definitions, and `[options]` is any combination of the following options, which may appear in any order. `<idl file>` is required and must appear last. At least **-f** must be specified.

   For example:

   ```
    idlj -v -fall myidl.idl
   ```

   You must also specify the **-oldImplBase** option to ensure that a CICS-compatible implementation is generated. If you do not use this option, the generated implementation will use the Portable Object Adapter (POA), which is not supported in CICS. For example:

   ```
    idlj -v -fall -oldImplBase myidl.idl
   ```

   -d<symbol>
   The equivalent of the following line in an IDL file: `#define <symbol>`

   -emitAll
   Emit all types, including those found in `#included` files.

   -f<side>
   Define the bindings to emit. <side> can be:

client	not applicable to CICS.
server	does not generate sufficient classes for normal use.
all	emits all bindings.
serverTIE	not supported in CICS.
allTIE	not supported in CICS

   If this option is not specified, then **-fclient** is assumed. In most cases you should use **-fall**.

   -i<include path>
   Add another directory. By default, the current directory is scanned for included files.

   -keep If a file to be generated already exists, do not overwrite it. By default it is overwritten.

-oldImplBase
This option is required. If you omit this option, IDLJ generates code which uses the Portable Object Adapter (POA). The POA is not supported under CICS.

-pkgPrefix <t> <pkg>
Make sure that wherever the type or module <t> is encountered, it resides within <pkg> in all generated files. <t> is a fully qualified Java-style name.

-v Verbose mode.

3. Write your server implementation in Java code. The idl compiler will generate an abstract class called_*interfacename***ImplBase**. Your program must extend this. If objects of this type are to be created by the Generic Factory, your implementation class must be called _*interfacename*Impl. If you do not use this naming convention, the GenericFactory will not be able to create references to your CORBA object. For example:
```
public class _BankAccountImpl extends _BankAccountImplBase
```
Your implementation class may make use of the JCICS API to interact with traditional CICS services.
4. Compile your program and the output from step 2, using the javac compiler or an equivalent, such as VisualAge® for Java. Ensure that the location of the output files is added to the end of the CICS standard class path, by using the CLASSPATH_SUFFIX option in the JVM profile.

Example

This example describes a bank account whose contents can be queried and updated. The example has a parameter that identifies the instance of the BankAccount, to satisfy the 'stateless' restriction. The following IDL defines the interface and operations:

```
  module bank {

  // this interface is used to manage the bank accounts
  interface BankAccount {
    exception ACCOUNT_ERROR { long errcode; string message;};

    // query methods
    long querybalance(in long acnum) raises (ACCOUNT_ERROR);
    string queryname(in long acnum) raises (ACCOUNT_ERROR);
    string queryaddress(in long acnum) raises (ACCOUNT_ERROR);

    // setter methods
    void setbalance(in long acnum, in long balance) raises (ACCOUNT_ERROR);
    void setaddress(in long acnum, in string address) raises (ACCOUNT_ERROR);
};
};
```

The server implementation of the above IDL must be called `_BankAccountImpl` if objects of this type are to be created by the GenericFactory and must extend `_BankAccountImplBase`, which is generated by the IDL compiler. It is part of the Java package `bank`. You can see full details of this implementation in the stateless CORBA BankAccount sample application distributed in :

```
/usr/lpp/cicsts/<username>/samples/dfjcorb
```

where *username* is a name you can choose during CICS installation, defaulting to `cicsts42`.

To use this example, you need the following resources:

- A TCPIPSERVICE resource defined and installed to listen on a given port under CICS. This TCPIPSERVICE must be:
  - Defined to use the IIOP protocol.
  - In "open" state in order to receive requests.
- A CORBASERVER resource defined to process IIOP requests on the TCPIPSERVICE.

You may optionally choose to add a REQUESTMODEL definition, in order to force the request to be processed under a given TRANSID.

Developing the IIOP client program

you write a client application that makes calls to the server using the generated stub class.

About this task

Note: This section assumes that you're using the CORBA development style to create a stateless CORBA object application (approach 1 in "Developing stateless CORBA objects" on page 195, rather than the RMI-IIOP approach). The RMI-IIOP approach is described in "Developing an RMI-IIOP stateless CORBA application" on page 204.

Procedure

1. Process the IDL file with an IDL- to-Java compiler suitable for your client system (using the same IDL file that you used to build the server application).
2. Obtain a stringified object reference to the GenericFactory by downloading `genfac.ior` (in ASCII mode) from the CorbaServer's shelf directory, where it was created when the CORBASERVER resource was published. Alternatively, you can use JNDI, as a Generic Factory IOR for the CorbaServer is published to the namespace if you issue an **`EXEC CICS PERFORM CORBASERVER PUBLISH`**, or a **`CEMT PERFORM CORBASERVER PUBLISH`** command. If you plan to use JNDI, then you must define a nameserver, see "Defining name servers" on page 363. The IOR is bound into the context identified by the JNDI prefix in the CORBASERVER resource definition, with the name GenericFactory. For example, the pathname would be:

   ```
   /jndiprefix/GenericFactory
   ```

   See the *CICS Resource Definition Guide* and the *CICS Supplied Transactions* manual.
3. Write your client program, containing calls to the server. To obtain an initial object reference, use the GenericFactory as shown in "Client example."
4. Compile the client program, and the output from step1, with javac or an equivalent compiler.

Results

Client example

The following example shows how the GenericFactory service is used by a client program to create an **account** object. The client must first create a proxy for the GenericFactory.

Java bindings for part of the CORBA CosLifeCycle and CosNaming modules are required. If they are not provided by the client ORB, you can build them using the client ORB's IDL-to-Java compiler, from the CORBA services IDL available from the OMG website (www.omg.org). Alternatively, you can use the precompiled Java version of the IDL provided in

```
/usr/lpp/cicsts/<cicsts42>/lib/omgcos.jar
```

Where *cicsts42* is your chosen value for the USSDIR installation parameter that you defined when you installed CICSTS.

The JAR file should be downloaded in binary mode and made available on the client's CLASSPATH environment entry.

The following example, and the supplied samples, require bindings that can be imported as org.omg.CosNaming and org.omg.CosLifeCycle.

In order to create an account object, the client must first create a proxy for the GenericFactory. The following example assumes that a stringified reference to the GenericFactory exists in a file available to a client, and is returned by the getFactoryIOR() method.

```
import java.io.*;
import org.omg.CORBA.*;
import org.omg.CosLifeCycle.*;
import org.omg.CosNaming.*;
public class bankLineModeClient{

//The following method reads the ior from a file and returns it in the string
 String factoryIOR = getFactoryIOR();
// Turn the stringified reference into the proxy
 org.omg.CORBA.Object genFacRef = orb.string_to_object(factoryIOR);
// narrow to correct interface
 GenericFactory fact = GenericFactoryHelper.narrow(genFacRef);
```

Now that the client has a generic factory, it can use it to create an account object.

```
// The Generic factory needs a key, which is a sequence of namecomponents
 NameComponent nc = new NameComponent("bank::BankAccount","object interface");
 NameComponent key[] = {nc};
//The  Generic factory also requires criteria (which it ignores)
 NVP mycriteria[] = {};

//Now create the object
 org.omg.CORBA.Object objRef = fact.create_object(key, mycriteria);
// and narrow to correct interface
BankAccount acctRef = BankAccountHelper.narrow(objRef);
```

Now the client has an object, it can use it:

```
int ac1 = 1234; // Tony's account
int ac2 = 3456; // Lou's account
String name;
String address;
int balance;


try {
  name=acctRef.queryname(ac1);
  System.out.println("a/c num:"+ac1+" name:"+name);
}
catch (exception e) {
  System.err.println("query error");
}
```

Note: NVP (Name Value Pair) is a datatype defined in the CORBA IDL for the Generic Factory interface.

Developing an RMI-IIOP stateless CORBA application

You can use the RMI-IIOP development style to create a stateless CORBA object application.

This is the development style defined in approach 2 in “Developing stateless CORBA objects” on page 195, rather than the CORBA development approach described in previous sections.

The RMI-IIOP approach involves developing a standard Java Remote Method Invocation (RMI) application and deploying it to use IIOP as its transport protocol. This is the approach taken by enterprise beans.

Note: This section specifically documents how to develop a stateless CORBA application using RMI-IIOP. Enterprise beans are deployed using other tools. For information about deploying enterprise beans, see “Deploying enterprise beans” on page 295.

When using RMI-IIOP there is no need to define an interface using IDL—though, if required, the IDL can optionally be generated later. Instead, we start by defining at least one remote interface. In this context, a “remote interface” means any Java interface that extends `java.rmi.Remote`. This is not the same thing as an enterprise bean's “Remote Interface”. Using the terminology just defined, both an enterprise bean's Remote Interface and its Home Interface would qualify as “remote interfaces”, because they both ultimately extend `java.rmi.Remote`.

This remote interface should be coded to follow the rules of Java RMI. An example remote interface is shown below:

```
package hello;
public interface HelloWorldRMI extends java.rmi.Remote
{
   public String sayHello(String msgFromClient) throws java.rmi.RemoteException;
}
```

The above interface defines a single method called sayHello that takes a String as a parameter and returns a String. All the methods on the interface must be defined to throw java.rmi.RemoteException.

Next, you should provide a server-side implementation of this interface. An example is shown below:

```
package hello;
public class _HelloWorldRMIImpl implements HelloWorldRMI
{
 public String sayHello(String msgFromClient)
 { return "Hello: You said: " + msgFromClient;}
}
```

The implementation class implements the interface previously created. The naming convention used for the implementation class is _<*interface name*>Impl. This naming convention is required if the server object is to be located using the CORBA CosLifeCycle Generic Factory approach. If you do not use this naming convention, the Generic Factory will not be able to construct instances of your stateless CORBA object.

One of the advantages of RMI-IIOP over the more traditional IDL-based development process is that you are not forced to extend a base class. This means that you can choose to use your own inheritance hierarchy if you want. You may also implement multiple remote interfaces with a single server object.

You should compile both of the above classes using the `javac` compiler or equivalent.

The next thing to do is to produce the server-side Tie file for this stateless CORBA object. This is done using the RMI compiler (RMIC). You must use an RMI compiler shipped with an IBM Java 2 SDK. If you use the version of RMIC supplied with the Java 2 SDK, the generated Tie file is not guaranteed to work with the CICS ORB.

The command to use is as follows:

```
 rmic -iiop hello._HelloWorldRMIImpl
```

Note that RMIC is being run against the server-side implementation class.

Next we need the client-side stub class. This is also produced using the RMI compiler. Ensure that you use an appropriate RMI compiler for your client ORB. The command to use is as follows:

```
rmic -iiop hello.HelloWorldRMI
```

Note that RMIC is being run against the remote interface class.

Once this is complete, you should have the following classes available:

```
hello\HelloWorldRMI.class            - the remote interface
hello\_HelloWorldRMIImpl.class       - the stateless CORBA object
hello\__HelloWorldRMIImpl_Tie.class  - the RMI-IIOP server side Tie file
hello\_HelloWorldRMI_Stub.class      - the RMI-IIOP client side Stub file
```

The next thing to do is to write the client application. The client application is very similar to the client application developed using the IDL-based approach to CORBA development (described in “Developing the IIOP client program” on page 202). As before, we still need to find a reference to the stateless CORBA object using the CORBA CosLifeCycle Generic Factory. Here is part of an example RMI-IIOP client application:

```
ORB orb = ORB.init((String[]) null, (java.util.Properties) null);

// The following method reads the generic factory IOR from a file and returns
// it in the string
String factoryIOR = getFactoryIOR();

// Turn the stringified reference into the proxy
org.omg.CORBA.Object genFacRef = orb.string_to_object(factoryIOR);

// narrow to correct interface
GenericFactory fact = GenericFactoryHelper.narrow(genFacRef);

// The Generic factory needs a key, which is a sequence of namecomponents
NameComponent nc = new NameComponent("hello::HelloWorldRMI","object interface");

//Now create the object
org.omg.CORBA.Object objRef=fact.create_object(new NameComponent[]{nc},
                                              new NVP[] {});

// and narrow to correct interface using the RMI-IIOP narrow operation
HelloWorldRMI remote = (HelloWorldRMI) javax.rmi.PortableRemoteObject.narrow
```

```
                        (objRef, HelloWorldRMI.class);

// Invoke the remote method
System.out.println("Received from Server: "+remote.sayHello("Hi!")+"\n");}
```

As with the IDL-based client application, it will be necessary to have the `omgcos.jar` file from the CICS lib z/OS UNIX directory on your workstation and client machines in order to find the CosLifeCycle classes.

All that remains is to package the server- and client-side applications into JAR files and to add the server-side JAR file to the standard class path.

If you want to generate IDL, for the RMI-IIOP remote interface, that would be suitable for use with a non-Java-based CORBA client application, use the following command:

```
rmic -idl hello.HelloWorldRMI
```

Stand-alone CICS CORBA client applications

CICS CORBA support is primarily focused on supporting IIOP server-side objects—that is, enterprise beans and stateless CORBA objects. These server-side components run in a CICS EJB/CORBA server, in a CorbaServer execution environment represented by a CORBASERVER resource. Because they run in a CICS EJB/CORBA server, they have access to a rich ORB feature set.

In this section, the term "*stand-alone CICS CORBA client applications*" refers to CICS applications that:
1. Are CORBA client applications
2. Are defined to CICS as standard Java applications, by means of a PROGRAM definition on which JVM=YES specified
3. Create an ORB instance using the `new` operator
4. Do not run in a CICS CorbaServer execution environment

Stand-alone CICS CORBA client applications do not run in a CICS EJB/CORBA server, and thus do not have access to the same quality of CORBA support as server-side components. The ORB available to these client applications is a client-only ORB sometimes referred to as the "JCICS ORB". This ORB cannot listen on a socket for inbound connections; therefore any IORs published by this ORB cannot be supported. Similarly, a CICS CORBA client application cannot initiate (or participate in) a distributed OTS transaction. A CICS CORBA client application also cannot participate in asserted identity authentication.

These limitations do not extend to the CICS server ORB environment. Any server object in a CICS EJB/CORBA server can make outbound client IIOP calls that participate in an OTS transaction, providing that the ORB instance used to perform these outbound calls is the current CICS EJB/CORBA server ORB. If a new ORB instance is created by the server object using the new operator, CICS cannot automatically propagate the existing transaction context using this new ORB. An IIOP server object can programmatically get a handle to the current server ORB instance by using the following static method call:

```
com.ibm.cics.iiop.ORBFactory.getORB()
```

CORBA interoperability

The CICS implementation of the CORBA architecture provides a link between applications based on CORBA ORBs and CICS services, including enterprise beans.

An enterprise bean hosted by CICS can be made to inter-operate with objects on other CICS regions (including back-level CICS regions from CICS TS 1.3 onwards), WebSphere Application Server, and third-party J2EE application servers and ORBs. Enterprise beans are available to pure CORBA clients, and can act as clients to remote CORBA objects (potentially implemented in a different programming language and hosted on a different platform).

The CICS ORB can be used to host only client and server applications written in Java. However, it can be used to interoperate with remote ORBs which serve clients and servers written in other programming languages.

Using non-Java CORBA clients

Different programming languages require different language bindings to an ORB.

This requires a level of interoperability between the ORBs which should be taken into consideration. The CORBA architecture defines language bindings for a number of languages, including C++, Java, COBOL, Ada, PL/I, Smalltalk, and others. Note that language bindings for some programming languages might not support all IDL and IIOP features. In particular, valuetypes have been defined only for the C++ and Java language bindings. CORBA access to enterprise beans requires valuetypes, so today only C++ and Java applications can access most enterprise beans through a CORBA interface.

Writing a CORBA client to an enterprise bean

For client programming languages other than Java, such as C++, the CORBA architecture is often the only viable option for accessing enterprise beans.

About this task

For client programming languages other than Java, such as C++, the CORBA architecture is often the only viable option for accessing enterprise beans. Enterprise beans are available to CORBA clients through the CORBA programming model as follows:

- Write the enterprise bean.
- Generate IDL for the enterprise bean, using the RMI compiler with the -IDL option. (This is the reverse of the typical CORBA model, in which IDL is used to generate the object.)

  If you use only CORBA primitives as data and return types, it will be easier to access the bean from non-Java clients.
- Using an IDL compiler suitable for the client environment, compile the IDL to generate client-side stubs.
- Write the client, using the generated stub.
- Make an IOR for the enterprise bean available to the client application. The IOR contains sufficient information for any CORBA ORB to locate the enterprise bean.

Even if a session bean has been coded to use only CORBA primitives as parameter and return types, exception types are still returned as CORBA valuetypes. If your CORBA client ORB does not support valuetypes, you will be forced to work with unknown exceptions.

Note: It is not recommended to use a Java CORBA client to an enterprise bean. Use RMI-IIOP instead.

Enterprise beans as CORBA clients

Enterprise beans are Java objects operating in a sophisticated runtime environment which includes an ORB.

If the enterprise bean is to make outbound IIOP calls to remote CORBA objects (without using RMI-IIOP) it is strongly recommended that the application make use of the existing ORB instance. If the enterprise bean creates a new ORB instance using the new operator, CICS cannot propagate the existing transaction and security context under which the bean is running to method requests on this new ORB.

If you need to get a handle to the current ORB from within an enterprise bean you can use the following static method call:

```
com.ibm.cics.iiop.ORBFactory.getORB()
```

Code sets

CICS can accept GIOP char/wchar and string/wstring datatypes only if they are encoded using one of these code pages.
- UCS2—the standard Java codeset (Unicode)
- UTF-8

Using the IIOP samples

These sample applications demonstrate the use of IIOP applications (stateless CORBA objects) and the CICS Java programming support (JCICS).

`HelloWorld sample`

This sample provides a simple test of the IIOP components. The client program:
- reads the file genfac.ior to obtain a reference to the generic factory
- uses the generic factory to create a HelloWorld object
- invokes method sayHello to send a greeting to the server (Hello from HelloWorldClient)and receive a greeting from it in reply (Hello from CICS TS)

The design of the application is described in comments in the code.

`BankAccount sample`

The sample consists of the following main parts:
1. A traditional CICS application that uses BMS and the **EXEC CICS** API, written in C. This application consists of two transactions:

   BNKI Initializes a file with information about a number of bank accounts. These accounts have numbers in the range 23 through 30.

   BNKQ
   Queries the information in the accounts. There is also a CICS program, DFH$IICC, which performs a credit check for an account.
2. An implementation of an IDL interface that defines a bank account object. The implementation is written in Java and runs as a stateless CORBA object. This implementation uses the bank account file to access bank account information and the DFH$IICC credit check program to obtain credit ratings.
3. A CORBA client application written in Java that displays information about bank account objects.

The design of the application is described in comments in the code.

Setting up the IIOP sample environment

You can use the provided samples to set up an IIOP environment in CICS.

Before you begin

To configure CICS as an IIOP server or client, you must have a CICS region that has permission to access z/OS UNIX and the IBM 64-bit SDK for z/OS, Java Technology Edition. Language Environment must be configured and active.

Procedure

1. Define the JCL parameter **`REGION`** in the startup job stream for a CICS region that supports IIOP. Set the value at a minimum of `1000M`.
2. Define the following system initialization parameters in the startup job for a CICS region that supports IIOP:

   ```
   EDSALIM=500M
   MAXJVMTCBS=number
   TCPIP=YES
   ```

   Set a minimum value of `500M` for the **`EDSALIM`** parameter. To work out an appropriate setting for the **`MAXJVMTCBS`** parameter, see "Managing your JVM pool for performance" on page 161.
3. Add DD statements to the startup job stream for a CICS region that supports IIOP to create these files:

   DFHEJDIR
   A recoverable shared file containing the request streams directory. This can be a VSAM file or a coupling facility data table. CICS supplies sample JCL to help you create this file, in the DFHDEFDS member of the SDFHINST library.

   DFHEJOS
   A non-recoverable shared file used by CICS when CORBASERVER resources are installed. This file is also used to store stateful session beans that have been passivated. DFHEJOS can be a VSAM file or a coupling facility data table. CICS supplies sample JCL to help you create this file, in the DFHDEFDS member of the SDFHINST library.

   Sample local VSAM data set definitions for these files are provided in the CICS-supplied RDO group DFHEJVS. These data sets must be authorized with RACF® for UPDATE access. See Authorizing access to CICS data sets, in the *CICS RACF Security Guide*.
4. Create a shelf directory on z/OS UNIX and give the CICS region user ID full access to it. See Giving CICS regions access to z/OS UNIX System Services for guidance.
5. Choose a suitable JVM profile and ensure that CICS is able to locate the profile, as described in "Setting up pooled JVMs" on page 88.
6. Ensure that the value of JAVA_HOME is correctly defined in the JVM profile for the server side application. JAVA_HOME defines the installation directory for the IBM 64-bit SDK for z/OS, Java Technology Edition. The default for Version 6.0.1 of the SDK is `/usr/lpp/`*`java/J6.0.1_64`*`/`.
7. Ensure that the following files are added to a suitable class path in the JVM profile:
   -

The sample Java source and makefiles that are stored in the z/OS UNIX System Services file system during CICS installation, in the following directories:
  - `$CICS_HOME/samples/dfjcorb/HelloWorld`
  - `$CICS_HOME/samples/dfjcorb/BankAccount`
- The location where you have compiled the classes for the server side applications.

For guidance, see "Classes and class paths in JVMs" on page 8.

8. Ensure that the CICS-supplied resource definition groups DFHIIOP and DFH$IIOP are installed. The supplied group DFH$IIOP contains the following definitions:
   - Resource definitions required for the TCP/IP listener region (which might also be the same region that runs the sample programs):
     - SSL TCPIPSERVICE definition
     - NOSSL TCPIPSERVICE definition
   - Resource definitions required for the HelloWorld sample:
     - IIHE TRANSACTION definition
     - DFJIIRH REQUESTMODEL definition
     - IIOP CORBASERVER definition
   - Resource definitions required for the BankAccount sample:
     - DFH$IIBI PROGRAM definition
     - DFH$IIBQ PROGRAM definition
     - DFH$IICC PROGRAM definition
     - BANKINQ MAPSET definition
     - BNKI TRANSACTION definition
     - BNKQ TRANSACTION definition
     - BNKS TRANSACTION definition
     - BANKACCT FILE definition
     - DFJIIRB REQUESTMODEL definition
     - IIOP CORBASERVER definition

   The TCPIPSERVICE and IIOP CORBASERVER definitions refer to the default port numbers, 683 and 684. You might need to change these to port numbers that are available to you. Also, the IIOP definition refers to CICSHOST as the host of the CorbaServer. You must change this to your own host name. See TCPIPSERVICE resources and CORBASERVER resources.
9. Translate and compile the following CICS C language programs and map set and include them in a library in the CICS DFHRPL concatenation. They are stored in SDFHSAMP during CICS installation. The order of compilation is important. Both DFH$IIBI and DFH$IICC can be compiled independently, but the BMS map set DFH$IIMA must be compiled before compiling DFH$IIBQ. For guidance on translating, compiling, and linking CICS application programs, see the *CICS Application Programming Guide*.

   The file DFH$IIMA contains one map set BANKINQ with two maps. Compile and link the map set BANKINQ.

   See Installing map sets and partition sets, in the *CICS Application Programming Guide*, for guidance on compiling and linking BMS maps.

   DFH$IIBI
   C program that initializes the BANKACCT file. Run by the BNKI transaction.

   DFH$IIBQ
   C program that queries the accounts held in BANKACCT.

DFH$IICC
C program that performs a credit check. This is called by DFH$IIBQ.

DFH$IIMA
BMS map set BANKINQ.

Note: In the names of sample programs and files described in this book, the dollar symbol ($) is used as a national currency symbol and is assumed to be assigned the EBCDIC code point X'5B'. In some countries a different currency symbol, for example the pound symbol (£), or the yen symbol (¥), is assigned the same EBCDIC code point. In these countries, the appropriate currency symbol should be used instead of the dollar symbol.

10. To compile the IIOP HelloWorld client you require the CosLifeCycle and CosNaming runtime classes. If your client ORB environment does not provide these services ready-built you can use the `omgcos.jar` file shipped in the `$CICS_HOME/lib` directory. Alternatively, you might choose to build these classes from the original OMG supplied IDL. In this case a copy of the relevant IDL files is available in `$CICS_HOME/samples/dfjcorb`. The process of turning pure IDL into executable code is ORB dependent, but if you are using an ORB supplied with a JVM then it is likely that the following commands will work:

```
idlj -pkgprefix CosNaming org.omg -pkgprefix CosLifeCycle org.omg -fall CosLifeCycle.idl
idlj -pkgprefix CosNaming org.omg -pkgprefix CosLifeCycle org.omg -fall CosNaming.idl
javac org\omg\CosLifeCycle\*.java org\omg\CosNaming\NamingContextPackage\*.java
      org\omg\CosNaming\*.java
```

    You must ensure that these classes are available on your classpath environment variable when you attempt to build any CICS stateless CORBA client application.

11. Obtain a `genfac.ior` file containing an object reference to your server's generic factory, and place it in the current directory. The `genfac.ior` file is created when you issue a **PERFORM CORBASERVER PUBLISH** command for the installed sample IIOP CORBASERVER resource. It is written to the shelf directory of the CORBASERVER:

    ```
    /var/cicsts/applid/IIOP
    ```

    where *applid* is the APPLID identifier associated with the CICS region.

    To publish the CORBASERVER definition, you can use a **CEMT PERFORM CORBASERVER** command or an **EXEC CICS PERFORM CORBASERVER** command issued from a CICS application.

    You can download the IOR to your client workstation (in ASCII mode) from the shelf using FTP.

Results

You have used the samples to set up an IIOP environment.

Running the IIOP HelloWorld sample

This section tells you what you need to do to run the HelloWorld sample application.

It covers the following topics:

- "Building the server side HelloWorld application" on page 212
- "Building the client side HelloWorld application" on page 212
- "Running the HelloWorld sample application" on page 212

Building the server side HelloWorld application:

The makefile in `$CICS_HOME/samples/dfjcorb/HelloWorld/server` builds everything required for the server side application.

`$CICS_HOME/samples/dfjcorb/HelloWorld/server` should be added to the standard class path by using the CLASSPATH_SUFFIX option in the JVM profile, DFHJVMCD.

To build the programs, enter the command `make` from `$CICS_HOME/samples/dfjcorb/HelloWorld/server`. This command makes the HelloWorld object.

Building the client side HelloWorld application:

`$CICS_HOME/samples/dfjcorb/HelloWorld/client` contains the CORBA client part of the application. The source of the Java client application is called `HelloWorldClient.java`. This application should run with any CORBA-compliant ORB.

About this task

The following steps are required to build the Java client application:

1. Download the following files to the client workstation (in ASCII mode):
   - `.../dfjcorb/HelloWorld/HelloWorld.idl`
   - `.../dfjcorb/HelloWorld/client/HelloWorldClient.java`
2. Compile the provided IDL with the IDL-to-Java compiler of the client ORB to produce the Java client side stubs required by the sample application. These stubs will be created in a subdirectory called `hello`. Move the client application `HelloWorldClient.java` into this subdirectory.
3. Compile the client application, ensuring that the Java classes produced in the previous step are available through the CLASSPATH environment variable. To compile the client application from the current directory, enter:

   ```
   javac hello\HelloWorldClient.java
   ```

   You also need the `CosLifeCycle` and `CosNaming` runtime classes. If your client ORB environment does not provide these services ready built, you can use the `omgcos.jar` file shipped in the `$CICS_HOME/lib` directory on z/OS UNIX. Alternatively you may choose to build these classes from the original OMG-supplied IDL. In this case a copy of the relevant IDL files is available in `$CICS.HOME/samples/dfjcorb/`.

   The process of turning pure IDL into executable code is ORB-dependent, but if you are using an ORB supplied with a JVM then it is likely that the following commands will work:

```
idlj -pkgprefix CosNaming org.omg -pkgprefix CosLifeCycle org.omg -fall CosLifeCycle.idl
idlj -pkgprefix CosNaming org.omg -pkgprefix CosLifeCycle org.omg -fall CosNaming.idl
javac org\omg\CosLifeCycle\*.java
            org\omg\CosNaming\NamingContextPackage\*.java
            org\omg\CosNaming\*.java
```

   These classes must be in your classpath when you attempt to build any CICS stateless CORBA client application.

Running the HelloWorld sample application:

You must use this command to run the client application.

About this task

```
java hello.HelloWorldClient
```

Running the IIOP BankAccount sample

This section tells you what you need to do to run the BankAccount sample application.

It covers the following topics:
- "Building the server side BankAccount application"
- "Building the client side BankAccount application"
- "Running the BankAccount sample application" on page 214

Creating the VSAM file:

You must define the VSAM file to hold the bank account data using these IDCAMS parameters.

```
DEFINE    CLUSTER (                          -
                 NAME (CICS610.BANKACCT )    -
                 CYLINDERS(01)               -
                 REUSE                       -
                 KEYS(4 0)                   -
                 RECORDSIZE(168 168))
```

Building the server side BankAccount application:

The makefile in `$CICS_HOME/samples/dfjcorb/BankAccount/server` builds everything required for the CORBA part of the server side application.

Add `$CICS_HOME/samples/dfjcorb/BankAccount/server` to the standard class path by using the CLASSPATH_SUFFIX option in the JVM profile, DFHJVMCD.

To build the Java server program, enter the command `make` from `$CICS_HOME/samples/dfjcorb/BankAccount/server`.

Building the client side BankAccount application:

`$CICS_HOME/samples/dfjcorb/BankAccount/javaclient` contains the CORBA client part of the application. The source of the Java client application is called `bankLineModeClient.java`. This application can run with any CORBA-compliant ORB.

About this task

The following steps are required to build the Java client application:
1. Download the following files to the client workstation (in ascii mode):
   - `.../dfjcorb/BankAccount/BankAccount.idl`
   - `.../dfjcorb/BankAccount/javaclient/bankLineModeClient.java`
2. Compile the provided IDL with the client ORB's IDL-to-Java compiler to produce the Java client side stubs required by the sample application. After compiling the IDL to create the subdirectory, `bank`, move the Java file into this subdirectory. Compile the program from the current directory using the following command:
   ```
   javac bank\bankLineModeClient.java
   ```
3. Ensure that the Java classes produced in the previous step are available through the CLASSPATH environment variable.

You also require the CosLifeCycle and CosNaming runtime classes. If your client ORB environment does not provide these services ready built, you can obtain them in the same way as in "Building the client side HelloWorld application" on page 212.

Running the BankAccount sample application:

You must perform these steps to run the sample application:

About this task

Procedure

1. Run the BNKI CICS transaction to load data into the account file.
2. Run the client application using:
   ```
   java  bank.bankLineModeClient
   ```

Using enterprise beans

This section tells you what you need to know to develop and use enterprise beans in CICS.

- "What are enterprise beans?"
- "Setting up an EJB server" on page 238
- "Using the EJB IVP" on page 255
- "Running the sample EJB applications" on page 259
- "Writing enterprise beans" on page 283
- "Deploying enterprise beans" on page 295
- "Updating enterprise beans in a production region" on page 301
- "The CCI Connector for CICS TS" on page 311
- "Dealing with CICS enterprise bean problems" on page 327
- "Managing security for enterprise beans" on page 334
- "CICSPlex SM with enterprise beans" on page 345

What are enterprise beans?

CICS supports the Enterprise JavaBeans (EJB) architecture.

If you need a full description of the EJB architecture, see http://www.oracle.com/technetwork/java/index.html.

The section covers the following topics:

- "Enterprise beans" on page 215
- "JavaBeans and Enterprise JavaBeans" on page 215
- "The EJB server—overview" on page 217
- "The EJB container—overview" on page 217
- "Enterprise beans—the home and component interfaces" on page 218
- "Enterprise beans—the deployment descriptor" on page 219
- "Types of enterprise bean" on page 220
- "Enterprise beans—managing transactions" on page 222
- "Enterprise beans—security overview" on page 224
- "Enterprise beans—user tasks" on page 225
- "Overview of deploying enterprise beans" on page 226
- "Overview of configuring CICS as an EJB server" on page 229
- "Enterprise beans—what can a client do with a bean?" on page 236

- "Enterprise beans—what can a bean do?" on page 237

Enterprise beans

The *Enterprise JavaBeans Specification, Version 1.1* defines a model for the development of reusable Java server components known as *enterprise beans*. These components can be used in any application server that provides the services and interfaces defined by the specification.

You can configure CICS as an *EJB server*. CICS provides a runtime environment where requests for EJB services are mapped to existing or enhanced CICS services.

You can write enterprise beans that give Java clients access to your past investment in CICS applications and data. For example, you can write enterprise beans that:

- Use the JCICS classes to access CICS resources. Enterprise beans that use the JCICS classes are not portable to a non-CICS environment.
- Use JCICS to link to existing CICS programs written in procedural languages such as COBOL.

Figure 12 shows, in simplified form, a CICS EJB application server interacting with its environment. It shows enterprise beans that have been developed on a workstation being installed into the EJB server by a process known as *deployment*. Once installed in the server, the enterprise beans are executed in a Java Virtual Machine (JVM) at the request of a client program.

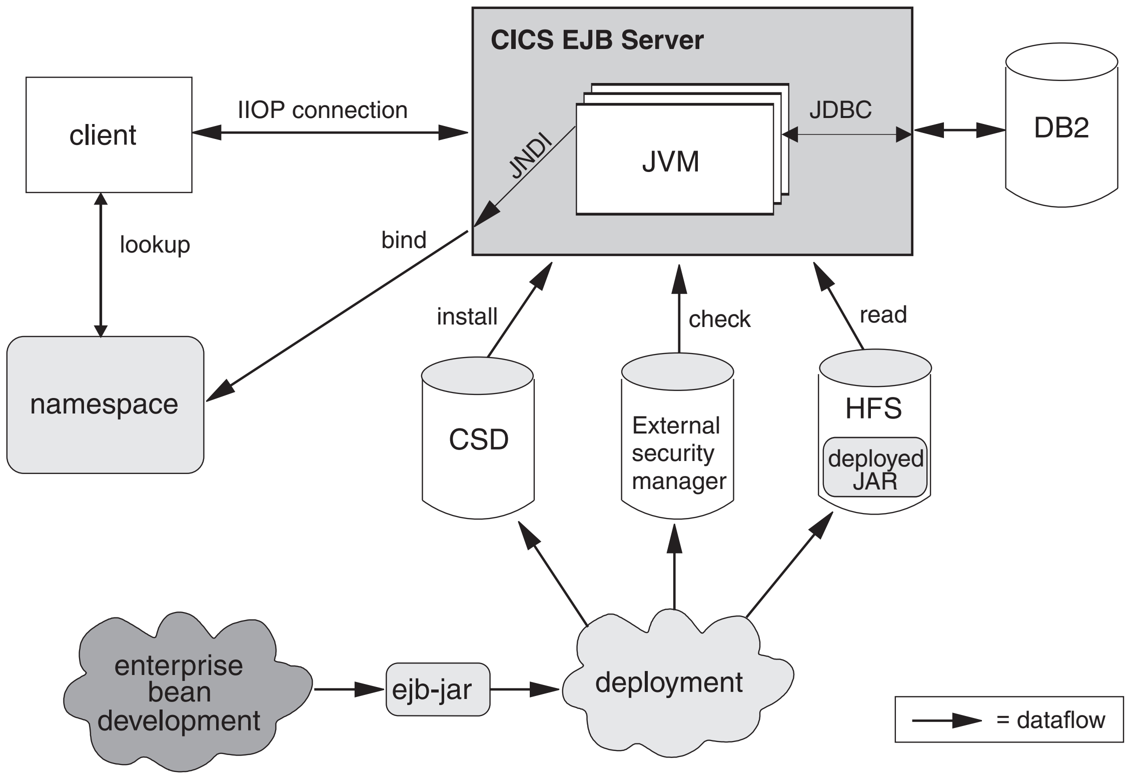


Figure 12. A CICS EJB application server

JavaBeans and Enterprise JavaBeans

JavaBeans and Enterprise JavaBeans are component architectures for the Java language.

Components:

A **component** is a reusable software building block; a pre-built piece of encapsulated application code that can be combined with other components and with handwritten code to produce a custom-built application rapidly.

An application developer can make use of a component without requiring access to its source code. Components can be customized to suit the specific requirements of an application through a set of external property values. For example, a button component has a property that specifies the caption that should appear on the button. An account management component has a property that specifies the location of the account database.

Components execute within a construct called a **container**, which (among other things) provides an operating system process in which to execute the component.

The **component model** defines the interfaces by which the component interacts with its container and with other components. The developer of a component may code it using a variety of internal methods and properties but, to ensure that it can be used with other components, he or she must implement the interfaces defined in the component model. These interfaces also allow components to be loaded into rapid application development (RAD) tools, such as WebSphere Studio Application Developer.

JavaBeans:

A **JavaBean** is a self-contained, reusable software component, written in Java, usually intended for use in a *desktop or client* application.

Typically, desktop JavaBeans have a visual element, and execute within some type of visual container, such as a form, panel, or Web page. Examples might range from a simple button to a fully-featured software CD player.

Bean developers can use a visual tool, such as WebSphere Studio Application Developer, to create JavaBeans. Application developers can use such tools to "wire" JavaBeans together into a larger application, and to set the properties of individual beans.

Enterprise JavaBeans:

The **Enterprise JavaBeans architecture** supports *server components*. Server components are application components that run in an application server such as CICS. Unlike desktop components, they do not have a visual element and the container they run in is not visual.

Server components written to the Enterprise JavaBeans specification are known as **enterprise beans**. They are portable across any EJB-compliant application server.

To be useful, server components require access to the application server's infrastructure services, such as its distributed communication service, naming and directory services, transaction management service, data access and persistence services, and resource-sharing services. Different application servers implement these infrastructure services using different technologies. However, an EJB-compliant application server provides an enterprise bean with access to these services through standard interfaces, and manages many of them on behalf of the bean.

Bean developers can use a visual tool, such as WebSphere Studio Application Developer, to create enterprise beans. Application developers can combine method calls to enterprise beans with desktop JavaBeans, Web servlets, and handwritten code to form client/server applications.

The EJB server—overview

An EJB-compliant application server is known as an *EJB server*.

An EJB server could be a transaction processing monitor such as CICS, a Web server, a database, or some other type of server. Note that a CICS EJB server may comprise multiple CICS regions, as described in "Logical servers: Enterprise beans in a sysplex" on page 230.

An EJB server provides a standard set of services to support enterprise bean components. These services include:

- Support of the Java Remote Method Invocation (RMI) interface that is used by enterprise beans for communication. RMI has two transport protocol options—JRMP for Java-to-Java interoperation and IIOP for interlanguage interoperation, mediated using a CORBA Object Request Broker (ORB). (For a description of the CICS ORB, see "The Object Request Broker (ORB)" on page 351.)

  CICS Transaction Server for z/OS, Version 4 Release 2 supports RMI over IIOP (RMI-IIOP), but not JRMP. (JRMP is a proprietary protocol that cannot be used to interoperate with non-Java components. CICS does not support distributed transactions over JRMP.)
- A container, called an **EJB container**, which provides management services for enterprise beans.
- A distributed transaction management service that implements the javax.transaction.UserTransaction interface of the Java Transaction API (JTA). The javax.transaction.UserTransaction interface is used by session beans that manage their own transactions.
- Security services.
- Support for the Java Naming and Directory Interface (JNDI). The JNDI API provides directory and naming functionality for Java applications. It enables a client to locate an enterprise bean.
- Support for the Java Data Base Connectivity (JDBC) interface.

The EJB container—overview

Whereas desktop JavaBeans usually run within a visual container such as a form or a Web page, an enterprise bean runs within a container provided by the application server.

The EJB container creates and manages enterprise bean instances at run-time, and provides the services required by each enterprise bean running in it.

The EJB container supports a number of implicit services, including life cycle, state management, security, and transaction management:

Life cycle
: Individual enterprise beans do not need to manage process allocation, thread management, object activation, or object passivation explicitly. The EJB container automatically manages the object life cycle on behalf of the enterprise bean.

State management
Individual enterprise beans do not need to save or restore object state between method calls explicitly. The EJB container automatically manages object state on behalf of the enterprise bean.

Security
Individual enterprise beans do not need to authenticate users or check authorization levels explicitly. The EJB container can automatically perform all security checking on behalf of the enterprise bean.

Transaction management
Individual enterprise beans do not need to specify transaction demarcation code to participate in distributed transactions. The EJB container can automatically manage the start, enrollment, commitment, and rollback of transactions on behalf of the enterprise bean.

The execution environment:

Before enterprise beans can be deployed into an EJB server, their execution environment must be configured.

In CICS, this is achieved by installing a CORBASERVER resource definition. A CORBASERVER defines an execution environment for enterprise beans and CORBA stateless objects. For convenience, we shall refer to the execution environment defined by a CORBASERVER definition as a **CorbaServer**.

Note that:
- A CICS EJB server may contain more than one CorbaServer.
- Any number of enterprise beans can be deployed into the same CorbaServer.
- A specific enterprise bean can be deployed multiple times into the same CICS EJB server, but not into the same CorbaServer. (In other words, to install a specific enterprise bean multiple times into the same CICS EJB server you must install it into different CorbaServer execution environments. One reason for doing this might be to make the bean available with different deployment properties—see "Enterprise beans—the deployment descriptor" on page 219.) Each deployment results in the creation of a distinct home object (see "Enterprise beans—the home and component interfaces").

Enterprise beans—the home and component interfaces

Client applications do not interact with an enterprise bean directly.

Instead, the client interacts with the enterprise bean through two intermediate objects that are created by the container from classes generated by a deployment tool—one of which classes implements the EJB **home interface** and the other the EJB **component interface**. As the client invokes operations using these intermediate objects, the container intercepts each method call and inserts the management services.

The home and component interfaces are implemented as Java RMI remote objects, which allows the ORB to support them as distributed objects.

The home interface
The home interface is the mechanism by which the client identifies the enterprise bean it wants. It allows a client to create, remove, and (for entity beans, not supported by CICS) find existing instances of, enterprise beans. *Note that the "client" might not be a program running on a network workstation; it might,*

for example, be a servlet running on a Web server; or an enterprise bean, program, or object on the local EJB server, or on another EJB server.

When a bean is deployed in an EJB server, the container registers the home interface in a namespace that is accessible remotely. Using the Java Naming and Directory Interface (JNDI) API, any client with access to the namespace can locate the home interface by name. (To be precise, the client locates, by name, an object that implements the home interface. The home interface extends the EJBHome interface.)

The component interface

The component interface allows a client to access the business methods of the enterprise bean. It intercepts all business method calls from the client and inserts whatever transaction, state management, persistence, and security services were specified when the bean was deployed.

When a client creates or finds an instance of an enterprise bean, the container returns a component interface object (one per instance). (To be precise, the container returns a reference to an instance of a class that implements the component interface. The component interface extends the EJBObject interface.)

Enterprise beans—the deployment descriptor

The rules governing an enterprise bean's life cycle, transaction management, security, and persistence are defined in an associated XML document called a **deployment descriptor**.

See “Overview of deploying enterprise beans” on page 226.

Re-usable components may be customizable through a set of external property values, so that they can be modified to suit the requirements of a particular application without changing the source code. An enterprise bean developer can provide (within the deployment descriptor) a set of **environment properties** to allow the application developer to customize the bean. For example, a property might be used to specify the location of a database or to specify a default national language. At run time, an environment object is created which contains the customized property values set during the application assembly process or the bean deployment process.

The EJB server: summary

This topic summarizes the information about EJB servers presented in the previous topics.

The following figure shows enterprise bean objects in a CICS EJB server. The EJB container manages and provides services to the enterprise beans contained within it. When a bean is deployed, the deployment tool generates the EJB home and component interface classes.

The home interface is accessible through JNDI and implements lifecycle services for the bean. The client uses it to create, remove, and (for entity beans, not directly supported by CICS) find instances of enterprise beans.

The container creates an EJB component interface object for each instance of the bean. The component interface provides access to the business methods within the bean. It intercepts all business method calls from the client and implements transaction, state management, persistence, and security services for the bean, based on the settings of the bean's deployment descriptor.

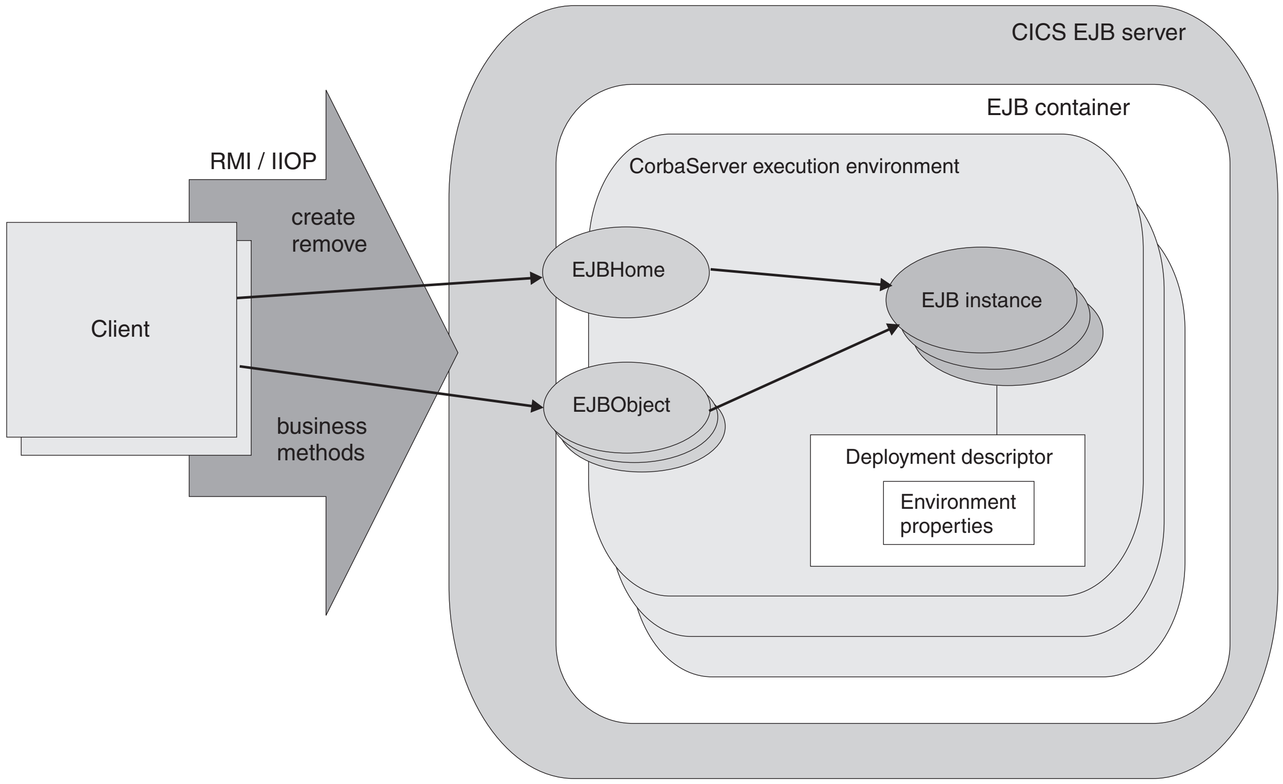


Figure 13. Enterprise bean objects in a CICS EJB server

Types of enterprise bean

This section discusses two types of enterprise bean—**session beans** and **entity beans**.

Session beans: A session bean:

- Is created by a client and represents a single conversation, or session, with that client.
- Typically, persists only for the life of the conversation with the client. In this sense, it can be likened to a pseudoconversational transaction.

  If the bean developer chooses to save information beyond the life of a session, he or she must implement persistence operations—for example, JDBC or SQL calls—directly in the bean class methods.
- Typically, performs operations on business data on behalf of the client, such as accessing a database or performing calculations.
- May or may not be transactional. If it's transactional, it can manage its own Object Transaction Service (OTS) transactions, or use container-managed OTS transactions. For an explanation of the relationship between OTS transactions and CICS units of work, see "Enterprise beans—managing transactions" on page 222.
- Is not recoverable—if the EJB server crashes, it may be destroyed.
- Has two flavours: **stateful** and **stateless**.

Stateful session beans:

A stateful session bean has a *client-specific* conversational state, which it maintains across methods and transactions; for example, a “shopping cart” object would maintain a list of the items selected for purchase by the user.

A stateful session bean that manages its own transactions can begin an OTS transaction in one method and commit or roll it back in a subsequent method.

Stateless session beans:

A stateless session bean has no client-specific (nor any other kind of) non-transient state; for example, a “stock quotation” object might return current share prices.

A stateless session bean that manages its own transactions and begins a transaction must commit (or roll back) the transaction in the same method in which it started it.

Entity beans:

CICS does not support entity beans directly. That is, entity beans cannot run in a CICS EJB server. However, a session bean or program running in a CICS EJB server can be a client of an entity bean running in a non-CICS EJB server.

Important

An entity bean:
- Is typically an object representation of business data, such as a customer order. Typically, the data:
  - Are maintained in a permanent data store, such as a database.
  - Need to persist beyond the life of a client instance. Therefore, an entity bean is relatively long-lived, compared to a session bean.
- Object can be accessed by more than one client at the same time. This is possible because each instance of an entity bean is identified by a **primary key**, which can be used to find it via the home interface.
- Can manage its own persistence (**bean-managed persistence**), or delegate the task to its container (**container-managed persistence**).

  If the bean manages its own persistence, the bean developer must implement persistence operations—for example, JDBC or SQL calls—directly in the bean.

  If the entity bean delegates persistence to the container, the latter manages the persistent state transparently; the bean developer doesn't need to code any persistence operations within the bean.
- May or may not be transactional. If it's transactional, all transaction functions are performed implicitly by the EJB container and server. There are no transaction demarcation statements within the bean code. Unlike session beans, an entity bean is not permitted to manage its own OTS transactions. See “Enterprise beans—managing transactions” on page 222.
- Is recoverable—it survives a server crash.

Session beans and entity beans compared:

This is a summary of the differences between entity and session beans.

Table 15. Comparison of session and entity beans

Session bean	Entity bean
Represents a single conversation with a client. Typically, encapsulates an action or actions to be taken on business data.	Typically, encapsulates persistent business data—for example, a row in a database.
Is relatively short-lived.	Is relatively long-lived.
Is created and used by a single client.	May be shared by multiple clients.
Has no primary key.	Has a primary key, which enables an instance to be found and shared by more than one client.
Typically, persists only for the life of the conversation with the client. (However, may choose to save information.)	Persists beyond the life of a client instance. Persistence can be container-managed or bean-managed.
Is not recoverable—if the EJB server fails, it may be destroyed.	Is recoverable—it survives failures of the EJB server.
May be stateful (that is, have a client-specific state) or stateless (have no non-transient state).	Is typically stateful.
May or may not be transactional. If transactional, can manage its own OTS transactions, or use container-managed transactions. A stateful session bean that manages its own transactions can begin an OTS transaction in one method and commit or roll it back in a subsequent method. A stateless session bean that manages its own transactions and begins an OTS transaction must commit (or roll back) the transaction in the same method in which it was started. The state of a transactional, stateful session bean is not automatically rolled back on transaction rollback. In some cases, the bean can use session synchronization to react to syncpoint.	May or may not be transactional. Must use the container-managed transaction model. If transactional, its state is automatically rolled back on transaction rollback.
Is not re-entrant.	May be re-entrant.

Enterprise beans—managing transactions

Clients can begin, commit, and roll back ACID transactions using an implementation of the Java Transaction Service (JTS) or the CORBA Object Transaction Service (OTS).

These ACID transactions [1] are analogous to CICS distributed units of work. We use the term **OTS transaction** to differentiate these transactions from CICS transaction definitions (the ones with 4-character transaction identifiers) and CICS transaction instances (which are sometimes loosely called "tasks").

1. Transactions possessing atomicity, consistency, isolation, and durability. Jim Gray and Andreas Reuter, *Transaction Processing: Concepts and Techniques*, 1993.

When a client calls an enterprise bean in the scope of an OTS transaction, information about the transaction flows to the EJB server in an IIOP "service context", which is like an extra (hidden) parameter on the method request. The EJB server uses this information if it needs to participate in the transaction. Whether the method of an enterprise bean needs to run under a client's OTS transaction (if there is one) is determined by the setting of the **transaction attribute** specified in the bean's deployment descriptor. The method may run under the client's OTS transaction, under a separate OTS transaction which is created for the duration of the method, or under no OTS transaction.

Entity beans must use **container–managed OTS transactions**. All transaction functions are performed implicitly by the EJB container and server. There are no transaction demarcation statements within the bean code.

Session beans can use either container-managed OTS transactions or **bean–managed OTS transactions**. A session bean that uses bean–managed transactions uses methods of the javax.transaction.UserTransaction interface to demarcate transactions. A stateful session bean that manages its own transactions can begin an OTS transaction in one method and commit or roll it back in a subsequent method. A stateless session bean that manages its own transactions and begins an OTS transaction must commit (or roll back) the transaction in the same method.

At runtime, the EJB container implements transaction services according to the setting of the transaction attribute specified in the bean's deployment descriptor. The possible settings of the transaction attribute are:

Mandatory
Indicates that the bean must always execute within the context of the caller's OTS transaction. If the caller does not have a transaction when it calls the bean, the container throws a javax.transaction.TransactionRequiredException exception and the request fails.

Never
Indicates that the bean must not be invoked within the context of an OTS transaction. If a caller has an OTS transaction when it calls the bean, the container throws a java.rmi.RemoteException exception and the request fails.

NotSupported
Indicates that the bean cannot execute within the context of an OTS transaction. If a caller has an OTS transaction when it calls the bean, the container suspends the transaction for the duration of the method call. It resumes the suspended transaction when the method has completed. The suspended transaction context of the client is not passed to resource managers or enterprise bean objects that are invoked from the method.

Required
Indicates that the bean must execute within the context of an OTS transaction. If a caller has an OTS transaction when it calls the bean, the method participates in the caller's transaction. If the caller does not have an OTS transaction, the container starts a new OTS transaction for the method.

RequiresNew
Indicates that the bean must execute within the context of a new OTS transaction. The container always starts a new OTS transaction for the method. If the caller has an OTS transaction when it calls the bean, the container suspends the caller's transaction for the duration of the method call. The

suspended transaction context of the client is not passed to resource managers or enterprise bean objects that are invoked from the method.

Supports
Indicates that the bean can run with or without a transaction context. If a caller has an OTS transaction when it calls the bean, the method participates in the caller's transaction. If the caller does not have an OTS transaction, the method runs without one.

Note: Enterprise bean methods always execute in a CICS task, under a CICS unit of work. Even if an enterprise bean method executes under no OTS transaction, any updates that the method makes to recoverable resources are committed only at normal termination of the CICS task, and backed out if there is a need to roll back.

The setting of a method's transaction attribute determines whether or not the CICS task under which the method executes makes its unit of work part of a wider, distributed OTS transaction.

A single CICS task cannot contain more than one enterprise bean, because CICS treats an execution of an enterprise bean method as the start of a new task. You can create an application that includes more than one enterprise bean, but the application will not operate as a single CICS task.

Enterprise beans—security overview

EJB security is concerned with authentication, access control, and the Java 2 security policy mechanism.

Authentication:

Authentication of EJB clients uses the TCP/IP secure sockets layer (SSL) protocol.

See Support for security protocols, in the *CICS RACF Security Guide*, for information about configuring CICS to use SSL.

Access control:

Access to enterprise bean methods is based on the concept of security roles. You can use CICS transaction security and resource security with EJB resources.

Security roles:

Access to enterprise bean methods is based on the concept of **security roles**. A security role represents a type of user of an application in terms of the permissions that the user must have to successfully use the application.

The roles that are permitted to execute a particular enterprise bean or particular methods of a bean are specified in the bean's deployment descriptor, and the mapping of security roles to individual users is done in the external security manager.

For more information about security roles, see “Security roles” on page 338.

CICS transaction and resource security:

You can use CICS transaction security and resource security with EJB resources.

CICS transaction security applies to the CICS transactions associated with enterprise bean methods—that is, the transactions named on EJB REQUESTMODEL definitions.

CICS resource security applies to the CICS resources accessed by enterprise beans (by means of, for example, JCICS).

The Java security manager:

The security of the enterprise beans container environment is protected by the Java security policy mechanism and is independent of CICS security. The security policy mechanism is one of the components that make up the Java security model.

The security policy mechanism is used to enforce the restrictions in the EJB specification concerning Java functions that may not be issued by enterprise beans. CICS provides a policy file that enforces this behaviour.

To use JDBC or SQLJ from enterprise beans with a Java security policy mechanism active, you must use the JDBC 2.0 driver provided by DB2. The IBM Data Server Driver for JDBC and SQLJ provided by DB2 does not support Java security, and will fail with a security exception unless you disable the mechanism.

Enterprise beans—user tasks

The roles involved in the development and deployment of applications that use enterprise beans are, a bean provider, an application assembler, a deployer, and a system administrator.

Note: In smaller organizations, one person may be responsible for more than one of these roles.

The bean provider:

The bean provider develops reusable enterprise beans that typically implement business tasks or business entities.

The bean provider's output is an **ejb-jar file** that contains one or more enterprise beans. The bean provider is responsible for:

- The Java classes that implement an enterprise bean's business methods.
- The definition of the bean's component and home interfaces.
- The bean's deployment descriptor.

  The deployment descriptor includes the structural information—for example, the name of the enterprise bean class—of the enterprise bean and declares all the bean's external dependencies—for example, the names and types of the resource managers that the enterprise bean uses.

The application assembler:

The application assembler creates applications that use enterprise beans. He combines enterprise beans and hand-written client code into a client/server application. Although he must be familiar with the functionality provided by the enterprise beans' component and home interfaces, he does not need to have any knowledge of the enterprise beans' implementation.

The input to the application assembler is one or more ejb-jar files produced by the bean provider. His output is one or more ejb-jar files that contain the enterprise beans, along with their application assembly instructions and customized environment settings. He has inserted the application assembly instructions, security roles, and environment values into the deployment descriptors.

The application assembler may also combine enterprise beans with other types of application components—for example, JavaBeans—when assembling an application.

Typically, the application assembly step occurs before the deployment of the enterprise beans. However, sometimes assembly may be performed after the deployment of all or some of the enterprise beans.

The deployer:

The deployer takes one or more ejb-jar files produced by the application assembler and deploys the enterprise beans contained in the ejb-jar files into a specific CorbaServer in an EJB server.

The deployer must:
- Resolve all the external dependencies declared by the bean provider. For example, he must ensure that all resource manager connection factories used by the enterprise beans are present in the operational environment, and bind them to the resource manager connection factory references declared in the deployment descriptor.
- Follow the application assembly instructions defined by the application assembler. For example, the deployer is responsible for mapping the security roles defined by the application assembler to CICS user groups and external security manager profiles.

The deployment process is semi-automated. To perform his role, the deployer uses a **deployment tool**. Deployment tools are provided by CICS.

The deployer's output are enterprise beans that have been customized for the target operational environment, and deployed in one or more CorbaServers.

The system administrator:

The system administrator is responsible for configuring and administering the CICS regions that comprise the logical EJB server, together with their network connections. He or she is also responsible for overseeing the well-being of the deployed EJB applications at runtime.

Overview of deploying enterprise beans

A desktop Java bean is developed, installed, and run on a workstation. An enterprise bean, which runs on a server, requires an additional stage, **deployment**, to prepare the bean for the runtime environment and install it into the EJB server.

Enterprise beans are produced by the bean provider and customized by the application assembler. The application assembler may use a tool such as the Assembly Toolkit (ATK) (described in The enterprise bean deployment tool, ATK, in the *CICS Operations and Utilities Guide*) to customize the ejb-jar file. The customized ejb-jar file passed to the deployer contains:
- The Java classes for one or more enterprise beans.
- A single deployment descriptor, written in XML, that describes the characteristics of each of the enterprise beans, such as:

  - Transaction attributes
  - Environment properties
  - Security levels
  - Application assembly information.

Also required is information specific to CICS, such as resource definition requirements.

Here's an outline of the deployment process:

1. A deployment tool, such as the enterprise bean deployment tool, ATK. Use this tool to transform the ejb-jar file into a deployable JAR file, suitable for deployment. The transformed file contains the XML deployment descriptor and enterprise bean classes from the ejb-jar file, plus additional classes generated in support of the EJB container. The transformed file is stored as a deployed JAR file on the z/OS UNIX file system.

   Store the deployed JAR file in the CorbaServer's deployed JAR file directory (specified by the DJARDIR option of the CORBASERVER definition). The deployed JAR file directory is also known as the **"pickup" directory**. When CICS scans the pickup directory, it automatically creates and installs a definition of each new or updated deployed JAR file that it finds there. CICS scans the pickup directory in any of the following ways:
   - Automatically, when the CORBASERVER definition is installed
   - When instructed to by means of an explicit **EXEC CICS** or **CEMT PERFORM CORBASERVER SCAN** command
   - When instructed to by the resource manager for enterprise beans (otherwise known as the RM for enterprise beans), which issues a **PERFORM CORBASERVER SCAN** command on your behalf. (The resource manager for enterprise beans is described in The Resource Manager for Enterprise Beans, in the *CICS Operations and Utilities Guide*.)
2. CICS resource definitions are required for:
   - The CorbaServer execution environment (CORBASERVER). (The same CORBASERVER definition will be installed on each CICS AOR in the logical EJB server.)
   - TCP/IP services (for IIOP). One or more TCPIPSERVICE definitions will be installed on each CICS region in the logical EJB server.
   - Request models, to associate client IIOP requests with CICS TRANSIDs (and thus to associate bean methods with sets of execution characteristics, covering such things as security, priority, and monitoring). Request models are only required if the default TRANSID, CIRP, is unsuitable. (You may want to segregate your IIOP workload by transaction ID, for example.)

     Note: You can use the CREA CICS-supplied transaction to display the transaction IDs associated with particular beans and bean-methods in the CorbaServer. You can change the transaction IDs, apply the changes, and save the changes to new REQUESTMODEL definitions.
   - Deployed JAR files (DJARs), each of which includes the z/OS UNIX filename of a deployed JAR file. If you store your deployed JAR files in the CorbaServer's "pickup" directory, DJAR definitions are created and installed automatically when the CorbaServer is installed (or when a subsequent scan takes place).

   Note: "Setting up a logical EJB server" on page 231 contains more information about these RDO definitions.

3. Security definitions are added to the external security manager. These specify which roles can execute particular beans and methods, and which user IDs are associated with each role.
4. The resource definitions are installed in CICS. Installing a DJAR definition causes CICS to:
   - Copy the deployed JAR file (and the classes it contains) to a "shelf" directory on z/OS UNIX. The **shelf directory** is where CICS keeps copies of installed deployed JAR files.
   - Read the deployed JAR from the shelf, parse its XML deployment descriptor, and store the information it contains.

   Note: If you store your deployed JAR files in the CorbaServer's "pickup" directory, DJAR definitions are installed automatically when the CorbaServer is installed (or when a subsequent scan takes place).
5. A reference to the home interface class of each deployed bean is published in an external namespace. The namespace is accessible to clients through JNDI.

   If you specify AUTOPUBLISH(YES) on the CORBASERVER definition, the contents of a deployed JAR file are automatically published to the namespace when the DJAR definition is successfully installed into the CorbaServer. Alternatively, you can issue a **PERFORM CORBASERVER PUBLISH** or **PERFORM DJAR PUBLISH** command.

Figure 14 shows the deployment process.

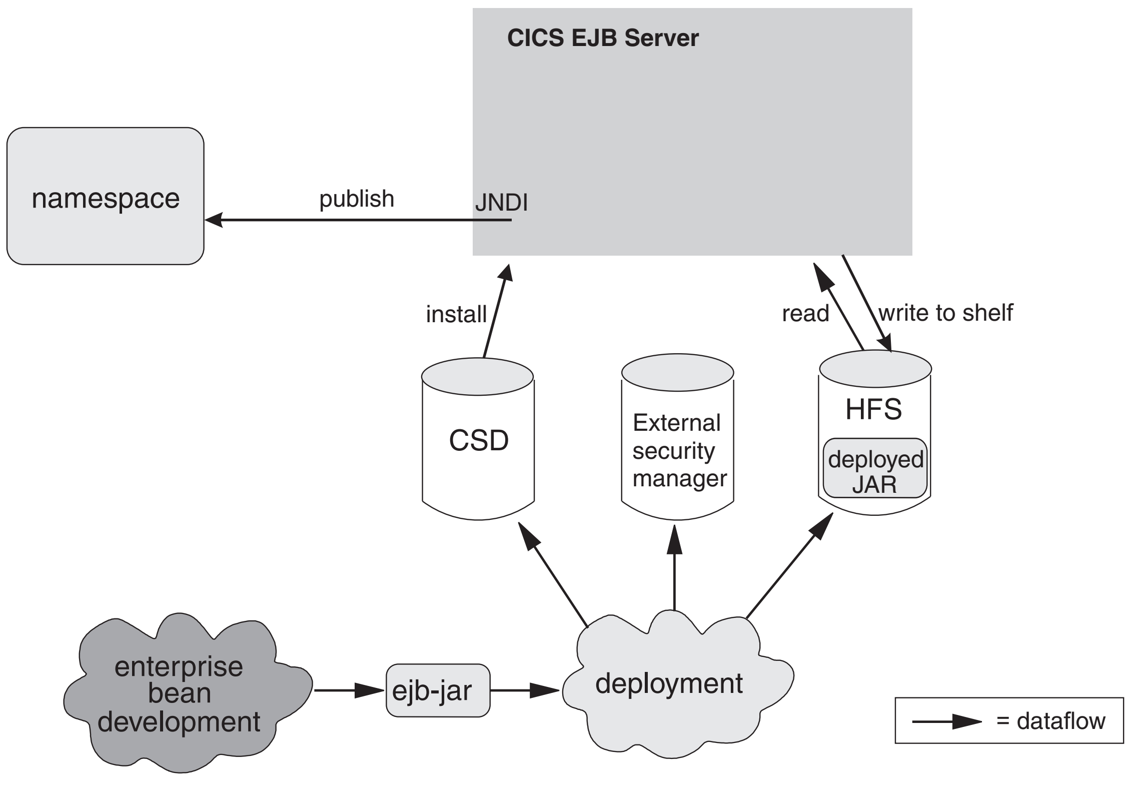


Figure 14. Deploying enterprise beans into a CICS EJB server. A deployment tool is used to perform code generation on the ejb-jar file containing the bean classes. The transformed file is stored as a deployed JAR file on z/OS UNIX. An RDO definition of the deployed JAR file is created and installed in CICS, together with other definitions for TCP/IP services, request models, and the CorbaServer execution environment. Security definitions are created on the external security manager.

Overview of configuring CICS as an EJB server

A CICS EJB server contains these basic components.

The listener
: The job of the listener is to listen for (and respond to) incoming TCP/IP connection requests. An IIOP listener is configured by a TCPIPSERVICE resource to listen on a specific TCP/IP port and to attach an IIOP **request receiver** to handle each connection.

  Once an IIOP connection has been established between a client program and a particular request receiver, all subsequent requests from the client program over that connection flow to the same request receiver.

The request receiver
: The request receiver analyzes the structured IIOP data. It passes the incoming request to a **request processor** by means of a **request stream**, which is an internal CICS routing mechanism. The object key in the request determines whether the request must be sent to a new or an existing request processor.

  If the request must be sent to a new request processor, a CICS transaction ID is determined by comparing the request data with templates defined in REQUESTMODEL resources. (If no matching REQUESTMODEL resource can be found, the default transaction, CIRP, is used.) The TRANSID defines execution parameters that are used by the request processor.

The request processor
: The request processor is a transaction instance that manages the execution of the IIOP request. It:

  - Locates the object identified by the request
  - For an enterprise bean request, calls the container to process the bean method
  - For a request for a stateless CORBA object, the ORB typically processes the request itself (although the transaction service may also be involved).

For comprehensive information about listeners, request receivers, and request processors, see "The IIOP request flow" on page 354.

Figure 15 on page 230 shows a CICS logical EJB server. In this example, the listener regions and AORs are in separate groups, connection optimization is used to balance client connections across the listener regions, and distributed routing is used to balance OTS transactions across the AORs.

The logical server consists of a set of cloned listener regions and a set of cloned AORs. In this example, connection optimization by means of dynamic DNS registration is used to balance client connections across the listener regions. Distributed routing is used to balance OTS transactions across the AORs.

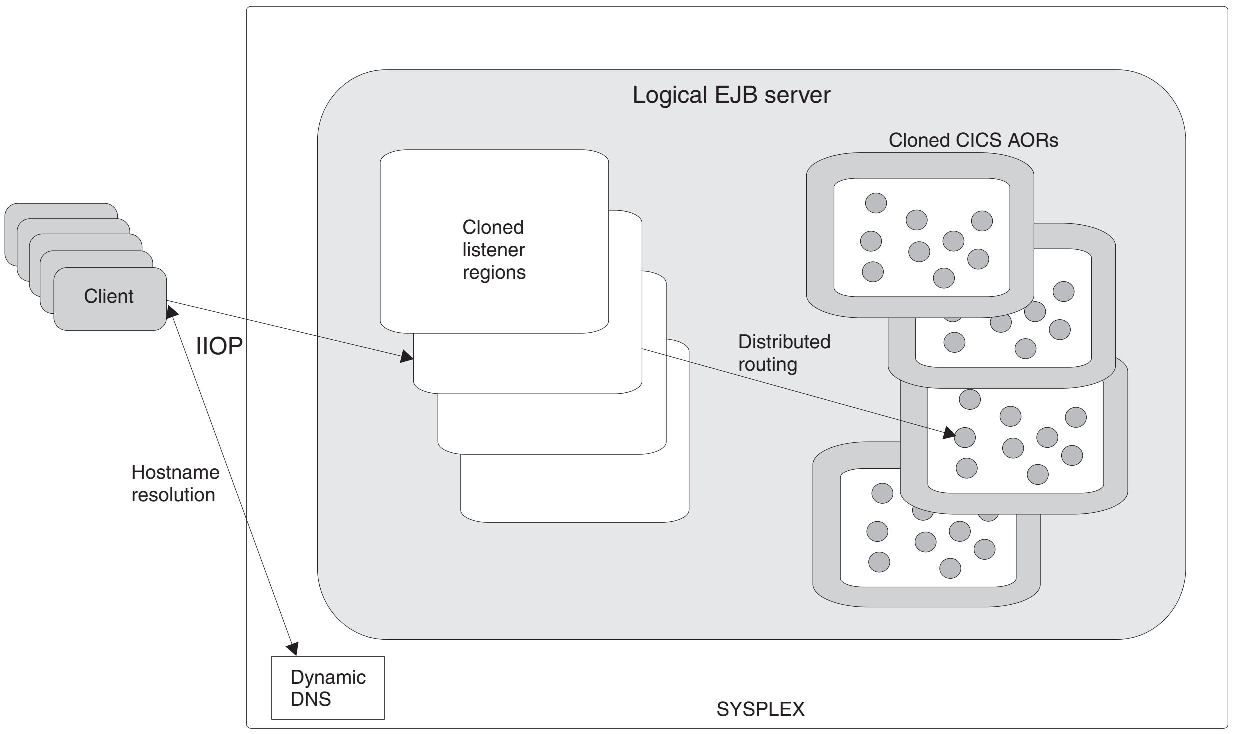


Figure 15. A CICS logical EJB server

Logical servers: Enterprise beans in a sysplex:

You can implement a CICS EJB server in a single CICS region.

However, in a sysplex it is likely that you will want to create a server consisting of multiple regions. Using multiple regions makes failure of a single region less critical and enables you to use workload routing. A CICS logical EJB server consists of one or more CICS regions configured to behave like a single EJB server.

Typically, a CICS logical EJB server consists of the following components:
- A set of cloned listener regions defined by identical TCPIPSERVICE definitions to listen for incoming IIOP requests.
- A set of cloned application-owning regions (AORs), each of which supports an identical set of enterprise bean classes in an identically-defined CORBA server.

Note: The listener regions and AORs can be separate or combined into listener AORs.

Workload routing in a sysplex:

Workload routing is implemented at two levels by directing client connections across the listener regions and routing OTS transactions across the AORs.
1. To route client connections across the listener regions, you can use any of the following methods:
   - Connection optimization by means of dynamic Domain Name System (DNS) registration.
   - IP routing.
   - A combination of connection optimization and IP routing.

With connection optimization by means of dynamic DNS registration, for example, multiple CICS regions are started to listen for IIOP requests on the same port (using virtual IP addresses). Each client IIOP connection request contains a generic host name and port number. The generic host name in each connection request is resolved to a real IP address by MVS DNS and Workload Management (WLM) services.

2. To route OTS transactions across the AORs, you can use either of the following:
   - CICSPlex SM
   - A customized version of the CICS distributed routing program, DFHDSRP.

   Important

   When you are using the distributed routing program it is convenient to talk of dynamically routing OTS transactions across AORs. Strictly speaking, however, what are dynamically routed are *method requests* for enterprise beans and CORBA stateless objects. There is a correspondence between routing method requests dynamically and routing OTS transactions dynamically: CICS invokes the routing program for requests for methods that will run under a *new* OTS transaction, but not for requests for methods that will run under an *existing* OTS transaction—these it directs automatically to the AOR in which the existing OTS transaction runs. However, because requests for methods that will run under *no OTS transaction* can also be dynamically routed, the correspondence is not exact.

   It is important to understand the difference between new and existing OTS transactions.

   a. A *new* OTS transaction is one in which the target logical server is not already participating, before the current method call; *not* necessarily an OTS transaction that was started immediately before the method call.
   b. An *existing* OTS transaction is one in which the target logical server is already participating, before the current method call; *not* an OTS transaction that was started some time ago.

   For example, if a client starts an OTS transaction, does some work, and then calls a method on an enterprise bean, so far as the CICS EJB server is concerned this is a new OTS transaction, because the server has not been called within this transaction's scope before. If the client then makes a second and third method call to the same target object, before committing its OTS transaction, these second and third calls occur within the scope of the existing OTS transaction.

Setting up a logical EJB server:

You must follow a number of steps to set up a CICS logical EJB server to support enterprise beans.

Before setting up a logical EJB server, make sure that the regions in a logical EJB server, both listeners and AORs, are at the same level of CICS.

Follow these steps to set up a CICS logical EJB server to support enterprise beans:

1. Create a set of cloned CICS Transaction Server for z/OS, Version 4 Release 2 listener regions. Each listener region must have the **IIOPLISTENER** system initialization parameter set to YES.
2. Create a set of cloned CICS Transaction Server for z/OS, Version 4 Release 2 AORs. Each of the AORs must meet these criteria:
   - Configured to use JNDI

- Use the same JNDI initial context as the other AORs
- Connected to all of the listener regions by MRO (not ISC)
- Configured with **IIOPLISTENER** system initialization parameter set to NO.

3. Create a shelf root directory on z/OS UNIX. For example, you might create a directory called `/var/cicsts/`. To do so, you need a z/OS UNIX user ID with write authority to the directory path to be used by CICS. Having created the shelf directory, you must give the user IDs of the AOR full access read, write, and run access to the directory.
4. Create a deployed JAR file (pickup) directory on z/OS UNIX. For example, you might create a directory called `/var/cicsts/pickup`. The AORs must have at least read access to it.

   If your AORs are to contain more than one CorbaServer runtime environment:
   - You must create a separate pickup directory for each CorbaServer.
   - Assign different sets of transaction IDs to the objects supported by each CorbaServer. That is, each CorbaServer in an AOR supports a different set of transaction IDs. To assign transaction IDs to bean methods, use REQUESTMODEL definitions; see step 5.
5. Create the following resource definitions. You can create them on a CSD that is shared by all the regions in the logical server, copy them to all the CSDs used by the regions, or add them to a CICSPlex SM Resource Description that applies to all the regions. Optionally, you can use the CICS scanning mechanism, the Resource Manager for enterprise beans, and the CICS-supplied transaction, CREA, to create some of these definitions, as described below.
   - A TCPIPSERVICE.
     - On the PROTOCOL option, specify IIOP.
     - On the SSL option, specify NO.
     - On the AUTHENTICATE option, specify NO. With this specification, the service on this port accepts unauthenticated inbound IIOP requests.
   - Some REQUESTMODEL definitions. In a single-region EJB server, the definitions are only required if the default TRANSID, CIRP, is unsuitable. In a multiregion logical server, however, the definitions are required if you want to route method requests across several AORs. The TRANSACTION definition for CIRP specifies DYNAMIC(NO). Definitions are also required if, for example, you want to segregate your IIOP workload by transaction ID.

     Note:
     a. The BEANNAME attribute of each REQUESTMODEL definition must “match” (in a pattern-matching sense) the name of an enterprise bean in the deployment descriptor in a deployed JAR file on z/OS UNIX. The value of the CORBASERVER attribute must match, either literally or in a pattern-matching sense, the name of the CorbaServer on the CORBASERVER definition.
     b. Copy the transaction definition for the TRANSID named on your REQUESTMODEL from that of CIRP. Set the DYNAMIC attribute to YES. You can change any of the other attributes, but the program name must be that of a JVM program with acJVMClass of com.ibm.cics.iiop.RequestProcessor.
     c. When the CorbaServer is operational, you can use the CREA CICS-supplied transaction to display the transaction IDs associated with

particular beans and bean methods in the CorbaServer. You can change the transaction IDs, apply the changes, and save the changes to new REQUESTMODEL definitions.

- A CORBASERVER definition.

  The value of the HOST option of the CORBASERVER definition must match that of the HOST or IPADDRESS option of the TCPIPSERVICE definition. However, if the TCPIPSERVICE specifies a value for DNSGROUP, the HOST option of the CORBASERVER definition must specify a matching generic host name.

  On the UNAUTH option, specify the name of the TCPIPSERVICE definition. You must always specify a value for the UNAUTH attribute when you define a CorbaServer, even if you intend that all inbound requests to the CorbaServer will be authenticated. This value is required because the port number from the TCPIPSERVICE is used to construct Interoperable Object References (IORs) that are exported from this logical server. You can, by specifying the name of other TCPIPSERVICE definitions on one or both of the CLIENTCERT or SSLUNAUTH options, cause your listener regions to listen on other ports for different types of authenticated inbound IIOP requests. For more information, see CORBASERVER resources in the Resource Definition Guide and TCPIPSERVICE resources in the Resource Definition Guide.

  On the SHELF option, specify the fully qualified name of the z/OS UNIX shelf directory that you created in step 3. Because the CORBASERVER definition is installed on all the AORs in the logical server, this “high-level” shelf directory is shared by all of them. Each AOR automatically creates its own subdirectory beneath the shelf directory and a subdirectory for the CorbaServer beneath that.

  On the DJARDIR option, specify the fully qualified name of the z/OS UNIX deployed JAR file directory (pickup directory) that you created in step 4. Like the shelf directory, the pickup directory (or directories, if your AORs contain multiple CorbaServers) is shared by all the AORs in the logical server. On each AOR, when a CORBASERVER definition is installed, CICS scans the CorbaServer pickup directory and installs any deployed JAR files that it finds there. It copies them to its shelf subdirectory and dynamically creates and installs DJAR definitions for them.

  Specify AUTOPUBLISH(YES) to cause CICS to publish beans to the namespace automatically, when a DJAR definition is successfully installed.

  On the STATUS option, specify Enabled.

- FILE definitions for the following files required by CICS:

  The EJB directory, DFHEJDIR

  Is a file containing a request streams directory, which must be shared by all the regions, listeners and AORs, in the logical EJB server. Request streams are used in the distributed routing of method requests for enterprise beans and CORBA stateless objects. You must define DFHEJDIR as recoverable.

  The EJB object store, DFHEJOS

  Is a file of stateful session beans that have been passivated. It must be shared by all the AORs in the logical EJB server. You must define it as nonrecoverable.

  To share DFHEJDIR and DFHEJOS across multiple regions, you can, for instance, use any of the following methods:

  – Define them as remote files in a file-owning region (FOR)

  - Define them as coupling facility data tables
  - Use VSAM RLS

  Sample FILE definitions are in these groups:

  - For DFHEJDIR and DFHEJOS are in the CICS-supplied RDO group, DFHEJVS
  - For DFHEJDIR and DFHEJOS are in the CICS-supplied RDO group, DFHEJCF

  Sample VSAM RLS FILE definitions for DFHEJDIR and DFHEJOS are in the CICS-supplied RDO group, DFHEJVR. DFHEJVS, DFHEJCF, and DFHEJVR are not included in the default CICS startup group list, DFHLIST.

   Note: These steps assume that the logical server has only one CorbaServer. To create another CorbaServer, create a second CORBASERVER definition and another TCPIPSERVICE definition.

6. Define the underlying VSAM data sets for DFHEJDIR and DFHEJOS. CICS supplies sample JCL to help you, in the DFHDEFDS member of the SDFHINST library.
7. Using a deployment tool such as the Assembly Toolkit (ATK), take one or more ejb-jar files and perform code generation on them to produce deployed JAR files on z/OS UNIX. Store the deployed JAR files in the pickup directory of the CorbaServer.
8. Start all the CICS regions. On each of the listener regions, the definitions to be installed from the CSD are as follows:
   - The TCPIPSERVICE definition
   - The REQUESTMODEL definitions
   - The file definition for DFHEJDIR

   On each of the AORs, the definitions to be installed from the CSD are as follows:
   - The TCPIPSERVICE definition.
   - The REQUESTMODEL definitions.

     The REQUESTMODEL definitions in the AORs are required for outbound requests to local objects. If a CORBA stateless object or enterprise bean makes a call to another object, and that object is available on the local AOR, CICS does not send the request to a listener region. Instead, it either runs the called method in the current task ("tight loopback") or starts another request processor in the local AOR ("normal loopback"). When normal loopback is used, it is preferable that the new request processor task uses the same REQUESTMODEL as that used for the call to the first object; otherwise, unpredictable results might occur. If your CORBA stateless objects and enterprise beans make no outbound calls, the REQUESTMODELs on the AOR are not strictly required.
   - The CORBASERVER definition.
   - The file definitions for DFHEJDIR and DFHEJOS.

   If you put your deployed JAR files in the shared pickup directory, DJAR definitions are created and installed on the AORs automatically when the CorbaServer is installed, or when a subsequent scan takes place. Create static (CSD-installed) DJAR definitions only for deployed JAR files that you place in other z/OS UNIX directories.

9. On each AOR, when the CORBASERVER definition is installed, CICS scans the pickup directory and installs any deployed JAR files it finds there. It copies them to its shelf directory and dynamically creates and installs DJAR definitions for them.

   You can put deployed Jis installed. If you do so, you can force CICS to perform another scan by issuing a **CORBASERVER PERFORM SCAN** command. Issue this command using **EXEC CICS**, the CEMT master terminal transaction, or the Web-based resource manager for enterprise beans, otherwise known as the RM for enterprise beans.
10. Because you specified AUTOPUBLISH(YES) on the CORBASERVER definition, when the DJAR definitions are successfully installed the homes of the enterprise beans are automatically bound into the JNDI namespace.

    If you specify AUTOPUBLISH(NO), you must issue a **PERFORM CORBASERVER(CorbaServer_name) PUBLISH** command on at least one of the AORs. You must issue this command using **EXEC CICS**, the CEMT master terminal transaction, the RM for enterprise beans, or from a CICSPlex SM WUI view.
11. On the DSRTPGM system initialization parameter for the listener regions, specify the name of the distributed routing program to be used. If you are using CICSPlex SM, specify the name of the CICSPlex SM routing program, EYU9XLOP. Otherwise, specify the name of your customized routing program. For information about the DSRTPGM system initialization parameter, see DSRTPGM system initialization parameter in the System Definition Guide.

Figure 16 on page 236 shows the RDO definitions required to define a CICS logical EJB server. It shows which definitions are required in the listener regions, which in the AORs, and which in both.

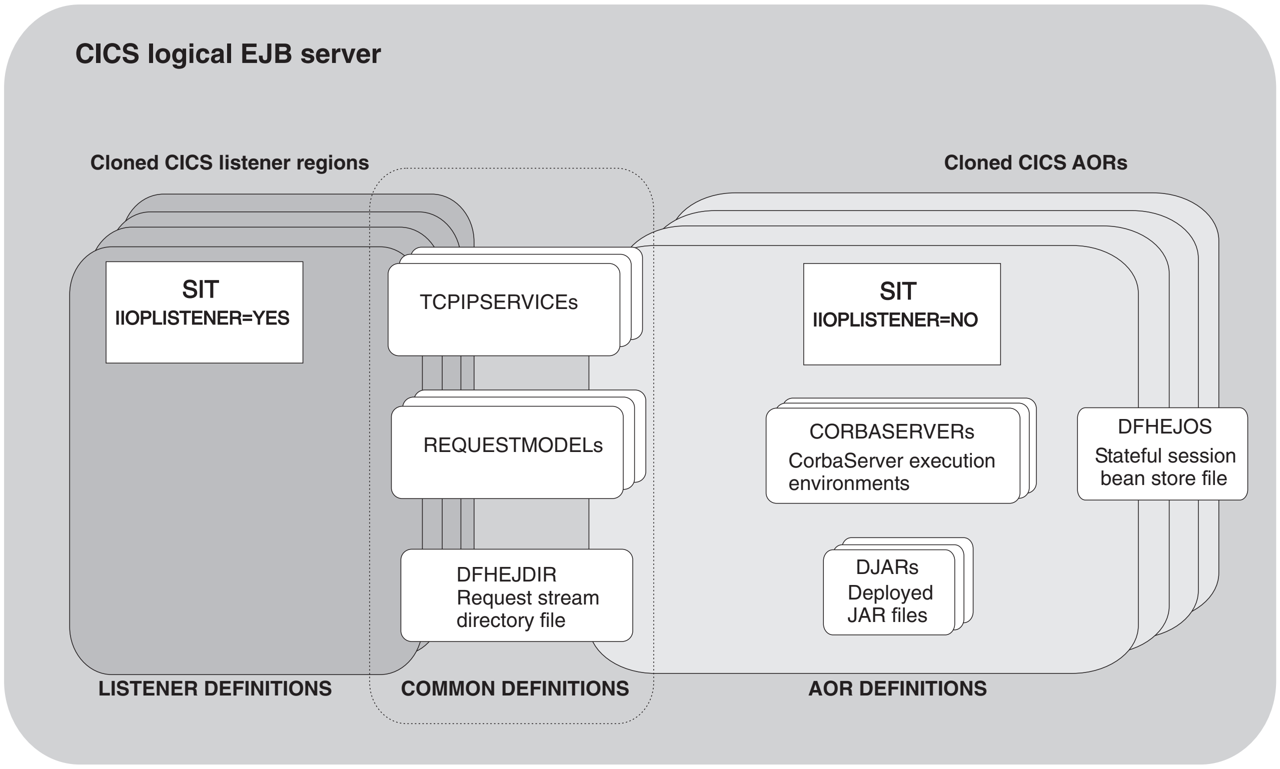


Figure 16. Resource definitions in a CICS logical EJB server

Enterprise beans—what can a client do with a bean?

This section contains example code fragments that illustrate how a client program can use an enterprise bean.

Get a reference to the bean's home:

In order to do anything with the bean, the client must obtain a reference to the bean's home interface.

To do this, it looks up a well-known name via JNDI:

```
// Obtain a JNDI initial context
Context initContext = new InitialContext();

// Look up the home interface of the bean
Object accountBeanHome = initContext.lookup("JNDI_prefix/AccountBean");
// where:
// 'JNDI_prefix/' is the JNDI prefix on the CORBASERVER definition
// 'AccountBean' is the name of the bean in the XML deployment descriptor

// Convert to the correct type
AccountHome accountHome = (AccountHome)
           PortableRemoteObject.narrow(accountBeanHome,AccountHome.class);
```

Use the home interface:

The client can use the bean's home interface to create a new instance of the bean, and delete an instance of the bean.

```
// Create two bean instances
Account anAccount = accountHome.create();
Account anotherAccount = accountHome.create("12345");

// Remove a bean instance
accountHome.remove("12345");
```

Use the component interface:

The client can use the bean's component interface to invoke the bean's methods, and delete the bean.

```
// Use the bean
anAccount.deposit(1000000);
// Remove it
anAccount.remove();
```

Enterprise beans—what can a bean do?

An enterprise bean benefits from many services—such as lifecycle management and security—that are provided implicitly by the EJB container, based on settings in the deployment descriptor.

This leaves the bean provider free to concentrate on the bean's business logic. This section looks at some of the things a bean can do.

Look up JNDI entries

A bean can use JNDI calls to retrieve:

- References to resources
- Environment variables
- References to other beans.

Access resource managers

A bean can:

- Obtain a connection to a resource manager
- Use the resources of the resource manager
- Close the connection.

Link to CICS programs

A bean can use JCICS or the CCI Connector for CICS TS to link to a CICS program, that may be written in any of the CICS-supported languages and be either local or remote. The bean provider can use the CCI Connector for CICS TS to build beans that make use of the power of existing (non-Java) CICS programs.

The CCI Connector for CICS TS is described in "The CCI Connector for CICS TS" on page 311.

Access files

A bean can use JCICS to read and write to files.

Call other beans

A bean can:

- Obtain references to the home and component interfaces of other bean objects
- Invoke the methods of another bean object
- Be called from another bean object.

A bean can act as the client of another bean object, as the server of another bean object, or as both.

Bear in mind that a single CICS task (one instance of a transaction) cannot contain more than one enterprise bean, because CICS treats an execution of an enterprise bean as the start of a new task. You can create an application that includes more than one enterprise bean, but the application will not operate as a single CICS task.

`Manage transactions`
Optionally, a session bean can manage its own OTS transactions, rather than use container-managed transactions. Alternatively, it may have its transaction managed by its caller.

Setting up an EJB server

This chapter tells you how to set up and test an EJB server.

Setting up a single-region EJB server

This section tells you how to set up a single-region CICS EJB server. The single-region is both a listener region and an AOR.

This minimal configuration can be used as the basis for developing a multi-region CICS EJB server, as described in "Setting up a multiregion EJB server" on page 246.

Important

- For clarity's sake, we're assuming that:
  1. You start from a basic, non-customized, CICS Transaction Server for z/OS, Version 4 Release 2 region.
  2. There will be only one CorbaServer execution environment in your EJB server.
- We recommend that, when creating your first EJB server, you use the default JVM profile, DFHJVMCD. After you've got your first EJB server up and running, you may want to customize your JVM profile. How to do this is described in "After running the EJB IVP—optional steps" on page 244.
- This section doesn't tell you how to deploy enterprise beans. Deployment is a separate process that occurs after you've set up your EJB server. It's described in "Deploying enterprise beans" on page 295.
- The rest of this section is split into two parts:
  – "Before running the EJB IVP" takes you as far as being able to run the EJB Installation Verification Program, which tests that you have configured CICS correctly as an EJB server and set up a name server correctly.

    Note: By default the EJB IVP uses the lightweight `tnameserv` COS Naming Server that is supplied with Java 1.3 and later. Therefore you don't need to have set up an enterprise-quality name server before running the IVP. However, after you've set up your "real" name server, you can use the IVP to test it.
  – "After running the EJB IVP—optional steps" on page 244 describes some optional ways in which you can customize your EJB server.

Before running the EJB IVP:

The steps in this section enable you to run the EJB Installation Verification Program, which tests that you have configured CICS correctly as an EJB server.

The steps in this section enable you to run the EJB Installation Verification Program, which tests that you have configured CICS correctly as an EJB server. Actions are required on:
1. z/OS or Windows NT, depending on the type of name server that you use
2. z/OS UNIX
3. CICS

Actions required on z/OS or Windows NT:

To run the EJB IVP, you need a name server that supports the Java Naming and Directory Interface (JNDI) Version 1.2. By default the IVP uses the lightweight `tnameserv` COS Naming Server that is supplied with Java 1.3 and later.

To start `tnameserv` on the local host, enter the following command at the z/OS UNIX System Services or Windows NT command prompt:

```
tnameserv -ORBInitialPort 2809
```

This causes the name server to listen for connections on TCP/IP port 2809. If this port is already in use on your system, you will be asked to try again with a different port.

Note: If you run firewall software, by default the firewall may block your specified port. You must ensure that your firewall policy allows CICS and any EJB client applications to communicate with the name server.

For information about choosing and setting up an enterprise-quality name server, see "Enabling JNDI references" on page 364.

Actions required on z/OS UNIX:

To perform the tasks in this section, you need a z/OS UNIX userid with write authority to the directory path to be used by CICS.

About this task

Create the following directories on z/OS UNIX, if they do not already exist. (If you have previously configured CICS as an IIOP server, some of these directories may already exist.) Remember that z/OS UNIX names are case-sensitive.
1. A CICS working directory. Each CICS region needs a working directory. The name is specified by the WORK_DIR parameter of the JVM profile. You need to set the directory permissions so that the USERID the region runs under can read and write to the directory. See Giving CICS regions access to z/OS UNIX System Services for guidance.
2. A shelf root directory. You can call your shelf directory anything you like. However, it's recommended that you create it somewhere under the `/var` directory. For example, you might create a z/OS UNIX directory called `/var/cicsts/`. Having created the shelf directory, you must give the CICS region userid full access to it—read, write, and execute. How to do this is described in Giving CICS regions access to z/OS UNIX System Services.
3. A deployed JAR file directory (also known as a pickup directory). You can call your pickup directory anything you like. However, it's recommended that you create it somewhere under the `/var` directory. For example, you might create a z/OS UNIX directory called `/var/cicsts/pickup`. You must give the CICS region userid at least read access to it.

Note:

a. If you were to install multiple CorbaServer execution environments into your EJB server, you would need to create a separate pickup directory for each one.

b. If you use the scanning mechanism (to install deployed JAR files from the pickup directory) in a production region, be aware of the security implications: specifically, the possibility of CICS command security on DJAR definitions being circumvented. To guard against this, we recommend that user IDs given write access to the z/OS UNIX deployed JAR file directory should be restricted to those given RACF authority to create and update DJAR and CORBASERVER definitions.

Actions required on CICS:

Note that if you have previously configured CICS as an IIOP server, to support method calls to CORBA stateless objects, you might already have completed some of these steps.

About this task

1. Install the IBM 64-bit SDK for z/OS, Java Technology Edition. You can download this product, and find out more information about it, at http://www.ibm.com/servers/eserver/zseries/software/java/.
2. Set up CICS to support IIOP calls. (CICS uses the same RMI-over-IIOP protocol to support client method requests for both CORBA stateless objects and enterprise beans.) How to do this is described in "Setting up CICS for IIOP" on page 375.

   Bear in mind when reading "Setting up CICS for IIOP" on page 375 that:

   - Because our single-region EJB server is a combined listener/AOR, you must specify 'YES' on the IIOPLISTENER system initialization parameter.
   - CICS loads JVM profiles from the z/OS UNIX directory that is specified by the **JVMPROFILEDIR** system initialization parameter. Make sure this value specifies the directory containing the JVM profiles used by your CICS region.
   - If you want to use your single-region server as the basis of a multi-region server, you should ensure that the request streams directory file, DFHEJDIR, and the EJB object store file, DFHEJOS, can be shared across multiple regions. For this reason, it is recommended that you define them in one of the following ways:
     - As remote files in a file-owning region (FOR)
     - As coupling facility data tables
     - Using VSAM RLS.
   - PROGRAM definitions are not required for enterprise beans as such. The only PROGRAM definitions required are those for the request receiver and request processor programs. The default request processor program—named by the default CIRP transaction on REQUESTMODEL definitions—is DFJIIRP. CIRP and DFJIIRP are defined in the supplied resource definition group DFHIIOP, as are CIRR and DFHIIRRS, the request receiver transaction and program. DFHIIOP is included in the default CICS startup group list.

     If you are using a JVM profile other than the default DFHJVMCD, you must specify the name of your profile on the JVMPROFILE option of the PROGRAM definition for the request processor program. (It is possible to use a CEMT SET PROGRAM JVMPROFILE command to change the JVM profile from that specified on the installed PROGRAM definition. However, if you create your own JVM profile you are recommended to create new

TRANSACTION and PROGRAM definitions for the request processor program, rather than change the default definitions.)
- You must specify the location of your name server on the **-Dcom.ibm.cics.ejs.nameserver** system property in the profiles that are used by CORBA applications or enterprise beans, including the profiles that CICS uses to publish deployed JAR files.

  For detailed information about defining the location of your name server, see "JVM system properties" on page 109.
- You don't need to install REQUESTMODEL or DJAR definitions at this stage, because:
  - The EJB IVP and EJB sample applications use the default REQUESTMODEL transaction ID, CIRP.
  - REQUESTMODEL definitions are most easily created by using the CREA transaction after you have deployed your enterprise beans into CICS. Deployment is a separate process that occurs after you have set up your EJB server. It is described in "Deploying enterprise beans" on page 295.
  - DJAR definitions are typically created and installed by the CICS scanning mechanism during deployment.

3. Create the following CICS resource definitions:
   - A TCPIPSERVICE
   - A CORBASERVER

   The CICS-supplied sample group, DFH$EJB, contains TCPIPSERVICE and CORBASERVER definitions suitable for running the EJB IVP. You must change some of the attributes of these resource definitions to suit your own environment. To do this, use the CEDA transaction or the DFHCSDUP utility.
   a. Copy the sample group to a group of your own choosing. For example:
   ```
   CEDA COPY GROUP(DFH$EJB) TO(mygroup)
   ```
   b. Display group `mygroup` and change the following attributes appropriately:
   - On the TCPIPSERVICE resource definition, modify the PORTNUMBER as necessary to a suitable TCP/IP port on your installation. The port number that you specify must be authorized by your network administrator.

     Note:
     1) Note that, on the supplied TCPIPSERVICE definition:
        - The PROTOCOL option specifies IIOP. This is the required protocol for method calls to enterprise beans and CORBA stateless objects.
        - The SSL option specifies NO.
        - The AUTHENTICATE option defaults to NO. This means that the service on this port will accept unauthenticated inbound IIOP requests.
     2) If you want to use your single-region server as the basis of a multi-region server, as described in "Setting up a multiregion EJB server" on page 246, you should specify a value for the DNSGROUP option. This ensures that, in a multi-region server, you will be able to use connection optimization, by means of dynamic DNS registration, to balance client connections across the listener regions.
     3) For reference information about TCPIPSERVICE definitions, see the *CICS Resource Definition Guide*.
   - On the CORBASERVER resource definition:

1) Modify the SHELF option so that it specifies the fully-qualified name of the z/OS UNIX shelf directory that you created in step 2 of "Actions required on z/OS UNIX" on page 239.

   Note: In a multi-region EJB server, because the CORBASERVER definition will be installed on all the AORs this "high-level" shelf directory will be shared by all of them. Each AOR will automatically create its own sub-directory beneath the shelf directory, and a sub-directory for the CorbaServer beneath that.
2) Modify the DJARDIR option so that it specifies the fully-qualified name of the z/OS UNIX deployed JAR file directory (pickup directory) that you created in step 3 of "Actions required on z/OS UNIX" on page 239.

   Note: In a multi-region EJB server, the pickup directory (or directories, if the AORs contain multiple CorbaServers), like the shelf directory, will be shared by all the AORs in the logical server.
3) Set the HOST to your TCP/IP hostname.

Note:
1) Note that, on the supplied CORBASERVER definition:
   - The UNAUTH option specifies the name of the TCPIPSERVICE definition.

     You must always specify a value for the UNAUTH attribute when you define a CorbaServer, even if you intend that all inbound requests to the CorbaServer should be authenticated. This is because the port number from the TCPIPSERVICE is used to construct Interoperable Object References (IORs) that are exported from this logical server. You can, by specifying the name of other TCPIPSERVICE definitions on one or both of the CLIENTCERT or SSLUNAUTH options, cause your listener regions to listen on other ports for different types of authenticated inbound IIOP requests. For more information, see the *CICS Resource Definition Guide*.
   - The AUTOPUBLISH option specifies YES. This causes CICS to publish beans to the namespace automatically, when a DJAR definition is successfully installed.
   - The STATUS option specifies Enabled.
2) The value of the HOST option of the CORBASERVER definition must be compatible with that of the HOST or IPADDRESS options for the associated TCPIPSERVICE resources. In a multi-region server, if dynamic DNS registration is used to balance client connections across the listener regions, the value of the HOST option must match the generic host name specified on the DNSGROUP option of the TCPIPSERVICE definition.
3) For reference information about CORBASERVER definitions, see the *CICS Resource Definition Guide*.

c. Install group `mygroup` to make these definitions known to CICS.

   When the CORBASERVER definition is installed, CICS:
   1) Scans the pickup directory that you specified on the DJARDIR option
   2) Copies any deployed JAR files that it finds in the pickup directory to its shelf directory

3) Dynamically creates and installs DJAR definitions for the deployed JAR files (if any) that it found in the pickup directory
4) Because the CORBASERVER definition specifies AUTOPUBLISH(YES), publishes any enterprise beans contained in the DJARs to the JNDI namespace.

d. Set the status of the TCPIPSERVICE to OPEN:

```
CEMT SET TCPIPSERVICE(EJBTCP1) OPEN
```

On the CICS Console, you should see, among others, messages similar to the following:

```
DFHEJ0701 CorbaServer EJB1 has been created.
DFHEJ5024 Scan commencing for CorbaServer EJB1, directory being scanned is
          DJARDIR_name.
DFHEJ5025 Scan completed for CorbaServer EJB1, 0 DJars created, 0 DJars
          updated.
DFHEJ1520 CorbaServer EJB1 is now accessible.
DFHSO0107 TCPIPSERVICE EJBTCP1 has been opened on port port_number at IP
          address xxx.xxx.xxx.xxx
```

where:
- **DJARDIR_name** is the name of your CorbaServer's deployed JAR file ("pickup") directory.
- **port_number** is the number of the TCP/IP port used by your CorbaServer.
- **xxx.xxx.xxx.xxx** is your CorbaServer's IP address.

4. Set up CICS to use JNDI. To enable Java code running under CICS to issue JNDI API calls, and CICS to publish references to the home interfaces of enterprise beans, you must specify the location of the name server. (For an LDAP name server there is additional information to be specified.) Specify the URL and port number of your name server on the **-Dcom.ibm.cics.ejs.nameserver** system property.

For example, to use tnameserv, the lightweight COS Naming Directory Server supplied with Java 1.3 and later, specify:

```
-Dcom.ibm.cics.ejs.nameserver=iiop://tnameserv.yourcompany.com:2809
```

where tnameserv.yourcompany.com is the address of the host on which you started the tnameserv name server and 2809 is the port you selected.

If you are using an enterprise-quality LDAP server you might specify:

```
-Dcom.ibm.cics.ejs.nameserver=ldap://demojndi.yourcompany.com:389
```

For the other properties that are required, and the way to set up your LDAP name server, see "Setting up an LDAP server" on page 364.

If you are using a standard COS Naming Directory Server you might specify:

```
-Dcom.ibm.cics.ejs.nameserver=iiop://demojndi.yourcompany.com:900
```

If you are using the COS Naming Directory Server supplied with WebSphere Application Server Version 5 or later, you should specify:

```
-Dcom.ibm.cics.ejs.nameserver=iiop://demojndi.yourcompany.com:2809/domain/legacyRoot
```

Important: For detailed information about defining the location of the name server, see the description of the **-Dcom.ibm.cics.ejs.nameserver** property in "JVM system properties" on page 109.

The JVM profile for the default request processor program is DFHJVMCD. If you have followed the previous steps in this section, the profile or profiles you are using should be in the z/OS UNIX directory specified by the **JVMPROFILEDIR** system initialization parameter.

Important: These instructions have shown you how to set up a single-region EJB server that contains a single CorbaServer execution environment. In a production region that supports multiple applications, each of which uses its own set of enterprise beans, you may require multiple CorbaServers. To facilitate maintenance in a production region, you should follow the guidelines on how to allocate beans to CorbaServers and transaction IDs in "Updating enterprise beans in a production region" on page 301.

Having completed the above steps, you can, if you wish, run the EJB Installation Verification Program, which tests that you have configured CICS correctly as an EJB server. For details of the EJB IVP, see "Using the EJB IVP" on page 255. Alternatively, you can continue with the next section before running the IVP.

After running the EJB IVP—optional steps:

Optionally, to finish the setup of your complete EJB server, you can customize one of the sample JVM profiles, or create your own JVM profiles for use with enterprise beans, rather than using the default JVM profile DFHJVMCD.

About this task

DFHJVMCD can only be customized in limited ways, because it is used for internal CICS programs, but other JVM profiles can be customized as you want.

"Setting up pooled JVMs" on page 88 tells you how to select and customize a JVM profile, or if you prefer, how to create your own JVM profile based on one of the supplied sample profiles. Follow the procedures in that section to customize or create your JVM profile.

When you have customized or created your JVM profile, in order for the profile to be used by enterprise beans:

1. Specify the name of your JVM profile on the JVMPROFILE option of the PROGRAM definition for the request processor program. (The supplied PROGRAM definition for the default request processor program, DFJIIRP, specifies the default profile, DFHJVMCD.)

   You should create your own TRANSACTION and PROGRAM definitions for the request processor program, as described in "Defining CICS resources" on page 377, rather than change the default definitions. Specify the name of your TRANSACTION on REQUESTMODEL definitions for bean methods that are to run under the new profile.
2. Place your profile in the z/OS UNIX directory specified by the **JVMPROFILEDIR** system initialization parameter.

Important: You must specify the location of your name server on the **-Dcom.ibm.cics.ejs.nameserver** system property in all the JVM profiles or optional properties files that are used by CORBA applications or enterprise beans, including the profiles that CICS uses to publish deployed JAR files. For detailed information about defining the location of your name server, see "JVM system properties" on page 109.

Testing your EJB server

This section tells you how to check that your single-region CICS EJB server is configured correctly.

Running the EJB IVP:

The easiest way to test your CICS EJB configuration, including that of your name server, is to run the EJB Installation Verification Program (IVP) supplied with CICS.

The IVP consists of:
- A line-mode client program that runs in UNIX System Services (USS) on z/OS
- An enterprise bean running on the CICS EJB server

To run the IVP, you must have completed all the steps in “Before running the EJB IVP” on page 238. You may or may not have completed the steps in “After running the EJB IVP—optional steps” on page 244. Running the IVP successfully confirms that external programs are able to invoke enterprise beans on your CICS EJB server.

For details of the EJB IVP, see “Using the EJB IVP” on page 255.

Using the EJB “Hello World” sample:

“Hello World” is a simple application consisting of an HTML form, a Java servlet and Java Server Pages running on a Web server, and a CICS enterprise bean.

It requests input from the user, uses the enterprise bean to append the user's input to a standard message, and then displays the resulting string.

To run the EJB “Hello World” sample, you must have completed all the steps in “Before running the EJB IVP” on page 238. You may or may not have completed the steps in “After running the EJB IVP—optional steps” on page 244.

For details of the EJB “Hello World” application, and instructions on how to install it, see “The EJB “Hello World” sample application” on page 259.

Using the EJB Bank Account sample:

After you've run the Hello World” sample successfully, you might want to try something more ambitious.

The EJB Bank Account sample demonstrates how you can use an enterprise bean to make CICS-controlled information available to Web users. It extracts customer information from data tables and returns it to the user.

The sample consists of an HTML form, a Java servlet and Java Server Pages running on a Web server, a CICS enterprise bean, two CICS COBOL server programs, and some DB2 data tables. The enterprise bean uses the CCI Connector for CICS TS to link to the CICS server programs, which access the DB2 data tables.

To run the EJB Bank Account sample, you must have completed all the steps in “Before running the EJB IVP” on page 238. You may or may not have completed the steps in “After running the EJB IVP—optional steps” on page 244.

For details of the EJB Bank Account application, and instructions on how to install it, see “The EJB Bank Account sample application” on page 266.

Using your own enterprise beans:

After you've run the sample applications and established that your CICS EJB server is working correctly, you'll probably want to deploy your own enterprise beans into CICS.

For details of how to do this, see “Deploying enterprise beans” on page 295.

Setting up a multiregion EJB server

This section tells you how to set up a CICS logical EJB server consisting of multiple listener regions and multiple AORs.

Before you begin

To set up a multiregion EJB server, you must have already created a single region EJB server as described in “Setting up a single-region EJB server” on page 238.

About this task

Ensure that all the regions in a multiregion EJB server, both listeners and AORs, are at the same level of CICS.

Procedure

1. Create a set of listener regions by cloning the single-region-server CICS. All the cloned regions share the CICS system definition file (CSD) of the single-region server. Optionally, you can discard the following resource definitions from the listener regions, where they are not required:
   - CORBASERVER
   - DJARs
   - DFHEJOS

   Leave the value of the **IIOPLISTENER** system initialization parameter set to YES.

   Note: If you use CICSPlex SM, you can define a CICS Group (CICSGRP) containing all of the listener regions. This has the advantage that resources can be associated (by means of a Resource Description) with the Group rather than with individual regions. When a region is added to or removed from the Group, the resources are automatically added to or removed from the region.
2. Create a set of AORs by cloning the single-region-server CICS. (All the cloned regions share the CSD of the single-region server.)

   Each of the AORs must use the same JNDI initial context as the other AORs.

   Because the AORs are not listener regions, change the value of the **IIOPLISTENER** system initialization parameter to 'NO'.

   Note: If you use CICSPlex SM, you can define a CICS Group (CICSGRP) containing all of the AORs. When a region is added to or removed from the Group, the resources are automatically added to or removed from the region.

   Figure 17 on page 248 shows which definitions are required in the listener regions, which in the AORs, and which in both.
3. Connect each of the AORs to all of the listener regions by MRO (not ISC). For information about how to define MRO connections between CICS regions, see the *CICS Intercommunication Guide*.

   If you use CICSPlex SM, you can significantly reduce the number of CONNECTION and SESSION definitions required (and the cost of maintaining them) by defining SYSLINKs from a single AOR to all of the listener regions. (CICSPlex SM automatically creates the reciprocal connections from the listeners to the AOR.) Use the SYSLINKs as models for the connections from the other AORs.
4. Ensure that the EJB Directory file, DFHEJDIR, is shared by all the regions in the EJB server. If you defined DFHEJDIR to the single-region EJB server in the way

suggested (that is, as a remote file, a coupling facility data table, or as using VSAM RLS) the file should be shared automatically across the cloned regions of the multiregion server.

Note: Ensure that the CICS region that owns the DFHEJDIR file is started before the other regions that access it, particularly the AORs. If you don't, attempts to install CORBASERVER and DJAR definitions on the other AORs will fail with message DFHEJ0736.

5. Ensure that the EJB Object Store file, DFHEJOS, is shared by all the AORs in the EJB server. If you defined DFHEJOS to the single-region EJB server in the way suggested, the file should be shared automatically across all the cloned regions of the multiregion server. (Optionally, you can delete the definition of DFHEJOS from the listener regions, where it's not required.)
6. To balance client connections across the listener regions, use connection optimization by means of dynamic DNS registration. How to set this up is described in "Domain Name System (DNS) connection optimization" on page 358.
7. Arrange for method requests for enterprise beans to be dynamically routed across the AORs. You can use either of the following:
   a. CICSPlex SM. How to use CICSPlex SM to route method requests for enterprise beans is described in "CICSPlex SM with enterprise beans" on page 345.
   b. A customized version of the CICS distributed routing program, DFHDSRP. How to write a distributed routing program to route method requests for enterprise beans and CORBA stateless objects is described in the *CICS Customization Guide*.

   On the DSRTPGM system initialization parameter for the listener regions, specify the name of the distributed routing program to be used. If you're using CICSPlex SM, specify the name of the CICSPlex SM routing program, EYU9XLOP. Otherwise, specify the name of your customized routing program. For information about the DSRTPGM system initialization parameter, see DSRTPGM system initialization parameter in the System Definition Guide.

   Remember:
   a. To route method requests for enterprise beans dynamically, the TRANSACTION definition for the transaction named on your REQUESTMODEL definitions must specify DYNAMIC(YES). The default transaction named on REQUESTMODEL definitions, CIRP, is defined as DYNAMIC(NO). We recommend that you take a copy of the TRANSACTION definition for CIRP, change the DYNAMIC setting, and save the definition under a new name. Then name your new transaction on REQUESTMODEL definitions. (The easiest way to create REQUESTMODEL definitions is to use the CREA transaction after you have deployed your enterprise beans into CICS.)
   b. The "common" transaction definition specified on the DTRTRAN system initialization parameter, and used for terminal-initiated transaction routing requests if no TRANSACTION definition is found, is never associated with method requests for enterprise beans. If, on the listener region, there is no REQUESTMODEL definition that matches the request, the request runs under the CIRP transaction (which specifies DYNAMIC(NO).
   c. In Figure 17 on page 248, the REQUESTMODEL definitions in the AORs are required for outbound requests to local objects. If a CORBA stateless object or enterprise bean makes a call to another object, and that object is available on the local AOR, CICS does not send the request to a listener region.

Instead, it either runs the called method in the current task ("tight loopback") or starts another request processor in the local AOR ("normal loopback"). Where normal loopback is used, it's preferable that the new request processor task should use the same REQUESTMODEL as that used for the call to the first object—otherwise, unpredictable results may occur. If your CORBA stateless objects and enterprise beans make no outbound calls, the REQUESTMODELs on the AOR are not strictly required.

Results

These steps describe how to set up a multiregion EJB server in which each region contains a single CorbaServer execution environment. In production regions that support multiple applications, each of which uses its own set of enterprise beans, you might require multiple CorbaServers. To facilitate maintenance in production regions, follow the guidelines on how to allocate beans to CorbaServers and transaction IDs in "Updating enterprise beans in a production region" on page 301.

This diagram shows which definitions are required in the listener regions, which in the AORs, and which in both.

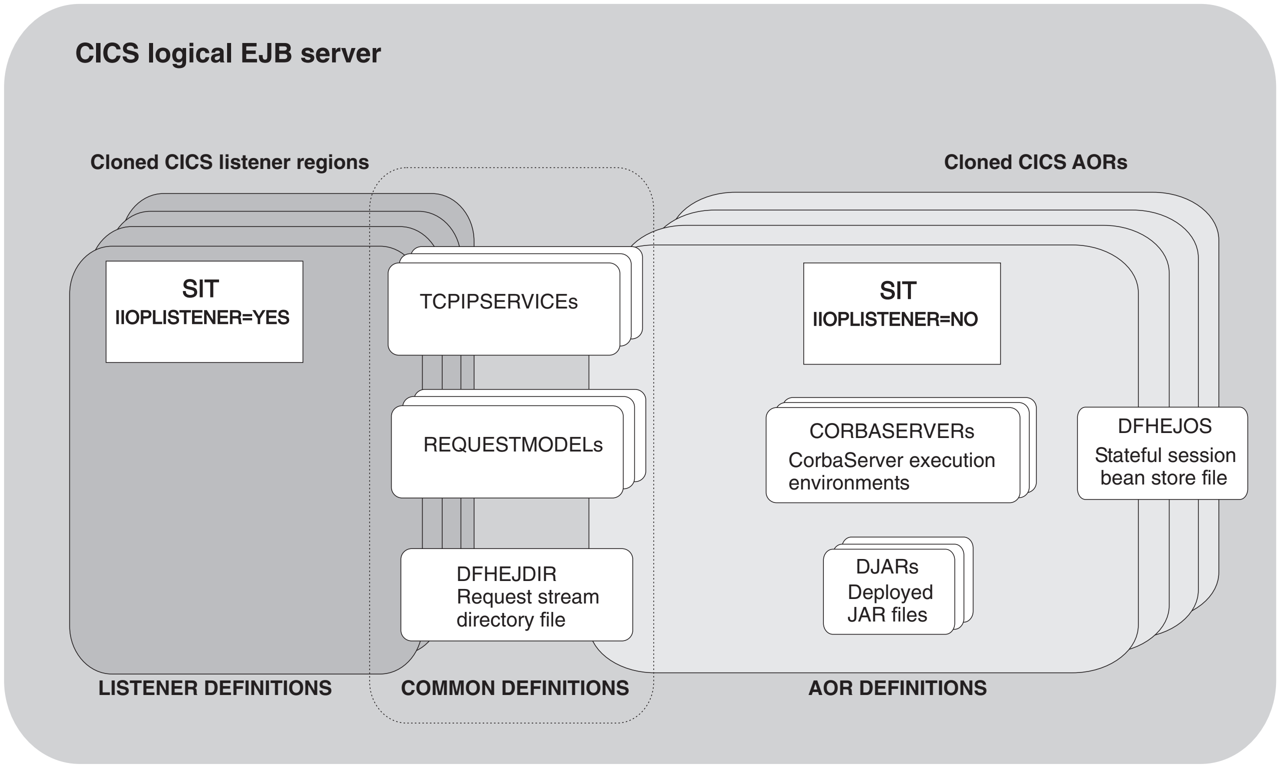


Figure 17. Resource definitions in a multiregion CICS EJB server

Upgrading an EJB server to CICS Transaction Server for z/OS, Version 4 Release 2

This section tells you how to upgrade a back-level EJB server to CICS TS for z/OS, Version 4.2.

Upgrading a single-region CICS EJB/CORBA server:

Perform these steps to upgrade a single-region CICS EJB/CORBA server to CICS Transaction Server for z/OS, Version 4 Release 2.

Procedure

1. Quiesce the workload.
2. Shut down the region.
3. Upgrade the region to CICS Transaction Server for z/OS, Version 4 Release 2, following the standard upgrade procedures described in the Upgrading information set for the release from which you are upgrading.
4. Review "Upgrade tips" on page 253, which describes some of the changes in EJB/CORBA support between different releases of CICS. You can also refer to "Setting up a single-region EJB server" on page 238, which describes in detail how to set up a single-region EJB server in CICS TS for z/OS, Version 4.2.
5. Restart the region.
6. Republish the Interoperable Object References (IORs) for all the enterprise beans and stateless CORBA objects processed by the server by issuing a **PERFORM CORBASERVER**(*CorbaServer_name*) PUBLISH command. You can issue this command using **EXEC CICS**, CEMT, the Resource Manager for enterprise beans, or from a CICSPlex SM WUI view. Remember to issue a separate command for each CorbaServer in the region.

Upgrading a multi-region CICS EJB/CORBA server:

To upgrade a multi-region CICS EJB/CORBA server to CICS Transaction Server for z/OS, Version 4 Release 2, you can use any of these methods.

About this task

1. **Shut down the server, upgrade all the regions, and restart the server.**

   This approach is very similar to that described in "Upgrading a single-region CICS EJB/CORBA server" on page 248, except that:

   a. You must upgrade all the regions to CICS Transaction Server for z/OS, Version 4 Release 2 before restarting the server. Again, follow the standard upgrade procedures described in the Upgrading information set for the release from which you are upgrading.
   b. You should refer to "Setting up a multiregion EJB server" on page 246, which describes in detail how to set up a multi-region EJB server in CICS TS for z/OS, Version 4.2.
   c. To republish the IORs of enterprise beans and stateless CORBA objects, issue a PERFORM CORBASERVER(*CorbaServer_name*) PUBLISH command on at least one of the AORs. Remember to issue a separate command for each CorbaServer in the AOR.

   The advantage of this approach is its relative simplicity, compared to solutions 2 and 3. Its main disadvantage is that the server's applications are unavailable during the upgrade process.
2. **Create a separate, CICS TS for z/OS, Version 4.2, logical server and gradually move applications from the old, back-level, server to the new one.**

   The advantages of this approach are:

   a. Applications are kept available throughout the upgrade process.
   b. You can start with a minimal CICS TS for z/OS, Version 4.2 server, perhaps consisting of just two regions—one listener and one AOR. As more applications are moved, you can expand the CICS TS for z/OS, Version 4.2 server and simultaneously reduce the number of regions in the back-level server, thereby conserving resources.
   c. It is probably easier to implement than solution 3.

To set up a new CICS TS for z/OS, Version 4.2 multi-region EJB server, follow all the steps in "Setting up a single-region EJB server" on page 238 and "Setting up a multiregion EJB server" on page 246.

3. **Perform a "rolling upgrade"**.

   In a "rolling upgrade", one region at a time is upgraded from the previous to the current level of CICS, while keeping the server operational.

   The advantages of this approach are:

   a. Applications are kept available throughout the upgrade process.
   b. Unlike solution 2, at no stage is it necessary to set up additional CICS regions.

   This method is described in detail in "Performing a "rolling upgrade"."

Performing a "rolling upgrade":

The mixed level of operation described in this section, in which different CICS regions in the same logical server are at different levels of CICS, is intended to be used only for rolling upgrades.

Important

It should not be used permanently, because it increases the risk of failure in some interoperability scenarios. The normal, recommended, mode of operation is that all the regions in a logical sever should be at the same level of CICS and Java.

This section describes how to perform a "rolling upgrade" of a multi-region CICS EJB/CORBA server to CICS Transaction Server for z/OS, Version 4 Release 2. The process consists of the following steps:

1. Checking that your logical server meets the criteria for a "rolling upgrade". See "Requirement."
2. "Preliminary steps"
3. "Upgrading the listener regions" on page 251
4. "Upgrading the AORs" on page 252
5. "Tidying up" on page 253

Requirement:

Your server must consist of separate listener and application-owning regions. This is because the upgrade process requires all of the listener regions to be updated before any of the application-owning regions (AORs).

If you run composite listener-AORs, which act both as request receivers and request processors, this cannot be done. And if you don't upgrade all the listeners before any of the AORs, your IIOP client applications may receive transient failures during the migration window, depending on the CICS version of the listener region that receives the request.

Preliminary steps:

About this task

1. Review "Upgrade tips" on page 253.
2. If you are upgrading from CICS TS **2.2**, ensure that APAR PQ 79565 is installed in all your CICS TS 2.2 regions. This APAR improves CICS TS 2.2 diagnostics, should CICS TS for z/OS, Version 4.2 workload arrive at a CICS TS 2.2 region.

It also allows a CICS TS 2.2 request processor (AOR) to receive work from a CICS TS for z/OS, Version 4.2 request receiver (listener).

3. Set the AUTOPUBLISH option on all your CORBASERVER definitions to `NO`. Setting a CorbaServer to autopublish IORs into the JNDI namespaces could disrupt the upgrade process.
4. If you use a distributed routing program to balance method requests for enterprise beans and CORBA stateless objects across the AORs of your logical server, customize your routing program to use the DYRLEVEL parameter. DYRLEVEL is an aid to upgrade. It contains the level of CICS required in the target AOR to successfully process the routed request. (Note that this is the **specific**, *not* the minimum, level of CICS required to process the request successfully.) In a mixed-level logical server, when your routing program is invoked for route selection (or route selection error), it can use the value of DYRLEVEL to determine whether to route the request to a back-level or CICS TS for z/OS, Version 4.2 AOR.

   For details of how to use DYRLEVEL, and definitive information about writing a distributed routing program, see the *CICS Customization Guide*.

   Install your customized program on *all* the regions (both listeners and AORs) of the EJB server.

   If you use CICSPlex SM to workload-balance method requests you can skip this step. The CICSPlex SM routing program supplied with CICS Transaction Server for z/OS, Version 4 Release 2 checks the DYRLEVEL field and routes requests accordingly.

Upgrading the listener regions:

Perform these steps to upgrade a listener region.

About this task

1. Quiesce a listener region and bring it down.
2. Upgrade this single listener region to CICS Transaction Server for z/OS, Version 4 Release 2, following the standard upgrade procedures described in the Upgrading information set for the release from which you are upgrading.

   Important:

   a. If you upgrade a CSD from CICS TS **2.2** to CICS TS for z/OS, Version 4.2 level, if it is shared by any CICS TS 2.2 regions other than that being upgraded, include the DFHCOMPA resource group (supplied with CICS TS for z/OS, Version 4.2) in the startup group list of these regions. DFHCOMPA is a compatibility group that provides a definition of DFJIIRP, the default request processor program, that can be used by a CICS TS 2.2 region when sharing a CICS TS for z/OS, Version 4.2 CSD.

      This step is necessary because, in CICS TS for z/OS, Version 4.2, the JVM profile used by DFJIIRP is DFHJVMCD. In CICS TS 2.2, it is DFHJVMPR.

   b. At this stage, don't enable any new, CICS TS for z/OS, Version 4.2-specific, options on resource definitions, because they won't be understood by the back-level AORs. Use of these new features must wait until the whole logical server—both listener regions and AORs—has been upgraded.

   For definitive information about setting up a listener region in CICS TS for z/OS, Version 4.2, refer to “Configuring CICS for IIOP” on page 362.
3. Bring the listener back up. This region is now at the newer version of CICS but may continue to participate as part of the back-level logical server.
4. Repeat steps 1 through 3 for all of the listener regions in the logical server.

Upgrading the AORs:

To upgrade an AOR for enterprise beans, perform these steps.

About this task

1. Quiesce an AOR and bring it down.
2. Upgrade this single AOR to CICS Transaction Server for z/OS, Version 4 Release 2, following the standard upgrade procedures described in the Upgrading information set for the release from which you are upgrading.

   If you are upgrading from CICS TS 2.2, part of this will involve updating the JVM profile used by the CorbaServers. Note the changes to JVM profiles and property files that were introduced in CICS TS 2.3, as described in "Upgrade tips" on page 253.

   Important:

   a. If you upgrade a CSD from CICS TS **2.2** to CICS TS for z/OS, Version 4.2 level, if it is shared by any CICS TS 2.2 regions other than that being upgraded, include the DFHCOMPA resource group (supplied with CICS TS for z/OS, Version 4.2) in the startup group list of these regions.
   b. At this stage, don't enable any new, CICS TS for z/OS, Version 4.2-specific, options on resource definitions.
3. Bring the AOR back up again.
4. Ensure that all TCPIPSERVICEs are open both in this AOR and in the listener regions.
5. Use the CEMT PERFORM DJAR PUBLISH command to re-publish the IORs of one or more enterprise beans in CICS TS for z/OS, Version 4.2 format. For each CorbaServer, select one or more deployed JAR files to re-publish. When choosing deployed JAR files to re-publish, bear the following in mind:
   - Try to pick DJARs whose entire workload can be processed by a single region.
   - Wherever possible, all the beans used by an application should be upgraded at the same time. For example, if bean A is known to call bean B the two beans should be upgraded together. If this is not possible, bean A should be upgraded first.

     This is particularly important if you are upgrading from CICS TS 2.2 and the beans are installed in the same CorbaServer but in different AORs that are at different levels of CICS. This is because a CICS TS 2.2 region cannot do a JNDI look up of an object in a CICS TS for z/OS, Version 4.2 region if both objects are in the same CorbaServer. For example, bean A in CorbaServer EJB1 in a CICS TS 2.2 AOR cannot look up bean B in CorbaServer EJB1 in a CICS TS for z/OS, Version 4.2 AOR.

     Note: If A and B are installed in different CorbaServers, or in AORs that are at the same level of CICS, they can be upgraded separately.

   Re-publish the selected DJARs to the JNDI namespace, in the same location as that used by the back-level AORs.

   At this point :

   - This AOR is ready to accept workload.
   - The logical server contains a pool of back-level AORs and a pool (currently containing only one region) of CICS TS for z/OS, Version 4.2 AORs.

- Any clients that look up the IOR of a re-published bean in the namespace get the new IOR in CICS TS for z/OS, Version 4.2 format. Your customized routing program or CICSPlex SM directs such requests to the CICS TS for z/OS, Version 4.2 AOR.
- Any clients that have a stale, cached, IOR for a bean that's been re-published are still able to use the bean. Your customized routing program or CICSPlex SM directs such old-format requests to one of the back-level AORs.

  Note: Many application servers cache the results of JNDI lookups locally to increase performance, so you may find that these caches have to be purged before the new IORs are used. Over a period of time, requests for re-published enterprise beans should move gradually from the pool of back-level AORs to the pool of CICS TS for z/OS, Version 4.2 AORs.

6. Repeat steps 1 through 5 for all of the AORs in the logical server. As each AOR is upgraded:
   - Re-publish a different set of enterprise beans, so that gradually more and more beans are supported by the pool of CICS TS for z/OS, Version 4.2 regions.
   - It becomes less important, when selecting deployed JAR files to re-publish, to choose those whose entire workload can be processed by a single region—because there are more AORs in the CICS TS for z/OS, Version 4.2 pool.

   Eventually, all the AORs will be running CICS TS for z/OS, Version 4.2 and processing 100% of the workload.

Tidying up:

To complete rolling upgrade, you must perform these final tasks.

About this task

Procedure

1. If required, reset the AUTOPUBLISH option on your CORBASERVER definitions to `YES`.
2. Enable any CICS TS for z/OS, Version 4.2-specific resource definition options that you want to use.

Results

Upgrade tips:

This section briefly lists some general tips, as a reminder of things to be aware of when upgrading an EJB server to CICS TS for z/OS, Version 4.2.

All these changes are described in detail in Chapter 4, "Setting up Java support," on page 75.

1. JVM profiles are stored in the z/OS UNIX directory pointed to by the **`JVMPROFILEDIR`** system initialization parameter.
2. The default JVM profile used by CorbaServers is DFHJVMCD.
3. Don't enable any new, CICS TS for z/OS, Version 4.2-specific, attributes on resource definitions during the "rolling upgrade" process. Use of these new features must wait until the whole logical server, both listener regions and AORs, has been upgraded.

4. From a CICS TS for z/OS, Version 4.2 AOR, you can re-publish a deployed JAR file that has previously been published from an earlier release of CICS without first retracting it. The IORs of the beans are updated to the format for the new release. **However, you cannot do the reverse**. From an earlier release of CICS, before re-publishing a deployed JAR file that has previously been published from a CICS TS for z/OS, Version 4.2 AOR you must first retract it; furthermore, because earlier CICS releases do not understand the format of CICS TS for z/OS, Version 4.2 IORs, *you must retract it from a CICS TS for z/OS, Version 4.2 AOR*.

   Bear this in mind if, for any reason, you need to back out the upgrade of one or more AORs. If you ever need to revert the IORs of enterprise beans that have been published from a CICS TS for z/OS, Version 4.2 AOR to an earlier level of CICS (so that they can be routed to a back-level AOR once more) you must:

   a. Retract the deployed JAR file from a CICS TS for z/OS, Version 4.2 AOR
   b. Publish the deployed JAR file from a back-level AOR

   Trying to re-publish the beans without retracting them first, or trying to retract them from the wrong level of CICS, results in an `InvalidUserKeyException: Bad version number` exception.

Potential problems:

1. After the EJB server has been upgraded to CICS TS for z/OS, Version 4.2, some clients may have stale, cached, IORs that point to the old server. This is because some application servers cache the results of JNDI lookups locally to increase performance. You may find that these caches have to be purged before the new IORs are used.
2. CICS TS 2.3 and later, including CICS TS for z/OS, Version 4.2, support GIOP 1.2, whereas CICS TS 2.2 supports only GIOP 1.1. If a GIOP 1.2 message is received in a CICS TS 2.2 region it will be rejected. Under normal conditions this should never happen, because the maximum version of GIOP supported by CICS is stored in the IORs that CICS publishes. If a client knows that a given server only supports GIOP 1.1, it will never attempt to use anything more recent when communicating with that server. This means that CICS TS for z/OS, Version 4.2 can send GIOP messages to CICS TS 2.2.

   The problem will only occur if the client thinks it is talking to CICS TS for z/OS, Version 4.2 (or CICS TS 3.1 or CICS TS 2.3) but its message is routed to a CICS TS 2.2 region. This will only happen if CICS TS 2.2 and CICS TS for z/OS, Version 4.2 regions are set up as sibling request processors (AORs) in the same logical server. (This is one reason why mixed-level logical servers are not recommended in CICS.) During a “rolling upgrade”, the logical server does, of course, contain mixed-level request processors. However, if you follow the steps in “Performing a “rolling upgrade”” on page 250, the problem (of a GIOP 1.2 message being received in a CICS TS 2.2 region) will not occur.
3. CICS TS 2.3 and later, including CICS TS for z/OS, Version 4.2, use a different format of IOR from CICS TS 2.2. If a GIOP 1.1 message intended for CICS TS for z/OS, Version 4.2 is routed to a CICS TS 2.2 region, the CICS TS 2.2 region will reject the request due to a unknown IOR format being in use. If all the regions in an EJB/CORBA server are at the same level of CICS and Java, this error cannot occur.

   During a “rolling upgrade”, the logical server does, of course, contain mixed-level regions. However, if you follow the steps in “Performing a “rolling upgrade”” on page 250, this problem will not occur.

Using the EJB IVP

The EJB Installation Verification Program (IVP) is a small application that CICS installers can use to verify the CICS EJB environment.

The EJB IVP uses a client program that does not require the use of a Web server. The IVP consists of:

- A line-mode client program that runs in UNIX System Services on z/OS
- A stateless session enterprise bean running on the CICS EJB server

The IVP tests:

- The CICS JVM (including its reusability).
- Optionally, your "real", enterprise-level, name server. (By default, the IVP uses the lightweight `tnameserv` COS Naming Server supplied with Java.)
- The EJB server's ability to run a basic enterprise bean.
- z/OS UNIX settings (including file access permissions).

Once configured, the client:

1. Performs a JNDI lookup to find the published reference to a specific enterprise bean in the JNDI namespace
2. Creates a new instance of the enterprise bean in CICS
3. Calls a remote method on the bean-instance

Prerequisites for the EJB IVP

Before running the EJB IVP, you will need these resources.

- A UNIX System Services user ID and file editor.
- A CICS EJB server. The way to set one up is described in "Setting up a single-region EJB server" on page 238.
- A name server that supports the Java Naming and Directory Interface (JNDI) Version 1.2 or later. The way to set up an enterprise-quality name server is described in "Enabling JNDI references" on page 364. Alternatively, you can use the lightweight `tnameserv` COS Naming Server supplied with Java.

Note:

1. These prerequisites assume you are testing a single-region CICS EJB server.
2. To run the IVP, you must have completed the steps in "Before running the EJB IVP" on page 238.
3. Before starting, check that the storage size for your TSO session is at least 6000 KB. To increase the storage size, at the standard TSO logon screen change the value in the SIZE field.

Installing the EJB IVP

To install the EJB you must set up z/OS UNIX, and CICS. On z/OS UNIX System Services you must configure the client.

z/OS UNIX setup for the EJB IVP:

The IVP uses the same CICS enterprise bean as the EJB "Hello World" sample application.

The sample is described in "The EJB "Hello World" sample application" on page 259. Thus, on z/OS UNIX, you must copy the `HelloWorldEJB.jar` deployed JAR file from the EJB samples directory to the deployed JAR file ("pickup") directory that you created in "Before running the EJB IVP" on page 238.

Note: Both the source and executable code of the enterprise bean is in the `HelloWorldEJB.jar` file.

The samples directory is: `/usr/lpp/cicsts/cicsts42/samples/ejb/helloworld`, where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OS UNIX.

Remember that z/OS UNIX names are case-sensitive.

CICS setup:

Before running the EJB IVP, you must perform these CICS setup tasks.

About this task

1. If EJB role-based security is active in your CICS region, you must turn it off before running the IVP. That is, if both the SEC and XEJB system initialization parameters currently specify 'YES', you must set XEJB to 'NO' and restart CICS.
2. The CICS-supplied sample resource group, DFH$EJB, contains TCPIPSERVICE and CORBASERVER definitions suitable for running the IVP. You must change some of the attributes of these resource definitions to suit your own environment, and install the changed definitions into CICS. You should already have done this, as part of the task of setting up your EJB server. If you have not, follow the step-by-step instructions in "Actions required on CICS" on page 240.
3. Issue a `CEMT PERFORM CORBASERVER(EJB1) SCAN` command.

   CICS:

   a. Scans the pickup directory that you specified on the DJARDIR option of the CORBASERVER definition
   b. Copies the `HelloWorldEJB.jar` deployed JAR file that it finds in the pickup directory to its shelf directory
   c. Dynamically creates and installs a DJAR definition for `HelloWorldEJB.jar`
   d. Because the CORBASERVER definition specifies AUTOPUBLISH(YES), publishes the enterprise bean contained in `HelloWorldEJB.jar` to the JNDI namespace.
4. If you have not already done so while setting up your CorbaServer, set the status of the TCPIPSERVICE to OPEN:

   ```
   CEMT SET TCPIPSERVICE(EJBTCP1) OPEN
   ```

   On the CICS Console, you should see, among others, messages similar to the following:

   ```
   DFHEJ5024 Scan commencing for CorbaServer EJB1, directory being scanned is
             DJARDIR_name.
   DFHEJ5030 New DJar HelloWorldEJB is being created during a scan against
             CorbaServer EJB1.
   DFHEJ0901 DJar HelloWorldEJB within CorbaServer EJB1 has been created.
   DFHEJ5025 Scan completed for CorbaServer EJB1, 1 DJars created, 0 DJars updated.
   DFHEJ5032 DJar HelloWorldEJB is having its contents automatically published to
             the namespace.
   DFHEJ5009 Published bean HelloWorld to JNDI server
             iiop://nameserver.location.company.com:2809 at location samples.
   DFHEJ1540 DJar HelloWorldEJB and the Beans it contains are now accessible.
   ```

   where:
   - **DJARDIR_name** is the name of your CorbaServer's deployed JAR file ("pickup") directory.

- **iiop://nameserver.location.company.com:2809** is the URL and port number of your name server. In this example, a COS Naming Server is used.

Configuring the client:

The source code of the client application is in the `HelloWorldCLI.jar` file.

About this task

On z/OS UNIX System Services, you must:

1. Copy the `runEJBIVP` script to a working directory. The original `runEJBIVP` script is located, with the IVP sample, in the following directory:

   ```
   /usr/lpp/cicsts/cicsts42/samples/ejb/helloworld
   ```

   where `cicsts42` is the install directory for CICS files on z/OS UNIX.
2. Edit your copy of `runEJBIVP` script as follows. This is necessary so that the client can locate the published enterprise bean in the JNDI namespace. (A typical client will not have access to the CICS JVM profile.)
   a. Modify the JAVA_HOME variable to your IBM SDK 6.0.1 installation directory, as indicated by the comments in the script. The line to be changed is:

      ```
      JAVA_HOME=/usr/lpp/<Java SDK java installation directory>/J6.0.1_64
      ```
   b. Modify the CICS_HOME variable to your install directory for CICS files on z/OS UNIX, as indicated by the comments in the script. The line to be changed is:

      ```
      CICS_HOME=/usr/lpp/cicsts/<CICS installation directory>
      ```
   c. Modify the JNDI_PROVIDER_URL variable to the URL and port number of your name server, as indicated by the comments in the script. The line to be changed is:

      ```
      JNDI_PROVIDER_URL=iiop://nameserver.location.company.com:2809
      ```

      The above line assumes that you are using a COS name server, such as `tnameserv`, the lightweight COS Naming Directory Server supplied with Java 1.3 and later, and that it is configured to listen on port 2809.

      If, for example, you are using a COS name server configured to listen on port 900, you might specify:

      ```
      JNDI_PROVIDER_URL=iiop://nameserver.location.company.com:900
      ```

      If you are using the `tnameserv` name server, configured to listen on port 2809, on a workstation named `myworkstation.acme.com` you should specify:

      ```
      JNDI_PROVIDER_URL=iiop://myworkstation.acme.com:2809
      ```

      To start the `tnameserv` program, type the following command at the workstation command prompt:

      ```
      tnameserv -ORBInitialPort 2809
      ```

      If you are using the COS Naming Directory Server supplied with WebSphere Application Server Version 5 or later, configured to listen on port 2809, you should specify:

```
JNDI_PROVIDER_URL=iiop://nameserver.location.company.com:2809/domain/legacyRoot
```

      If you are using an LDAP name server, the protocol should be `ldap` rather than `iiop`; the port number should be 389. For example:

      ```
      JNDI_PROVIDER_URL=ldap://nameserver.location.company.com:389
      ```

d. If you are using an LDAP name server, modify the LDAP_CONTAINERDN and LDAP_NODEROOTDN variables, as indicated by the comments in the script.

   If you are using a COS naming server, these properties are ignored.

e. If necessary, modify the INITIAL_CONTEXT_FACTORY variable as indicated by the comments in the script. Usually, you can leave this property to default. However, some JNDI service providers cannot be accessed using the default initial context factory. For example, if you are using WebSphere Application Server as your JNDI provider you should set this variable to `com.ibm.websphere.naming.WsnInitialContextFactory`.

f. If you have set up your CorbaServer and installed the IVP in the way suggested, the CORBASERVER_JNDI_PREFIX and BEAN_NAME variables will already be set to the correct values. See the comments in the script.

Running the EJB IVP

To run the EJB Installation Verification Program, you must perform these steps.

About this task

Procedure

1. Check that the name server is running.
   a. To start `tnameserv` on the local host, enter the following command at the z/OS UNIX System Services or Windows command prompt:

      ```
      tnameserv -ORBInitialPort 2809
      ```

      This causes `tnameserv` to listen for connections on TCP/IP port 2809.
2. Run the IVP client program from your z/OS UNIX System Services working directory by typing `./runEJBIVP`. On your z/OS UNIX System Services terminal, you should see messages similar to the following:

   ```
   CICS EJB IVP: Querying the Java SDK level
   java version "1.6.0"
   Java(TM) SE Runtime Environment (build pmz6460_26-20110218_01)
   IBM J9 VM (build 2.6, JRE 1.6.0 z/OS s390x-64 20110217_75924 (JIT enabled, AOT enabled)
   J9VM - R26_Java626_GA_20110217_1713_B75924
   JIT - r11_20110215_18645
   GC - R26_Java626_GA_20110217_1713_B75924
   J9CL - 20110217_75924)
   JCL - 20110207_01
   CICS EJB IVP: Starting the EJB client program
   HelloWorld client program started
   Performing JNDI lookup using CosNaming
   Testing the following location: samples/HelloWorld
   Located home interface for HelloWorld bean
   You said: Hello from CICS EJB IVP client
   HelloWorld client program ended
   CICS EJB IVP: Completed successfully
   ```

   Note:

   a. In this example, a COS Naming Server has been used. If you use an LDAP name server, similar messages are produced.
   b. If you get a `javax.naming.CommunicationException`, it may be because the MVS hostname is incorrect in your `tcpip.data` file. You may be able to fix the problem by adding an entry for the MVS system to your `/etc/hosts` file. For guidance, see the MVS manuals.

   In your JVM stdout file, you should see the following message:

   ```
   CICS EJB hello world sample called with string: Hello from CICS EJB IVP client
   ```

3. After running the IVP, you must perform the following steps.
   a. Discard the resource definitions that you created in `mygroup`.
   b. If you turned off EJB role-based security before running the IVP, turn it back on. To do this, restart CICS with the **`XEJB`** system initialization parameter set to 'YES'.

Running the sample EJB applications

The sample EJB applications require a CICS EJB server.

Important

You must configure CICS, as described in "Setting up an EJB server" on page 238, before attempting to install the samples.

CICS supplies the following sample EJB applications:

`The EJB Installation Verification Program (IVP)`
A simple application that you can use to test your CICS EJB environment and name server. A Web server is not required. See "Using the EJB IVP" on page 255.

`The EJB "Hello World" sample`
A simple application that you can use to test your EJB environment, including CICS, your name server, and your Web server. See "The EJB "Hello World" sample application."

`The EJB Bank Account sample`
A more complex application that demonstrates how you can use enterprise beans to make existing, CICS-controlled, information available to Web users. See "The EJB Bank Account sample application" on page 266.

The EJB "Hello World" sample application

"Hello World" is a simple application that you can use to test your EJB environment, including CICS, your name server, and your Web server.

What the EJB "Hello World" sample does:

The sample application requests input, appends the input to a standard message, and displays the resulting string.

The sample consists of:
- An HTML form.
- A Java servlet, plus JavaServer Pages (JSPs), running in a J2EE-compliant Web application server.
- An enterprise bean running on a CICS EJB server.

The sample works like this:
1. The user starts the application from a web browser. A form is displayed.
2. The form asks the user to input a phrase. When the user presses the SUBMIT button, the servlet is invoked.
3. The servlet:
   a. Looks up a reference to the enterprise bean in the JNDI namespace
   b. Creates a new remote instance of the enterprise bean in CICS
   c. Invokes a method on the bean-instance, passing as input the phrase input by the user

4. The enterprise bean appends the user's phrase to the string “You said ” and returns the result to the servlet.
5. The servlet uses a JavaServer Page to display the result on the user's web browser.

Figure 18 shows the components of the sample application. The main elements of the sample are a Java servlet and an enterprise bean. In this example, the servlet is running in a Web application server on a Windows server; a COS Naming Server is used. Other configurations are possible. For example, an LDAP name server could have been used; or the COS Naming Server might not have been hosted in the same application server as the servlet.

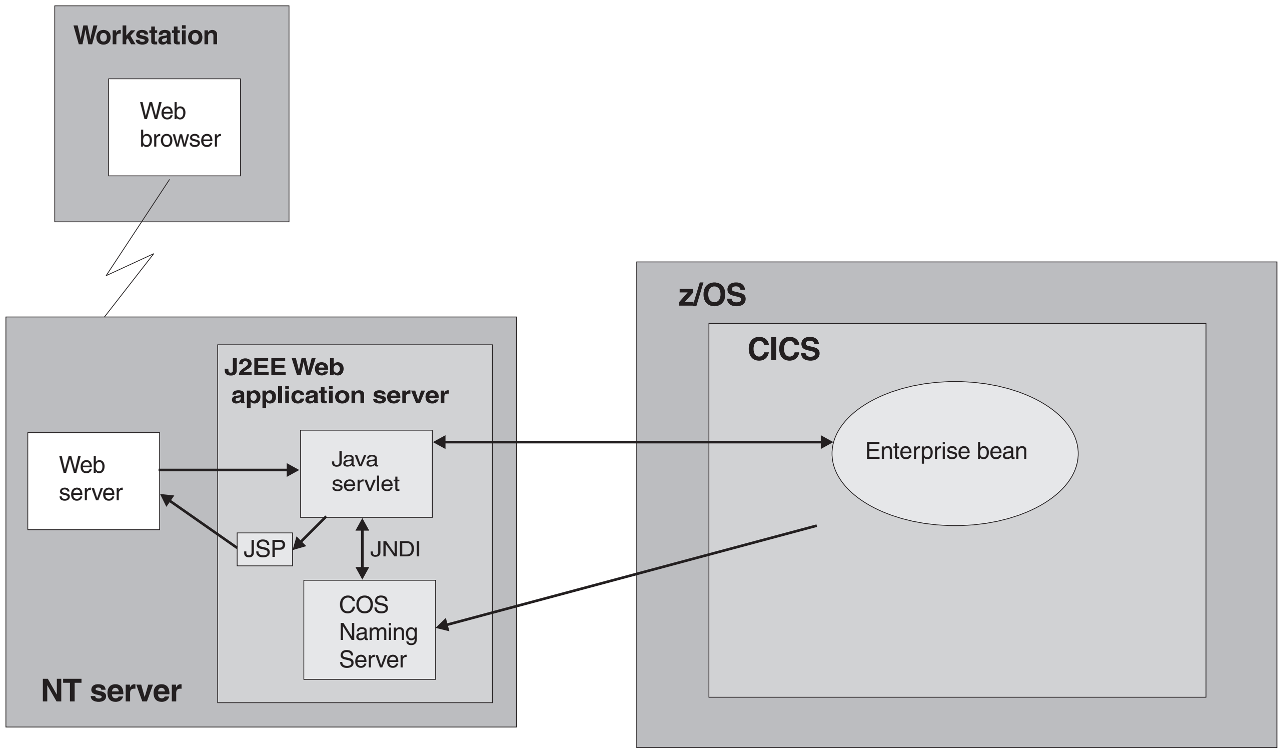


Figure 18. Overview of the EJB “Hello World” sample application

Prerequisites for the EJB “Hello World” sample:

You need these resources to run the EJB “Hello World” sample.
- A CICS EJB server. The way to set one up is described in “Setting up an EJB server” on page 238.
- A Web application server that supports J2EE Version 1.2.1 or later. If you are using WebSphere Application Server, note that the sample requires WebSphere Application Server Version 4 or later.
- A name server that supports the Java Naming and Directory Interface (JNDI) Version 1.2 or later. The way to set one up is described in “Actions required on z/OS or Windows NT” on page 239.

Supplied components of the EJB “Hello World” sample:

These files are supplied with the EJB “Hello World” sample.

Table 16. Supplied components of the EJB "Hello World" sample

Filename	Type	Default location	Comments
`CICSHelloWorld.ear`	EAR file	z/OS UNIXsamples directory: see Note.	The Web components of the sample application—Java servlet classes and source files; HTML and JSPs.
DFH$EJB	Resource definition group	CSD	Contains the CICS resource definitions required by the sample application.
`HelloWorldCLI.jar`	JAR file	z/OS UNIX samples directory: see Note.	Client EJB stubs required by the servlet.
`HelloWorldEJB.jar`	Deployed JAR file	z/OS UNIX samples directory: see Note.	Java classes, source files, deployment descriptor, plus supporting classes for the CICS enterprise bean. Doesn't need to be unpacked unless you want to modify the source code.
`readme.txt`	Text file	z/OS UNIX samples directory: see Note.	Contains: 1. Step-by-step instructions for installing the Web components of the EJB "Hello World" sample on WebSphere Application Server. 2. Hints, tips, and debugging information.
Note: The default z/OS UNIX samples directory is `/usr/lpp/cicsts/cicsts42/samples/ejb/helloworld` where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OS UNIX.			

Installing the EJB "Hello World" sample:

You must set up these resources to install the EJB "Hello World" sample.
1. z/OS UNIX. If you've previously run the EJB IVP, you will have performed this action already.
2. CICS. If you've previously run the EJB IVP, you will have performed these actions already.
3. The Web application server.

z/OS UNIX setup for EJB "Hello World" sample:

If necessary, on z/OS UNIX copy the `HelloWorldEJB.jar` deployed JAR file from the EJB samples directory to your CorbaServer's deployed JAR file ("pickup") directory.

Note:
1. You need to do this only if you haven't already installed the `HelloWorldEJB.jar` deployed JAR file while running the EJB IVP.
2. The deployed JAR file directory is the directory that you created in "Before running the EJB IVP" on page 238 and specified on the DJARDIR option of the CORBASERVER definition.
3. The samples directory is: `/usr/lpp/cicsts/cicsts42/samples/ejb/helloworld`, where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OS UNIX.
4. Remember that z/OS UNIX names are case-sensitive.
5. The `HelloWorldEJB.jar` file contains both the source and executable code for the enterprise bean.

CICS setup:

About this task

1. If EJB role-based security is active in your CICS region, you must turn it off before running the EJB “Hello World” sample. That is, if both the SEC and XEJB system initialization parameters currently specify 'YES', you must set XEJB to 'NO' and restart CICS.
2. The CICS-supplied sample group, DFH$EJB, contains TCPIPSERVICE and CORBASERVER definitions suitable for running the EJB “HelloWorld” sample. You must change some of the attributes of these resource definitions to suit your own environment, and install the changed definitions into CICS. You should already have done this, as part of the task of setting up your EJB server. If you haven't, follow the step-by-step instructions in “Actions required on CICS” on page 240.

   Note: Group DFH$EJB does not contain a REQUESTMODEL definition, because it's not necessary to install one. The sample uses the default transaction ID, CIRP.

   a. If necessary, issue a `CEMT PERFORM CORBASERVER(EJB1) SCAN` command. (You need to do this only if you haven't already installed the `HelloWorldEJB.jar` deployed JAR file while running the EJB IVP.) CICS:
      1) Scans the pickup directory
      2) Copies the `HelloWorldEJB.jar` deployed JAR file that it finds in the pickup directory to its shelf directory
      3) Dynamically creates and installs a DJAR definition for `HelloWorldEJB.jar`
      4) Because the CORBASERVER definition specifies AUTOPUBLISH(YES), publishes the enterprise bean contained in `HelloWorldEJB.jar` to the JNDI namespace.
3. If you have not already done so, set the status of the TCPIPSERVICE to OPEN:

   ```
   CEMT SET TCPIPSERVICE(EJBTCP1) OPEN
   ```

   If you issued the `CEMT PERFORM CORBASERVER(EJB1) SCAN` command, on the CICS Console you should see, among others, messages similar to the following:

   ```
   DFHEJ5024 Scan commencing for CorbaServer EJB1, directory being scanned is
             DJARDIR_name.
   DFHEJ5030 New DJar HelloWorldEJB is being created during a scan against
             CorbaServer EJB1.
   DFHEJ0901 DJar HelloWorldEJB within CorbaServer EJB1 has been created.
   DFHEJ5025 Scan completed for CorbaServer EJB1, 1 DJars created, 0 DJars updated.
   DFHEJ5032 DJar HelloWorldEJB is having its contents automatically published to
             the namespace.
   DFHEJ5009 Published bean HelloWorld to JNDI server
             iiop://nameserver.location.company.com:900 at location samples.
   DFHEJ1540 DJar HelloWorldEJB and the Beans it contains are now accessible.
   ```

   where:
   - **DJARDIR_name** is the name of your CorbaServer's deployed JAR file (“pickup”) directory.
   - **iiop://nameserver.location.company.com:900** is the URL and port number of your name server. In this example, a COS Naming Server is used.

Web application server setup:

On the Web application server, you must install the Web components of the EJB “Hello World” sample application.

About this task

From the z/OS UNIX EJB samples directory, you need:

- `CICSHelloWorld.ear`. A J2EE enterprise archive (EAR) file, containing the Web components of the sample and the source code of the servlet and JSPs.
- `readme.txt`. A text file, containing:
  1. Step-by-step instructions for installing the Web components of the sample on WebSphere Application Server.
  2. Hints, tips, and debugging information.

Note: The default samples directory is

```
/usr/lpp/cicsts/cicsts42/samples/ejb/helloworld
```

where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OS UNIX.

Important: The rest of this section contains generic instructions for installing the Web components of the sample on a J2EE-compliant Web application server (which may or may not be WebSphere). It is suitable for experienced users. If your Web application server is WebSphere Application Server Version 4 or later *and* you are a novice user of that product, we recommend that you follow instead the detailed, WebSphere-specific instructions in the `readme.txt` file.

1. Install the Web components of the EJB "Hello World" sample (contained in `CICSHelloWorld.ear`) in your J2EE Web application server, following the vendor's guidelines for installing applications. In WebSphere Application Sever, for example, this involves using the administration console to:
   a. Install a new application
   b. Generate the updated Web server plugin
   c. Save the configuration

   Note: `CICSHelloWorld.ear` includes a default configuration for the EJB "Hello World" sample. To run the sample, it is not necessary to edit or add any configuration information.
2. Start the application using your Web application server's standard procedure.

Testing the EJB "Hello World" sample:

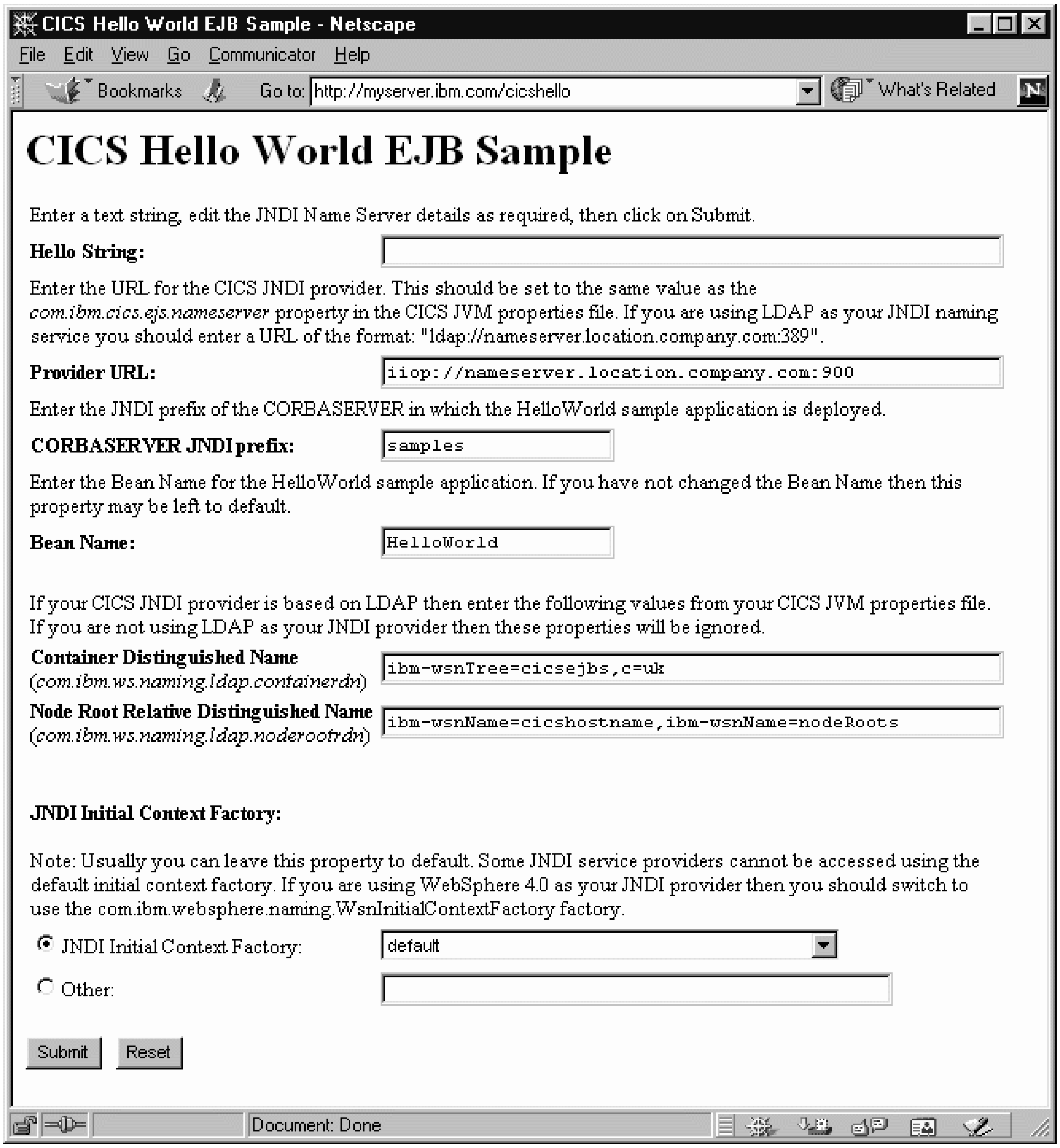
You must perform these steps to test the application.

About this task

1. Ensure that all the following are running:
   - The Web server
   - The Web application server and the sample application
   - The name server
   - The CICS region
2. Start a Web browser and point it at the URL of your Web server, followed by "cicshello". For example:

   ```
   http://myServer.ibm.com/cicshello
   ```

   The opening screen shown in Figure 19 on page 264 appears.


CICS Hello World EJB Sample - Netscape
File Edit View Go Communicator Help
Bookmarks
Go to: http://myserver.ibm.com/cicshello
What's Related
Submit
Reset
Document: Done

CICS Hello World EJB Sample

Enter a text string, edit the JNDI Name Server details as required, then click on Submit.

Hello String:

Enter the URL for the CICS JNDI provider. This should be set to the same value as the *com.ibm.cics.ejs.nameserver* property in the CICS JVM properties file. If you are using LDAP as your JNDI naming service you should enter a URL of the format: "ldap://nameserver.location.company.com:389".

Provider URL: `iiop://nameserver.location.company.com:900`

Enter the JNDI prefix of the CORBASERVER in which the HelloWorld sample application is deployed.

CORBASERVER JNDI prefix: `samples`

Enter the Bean Name for the HelloWorld sample application. If you have not changed the Bean Name then this property may be left to default.

Bean Name: `HelloWorld`

If your CICS JNDI provider is based on LDAP then enter the following values from your CICS JVM properties file. If you are not using LDAP as your JNDI provider then these properties will be ignored.

Container Distinguished Name (*com.ibm.ws.naming.ldap.containerdn*) `ibm-wsnTree=cicsejbs,c=uk`

Node Root Relative Distinguished Name (*com.ibm.ws.naming.ldap.noderootrdn*) `ibm-wsnName=cicshostname,ibm-wsnName=nodeRoots`

JNDI Initial Context Factory:

Note: Usually you can leave this property to default. Some JNDI service providers cannot be accessed using the default initial context factory. If you are using WebSphere 4.0 as your JNDI provider then you should switch to use the com.ibm.websphere.naming.WsnInitialContextFactory factory.

[✓ JNDI Initial Context Factory:] default

Other:

Figure 19. Opening screen of the EJB “Hello World” sample application

3. Enter a phrase in the `Hello String:` field.
4. Check that the `Provider URL:`, `CORBASERVER JNDI prefix:`, `Bean Name:`, `Container Distinguished Name:`, `Node Root Relative Distinguished Name:`, and `JNDI Initial Context Factory:` fields contain values that are valid for your installation. If they do not, overtype them as follows:

   `Provider URL:`
   Enter the URL and port number of the name server where the enterprise

bean is published. (These are specified by the **-Dcom.ibm.cics.ejs.nameserver** property in your JVM properties file.) For example:

- If you are using an LDAP name server with a URL of `myldapns.ibm.com` and a port number of 389, specify `"ldap://myldapns.ibm.com:389"`.
- If you are using a standard COS Naming Server with a URL of `mycosns.ibm.com` and a port number of 900, specify `"iiop://mycosns.ibm.com:900"`.
- If you are using the COS Naming Directory Server supplied with WebSphere Application Server Version 5 or later, with a URL of `mycosns.ibm.com` and a port number of 2809, specify:

  ```
  -Dcom.ibm.cics.ejs.nameserver=iiop://mycosns.ibm.com:2809/domain/legacyRoot
  ```

For detailed information about how to specify the location of the name server, see the description of the **-Dcom.ibm.cics.ejs.nameserver** property in "JVM system properties" on page 109.

CORBASERVER JNDI prefix:
Enter the JNDI prefix of your CorbaServer. If you are using the CORBASERVER definition supplied in DFH$EJB, you do not need to change the default value of "`samples`".

Bean name:
Enter the name of the enterprise bean used by the sample, as defined in the deployment descriptor in the supplied `HelloWorldEJB.jar` file. *Unless you have renamed the bean, you do not need to change the default value of "HelloWorld".*

Container Distinguished Name:
If you are using an LDAP name server, enter the distinguished name of the LDAP system namespace root, as supplied by your LDAP administrator. (The distinguished name of the LDAP system namespace root is specified by the **-Dcom.ibm.ws.naming.ldap.containerdn** property in your JVM properties file.) *If you are using a COS Naming Server, the value of this field is ignored.*

Node Root Relative Distinguished Name:
If you are using an LDAP name server, enter the distinguished name of the LDAP node root, as supplied by your LDAP administrator. (The distinguished name of the LDAP node root is specified by the **-Dcom.ibm.ws.naming.ldap.noderootrdn** property in your JVM properties file.) *If you are using a COS Naming Server, the value of this field is ignored.*

JNDI Initial Context Factory:
Select the appropriate JNDI initial context factory from the drop-down list. If your Web application server is WebSphere, the factory to use depends on:
- The version of WebSphere you're using
- The location of WebSphere—that is, whether it's on a distributed platform such as Windows NT or a host platform such as z/OS
- The type of name server you're using—COS naming or LDAP

Table 17 on page 266 shows the correct initial context factory to specify, if your Web application server is WebSphere.

Table 17. Setting the initial context factory, according to the version and location of WebSphere and the type of name server

WebSphere Version	Location of Web application server	Name server type	Initial context factory to use
3.5	Distributed	COS	`com.ibm.ejs.ns.jndi.CNInitialContextFactory`
3.5	Distributed	LDAP	`com.ibm.jndi.LDAPCtxFactory`
3.5	z/OS	COS	`com.sun.jndi.cosnaming.CNCtxFactory`
3.5	z/OS	LDAP	`com.sun.jndi.ldap.LdapCtxFactory`
4 or later	Distributed	COS or LDAP	`com.ibm.websphere.naming.WsnInitialContextFactory`
4 or later	z/OS	COS	`com.sun.jndi.cosnaming.CNCtxFactory`
4 or later	z/OS	LDAP	`com.sun.jndi.ldap.LdapCtxFactory`

If your Web application server is not WebSphere, choose the appropriate value from the drop-down list.

Note: The drop-down list contains several initial context factory classes, plus a “default” list item. The sample application assigns the value of the default list item as follows:

a. If the `com.ibm.websphere.naming.WsnInitialContextFactory` class is found in the Java classpath, the sample makes it the default item. This class is a “wrapper” class that wraps both `com.ibm.ejs.ns.jndi.CNInitialContextFactory` and `com.ibm.jndi.LDAPCtxFactory`. The sample determines the correct base class to use by examining the type of name server that you've specified in the **Provider URL** field: if the specified protocol is “iiop”, the sample uses `com.ibm.ejs.ns.jndi.CNInitialContextFactory`; if it's “ldap”, the sample uses `com.ibm.jndi.LDAPCtxFactory`.

b. If the `com.ibm.websphere.naming.WsnInitialContextFactory` class is *not* found in the Java classpath, the sample determines the correct class to use by examining the type of name server that you've specified in the **Provider URL** field: if the specified protocol is “iiop”, the sample uses `com.ibm.ejs.ns.jndi.CNInitialContextFactory`; if it's “ldap”, the sample uses `com.ibm.jndi.LDAPCtxFactory`.

If none of the values in the drop-down list are valid for your installation, select the `Other` radio button and enter the correct value in the lower text field.

5. Press the SUBMIT button. This invokes the servlet and runs the application.

   If the application is configured correctly and the input values are valid, the HelloWorldResults JSP displays the message “You said *your phrase*” in the web browser (where *your phrase* is the phrase you entered in step 3).

   If the application is not configured correctly, or one or more of the input values is invalid, the HelloWorldError JSP displays an error message in the web browser. The `readme.txt` file contains hints and tips that may help you debug a failed application.

The EJB Bank Account sample application

The EJB Bank Account sample demonstrates how you can use enterprise beans and DB2 to make existing, CICS-controlled, information available to Web users.

What the EJB Bank Account sample does:

The sample application extracts customer information from data tables and returns it to the user.

The sample consists of:
- An HTML form.
- A Java servlet, plus JavaServer Pages, running in a J2EE-compliant Web application server.
- An enterprise bean running on a CICS EJB server.
- Two DB2 data tables containing customer information. One contains account information such as current balance; the other contains name and address details.
- Two CICS server programs, written in COBOL. The DFH0ACTD program retrieves information from the accounts data table. The DFH0CSTD program retrieves information from the name and address data table.

The sample works like this:
1. The user starts the application from a Web browser. A form is displayed.
2. The form requests a customer number from the user. When the user has entered a customer number and pressed the SUBMIT button, the servlet is invoked.
3. The servlet:
   a. Looks up a reference to the enterprise bean in the JNDI namespace
   b. Creates a new remote instance of the enterprise bean in CICS
   c. Invokes a method on the bean-instance, passing as input the customer number input by the user
4. The enterprise bean uses the Common Connector Interface (CCI) of the CCI Connector for CICS TS to link to the CICS COBOL server programs, passing the customer number.

   The CCI Connector for CICS TS is described in "The CCI Connector for CICS TS" on page 311.
5. The server programs use the specified number as the key to the DB2 records for this customer. They retrieve the customer's details from the DB2 data tables and return the account number, balance, and address to the enterprise bean.
6. The enterprise bean returns the customer's details to the servlet, which uses a JavaServer Page to display them on the user's web browser. If the customer number is not valid, the web browser displays an error page.

Figure 20 on page 268 shows the components of the sample application. The main elements of the sample are a Java servlet, an enterprise bean, two CICS server programs, and two DB2 data tables. The sample extracts customer details from the data tables and returns them to the user. In this example, the servlet is running in a Web application server on a Windows server; an LDAP name server is used. Other configurations are possible. For example, a COS Naming Server could have been used.

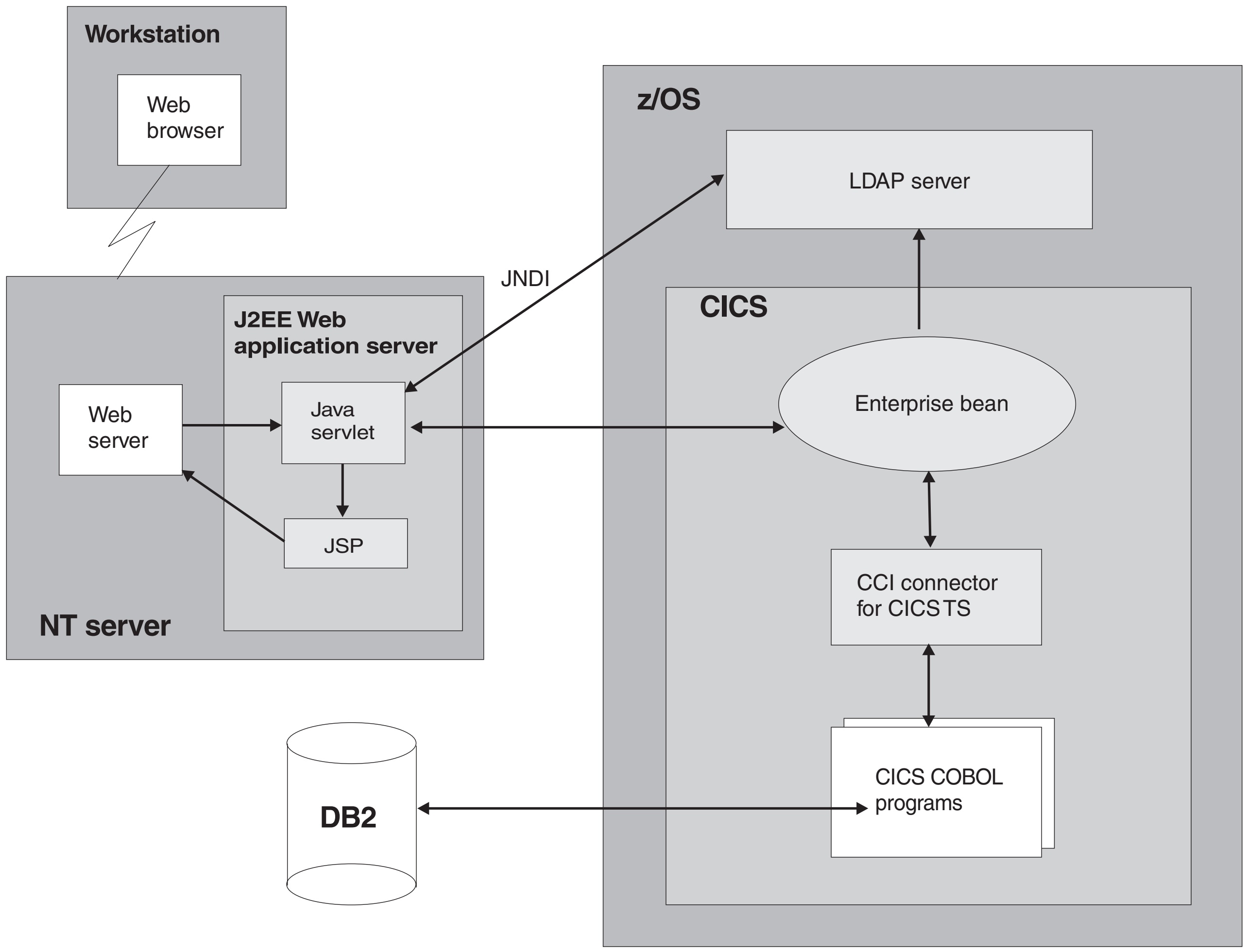


Figure 20. Overview of the EJB Bank Account sample application

Prerequisites for the EJB Bank Account sample:

You will need these resources to run the EJB Bank Account sample.
- A CICS EJB server. The way to set one up is described in “Setting up an EJB server” on page 238.
- DB2 Version 7 or later.
- A Web application server that supports J2EE Version 1.2.1 or later. If you are using WebSphere Application Server, note that the sample requires WebSphere Application Server Version 4 or later.
- A name server that supports JNDI Version 1.2 or later. The way to set one up is described in “Actions required on z/OS or Windows NT” on page 239.

Supplied components of the EJB Bank Account sample:

These files are supplied with the EJB Bank Account sample.

Table 18. Supplied components of the EJB Bank Account sample

Filename	Type	Default location	Comments
DFH$EDB2	Text deck	SDFHSAMP	DB2 data definition language (DDL) statements to define the DB2 data tables used by the sample and to populate them with data.
DFH$ESQL	Text deck	SDFHSAMP	DB2 data manipulation language (DML) statements to bind the DB2 data tables to the COBOL server programs.
DFH$EJB2	Resource definition group	CSD	Contains the CICS resource definitions required by the sample application.
DFH0ACTD	COBOL source code	SDFHSAMP	Source code of the DFH0ACTD server program.
DFH0CSTD	COBOL source code	SDFHSAMP	Source code of the DFH0CSTD server program.
DFHEBURM	Sample user replaceable program	SDFHSAMP	Changes the user ID under which the sample runs.
`CicsSample.ear`	EAR file	z/OS UNIX samples directory: see Note.	The Web components of the sample application—Java servlet classes and source files; HTML and JSPs.
`readme.txt`	Text file	z/OS UNIX samples directory: see Note.	Contains: 1. Step-by-step instructions for installing the Web components of the EJB sample on WebSphere Application Server. 2. Hints, tips, and debugging information.
`SampleCLI.jar`	JAR file	z/OS UNIX samples directory: see Note.	Client EJB stubs required by the servlet.
`SampleEJB.jar`	Deployed JAR file	z/OS UNIX samples directory: see Note.	Java classes, source files, deployment descriptor, plus supporting classes for the CICS enterprise bean. Doesn't need to be unpacked unless you want to modify the source code.
Note: The default z/OS UNIX samples directory is `/usr/lpp/cicsts/cicsts42/samples/ejb/bankaccount` where `cicsts42` is the install directory for CICS files on z/OS UNIX.			

Security of the EJB Bank Account sample:

It is recommended that you run the Bank Account sample in a secure environment. However, in order to simplify the installation process, you may choose not to do so at first.

If you don't want to activate the secure environment immediately, set the XEJB system initialization parameter to 'NO' and skip the rest of this section. To activate the secure environment at a later date, follow the instructions in the rest of this section.

You can implement security for the sample in a number of ways. For example, you can use any of the following alternatives:
- Allow all users to run the sample under the default user ID.
- Allow all users to run the sample under a user ID specified by the security exit program for IIOP.
- Use an SSL server-side certificate to encrypt the data sent between the Web-tier and CICS, allowing all users to run the sample over a secure transport, under the default user ID.
- Use an SSL server-side certificate to encrypt the data sent between the Web-tier and CICS, allowing all users to run the sample over a secure transport, under a user ID specified by the security exit program for IIOP.
- Use SSL client certification to automatically authenticate the Web-tier application server to CICS, allowing all users to run the sample over a secure transport, under a user ID assigned to the Web-tier application server.
- Use asserted identity authentication to allow Web-tier client applications running in WebSphere Application Server for z/OS to propagate their existing user IDs to CICS over a secure transport.

Note:
1. By default, the Bank Account application does not require the user to be authenticated at the Web-tier. You can choose to activate authentication in the Web container by following your application server's instructions. If you do authenticate in the Web tier, the security principle is not propagated to CICS, so in terms of CICS security it has no effect. However, early authentication in the Web-tier could be used to create a “protection domain” under which CICS trusts the Web-tier not to allow unauthenticated users to invoke business methods on CICS enterprise beans.
2. In order to use SSL encryption or authentication, you require a J2EE-compliant Web application server that fully supports SSL. Consult your vendor's documentation for further details.
3. For more information about SSL authentication, see SSL authentication, in the *CICS RACF Security Guide*.

Whichever authentication method you choose, you need (among other things) to:
1. Provide authorization information in the deployment descriptor of the enterprise bean in CICS. This authorization information consists of:

   A "security role" element
   Identifies a class of user who is allowed to perform a given action or use a given resource.

   A "method permission" element
   Identifies specific methods of the enterprise bean that members of the specified security role are authorized to use.
2. Update your CICS external security manager (ESM) to map the specified security role to a number of real user IDs. The following step-by-step instructions for implementing security assume that your ESM of choice is RACF. If you use a different ESM, consult your ESM vendor for guidance.

Implementing role-based security for the Bank Account sample:

You can implement role-based security for the Bank Account sample using the Assembly Toolkit (ATK, which is a component of the Application Server Toolkit, ASTK).

About this task

This tool is shipped as part of WebSphere Application Server Version 5.1 and later. You can use the graphical user interface of ATK to (among other things) edit the contents of an enterprise bean's deployment descriptor.

Before you start, ensure that you have ATK installed on your workstation. Once installed, the tool can be launched from an icon which is added to your Start menu in Windows.

ATK is used for the first stage of implementing role-based security, which involves editing the deployment descriptor for the enterprise bean. When you have completed that stage, follow the instructions for the second stage of implementing role-based security, which involves configuring other software.

Stage 1. Using ATK to edit the deployment descriptor:

At this point, in order to familiarise yourself with ATK, you can browse through the contents of the JAR file.

1. Copy the `SampleEJB.jar` file from the z/OS UNIX samples directory to your workstation. You can do this using FTP in binary mode, or any other method of your choice. The z/OS UNIX samples directory is `/usr/lpp/cicsts/cicsts42/samples/ejb/bankaccount`. For ATK, you also need to perform the same process for the `dfjcci.jar` file, which is in the `/usr/lpp/cicsts/cicsts42/lib` directory. You do not need to edit that JAR file, but ATK needs it to rebuild the JAR file for the EJB bank account sample correctly after editing.
2. Import the JAR file into ATK as an EJB project.
   a. Start ATK, and go to the J2EE perspective by selecting **Window > Open Perspective > J2EE**.
   b. Select the **Import** option from the **File** menu. Select **EJB JAR file** as the import source. Select **Browse** and find the `SampleEJB.jar` file. Enter a suitable name for the project. Select **Next** and choose to import all enterprise beans, which is the default. Select **Finish** to create the EJB project.
   c. When the project is created, you should see some errors appear in the Tasks list. To correct these errors, you need to add the `dfjcci.jar` file to the build path for the EJB project. In the left-hand navigation pane (using the J2EE hierarchy view), expand the EJB Modules item to see your EJB project. Right-click on the project name and select **Properties**. Select **Java Build Path**. Go to the **Libraries** tab and select the **Add External JARs** button. Navigate to the `dfjcci.jar` file and select **Open**. Select **OK**. ATK rebuilds the EJB project and the errors should disappear.

   For more information about the EJB deployment descriptor, see "Enterprise beans—the deployment descriptor" on page 219.
3. Add security roles to the deployment descriptor. In ATK, in the left-hand navigation pane (using the J2EE hierarchy view), expand the EJB Modules item to see your EJB project. Double-click on the project name to open the project. Select the **Assembly Descriptor** tab at the bottom of the pane. Under **Security Roles**, select the Add button to add a new security role.

If your organisation has already set up security roles for use with other applications, you may want to reuse an existing role. If so, supply the name of the role that you want to use in the field provided. If you don't have an existing security role that you want to reuse, enter a new role name, such as "All_users". You can also provide an optional description of the role to act as a memory aid in the future. Select **Finish** to return to the main window.

Note: If you reuse an existing security role which is already defined to your ESM, you must remove the `Display Name` element from the JAR file's deployment descriptor. This element is used by CICS to provide an application name which is prefixed to all security role names when performing a security check at runtime, thus providing support for security roles scoped at the application level rather than enterprise-wide. In ATK, you can remove this element by selecting the **Overview** tab at the bottom of the pane. Select the text in the `Display Name` field and delete it.

4. Now define a method permission and associate it with a security role. In ATK, select the **Assembly Descriptor** tab again. Under **Method Permissions**, select the **Add** button. The wizard presents a list of the security roles that you have defined. For the Bank Account sample, it's appropriate to run all the methods under the same security role. Select the security role that you want to associate with the method permission, and select **Next**. Select the CICSSample bean, and select **Next**. Check the box for CICSSample to select all the method elements for the bean. Select **Finish**. You are returned to the previous screen.
5. Save the updated deployment descriptor by selecting the **Save** option from the **File** menu.
6. Export the project from ATK back into a JAR file on your workstation. To do this, select the **Export** option from the **File** menu. Select **EJB JAR file** as the export destination, and select **Next**. Select your EJB project from the drop-down list. Select **Browse** and locate the `SampleEJB.jar` file to be used as the destination. (This overwrites your original version of the file. You might want to keep a backup of the original version of the file on your workstation under a different name.) Select the checkbox for **Export source files** to keep the source files with the JAR file. Select **Finish**. Exit ATK.
7. Copy the updated `SampleEJB.jar` file back to z/OS UNIX. You can use either FTP in binary mode or your preferred file transfer process. Save the `SampleEJB.jar` file to the pickup directory of your CorbaServer.

Stage 2. Configuring other security settings:

The CICS user ID (or IDs) that you choose to associate with the security role defined in the enterprise bean's deployment descriptor should be chosen according to which security implementation you opted for at the start of this section.

1. Ensure that both the SEC and the XEJB CICS system initialization parameters specify 'YES'. (If either specifies 'NO', EJB role-based security is turned off.)
2. If you reused an existing security role that had already been set up in your installation, you can skip this step, which is to update RACF to associate the EJB security role with a set of CICS user IDs.

   Note: If your ESM is not RACF, you must seek advice from your ESM vendor as to how to perform this step.

   For example:

   - If you want to allow all anonymous users to run the sample (whether using SSL or not), you should associate the CICSUSER default user ID with the security role.

- If you want to run the sample under a user ID (or IDs) selected by the security exit program for IIOP (whether using SSL or not), you should associate that user ID (or IDs) with the security role.
- If you want to use full SSL client certification, you should associate the user ID of the Web-tier application server's certificate with the security role.

To set up the necessary EJB security role-to-CICS user ID mapping:

a. Run the RACF EJBROLE generator utility against the updated `SampleEJB.jar` file. (The RACF EJBROLE generator utility is a Java program that extracts security role information from deployment descriptors, and generates a REXX program which defines security roles to RACF. For information on how to use the generator utility, see "Using the RACF EJBROLE generator utility" on page 344.)
b. Ask your RACF administrator to run the REXX program generated by the RACF EJBROLE generator utility.

3. If you don't want to use the the security exit program for IIOP to alter the user ID that the sample runs under (from the default CICS user ID to another ID of your choice), you can skip this step.

   CICS supplies a sample security exit program, DFHEBURM, that alters the user ID under which the Bank Account sample runs from the default CICS user ID to "SAMPLE". You can use this version of the user-replaceable program, or alter it to suit your needs. If you already have a customized security exit program for IIOP, you can update your version to perform a similar function.

   You must specify the name of your security exit program on the URM option of the TCPIPSERVICE definition under which the sample is to be run.

   For guidance information about the security exit program for IIOP, see"Using the IIOP user-replaceable security program" on page 384.

   For information about writing a security exit program for IIOP, see the *CICS Customization Guide*. Also, study the source of the supplied sample program, which contains comments and tips.

   For information about compiling and installing user-replaceable programs, see Assembling and link-editing user-replaceable programs, in the *CICS Customization Guide*.

   For information about coding TCPIPSERVICE definitions, see the *CICS Resource Definition Guide*.

4. If you are using SSL encryption or authentication, you must:
   - Configure your J2EE-compliant Web application server to use SSL. Refer to your Web server's documentation for guidance.
   - Have a server certificate available for use.
   - Alter the definitions of the CORBASERVER and TCPIPSERVICE resources under which the sample is to be run. That is:
     – If you are using SSL client-side authentication, the CLIENTCERT option of the CORBASERVER definition must specify the name of a TCPIPSERVICE that defines the port to be used for inbound IIOP requests with SSL client certification. Also, the Web application server's SSL certificate must be:
       - Included in the list of certificates trusted by CICS, in RACF
       - Mapped to a RACF user ID
     – If you are using SSL server-side authentication, the SSLUNAUTH option of the CORBASERVER definition must specify the name of a TCPIPSERVICE that defines the port to be used for inbound IIOP requests with SSL but no client certification.

For information about coding CORBASERVER resource definitions and TCPIPSERVICE resource definitions, see the the *CICS Resource Definition Guide*.

- If you are using asserted identity authentication for encryption, authentication, and identity propagation, you must:
  - Configure WebSphere Application Server for z/OS to authenticate users.
  - If you are using WebSphere Application Server for z/OS Version 6.1 or later, to enable a suitable authentication protocol, specify the system property **`-Dcom.ibm.cics.iiop.CSIv2Enabled=true`** in all of the JVM properties files used in the CICS region. (Release 6.1.0.13 or later of WebSphere Application Server for z/OS is required to support this function.)
  - Enable SSL client certification in WebSphere.
  - Have a server SSL certificate available for use in CICS.
  - Include the server certificate associated with WebSphere Application Server in the RACF's list of certificates trusted by CICS. Additionally, the userid associated with the RACF certificate must be granted permission to assert the identity of other users.
  - Alter the definitions of the CORBASERVER and TCPIPSERVICE resources under which the sample is to run. The ASSERTED option of the CORBASERVER definition must specify the name of a TCPIPSERVICE that defines the port to be used for inbound IIOP requests with asserted identity authentication.

Installing the EJB Bank Account sample:

Installing the EJB Bank Account sample requires actions on:
1. z/OS (DB2 and CICS)
2. The Web application server

z/OS setup:

Use the following procedure to install the EJB sample on z/OS.

About this task

1. Compile and link-edit the CICS COBOL DB2 server programs, using the normal procedures for your organization. The DFH0ACTD and DFH0CSTD members of the SDFHSAMP library contain the source code of the server programs.

   Store the load modules in an application load library that is included in the CICS DD DFHRPL concatenation.
2. Define the DB2 data tables used by the sample, and populate the tables with data. The DFH$EDB2 text deck contains the necessary DB2 DDL statements and the supplied data.

   Before using DFH$EDB2, you must modify the following line to suit your system:
   ```
   CREATE STOGROUP EBSAMPSG VOLUMES(SYSDA,SYSDB) VCAT DSNxxxxx;
   ```
   Change `DSNxxxxx` to the name of your high-level integrated catalog facility (ICF) catalog identifier for user-defined VSAM data sets.

   Authority required: DB2 authority to create a database, storage group, tablespace, tables, and indices.

3. Bind the DB2 tables to the COBOL server programs. The DFH$ESQL text deck contains the necessary DB2 DML statements.

   Authority required: DB2 authority to perform a BIND for this database.

   Note:

   a. This step statically binds the SQL statements in the server programs to DB2, so that they do not need to be dynamically bound at execution time, thus improving runtime performance.
   b. If you subsequently recompile one of the server programs and it needs to access DB2, each time you recompile, use the following steps:
      1) Rebind the DB2 tables to the COBOL server programs.
      2) Refresh the copy of the server program on CICS by running the following CICS command in the CICS region:

         `CEMT SET PROG(`*`program_name`*`) NEW`

         For example, if you change the DFH0CSTD program and recompile it, use `CEMT SET PROG(DFH0CSTD) NEW`. (DFH0CSTD is defined to the CICS region in the DFH$EJB2 resource definition group—see step 5.)
4. Grant authority to the CICS user ID to access the DB2 plan, using the normal procedures for your organization (for example, SPUFI). For information about granting authority to access a DB2 plan, see Controlling users' access to plans in the *CICS DB2 Guide*.
5. Define the programs and DB2 connections used by the sample to CICS. The CICS-supplied sample group, DFH$EJB2, contains resource definitions for the EJB "Bank Account" sample. You must change some of the attributes of these resource definitions to suit your own environment. To do this, use the CEDA transaction or the DFHCSDUP utility.
   a. Copy the sample group to a group of your own choosing. For example:
      ```
      CEDA COPY GROUP(DFH$EJB2) TO(mygroup)
      ```
   b. Display group `mygroup` and change the attributes of the following definitions as shown:
      - On the DB2CONN definition, change the value of DB2ID to the ID of the DB2 subsystem on which you created the DB2 tables used by the sample.
      - The PROGRAM definitions do not need to be modified.
   c. Discard the definitions that you do not need from group `mygroup`.

      As well as DB2CONN and PROGRAM definitions, DFH$EJB2 also contains a CORBASERVER and a TCPIPSERVICE definition. However, these are for reference only. It is strongly recommended that you set up your EJB server, as described in "Setting up an EJB server" on page 238, *before* attempting to install the sample programs. If you do this, you do not need the CORBASERVER and TCPIPSERVICE definitions in DFH$EJB2 because you have already created your own, based on those supplied in resource group DFH$EJB. Discard them from group `mygroup`.

      If you *do* decide to use the CORBASERVER and TCPIPSERVICE definitions in DFH$EJB2, you must modify them as described in "Actions required on CICS" on page 240.

      If your CICS region uses program autoinstall, you do not need the PROGRAM definitions. Discard them from group `mygroup`.

      Note: There is no supplied REQUESTMODEL definition, because it is not necessary to install one. The sample uses the default transaction ID, CIRP.

   d. Add the resource group containing the modified resource definitions to the CICS CSD, and to the CICS startup group list. You can use the CICS system definition utility program, DFHCSDUP. See System definition file utility program (DFHCSDUP) in the *CICS Resource Definition Guide*.

      Authority required: RACF authority to install resource definitions into the CICS region.

6. If you did not do so when you set up security, put the supplied `SampleEJB.jar` deployed JAR file into the pickup directory of your CorbaServer.
7. Ensure that the name server has been started. If CICS has not been started, start it now.
8. Issue the following command at the CICS region console:
   ```
   CEMT PERFORM CORBASERVER(corbaserver_name) SCAN
   ```
   CICS scans the pickup directory, copies the `SampleEJB.jar` deployed JAR file to its shelf directory, and creates and installs a DJAR definition for it.

   Note: If you had to start CICS in step 7, this step is not necessary, because CICS will have scanned the pickup directory on startup.

   Authority required: RACF authority to create a DJAR and update access to the CORBASERVER.
9. Publish the enterprise bean to the JNDI namespace. If your CORBASERVER definition specifies AUTOPUBLISH(YES), this happened automatically when the `SampleEJB.jar` deployed JAR file was installed. If your CORBASERVER definition specifies AUTOPUBLISH(NO), issue the following command at the CICS region console:
   ```
   CEMT PERFORM DJAR(SampleEJB) PUBLISH
   ```
   Authority required: RACF authority to update a DJAR.
10. Use the `CICSConnectionFactoryPublish` sample program to create a ConnectionFactory object for use by the CCI Connector for CICS TS, and to publish it to the name server. For instructions on how to use the `CICSConnectionFactoryPublish` program, see “Using the sample utility programs to manage and acquire a connection factory” on page 320.
11. Ensure that the DB2 connection status is CONNECTED by issuing the following command at the CICS system console:
    ```
    CEMT SET DB2CONN CONNECTED
    ```

Web application server setup:

On the Web application server, you must install the Web components of the EJB Bank Account sample application.

About this task

From the z/OS UNIX EJB samples directory, you need:
- `CicsSample.ear`. A J2EE enterprise archive (EAR) file containing the Web components of the sample.
- `readme.txt`. A text file containing:
  1. Step-by-step instructions for installing the Web components of the sample on WebSphere Application Server.
  2. Hints, tips, and debugging information.

Note: The default samples directory is

```
/usr/lpp/cicsts/cicsts42/samples/ejb/bankaccount
```

where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OS UNIX.

Important: The rest of this section contains generic instructions for installing the Web components of the sample on a J2EE-compliant Web application server (which may or may not be WebSphere). It is suitable for experienced users. If your Web application server is WebSphere Application Server Version 4 or later *and* you are a novice user of that product, we recommend that you follow instead the detailed, WebSphere-specific instructions in the `readme.txt` file.

Procedure

1. Install the Web components of the EJB Bank Account sample (contained in `CicsSample.ear`) in your J2EE Web application server, following the vendor's guidelines for installing applications. In WebSphere Application Sever, for example, this involves using the administration console to:
   a. Install a new application
   b. Generate the updated Web server plugin
   c. Save the configuration

   Note: `CicsSample.ear` includes a default configuration for the EJB Bank Account sample. To run the sample, it is not necessary to edit or add any configuration information.
2. Start the application using your Web application server's standard procedure.

Results

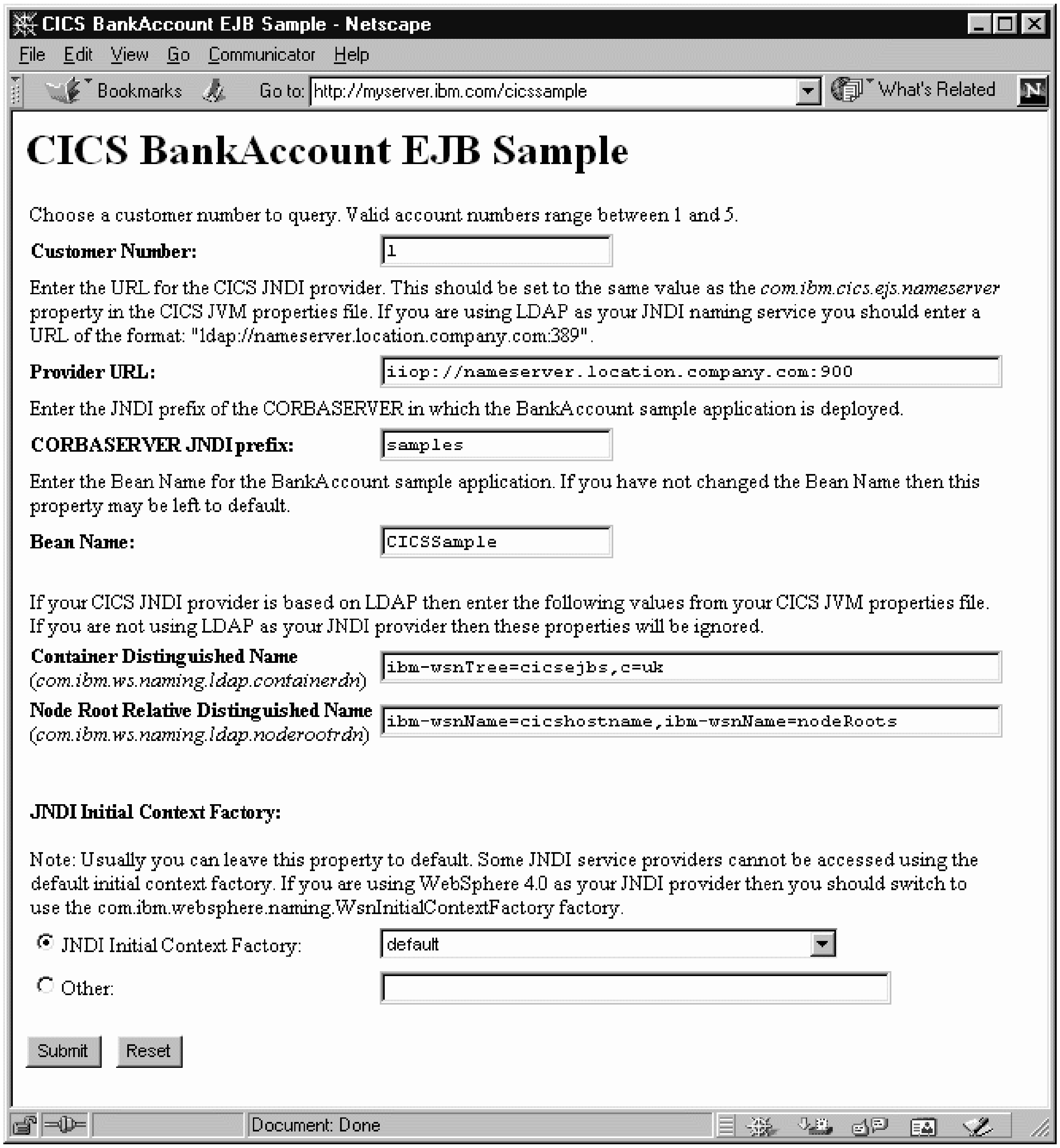
Testing the EJB Bank Account sample:

You must perform these steps to test the application.

About this task

1. Ensure that all the following are running:
   - The Web server
   - The Web application server and the sample application
   - The name server
   - The CICS region
   - The DB2 subsystem
2. Start a Web browser and point it at the URL of your Web server, followed by “cicssample”. For example:
   ```
   http://myServer.ibm.com/cicssample
   ```

   The opening screen shown in Figure 21 on page 278 appears.


CICS BankAccount EJB Sample - Netscape
File Edit View Go Communicator Help
Bookmarks
Go to: http://myserver.ibm.com/cicssample
What's Related
Submit
Reset
Document: Done

CICS BankAccount EJB Sample

Choose a customer number to query. Valid account numbers range between 1 and 5.

Customer Number: 1

Enter the URL for the CICS JNDI provider. This should be set to the same value as the *com.ibm.cics.ejs.nameserver* property in the CICS JVM properties file. If you are using LDAP as your JNDI naming service you should enter a URL of the format: "ldap://nameserver.location.company.com:389".

Provider URL: iiop://nameserver.location.company.com:900

Enter the JNDI prefix of the CORBASERVER in which the BankAccount sample application is deployed.

CORBASERVER JNDI prefix: samples

Enter the Bean Name for the BankAccount sample application. If you have not changed the Bean Name then this property may be left to default.

Bean Name: CICSSample

If your CICS JNDI provider is based on LDAP then enter the following values from your CICS JVM properties file. If you are not using LDAP as your JNDI provider then these properties will be ignored.

Container Distinguished Name (*com.ibm.ws.naming.ldap.containerdn*) ibm-wsnTree=cicsejbs,c=uk

Node Root Relative Distinguished Name (*com.ibm.ws.naming.ldap.noderootrdn*) ibm-wsnName=cicshostname,ibm-wsnName=nodeRoots

JNDI Initial Context Factory:

Note: Usually you can leave this property to default. Some JNDI service providers cannot be accessed using the default initial context factory. If you are using WebSphere 4.0 as your JNDI provider then you should switch to use the com.ibm.websphere.naming.WsnInitialContextFactory factory.

[✓ JNDI Initial Context Factory:] default

Other:

Figure 21. Opening screen of the EJB Bank Account sample application

3. Enter a customer number. (Using the supplied DB2 data, valid customer numbers are 1 through 5).
4. Check that the `Provider URL:`, `CORBASERVER JNDI prefix:`, `Bean Name:`, `Container Distinguished Name:`, `Node Root Relative Distinguished Name:`, and `JNDI Initial Context Factory` fields contain values that are valid for your installation. If they do not, overtype them as follows:

   `Provider URL:`
   Enter the URL and port number of the name server where the enterprise

bean is published. (These are specified by the **-Dcom.ibm.cics.ejs.nameserver** property in your JVM properties file.) For example:

- If you are using a COS Naming Server with a URL of mycosns.ibm.com and a port number of 900, specify "iiop://mycosns.ibm.com:900".
- If you are using an LDAP name server with a URL of myldapns.ibm.com and a port number of 389, specify "ldap://myldapns.ibm.com:389".
- If you are using the COS Naming Directory Server supplied with WebSphere Application Server Version 5 or later, with a URL of mycosns.ibm.com and a port number of 2809, specify:

```
-Dcom.ibm.cics.ejs.nameserver=iiop://mycosns.ibm.com:2809/domain/legacyRoot
```

For detailed information about how to specify the location of the name server, see the description of the **-Dcom.ibm.cics.ejs.nameserver** property in "JVM system properties" on page 109.

CORBASERVER JNDI prefix:
Enter the JNDI prefix of your CorbaServer. If you are using the CORBASERVER definition supplied in DFH$EJB, you do not need to change the default value of "samples".

Bean name:
Enter the name of the enterprise bean used by the sample, as defined in the deployment descriptor in the supplied SampleEJB.jar file. *Unless you have renamed the bean, you do not need to change the default value of "CICSSample".*

Container Distinguished Name:
If you are using an LDAP name server, enter the distinguished name of the LDAP system namespace root, as supplied by your LDAP administrator. (The distinguished name of the LDAP system namespace root is specified by the **-Dcom.ibm.ws.naming.ldap.containerdn** system property.) *If you are using a COS Naming Server, the value of this field is ignored.*

Node Root Relative Distinguished Name:
If you are using an LDAP name server, enter the distinguished name of the LDAP node root, as supplied by your LDAP administrator. (The distinguished name of the LDAP node root is specified by the **-Dcom.ibm.ws.naming.ldap.noderootrdn** property.) *If you are using a COS Naming Server, the value of this field is ignored.*

JNDI Initial Context Factory:
Select the appropriate JNDI initial context factory from the drop-down list. If your Web application server is WebSphere, the factory to use depends on:
- The version of WebSphere you're using
- The location of WebSphere—that is, whether it's on a distributed platform such as Windows NT or a host platform such as z/OS
- The type of name server you're using—COS naming or LDAP

Table 19 shows the correct initial context factory to specify, if your Web application server is WebSphere.

Table 19. Setting the initial context factory, according to the version and location of WebSphere and the type of name server

WebSphere Version	Location of Web application server	Name server type	Initial context factory to use
3.5	Distributed	COS	com.ibm.ejs.ns.jndi.CNInitialContextFactory
3.5	Distributed	LDAP	com.ibm.jndi.LDAPCtxFactory

Table 19. Setting the initial context factory, according to the version and location of WebSphere and the type of name server (continued)

WebSphere Version	Location of Web application server	Name server type	Initial context factory to use
3.5	z/OS	COS	`com.sun.jndi.cosnaming.CNCtxFactory`
3.5	z/OS	LDAP	`com.sun.jndi.ldap.LdapCtxFactory`
4 or later	Distributed	COS or LDAP	`com.ibm.websphere.naming.WsnInitialContextFactory`
4 or later	z/OS	COS	`com.sun.jndi.cosnaming.CNCtxFactory`
4 or later	z/OS	LDAP	`com.sun.jndi.ldap.LdapCtxFactory`

If your Web application server is not WebSphere, choose the appropriate value from the drop-down list.

Note: The drop-down list contains several initial context factory classes, plus a "default" list item. The sample application assigns the value of the default list item as follows:

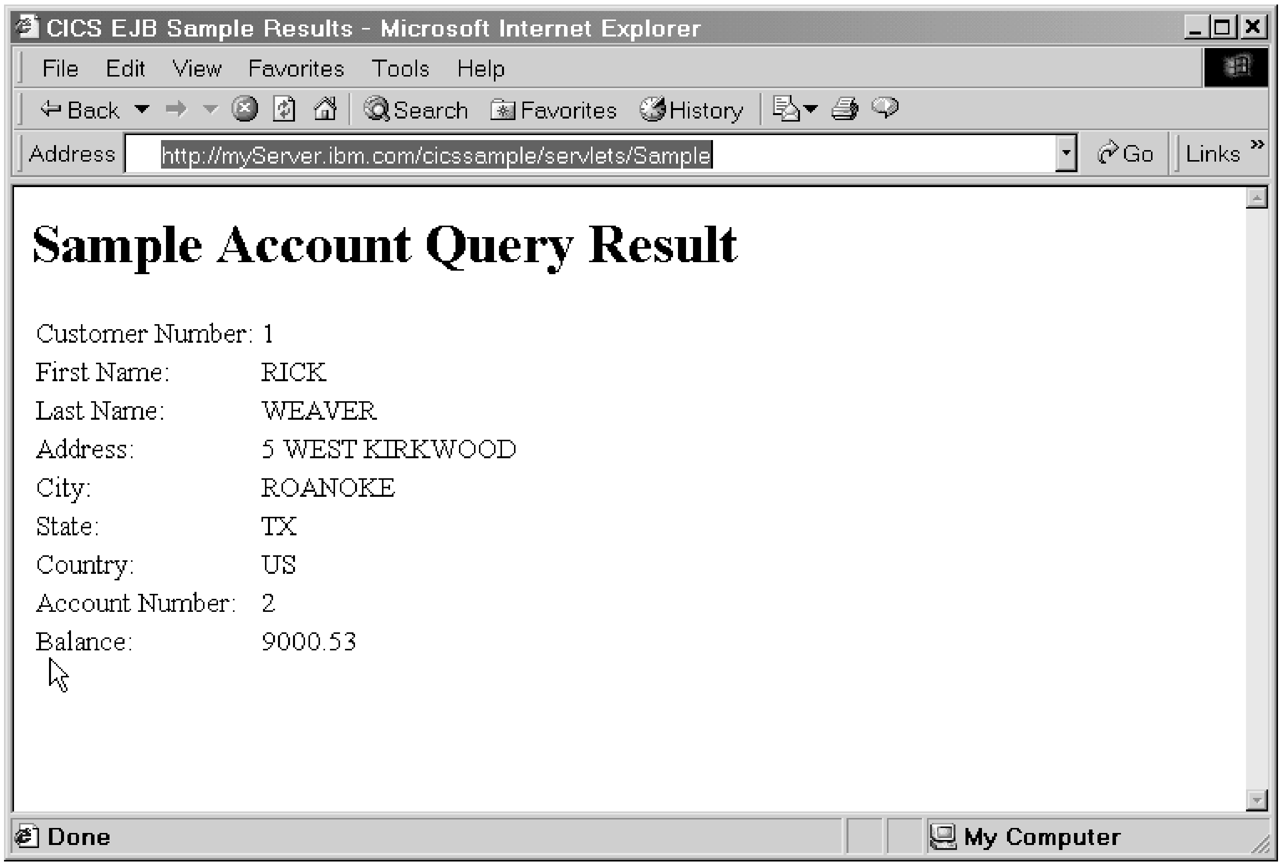
a. If the `com.ibm.websphere.naming.WsnInitialContextFactory` class is found in the Java classpath, the sample makes it the default item. This class is a "wrapper" class that wraps both `com.ibm.ejs.ns.jndi.CNInitialContextFactory` and `com.ibm.jndi.LDAPCtxFactory`. The sample determines the correct base class to use by examining the type of name server that you've specified in the **Provider URL** field: if the specified protocol is "iiop", the sample uses `com.ibm.ejs.ns.jndi.CNInitialContextFactory`; if it's "ldap", the sample uses `com.ibm.jndi.LDAPCtxFactory`.

b. If the `com.ibm.websphere.naming.WsnInitialContextFactory` class is *not* found in the Java classpath, the sample determines the correct class to use by examining the type of name server that you've specified in the **Provider URL** field: if the specified protocol is "iiop", the sample uses `com.ibm.ejs.ns.jndi.CNInitialContextFactory`; if it's "ldap", the sample uses `com.ibm.jndi.LDAPCtxFactory`.

If none of the values in the drop-down list are valid for your installation, select the `Other` radio button and enter the correct value in the lower text field.

5. Press the SUBMIT button. This invokes the servlet and runs the application.

   If the application is configured correctly and the input values are valid, the `SampleResults` JSP displays the customer's details in the web browser. Figure 22 on page 281 shows the result of a successful inquiry.


CICS EJB Sample Results - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
Address http://myServer.ibm.com/cicssample/servlets/Sample
Go Links
Done
My Computer

Sample Account Query Result

Customer Number:	1
First Name:	RICK
Last Name:	WEAVER
Address:	5 WEST KIRKWOOD
City:	ROANOKE
State:	TX
Country:	US
Account Number:	2
Balance:	9000.53

Figure 22. Results screen of the EJB Bank Account sample application

If the application is not configured correctly, or one or more of the input values is invalid, the `SampleError` JSP displays an error message in the web browser. The `readme.txt` file contains hints and tips that may help you debug a failed application.

A note about distributed transactions:

A number of protocols exist to support distributed transactions.

The CICS enterprise Java environment supports only the CORBA Object Transaction Service (OTS) protocol. However, some J2EE-compliant web application servers (such as WebSphere) either do not use this protocol, or do not use this protocol by default. WebSphere can be configured to use pure OTS distributed transactions; for detailed instructions on how to set up WebSphere to use the OTS, see the `readme.txt` file supplied with the Bank Account sample.

If objects on your web application server call CICS enterprise beans within the scope of existing transaction contexts, you must set up your web application server to use the CORBA OTS.

Changing the sample to use distributed transactions:

You can try this exercise to test whether or not your J2EE web application server is fully compatible with CICS.

About this task

By default, the EJB Bank Account sample is not configured to use distributed transactions. However, you can change this. The `SampleServlet` servlet contains sample code, which has been commented-out, to turn on client-demarcated transactions. (The `SampleServlet.java` source file is in the `CicsSample.ear` file.)

To turn on client-demarcated transactions:
1. Uncomment the transaction-related code in `SampleServlet.java`.
2. Recompile the `SampleServlet` servlet.
3. Install the updated copy of the servlet into your web application server.

If you set up the sample to use client-demarcated transactions but your J2EE web application server does not support (or is not configured to use) pure OTS transactions, when you run the sample CICS throws an `org.omg.CORBA.INVALID_TRANSACTION` exception. This is because a transaction context was sent but CICS could not use it.

Changing the enterprise bean's transaction attribute:

You may also want to change the enterprise bean's transaction attribute (in the deployment descriptor) from 'Supports' to 'Mandatory'.

If you do this, CICS allows the remote method of the bean to be invoked only if an existing OTS transaction context is passed from the client's environment on the call.

If, on the other hand, you leave the enterprise bean's transaction attribute set to 'Supports', CICS binds the method invocation to the client's transaction context if such a context exists; otherwise the method runs in an atomic transaction and does not propagate a new transaction context when calling other beans.

To change the transaction attribute, you can use the Assembly Toolkit (ATK), which is described in the *CICS Operations and Utilities Guide*. Having changed the transaction attribute, to make the change effective you must:
1. Store the updated `SampleEJB.jar` file in your pickup directory (overwriting the previous version).
2. Issue a `CEMT CORBASERVER(corbaserver_name) PERFORM SCAN` command.

If you set the transaction attribute to 'Mandatory' but don't update the servlet to use client-demarcated transactions, when you run the sample CICS throws a `javax.transaction.TransactionRequiredException`. This is because no transaction context has been sent.

A note about data conversion:

To represent text data, Java programs always use the Unicode character set, while CICS TS programs use EBCDIC.

When a Java program or enterprise bean calls a CICS TS server program, any text values in the communications area of the server program must be converted from Unicode to EBCDIC on input, and from EBCDIC to Unicode on output. The enterprise bean in the EJB Bank Account sample uses the CCI Connector for CICS TS, which handles this data conversion automatically—see “Data conversion and the CCI Connector for CICS TS” on page 319.

Note: Only the text data returned by COBOL program DFH0CSTD is converted from EBCDIC to Unicode . (No conversion is necessary for server program DFH0ACTD, nor on input to DFH0CSTD, because there are no text values in the communications areas.)

Writing enterprise beans

You can write session beans. The interfaces used by these beans are mapped to CICS services and resources and the beans are portable to any other EJB-compliant server.

Session beans use the interfaces defined by the *Enterprise JavaBeans Specification, Version 1.1*. To download the specification, go to the Oracle Technology Network Java website and search for *"Enterprise JavaBeans specification"* to find the specifications web page.

You can also write session beans that use the JCICS classes to access CICS services and resources directly. These beans are portable only to other CICS EJB servers.

CICS does not support entity beans—that is, you cannot run entity beans in a CICS EJB server. (A session bean or program running in a CICS EJB server can communicate with an entity bean running in a non-CICS EJB server.)

You can write your beans on a workstation using any integrated development environment (IDE) that supports the *Enterprise JavaBeans Specification, Version 1.1*.

When developing new Java enterprise beans and programs for CICS , you should use an application development environment that supports Java 2 at the SDK 5.0 level. You should **not**:
- Use any API calls that are supported only by a newer version of the Java SDK than that supported by CICS.
- Use features supported only by a later version of the *Enterprise JavaBeans Specification* than that supported by CICS. (Currently, CICS supports the *Enterprise JavaBeans Specification, Version 1.1*.)

Any enterprise beans developed to the EJB 1.0 specification must be migrated to the EJB 1.1 specification level using the supplied development tools—see "The deployment tools for enterprise beans in a CICS system" on page 296.

"Coding a session bean" on page 284 gives an example of the steps involved in writing a session bean without using an IDE.

You can use the CCI Connector for CICS TS to build enterprise beans that make use of existing CICS programs. See "The CCI Connector for CICS TS" on page 311 for a description of the CCI Connector for CICS TS , and how to use it.

Preparing beans for execution

The process of installing and preparing an enterprise bean for execution is known as **deployment**.

CICS provides workstation based tools to manage the deployment of enterprise beans into the host CICS environment.

The workstation and WebSphere components of the deployment tools are supplied as a set of InstallShield packages. You can download these packages from your z/OS system or run them from the supplied CD on the target workstation.

See “Deploying enterprise beans” on page 295 for a description of the deployment process, and “Using CICS deployment tools for enterprise beans” on page 296 for guidance on using the tools.

Coding a session bean

This section describes how to code a very simple session bean.

When you have completed the steps in this section, you will have a JAR file that is ready for deployment. See “Deploying enterprise beans” on page 295 for a description of the deployment process and the tools available to help you.

The example bean shown here simulates a roulette wheel in a casino. The roulette wheel is a stateful session bean, containing two stateful fields. The first field is the current number that the wheel is on; the second field is the amount of credit the gambler still has for betting. The client creates a roulette wheel, optionally specifying the amount of money to gamble (defaulting to 100 dollars if the amount is not supplied). The client can place bets on the color that will come up and then the wheel spins and tells the caller if he has won or not. The client may then collect the winnings or continue betting.

There are three elements that you must code:
1. “Coding the home interface.”
2. “Coding the remote interface.”
3. “Coding the bean implementation” on page 285.

Then you need to compile and package your program:
1. “Compiling the code” on page 287
2. “Packaging the code” on page 287

Coding the home interface:

The home interface for a bean extends the javax.ejb.EJBHome interface. It defines one or more create methods that the client program may call to create a bean instance.

For stateless session beans there must be exactly one create method taking no parameters. Stateful session beans may overload the create method with different variants taking different combinations of parameters. The RouletteWheel bean is a stateful session bean. We overload create so that we can specify the amount of credit we have on a roulette wheel instance when it is created:

```
package casino;

     public interface RouletteWheelHome extends javax.ejb.EJBHome {

       public RouletteWheel create()
         throws javax.ejb.CreateException, javax.ejb.EJBException;

       public RouletteWheel create(int dollars)
         throws javax.ejb.CreateException, javax.ejb.EJBException;
     }
```

Coding the remote interface:

The remote interface for a bean extends the javax.ejb.SessionBean interface. The remote interface defines the actual business methods a client program may call on an individual bean instance.

```
package casino;

     public interface RouletteWheel extends javax.ejb.EJBObject {

       // Place a bet on either "red" or "black" of the given amount,
       // the return value indicates to the caller whether the bet was
       // successful or not.
       public String bet(String bet,int amount) throws javax.ejb.EJBException;

       // Check the current status of the wheel.
       public String getCurrentStatus() throws javax.ejb.EJBException;

       // Collect winnings from the wheel (if any!)
       public int collectWinnings() throws javax.ejb.EJBException;

     }
```

Coding the bean implementation:

This class implements the business methods defined in the bean remote interface.

It also defines some standard methods that are declared abstract on SessionBean and so these methods should be implemented for our bean implementation to be complete. Finally, because we overloaded the create method on the home interface, we must provide matching ejbCreate methods in the bean implementation that accept the same sets of parameters. This is because the bean implementation class is the only place that you put your bean code. The implementation of the home interface that we defined in “Coding the home interface” on page 284 is generated by the tooling, so if we need to implement an overloaded create method, we have to do it here:

```
package casino;

     import java.util.Random;
     import javax.ejb.*;

     public class RouletteWheelBean implements SessionBean {

       // Necessary code to fulfill SessionBean interface definition.

       private SessionContext ctx = null;

       public void ejbActivate() throws javax.ejb.EJBException {}
       public void ejbPassivate() throws javax.ejb.EJBException {}
       public void ejbRemove() throws javax.ejb.EJBException {}
       public SessionContext getSessionContext() { return ctx; }
       public void setSessionContext(SessionContext ctx) throws
         javax.ejb.EJBException { this.ctx = ctx;
       }

       ////////////////////////////
       // The bean state information
       private int wheelValue;

       private int currentCredit;

       ////////////////////
       // Our create methods

       public void ejbCreate() throws javax.ejb.EJBException, CreateException {
         currentCredit = 100;
         wheelValue = ((int)System.currentTimeMillis())%37;
       }

       public void ejbCreate(int credit) throws javax.ejb.EJBException,
         CreateException { currentCredit = credit;
         wheelValue = ((int)System.currentTimeMillis())%37;
       }

       ////////////////////////////////////////////////////////////////////////////
       // Implementations of the remote methods the client may call on an instance

       //
       // Place a bet, either "red" or "black" for the specified amount.
       // Then simulate the wheel spinning and construct a response string
       // indicating the outcome to the caller.
       //
       public String bet(String color,int amount) throws javax.ejb.EJBException {

         if (!color.equalsIgnoreCase("red") && !color.equalsIgnoreCase("black"))
           return new String("You can only bet on red or black");

         if (amount > currentCredit)
           return new String("You only have $"+currentCredit+" !");

         // Use the current wheel value as the random number seed
         Random randomizer = new Random((long)wheelValue);

         // Spin the wheel
         wheelValue = Math.abs(randomizer.nextInt()) % 37;

         // Construct a reply
         StringBuffer result =
           new StringBuffer("Number: "+wheelValue+" Color: "+color(wheelValue)+"\n");

         // Did the caller win?
         if (color(wheelValue).equalsIgnoreCase(color)) {
           currentCredit+=(amount*2);
           result.append("Well Done! You won $");
           result.append((amount*2));
         } else {
           currentCredit -= amount;
           result.append("Bad Luck! You lost $");
           result.append(amount);
         }
         result.append(", you now have $");
         result.append(currentCredit);
         return result.toString();
       }


       //
       // Return the current status of this roulette wheel instance.
       // The number and color
       // it is currently on and the amount of credit the client still has to gamble.
       //
       public String getCurrentStatus() throws javax.ejb.EJBException {
         return new String("Number:"+wheelValue+" Color:"+color(wheelValue)+"
         You have $"+currentCredit);
       }


       //
       // Allow the client to collect his winnings, then zero the credit so
       // they cannot collect twice!
       //
       public int collectWinnings()throws javax.ejb.EJBException {
         int winnings = currentCredit;
         currentCredit = 0;
         return winnings;
       }
```

```
  //
  // Convert a number on the wheel into a color
  //
  private String color(int value) {
    if (value == 0) return "Green";
    if (value % 2 == 0) return "Black";
    return "Red";
  }

}
```

Compiling the code:

All that you need in addition to the base SDK is the JAR file containing the `javax.ejb` interfaces.

This is available as `ejb11.jar` in the `standard/ejb/1_1` directory of the java installation. If you add `ejb11.jar` to your CLASSPATH, you should be able to compile the classes and interfaces described.

Packaging the code:

The compiled classes must be packaged in a JAR file ready for deployment.

Assuming the class files are in the sub directory casino, the following jar command can be used:

```
jar -cvf casino.jar casino\*.class
```

Writing the client program

A client program is any program that calls an enterprise bean.

It can be:

1. Another enterprise bean, JavaBean, Java program, or object executing in the same CICS
2. An enterprise bean, JavaBean, Java program, or object executing in another CICS
3. An enterprise bean, JavaBean, Java program, or object executing on a non-CICS system or workstation

The client obtains references to bean homes of enterprise beans that it wants to call by using the JNDI namespace it shares with the CICS server environment.

Creating object references in the namespace:

To create object references, you need to publish the beans that are installed in your CICS region.

About this task

You can do this in two ways:

1. Issue PERFORM DJAR(XXXX) PUBLISH on the server CICS system. You can use any of the following methods to do this:
   - CEMT
   - CICSPlex SM
   - A CICS application

For each bean installed from the named DJAR, an object reference is published to the naming directory server. See “Defining name servers” on page 363 for information about using name servers.

2. If you have installed a number of DJARs into a single CORBASERVER, you can use the PERFORM CORBASERVER(XXXX) PUBLISH command to publish every bean currently installed under that CORBASERVER. The subcontext in the namespace where the object references for the beans will appear is determined by the JNDI prefix defined in the resource definition of the CORBASERVER into which the DJAR was installed.

Retraction is never done implicitly. The recommended way to 'unpublish' beans is to issue PERFORM DJAR(XXXX)/CORBASERVER(XXXX) RETRACT. If a DJAR or CORBASERVER is discarded, the bean object references will still exist in the namespace, although they will be unusable by a client since the actual beans no longer exist in CICS. It is possible to reinstall a DJAR and retract those references.

Using JNDI to obtain bean references:

Java Naming and Directory Interface (JNDI) defines an application programming interface (API) specified in the Java programming language that provides the naming and directory function to Java programs.

It also defines a service provider interface (SPI) that allows various directory and naming service drivers to be plugged in.Figure 23 illustrates this by showing a Naming Manager interfacing with a Java application by means of the JNDI API, and with various Name servers via the JNDI SPI.

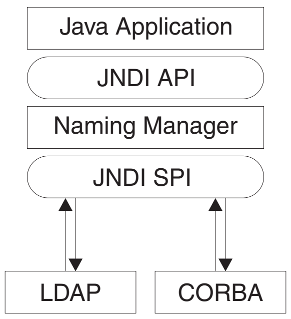


Figure 23. JNDI structure

The JNDI interfaces are described at the following web site: http://www.oracle.com/technetwork/java/index.html.

After an enterprise bean has been registered in a name server by the administrator of the server system, a client application can use the JNDI interface to locate its home interface.

Set up a suitable name server that supports the Java Naming and Directory Interface (JNDI) Version 1.2 and define its location to CICS. For more information, see “Setting up an LDAP server” on page 364 and “Setting up a COS Naming Directory Server” on page 374. For details of the JVM properties that are required, see “JVM system properties” on page 109.

Writing a Client program to use LDAP:

CICS Transaction Server supports LDAP. Some changes to your client programs might be necessary to allow a client program to find the bean homes published from a CICS region.

An LDAP client must use either the WebSphere Context Factory or the LDAP Context Factory provided by Java. The advantage of using the WebSphere Context Factory is that it understands automatically the system namespace (that is the structured namespace on the LDAP server into which CICS publishes your bean homes). However, this context factory has a number of dependencies and so is not the most lightweight client. The context factory provided by Java has no dependencies apart from the base IBM Developer Kit for the Java Platform and so is very lightweight. However it does not understand the system namespace and so it is necessary to negotiate it programmatically, but there are some utility methods provided by CICS to help with this.

These alternatives are best demonstrated by examples.

WebSphere Context Factory:

This is an example of some client source code that uses the WebSphere context factory to locate the home for a HelloWorld bean.

```
   import org.omg.CORBA.ORB;
   import java.io.*;
   import javax.naming.*;
   import examples.helloworld.*;
   import java.util.*;

   public class WASNamingClient {
      public static void main(String[] argv) {
         try {

   // Set the necessary properties
         Properties prop = new Properties();

   // These four are *fixed* values, you never need to change them.

     prop.put(Context.INITIAL_CONTEXT_FACTORY,
          "com.ibm.websphere.naming.WsnInitialContextFactory");

     prop.put("com.ibm.websphere.naming.namespaceroot","bootstraphostroot");
     prop.put("com.ibm.ws.naming.ldap.config","local");
     prop.put("com.ibm.ws.naming.implementation","WsnLdap");

   // These two depend on your server settings and should match your CICS region settings

     prop.put("com.ibm.ws.naming.ldap.containerdn","ibm-wsnTree=WASNaming,c=us");
     prop.put("com.ibm.ws.naming.ldap.noderootrdn",
 "ibm-wsnName=legacyroot,ibm-wsnName=PLEX2,ibm-wsnName=domainRoots");

// Finally, instead of com.ibm.cics.ejs.nameserver,
// set com.ibm.ws.naming.ldap.masterurl to your destination LDAP server

       prop.put("com.ibm.ws.naming.ldap.masterurl","ldap://wibble.example.com:389");

       InitialContext ctx = new InitialContext(prop);
       org.omg.CORBA.Object obj =
            (org.omg.CORBA.Object)ctx.lookup("samples/HelloWorld");

       HelloWorldHome hhome =
            (HelloWorldHome)javax.rmi.PortableRemoteObject.narrow
            (obj,HelloWorldHome.class);

       System.out.println("HelloWorldHome successfully found!");
```

```
        HelloWorld hello = hhome.create();
        System.out.println(hello.sayHello());

    } catch (Exception e) {
      System.err.println("Exception while looking up and calling the HelloWorld bean:");
      e.printStackTrace();
     }
   }
}
```

As noted in the comments, the first four properties are fixed, the remaining three match settings for your CICS region (Albeit the **-Dcom.ibm.cics.ejs.nameserver** property has become com.ibm.ws.naming.ldap.masterurl). However, the WebSphere Context Factory has dependencies on components of WebSphere so in order to run it from the command line you must run a script to set up your environment appropriately.

The script DFHWAS4Setup.bat is a command line script provided with CICS. It can be downloaded from the utils subdirectory in the z/OS UNIX area where CICS is installed. It must be run on a system that has WebSphere installed, because it relies on the environment variable WAS_HOME being set to point to the location where WebSphere has been installed, for example c:\WebSphere\AppServer. When the the script has been run, you should extend your CLASSPATH further to include the necessary client side code for your Enterprise Bean. For the example above this is the HelloWorld.jar - then the code above can be compiled and executed. (The example code assume that the home is published in a CorbaServer whose JNDI Prefix is *samples*).

In CICS we set **-Dcom.ibm.cics.ejs.nameserver =** <*hostname*> but in this client program, we set **com.ibm.ws.naming.ldap.masterurl =** <*hostname*>. CICS understands the former, WebSphere understands the latter.

LDAP Context Factory supplied with Java:

From an IBM Developer Kit for the Java Platform configuration point of view, it is much easier to use the LDAP Context Factory provided with Java, because it is provided in the IBM Developer Kit for the Java Platform base and has no dependencies outside of it.

However, because this context factory does not understand the namespace structure that exists on any LDAP server configured for WebSphere, it can be more demanding for the client application programmer. CICS provides some namespace helper functions that ease this added complexity. The com.ibm.cics.portable.CICSNameSpaceHelper class is provided in CICSEJBClient.jar. This JAR file is available in the utils subdirectory in the z/OS UNIX area where CICS is installed.

Here is an example of using this class:

```
import org.omg.CORBA.ORB;
import java.io.*;
import examples.helloworld.*;
import javax.naming.*;
import javax.naming.directory.*;
import java.util.*;
import com.ibm.cics.portable.CICSNameSpaceHelper;

public class SUNNamingClient {

public static void main(String[] argv) {
        try {
           Hashtable env = new Hashtable();

     // Set up the first two obvious properties, the LDAP factory and LDAP server supplied with Java
           env.put(Context.INITIAL_CONTEXT_FACTORY, "com.sun.jndi.ldap.LdapCtxFactory");
           env.put(Context.PROVIDER_URL,   "ldap://wibble.example.com:389");
     // These two settings match the values from the CICS system
           env.put("com.ibm.ws.naming.ldap.containerdn",  "ibm-wsnTree=WASNaming,c=us");
           env.put("com.ibm.ws.naming.ldap.noderootrdn",
                 "ibm-wsnName=legacyroot,ibm-wsnName=PLEX2,ibm-wsnName=domainRoots");

     // Use the LDAPSNSLookup helper method to negotiate the WebSphere System Name
     // Space on wibble.example.com and locate our HelloWorld bean.  "samples"
     // is the JNDI prefix on the CICS CorbaServer that published the HelloWorld Bean.
           org.omg.CORBA.Object obj =
           CICSNameSpaceHelper.LDAPSNSLookup(env,"samples/HelloWorld");

        HelloWorldHome hhome =
               (HelloWorldHome)javax.rmi.PortableRemoteObject.narrow
               (obj,HelloWorldHome.class);

        System.out.println("HelloWorld home successfully found!");
        Hello hello = hhome.create();
          System.out.println(hello.sayHello());
      } catch (Exception e) {
        System.err.println("Exception while looking up and calling the HelloWorld bean:");
       e.printStackTrace();
    }
  }
}
```

You are using the LDAP code supplied with Java, which understands the providerURL property, rather than the masterurl property used in the WebSphere Context Factory example.

The helper class CICSNameSpaceHelper may also work with other context factories. Notice that the syntax of the name passed to LDAPSNSLookup is JNDI syntax a/b/c/d.

Writing a client program to use COS Naming: The following example shows a client program, Gambler.java, that works with the RouletteWheel bean developed in "Coding a session bean" on page 284. When a bean reference is obtained from a COS Naming namespace, there are a number of operations that must be performed before the client can use that reference. These operations are the same for the majority of client programs, so they are collected in the utility class EJBUtils. This utility class is used by the client program Gambler.

EJBUtils.java:

This is the implementation of the utility class, EJBUtils.

```
import javax.naming.*;
import java.util.Hashtable;

class EJBUtils {

  public static Object jndi_lookup(String name, Class resultClass) {

    // Set up environment for creating initial context
    Hashtable env = new Hashtable(11);

    // Define the nameserver - see note 1 below
    env.put(Context.PROVIDER_URL,
      "iioop://wibble.example.com:900");

    // Define the initial context factory -see note 2
    env.put(Context.INITIAL_CONTEXT_FACTORY,
      "com.sun.jndi.cosnaming.CNCtxFactory");

    try {

      // Create the initial context
      Context ctx = new InitialContext(env);

      // Lookup the object
      Object tempObject = ctx.lookup(name);

      // Narrow that to the requested class
      return javax.rmi.PortableRemoteObject.narrow(tempObject,resultClass);

    } catch (NamingException ne) {
      System.err.println("EJBUtils.jndi_lookup() failed:");
      ne.printStackTrace();
    }
    return null;
  }

}
```

Note:

1. Here we define the nameserver that will be used to lookup beans as "iiop://wibble.example.com:900". This value should be the name of your nameserver, and must match the **`-Djava.naming.provider.url`** that was defined in the CICS JVM properties file, so that the client looks up the bean on the same nameserver it was published into by CICS. See "Defining name servers" on page 363 for information about using name servers.
2. Here we define the initial context factory for your client environment. you should set it to the value required by your client environment. The example shows the value you would set when using the ORB included with the IBM SDK. If your client is a java application or enterprise bean running in CICS Transaction Server for z/OS, Version 2, then you should not specify an initial context factory here, but should allow it to default to `com.ibm.websphere.naming.wsnInitialContextFactory`.

Gambler.java:

This is the implementation of the example client program, `Gambler.java`.

```
import org.omg.CORBA.ORB;
import java.io.*;
import casino.*;

public class Gambler {

  public static void main(String[] argv) {

    try {

      System.out.println("Gambler\n");

      System.out.println("Looking up RouletteWheel home");
      RouletteWheelHome wheelHome =
        (RouletteWheelHome)
        EJBUtils.jndi_lookup("cics/ejbs/RouletteWheel",
                             RouletteWheelHome.class);
        //
```

```
          // See Note 1.
          //
        System.out.println("Creating a new roulette wheel");
        RouletteWheel wheel = wheelHome.create();

        System.out.println("");
        System.out.println("Gambling $50 on red !");
        System.out.println(wheel.bet("red",50));

        System.out.println("");
        System.out.println("Gambling $20 on black !");
        System.out.println(wheel.bet("black",20));

        System.out.println("");
        System.out.println("Gambling $20 on red !");
        System.out.println(wheel.bet("red",20));

        System.out.println("");
        System.out.print("Collecting winnings:$");
        System.out.println(wheel.collectWinnings());


        System.out.println("");
        System.out.print("Removing the roulette wheel");
        wheel.remove();

      } catch (Exception e) {
        System.err.println("Error while gambling:");
        e.printStackTrace();
      }

    }

  }
```

Note:

1. The client program Gambler.java looks up the RouletteWheel at "cics/ejbs" in the namespace. This means the CORBASERVER in CICS into which you have installed the RouletteWheel bean must have a JNDI prefix of cics/ejbs. Once installed and published the RouletteWheel will then be accessible by the client program.
2. There is a `remove` call at the end of this client program. The roulette wheel bean is stateful and CICS manages the state of every instance. Unless `remove` is called when you finish operating with that bean instance then CICS will continue to store it. Bean timeout can be controlled using the SESSBEANTIME parameter of the CORBASERVER resource definition. This indicates to CICS how long it should manage instance state if no requests are coming in to utilize that instance, implementing a kind of garbage collection. However, it is good programming practice to call `remove` when you have finished working with an instance so that you do not depend on this type of garbage collection.

Using the client program:

When compiling the client program, your classpath must be set carefully to include the deployed JAR file you successfully processed earlier with the CICS Jar Development Tool, and also the javax.ejb interfaces for EJB 1.1 support, which are available in `ejb11.jar` in the `standard/ejb/1_1` directory of the java installation.

Once compiled, run the client with:

```
java Gambler
```

Transaction interoperability with web application servers:

A number of protocols exist to support distributed transactions. The CICS enterprise Java environment supports only the standard CORBA Object Transaction Service (OTS) protocol. However, some J2EE-compliant web application servers (such as WebSphere Version 4) either do not use this protocol, or do not use this protocol by default.

If objects on your web application server call CICS enterprise beans within the scope of existing transaction contexts, you must set up your web application server to use the CORBA OTS. If this is not possible, your web application server is not fully compatible with CICS enterprise Java support. (For a way of using the EJB Bank Account sample application to test whether your web application server is fully compatible with CICS enterprise Java support, see "A note about distributed transactions" on page 281.)

If your web application server is WebSphere Application Server Version 4, be aware that, by default, it does not use the standard CORBA OTS, but can be made to do so. If you have WebSphere objects that call CICS enterprise beans within the scope of existing transaction contexts, you must set up WebSphere to use the CORBA OTS. Versions of WebSphere Application Server from Version 5 onwards are not affected by this problem.

To force WebSphere Application Server to use the CORBA OTS:
1. At the WebSphere Administration Console, select the JVM settings tab.
2. Enter the following in the System Properties section:
   ```
   com.ibm.ejs.jts.ControlSet.interoperabilityOnly=true
   com.ibm.ejs.jts.ControlSet.nativeOnly=false
   ```
   Save your changes.
3. Restart the application server.

Working with EJB Handles, HomeHandles and EJBMetaData

The Enterprise JavaBeans specification describes how a session bean supports not only the methods defined on its remote interface but some additional methods.
- There are methods defined on the EJBHome interface, they are callable by a client wishing to:
  - obtain a "storable" reference to the home (a home handle), or
  - obtain the EJBMetaData for the bean type.

  .
- There are methods defined on the EJBObject interface, they are callable by a client wishing to:
  - obtain the home for the EJB, or
  - obtain a "storable" reference to the object itself (a handle).

The purpose of handles is that they are serializable, once a handle is obtained for a bean instance it can be serialized, perhaps to a flat file. If, sometime later, a program wants make calls against that same instance, it can deserialize the handle and start calling methods again. The implementations of the handles and the meta data class are product specific.

In CICS, the implementations of the three interfaces HomeHandle, Handle and EJBMetaData are:
- com.ibm.cics.portable.CICSSessionHomeHandle

- com.ibm.cics.portable.CICSSessionHandle
- com.ibm.cics.portable.CICSEJBMetaData

These implementations are included in the `CICSEJBClient.jar` JAR file, which can be downloaded from the `utils` subdirectory in the z/OSUNIX area where CICS is installed. This JAR file should be included in the CLASSPATH of any client program calling the special methods described above, to ensure it understands the types of object returned from the server. If, for example, its CLASSPATH does not include `CICSEJBClient.jar`, a client program that calls the **getEJBMetaData** function of an enterprise bean may be returned either of the following:
1. An exception
2. Null

The precise value returned depends on the implementation of the client's object request broker (ORB).

Using EDF with enterprise beans

To use EDF to test enterprise beans, you must perform these tasks.

About this task

- Set the CEDF parameter to YES in the PROGRAM resource definition for DFJIIRP that is supplied in group DFHIIOP.
- Set MAXACTIVE to one in TRANCLASS(DFHEDFTC).
- Activate EDF by entering CEDX (*transid*) at the terminal where the transaction will be trapped. The transid is either the default transid CIRP or the transaction specified on the RequestModel definition.
- Initiate the bean.

Bean-to-bean communication:

If your bean uses bean-to-bean communication with the same transaction id within the same AOR, setting MAXACTIVE to one will result in the communication not working.

This is because the execution of the second transaction will be suspended waiting for a slot in which to execute, and the original bean will then experience a “timeout” condition. The way to avoid this is to take one of the following actions:
- Use REQUESTMODELs to specify a unique transaction id for each bean.
- Allow all create methods to use CIRP (the default transaction id), and use REQUESTMODELs to define a unique transaction id for each set of business methods.

Note: When a bean is running inside a request processor, CICS will only utilize requestmodels (and therefore start a new CICS transaction under the new transaction ID) if a remote method call made by that bean cannot be satisfied in the current request processor. A method call cannot be satisfied locally in the current request processor if:
- The transaction attributes of the method being called require a different transaction context
- The bean being called is in a different CorbaServer

Deploying enterprise beans

This section explains the process of deploying enterprise beans into a CICS EJB server in more detail.

The concept of deployment is introduced in "Overview of deploying enterprise beans" on page 226.

The term "deployment" used in the EJB specification describes a series of tasks that makes the enterprise beans in one or more JAR files available for use in a specific operating environment (in this case, a CICS EJB server).

The deployment tools for enterprise beans in a CICS system

CICS supplies three tools to assist you in deploying enterprise beans into a CICS EJB server.

The Assembly Toolkit (ATK)

The Assembly Toolkit (ATK) is a general tool used by several IBM EJB servers, including CICS, to build JAR files ready for the runtime environment. The Assembly Toolkit for Windows is supplied with WebSphere Application Server.

For detailed information about using ATK, see the *CICS Operations and Utilities Guide*.

The resource manager for enterprise beans

The resource manager for enterprise beans is a Web-based tool that you can use to perform certain operations on the resources (CORBASERVERs and DJARs) that are installed in CICS to support the use of enterprise beans. You can also use the tool for EJB-related problem diagnosis, because it offers the ability to view any errors associated with DJAR definitions and indicates if the beans in a deployed JAR file have been published to the naming service.

For a full description of the resource manager for enterprise beans, see the *CICS Operations and Utilities Guide*.

CREA transaction

CREA is a CICS-supplied transaction that you can use to create REQUESTMODEL resource definitions for the beans in an installed deployed JAR file. CREA can install definitions into a running CICS system by using **EXEC CICS CREATE** commands, or can write the definitions to the CSD. CREC is a read-only version of CREA. It offers inspection facilities without giving the ability to make changes.

For full descriptions of CREA and CREC, see CREA - create REQUESTMODELs for enterprise beans in *CICS Supplied Transactions*.

You can use CREA and CREC without needing to access a 3270 terminal. For details, see Connecting CICS to the web in the *CICS Internet Guide*.

Using CICS deployment tools for enterprise beans

To develop and deploy a bean into CICS, an application developer, working with a CICS system programmer in the later stages, has to carry out a number of steps.

About this task

Develop the bean and make it deployable
Develop the bean and package it into a JAR file. The bean can be written and tested using your choice of tooling.

Note: The JAR file may contain the Java classes for one or for several enterprise beans. Typically a JAR file used in a CICS EJB server contains several enterprise beans.
After the bean has been packaged in a JAR file, use ATK to make it deployable. For a short introduction to ATK and a reference to further information, see The enterprise bean deployment tool, ATK, in the *CICS Operations and Utilities Guide*.

Store in z/OS UNIX pickup directory
Store a copy of the deployable JAR file in the z/OS UNIX pickup directory of the CorbaServer in which you want to run the bean. You can do this using FTP, NFS, or SMB. If the z/OS UNIX directory can be mounted on your workstation, this process can be integrated into the previous JAR file creation process.

Scan the pickup directory
Using either CEMT or the resource manager for enterprise beans, initiate a scan of the pickup directory. (For a description of the resource manager for enterprise beans, see The Resource Manager for Enterprise Beans, in the *CICS Operations and Utilities Guide*.) CICS creates and installs a DJAR definition for the deployed JAR file in the pickup directory.

After the pickup directory has been scanned, you can view the state of the new DJAR definition to determine if the deployed JAR file is ready for use.

If the deployed JAR file is not ready for use, the cause of the error can be determined and in most cases corrected by an application developer without the need for a system programmer to become involved.

Publish
Publish a reference to the home interface of each bean in the deployed JAR file to an external namespace. The namespace is accessible to clients through JNDI.

If you specify AUTOPUBLISH(YES) on the CORBASERVER definition, the beans in a deployed JAR file are automatically published to the namespace when the DJAR definition is successfully installed into the CorbaServer. Alternatively, you can issue a PERFORM CORBASERVER PUBLISH or PERFORM DJAR PUBLISH command.

The Resource Manager for enterprise beans (see The Resource Manager for Enterprise Beans, in the *CICS Operations and Utilities Guide*) indicates if the "autopublish" feature is on or off.

Ensure any additional classes are on class paths
For enterprise beans, you do not need to add the deployed JAR files to the class paths in the JVM profile or JVM properties file. CICS manages the loading of the classes included in these files by means of the DJAR definitions. However, if your enterprise beans use any classes, such as classes for utilities, that are **not** included in the deployed JAR file, you do need to include these classes on the class path that will be used by the JVM for the request processor program. Chapter 5, "Enabling applications to use a JVM," on page 81 tells you how to do this.

Unit Test
Once the beans in the deployed JAR file have been published to the naming server, the application programmer can unit test them in the CICS environment.

System Test
When the beans are ready for system testing, an application programmer

can work with a system programmer to consider if any REQUESTMODEL definitions are needed. Use the CICS-supplied transaction CREA to generate REQUESTMODEL definitions. (For a description of CREA, see CREA - create REQUESTMODELs for enterprise beans, in the *CICS Supplied Transactions* manual.)

You can identify the beans and bean methods from the application. Your system programmer can associate the bean methods with transaction IDs by causing the optimum set of REQUESTMODEL definitions to be generated. Running different beans under different transaction IDs is useful, for example, for workload-management purposes, and for gathering effective monitoring and statistical information.

Install in production environment

To move from a system test to a production environment:

1. Use ATK to verify that the container bindings for resources and references that have been set in the deployment descriptor of each JAR file are appropriate for your production environment.
2. If you have set the DJARDIR parameter in your production region CORBASERVER definition to identify a pickup directory:
   a. Store the deployable JAR file in the pickup directory of the CorbaServer.
   b. Install the CORBASERVER definition.
   c. A suitable DJAR definition is produced.
3. If not:
   a. Store the deployable JAR file in the z/OS UNIX directory that you intend to use in the production region.
   b. Install the production CORBASERVER definition.
   c. Create and install a DJAR definition equivalent to that which you had in your test region, using whatever process you would normally use in your installation.
4. If you have set the AUTOPUBLISH(YES) parameter in your production region CORBASERVER definition:
   a. The beans in the deployed JAR file is automatically published to the namespace when the DJAR definition is successfully installed into the CorbaServer.
5. If not:
   a. Publish the beans to the JNDI server that you use for production using CEMT PERFORM CORBASERVER PUBLISH or CEMT PERFORM DJAR PUBLISH.
6. Transfer REQUESTMODEL definitions from the test region CSD to the production CSD using the process that you normally use in your installation.
7. Ensure that any additional classes, such as classes for utilities, that are not included in the deployed JAR files for your enterprise beans, are present on the standard class path.

Note: If you want to update enterprise beans in a production region, see "Updating enterprise beans in a production region" on page 301.

Tuning for enterprise beans

If you are using enterprise beans in your CICS system, this tuning information might help:

About this task

- Heavy usage of enterprise beans might mean that you need to increase the size of the EJB Object Store, DFHEJOS. “Customizing DFHEJOS for your anticipated stateful enterprise bean usage” explains how.
- The use of client-controlled OTS (object transaction service) transactions might affect your requirements for JVMs. “Enterprise beans that are involved in client-controlled OTS (object transaction service) transactions” explains what to look out for.
- The use of more than one request processor by a single enterprise bean method can lead to deadlocks. “Enterprise bean methods that require multiple request processors” tells you how to remove this possibility.

Customizing DFHEJOS for your anticipated stateful enterprise bean usage

The EJB Object Store, DFHEJOS, is a file used to store stateful session beans that have been passivated. It can be a VSAM file or a coupling facility data table. CICS supplies sample JCL to help you create this file, in the DFHDEFDS member of the SDFHINST library.

The CICS-supplied settings for DFHEJOS are designed for storage of a low number of objects (passivated beans), with a maximum size of 8K, to minimize storage wastage. If you anticipate heavy usage of stateful enterprise beans, increase the space allocations and record sizes for this data set.

Defining the EJB data sets in the *CICS System Definition Guide* describes how to create DFHEJOS and the procedure to calculate the appropriate settings for the record sizes.

Enterprise beans that are involved in client-controlled OTS (object transaction service) transactions

The use of client-controlled OTS (object transaction service) transactions can affect your JVM requirements.

The typical enterprise bean workload in CICS begins with an incoming IIOP message, containing a GIOP request that is received by an IIOP listener task in CICS. The request is passed to a request receiver task, that examines the GIOP message and passes processing of the message to a request processor task. Finally, on completion of the request processor task, a response is sent back to the requesting client by the request receiver task.

If the GIOP request forms part of a client-controlled OTS transaction, then the request processor and request receiver tasks are not ended until the OTS transaction is committed or rolled back. Because the request processor task is executing in a JVM, that JVM is not available for any other task to use until the OTS transaction has ended. If this happens frequently, you might need to increase the number of JVMs in your JVM pool to avoid excessive waiting times for incoming requests.

Enterprise bean methods that require multiple request processors

About this task

If a single execution of an enterprise bean method requires more than one request processor, your application could experience deadlock problems. (A method can be said to “require more than one request processor” if it calls one or more other, typically remote, methods, each of which must execute in a different request processor.) Deadlocks can be caused by all the request processors required to satisfy the method being forced to wait for a JVM when no more JVMs are permitted. This can occur for two reasons:

1. In the simple case, the maximum number of JVMs allowed to exist concurrently under CICS (MAXJVMTCBS) is smaller than the number of request processors required to service the method request.
2. In the complex case:
   - CICS is processing multiple requests simultaneously.
   - All the requests are waiting for another JVM.
   - All the permitted JVMs are currently in use.

Avoiding the simple case is easy; avoiding the complex case is more difficult. It is necessary to ensure there are always enough free JVMs to allow at least one method's requirement of request processor instances to be satisfied.

The maximum number of concurrent JVMs available to a bean method is set by the MAXACTIVE attribute of the TRANCLASS definition that applies to the request processor transaction. The maximum number of concurrent JVMs available to CICS is set by the MAXJVMTCBS system initialization parameter.

To remove the possibility of deadlocks caused by bean methods that use multiple request processors:

1. Wherever it is consistent with your applications' requirements, try to minimize the number of request processors each method requires, preferably to one. If you can reduce the requirements of all methods, in all applications, to one request processor, you need do no more.
2. If it is not possible to reduce the requirements of all methods to one request processor, discover which is your “worst case”—that is, the bean method that requires the most request processors in order to be satisfied.
3. Create a new TRANCLASS definition. This transaction class will apply to the request processor transaction under which bean methods that require multiple request processors will run.
4. On the TRANCLASS definition, set the value of MAXACTIVE using the following formula:
   ```
   MAXACTIVE <= ((MAXJVMTCBS - n) / (n - 1)) + 1
   ```
   where `n` is the maximum number of request processors required by your “worst case” method.

   If the result of this calculation is a decimal value, round it down to the nearest (lower) whole number.
5. Create new TRANSACTION and REQUESTMODEL definitions:
   a. Create a new TRANSACTION definition for the request processor transaction under which bean methods that require multiple request processors will run. (The easiest way to do this is to copy the definition of the default CIRP request processor transaction and modify it.) On the TRANCLASS option, specify the name of your new transaction class.
   b. Create one or more REQUESTMODEL definitions. Between them, your new REQUESTMODEL definitions must cover all requests that may be received for bean methods that require multiple request processors. On the TRANSID option of the REQUESTMODEL definitions, specify the name of your new transaction.

Updating enterprise beans in a production region

This section considers how best to update enterprise beans in a production region. It contains the following topics:

- "The problem"
- "Possible solutions" on page 303

The problem

How do you update enterprise beans in a running CICS production region, while causing the minimum disruption to the current workflow and without recycling CICS?

It is simple enough to introduce new enterprise beans into a running EJB server without disrupting the current workflow. You can do either of the following:

1. Use the CICS scanning mechanism. That is, place the deployed JAR file containing the new beans into a CorbaServer's deployed JAR file ("pickup") directory and issue a **PERFORM CORBASERVER SCAN** command. Repeat on all the AORs in the logical EJB server. If the CORBASERVER definition specifies AUTOPUBLISH(NO), on one of the AORs issue a **PERFORM DJAR PUBLISH** command.

   Note: If you use the scanning mechanism in a production region, be aware of the security implications: specifically, the possibility of CICS command security on DJAR definitions being circumvented. To guard against this, we recommend that user IDs given write access to the z/OS UNIX deployed JAR file directory should be restricted to those given RACF authority to create and update DJAR and CORBASERVER definitions.
2. Use an **EXEC CICS CREATE DJAR** command to install a definition of the deployed JAR file which contains the new beans. Repeat on all the AORs in the logical EJB server. On one of the AORs, issue a **PERFORM DJAR PUBLISH** command.

Unfortunately, because of the unpredictable effects on in-flight transactions, you can't use these methods to *update* beans in an active EJB server. You would have no way of controlling which version of a bean, the old or the new, was used by successive method calls. (Because of timing differences, the problem could well be exacerbated in a multi-region EJB server.)

An alternative approach would be to quiesce and shut down CICS, then restart it with the updated DJAR definitions in place. While this is acceptable in a test environment, it is not an attractive solution for a production region. Consider Figure 24 on page 303. Imagine that you want to update `bean5` and `bean6` in CorbaServer `COR2`. If you were to close down CICS, not only would `bean5` and `bean6` be unavailable during the shutdown, but also all the beans in CorbaServer `COR1`.

What if your EJB server contains several AORs, with workload management being used to balance requests across them? Could you not then shut down and upgrade each AOR in turn, with a minimal effect on performance? Unfortunately not, because:

- During the upgrade process, different AORs would have different versions of the beans. Unless the new versions of the beans were completely compatible with the old versions, this would cause unpredictable effects. (For the new version of a bean to be completely compatible with an old version, among other things, the home and component interfaces of the two versions must be identical, and the state of any stateful session beans must be preserved.)

- Shutting down even one AOR would inevitably degrade the performance of the EJB server to some extent. (If the upgrade is an important one, this might be acceptable. To compensate for the degraded performance you could, perhaps, add an extra AOR to your EJB server.)

The rest of this section discusses what you need to do on a CICS EJB server to update enterprise beans in production regions. Note that changes might also be required on the client side. In particular, if, due to an update, the home or component interface of an enterprise bean changes, before any client applications can use the updated bean they must be rewritten to use the new interface.

The following figure shows the clients are invoking bean methods in CorbaServers COR1 and COR2. You can divide beans between CorbaServers based on the maintenance and availability requirements of the beans.

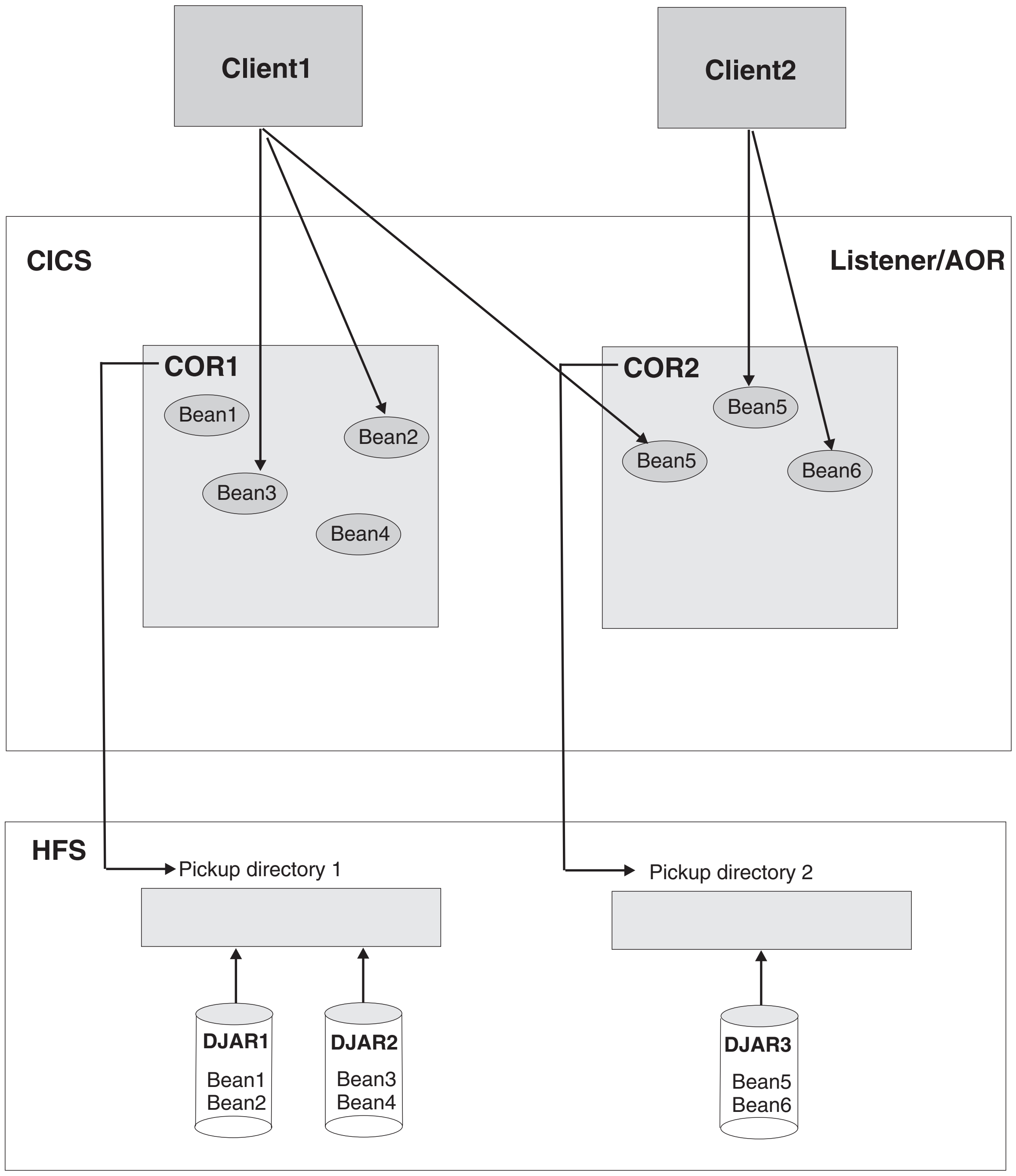


Figure 24. A CICS EJB production region

For some suggested solutions to the problem of how best to update beans in a production region, see “Possible solutions.”

Possible solutions

Here are some suggested solutions for our problem of how best to update beans in a production region. The solutions offered depend on whether your EJB server consists of a single listener/AOR or of multiple listeners and AORs.

As a general rule, upgrade solutions will be easier to implement if you:

1. Divide your enterprise beans between CorbaServers based not only on the beans' functions but also on their maintenance and availability requirements. That is, sets of beans that have distinct maintenance and availability requirements should be installed in distinct CorbaServers.
2. Allocate CICS transaction IDs to enterprise bean methods based not only on the beans' functions but also on their maintenance and availability requirements. That is, for ease of maintenance sets of beans that have distinct maintenance and availability requirements should run under distinct CICS transaction IDs.

   Important:
   a. In a multi-region EJB server, if your AORs contain multiple CorbaServers you are strongly advised to assign different sets of transaction IDs to the objects supported by each CorbaServer. That is, each CorbaServer in an AOR should support a different set of transaction IDs.
   b. This makes it easier for the distributed routing program to route around a disabled CorbaServer, while keeping available any other, enabled, CorbaServers in the region. For further information about how to code a distributed routing program to deal with a disabled CorbaServer, see the *CICS Customization Guide*.

   Note: The CICS transaction under which a bean method runs is specified on the REQUESTMODEL definition that matches the method. You can use the CREA CICS-supplied transaction to:
   - Display the transaction IDs associated with particular beans and bean methods
   - Change the transaction IDs, apply the changes, and save the changes to new REQUESTMODEL definitions

Solutions for a single listener/AOR:

These solutions are valid for an EJB server consisting of a single listener/AOR.

Let us assume that, in Figure 24 on page 303, you want to update `bean5` and `bean6` in CorbaServer `COR2`. `DJAR3.jar` is the deployed JAR file containing the beans to be updated. You require:
1. CorbaServer `COR1` and its beans to remain available throughout the upgrade process.
2. If possible, the upgrade to the beans in CorbaServer `COR2` to be seamless. That is, there should be no time (or, at least, the smallest possible period of time) during which it is impossible to create a new instance of `bean5` or `bean6`.

Solution 1:
About this task

The advantage of this solution is that it is relatively easy to implement. The disadvantage is that it is not seamless—that is, there is a period (while instances of the old versions of `bean5` and `bean6` are being destroyed or passivated) during which it is impossible to create a new instance of `bean5` or `bean6`.
1. Issue an **EXEC CICS SET CORBASERVER**(`COR2`) ENABLESTATUS(`DISABLED`) command or a **CEMT SET CORBASERVER**(`COR2`) DISABLED command. Any attempts to create new instances of `bean5` or `bean6`, regardless of whether the clients have references to the beans' home interfaces, will fail.

   Typically, currently-executing methods on instances of `bean5` and `bean6` will proceed to completion.

An instance of `bean5` or `bean6` that is not participating in an OTS transaction is destroyed or passivated at the end of the currently-executing method. (If there is no currently-executing method, all instances will already have been destroyed or passivated.)

Note: *Stateless* session beans are destroyed. *Stateful* session beans are passivated.

An instance of `bean5` or `bean6` that *is* participating in an OTS transaction is not destroyed or passivated until the end of the OTS transaction; typically, any future method calls against this instance (within the scope of the OTS transaction) will succeed. At the end of the OTS transaction the instance is destroyed or passivated.

2. Check when all instances of `bean5` and `bean6` have been destroyed or passivated by issuing **EXEC CICS** or **CEMT INQUIRE CORBASERVER**(`COR2`) ENABLESTATUS commands. A status of DISABLED indicates that all bean instances have been destroyed or passivated.
3. When all instances of `bean5` and `bean6` have been destroyed or passivated, install the updated version of the `DJAR3.jar` deployed JAR file, using either the CICS scanning mechanism or a static DJAR definition. (You cannot use the scanning mechanism to update a static DJAR definition.)

   Either:

   a. Put the new version of the `DJAR3.jar` deployed JAR file into CorbaServer `COR2`'s pickup directory.
   b. Issue a **PERFORM CORBASERVER**(`COR2`) SCAN command. CICS scans `COR2`'s pickup directory, installs the new definition of `DJAR3.jar`, and copies the new versions of `bean5` and `bean6` to `COR2`'s shelf directory.

   or:

   a. Issue an **EXEC CICS** or **CEMT DISCARD DJAR** (`DJAR3`) command, to remove the current definition of `DJAR3.jar` from CICS.
   b. Issue a **CEDA INSTALL DJAR**(`DJAR3`) or an **EXEC CICS CREATE DJAR**(`DJAR3`) CORBASERVER(`COR2`) HFSFILE(`new_version_of_DJAR3.jar_on_HFS`) command. CICS installs the new definition of `DJAR3.jar`, and copies the new versions of `bean5` and `bean6` to `COR2`'s shelf directory.

   Note:

   a. It is *not* necessary to re-publish the updated versions of `bean5` and `bean6` to the namespace, even if the home or component interfaces of the beans have changed since the previous version.
   b. If the home or component interface of `bean5` or `bean6` has changed since the previous version, before using the changed bean client applications must be updated to use the new signature.
   c. If you update a *stateful* session bean, depending on exactly what changes are made you may change the structure of its serialised state. If this happens, you will invalidate any passivated instances of the bean in the object store. If this happens, any attempts to use the now invalidated bean will result in an exception. You should code your client applications to cope with this possibility.
4. Issue a **CEMT SET CORBASERVER**(`COR2`) ENABLED command. *From this moment, all new work will use the updated versions of `bean5` and `bean6`.*

Solution 2:

This solution requires CICSPlex System Manager. All CICS applications on your listener/AOR must be suitable for cloning across multiple regions.

About this task

The advantage of this solution is that, unlike solution 1, it is relatively seamless—that is, there should at worst be only a tiny period during which it is impossible to create a new instance of `bean5` or `bean6`. The disadvantage is that it is more complicated to implement than solution 1.

1. Using CICSPlex SM:
   a. Clone your single listener/AOR.
   b. Direct all new workload to the clone—that is, quiesce the original AOR and activate the clone. For information on how to do this, see Balancing an enterprise bean workload, in the *CICSPlex System Manager Managing Workloads* manual.

      All requests for bean methods that will run under a new OTS transaction, or under no OTS transaction, whether in COR1 or COR2, are routed to the clone.

      Requests for bean methods that will run under an existing OTS transaction (whether in COR1 or COR2) are routed to the original region.

      Note:
      1) By "a *new* OTS transaction" we mean an OTS transaction in which the bean's participation begins *after* all new work is directed to the clone.
      2) By "an *existing* OTS transaction" we mean an OTS transaction in which the bean's participation began *before* all new work was directed to the clone.

      On the original region:
      - An instance of an enterprise bean that is not participating in an OTS transaction is destroyed or passivated at the end of the currently-executing method. (If there is no currently-executing method, all instances will already have been destroyed or passivated.)
      - An instance of an enterprise bean that *is* participating in an OTS transaction is not destroyed or passivated until the end of the OTS transaction; typically, any future method calls against this instance (within the scope of the OTS transaction) will succeed. At the end of the OTS transaction the instance is destroyed or passivated.
2. On the original region:
   a. Check when all instances of `bean1` through `bean6` have been destroyed or passivated:
      1) If you don't already know the CICS transaction ID or IDs associated with `bean1` through `bean6`, use the CREC transaction to display this information.
      2) Use the **`INQUIRE TASK`** command to check whether any instances of these transactions are running.
   b. When all instances of `bean1` through `bean6` have been destroyed or passivated, install the updated version of the `DJAR3.jar` deployed JAR file, using either the CICS scanning mechanism or a static DJAR definition. (You cannot use the scanning mechanism to update a static DJAR definition.)

      Either:

1) Put the new version of the `DJAR3.jar` deployed JAR file into CorbaServer `COR2`'s pickup directory.
2) Issue a **`PERFORM CORBASERVER`**(`COR2`) SCAN command. CICS scans `COR2`'s pickup directory, updates its definition of `DJAR3.jar`, and copies the new versions of `bean5` and `bean6` to `COR2`'s shelf directory.

or:

1) Issue a **`CEMT DISCARD DJAR`**(`DJAR3`) command to delete the old definition of `DJAR3.jar`.
2) Issue a **`CEDA INSTALL DJAR`**(`DJAR3`) or an **`EXEC CICS CREATE DJAR`**(`DJAR3`) CORBASERVER(`COR2`) HFSFILE(`new_version_of_DJAR3.jar_on_HFS`) command. CICS installs the new definition of `DJAR3.jar`, and copies the new versions of `bean5` and `bean6` to `COR2`'s shelf directory.

Note:

1) It is *not* necessary to re-publish the updated versions of `bean5` and `bean6` to the namespace, even if the home or component interfaces of the beans have changed since the previous version.
2) If the home or component interface of `bean5` or `bean6` has changed since the previous version, before using the changed bean client applications must be updated to use the new signature.
3) If you update a *stateful* session bean, depending on exactly what changes are made you may change the structure of its serialised state. If this happens, you will invalidate any passivated instances of the bean in the object store. If this happens, any attempts to use the now invalidated bean will result in an exception. You should code your client applications to cope with this possibility.

3. Using CICSPlex SM, direct all new workload to the original region—that is, quiesce the clone and activate the original region.

   All requests for bean methods that will run under a new OTS transaction, or under no OTS transaction, whether in COR1 or COR2, are now routed to the original region. *From this moment, all new work will use the updated versions of `bean5` and `bean6`*. Requests for bean methods that will run under an existing OTS transaction (whether in COR1 or COR2) continue to be routed to the clone.

   Note:

   a. By "a *new* OTS transaction" we mean an OTS transaction in which the bean's participation begins *after* all new work is redirected to the original region.
   b. By "an *existing* OTS transaction" we mean an OTS transaction in which the bean's participation began *before* all new work was redirected to the original region.

   Eventually, all instances of enterprise beans on the clone will be destroyed or passivated, as described above.
4. On the clone region, use the **`INQUIRE TASK`** command to check when all instances of `bean1` through `bean6` have been destroyed or passivated. When this has happened, you can discard the clone region.

Solutions for a multi-region EJB server:

These solutions are valid for an EJB server consisting of one or more listener regions and multiple, identical, AORs.

Assume that your EJB server consists of three identical listener regions and five identical AORs. Each of the AORs is a clone of the region shown in Figure 24 on page 303 (except that it is an AOR rather than a listener/AOR). All the AORs share the same pickup directories, and the same sets of enterprise beans are deployed on each, in identical CorbaServers named `COR1` and `COR2`.

You want to update `bean5` and `bean6` in logical CorbaServer `COR2`. `DJAR3.jar` is the deployed JAR file containing the beans to be updated.

You require:
1. Logical CorbaServer `COR1` and its beans to remain available throughout the upgrade process.
2. If possible, the upgrade to the beans in logical CorbaServer `COR2` to be seamless. That is, there should be no time (or, at least, the smallest possible period of time) during which it is impossible to create a new instance of `bean5` or `bean6`.

Solution 1:

This solution is a development of solution 1 for a single-region.

About this task

Its advantage is that it is relatively easy to implement. Its disadvantage is that it is not seamless—that is, there is a period (while instances of the old versions of `bean5` and `bean6` are being destroyed or passivated) during which it is impossible to create a new instance of `bean5` or `bean6`.
1. On each of the AORs, issue an **EXEC CICS SET CORBASERVER**(`COR2`) ENABLESTATUS(`DISABLED`) or a **CEMT SET CORBASERVER(**`COR2`) DISABLED command. On all the AORs:
   - Any attempts to create new instances of `bean5` or `bean6`, regardless of whether the clients have references to the beans' home interfaces, will fail.
   - Typically, currently-executing methods on instances of `bean5` and `bean6` will proceed to completion.
   - An instance of `bean5` or `bean6` that is not participating in an OTS transaction is destroyed or passivated at the end of the currently-executing method. (If there is no currently-executing method, all instances will already have been destroyed or passivated.)
   - An instance of `bean5` or `bean6` that *is* participating in an OTS transaction is not destroyed or passivated until the end of the OTS transaction; typically, any future method calls against this instance (within the scope of the OTS transaction) will succeed. At the end of the OTS transaction the instance is destroyed or passivated.
2. On each of the AORs, check when all instances of `bean5` and `bean6` have been destroyed or passivated by issuing **EXEC CICS** or **CEMT INQUIRE CORBASERVER**(`COR2`) ENABLESTATUS commands. A status of DISABLED indicates that all bean instances have been destroyed or passivated.
3. When all instances of `bean5` and `bean6`, on all the AORs, have been destroyed or passivated, install the updated version of the `DJAR3.jar` deployed JAR file, using either the CICS scanning mechanism or static DJAR definitions. (You cannot use the scanning mechanism to update static DJAR definitions.)

   Either:
   1. Put the new version of the `DJAR3.jar` deployed JAR file into CorbaServer `COR2`'s pickup directory (which is shared by all the AORs).

   b. On each of the AORs, issue a **PERFORM CORBASERVER**(COR2) SCAN command. The AOR scans COR2's pickup directory, installs the new definition of DJAR3.jar, and copies the new versions of bean5 and bean6 to COR2's shelf directory.

   or, on each of the AORs:

   a. Issue an **EXEC CICS** or **CEMT DISCARD DJAR**(DJAR3) command, to remove the current definition of DJAR3.jar from CICS.

   b. Issue a **CEDA INSTALL DJAR**(DJAR3) or an **EXEC CICS CREATE DJAR**(DJAR3) CORBASERVER(COR2) HFSFILE(new_version_of_DJAR3.jar_on_HFS) command. CICS installs the new definition of DJAR3.jar, and copies the new versions of bean5 and bean6 to COR2's shelf directory.

   Note:

   a. It is *not* necessary to re-publish the updated versions of bean5 and bean6 to the namespace, even if the home or component interfaces of the beans have changed since the previous version.

   b. If the home or component interface of bean5 or bean6 has changed since the previous version, before using the changed bean client applications must be updated to use the new signature.

   c. If you update a *stateful* session bean, depending on exactly what changes are made you may change the structure of its serialised state. If this happens, you will invalidate any passivated instances of the bean in the object store. If this happens, any attempts to use the now invalidated bean will result in an exception. You should code your client applications to cope with this possibility.

4. On each of the AORs, issue a **CEMT SET CORBASERVER**(COR2) ENABLED command. *From this moment, all new work will use the updated versions of bean5 and bean6.*

Solution 2:
About this task

This solution requires CICSPlex System Manager. It is a development of solution 2 for a single-region. Its advantage is that it is relatively seamless—that is, there should at worst be only a tiny period during which it is impossible to create a new instance of bean5 or bean6. Its disadvantage is that it is more complicated to implement than solution 1.

1. Using CICSPlex SM:

   a. Create clones of all your AORs.

   b. Direct all new workload to the clones—that is, quiesce the original AORs and activate the clones. For information on how to do this, see Balancing an enterprise bean workload, in the *CICSPlex System Manager Managing Workloads* manual.

      Each request for a bean method that will run under a new OTS transaction, or under no OTS transaction, whether in COR1 or COR2, is routed to one or other of the clones.

      Each request for a bean method that will run under an existing OTS transaction (whether in COR1 or COR2) is routed to the appropriate original AOR.

      Note:

      1) By "a *new* OTS transaction" we mean an OTS transaction in which the bean's participation begins *after* all new work is directed to the clones.

2) By "an *existing* OTS transaction" we mean an OTS transaction in which the bean's participation began *before* all new work was directed to the clones.
3) By "the *appropriate* original AOR" we mean the original AOR containing the request processor for the OTS transaction.

2. On each of the original AORs:

   Check when all instances of `bean1` through `bean6` have been destroyed or passivated:

   a. If you don't already know the CICS transaction ID or IDs associated with `bean1` through `bean6`, use the CREC transaction to display this information.
   b. Use the **`INQUIRE TASK`** command to check whether any instances of these transactions are running.

3. When all instances of `bean1` through `bean6`, on all the original AORs, have been destroyed or passivated, install the updated version of the `DJAR3.jar` deployed JAR file, using either the CICS scanning mechanism or static DJAR definitions. (You cannot use the scanning mechanism to update static DJAR definitions.)

   Either:

   a. Put the new version of the `DJAR3.jar` deployed JAR file into `COR2`'s pickup directory (which is shared by all the original AORs).
   b. On each of the original AORs, issue a **`PERFORM CORBASERVER`**(`COR2`) SCAN command. The AOR scans `COR2`'s pickup directory, updates its definition of `DJAR3.jar`, and copies the new versions of `bean5` and `bean6` to `COR2`'s shelf directory.

   or:

   a. On each of the original AORs, issue a **`CEMT DISCARD DJAR`**(`DJAR3`) command to delete the old definition of `DJAR3.jar`.
   b. On each of the original AORs, issue a **`CEDA INSTALL DJAR`**(`DJAR3`) or an **`EXEC CICS CREATE DJAR`**(`DJAR3`) CORBASERVER (`COR2`) HFSFILE(`new_version_of_DJAR3.jar_on_HFS`) command. CICS installs the new definition of `DJAR3.jar`, and copies the new versions of `bean5` and `bean6` to `COR2`'s shelf directory.

   Note:

   a. It is *not* necessary to re-publish the updated versions of `bean5` and `bean6` to the namespace, even if the home or component interfaces of the beans have changed since the previous version.
   b. If the home or component interface of `bean5` or `bean6` has changed since the previous version, before using the changed bean client applications must be updated to use the new signature.
   c. If you update a *stateful* session bean, depending on exactly what changes are made you may change the structure of its serialised state. If this happens, you will invalidate any passivated instances of the bean in the object store. If this happens, any attempts to use the now invalidated bean will result in an exception. You should code your client applications to cope with this possibility.

4. Using CICSPlex SM, direct all new workload to the original AORs—that is, quiesce the clones and activate the original AORs.

   All requests for bean methods that will run under a new OTS transaction, or under no OTS transaction, whether in `COR1` or `COR2`, are now routed to the original AORs. *From this moment, all new work will use the updated versions of `bean5` and `bean6`.* Requests for bean methods that will run under an existing OTS transaction (whether in `COR1` or `COR2`) continue to be routed to the clones.

Note:

a. By "a *new* OTS transaction" we mean an OTS transaction in which the bean's participation begins *after* all new work is redirected to the original AORs.

b. By "an *existing* OTS transaction" we mean an OTS transaction in which the bean's participation began *before* all new work was redirected to the original AORs.

Eventually, all instances of enterprise beans on the clones will be destroyed or passivated.

5. On each of the clones, use the **`INQUIRE TASK`** command to check when all instances of `bean1` through `bean6` have been destroyed or passivated. When this has happened, you can discard the clone.

Other possible solutions: The solutions described in "Solutions for a single listener/AOR" on page 304 and "Solutions for a multi-region EJB server" on page 307 are not the only possibilities. Another approach, for example, is to:

1. Use non-default TRANIDs for the request processors associated with the beans to be updated. (In other words, segregate your enterprise beans by CorbaServer and transaction ID in the way previously suggested.)
2. Disable the request processor transactions, or put the transactions into a transaction class and reduce the TCLASS limit to zero.
3. When all instances of the beans have been destroyed or passivated, install the updated versions of the deployed JAR files in one of the ways described for the other solutions.

The CCI Connector for CICS TS

The CCI Connector for CICS TS helps you to build Enterprise JavaBean (EJB) server components that make use of existing CICS programs.

Overview of the CCI Connector for CICS TS

The CCI Connector for CICS TS helps you to build Enterprise JavaBean (EJB) server components that make use of existing CICS programs.

The background—connectors:

Frequently, new Java applications can be developed more quickly and reliably by harnessing the power of existing (non-Java) CICS programs.

A **CICS connector** is a software component that allows a Java client application to invoke a CICS application. Typically, the Java client programs that use a CICS connector are servlets.

For several releases, CICS has supported CICS connectors that enable a Java client program, *running outside CICS* (on, for example, Windows, UNIX, or native z/OS), to connect to a specified program on a CICS server. The CCI Connector for CICS TS enables a Java program or enterprise bean *running on CICS Transaction Server for z/OS* to link to a CICS server program.

The CCI Connector for CICS TS implements the industry-standard **Common Client Interface (CCI)** defined by the J2EE Connector Architecture Specification, Version 1.0.

Note: The CICS Connector for CICS TS, introduced in CICS TS for z/OS, Version 2.1, is no longer supported. Unlike the CCI Connector for CICS TS, the CICS Connector for CICS TS implemented a non-standard, IBM-proprietary, client interface.

The Common Client Interface:

This section presents an overview of the Common Client Interface (CCI). The Common Client Interface is part of the J2EE Connector architecture.

For definitive information about the interface, see the J2EE Connector Architecture specification. To download the specification, go to the Oracle Technology Network Java website and search for *J2EE Connector architecture*.

The CCI provides a standard interface that allows developers to communicate with any number of Enterprise Information Systems (EISs) through their specific resource adapters, using a generic programming style. The CCI is closely modeled on the client interface used by Java Database Connectivity (JDBC), and is similar in its use of *Connections* and *Interactions*.

Within the CCI, there are two distinct types of class: for convenience, we shall call them *framework* classes and *input/output* classes.

Framework classes:

Framework classes are used to request a connection to an EIS such as CICS, and execute commands on the EIS, passing input and retrieving output.

The framework classes are:

ConnectionFactory
: A ConnectionFactory object is used to manufacture connections that a Java component can use to communicate with a specific EIS. Attributes of the ConnectionFactory specify the EIS for which connections can be created. A ConnectionFactory is the factory for a Connection object.

Connection
: A Connection object identifies a unique connection to a specific server. It is the factory for an Interaction object.

Interaction
: The execute method of an Interaction object allows you to drive an interaction with a server. In CICS TS, the execute method takes three arguments—an InteractionSpec object that specifies the type of interaction, and two Record objects that carry the input and output data.

J2EE components use the framework classes to acquire a connection to an EIS and to send and receive data. First, a J2EE component obtains a ConnectionFactory object for the particular EIS that is to be accessed—for example, CICS. (The component may manufacture the ConnectionFactory programatically or, more likely, look it up in a JNDI namespace.) It uses the ConnectionFactory to get a Connection object. Then it uses the **Connection** object to create one or more Interaction objects. It executes commands on the EIS through these Interaction objects.

Figure 25 on page 313 shows the CCI framework classes being used to connect to an EIS and execute a command.

```
ConnectionFactory cf = <Lookup from JNDI namespace>
Connection conn = cf.getConnection();
Interaction int = conn.createInteraction();
int.execute(<Input output data>);
int.close();
conn.close();
```

Figure 25. Using the CCI framework classes to connect to an EIS and execute a command

Input/output classes:

Using the framework classes gives a generic way of accessing an EIS by means of a J2EE resource adapter.

However, because every EIS has different input and output needs, the CCI interfaces provide a way for J2EE components to pass EIS-specific information to a J2EE resource adapter. The following types of object are used for this purpose by a J2EE component:
- ConnectionSpec objects
- InteractionSpec objects
- Record objects

ConnectionSpec
A ConnectionSpec object can be used to specify security attributes (such as userid and password) used in an interaction with a server.

Note: CICS ignores any security settings specified in a ConnectionSpec object, because it has already established a suitable security context for the connector.

The CCI Connector for CICS TS's ConnectionSpec class is called ECIConnectionSpec.

InteractionSpec
An InteractionSpec object holds essential attributes necessary for an interaction with a server—for example, the name of the target program. It is passed as a required argument on an **Interaction.execute()** method call when a particular interaction is to be carried out.

The CCI Connector for CICS TS's InteractionSpec class is called ECIInteractionSpec.

Record
Record objects are beans that hold the data exchanged with the target program—you can think of them as the equivalent of CICS communication areas (COMMAREAs). The data is accessible through Record-defined interfaces.

Figure 26 on page 314 shows the CCI framework classes and input/output classes being used together to connect to an EIS, pass EIS-specific input/output parameters, and execute a command.

```
ConnectionFactory cf = <Lookup from JNDI namespace>
ECIConnectionSpec cs = new ECIConnectionSpec();
cs.setXXX();     //Set any connection specific properties

Connection conn = cf.getConnection(cs);
Interaction int = conn.createInteraction();
ECIInteractionSpec is = new ECIInteractionSpec();
is.setXXX();    //Set any interaction specific properties

RecordImpl in = new RecordImpl();
RecordImpl out = new RecordImpl();
int.execute(is,in,out);
int.close();
conn.close();
```

Figure 26. Complete CCI interaction with an EIS

The CCI Connector for CICS TS:

The CICS Transaction Gateway includes an External Call Interface (ECI) resource adapter for CICS.

The **ECI resource adapter** provides standard CCI interfaces that enable J2EE components to call CICS server programs, using data areas (COMMAREAs) to pass information to and from the server. Typically, these J2EE components are servlets or enterprise beans; in all cases, they execute outside CICS.

CICS TS includes the CCI Connector for CICS TS, which provides standard CCI interfaces that enable Java programs and components (for example, enterprise beans) running *within CICS* to call CICS server programs.

A Java program or enterprise bean running on CICS TS can use the CCI Connector for CICS TS to link to a suitable CICS server program. The CICS server program:
- May be written in any of the CICS-supported languages
- Must use a suitable communications area (COMMAREA)
- Must not do any terminal input/output
- Typically, runs on a separate back-end CICS Transaction Server for z/OS region, but optionally may be on the same CICS region as the Java program or bean.

The connector uses a JCICS `Program.link()` call to access the back-end server program. Link and distributed program link (DPL) calls are supported. This scenario is shown in Figure 27 on page 315. In this example, a Java client application or servlet uses RMI-IIOP to create an instance of an enterprise bean in a CICS EJB server. The enterprise bean uses the CCI Connector for CICS TS to link to a server program on a back-end CICS Transaction Server for z/OS region.

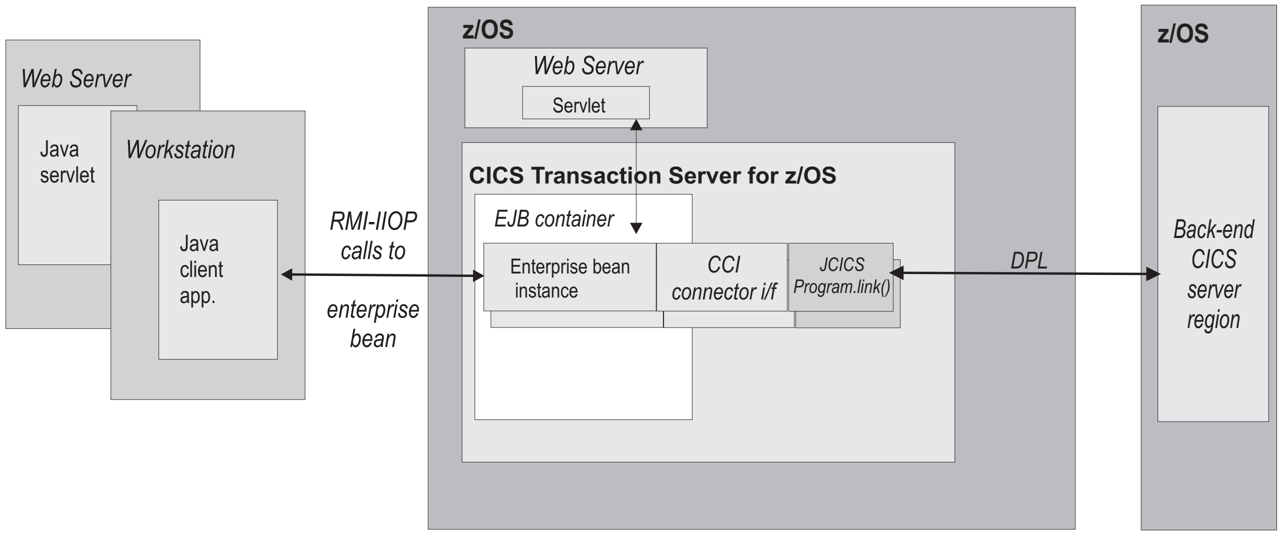


Figure 27. A CICS enterprise bean uses the CCI Connector for CICS TS to connect to a CICS server program.

A Java client application or servlet uses RMI-IIOP to create an instance of an enterprise bean, which exists in a CICS EJB container. The enterprise bean uses the CCI Connector for CICS TS to link to a server program on a back-end CICS TS for z/OS region.

To create an enterprise bean that uses the CCI Connector for CICS TS, the Java programmer requires a reasonable knowledge of CICS (although somewhat less than if he or she were using JCICS). However, the enterprise beans that are created can be used by Java programmers who have little knowledge of CICS.

The CCI Connector for CICS TS is highly optimized for execution within CICS; there is very little overhead involved in using it rather than a JCICS `Program.link()` call.

Benefits of the CCI Connector for CICS TS:

There are a number of benefits in using CCI Connector for CICS TS to build powerful server components that make use of existing CICS programs.

1. CICS enterprise beans that use the connector:
   - Enable programmers of Java client applications, who typically have little or no knowledge of CICS, to add the power of CICS to their applications.
   - Can be called by Java client applications and servlets running on many platforms. The client code used to call the bean (and through it the CICS server program) is identical on all Java platforms. Thus, for example, the client could be an enterprise bean running on WebSphere, a servlet running on a Web server, or a stand-alone application on a workstation.
   - If written correctly, should be portable, with little or no modification, between all EJB servers that support the Common Client Interface.
2. Because the Common Client Interface is a non-proprietary standard, the CCI code that calls the server program should be portable, with little or no modification, to and from most Java-enabled platforms.
3. Because the CCI Connector for CICS TS runs *inside* CICS, no network flows are required between the connector and CICS. Thus, the connector's performance is better than that of CCI connectors that use the ECI resource adapter to access CICS programs from outside CICS.

4. Using the connector from a CICS session bean results in a simple, two-tier deployment model: Client → CICS TS.
5. Programs written to use the ECI resource adapter can be easily adapted to use the CCI Connector for CICS TS. Thus, client programs that previously accessed CICS server programs from outside CICS can be migrated to run inside CICS.

   Note: If you port a program written to use the ECI resource adapter to use the CCI Connector for CICS TS, you must recompile the program to use the CICS TS-supplied classes in the `dfjcci.jar` JAR file, rather than the CICS Transaction Gateway classes.
6. The CCI Connector for CICS TS supports the Java 2 security policy mechanism.

Sample applications:

CICS supplies two sample applications that illustrate how a CICS Java program or enterprise bean can use the CCI Connector for CICS TS to call a CICS server program.
1. The CCI Connector sample. This is a relatively simple application that shows how to code the CCI APIs directly.

   The CCI Connector sample illustrates how to:
   a. Look up a previously-published connection factory in a JNDI namespace
   b. Use the CCI Connector for CICS TS to call a CICS server program

   The CCI Connector sample is described in "The CCI Connector sample application" on page 323.
2. The EJB Bank Account sample. This is a more complex sample that illustrates how you can use enterprise beans and DB2 to make CICS-controlled information available to Web users. The sample implements a CICS enterprise bean that uses the CCI Connector for CICS TS to link to back-end CICS COBOL programs. The COBOL programs extract information from DB2 data tables.

   The EJB Bank Account sample is described in "The EJB Bank Account sample application" on page 266.

CICS also supplies two sample utility programs that show you how to:
1. Publish a connection factory to a JNDI namespace (the `CICSConnectionFactoryPublish` sample). This is described in "Publishing a connection factory using CICSConnectionFactoryPublish" on page 321.
2. Retract a previously-published connection factory from the JNDI namespace (the `CICSConnectionFactoryRetract` sample). This is described in "Retracting a connection factory using CICSConnectionFactoryRetract" on page 323.

Using the CCI Connector for CICS TS

CICS Java components that use the CCI Connector for CICS TS can be programmed in two ways.

About this task

1. Program directly to the connector's implementation of the Common Client Interface. This approach produces the best performance.
2. Use a rapid application development (RAD) tool that provides visual interfaces and high-level constructs for programming the connector's Common Client Interface.

Whichever method you choose, you need to understand how to use the CCI Connector for CICS TS from a Java component running in CICS TS.

The logic a CICS enterprise bean should use to link to a back-end CICS program is shown in Figure 26 on page 314. That is:

1. Use the CICS-supplied sample program, `CICSConnectionFactoryPublish`, to publish a ConnectionFactory object suitable for use with the CCI Connector for CICS TS to the JNDI namespace used by the local CICS region. (See "Using the sample utility programs to manage and acquire a connection factory" on page 320.)
2. Declare a ConnectionFactory object, and set it to the CICS connection factory by means of a JNDI lookup.
3. Create an ECIConnectionSpec object. Set its properties as necessary.

   Note: This step is included for completeness. However, any userid or password specified in the ECIConnectionSpec object is ignored by CICS.
4. Use the ConnectionFactory to create a Connection object. This object represents a single connection to CICS.
5. Create an Interaction object from the Connection object.
6. Create an ECIInteractionSpec object. Set its properties, including the name of the target program and the mode—synchronous or asynchronous—of the interaction. (For CICS TS, only synchronous mode is supported.)
7. Create two Record objects, to represent the input and output communications areas of the target program.
8. Run the execute method of the Interaction object, passing the ECIInteractionSpec, and the input and output Record objects, as arguments.
9. Retrieve the data returned by the target program from the output Record object.
10. Execute the close method of the Interaction object.
11. Execute the close method of the Connection object.

Note: To specify the CICS server region which owns the program to be linked to, use the local PROGRAM resource of the server program. Specify the location of the server program (local or remote) and, if it is remote, whether dynamic routing should occur.

Important: Use the Javadoc for the CCI Connector architecture API to help code your CCI applications. It also provides information such as the exceptions used by CCI implementations. Javadoc for the CICS-specific ECIConnectionSpec and ECIInteractionSpec classes is in the *CCI Connector for CICS TS: Class Reference*, in the CICS Information Center.

Which classes to use?:

Which classes should you use, the standard CCI classes in the `javax.resource.cci` package or the CICS-specific classes provided by the CCI Connector for CICS TS in the `com.ibm.connector2.cics` package?

Framework classes:

The CCI Connector for CICS TS provides implementations of the framework classes called **ECIConnectionFactory**, **ECIConnection**, and **ECIInteraction**.

However, the standard **ConnectionFactory**, **Connection**, and **Interaction** classes should be used, rather than the CICS-specific implementations. For guidance information about programming these classes, see the *CICS Transaction Gateway:*

Programming Guide. For reference information, see the Sun Javadoc generated from the **ConnectionFactory**, **Connection**, and **Interaction** classes' source code.

Note that not all the information in the *CICS Transaction Gateway: Programming Guide* is applicable to the CCI Connector for CICS TS. The following properties of the **ConnectionFactory** class (and of the CICS-supplied **ECIManagedConnectionFactory** class) are ignored by CICS TS:
- clientSecurity
- connectionURL (in CICS TS, this is always `local:`)
- password
- portNumber
- serverName
- serverSecurity
- userName

Specifying a value for any of the above properties has no effect.

Input/output classes:

The CCI Connector for CICS TS provides implementations of the input/output classes. Use these CICS-specific classes (ECIConnectionSpec and ECIInteractionSpec} rather than the standard ConnectionSpec and InteractionSpec classes.

For guidance information about programming the CICS-specific classes, see the *CICS Transaction Gateway: Programming Guide*. For reference information, see the CICS Javadoc generated from the ECIConnectionSpec and ECIInteractionSpec classes in the *CCI Connector for CICS TS: Class Reference*. Special considerations that apply to the CCI Connector for CICS TS are listed below.

Note: Specifying a property or value described as "not supported by CICS TS" results in an exception. Specifying a property or value described as "ignored by CICS TS" has no effect.

ECIConnectionSpec
This class allows the J2EE component to pass security credentials different from those defined for the connection factory. Properties include:

Password
The password for the userid specified in UserName. Ignored by CICS TS.

UserName
The userid to be used to access CICS. Ignored by CICS TS.

ECIInteractionSpec
This class holds all the interaction-relevant attributes (for example, the name of the target program and the mode of the interaction—synchronous or asynchronous) necessary for an interaction with CICS. It is a required parameter on each Interaction.execute() method call. Its properties are:

InteractionVerb
The mode of the call to CICS—synchronous or asynchronous. The CCI Connector for CICS TS supports only the following:

SYNC_SEND_RECEIVE
A synchronous call. This is used to link to a CICS program.

FunctionName
The name of the program to execute on CICS. The CCI Connector for CICS TS requires you to specify FunctionName.

Note: FunctionName can refer to either a local or a remote program. The PROGRAM definition in the local region should specify the location of the server program (local or remote) and, if it's remote, whether or not dynamic routing should occur.

ExecuteTimeout
The timeout value for interactions with CICS.

0 No timeout. This is the default value, and the only value supported by CICS TS.

A positive integer
The length of time in milliseconds. Ignored by CICS TS.

CommareaLength
The length of the communications area (COMMAREA) being passed to CICS inside your input record. If this is not supplied, the default used by the CCI Connector for CICS TS is the length of the input record data.

ReplyLength
The amount of data you want back from CICS. Where only a small amount of a large returned COMMAREA is required by your enterprise bean or Java component, you can use this setting to cut down on network bandwidth. If not supplied, the default is to receive all data in the COMMAREA.

Note: You are recommended not to set ReplyLength. Because the CCI Connector for CICS TS always runs in local mode—that is, the enterprise bean or Java component that calls the connector executes on the same CICS region as the connector itself—there is no network flow to consider and therefore no need to receive less than the whole reply.

Record
For input and output, the CCI Connector for CICS TS supports only Record classes that implement the javax.resource.cci.Streamable interface. This allows the connector to read and write the streams of bytes that make up CICS COMMAREAs directly to and from the Record objects supplied to the **execute()** method of ECIInteraction.

For further information about using the javax.resource.cci.Streamable interface to build input records and retrieve byte arrays from output records, see the *CICS Transaction Gateway: Programming Guide*.

Data conversion and the CCI Connector for CICS TS

To represent text data, Java programs always use the Unicode character set, while CICS TS programs use EBCDIC.

When a Java program or enterprise bean calls a CICS TS server program, any text values in the communications area of the server program must be converted from Unicode to EBCDIC on input, and from EBCDIC to Unicode on output. However, the CCI Connector for CICS TS handles this data conversion automatically. When converting to and from Unicode, the JCICS Program.link() call issued by the connector uses, as the alternative coding system, the coding system of the execution environment; because the connector runs on z/OS, the alternative coding system is EBCDIC.

Note: By default, the Record objects passed to the connector's Interaction.execute() method use the EBCDIC code page used by the connector's execution environment.

Installing the CCI Connector for CICS TS

Compiling CCI applications

To compile an application that uses the CCI Connector for CICS TS, you must include these CICS-supplied JAR files in your Java classpath:

`connector.jar`
The CCI APIs, required by all CCI applications

`dfjcci.jar`
The CICS TS implementations of the CCI APIs

When you install CICS, `connector.jar` is installed into the `%JAVA_HOME%/standard/jca` z/OS UNIX directory (where %JAVA_HOME% is the value of the JAVADIR parameter on the DFHISTAR CICS installation job); `dfjcci.jar` is installed into the `/usr/lpp/cicsts/cicsts42/lib` directory (where `cicsts42` is the value of the USSDIR parameter on the DFHISTAR installation job).

Using the sample utility programs to manage and acquire a connection factory

About this task

CICS supplies three sample programs that illustrate how to:

1. Publish a connection factory to a JNDI namespace (the `CICSConnectionFactoryPublish` sample). You can use the sample to create a **ConnectionFactory** object suitable for use with the CCI Connector for CICS TS, and to publish it to the JNDI namespace used by the local CICS region. An enterprise bean or Java program, running on CICS, can then perform a JNDI lookup to obtain a reference to the connection factory.

   This sample is described in "Publishing a connection factory using CICSConnectionFactoryPublish" on page 321.
2. Retract a previously-published connection factory from the JNDI namespace (the `CICSConnectionFactoryRetract` sample). This sample is described in "Retracting a connection factory using CICSConnectionFactoryRetract" on page 323.
3. Look up a connection factory in the JNDI namespace (the CCI Connector sample application). This sample also shows you how to use the CCI Connector for CICS TS to call a CICS server program. It is described in "The CCI Connector sample application" on page 323.

Using the `CICSConnectionFactoryPublish` and `CICSConnectionFactoryRetract` samples, you can create, publish, and manage a connection factory separately from the applications that use it.

To use the sample programs, you need a suitably configured name server. If you need to configure a name server, see "Enabling JNDI references" on page 364 and "Specifying the location of the JNDI name server" on page 364.

Installing the publish and retract sample programs:

This section describes how to install the `CICSConnectionFactoryPublish` and `CICSConnectionFactoryRetract` programs.

About this task

How to install the CCI Connector application is described in "Installing the CCI Connector sample" on page 325.

The CICS-supplied JAR file `CICSCCISamples.jar` contains the object (.class) files for the sample programs. CICS installs `CICSCCISamples.jar` into the `/usr/lpp/cicsts/cicsts42/samples/cci` directory (where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OSUNIX). Also installed into the `/usr/lpp/cicsts/cicsts42/samples/cci` directory are the source (.java) files of the programs.

To install the `CICSConnectionFactoryPublish` and `CICSConnectionFactoryRetract` programs:

Procedure

1. Add the JAR file containing the programs, `/usr/lpp/cicsts/cicsts42/samples/cci/CICSCCISamples.jar`, to the CLASSPATH_SUFFIX statement in the JVM profile that the programs will use. As supplied, the sample programs use the CICS-supplied sample JVM profile DFHJVMPR, which is the default if no JVM profile is specified in the program's resource definition. CICS installs DFHJVMPR into the `/usr/lpp/cicsts/cicsts42/JVMProfiles` directory.
2. Place your edited version of DFHJVMPR in the z/OS UNIX directory specified on the **`JVMPROFILEDIR`** system initialization parameter. (In a default CICS installation, **`JVMPROFILEDIR`** specifies `/usr/lpp/cicsts/cicsts42/JVMProfiles`
3. Use CEDA to install transactions CCPB and CCRT from group DFH$CCI.
4. Use CEDA to install programs DFJ$CCPB and DFJ$CCRT from group DFH$CCI.

   Note: If your CICS region uses program autoinstall, this last step is not required.

Results

Publishing a connection factory using CICSConnectionFactoryPublish:

The `CICSConnectionFactoryPublish` program performs these tasks.
1. Gets the initial JNDI context of the CICS region.
2. Checks to see if a `ConnectionFactory` subContext exists in the context structure.
3. If the `ConnectionFactory` subContext does not exist, creates it.
4. If the `ConnectionFactory/CICSConnectionFactory` connection factory has not already been published (bound) to the name server, publishes it.

The default name of the connection factory, as set by the supplied version of the `CICSConnectionFactoryPublish` program, is `CICSConnectionFactory`. The default name of the JNDI subContext in which the connection factory is published is `ConnectionFactory`. By editing the source code of the `CICSConnectionFactoryPublish` program, you can change:
- The name of the connection factory.
- The JNDI subContext.

- If the linked-to server program is remote, the name of the mirror transaction under which the program runs on the remote region. However, the recommended way to specify the mirror program is on the local PROGRAM definition of the server program.

For instructions on how to make the changes, see the comments in the source code.

If you change the name of the connection factory, or of the subContext, remember to make the same change in all three of the sample programs.

Running the program:

To publish (bind) a ConnectionFactory suitable for use with the CCI Connector for CICS TS to the CICS JNDI name server, run transaction CCPB.

Unless you have changed the `CICSConnectionFactoryPublish` program, the ConnectionFactory will be named `CICSConnectionFactory`, and will be published to subContext `ConnectionFactory` in the JNDI server's namespace.

The following message appears on your screen:

```
ccpb - ConnectionFactory published to JNDI successfully.
```

Note: If a ConnectionFactory with the same name and subContext has already been published to the JNDI server (and not retracted), a different message appears:

```
ccpb - The ConnectionFactory is already published to JNDI.
```

Assuming that the connection factory is published successfully, the following output is sent to **stdout**:

```
***************************************************************************************************
**** CICSConnectionFactoryPublish: Started
**** CICSConnectionFactoryPublish: Binding ConnectionFactory ConnectionFactory/CICSConnectionFactory
**** CICSConnectionFactoryPublish: ConnectionFactory bound to JNDI
**** CICSConnectionFactoryPublish: Ended
***************************************************************************************************
```

Figure 28. Stdout output from transaction CCPB to publish a ConnectionFactory with default name and subContext

It is not recommended that you run `CICSConnectionFactoryPublish` as a PLTPI program, or link to it from a PLTPI program. This is because, if a JVM is not available, CICS startup time will be lengthened.

Looking up a connection factory:

This code example shows you how to look up a previously-published connection factory in the JNDI namespace used by CICS.

```
// Declare a ConnectionFactory object
ConnectionFactory cf = null;

try{
    // Get the initial JNDI context
    javax.naming.Context ic = new javax.naming.InitialContext();

    // Do the lookup, casting the returned CICSConnectionFactory to type
    // ConnectionFactory
    cf = (ConnectionFactory)ic.lookup("ConnectionFactory/CICSConnectionFactory");

    // Use the connection factory to create a connection to CICS
    Connection eciConn = (Connection)cf.getConnection();
}
catch (Exception e){
    // Lookup failed, or specified connection factory has not been published
    // Exception processing
}
```

This is illustrated in the CCI Connector application—see "The CCI Connector sample application."

Retracting a connection factory using CICSConnectionFactoryRetract:

To retract (unbind) a connection factory that you have published, run transaction CCRT. Unless you have changed the `CICSConnectionFactoryRetract` program, the ConnectionFactory to be retracted will be `CICSConnectionFactory`, in subContext `ConnectionFactory` in the JNDI server's namespace.

The following message appears on your screen:

```
ccrt - ConnectionFactory retracted from JNDI successfully.
```

Note: If the ConnectionFactory named in the `CICSConnectionFactoryRetract` program does not exist on the JNDI server (it may, for example, have already been retracted), a different message appears:

```
ccrt - unable to locate ConnectionFactory on JNDI.
```

Assuming that the connection factory is retracted normally, the following output is sent to **stdout**:

```
********************************************************************************
**** CICSConnectionFactoryRetract: Started
**** CICSConnectionFactoryRetract: Unbinding ConnectionFactory/CICSConnectionFactory
**** CICSConnectionFactoryRetract: ConnectionFactory/CICSConnectionFactory unbound
**** CICSConnectionFactoryRetract: Ended
********************************************************************************
```

Figure 29. Stdout output from transaction CCRT to retract a connection factory with default name and subContext

It is not recommended that you run `CICSConnectionFactoryRetract` as a PLTSD program, or link to it from a PLTSD program. This is because CICS shut down time will be lengthened.

The CCI Connector sample application

The CCI Connector sample is a relatively simple application that shows how to code the CCI APIs directly.

It illustrates how to:

1. Look up a previously-published connection factory in a JNDI namespace
2. Use the CCI Connector for CICS TS to call a CICS server program

The sample consists of:

- A CICS Java program
- A custom Record that demonstrates the use of the javax.resource.cci.Streamable interface
- A CICS COBOL server program

The sample works like this:

1. A user starts the application by running the CCCI transaction from a CICS terminal.

2. The CICS Java program, `CICSCCISample` (DFJ$CCIC), is started. The Java program:
   a. Asks the user to input a sequence of random, unsorted, decimal numbers
   b. Does a JNDI lookup of the name server, to obtain a CICS connection factory
   c. If a connection factory has not been published to the name server, creates one programatically
   d. Uses the connection factory to create a connection to CICS
   e. Creates an Interaction object from the **Connection** object, and sets the properties of the interaction (including the name of the target program) by means of an ECIInteractionSpec object
   f. Uses the Interaction.execute method to link to the COBOL program, DFH$0CCIS, passing as input (in a custom Record object) the user's sequence of unsorted numbers, plus the ECIInteractionSpec object
3. The COBOL program sorts the numbers into ascending order and returns the sorted sequence in its output COMMAREA.
4. The Java program retrieves the COBOL program's output from the output **Record** object and displays the sorted list on the user's terminal.

Figure 30 on page 325 shows the components of the sample application.

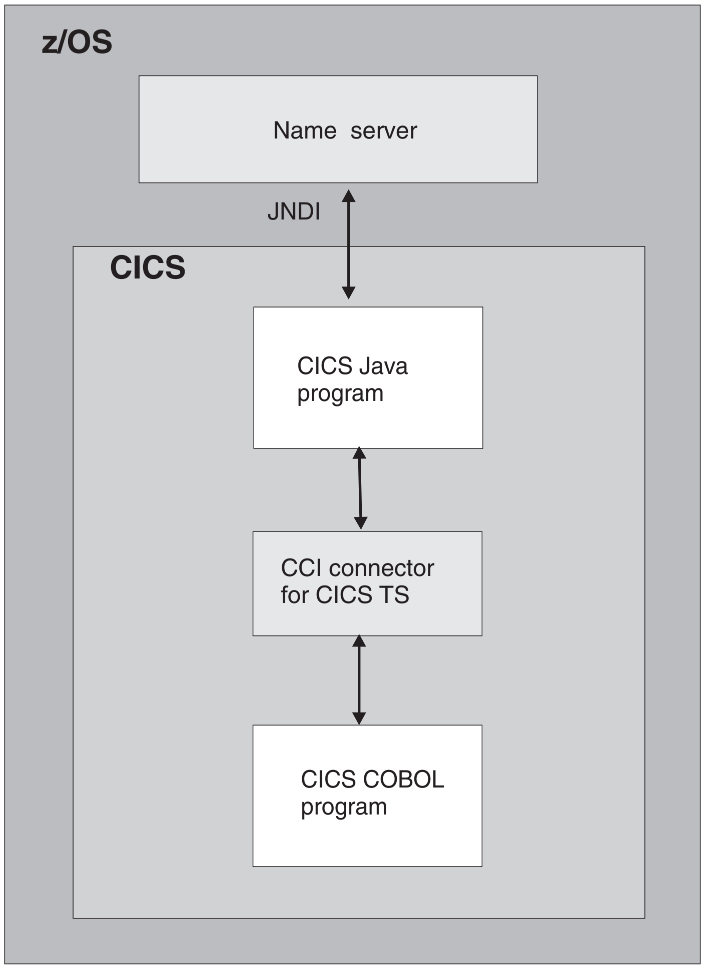


Figure 30. Overview of the CCI Connector sample application. The main elements of the sample are a CICS Java program and a CICS COBOL server program. The Java program uses the CCI Connector for CICS TS to link to the COBOL server program. The CICS connection factory can be published to either a COS Naming Server or an LDAP name server.

Requirements for the CCI Connector sample:

To enable the CCI Connector sample to obtain a CICS connection factory by performing a JNDI lookup, you need a name server that supports the Java Naming and Directory Interface (JNDI), Version 1.2 or later.

The way to set one up is described in “Actions required on z/OS or Windows NT” on page 239. You can use either a COS Naming Server or an LDAP server.

However, if the sample cannot connect to the name server, or a CICS connection factory has not been published to the name server, the sample creates the connection factory programatically. Therefore, strictly speaking, a name server is not a requirement to run the sample.

Installing the CCI Connector sample:
About this task

Procedure

1. If you have not already done so when running the `CICSConnectionFactoryPublish` and `CICSConnectionFactoryRetract` samples,

locate the JAR file containing the sample programs, /usr/lpp/cicsts/cicsts42/samples/cci/CICSCCISamples.jar, where /usr/lpp/cicsts/cicsts42 is the install directory for CICS files on z/OS UNIX. Add this JAR file to the CLASSPATH_SUFFIX statement in the JVM profile that the programs will use. As supplied, the sample programs use the CICS-supplied sample JVM profile DFHJVMPR, which is the default if no JVM profile is specified in the program's resource definition.

CICS installs DFHJVMPR into the /usr/lpp/cicsts/cicsts42/JVMProfiles directory.

Place your edited version of DFHJVMPR in the z/OS UNIX directory specified on the **JVMPROFILEDIR** system initialization parameter.

2. Ensure that the connector.jar and dfjcci.jar files are on the standard class path.

   Note: When you install CICS, connector.jar is installed into the %JAVA_HOME%/standard/jca directory and dfjcci.jar is installed into the /usr/lpp/cicsts/cicsts42/lib directory, as described in "Compiling CCI applications" on page 320. The /usr/lpp/cicsts/cicsts42/lib directory is on the base class path built by CICS, which is not visible in the JVM profiles, so this directory is always included.
3. Ensure that the name server is running.
4. Use the CICSConnectionFactoryPublish program to create a ConnectionFactory object for use by the CCI Connector for CICS TS, and to publish it to the name server. See "Publishing a connection factory using CICSConnectionFactoryPublish" on page 321.
5. Use CEDA to install transaction CCCI from group DFH$CCI.
6. Use CEDA to install definitions of the CICS Java and COBOL programs. Install programs DFJ$CCIC and DFH0CCIS from group DFH$CCI.

   Note: If your CICS region uses program autoinstall, this step is not required.

Testing the sample:
About this task

To test the CCI Connector sample:
1. Start transaction CCCI at a CICS terminal.
2. The sample asks you to input some numbers. Enter at least five decimal numbers, separated by spaces, and press the Return key. (Each number should be of five digits or less, and the numbers should not be ordered by size.)
3. The sample writes the sorted list of numbers to your screen and to **stdout**. If, for example, you entered the numbers 54, 3, 77, 55, and 19, your screen would look like this:

```
CCCI - CCI sample transaction starting.

A Connection object has been instantiated.

An Interaction object has been instantiated.

Enter a series of numbers:  54 3 77 55 19

An InteractionSpec object has been instantiated.

Connecting to program DFH0CCIS by invoking execute() on Interaction object.

Commarea sent:    54    3   77   55   19*
Commarea returned:     3   19   54   55   77*

CCCI - CCI sample transaction finished.
```

Problem determination

You can use CCI Connector for CICS TS messages, and CICS trace, to diagnose problems.

CCI Connector for CICS TS messages:
CICS messages related to the CCI Connector for CICS TS are described in the *CICS Messages and Codes Vol 1* manual.

Tracing the CCI Connector for CICS TS:

The CICS trace points related to the connector are in the range EJ 0600 - EJ 06FF.

These are described in Trace entries overview in Trace Entries.

To control the output of CICS trace information from the connector, use CICS trace control in the normal way.

Dealing with CICS enterprise bean problems

This section contains information on guidance in dealing with problems setting up and using the CICS enterprise bean support.

See Problem determination overview in Problem Determination for guidance on the more general aspects of CICS problem determination and diagnostics.

- "CICS enterprise bean set-up problems"
- "Using EJB server runtime diagnostics" on page 328
- "Using EJB client runtime diagnostics" on page 330
- "Class version issues with RMI-IIOP" on page 332
- "Using EJB trace and serviceability commands" on page 333

CICS enterprise bean set-up problems

If you have difficulties setting up the CICS EJB server, the problem could be related to your basic CICS Java set up. Try running the Java HelloWorld sample. If this also fails it points to a problem with the set up of your JVM rather than anything else.

Methods that require multiple request processors:

If a single execution of an enterprise bean method requires more than one request processor, your application could experience deadlock problems.

About this task

(A method can be said to "require more than one request processor" if it calls one or more other, typically remote, methods, each of which must execute in a different request processor.) Deadlocks can be caused by all the request processors required to satisfy the method being forced to wait for a JVM when no more JVMs are permitted. This can occur for two reasons:

1. In the simple case, the maximum number of JVMs allowed to exist concurrently under CICS (**MAXJVMTCBS**) is smaller than the number of request processors required to service the method request.

2. In the complex case:
   - CICS is processing multiple requests simultaneously.
   - All the requests are waiting for another JVM.
   - All the permitted JVMs are currently in use.

Avoiding the simple case is easy; avoiding the complex case is more difficult. It is necessary to ensure there are always enough free JVMs to allow at least one method's requirement of request processor instances to be satisfied.

The maximum number of concurrent JVMs available to a bean method is set by the MAXACTIVE attribute of the TRANCLASS definition for the request processor transaction. The maximum number of concurrent JVMs available to CICS is set by the **MAXJVMTCBS** system initialization parameter.

To remove the possibility of deadlocks caused by bean methods that use multiple request processors:

1. Wherever it is consistent with your applications' requirements, try to minimize the number of request processors each method requires, preferably to one. If you can reduce the requirements of all methods, in all applications, to one request processor, you need do no more.
2. If it is not possible to reduce the requirements of all methods to one request processor, discover which is your "worst case"—that is, the bean method that requires the most request processors in order to be satisfied.
3. Create a new TRANCLASS definition. This transaction class will apply to the request processor transaction under which bean methods that require multiple request processors will run.
4. On the TRANCLASS definition, set the value of MAXACTIVE using the following formula:
   ```
   MAXACTIVE <= ((MAXJVMTCBS - n) / (n - 1)) + 1
   ```
   where `n` is the maximum number of request processors required by your "worst case" method.

   If the result of this calculation is a decimal value, round it down to the nearest (lower) whole number.
5. Create new TRANSACTION and REQUESTMODEL definitions:
   a. Create a new TRANSACTION definition for the request processor transaction under which bean methods that require multiple request processors will run. (The easiest way to do this is to copy the definition of the default CIRP request processor transaction and modify it.) On the TRANCLASS option, specify the name of your new transaction class.
   b. Create one or more REQUESTMODEL definitions. Between them, your new REQUESTMODEL definitions must cover all requests that may be received for bean methods that require multiple request processors. On the TRANSID option of the REQUESTMODEL definitions, specify the name of your new transaction.

Using EJB server runtime diagnostics

The EJB server provides runtime diagnostics to help you diagnose and resolve problems. These include error messages, JVM trace, and the Java Platform Debugger Architecture (JPDA).

CICS enterprise bean errors and messages:

This is a list of places to look for error messages from CICS.

Enterprise Java domain (DFHEJnnnn) messages
CICS issues a large number of information, warning and error messages from the enterprise Java domain. Most of these are routed to the CEJL and CJRM transient data queues, others are sent to the console. See the *CICS Messages and Codes Vol 1* manual for a complete listing.

CICS JVM (DFHSJnnnn) messages
These are messages issued by the CICS JVM. Most are routed to the transient data queue CSMT. See the *CICS Messages and Codes Vol 1* manual for a complete listing.

CICS Development Deployment Tool (DFHADnnnn) messages
These are messages issued by this tool and routed to CICS as SYSPRINT messages. See the *CICS Messages and Codes Vol 1* manual for a complete listing.

CICS abend codes

- AJMA to AJM9 are issued by the CICS JVM
- AJ01 to AJ99 are issued by Java environment setup class Wrapper

See the *CICS Messages and Codes Vol 1* manual for a listing.

JVM trace:

Java Virtual Machines (JVMs) have their own internal trace facility. JVM trace can aid in the diagnosis of problems in the JVM. JVM trace can produce a large amount of output, so activate JVM trace for special transactions, rather than turning it on globally for all transactions.

"Defining and activating tracing for pooled JVMs" on page 188 explains the different ways to activate pooled JVM trace and change the JVM trace options.

When you activate JVM trace, each JVM trace point that is generated appears as an instance of a CICS trace point in the SJ domain.

In addition to the JVM trace options, the standard trace points for the SJ domain, at CICS trace levels 0, 1 and 2, can be used to trace the actions that CICS takes in setting up and managing JVMs and the shared class cache.

Java platform debugger architecture (JPDA):

The JVM in CICS supports the Java Platform Debugger Architecture (JPDA), which is the standard debugging mechanism provided in the Java 2 Platform.

The JVM in CICS supports the Java Platform Debugger Architecture (JPDA), which is the standard debugging mechanism provided in the Java 2 Platform. This architecture provides a set of APIs that allow the attachment of a remote debugger to a JVM. A variety of third party debuggers are available that exploit JPDA and can be used to attach to and debug a JVM that is running an enterprise bean, CORBA object or CICS Java program. Typically the debugger provides a graphical user interface that runs on a workstation and allows you to follow the application flow, setting breakpoints and stepping through the application source code, as well as examining the values of variables.

See "Debugging a Java application" on page 190 for guidance on setting up and using a debugger with the CICS JVM.

To find information about JPDA and JPDA-compliant applications, go to the Oracle Technology Network Java website and search for *Java Platform Debugger Architecture* to find the JPDA home page.

Using EJB client runtime diagnostics

Most of the error messages issued by the client are of limited use if the problem is in CICS, but you can sometimes get useful information from the client, and it is an obvious place to start.

Some of the more useful client exceptions are as follows:

`NoClassDefFoundException` and `ClassNotFoundException`
If the client issues either of these, there is probably something missing or corrupt on your client-side classpath. The exception should give you a good indication of which class is missing, and from this you may be able to work out which JAR file to add to the classpath. Remember that you need `j2ee.jar`, and the fully deployed jar in the classpath. It is unlikely that CICS will issue any useful additional information for these problems.

NoClassDefFoundError:javax/ejb/HomeHandle
This indicates that a client application does not have EJB 1.1 level classes available on the classpath. Ensure that `j2ee.jar` is available.

ObjectNotFoundException
This exception can indicate that a session bean has timed out or that an attempt has been made to use the session bean in two or more concurrent transactions.

`RemoteException`
This indicates a problem in the server application and often contains a nested exception giving more information. These include:

NoClassDefFoundError
This points to a missing JAR file on the server side. Check the CICS system console and the JVM standard error and output files for additional information.

CORBA.INTERNAL
This indicates a failure in the server side application outside the JVM (for example, in a COBOL program called by an enterprise bean). Check the CICS system console for more information.

CORBA exceptions:

These exceptions can sometimes provide useful information.

The **completion status** can have one of three values:
- **No** means that the server definitely did not complete running the invoked method successfully.
- **Yes** means that the invoked operation on the server did complete.
- **Maybe** means that the client cannot determine whether or not the operation completed on the server.

If the completion status is **Yes**, you can be sure that the client found something to run on a server (however if your JNDI/IOR is incorrect, it may not have been the correct enterprise bean or on the expected CICS region). You will usually find some more useful information in the CICS output about why the method call failed.

Some of the more common CORBA exceptions received by the client are:

org.omg.CORBA.COMM_FAILURE
This can occur in one of the following situations:

- The JNDI nameserver is not running (if it is on a JNDI lookup)
- The enterprise bean has not been published to the JNDI nameserver.
- The CICS region is down
- TCPIPSERVICE is not installed or is open (for method invocations on CICS)

org.omg.CORBA.INTERNAL
This is usually caused by an abend or failure of the server-side application. Look in the CICS console for more information.

org.omg.CORBA.INVALID_TRANSACTION
This can occur because of transaction interoperability problems between a web application server and CICS.

A number of protocols exist to support distributed transactions. The CICS enterprise Java environment supports only the standard CORBA Object Transaction Service (OTS) protocol. However, some J2EE-compliant web application servers (such as WebSphere Version 4) either do not use this protocol, or do not use this protocol by default. (Versions of WebSphere Application Server from Version 5 onwards are not affected by this problem.)

If objects on your web application server call CICS enterprise beans within the scope of existing transaction contexts, you must set up your web application server to use the CORBA OTS. If this is not possible, your web application server is not fully compatible with CICS enterprise Java support. (For a way of using the EJB Bank Account sample application to test whether your web application server is fully compatible with CICS enterprise Java support, see “A note about distributed transactions” on page 281.)

To force WebSphere Application Server to use the CORBA OTS:

1. At the WebSphere Administration Console, select the JVM settings tab.
2. Enter the following in the System Properties section:
   ```
   com.ibm.ejs.jts.ControlSet.interoperabilityOnly=true
   com.ibm.ejs.jts.ControlSet.nativeOnly=false
   ```
   Save your changes.
3. Restart the application server.

org.omg.CORBA.OBJECT_NOT_EXIST
This can occur when a client finds a reference to a bean on the JNDI nameserver but the bean is no longer installed in CICS.

org.omg.CORBA.UNKNOWN
There are many reasons for this exception including errors in your code, and errors in CICS. See the CICS output for more clues about the cause of the problem

In many instances, the CORBA exception includes a CICS specific minor code to aid in problem determination. CICS currently uses the following minor codes:

Table 20. CICS specific CORBA minor codes

Code	CICS component detecting problem
1229111296	CICS IIOP request receiver

Table 20. CICS specific CORBA minor codes (continued)

Code	CICS component detecting problem
1229111297	Elsewhere in CICS II domain
1229111298	ORB component of CICS OT domain
1229111299	JTS component of CICS OT domain
1229111300	CSI component of CICS OT domain
1229111301	CSI component of CICS EJ domain

If the client receives a CORBA exception containing any of the CICS minor codes, you should examine the CICS message logs for further information about the error.

Class version issues with RMI-IIOP

Remote Method Invocation over IIOP (RMI-IIOP) is the communication protocol used, in CICS, by both enterprise beans and CORBA stateless objects. The information in this section therefore applies to both enterprise beans and CORBA stateless objects.

Java RMI is an object-by-value protocol. This means that whenever a Java object is used as a parameter on a method call what gets sent on the wire is the object state. The same is true of return types and exceptions. This state is a "serialized" Java object. The state can be de-serialized by the remote JVM to create a new copy of the original object in the remote JVM. The serialized state contains, among other things, a version number to indicate the version of the class that the state represents. In order for the serialized object to be de-serialized by the remote JVM, it is necessary for the same version of the class file to be present at each end of the IIOP connection. If the remote JVM cannot understand the object state, it will probably cause the following exception to be thrown:

```
java.rmi.MarshalException:unable to read from underlying bridge
```

(This exception may be thrown for other reasons too.)

When you create a class in Java it is possible to provide your own customised serialization mechanism. Using this mechanism, you can handle versioning of your classes explicitly, rather than rely on Java's default serialization process. Moreover, if you provide a custom serialization mechanism you can achieve significant performance savings over the default mechanism. If you want to take advantage of custom serialization, your objects must implement the `java.io.Externalizable` interface.

Often the objects that must be serialized are instances of classes from the standard Java class library. These usually do not change from one version of Java to the next, but if they do it can lead to the kind of problem described above. In order to minimize these problems, it is recommended that you use the same version of Java on the partner machines as CICS uses. For example, between Java 1.3.1 and Java 1.4 the `java.lang.Throwable` class changed significantly. This class is the super-type of all exceptions in Java and thus many exceptions serialized by Java 1.4.1 and later cannot be de-serialized by older versions of Java.

There is a mechanism in CORBA that is used by many ORBs to get around the problem of version changes in classes. Unfortunately, that mechanism does not fully work in CICS because it involves affinities between the partner ORB and the JVM in CICS. Multiple RMI-IIOP calls to the same CORBA object in CICS are likely to be processed in different JVMs. This means that affinities are not supported and that the mechanism for avoiding class versioning issues does not work in CICS. CICS applications suffer from this problem only when sending serialized objects to a remote JVM. If a remote JVM sends a serialized object to CICS, CICS can use the standard CORBA mechanism to cope with any version incompatibilities.

If you experience this kind of problem and are unable to change the version of Java in use at the partner platform, it is recommended that the application be changed to use a datatype that does not cause versioning issues.

Using EJB trace and serviceability commands

You might want to trace an EJB request when you are trying to diagnose hanging or failing requests, or when you need to be able to uniquely identify all transactions associated with a single request in order to monitor that activity or perhaps for accounting purposes.

The main problems when trying to diagnose hanging or failing requests when an EJB logical server comprises multiple CICS regions are that you must determine:

- The region where the request originated (the request receiver)
- The target (a CICS region or other server) that the request has been routed to.

The system programming interface (SPI) commands **INQUIRE WORKREQUEST** and **SET WORKREQUEST** enable you to:

- determine which transactions are associated with a single request
- correlate all transactions associated with a single request
- purge selected work requests

Each request shows:

- the local task number and transaction ID
- the type of request, the first type supported is IIOP
- a unique (printable) string that can be entered on the command as a filter e.g.
  - Worktype
  - ClientIPAddress
  - Target SNA (z/OS Communications Server) applid or TCPIP address

For more information about these commands, see the *CICS System Programming Reference* and the *CICS Supplied Transactions* manuals.

The INQUIRE and SET WORKREQUEST commands are only available for IIOP tasks.

WorkRequests associated with RequestReceivers are not included, they are lightweight and all this information is available in the RequestProcessor. A RequestReceiver may process more that one request per instance and may have left the system long before the request has completed.

When you interrogate a logical server using the CPSM WUI, you have a single screen displaying all WorkRequests in the server

You are able with these commands to purge a RequestProcessor in a manner similar to purging a task from the CEMT INQ TASK list.

Managing security for enterprise beans

The security mechanisms, Java2 security, Secure Sockets Layer (SSL) security, MRO security, and Security Roles can be used with enterprise beans.

You can implement any combination of these.

`Java security`
This form of security control is implemented by the Java Virtual Machine (JVM) and can be used with any Java program that executes under JVM control. See "Enabling a Java security manager" on page 87 for guidance on how to set up this type of security control.

`Secure Sockets Layer (SSL) security`
The Secure Sockets Layer (SSL) is a security protocol that provides privacy and authentication between clients and servers communicating using TCP/IP. For more information about SSL, see Support for security protocols in the RACF Security Guide.

`MRO security`
After the request receiver has established a CICS USERID to be associated with the request, it might have to be routed to an application-owning-region (AOR). If the routing mechanism uses a multiple region operation (MRO) connection, the transmission of the user ID is subject to MRO security rules. See Link security with MRO.

`Security roles`
A security role represents a type of user of an application in terms of the permissions that the user must have to successfully use the application. See "Security roles" on page 338.

The CICS-supplied enterprise beans policy file

The CICS-supplied enterprise beans policy file, `dfjejbpl.policy`, is based on the Java security policy mechanism.

The Java security policy mechanism is described in the *Enterprise JavaBeans Specification, Version 1.1*. The sample policy file is shown in Figure 31 on page 335.

In Java, the security policy is defined in terms of protection domains which map permissions to code sources. A protection domain contains a code source with a set of associated permissions.

The CICS-supplied enterprise beans policy file defines two protection domains, which do the following:

1. Grants the required permissions to the CICS enterprise beans Container code source for execution. See the 'grant codeBase' block in Figure 31 on page 335.
2. Grants any code source only the permissions outlined in the *Enterprise JavaBeans* specification, Version 1. See the default 'grant' block in Figure 31 on page 335:
   - To allow anyone to initiate a print job request.
   - To allow outbound connection on any TCP/IP ports.
   - To allow all system properties to be read.

Remember that if you want to use JDBC or SQLJ from enterprise beans, amend the CICS-supplied enterprise beans policy file to grant permissions to the JDBC driver. For more information, see Using JDBC and SQLJ to access DB2 data from Java programs in the DB2 Guide.

```
 // permissions granted to CICS enterprise beans Container codesource protection
 //domain
    grant codeBase "file:usr/lpp/cicsts/cicsts42//-" {
      permission java.security.AllPermission;
    };

// default EJB 1.1 permissions granted to all protection domains
    grant {
      // allows anyone to initiate a print job request
      permission java.lang.RuntimePermission "queuePrintJob";

      // allows outbound connection on any TCP/IP ports
      permission java.net.SocketPermission "*:0-65535", "connect";

      // allows anyone to read properties
      permission java.util.PropertyPermission "*", "read";
    };
```

Figure 31. Sample CICS enterprise beans security policy

Using enterprise bean security

The EJB 1.1 specification defines the following security APIs to allow enterprise beans to make application decisions based on the security details of the caller.

`java.security.Principal getCallerPrincipal()`
: This method is used to determine who invoked the current bean method. The getCallerPrincipal method is fully supported in CICS. Details of the way that the identity of the current caller is determined are shown in "Deriving distinguished names" on page 337.

`boolean isCallerInRole(String SecurityRoleReference)`
: This method is used to test whether the current caller is assigned to a security role that is linked to the security role reference specified on the method call.

CICS will throw a runtime exception (which conforms to the EJB 1.1 specification) if the following deprecated EJB 1.0 security APIs are used.

- java.security.Identity getCallerIdentity()
- boolean isCallerInRole(java.security.Identity role)

Note: Enterprise beans developed to the Enterprise JavaBeans (EJB) 1.0 specification need to be upgraded to the Enterprise JavaBeans 1.1 specification level, using the supplied development tools.

- See "The deployment tools for enterprise beans in a CICS system" on page 296 for information about deployment tools.
- See "Writing enterprise beans" on page 283 for information about writing enterprise beans.

Defining file access permissions for enterprise beans:

To successfully run enterprise beans in CICS, the CICS region userid must be permitted to access the files used by the enterprise logic.

These file permissions are required to run enterprise beans, regardless of the level of security implemented. See also the *CICS Transaction Server for z/OS Installation Guide*.

Access to z/OS UNIX files used by enterprise beans:

These file permissions are required to run enterprise beans.

Table 21. File access permissions required for CICS enterprise beans

File/Directory structure	Minimum permission	Comments
CORBASERVER Shelf directory (for example, /var/cicsts/)	Read, write and execute	The shelf is accessed during CORBASERVER and DJAR installation, and each CICS needs to create unique subdirectories (see note 1).
/usr/lpp/cicsts/cicsts42 directory structure and classes	Read and execute	Contains the CICS-supplied Java code (see note 2).
/usr/lpp/java/J6.0.1_64/bin and /usr/lpp/java/J6.0.1_64/bin/classic directories	Read and execute	Contain the IBM JVM code (see note 3).
CICS working directory	Read, write and execute	Used to create stdin files (see note 4).
Deployed jar file	Read	Used during DJAR installation by the deployment process.
Security policy file (if required)	Read	Required if the **-Djava.security.policy** property is specified in the JVM system properties file.
System properties file	Read	Optional when creating a JVM (see note 5).

Note:
1. /var/cicsts/ is the default SHELF directory name when you define a CORBASERVER resource definition. Each CICS region creates a unique subdirectory in this shelf when it installs the resource definition
2. *cicsts42* is your chosen value for the USSDIR installation parameter that you defined when you installed CICS TS.
3. java/J6.0.1_64 is your install location for the IBM 64-bit SDK for z/OS, Java Technology Edition.
4. The CICS working directory is defined by the WORK_DIR parameter in the JVM profile.
5. The optional system properties directory and file name are named on the JVMPROPS option in the JVM profile.

File ownership and permissions may be defined using the **chmod** and **chown** commands. For more information, see *z/OS UNIX System Services Command Reference*.

Access to data sets used by enterprise beans:

Before CORBASERVERs can be installed in a CICS region, the following two data sets must be created with UPDATE access, defined to CICS and installed. These files can be VSAM data sets or coupling facility data tables.

Figure 32 on page 337 shows an example of RACF commands to access data sets with the necessary authorization.

Note: These files are used internally by CICS, so no users should be given resource level security access to them. This will prevent VSAM applications from accessing the data in these files.

DFHEJDIR
: This data set contains a request streams directory which is shared by the listener regions and AORs comprising a CICS IIOP server. The file must be recoverable.

DFHEJOS
: DFHEJOS is a data set containing passivated stateful session beans. It is shared by all the AORs comprising a CICS IIOP server. This file must not be recoverable.

```
ADDSD  'CICSTS42.CICS.CICS.DFHEJDIR' NOTIFY(cics_sys_admin_id) UACC(NONE)
PERMIT 'CICSTS42.CICS.CICS.DFHEJDIR' ID(cics_id1,...,cics_group1,..,cics_groupn)
       ACCESS(UPDATE)
ADDSD  'CICSTS42.CICS.CICS.DFHEJOS'  NOTIFY(cics_sys_admin_id) UACC(NONE)
PERMIT 'CICSTS42.CICS.CICS.DFHEJOS'  ID(cics_id1,...,cics_group1,..,cics_groupn)
       ACCESS(UPDATE)
```

Figure 32. An example of RACF commands used to authorize access to CICS data sets

See Authorizing access to CICS data sets, in the *CICS RACF Security Guide*, for more information about authorizing access to CICS data sets.

Deriving distinguished names:

Enterprise beans can identify their end-user, or client, by means of a *Principal* object.

The getCallerPrincipal method returns a Principal object representing the client, and that Principal object contains methods that can be invoked to return information about the client. In particular, the getName method of the Principal object returns a String that contains the "distinguished name" of the client. The distinguished name, or DN, is a sequence of keyword and value pairs, known as relative distinguished names, or RDNs, and forms part of the X.500 recommendation (Standard ISO/IEC 9594). The string representation of a distinguished name is suggested by RFC2253, *LDAP V3: UTF-8 String Representation of Distinguished Names.*

Note: CICS Transaction Server for z/OS, Version 4 Release 2 does not verify that a stateful session bean instance is used only by the same principal that created it. Therefore the principal's userid and distinguished name may be different after a bean instance has been reactivated.

If the bean's client has been identified and authenticated by means of a client certificate using the secure sockets layer protocol, the distinguished name is always obtained from that certificate. However, if the bean's client has not provided a certificate, the distinguished name is obtained by invoking the DFHEJDNX user-replaceable module. The inputs to the DFHEJDNX module are the title, organizational unit, organization, locality, state, and country, obtained from the server certificate whose label is specified in the CERTIFICATE option of the CORBASERVER definition, and the userid and common name associated with the user ID of the user executing the bean, but if SEC=NO is specified, the CICS region userid is used. The common name is derived by transforming the username for that user to a mixed-case string.) The certificate label specifies a certificate within the key ring identified by the KEYRING system initialization parameter. If the CERTIFICATE option is omitted, information is obtained from the default certificate in the key ring. If the KEYRING parameter is omitted, no certificate information is passed to DFHEJDNX, and only the common name RDN is available.

The CICS-supplied version of DFHEJDNX accepts the inputs derived from the CORBASERVER certificate and the username, and formats them into a distinguished name in the following style:

T=CICS EJB Container,CN=Louise Peters,OU=CICS/390 Development, O=IBM,L=Hursley,ST=Hampshire,C=GB

CICS-supplied samples of DFHEJDNX are located in the SDFHSAMP library, *CICSTS42.CICS.CICS.SDFHSAMP*, as:
- DFHEJDN1 for Assembler language
- DFHEJDN2 for C language

Security roles

Access to enterprise bean methods is based on the concept of *security roles*. A security role represents a type of user of an application in terms of the permissions that the user must have to successfully use the application.

For example, in a payroll application:
- A `manager` role could represent users who are permitted to use all parts of the application
- A `team_leader` role could represent users who are permitted to use the administration functions of the application
- A `data_entry` role could represent users who are permitted to use the data entry functions of the application

The security roles for an application are defined by the application assembler, and are specified in the bean's deployment descriptor. For more information, see "Security roles in the deployment descriptor" on page 342

The security roles that are permitted to execute a bean method are also specified in the bean's deployment descriptor, again by the application assembler. In the example, methods which update the hours worked by employees each week might be assigned to the `data_entry` role, while methods which delete an employee from the payroll might be assigned to the `team_leader` role.

To distinguish similarly named security roles in different applications, or in different systems, the security roles specified in the bean's deployment descriptor can be given a one- or two-part qualifier when the bean is deployed in a CICS system. For example:
- Security role with no qualifiers:
  ```
  team_leader
  ```
- Security role with one qualifier:
  ```
  payroll.team_leader
  ```
- Security role with two qualifiers:
  ```
  test.payroll.team_leader
  ```

A security role with its qualifiers is known as a **deployed security role**. For more information, see "Deployed security roles" on page 339.

The mapping of security roles to individual users is done in the external security manager. The mapping is not neccesarily one-to-one. For example, several users might be assigned to the `data_entry` role, while a some users might be assigned to both the `team_leader` role and the `data_entry` role. For more information, see "Implementing security roles" on page 344.

The security role and display name in the deployment descriptor can contain any ASCII or Unicode character. This is not so for names used in RACF, which are restricted to characters in EBCDIC code page 037. In addition, some characters — the asterisk (`*`) for example — have special meaning when used in RACF commands. Therefore, when CICS constructs the deployed security role from its components, some characters are replaced with a different character, and others are replaced with an escape sequence. For details, see "Character substitution in deployed security roles" on page 340.

Deployed security roles:

A direct mapping between the security roles specified in a bean's deployment descriptor and individual users may not adequately control access to bean methods.

For example
- Two applications, provided by different suppliers, might use similar names for security roles. In your enterprise, the users of each application might be different.
- A bean could be used in more than one application. A user may be entitled to use a particular method in one application, but not in the other.
- An application could be deployed in a test system and a production system. Members of the test department may be permitted to use all bean methods in the test system, but not in the production system.

To provide the degree of control that is needed in these and other cases, you can qualify the security roles at the application level and the system level. A security role with its qualifiers is known as a **deployed security role**. Here is an example of a role name which is qualified at both levels:

```
test.payroll.team_leader
```

- `payroll` qualifies the security role at the application level, and is used to distinguish between the `team_leader` role in the payroll application and the `team_leader` role in other applications.
- `test` qualifies the security role at the system level, and is used to distinguish between the payroll.team_leader role in the test system and the payroll.team_leader role in other systems.

At the application level, security roles are qualified by the **display name**, if one is specified in the deployment descriptor. If a display name is not specified, the security roles are not qualified at the application level. If an application level qualifier is used, a period (`.`) is used as the delimiter; if no qualifier is used, there is no delimiter.

At the system level, security roles are optionally qualified with a prefix which is specified in the EJBROLEPRFX system initialization parameter. If EJBROLEPRFX is not specified, the security roles are not qualified at the system level. If a system level qualifier is used, a period (`.`) is used as the delimiter; if no qualifier is used, there is no delimiter.

This example shows how security roles defined in a bean's deployment descriptor can be qualified:

- A bean contains three security roles: manager, team_leader, and data_entry
- The bean is used in a payroll application, with a display name of `payroll`. The bean is also part of a test application, which does not have a display name.
- The payroll application is used on two production systems: the first does not specify a prefix, while the second specifies a prefix of `executive`.
- The test application is used on a test system with a prefix of `test1`.

When the two levels of qualification are applied to the security roles specified in the deployment descriptor, the deployed security roles are:

```
payroll.manager       executive.payroll.manager       test1.manager
payroll.team_leader   executive.payroll.team_leader   test1.team_leader
payroll.data_entry    executive.payroll.data_entry    test1.data_entry
```

Each of these deployed roles can be mapped to individual users (or groups of users) to suit the security need of the enterprise.

If a security role is not qualified at the application level, or at the system level, then the deployed security role is the same as the security role defined in the deployment descriptor. For example, if the bean in the previous example is used in an application which does not have a display name, and the application is used in a system that does not specify EJBROLEPRFX, then the deployed security roles are:

```
manager
team_leader
data_entry
```

Enabling and disabling support for security roles:

By default, CICS support for security roles is enabled.

You can use the XEJB system initialization parameter to disable (or explicitly enable) support for security roles. If you disable the support:
- CICS does not perform method authorization checks: all users are permitted to use all bean methods.
- The isCallerInRole() method returns `true` for all users.

Security role references:

Within an application, the isCallerInRole() method can be used to determine if the user of the application is defined to a given role.

The method takes a **security role reference** as an argument, rather than a security role. The security role references coded in the bean are defined by the bean provider, and declared in the bean's deployment descriptor.

For more information, see “Security roles in the deployment descriptor” on page 342

Each security role reference is linked to a security role by the application assembler; the linkage is declared in the deployment descriptor for the bean. For example, the security role reference of administrator used within the bean's code might be linked, in the deployment descriptor, to the team_leader role.

For more information, see “Security roles in the deployment descriptor” on page 342

Character substitution in deployed security roles:

The security role and display name in the deployment descriptor can contain any ASCII or Unicode character.

The character set which can be used in deployed security roles is more restricted:

- Profile names used in RACF are restricted to characters in EBCDIC code page 037.
- Some characters — the asterisk (`*`) for example — have special meaning when used in RACF commands, and cannot be used in a profile name.

When Unicode characters in the security role and display name cannot be used directly in the deployed security role, they are replaced by the escape sequences shown in Table 22. Substitution occurs:

- when the EJBROLE generator utility (`dfhreg`) processes the deployment descriptor to generate RACF commands
- when CICS maps a security role to a RACF user ID

Table 22. Escape sequences used in security roles

Character	Description	ASCII/Unicode	EBCDIC code page 037	Escape sequence
ASCII and Unicode values whose equivalent EBCDIC value cannot be used in a deployed security role name are replaced with a three-character escape sequence as follows:				
	blank	X'20'	X'40'	¢
¢	cent	X'A2'	X'4A'	\A2
\	backslash	X'5C'	X'E0'	\5C
*	asterisk	X'2A'	X'5C'	\2A
&	ampersand	X'26'	X'50'	\26
%	per cent	X'25'	X'6C'	\25
,	comma	X'2C'	X'6B'	\2C
(	left parenthesis	X'28'	X'4D'	\28
)	right parenthesis	X'29'	X'5D'	\29
;	semicolon	X'3B'	X'5E'	\3B
Unicode values which do not have an equivalent in EBCDIC code page 037 are replaced with the Unicode escape sequence: a character with a Unicode representation of X'yyyy' is replaced by `\uyyyy`. For example:				
€	Euro symbol	X'20AC'	not supported	\u20AC
	Hiragana Ki	X'304D'	not supported	\u304D
α	alpha	X'03B1'	not supported	\u03B1

Here are two examples that illustrate the way that characters are substituted:

Example 1

- The EJBROLEPRFX has a value of `test`
- The display name in the deployment descriptor has a value of `year.end.processing`
- The security role in the deployment descriptor has a value of `auditor 1`

In this example, when the deployed security role is constructed:

1. Each space is replaced with `¢`

2. The deployed security role is composed from the EJBROLEPRFX value, the display name, and the security role; a period is used as the delimiter.

The resulting deployed security role is:

```
test.year.end.processing.auditor¢1
```

Example 2

- The EJBROLEPRFX has a value of `test`
- The display name in the deployment descriptor has a value of `αβ32`. The Unicode encoding is X'03B1 03B2 0033 0034'.
- The security role in the deployment descriptor has a value of `auditor 1`

In this example, when the deployed security role is constructed:

1. Each Unicode character that has an equivalent in EBCDIC code page 037 is replaced accordingly: In the display name, X'0033 0034' is replaced by `34`.
2. Each Unicode character that does ***not*** have an equivalent in EBCDIC code page 037 is replaced with the corresponding escape sequence. In the display name, X'03B1 03B2' is replaced by `\u03B1\u03B2`
3. Each space is replaced with `¢`
4. The deployed security role is composed from the EJBROLEPRFX value, the display name, and the security role; a period is used as the delimiter.

The resulting deployed security role is:

```
test.\u03B1\u03B234.auditor¢1
```

Security roles in the deployment descriptor:

This shows a fragment of a deployment descriptor. It includes the following security role information.

- 1 A display name of `payroll`.
- 2 The security role reference of `administrator` which is linked to the `team_leader` role.
- 3 A security role of `team_leader`.
- 4 A method permission that allows a user defined in the `team_leader` role to invoke the create() method.

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE ejb-jar PUBLIC
"-//Sun Microsystems, Inc.//DTD Enterprise JavaBeans 1.1//EN"
"http://java.sun.com/j2ee/dtds/ejb-jar_1_1.dtd">
  <ejb-jar id="ejb-jar_ID">
    <display-name>payroll</display-name>        1
      <enterprise-beans>
        <session id="Session_1">
          .
          .
          <security-role-ref id="SecurityRoleRef_1">
            <role-name>administrator</role-name> 2
            <role-link>team_leader</role-link>
          </security-role-ref>
          .
          .
        </session>
      </enterprise-beans>
      <assembly-descriptor id="AssemblyDescriptor_1">
        <security-role id="SecurityRole_1">
          <role-name>team_leader</role-name>     3
        </security-role>
        .
        .
        <method-permission id="MethodPermission_1">
          <description>team_leader:+:</description>
          <role-name>team_leader</role-name>     4
          <method id="MethodElement_01">
            <ejb-name>Managed</ejb-name>
            <method-intf>Home</method-intf>
            <method-name>create</method-name>
            <method-params>
            </method-params>
          </method>
           .
           .
        </method-permission>
         .
         .
      </assembly-descriptor>
       .
       .
     </ejb-jar>
```

Figure 33. Example of a deployment descriptor containing security roles

If an application with this deployment descriptor is used in a CICS system with the following system initialisation parameters:

```
SEC=YES
XEJB=YES
EJBROLEPRFX='test'
```

- The deployed security role of `test.payroll.team_leader` must be defined to RACF.
- Users that have READ access to that deployed security role will be permitted to invoke the create() method.
- `isCallerInRole('administrator')` will return `true` for users defined in the deployed security role of `test.payroll.team_leader`, and `false` for other users.

For detailed information about the contents of the deployment descriptor, refer to *Enterprise JavaBeans Specification, Version 1.1*.

To view the contents of a deployment descriptor, you can use the Assembly Toolkit (ATK). For more information about ATK, see The enterprise bean deployment tool, ATK, in the *CICS Operations and Utilities Guide*.

Implementing security roles

Access to enterprise bean methods is based on the concept of **security roles**.

About this task

These are described in “Security roles” on page 338.

To implement the use of security roles in a CICS enterprise bean environment, you must:

1. Determine which security roles are defined in the application's deployment descriptor.
2. Determine the display names associated with the security roles in the application's deployment descriptor. The display name qualifies the security role at the application level.
3. Decide whether you need to qualify the security role name at the system level, and — if you do — the value of the prefix which you will use in each system where the application executes.
4. Using the information gathered in steps 1 through 3, determine the names of the deployed security roles used by the application in each system. Characters in the security role and display name that do not have a direct equivalent in EBCDIC code page 37 (and some other characters) must be replaced with a different character or an escape sequence when constructing the deployed security role. See “Character substitution in deployed security roles” on page 340 for more information.
5. Using the information gathered in steps 1 through 3, define RACF profiles for the deployed security roles. See “Defining security roles to RACF” on page 345 for more information.
6. Associate individual users or groups of users with each deployed security role in RACF. See “Defining security roles to RACF” on page 345 for more information.
7. Specify these system initialization parameters:
   - `SEC=YES`
   - `XEJB=YES`. This is the default value, so you do not need to specify it explicitly.
8. For those systems where the deployed security roles contain a system level qualifier (see step 3), specify the EJBROLEPRFXEJBROLEPRFX system initialization parameter.

Using the RACF EJBROLE generator utility:

The RACF EJBROLE generator utility, dfhreg, is a Java application program that extracts security role information from deployment descriptors, and generates a REXX program that you can use to define security roles to RACF.

The REXX program that dfhreg generates contains the RACF commands that define security roles as members of a profile in the GEJBROLE class. Before you run the REXX program, modify it to change the name of the profile that is defined.

The dfhreg invocation scripts for z/OS UNIX (`dfhreg`) and for Windows (`dfhreg.bat`) are in the `$CICS_HOME/lib/security` directory. The implementation of dfhreg (`dfhreg.jar`) is also in this directory. The other JAR files required to run dfhreg (`dfjcsi.jar`, `dfjejbdd.jar`, and `dfjorb.jar`) are in the `$CICS_HOME/lib` directory. `$CICS_HOME` is the z/OS UNIX directory in which you have installed the USS components of CICS.

You can run dfhreg on any platform that supports Java; however, you must run the resulting REXX program against the RACF database on the z/OS system where you want to define the security roles. When you run dfhreg, you must meet the following requirements:

1. Your classpath must contain the following JAR files:
   ```
   dfhreg.jar
   dfjcsi.jar
   dfjejbdd.jar
   dfjorb.jar
   ```
2. You must be using a supported version of the Java 2 SDK.

The REXX program that the utility generates is in the code page of the platform on which you run the utility. If you run the utility on a platform that uses an ASCII code page, you must convert the REXX program to the EBCDIC code page that is used on the target z/OS system.

Defining security roles to RACF:

In RACF, deployed security roles are managed as general resources. To define the deployed security roles, define profiles in the GEJBROLE or EJBROLE resource classes, with appropriate access lists.

For example, to use the following commands to define deployed security roles `deployed_security_role_1`and `deployed_securityrole_2` as members of the `securityrole_group` profile in the GEJBROLE class, and give READ access to `user1` and `user2`:

```
RDEFINE GEJBROLE securityrole_group UACC(NONE)
                 ADDMEM(deployed_security_role_1, deployed_securityrole_2, ...)
                 NOTIFY(sys_admin_userid)
PERMIT securityrole_group CLASS(GEJBROLE) ID(user1, user2) ACCESS(READ)
```

Alternatively, use the following commands to define deployed security roles in the EJBROLE class, and to give users READ access to each deployed security role:

```
RDEFINE EJBROLE (deployed_security_role1, deployed_security_role2, ...) UACC(NONE)
                 NOTIFY(sys_admin_userid)
PERMIT deployed_security_role1 CLASS(EJBROLE) ID(user1, user2) ACCESS(READ)
PERMIT deployed_security_role2 CLASS(EJBROLE) ID(user1, user2) ACCESS(READ)
```

Note:

1. The security role you specify is the deployed security role, and not the unqualified security role which is defined in the deployment descriptor.
2. To execute a bean method, or to receive a `true` response from the isCallerInRole() method, a user requires READ access.

CICSPlex SM with enterprise beans

The management of enterprise beans may be undertaken at a CICSplex wide level.

CICSPlex SM support for enterprise beans

The management of enterprise beans can be undertaken at a CICSplex wide level, by using the Operator and API services of CICSPlex SM.

The function provided by CICSPlex SM for the support of Enterprise JavaBeans includes:

- Object management for CorbaServer and DJAR definitions
- Object management for installed CorbaServer and DJAR instances
- Dynamic management of enterprise bean execution

The CICSPlex SM areas that cover these facilities are:

- The application programming interface (API) - to allow the definition, inquiry, and management of enterprise bean objects through the **EXEC CPSM** interface. See the *CICSPlex System Manager Application Programming Guide* for information.
- The web user interface - to allow the inquiry and management of enterprise bean objects through a web browser. See the *CICSPlex System Manager Web User Interface Guide* for information about the Web User Interface.

CICSPlex SM definition support for enterprise beans

Business Application Services (BAS) is the CPSM component concerned with the definition and installation of CICS resources

For more information on BAS, see the *CICSPlex System Manager Managing Business Applications* manual. The BAS objects that are specific to Enterprise JavaBeans are:

- EJCODEF—enterprise bean CorbaServer definition
- EJDJDEF—enterprise bean CICS-deployed JAR file definition

The CorbaServer definition object (EJCODEF) allows the specification of exactly the same CorbaServer characteristics as the CEDA version. EJCODEF is described in Defining CorbaServers using BAS, in the *CICSPlex System Manager Managing Business Applications* manual

The CICS-deployed JAR file definition object (EJDJDEF) allows the specification of exactly the same DJAR characteristics as the CEDA version. EJDJDEF is described in Defining a CICS-deployed JAR file using BAS, in the *CICSPlex System Manager Managing Business Applications* manual.

These resources are fully integrated into the standard BAS functionality, and they may be managed and installed automatically, or on an ad hoc basis as a user may require.

In addition to these two object types, there are some other BAS objects that are related to enterprise bean operation:

- TCPDEF—TCPIPSERVICE definition
- RQMDEF—REQUESTMODEL definition
- TRANDEF—CICS TRANSACTION definition
- PROGDEF—PROGRAM definition

Enterprise bean execution requests from clients reach the CICS listener region through a TCP/IP port. If using BAS, the number of this port must be specified through a TCPDEF object that should be installed at all listener regions expected to respond to these calls. The content of a TCPDEF should mirror that specified for the CEDA TCPIPSERVICE definition. See “Setting up TCP/IP for IIOP” on page 374 for information.

If users require the execution requests for specific enterprise beans to be recognized and managed differently to that for generic enterprise bean executions, then a request model may be used to associate it with a user specified transaction code. Within CICSPlex SM, request models are defined through RQMDEF objects, and should be installed on all listener regions where such requests need interception. Depending on the complexity of the enterprise bean, it may be necessary to additionally install the request models on the associated AORs. The contents of these RQMDEFs should mirror that specified for the CEDA REQUESTMODEL definition. See “Obtaining a CICS TRANSID” on page 385 for information.

In a distributed enterprise bean processing environment, it would be expected that certain CICS regions will act as listeners to receive the IIOP execution requests, and others will act as the AORs, to provide the actual EJB environment for execution of the required enterprise beans. The CICSPlex SM TRANDEF object is a particularly powerful tool to employ here, because a single transaction definition object may be installed both dynamically on the Listener regions, and statically on the AORs, through a single BAS resource assignment (RASGNDEF), as described in Resource assignments, in the *CICSPlex System Manager Managing Business Applications* manual.

BAS logical scope considerations

One of the benefits of using BAS to define and install user business application suites, is that users may then scope their object views to the resources pertinent to their installed application instances.

For example, if a business application comprises of a particular set of files, transactions, and programs, the LOCTRAN, LOCFILE and PROGRAM views will be isolated to instances of only the matching objects on the regions where they are installed. The facility to allow this restricted object view is known as "logical scoping". The CorbaServer and DJAR objects may participate in logical scoping in exactly the same way as other traditional BAS definitions.

Note: Enterprise beans are not defined to CICS as such. They become identified to CICS when their associated DJARs come into service after installation in a CICS region. Therefore, enterprise beans may "adopt" a logical scope through the association of their DJAR. However, the Enterprise JavaBean specification allows the enterprise beans for different applications, to be installed in a single DJAR. If you follow this practice, it will be impossible for the logical scope process to differentiate between the installed enterprise beans and the appropriate business application names. As such, if users want to exploit BAS logical scoping to augment their CICSPlex views of enterprise bean objects, separate DJARs should be employed to contain enterprise beans discrete to the scoped business applications.

Migration of enterprise bean components

CICSPlex SM provides a toolset to assist users in migrating their RDO (resource definition online) objects from the CICS CSD to the CICSPlex SM data repository.

This toolset comprises an exit program for the CICS offline CSD utility program, and some sample JCL to execute it: see Extracting records from the CSD, in the *CICSPlex System Manager Managing Business Applications* manual.

This CICSPlex SM exit will recognise CORBASERVER and DJAR definitions in a CSD, and generate the appropriate BAS CREATE EJCODEF and CREATE EJDJDEF statements, for input via the CICSPlex SM BatchRep process. All of the normal selection rules for resource identification may be applied to these EJB resource types.

CICSPlex SM inquiry support for enterprise beans

Installed CorbaServer and DJAR instances may be managed by CICSPlex SM through any of the three interfaces described in "CICSPlex SM support for enterprise beans" on page 345. All of the interactive operator services provided through the CICS CEMT and CEOT transactions are functionally replicated in CICSPlex SM via the Web user Interface (WUI). In either case, the installed CICS objects mapped by CICSPlex SM are:

- EJCOSE—CorbaServer instances
- EJDJAR—CICS-deployed JAR file instances

Additionally, any executable enterprise beans may be listed through these objects:

- EJCOBEAN—Enterprise JavaBeans directly associated with a CorbaServer
- EJDJBEAN—enterprise beans directly associated with a DJAR

Both of these objects describe an enterprise bean structure: one is keyed through a CorbaServer name, and the other is keyed through a DJAR id. In both cases, the only enterprise bean content available for inquiry is the CorbaServer name, the DJAR name, and the enterprise bean name up to 240 characters in length. The Enterprise JavaBean specification states that enterprise bean names may be much longer, but the CICS implementation limits them to 240 bytes. An additional detail that CICSPlex SM inquiries provide over a standard CICS inquiry is a count of the available beans in any given DJAR or CorbaServer. When a new set of enterprise beans are deployed via a DJAR to a particular CorbaServer, the enterprise bean count can provide an instant confirmation as to the availability of the enterprise beans in question. The value is incremented according to the number of enterprise beans accepted through the DJAR installation process.

Other Enterprise Java associated CICS objects that are inquirable through CPSM are:

- TCPIPS - TCPIPSERVICE instances
- RQMODEL—REQUESTMODEL instances
- LOCTRAN—local transaction instances
- UOWORK—unit of work instances
- UOWLINK—unit-of-work-link (UOWLINK) instances
- PROGRAM—program instances

All of these objects include attributes which have relevance to the management and execution of enterprise beans.

Types of inquiry available for enterprise bean objects

There are several ways to inquire on the state of your EJB objects with CICSPlex SM.

The CICSPlex SM Application Programming Interface

To inquire on EJB objects using the available CICSPlex SM API commands, refer to the *CICSPlex System Manager Application Programming Reference*. Also refer to the details of the attributes and actions that are allowed against each CICSPlex SM object in the *CICSPlex System Manager Resource Tables Reference Vol 1*.

The CICSPlex SM Web User Interface

To inquire on EJB objects using the WUI, refer to the *CICSPlex System Manager Web User Interface Guide*.

The Web User Interface has a starter set that comprises a set of menus and panels. This starter set includes a set of Enterprise Java component views.

Using CICSPlex SM to manage EJB workloads

One of the standard CICSPlex SM component functions is the facility for balancing and separating CICS transactions in an MRO environment, known as workload management (WLM).

This facility is well suited to the management of EJB workloads, where the enterprise beans are executed in a distributed, or logical CorbaServer, environment. In its most simple configuration, CICSPlex SM can balance an enterprise bean execution workload across a series of application owning regions (AORs), depending on performance targets and stability algorithms established by user definitions. These functions are implemented when the CICSPlex SM supplied distributed routing exit program (EYU9XLOP) is named as the DSRTPGM parameter in the system initialisation parameters of participating listeners and AORs (see Balancing an enterprise bean workload, in the *CICSPlex System Manager Managing Workloads* manual).

The algorithms used by CICSPlex SM to select suitable AORs for enterprise bean execution has been established and tuned since the inception of the product. However, users may choose to develop their own routing algorithm program, and replace the supplied CICSPlex SM version (EYU9WRAM) if they require to do so.

Workload routing:

CICSPlex SM workload routing provides function that selects the most suitable AOR to host the execution of an enterprise bean, according to predetermined selection criteria.

The AOR selection process evaluates all concurrent execution activity, over the regions designated as possible routing targets, and selects the most suitable region in terms of execution workload, and region stability at the point of inquiry. This is *not* the same as the cyclic selection of an AOR from all those available in a target scope for serially executed beans. It *is* the evaluation of all active transactions in the WLM scope at the time when a new transaction (enterprise bean) is about to be run, and the selection of the least loaded, or most stable, region to host the object execution. The implementation of basic workload routing for all Enterprise Java bean throughput has the following prerequisites:

- The necessary TCP/IP definitions are installed on the designated listener regions.
- DSRTPGM=EYU9XLOP is specified as a SIT parameter on all listeners and AORs.
- MASPLTWAIT(YES) is included as an EYUPARM on all of the listener regions.
- The request processor transaction (the default transaction is CIRP) has been dynamically defined to the listener regions and statically defined to the AORs.
- The necessary CorbaServer and DJAR definitions are installed (either through BAS or CEDA) to establish the executable EJB environment.
- The enterprise beans have been deployed and are in service.

When these criteria have been met, you define a workload specification object (WLMSPEC) and specify the AORs as the target scope. You can then install the WLMSPEC object on all listeners and AORs that are to join the workload. When the WLMSPEC has been installed, all regions encompassed by it will have their EJB workloads routed after they have been restarted. A detailed example of enterprise bean workload routing is given in Balancing an enterprise bean workload, in the *CICSPlex System Manager Managing Workloads* manual.

Workload separation:

Workload separation is the workload management (WLM) function that causes transactions that meet predesignated selection criteria to be routed to specific target scopes.

The target scope for a separated workload item might vary from a single application owning region (AOR) to a large AOR group comprising many CICS regions. If an AOR group is the target, the routing algorithm will be applied to select the most suitable region from those defined to it. To implement a workload that includes separated enterprise beans, you must first establish the prerequisite workload routing described in "Workload routing" on page 349. That configuration needs to be augmented with the following additional components:

- A cloned CIRP transaction for each enterprise bean that needs to be separated (a simple copy of the existing definition to a new name)
- A request model for each enterprise bean to be separated, to associate it with one of the cloned CIRP transactions

This allows the CICS and EJB environments to be established, enabling enterprise bean separation. The WLM definitions will then need to be created to implement it. This entails identifying the cloned CIRP transactions as being objects of interest, and associating them with the required target scopes through a series WLM definitions. These WLM definitions must be associated to an overall WLM specification, via an intermediate WLM group, and then the specification must be added to the CICS group that includes all listeners and AORs that are to participate in the workload. A detailed example of enterprise bean workload separation is given in Separating enterprise beans in a workload, in the *CICSPlex System Manager Managing Workloads* manual.

CICSPlex SM resource monitoring for enterprise beans

CICSPlex SM monitoring allows the collection of performance-related data, at user-defined intervals, for named resource instances within a set of CICS systems.

Currently, no performance-related data is recorded for specific EJB objects (CorbaServers and DJARs). However, performance data for the IIOP request receiver and request processor transactions are available as normal, and so the execution performance of enterprise beans may be monitored through an associated transaction code (see the *CICSPlex System Manager Monitor Views Reference*). Users will require request models and CIRP clones for each bean that needs to be monitored, in the same way as for enterprise bean workload separation, described in "Workload separation." However, CICSPlex SM monitoring is not integrated with BAS logical scoping, so your monitor views scope should be set to the physical CICS group that covers the regions to be monitored, rather than the BAS resource description that installed the transaction definitions. An overview of the monitoring function is given in Collecting statistics using CICSPlex SM monitoring, in the *CICSPlex System Manager Concepts and Planning* manual. Full details of the monitoring function is given in Preparing to monitor resources, in the *CICSPlex System Manager Managing Resource Usage* manual.

CICSPlex SM real-time analysis considerations for enterprise beans

The real-time analysis (RTA) function of CICSPlex SM provides the automatic and external notification of conditions in which users have expressed an interest.

Real-time analysis may be divided between several sub-components:

- System Availability Monitoring (SAM) - monitors CICS regions during their planned hours of availability, and generates notifications when no responses are received from a region that is expected to be active.
- MAS Resource Monitoring (MRM) - monitors the state of any inquirable CICS resource, and generates notifications when that state varies from a predetermined norm.
- Analysis Point Monitoring (APM) - replicates the function of MRM, except that it analyses states at a CICSplex level, rather than at a specific CICS region. APM is particularly useful in environments that use cloned AORs, where regions are identical and one notification is sufficient to alert you to a general problem.

Clearly SAM is a useful function for reporting the availability of CICS regions, regardless of whether they are designated listeners or AORs. If you are executing enterprise beans in a distributed environment, then MRM may be more useful for monitoring the state of CorbaServers and DJARs, rather than the region based functions of APM. However, be aware that you cannot monitor enterprise bean objects themselves (EJCOBEAN and EJDJBEAN) within RTA. Enterprise bean inquiries may be keyed only on their corresponding CorbaServer or DJAR names. Specific inquiries may not be made solely on the enterprise bean name. An overview of the RTA function is given in Exception reporting using real-time analysis (RTA), in the *CICSPlex System Manager Concepts and Planning* manual. Full detail of the RTA function is given in Preparing to perform real-time analysis, also in the *CICSPlex System Manager Managing Resource Usage* manual.

CICS and IIOP

This section tells you what you need to know to configure CICS to support distributed IIOP applications.

- "IIOP support in CICS"
- "The IIOP request flow" on page 354
- "Configuring CICS for IIOP" on page 362
- "Processing IIOP requests" on page 381

IIOP support in CICS

The Internet Inter-ORB protocol (IIOP) is a TCP/IP based implementation of the General Inter-ORB Protocol (GIOP) that defines formats and protocols for distributed applications.

It is part of the Common Object Request Broker Architecture (CORBA). Both client and server systems require a CORBA Object Request Broker (ORB) to implement IIOP interoperability.

The Common Object Request Broker Architecture (CORBA) is a specification for a standard object-oriented architecture for distributed applications. It was defined by a consortium of over 500 information technology organizations called The Object Management Group (OMG). You can read the CORBA *Architecture and Specification* document at their Web site: http://www.omg.org/

CICS provides an ORB and support for IIOP defined by CORBA 2.3.

The Object Request Broker (ORB)

CORBA uses a **broker**, or intermediary, to handle requests between clients and servers in the system. The broker chooses the best server to meet the client's request and separates the **interface** that the client sees from the **implementation** of the server.

The broker, known as the ORB, intercepts client method calls and is responsible for finding objects that can implement requests, passing them parameters, invoking their methods, and returning results. The client does not need to know where the object is located, its programming language, its operating system, or any other system aspects that are not part of the object's interface.

In this way, the ORB provides interoperability between applications on different machines in heterogeneous distributed environments, and interconnects multiple object systems.

The CICS ORB implements the following level of function:
- Support for CORBA Version 2.3, *except for*:
  - Stateful CORBA objects (only stateless CORBA objects are supported).

    Note: The only exception to this rule is stateful session beans—which *are* supported.
  - The Dynamic Invocation Interface (DII).
  - The Dynamic Skeleton Interface (DSI).
  - GIOP 1.1 fragments.
  - The Portable Object Adapter (POA).
  - Bi-directional GIOP
- Support for IIOP 1.2—including GIOP 1.2 fragments.
- Support for both inbound and outbound IIOP requests. IIOP applications can act as both client and server.
- Support for **transactional objects**. CICS method invocations may participate in Object Transaction Service (OTS) distributed transactions. If a client calls an IIOP application within the scope of an OTS transaction, information about the transaction flows as an extra parameter on the IIOP call. If the client ORB sends an OTS Transaction Service Context and the target stateless CORBA object implements `CosTransactions::TransactionalObject`, the object is treated as transactional.

  Note: An **OTS transaction** is a distributed unit of work, not a CICS transaction instance or resource definition. For a description of a CICS transaction, see "CICS transactions" on page 25.

ORB function is implemented in CICS by:
- The CICS sockets domain listener
- The CICS IIOP request receiver
- The CICS IIOP request processor

CICS IIOP application models

IIOP applications are client/server object-oriented programs that run in a TCP/IP network.

CICS supports the following types of IIOP application:

`Stateless CORBA objects`

Stateless CORBA objects are Java server applications that communicate with a client application using the IIOP protocol. No state is maintained in object attributes between successive invocations of methods; state is initialized at the start of each method call and referenced by explicit parameters.

Stateless CORBA objects can receive inbound requests from a client and can also make outbound IIOP requests.

CICS stateless CORBA objects execute in a CICS JVM.

You can read more about CICS stateless CORBA objects in “Stateless CORBA objects” on page 195.

Enterprise beans

Enterprise beans are portable Java server applications that use interfaces defined by *Enterprise JavaBeans Specification, Version 1.1*. CICS has implemented these interfaces by mapping them to underlying CICS services.

Enterprise beans communicate using the Java Remote Method Invocation (RMI) interface. CICS supports RMI over IIOP, mediated by a CORBA Object Request Broker (ORB).

Enterprise beans can link to other CICS programs using the **CCI Connector for CICS TS**. You can also develop enterprise beans that use the JCICS class library to access CICS services or programs directly, but these server applications are not portable to a non-CICS platform.

Enterprise beans run in a pooled JVM.

You can read more about enterprise beans in “What are enterprise beans?” on page 214.

Some common CORBA terminology

These terms are used throughout this information segment.

CORBA
The Common Object Request Broker Architecture. An architecture and a specification for distributed, object-oriented, computing.

GIOP The General Inter-Orb Protocol. The CORBA data representation specification and interoperability protocol. It defines how different ORBs communicate; it does not define which transport protocol to use.

IDL Interface Definition Language. A definition language that is used in CORBA to describe the characteristics and behavior of a kind of object, including the operations that can be performed on it.

IIOP The Internet Inter-Orb Protocol. Defines how to send GIOP messages over a TCP/IP transport layer. IIOP is GIOP over TCP/IP.

Interface
Describes the characteristics and behavior of a kind of object, including the operations that can be performed on those objects. This maps to a Java **class**. In CORBA terminology, the client request specifies, in IDL, an interface that defines the server object.

IOR Interoperable Object Reference. A “stringified” reference to a remote CORBA object. It is published by the server ORB. The client application must have access to the IOR at runtime. The client ORB can deconstruct the IOR to determine (among other things) the location of the remote ORB and object, the maximum version of GIOP supported by the remote ORB, and any relevant CORBA services supported by the remote ORB.

Module
An IDL packaging construct containing interfaces. This maps to a Java **package**.

OMG The Object Management Group. The consortium of software organizations that has defined the CORBA architecture.

Operation
An action that can be performed on an object. This maps to a Java method.

In CORBA terminology, the client requests an operation, defined in IDL, that is mapped to a method on the server object.

ORB The Object Request Broker. A CORBA system component that acts as an intermediary between the client and server applications. Both client and server platforms require an ORB; each is tailored for a specific environment, but supports common CORBA protocols and IDL.

RMI-IIOP
The Remote Method Invocation (RMI) over IIOP specification and protocol. The specification defines how to make the Java-specific RMI application architecture inter-operate, using CORBA protocols. This is the communication protocol used by enterprise beans.

Skeleton
A piece of code generated by the server IDL compiler. It is used by the server ORB to parse a message into a method call on a local (to the server) object.

Stub or proxy
A piece of code generated by the client IDL or RMI compiler. It is used by the client application to invoke methods on the remote object. The stub class calls methods on the client ORB, which in turn sends remote method requests to the server ORB. The stub class must be generated for the specific client ORB it is to be used with. If you use client ORBs from different vendors, you should ensure that you are using client-side stubs generated using the tools provided with the correct client ORB.

Tie A piece of code generated by the RMI compiler. It is used by the server ORB to parse a message into a method call on a local (to the server) object.

The IIOP request flow

This diagram shows the execution flow of an incoming request.

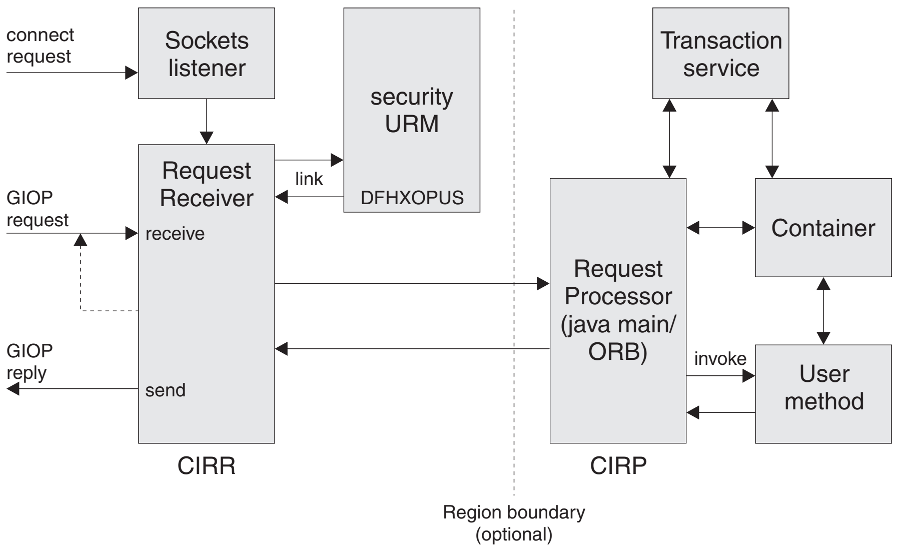


Figure 34. IIOP request execution flow

The TCP/IP listener

The CICS TCP/IP listener monitors specified ports for inbound requests. You specify IIOP ports and configure the listener by defining and installing TCPIPSERVICE resources.

The listener receives the incoming request and starts the transaction specified in the TCPIPSERVICE definition for that port. For IIOP services, this transaction resource definition must have the program attribute set to DFHIIRRS, the request receiver program. The default transaction name is CIRR.

Request receiver

The request receiver retrieves the incoming request and examines the contents of the GIOP formatted message stream. The following GIOP message types can be received and are handled as follows:

Request

- A CICS USERID is determined from Secure Sockets Layer (SSL) parameters, or by calling a CICS user-replaceable program specified by the TCPIPSERVICE resource definition. The CICS USERID is used for authorization of the request by the request processor.
- A CICS TRANSID is determined, from the message content, by comparison with installed REQUESTMODEL resource definitions. The CICS TRANSID defines execution parameters that are used if a new request processor instance is created to handle the request.
- The request is passed to the request processor using an associated **request stream**, which is an internal CICS routing mechanism. The object key in the request, or any transaction service context, determines if the request must be sent to an existing processor.

  Note: A *transaction* in this context means a unit of work defined and managed using the **Object Transaction Service** (OTS) specification.

  The request-handling logic uses a directory to determine if an IIOP request should be routed to an existing request processor instance (by means of its associated request stream). The directory, DFHEJDIR, relates request streams (and request processor instances) to OTS transactions and the object keys of stateful session beans that manage their own transactions. DFHEJDIR is a recoverable CICS file.
- Incoming GIOP 1.1 Fragments are rejected with a GIOP MessageError message.

LocateRequest

Locate requests have no **operation** or parameters. They are passed to a new instance of the request processor.

CancelRequest

A cancel request notifies a server that the client is no longer expecting a reply to a specified pending Request or LocateRequest message. This is an advisory message only, no reply is expected. A cancel request received during fragment processing causes the request in progress to be terminated. All other cancel requests are ignored.

MessageError

A message error indicates that the client has not recognized a reply that the request receiver has sent to it. This error is recorded for diagnostic purposes and a CloseConnection message sent to end the connection.

Fragments
: A fragment is a continuation of a Request or a Reply. It contains a GIOP message header followed by data. Incoming GIOP 1.1 fragments are rejected with a GIOP MessageError message.

Linkage from the request receiver to the request processor can exploit CICS dynamic routing services to provide load balancing within the CICSplex.

The CIRR request receiver terminates when it has no further work to do. (That is, CIRR terminates when there are no outstanding GIOP requests to read from the TCPIPSERVICE and no outstanding responses to send from earlier requests. Should further workload arrive for the TCPIPSERVICE after the CIRR task has been terminated, a new CIRR task is started.)

Request processor

The request processor manages the execution of the IIOP request. It :

- Locates the object identified by the request
- For an enterprise bean request, calls the container to process the bean method
- For a request for a stateless CORBA object, processes the request itself (although the transaction service may also be involved)

The request processor instance that handles each IIOP request is configured by a CORBASERVER resource definition.

IIOP in a sysplex

You can implement a CICS CORBA server in a single CICS region. However, in a sysplex you probably want to create a server that consists of multiple regions.

With multiple regions, failure of a single region is less critical, and you can use workload routing. A CICS logical server consists of one or more CICS regions configured to behave like a single server.

Typically, a CICS logical server consists of the following:

- A set of cloned listener regions defined by identical TCPIPSERVICE resource definitions to listen for incoming IIOP requests.
- A set of cloned application-owning regions (AORs), each of which supports an identical set of IIOP applications or enterprise bean classes in an identically-defined CORBA server. Multiple methods for the same OTS (object transaction service) transaction are directed to the same AOR. Each AOR must have TCPIPSERVICE definitions that match those in the corresponding listener regions.

The listener regions and AORs can be separate, or they can be combined into listener AORs. You must specify the following system initialization parameters:

IIOPLISTENER=YES
: Specify this value in a listener region, or in a combined listener AOR. YES is the default value.

IIOPLISTENER=NO
: Specify this value in an AOR that is not also a listener region.

Workload routing of IIOP requests

To route client connections across listener regions, you can use either IP routing, or connection optimization by using Domain Name System (DNS) registration. To route object transaction service (OTS) transactions across a set of cloned application owning regions (AORs), you use distributed routing. To implement distributed routing, you can use either CICSPlex SM or a customized version of the CICS distributed routing program, DFHDSRP.

Domain Name System (DNS) connection optimization

Connection optimization is a technique that uses DNS to balance IP connections in a sysplex domain. With DNS, multiple CICS systems are started to listen for IIOP requests on the same port (using Virtual IP addresses), and registered with MVS Workload Manager (WLM). Each client IIOP request contains a generic host name and port number. This host name is resolved to an IP address by DNS and WLM services.

Connection Optimization using WLM is described in the *z/OS Communication Server: IP Configuration Guide*.

Distributed routing

Distributed routing is used to route method calls for enterprise beans and CORBA stateless objects across a set of CICS AORs. The dynamic selection of the target is made by the workload manager (CICSPlex SM or a user-written distributed routing program) that selects the least loaded or most efficient application region. CICS invokes the workload manager for method requests that will run under a new, or no, OTS transaction, but not for method requests that will run under an existing OTS transaction; these are directed automatically to the AOR in which the existing OTS transaction runs. See Writing a distributed routing program , in the *CICS Customization Guide*, for guidance on writing a customized distributed routing program. See Workload management and dynamic routing, in the *CICSPlex System Manager Managing Workloads* manual, for information about CICSPlex SM Workload Management.

The following diagram shows a CICS logical server. In this example, the listener regions and AORs are in separate groups, connection optimization is used to balance client connections to the listener regions, and distributed routing is used to route OTS transactions across the AORs.

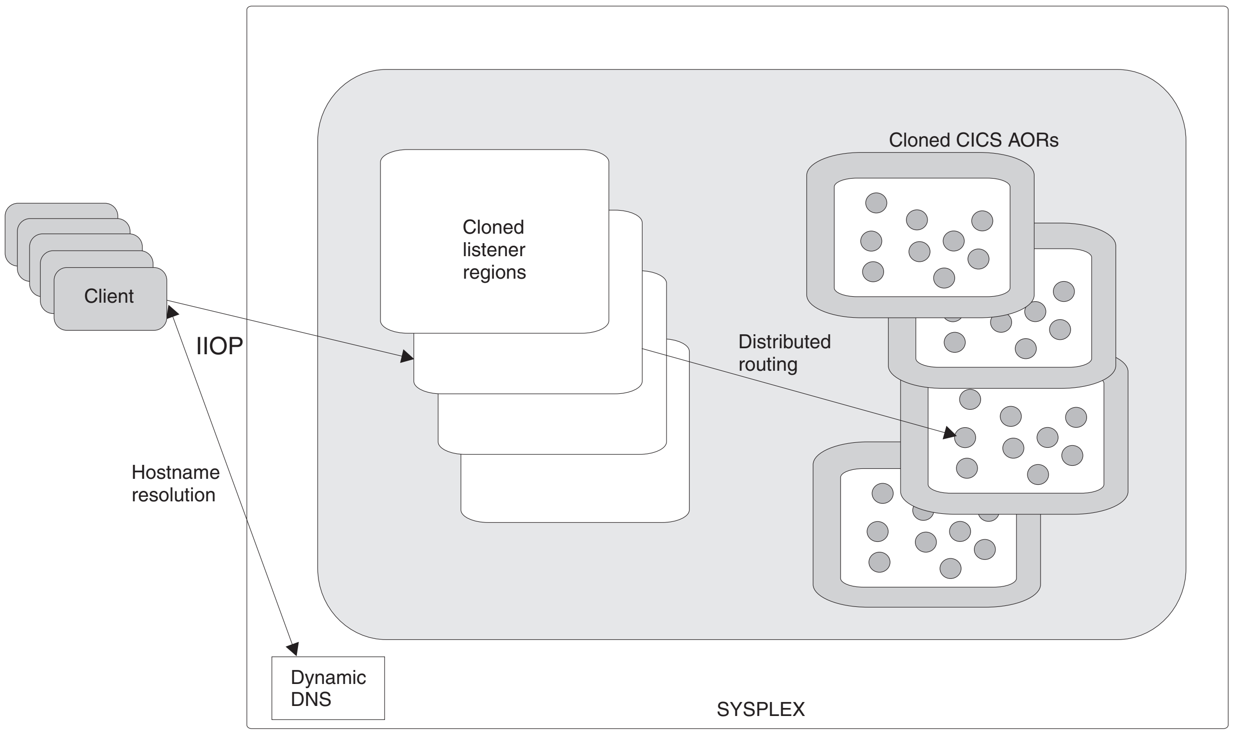


Figure 35. A CICS logical server. In this example, the logical server consists of a set of cloned "listener" regions and a set of cloned AORs. Connection optimization by means of dynamic DNS registration is used to route client connections to the listener regions. Distributed routing is used to balance OTS transactions across the AORs.

Domain Name System (DNS) connection optimization

Connection optimization is a technique that uses DNS to balance IP connections and workload in a sysplex domain.

In DNS terms, a sysplex is a subdomain that you add to your DNS namespace. Connection optimization extends the concept of a "DNS host name" to clusters, or groups of server applications or hosts. Server applications within the same group are considered to provide equivalent service. Connection optimization uses load-based ordering to determine which addresses to return for a given cluster.

Connection optimization registration:

Server applications register with the MVS Workload Manager (WLM), which quantifies the availability of server resources within a sysplex.

The WLM must be configured in goal mode on all hosts within the sysplex. TCP/IP stacks can also register with the WLM to provide information on the started IP addresses, or static definitions can be used if stacks do not support registration. When registering, server applications provide the following information:

`Group name`
This is the name of a cluster of equivalent server applications in a sysplex. It is the name within the sysplex domain that client applications use to access the server applications. CICS uses the DNSGROUP parameter of the TCPIPSERVICE resource definition as the group name to register with the WLM.

Server name
This is the name of the server application instance. The server name must be unique among all servers that share the same group name. A server application instance can belong to more than one group. CICS registers with WLM using the specific APPLID of the region as specified by the APPLID system initialization parameter.

Host name
This is the host name of the TCP/IP stack on which the server application runs. During startup, CICS calls the TCP/IP function *gethostbyaddr* to determine the host name of the machine on which it is running, and passes it to the WLM for registration.

Name resolution example:

This example shows a CICSplex consisting of four CICS regions, each running on separate machines within a sysplex.

The MVS systems are named MVS1A, MVS1B, MVS1C and MVS1D, with the CICS

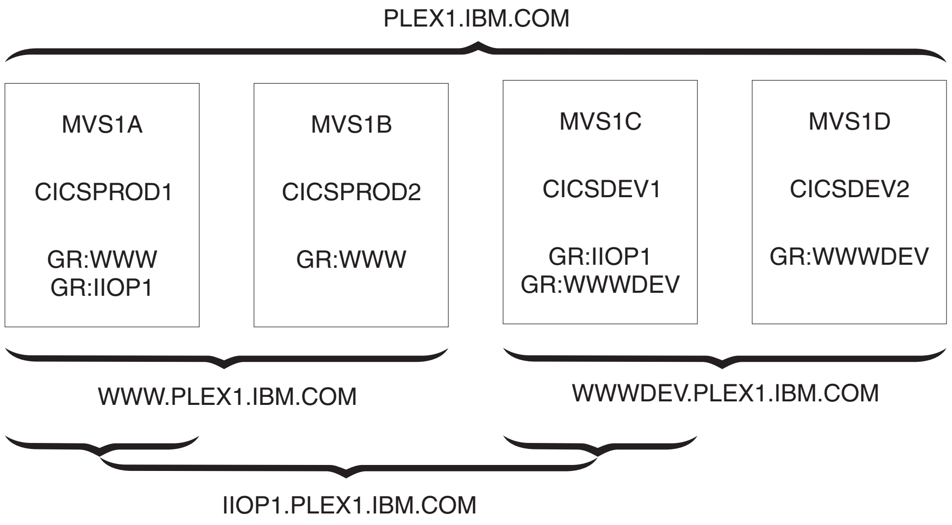


Figure 36. CICSplex using DNS connection optimization

regions having APPLIDs of CICSPROD1, CICSPROD2, CICSDEV1 and CICSDEV2

The sysplex is defined to the DNS to have the name PLEX1 and each MVS machine has a single IP address. The diagram describes the names that a client machine might use to access the CICS regions based on the following resource definitions installed on each CICS:

- The region CICSPROD1 running on machine MVS1A has two TCPIPSERVICE resources, one specifying a group_name of WWW and the second specifying a group_name of IIOP1.
- The region CICSPROD2 running on machine MVS1B has one TCPIPSERVICE resource, specifying a group_name of WWW.
- The region CICSDEV1 running on machine MVS1C has two TCPIPSERVICE resources, one specifying a group_name of IIOP1 and the second specifying a group_name of WWWDEV.
- The region CICSDEV2 running on machine MVS1D has one TCPIPSERVICE resource, specifying a group_name of WWWDEV.

The client can access the following names:

- PLEX1.IBM.COM returns the IP address of any of the machines in the sysplex.
- WWW.PLEX1.IBM.COM returns either the address of MVS1A or MVS1B.
- IIOP1.PLEX1.IBM.COM returns either the address of MVS1A or MVS1C.
- WWWDEV.PLEX1.IBM.COM returns either the address of MVS1C or MVS1D.

You can also address individual CICS regions within a group by using their APPLIDs (or server names). For example, CICSPROD1.WWW.PLEX1.IBM.COM returns the address of MVS1A. This address is equivalent to MVS1A.PLEX1.IBM.COM, but the client does not have to know the machine on which the CICSPROD1 server is running, only that CICSPROD1 is part of the WWW group.

Since these names dynamically become available as CICS regions register with the WLM, adding more CICS regions and more MVS machines does not result in any more administration. Using the generic host names (such as WWWDEV.PLEX1.IBM.COM) decouples client applications from specific CICS regions and MVS hosts, which enhances availability and scalability.

Resource definition for DNS connection optimization:

These TCPIPSERVICE options must be defined for TCP/IP ports that use DNS connection optimization.

`DNSGROUP`
: specifies the location parameter passed on the IWMSRSRG register call to Workload Manager. The value may be up to 18 characters in length, with trailing blanks ignored.

  This parameter is referred to as `group_name` by the OS/390 TCP/IP DNS documentation. It is the generic name of a cluster of equivalent server applications in a sysplex. It is also the name within the sysplex domain that clients use to access the CICS TCPIPSERVICE.

  More than one TCPIPSERVICE is allowed to specify the same group name.

  The register call is made to WLM when the first service with this group name specified is opened. Subsequent services with the same group name do not cause more register calls to be made.

  The deregister action is dictated by the GRPCRITICAL attribute, as described below. It is also possible to explicitly deregister CICS from a group by issuing the master terminal (CEMT) or **`EXEC CICS`** command **`SET TCPIPSERVICE DNSSTATUS DEREGISTERED`**, or by using the equivalent CICSPlex SM command.

`GRPCRITICAL`
: marks the service as a critical member of the DNS group such that this service closing or failing causes a deregister call to be made to WLM for this group name.

  The default is NO, allowing two or more services in the same group to fail independently and CICS still to remain registered to the group. Only when the last service in a group is closed is the deregister call made to WLM, if it has not already been done so explicitly.

  Multiple services with the same group name can have different grpcritical settings. The services specifying GRPCRITICAL(NO) can be closed or fail without causing a deregister. If a service with GRPCRITICAL(YES) is closed or fails, the group is deregistered from WLM.

To implement DNS connection optimization for IIOP requests (including requests for enterprise beans), the following CORBASERVER options must be defined:

- The HOSTNAME option of the CORBASERVER definition must specify a generic host name. This generic hostname is the DNSGROUP value from the TCPIPSERVICE definition, suffixed by the domain or subdomain name managed by the nameserver on MVS. This domain name is established by the TCP/IP administrator. For example, in the previous example, WWW.PLEX1.IBM.COM could be used to route to CICSPROD1 and CICSPROD2.
- The CORBASERVER with the generic hostname (or the DJARS within it) must be published to the nameserver.

The nameserver must be configured to allow it to look up and resolve the generic host name.

Avoiding Domain Name System (DNS) problems:
Important

To avoid difficulties in using nameservers, you should be aware of the following:

- Lookups for dynamic names should not be cached. If you use a client that caches nameserver lookup results you cannot be certain that you continue to work with the correct IP address. This might result in the client continuously attempting to call a server region that has been closed, rather than obtaining the address of another server region that has taken over the role previously fulfilled by the other server.
- A problem can arise due to stress on the nameserver being used. Some lookups succeed, others fail with a `NameNotFoundException`.

  When the number of concurrent lookups becomes high, perhaps when a client or bean does repeated lookups without caching, the likelihood of encountering one of these nameserver "blips" increases. Possible measures to consider are:
  - Install a machine of higher capacity to run the name server.
  - Code your applications to recognize this possibility and to retry when this error is encountered.
  - Setup the MVS system so that the most commonly used addresses are included in its `/etc/hosts` file. This bypasses the nameserver lookup for these names and uses the address coded in the file.
  - Rather than specify IP addresses by name, specify them by number. (However, this solution is not advisable in a production environment.)

The IIOP user-replaceable security program

This is an optional identification mechanism.

It is *not* an authentication mechanism, but a way to supply a CICS USERID. To use it, you must specify the name of your security program on the URM option of the TCPIPSERVICE definition for the IIOP port. If you do so, your security program is called by the IIOP request processor.

On invocation, the security program is primed with the value defined by the system initialization parameter DFLTUSER (which defaults to CICSUSER), but can override it. Before routing the IIOP request to a request processor, CICS checks with RACF that the request receiver transaction is allowed to initiate work on behalf of the USERID generated by the security program.

You can write your own program to supply a USERID, or use the sample security program, DFHXOPUS. See “Using the IIOP user-replaceable security program” on page 384.

CONNECTION authentication

The client USERID is transmitted from the listener region to the AOR only if ATTACHSEC(IDENTIFY) is specified in the CONNECTION definition in the AOR.

See Link security with MRO, in the *CICS RACF Security Guide*, for more information.

IIOP users are recommended to specify SEC=YES and ATTACHSEC(IDENTIFY).

Configuring CICS for IIOP

You have to configure CICS as a CORBA participant to run all IIOP-based applications, including enterprise beans.

In addition to the requirements for running Java, you might also require the following software:

- Java Naming and Directory Interface (JNDI) Version 1.2.
- DB2 with IBM Data Server Driver for JDBC and SQLJ extensions.

Perform the following steps:

- “Setting up the host system for IIOP”
- “Setting up TCP/IP for IIOP” on page 374
- “Setting up CICS for IIOP” on page 375

You might also need to perform one of these steps:

- “Setting up an LDAP server” on page 364
- “Setting up a COS Naming Directory Server” on page 374

If you choose “Setting up an LDAP server” on page 364, also read “The LDAP namespace structure” on page 370.

Setting up the host system for IIOP

To support IIOP, perform these system tasks:

About this task

Procedure

1. Giving CICS regions access to z/OS UNIX System Services. As part of this task, you will:
   a. Give CICS access to the z/OS UNIX directories and files that are needed to create JVMs
   b. Create and give CICS access to the z/OS UNIX working directory that you have specified for input, output, and messages from the JVMs
2. “Setting up pooled JVMs” on page 88. During this task, you will:
   a. Enable CICS to locate JVM profiles and any associated JVM properties files.
   b. Choose appropriate JVM profiles for your CORBA stateless objects and enterprise beans.
   c. If necessary, customize the JVM profiles to fit the requirements of your CICS region. (In the course of setting up CICS as a CORBA server, you will need to add some further information.)

Bear in mind when reading "Setting up pooled JVMs" on page 88 that, *for CORBA stateless objects and enterprise beans*:

- The JVM profile used is that specified on the PROGRAM definition of the **request processor** program.
- As for all CICS Java programs, if you use a JVM properties file it must be specified on the JVM profile.
- The default JVM profile, specified on the PROGRAM definition of the default request processor program, is DFHJVMCD.
- If you plan to use the default JVM profile with your CORBA stateless object and enterprise bean requests, then you need only to locate DFHJVMCD and customize the profile for your CICS region, as described in "Setting up pooled JVMs" on page 88.

  If you plan to use customized JVM profiles, you should still make the changes to DFHJVMCD that are required to fit with the setup of your CICS region, because DFHJVMCD is used internally by CICS, as well as being used for the default request processor program.

3. "Defining a shelf directory." The shelf directory is used for deployed JAR files.
4. "Defining name servers." This step is necessary only if you need to define name servers for the purposes described in that procedure.

Defining a shelf directory:

Every CORBASERVER definition must specify the name of a shelf directory on z/OS UNIX.

When a DJAR definition is installed, CICS copies the deployed JAR file into a sub-directory of the shelf root directory. (Also, when a PERFORM CORBASERVER PUBLISH command is issued, the IOR of the CorbaServer is written to the sub-directory.)

You can call your shelf directory anything you like. However, it's recommended that you create it somewhere under the `/var` directory. For example, you might create a z/OS UNIX directory called `/var/cicsts/`. Having created the shelf directory, you must give the CICS region userid full access to it—read, write, and execute. See Giving CICS regions access to z/OS UNIX System Services for guidance.

Defining name servers:

You might need to define name servers for two purposes:

1. If you are using Domain Name system connection optimization, the listener regions need to be configured to talk to the same name server on z/OS that the MVS Workload Manager is configured to use.

   You can define the name server to be used by TCP/IP by providing a SYSTCPD DD statement in the CICS startup JCL for the listener region, as described in Enabling TCP/IP in a CICS region , in the *CICS Transaction Server for z/OS Installation Guide* manual.
2. A client application can locate an IIOP server application using object references that have been registered in a name server. For example, a Java client can use the JNDI interface to obtain a reference to a server application object such as an instance of the home interface of an enterprise bean. Object references can be registered in a name server from CICS by issuing the commands PERFORM CORBASERVER PUBLISH, or PERFORM DJAR PUBLISH.

Enabling JNDI references:

To enable your applications to obtain references using a JNDI Interface, set up a name server that supports the Java Naming and Directory Interface (JNDI) V 1.2.

You can use either of the following:

A Lightweight Directory Access Protocol (LDAP) server
: If you use an LDAP name server on z/OS, enterprise beans from CICS and WebSphere can interoperate more readily in a shared namespace. See "Setting up an LDAP server."

A Corba Object Services (COS) Naming Directory Service.
: COS Naming Servers run on an external machine.

  Any industry-standard COS Naming Service that supports JNDI Version 1.2 can be used. See "Setting up a COS Naming Directory Server" on page 374.

Specifying the location of the JNDI name server:

To enable Java code running under CICS to issue JNDI API calls, and CICS to publish references to the home interfaces of enterprise beans or IORs of stateless CORBA objects, you must define the location of the name server.

About this task

Specify the Web address (URL) and TCP/IP port number of your name server using the **`-Dcom.ibm.cics.ejs.nameserver`** system property. "JVM system properties" on page 109 has more detailed information.

Important:

1. You must specify the location of your name server on the **`-Dcom.ibm.cics.ejs.nameserver`** system property in all the JVM profiles or optional properties files that are used by your CORBA stateless objects or enterprise beans.
2. In particular, be sure to specify the location of your name server in the DFHJVMCD JVM profile. The DFHJVMCD profile is used by CICS-defined programs, including the default request processor program and the program that CICS uses to publish and retract deployed JAR files.
3. You also need to specify the location of your name server in any other JVM profiles that you choose to use for CORBA stateless objects or enterprise beans. These might be CICS-supplied sample JVM profiles or your own JVM profiles. For CORBA stateless objects and enterprise beans, the JVM profiles are named in the PROGRAM resource definitions for your request processor programs.
4. For detailed information about defining the location of your name server, see "JVM system properties" on page 109.

Setting up an LDAP server

Either use an existing LDAP server configured for WebSphere, or configure a new one.

If you have an existing LDAP server configured for WebSphere:

If the nameserver that you have chosen for use by CICS has already been configured for WebSphere Application Server for z/OS, there is likely to be very little configuration needed to enable CICS to use it.

Correct operation of the EJB support in CICS requires the chosen LDAP namespace to be configured with a WebSphere System Namespace - the publish and retract mechanisms of CICS both attempt to operate within a System Namespace structure. However, once inside an EJB method or if executing a regular Java transaction in CICS, you can communicate with any LDAP namespace regardless of whether it supports a System Namespace.

When you use an LDAP server that is not configured with a WebSphere System Namespace, use an alternative directory service, such as the LDAP service supplied with the IBM Developer Kit for the Java Platform 5.0 base, rather than the WebSphere context factory supplied with CICS. See "LDAP Context Factory supplied with Java" on page 290 for details of using the LDAP factory.

An understanding of the WebSphere naming structure that exists on the LDAP server (see "The LDAP namespace structure" on page 370) makes it easier for you or your LDAP administrator to determine suitable values for the six key properties a CICS region needs to know. These are described in "JVM system properties" on page 109. The three security properties are only necessary if the LDAP namespace is setup in a secure manner. On some LDAP servers it may be the case that all users have write access and neither the principal or credentials properties need to be set for the CICS region.

If the structure laid out in the namespace by WebSphere is suitable for your needs, no further configuration is necessary.

The values for nameserver, containerdn and noderootrdn can be obtained by understanding the System Namespace structure and observing the structure in place on your chosen LDAP server, the final part of this section discusses how to determine the property values if you are browsing an existing namespace.

Reasons for further configuration:

You might need to proceed with LDAP server configuration, even though the server is already configured for WebSphere Application Server for z/OS, for any of these reasons.
1. The security configuration needs changing to cope with the CICS regions being introduced. See "The LDAP namespace structure" on page 370 and "Security considerations" on page 372 for further information about the LDAP structure and security issues.
2. CICS needs to run in a separate *domain* from WebSphere. If you are building a new, separate, domain, WebSphere Application Server for z/OS and CICS will not easily be able to locate each other's enterprise beans. However, if you just intend to build a new domain the only configuration steps you need to execute are Step 4. "Build the legacyRoot node" and Step 5. "Apply security at CICS region level".
3. CICS needs to run in an entirely different system namespace structure on the LDAP server. That is, CICS needs to have a `containerdn` that points to somewhere other than the existing namespace root location on the server. In this case, start the configuration procedure at Step 2. "Add a new suffix". In this case, it is not possible for CICS and WebSphere Application Server for z/OS systems working with the differing container settings to locate each other's Enterprise Beans.

Configuring a new LDAP server:

If you do not have an existing LDAP server configured for WebSphere Application Server for z/OS, perform these steps to configure a new LDAP server.

About this task

1. Install the WebSphere naming schema
2. Add a new suffix
3. Build the system namespace root node (containerdn)
4. Build the legacyRoot node below the namespace root node (noderootrdn)
5. Optionally, apply security measures at the CICS region level.

In order to perform many of the steps you are likely to need access to a LDAP principal that has suitable authority on your LDAP server to create new entries at the *root* level.

When these steps are completed, you can determine the values of the system properties that are needed in your JVM properties files to enable CICS to operate with the LDAP server, and add these system properties to all the relevant JVM properties files.

The steps in the following example enable you to configure an LDAP server with the following values for the system properties in your JVM properties files:

```
-Dcom.ibm.cics.ejs.nameserver=ldap://wibble.example.com:389
-Dcom.ibm.ws.naming.ldap.containerdn=ibm-wsnTree=t1,o=WASNaming,c=US
-Dcom.ibm.ws.naming.ldap.noderootrdn=ibm-wsnName=legacyRoot,ibm-wsnName=PLEX2,
      ibm-wsnName=domainRoots
-Djava.naming.security.authentication=simple
-Djava.naming.security.principal=cn=CICSSystems,c=US
-Djava.naming.security.credentials=secret
```

Similar values are given for the example system properties in the CICS-supplied sample JVM properties files.

An example:

There are notes throughout the configuration files that are used in this example which guide you to tailor this set of properties to your particular needs.

The one most likely to change is *noderootrdn*, you will probably have some domain other than PLEX2 as the grouping for your nodes - this value is input into the system at Step 4. "Build the legacyRoot node".

Notice that the example assumes a principal of 'cn=admin' exists on the LDAP server, with password 'adminpwd' and that this principal is authorised to perform any operation on the LDAP server.

1. Install the WebSphere naming schema.

   If the LDAP server to be configured already has the WebSphere naming schema, this step can be skipped. An LDAP name server configured for WebSphere will already have this schema.

   If it is any other LDAP server, install the WebSphere naming schema. The schema is shipped with CICS as /usr/lpp/cicsts/cicsts42/utils/namespace/WebSphereNamingSchema.ldif on z/OS UNIX.

   Note: The WebSphereNamingSchema.ldif file requires that RFC2256.ldif and RFC2713.ldif be loaded first. This is because the definition of the **ibm-wsnEntry** object class refers to the **javaClassName** attribute type. When using the LDAP server on z/OS, these prerequisite LDAP files are not loaded by default when the LDAP server is set up.

The LDAP server on z/OS needs to store the schema entries in the back-end store to which they apply. This is achieved by adding a suffix to the dn of each schema entry. The supplied `WebSphereNamingSchema.ldif` file does not specify a suffix on the schema entries, so you must add one. For example, if the suffix for the back-end store is “`c=US`”, you should change every instance of “`dn:cn=schema`” in the `ldif` file to “`dn:cn=schema,c=US`”.

Apply the schema to the nameserver using the **ldapmodify** command :

```
ldapmodify -h <hostname>
           -p <portnumber>
           -D <authorized_principal>
           -w <authorized_principal_password>
           -f WebSphereNamingSchema.ldif
```

Where `hostname` and `portnumber` are those for the LDAP server and the authorised principal is the distinguished name of a user with sufficient authority on the nameserver to write entries.

The **ldapmodify** command must be available for your chosen LDAP server. If it is not, consult your LDAP server documentation to determine how a new schema (in ldif form) should be installed.

A specific example might be:

```
ldapmodify -h wibble.example.com
           -p 389
           -D cn=admin
           -w adminpwd
           -f WebSphereNamingSchema.ldif
```

2. Add a new suffix.

   To build a new hierarchy in the namespace it is necessary to create a new base distinguished name suffix. In this example configuration the suffix is *c=US*, and the new hierarchy is to be *ibm-wsnTree=t1,o=WASNaming,c=US*. The procedure for adding a suffix varies between the different LDAP providers. Your LDAP documentation should indicate how to do this for your chosen provider. As an example, here is the procedure for adding a suffix to a z/OS Communications Server installation on Windows 32:

   - Start the LDAP Administration interface on a Web browser by typing `http://[hostname]/ldap`, where hostname is the host name of the machine where the LDAP directory is installed. The Administration logon window displays.
   - Type the administrator user ID (for example, in the format cn=root) and password.
   - Make sure that the LDAP server is running.
   - In the left navigation pane, click the Settings folder, and then click Suffixes.
   - Type the name of the Base DN to be used as the suffix (in our example, "c=US"), and click Update.
   - After the Base DN suffix is added, stop and restart the LDAP server.

   The suffix now exists on your LDAP system

   On a z/OS system, update the `slapd.conf` file to introduce your new suffix to the system, then restart the nameserver. The extra line to add to `slapd.conf` is:

   ```
   suffix "c=US"
   ```

3. Build the system namespace root node (containerdn)

   An ldif file to build the root of the system namespace (a node called the containerdn) is supplied with CICS in `utils/namespace/dfhsns.ldif`. This file contains comments describing how to tailor it for your environment. If it is used without alteration, it creates a containerdn of `ibm-wsnTree=t1,o=wasnaming,c=US` and also two CICS users on the LDAP namespace. The first CICS user has a distinguished name of `cn=CICSSystems,c=US` and the second is `cn=CICSUser,c=US`.

Two userids are defined. To understand how they are used, see “Security considerations” on page 372.

The ldapmodify command must be available for your chosen LDAP server, if it is not, consult your LDAP server documentation to determine how the root of the system namespace should be built..

This LDIF file can be applied to the LDAP server as follows:

```
ldapmodify-h <hostname>
        -p <portnumber>
        -D <authorized_principal>
        -w <authorized_principal_password>
        -f dfhsns.ldif
```

Where hostname and portnumber are those for the LDAP server and the authorised principal is the distinguished name of a user with sufficient authority on the nameserver to write entries.

A specific example is:

```
ldapmodify-h wibble.example.com
        -p 389
        -D cn=admin
        -w adminpwd
        -f dfhsns.ldif
```

4. Build the legacyRoot node below the namespace root node (noderootrdn)

   The legacyRoot node in the namespace is the point where CICS is usually configured to position itself when called to create a new InitialContext. For this step , the script `DFHBuildSNS` is shipped with CICS in the directory `utils/namespace`.

   The syntax is :

```
DFHBuildSNS   -ldapserver  <server_url>
             [-node        <node within the domain>]
              -domain      <domain_name>
              -containerdn <Root of the namespace>
              -principal   <principal authorised to write to the namespace>
              -credentials <password for that principal>
             [-force]
```

   For example:

```
DFHBuildSNS    -ldapserver ldap://wibble.example.com:389
               -domain PLEX2
               -containerdn ibm-wsnTree=t1,o=WASNaming,c=US
               -principal cn=admin
               -credentials adminpwd
```

   (The *-force* option is only used with the *-node* flag, but neither are used in a CICS environment.

5. Optionally apply the additional measures described in “Security at the CICS region level” on page 372.

After running this script, the values of the system properties required in your JVM properties files can be determined, and you can add them to all the relevant JVM properties files.

Determining the values for the LDAP system properties:

These system properties relate to the use of an LDAP namespace for JNDI.

"JVM system properties" on page 109 has full descriptions of each of these system properties.

- If you have just set up this LDAP namespace, you know the values that you used. Some of these are the ones required for setting the CICS properties.
- If you are using or reusing an existing system namespace, ask your LDAP administrator for suitable values for these properties.
- If you do not have access to the LDAP administrator or the values are unavailable, you might be able to determine them, with the help of the following information, by browsing the namespace.

  You are unlikely to discover that the security principal or credentials by browsing the namespace.

`-Dcom.ibm.cics.ejs.nameserver`
: Is the URL for the LDAP server being configured. In the example in "Configuring a new LDAP server" on page 365, it is *ldap://wibble.example.com:389*

`-Dcom.ibm.ws.naming.ldap.containerdn`
: Is the value specified in the `dfhsns.ldif` file. The default is *ibm-wsnTree=t1,o=WASNaming,c=US* if you did not tailor the ldif file. If you are seeking this value by browsing an existing namespace, look for a node of type ibm-wsnTree; the path to this node is a possible value for containerdn.

`-Dcom.ibm.ws.naming.ldap.noderootrdn`
: Can be determined from the domain that you specified on the DFHBuildSNS call. In the example, the noderootrdn is *ibm-wsnName=legacyRoot,ibm-wsnName=PLEX2,ibm-wsnName=domainRoots*. If you are seeking this value by browsing an existing namespace, look for the path from the chosen containerdn to the legacyRoot entry.

`-Djava.naming.security.authentication`
: Is set to *simple* if CICS must authenticate itself to LDAP to bind (or write) to it. Using the the defaults in the supplied scripts, authentication is necessary because the `dfhsns.ldif` script removed default write access for the ANYBODY group, and granted write access to the new principal `cn=CICSUser,c=US` that it created. If CICS does not have to authenticate itself to LDAP to write to it, do not set a value for this system property.

  Important: If you do specify this system property, you must also specify **`-Djava.naming.security.principal`** and **`-Djava.naming.security.credentials`**. Because these system properties hold the UserID and password that CICS requires to access the secure LDAP service, you must give particular attention to the access controls in force at your installation for the files containing these system properties. You must ensure that the files are secure, with update authority restricted to system administrators.

`-Djava.naming.security.principal`
: Is a principal with the authority to bind to the namespace. You might choose the system principal that has write access to the entire namespace if security is not a real concern. However, you are advised to use at least the *cn=CICSUser,c=US* distinguished name specified in `dfhsns.ldif`, because that ID can write to only a particular area of the LDAP namespace (the containerdn and below).

If you want even tighter security, the principal can be *cn=CICSSystems,c=US*. If you use this ID, you must perform an extra LDAP configuration. See "Security considerations" on page 372 for a full discussion of CICS LDAP security configuration.

-Djava.naming.security.credentials
Is the password for the principal. The default if you did not tailor`dfhsns.ldif` is *secret*.

When you have determined the values of these system properties, you specify them in all the JVM profiles or optional JVM properties files that are used by CORBA applications or enterprise beans.

In particular, specify them in the DFHJVMCD JVM profile or referenced properties file. The DFHJVMCD profile is used by CICS-defined programs, including the default request processor program and the program that CICS uses to publish and retract deployed JAR files.

You must also specify these system properties in the JVM profiles or properties files referenced by any other JVM profiles that you choose to use for CORBA stateless objects or enterprise beans. These profiles might be CICS-supplied sample JVM profiles or your own JVM profiles. For CORBA stateless objects and enterprise beans, the JVM profiles are named in the PROGRAM resource definitions for your request processor programs.

The LDAP namespace structure

The LDAP namespace structure used by WebSphere Application Server Version 4 for z/OS, is a convenient structure for use in a CICS environment.

Note: WebSphere Application Server Version 5 and later use a COS Naming Server by default and support LDAP only for backwards compatibility with WebSphere Application Server Version 4.

There are two important nodes in the LDAP namespace structure used by WebSphere, the container root, and the legacy root.

The container root:

The container root is a node of type ibm-wsnTree. By default, this is called: *ibm-wsnTree=t1, o=wasnaming, c=us* However, this is customisable by changing the *bboldif.cb* file shipped with WebSphere.

The legacy root:

The legacy root is a node of type *ibm-wsnName* some way below the container root .

A typical name for this might be: *ibm-wsnName=legacyRoot,ibm-wsnName=PLEX2,ibm-wsnName=domainRoots,ibm-wsnTree=t1,o=WASNaming,c=us* The names legacyRoot and domainRoots are fixed. The only variable is the middle name, in this example PLEX2.

There may be several legacyRoot nodes, each with a different name. Each of these is a "domain". The WebSphere Application Server for z/OS configuration maps a domain to a sysplex. It is configured when the sysplex name is entered into the customization dialog when WebSphere Application Server for z/OS is installed.

Domains:

A domain contains a number of servers.

In WebSphere Application Server for z/OS, each server has a node below legacyRoot, for example a server called BBOSV1 would have a name *ibm-wsnName=BBOSV1,ibm-wsnName=PLEX2* relative to the legacy root, and the objects it publishes would be below this node.

When CICS is configured to use the same LDAP server as WebSphere, each CICS CorbaServer has a node directly below legacyRoot. So if a CorbaServer has a JNDI prefix of CICS1, there will be a node *ibm-wsnName=CICS1* relative to the legacy root, and CICS publishes the CorbaServer's objects below this node. When a new InitialContext is created in WebSphere Application Server for z/OS, or in CICS configured as above, the InitialContext will be based on the legacyRoot node. This makes it easy for enterprise beans in CICS to look up objects published by WebSphere, and for enterprise beans or servlets in WebSphere to look up objects published by CICS.

Note: Any JNDI sub-context below a CICS region's initial JNDI context (which is typically the legacyRoot node) may be transient. This is the case if CICS has write access to the initial context node.

A CorbaServer's JNDI sub-context is specified on the JNDIPREFIX option of the CORBASERVER definition. CICS creates the sub-context (if it has the necessary write permission and the sub-context does not already exist in the namespace structure) when an enterprise bean is published from the CorbaServer. However, if all the enterprise beans in the CorbaServer are retracted, CICS may delete the sub-context from the namespace structure. Where multiple CorbaServers share part of a prefix hierarchy, CICS never removes contexts that are still in use by any of them. But if the contexts in the prefix are empty they are removed, as far back as the initial context.

If you want to protect the top-level node of the sub-context hierarchy from deletion, do not give CICS write access to the initial context node. (This means that you must create the top-level node of the sub-context manually.) If you want to protect several higher levels of the sub-context hierarchy, give CICS write permission only to the lower levels. (This means that you must create the higher-level nodes of the sub-context manually.) For more information, see "Security at the CICS region level" on page 372.

Versions of WebSphere Application Server for distributed platforms have a similar concept of domain, but that concept does not relate to a sysplex.

Nodes:

There is another concept, that of a ***node***. A domain represents a number of nodes, and you can navigate your way to a domain by knowledge of the nodename rather than the domain name. Thus a node is a sort of alias for a domain.

Nodes are used in versions of WebSphere Application Server for distributed platforms, but not in WebSphere Application Server for z/OS. They are not used by CICS. However, part of the structure for support of nodes is built when you set up a new LDAP server for use by CICS. Since WebSphere Application Server for z/OS does not use nodes, the nodename is an optional parameter to the DFHBuildSNS utility, which under CICS builds the system namespace.

Security considerations: If you specified that CICS must authenticate itself to LDAP in order to write to it, by coding the system property **-Djava.naming.security.authentication=***simple* in your JVM profiles, you now have a choice between
- "Security at the containerdn level," or
- "Security at the CICS region level."

To help you decide, a very simplified view of part of the LDAP namespace is shown in Figure 37.

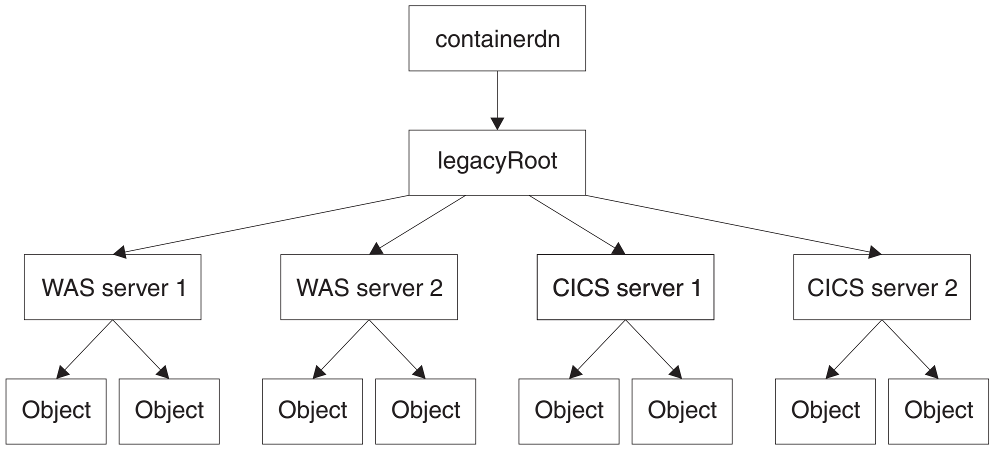


Figure 37. Simplified view of part of an LDAP namespace

If you use security at the containerdn level, CICS has write access to containerdn and all nodes below it. This allows CICS, or a CICS application using the JNDI interfaces, to write to all these nodes, including those that belong to WebSphere Application Server for z/OS. If you use security at the CICS region level, then CICS and CICS applications are only able to write to the specific CICS nodes in the tree.

Security at the containerdn level: To use security at the containerdn level, use the CICS administration principal (cn=CICSUser,c=us) created by the *dfhsns.ldif* file (see Step 3. "Build the system namespace root node"). Give this principal access to the containerdn node when you create it. Ensure that this userid and its password appear in the system properties `-Djava.naming.security.principal`and `-Djava.naming.security.credentials` in your JVM properties files.

Security at the CICS region level:

Give this principal access to the containerdn node when you create it. Ensure that this userid and its password appear in the system properties `-Djava.naming.security.principal`and `-Djava.naming.security.credentials` in your JVM properties files.

To use security at the CICS region level, use the CICS runtime principal (cn=CICSSystems,c=US) created by the *dfhsns.ldif* file, see Step 3. "Build the system namespace root node". This involves some additional steps. Ensure that this userid and its password appear in the system properties `-Djava.naming.security.principal`and `-Djava.naming.security.credentials` in your JVM properties files. Additionally, as CICS does not have write access to legacyRoot, CICS will be unable to create its own node (called CICS server 1 in

Figure 37 on page 372), so you must do it manually, and then give the CICS runtime principal (cn=CICSSystems,c=US) write access to this node. This is described below.

To configure a CICS region in this way and then use the new subcontext:

- Choose a suitable subcontext, we shall call it *cicsabcd*.
- Create that subcontext below the legacyRoot for use by a CICS system (see "Creating a subcontext").
- Ensure the CICS runtime principal can write to it.
- Specify the CICS runtime principal and credentials using the system properties **`-Djava.naming.security.principal`** and **`-Djava.naming.security.credentials`** in the JVM properties files that are in use in the region.
- Ensure that any CORBASERVER definitions created in the CICS region have JNDIPREFIX attributes which start with *cicsabcd*. This means that references which they publish, are published *under* the new subcontext *cicsabcd* under legacyRoot.

Security configuration is now complete. A user browsing the LDAP namespace is able to locate this context *cicsabcd* below legacyRoot, and relate it to the CORBASERVER definitions.

Creating a subcontext: To create the subcontext *cicsabcd* below the legacyRoot in the LDAP namespace, and to set suitable Access Control Lists (ACLs) for it, use the LDIF file supplied with CICS in *utils/namespace/dfhNewCICSSubcontext.ldif*.

- The LDIF file contains comments to explain the steps involved, and the values that are likely to need altering for a particular LDAP System Name Space configuration.
- The LDIF file can be applied to the LDAP server using the ldapadd command:

  ```
  Ldapadd -h wibble.example.com
          -p 389
          -D cn=CICSUser,c=us
          -w CICSUserpwd
          -f dfhNewCICSSubcontext.ldif
  ```

  where `CICSUserpwd` is the password for `CICSuser` established when `CICSuser` was set up.

  This command needs to be run with a principal (and credentials) that can write to the legacyRoot node. In the example we are using, that is *cn=CICSUser,c=US id*, which has been created for this purpose.
- The most important line of the LDIF file to change is the distinguished name of the node being created, assuming the LDAP System Namespace was configured using all the default scripts supplied with CICS, the distinguished name is:

  ```
  ibm-wsnName=cicsabcd,ibm-wsnName=legacyRoot,ibm-wsnName=PLEX2,
  ibm-wsnName=domainRoots,ibm-wsnTree=t1,o=wasnaming,c=US
  ```
- The rest of the LDIF sets the Access Control Lists appropriately for the new node.
- The comments in this LDIF file are important, they explain other things that you might have to consider. For example, there might be some additional ACL entries that are appropriate in your installation depending on which principals currently have write access to the System Namespace.
- Once the LDIF is applied, the new node exists on the LDAP server below the legacyRoot, and the Access Control Lists are set such that the CICS runtime principal has write access.

Other considerations: You might want to consider the following:

- You could create several different CICS runtime principals for different regions, and so reduce scope of the access granted to each principal.
- If you are using this process within an existing system namespace, there may be other principals (and credentials) in use. They need to be given write access to the new subcontext created by *dfhNewCICSSubcontext*. The comments in the dfhNewCICSSubContext LDIF file discuss ways to check if this is so, and how to tailor the LDIF file appropriately before executing the ldapadd.

Setting up a COS Naming Directory Server

The most convenient way to set up a COS Naming Directory Server is to use IBM WebSphere Application Server running on an external Windows machine.

About this task

The most convenient way to set up a COS Naming Directory Server is to use IBM WebSphere Application Server running on an external Windows machine. Follow the installation instructions supplied with it.

Setting up TCP/IP for IIOP

To configure a CICS region as a TCP/IP Listener to accept and send IIOP requests, you need to make these definitions in CICS.

About this task

1. In the CICS startup job stream for every CICS region where the Listener is required, set the following system initialization parameters:
   - **IIOPLISTENER** to **YES**
   - **TCPIP** to **YES**
2. Define and install TCPIPSERVICE resource definitions in the Listener region for every port that the Listener will monitor, specifying:
   - PROTOCOL(IIOP)
   - The port or IP address on which CICS will listen for incoming IIOP requests

     Note: If the SSL connection fails, some clients will attempt to retry on an associated non-SSL port. CICS TS defines this port to be SSL port–1. Ensure that this port (SSL port–1) is not defined for any other purpose. The well-known IIOP ports are 683(non-SSL) and 684(SSL).
   - The CICS transaction to start when a request arrives. For an IIOP service, this should be set to the CICS IIOP Request Receiver, CIRR.
   - The level of Secure Sockets Layer (SSL) authentication to be used.
   - The DNSGROUP name if DNS connection optimization is to be used. See "Resource definition for DNS connection optimization" on page 360
   - The name of the user-replaceable program to be called to associate this request with a CICS USERID for security or workload management purposes. If omitted, no user-replaceable program is called. A sample user-replaceable program, DFHXOPUS, is supplied—see "Using the IIOP user-replaceable security program" on page 384.

   For example:

```
DEFINE TCPIPSERVICE(IIOPNSSL) GROUP(DFH$IIOP)
     DESCRIPTION(IIOP TCPIPSERVICE with no SSL support)
     URM(DFHXOPUS)         BACKLOG(10)          PORTNUMBER(683)
     TRANSACTION(CIRR)     SSL(NO)
     STATUS(CLOSED)        PROTOCOL(IIOP)
```

Important: In a multiregion server, the TCPIPSERVICE definitions must be installed in *all* the regions (both listeners and AORs) of the logical server. In the listener regions, the IIOPLISTENER system initialization parameter must be set to 'YES'. In the AORs, it must be set to 'NO'. In a combined listener/AOR, it must be set to 'YES'.

See TCPIPSERVICE resources in the Resource Definition Guide for the full syntax of the TCPIPSERVICE resource definition.

Using DNS connection optimization:

To use DNS connection optimization with IIOP, you need to define a DNSGROUP name in the IIOP TCPIPSERVICE resource definition.

All CICS regions providing the same TCPIPSERVICE, with the same DNSGROUP name are registered with MVS Workload Management (WLM) with the same *group-name*, as candidates for client requests requiring the same service. This registration also includes the region's *Host name*, obtained by the TCP/IP function **gethostbyaddr**, and a unique *Server name*, which CICS obtains from the specific APPLID of the region as specified by the APPLID system initialization parameter.

Listener regions need to be configured to talk to the same DNS name server on z/OS that the MVS Workload Manager is configured to use. You can define the name server to be used by TCP/IP by providing a SYSTCPD DD statement in the CICS startup JCL, as described in Enabling TCP/IP in a CICS region, in the *CICS Transaction Server for z/OS Installation Guide*.

Note:
1. Both the client and the CICS server must use the same TCP/IP name server.
2. The name server must be able to perform a reverse look-up, that is, it must be able to translate the IP address of the server into a full hostname.

Setting up CICS for IIOP

To support IIOP you must define a CICS startup job stream, and define and install some CICS resources.

Defining CICS startup job stream:

You must define parameters in the startup job stream for a CICS region that supports IIOP:

JCL parameter

REGION
1000M minimum is recommended

CICS system initialization parameters

EDSALIM
500M minimum is recommended.

IIOPLISTENER
- Specify IIOPLISTENER=YES if the CICS region is an IIOP listener region, or a combined listener and application owning region (AOR).
- Specify IIOPLISTENER=NO if the CICS region is an IIOP application owning region. TCPIPSERVICE definitions installed in the region that specify PROTOCOL(IIOP) cannot be opened.

JVMPROFILEDIR
: Set to the z/OS UNIX directory containing the JVM profiles that you are using for your applications. "Setting the location for the JVM profiles" on page 75 tells you how to do this.

KEYRING
: Required if you are using Secure Sockets Layer (SSL) authentication with certificates registered to RACF.

MAXJVMTCBS
: Specify the number of JVMs that your CICS region can support. "Managing your JVM pool for performance" on page 161 describes how to work out an appropriate setting for the **MAXJVMTCBS** system initialization parameter.

TCPIP Set to YES.

DD statements for CICS data sets

Sample local VSAM data set definitions are provided in the CICS-supplied RDO group DFHEJVS. These data sets must be authorized with RACF for UPDATE access. See Authorizing access to CICS data sets, in the *CICS RACF Security Guide*.

DFHEJDIR
: A recoverable shared file containing the request streams directory. This can be a VSAM file or a coupling facility data table. CICS supplies sample JCL to help you create this file, in the DFHDEFDS member of the SDFHINST library.

  Note: In most cases, the RECORDSIZE parameter in the supplied JCL should not require modification. However, if you intend to install more than 40 CorbaServers in your logical EJB/CORBA server, see "Specifying the RECORDSIZE of DFHEJDIR and DFHEJOS."

DFHEJOS
: A non-recoverable shared file used by CICS when CorbaServers are installed and to store stateful session beans that have been passivated. This can be a VSAM file or a coupling facility data table. CICS supplies sample JCL to help you create this file, in the DFHDEFDS member of the SDFHINST library.

  Note: In most cases, the RECORDSIZE parameter in the supplied JCL should not require modification. However, if you intend to install more than 40 CorbaServers in your logical EJB/CORBA server, see "Specifying the RECORDSIZE of DFHEJDIR and DFHEJOS."

Specifying the RECORDSIZE of DFHEJDIR and DFHEJOS:

The maximum number of CorbaServers that can be defined to a CICS EJB/CORBA logical server is controlled by the RECORDSIZE values of the request streams directory file, DFHEJDIR, and the EJB object store file, DFHEJOS.

The RECORDSIZE attributes in the supplied JCL and FILE definitions for DFHEJDIR specify a RECORDSIZE of 1017 bytes. The RECORDSIZE attributes in the supplied JCL and FILE definitions for DFHEJOS specify a RECORDSIZE of 8185 bytes. Normally, these values should not require modification. Only if you intend to install more than 40 CorbaServers in your logical EJB/CORBA server do you need to change these values.

Both DFHEJDIR and DFHEJOS contain a control record which is made up of a 24-byte header and a repeating group of CorbaServer control fields, each 24 bytes long. The default length of 1017 for DFHEJDIR effectively limits the logical server to 41 CorbaServers: (1 + 41) * 24 = 1008 bytes. If you need to install more CorbaServers than this into your logical server, calculate the required RECORDSIZE for DFHEJDIR like this:

1. Multiply the required number of CorbaServers by 24.
2. Add 24 bytes for the control record header. This gives the absolute minimum record size.
3. Round up the last value to the next multiple of 512 to get the minimum control interval size.
4. Subtract 7 to get the value for the RECORDSIZE parameter.

Make the RECORDSIZE value for DFHEJOS greater than that of DFHEJDIR. Too short a length will result in collisions when passivating beans. (The supplied definitions make the RECORDSIZE of DFHEJOS almost 8 times that of DFHEJDIR.)

Note: The sample JCL for DFHEJDIR and DFHEJOS is in the DFHDEFDS member of the SDFHINST library. Sample FILE resource definitions for DFHEJDIR and DFHEJOS are in the DFHEJVS RDO group, with sample coupling facility FILE definitions in the DFHEJCF group, and sample VSAM RLS FILE definitions in the DFHEJVR group.

Defining CICS resources:

You must create the required CICS resources for enterprise beans.

FILE

Provide and install FILE resource definitions for the following files required by CICS:

The "EJB Directory", DFHEJDIR

A file containing a request streams directory; the directory is used in the routing of method requests for both enterprise beans and CORBA stateless objects. You must define DFHEJDIR as recoverable.

The "EJB Object Store", DFHEJOS

A file of stateful session beans that have been passivated. It is also used when CorbaServers are installed. You must define it as non-recoverable.

In a single-region CICS EJB/CORBA server, it is acceptable to define DFHEJDIR and DFHEJOS as local files. However, in a multiple-region CICS EJB/CORBA server:

- DFHEJDIR must be shared by all the regions (listeners and AORs) in the server.
- DFHEJOS must be shared by all the AORs in the server.

To enable DFHEJDIR and DFHEJOS to be shared across multiple regions, you can define them in one of the following ways:

- As remote files in a file-owning region (FOR)
- As coupling facility data tables
- Using VSAM RLS.

There are sample FILE definitions for DFHEJDIR and DFHEJOS in the CICS-supplied RDO group, DFHEJVS. There are sample coupling facility FILE definitions for DFHEJDIR and DFHEJOS in the CICS-supplied RDO group, DFHEJCF. There are sample VSAM RLS FILE definitions for DFHEJDIR and DFHEJOS in the CICS-supplied RDO group, DFHEJVR. (DFHEJVS, DFHEJCF, and DFHEJVR are not included in the default CICS startup group list, DFHLIST.)

Note: In most cases, the values of the RECORDSIZE attributes in the supplied FILE definitions should not require modification. However, if you intend to install more than 40 CorbaServers in your logical EJB/CORBA server, see "Specifying the RECORDSIZE of DFHEJDIR and DFHEJOS" on page 376.

For reference information about FILE definitions, see FILE resources.

TRANSACTION and PROGRAM

CORBA stateless objects and enterprise beans don't have PROGRAM resource definitions as such. The PROGRAM resource definition that is relevant to a CORBA stateless object or enterprise bean is that for the request processor program.

Required default TRANSACTION and PROGRAM definitions for the CICS-supplied request receiver and request processor programs are in resource group DFHIIOP, which is included in the default CICS startup group list, DFHLIST.

Normally, you should not need to replace the default TRANSACTION and PROGRAM definitions for the request receiver (CIRR and DFHIIRRS, respectively). This is the definition of CIRR in DFHIIOP:

```
DEFINE TRANSACTION(CIRR)      GROUP(DFHIIOP)
       PROGRAM(DFHIIRRS)      TWASIZE(0)
       PROFILE(DFHCICST)      STATUS(ENABLED)
       TASKDATALOC(ANY)       TASKDATAKEY(USER)
       RUNAWAY(SYSTEM)        SHUTDOWN(ENABLED)
       PRIORITY(1)            TRANCLASS(DFHTCL00)
       DTIMOUT(NO)            TPURGE(NO)
       SPURGE(YES)            ISOLATE(NO)
       RESSEC(NO)             CMDSEC(NO)
       RESTART(NO)
       DESCRIPTION(Default CICS IIOP Request Receiver transaction)
```

One reason for creating your own TRANSACTION and PROGRAM definitions for the request processor program is to specify a JVM profile other than the default. The name of the JVM profile to be used is specified on the JVMPROFILE option of the PROGRAM definition for the request processor program. The default PROGRAM definition for the request processor (DFJIIRP in DFHIIOP) specifies the JVM profile DFHJVMCD. This is the definition of DFJIIRP in DFHIIOP:

```
DEFINE PROGRAM(DFJIIRP)       GROUP(DFHIIOP)
     DESCRIPTION(CICS IIOP Request Processor)
     JVM(YES)
     JVMCLASS(com.ibm.cics.iiop.RequestProcessor)
     JVMPROFILE(DFHJVMCD)
     LANGUAGE(LE370)
     RELOAD(NO)
     EXECKEY(USER)
     RESIDENT(NO)
     USAGE(NORMAL)
     USELPACOPY(NO)
     STATUS(ENABLED)
     CEDF(NO)
     DATALOCATION(ANY)
     DYNAMIC(NO)
```

Note: The CEDF attribute can be set to YES for debugging purposes. See "Using EDF with enterprise beans" on page 295.

If you do create your own PROGRAM definition for the request processor, you can provide one with any name, but the JVMCLASS parameter must be set to **com.ibm.cics.iiop.RequestProcessor**. Choose another JVM profile for the request processor to use, and specify the name of your JVM profile on the JVMPROFILE option. CICS supplies sample JVM profiles in the `/usr/lpp/cicsts/cicsts42/JVMProfiles` z/OS UNIX directory, where `/usr/lpp/cicsts/cicsts42` is the install directory for CICS files on z/OS UNIX. "Setting up pooled JVMs" on page 88 tells you how to locate, choose and customize JVM profiles.

TCPIPSERVICE

Provide and install TCPIPSERVICE resource definitions to configure the CICS Listener to receive IIOP requests and call the IIOP *request receiver*. The TCPIPSERVICE resource definition also specifies load-balancing and security options. See "Setting up TCP/IP for IIOP" on page 374.

CICS supplies, in resource group DFH$EJB, a TCPIPSERVICE definition for use with the EJB installation verification program (IVP) and the EJB "Hello World" sample application. If you are setting up a CICS EJB server, we suggest that you follow the step-by-step example of how to configure this definition in "Actions required on CICS" on page 240.

CORBASERVER

Provide and install a CORBASERVER resource definition. Note that the DFHEJDIR file must be defined, installed, and available before a CORBASERVER can be installed.

CICS supplies, in resource group DFH$EJB, a CORBASERVER definition for use with the EJB IVP program and the EJB "Hello World" sample application. If you are setting up a CICS EJB server, we suggest that you follow the step-by-step example of how to configure this definition in "Actions required on CICS" on page 240.

REQUESTMODEL

Provide and install REQUESTMODEL resource definitions to enable the *request receiver* to match the incoming request to a CICS transaction, to define execution parameters that are used if a new request processor instance is created to handle the request. The default TRANSID on REQUESTMODEL definitions is CIRP, which specifies the default request processor program DFJIIRP. If you choose to use your own TRANSACTION definition, you must define and install it; it must specify a PROGRAM definition with the JVMCLASS parameter set to **com.ibm.cics.iiop.RequestProcessor**. See "Obtaining a CICS TRANSID" on page 385.

Note:

1. You need to provide REQUESTMODEL definitions only if the default TRANSID, CIRP, is unsuitable, or if you want to segregate your IIOP workload by transaction ID (for monitoring purposes, for example).
2. The TRANSACTION definition for CIRP specifies DYNAMIC(NO). If you want to use dynamic routing of method requests for enterprise beans and CORBA stateless objects, you must provide one or more TRANSACTION definitions that specify DYNAMIC(YES), and specify them on your REQUESTMODEL definitions.
3. After the CorbaServer is operational, you can use the CREA CICS-supplied transaction to display the transaction IDs associated with particular

enterprise beans and bean-methods in the CorbaServer. You can change the transaction IDs, apply the changes, and save the changes to new REQUESTMODEL definitions. This is an easier method than building REQUESTMODEL definitions by hand.

4. In a multi-region CICS logical server, it's recommended that you install your REQUESTMODEL definitions on the AORs as well as the listener regions—see Figure 38 on page 381. The REQUESTMODEL definitions in the AORs are required for outbound requests to local objects. If a CORBA stateless object or enterprise bean makes a call to another object, and that object is available on the local AOR, CICS does not send the request to a listener region. Instead, it either runs the called method in the current task (“tight loopback”) or starts another request processor in the local AOR (“normal loopback”). Where normal loopback is used, it's preferable that the new request processor task should use the same REQUESTMODEL as that used for the call to the first object—otherwise, unpredictable results may occur. If your CORBA stateless objects and enterprise beans make no outbound calls, the REQUESTMODELs on the AOR are not strictly required.

DJAR

Provide and install DJAR resource definitions for any enterprise beans.

Note: DJAR definitions are typically created and installed by the CICS scanning mechanism (see DJAR resources in the Resource Definition Guide).

Figure 38 on page 381 shows the RDO definitions required to define a CICS logical server. It shows which definitions are required in the listener regions, which in the AORs, and which in both.

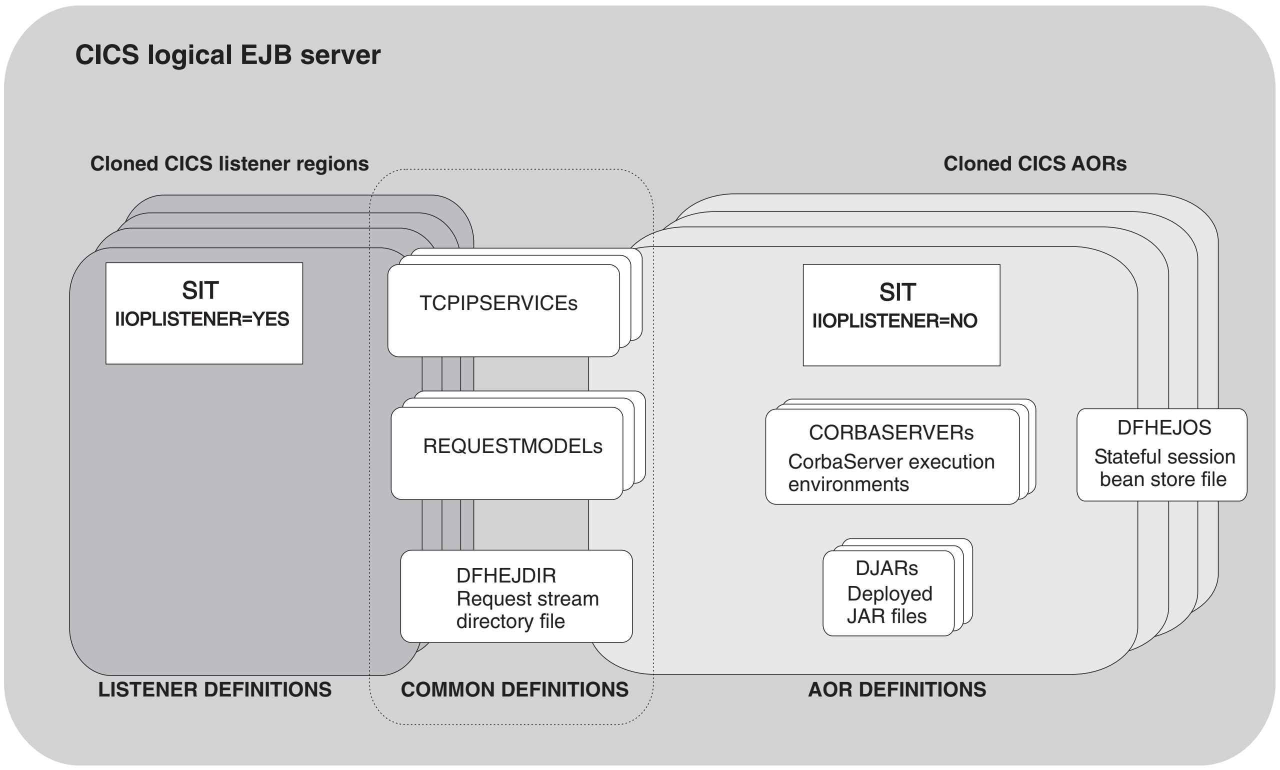


Figure 38. Resource definitions in a CICS logical server. The picture shows which definitions are required in the listener regions, which in the AORs, and which in both.

Processing IIOP requests

The CICS request receiver derives a CICS USERID and TRANSID that establish CICS execution parameters for the request, before passing control to the IIOP request processor to invoke the target methods.

Obtaining a CICS user ID

For IIOP requests, you can authenticate and identify the user in the following ways.

About this task

1. Using Secure Sockets Layer (SSL) client authentication. See the *CICS RACF Security Guide* for more information.
2. If SSL authentication does not provide a user ID, you can use the IIOP user-replaceable security program to provide one. Specify the name of your IIOP security program on the URM attribute of the TCPIPSERVICE definition for the port. See "Using the IIOP user-replaceable security program" on page 384 for more information.
3. If neither of these mechanisms provides a user ID, the default user ID is used.

If you specify the name of a security program on the TCPIPSERVICE definition, but omit the PROGRAM resource definition for it, CICS tries to build a resource definition for it (autoinstall); if this fails, or your security program does not return a USERID, CICS uses the user ID associated with the SSL client certificate, if there is one. Otherwise, the default user ID is used.

The following communications area is passed to the user-replaceable program. This structure is based on the format of an IIOP message defined in *The Common Object Request Broker: Architecture and Specification* obtainable from the OMG Web site at http://www.omg.org/library

Offset Hex	Type	Len	Name
(0)	STRUCTURE	80	sXOPUS
(0)	CHARACTER	4	standard_header
(4)	FULLWORD	4	pIIOPData
(8)	FULLWORD	4	lIIOPData
(C)	FULLWORD	4	pRequestBody
(10)	FULLWORD	4	lRequestBody
(14)	CHARACTER	4	corbaserver
(18)	FULLWORD	4	pBeanName
(1C)	FULLWORD	4	lBeanName
(20)	FULLWORD	4	BeanInterfaceType
(24)	FULLWORD	4	pModule
(28)	FULLWORD	4	lModule
(2C)	FULLWORD	4	pInterface
(30)	FULLWORD	4	lInterface
(34)	FULLWORD	4	pOperation
(38)	FULLWORD	4	lOperation
(3C)	CHARACTER	8	userid
(44)	FULLWORD	4	transid
(48)	FULLWORD	4	flag_bytes
(4C)	FULLWORD	4	return_code
(50)	FULLWORD	4	reason_code

`standard_header`
contains a standard header with the following format:

function
1–byte field set to X'00'

domain
2–character field containing II

* 1–character reserved field

pIIOPData
contains the address of the first megabyte of the unconverted IIOP buffer.

lIIOPData
contains the length of the unconverted IIOP buffer.

pRequestbody
contains the address of the incoming IIOP request.

lRequestbody
contains the length of the incoming IIOP request.

corbaserver
contains the name of the CorbaServer associated with this request.

pBeanName
contains a pointer to the EBCDIC bean name.

lBeanName
contains the length of the bean name.

BeanInterfaceType
contains an enumerated value. X'00' indicates home; X'01' indicates remote.

pModule
contains a pointer to the EBCDIC Module name.

lModule
contains the length of the Module name.

pInterface
contains a pointer to the EBCDIC Interface name.

lInterface
contains the length of the Interface name.

pOperation
contains a pointer to the EBCDIC Operation name.

lOperation
contains the length of the Operation.

userid
contains the input and output user ID. The output user ID must be exactly 8 characters long. If it is shorter than 8 characters it must be padded with blanks.

transid
contains the input TRANSID

Flag_bytes
contains the following indicators::

littleEndian
1–byte field showing byte-order, where **1** indicates TRUE and **0** indicates FALSE

sslClientUserid
1–byte field showing the derivation of the USERID if SSLTYPE CLIENTAUTH is specified in the TCPIPSERVICE definition, where:

0 USERID set from DFLTUSER

	1	USERID set from SSL CERTIFICATE
*	2–byte reserved field	

return_code
contains the return code.

reason_code
contains the reason code.

RETNCODE is set to RCUSRID (X'01') if a USERID is being returned. The user-replaceable program should return all other fields unchanged, or unpredictable results will occur.

For information about installing user-replaceable programs, see Customizing with user-replaceable programs in the *CICS Customization Guide*.

Using the IIOP user-replaceable security program:

You may optionally provide an IIOP security program to examine elements of the incoming IIOP request and generate a USERID.

You must specify the name of your security program on the URM attribute of the TCPIPSERVICE resource definition, and also supply a PROGRAM resource definition for it. If you do not specify a value for URM on the TCPIPSERVICE, no program is called.

The IIOP security program is called only if CICS cannot obtain a user ID using SSL client authentication. See SSL authentication, in the *CICS RACF Security Guide*, for more information.

A sample IIOP security program, DFHXOPUS, is supplied

Your security program may use CICS services, such as a task-related user exit to access DB2, and application parameters encoded within the body of the request.

Using DFHXOPUS:

The CICS supplied sample user-replaceable program, DFHXOPUS, accepts the RACF USERID associated with the client certificate, if there is one.

If there is no RACF USERID associated with a certificate:
- For SSL(CLIENTAUTH), DFHXOPUS uses the first eight characters of the COMMONNAME extracted from the client certificate.
- For SSL(YES) or SSL(NO), DFHXOPUS uses the first eight characters of the IIOP Principal, if there is one.

  Note: Versions of the General Inter-ORB Protocol (GIOP) from 1.2 onwards do not support the IIOP Principal field in request headers. So DFHXOPUS will only ever return a user ID derived from the IIOP Principal when the request is in GIOP 1.1, or earlier, format.

If a USERID has not been found using these procedures, DFHXOPUS returns the USERID specified in the CICS system initialization DFLTUSERDFLTUSER system initialization parameter.

The security exit program returns the user ID in the `userid` field of the communications area. If the user ID is less than 8 characters long, the exit program pads the field with blanks. Because a user ID is being returned, the `return_code` field is set to RCUSRID (X'01') .

If you write your own security exit program, it should return all fields other than `userid` and `return_code` unchanged, or unpredictable results may occur.

Obtaining a CICS TRANSID

To associate the incoming GIOP request with a CICS transaction ID, you need to provide and install a REQUESTMODEL resource definition.

You should supply REQUESTMODEL resources for all possible requests that should run under a non-default transaction ID. At run-time, when CICS receives a GIOP request it compares fields in the request with predefined values in the REQUESTMODELs, to find the REQUESTMODEL that most exactly matches the request. The selected REQUESTMODEL provides the TRANSID name that is used to process the request. If no match is found, a default TRANSID (CIRP) is used. REQUESTMODELs can be used with enterprise beans, stateless CORBA objects, or both. They specify:

- CORBA MODULE and INTERFACE patterns to match against requests for stateless CORBA objects
- Bean names for matching enterprise beans.
- OPERATION patterns to match against:
  - Enterprise bean method names
  - CORBA stateless object method names
  - IDL operations (CORBA stateless objects only)

  Note: The OPERATION field is subject to the Java-to-IDL name-mangling rules described in “Name-mangling of the OPERATION field” on page 386.
- The CICS transaction to be started when a matching request is received. The default is CIRP, which specifies the default DFJIIRP program. If you choose to use your own transaction definition, you should base it on CIRP and provide a TRANSACTION resource definition with the PROGRAM parameter set to the name of a CICS program that is defined with the JVMCLASS parameter set to **com.ibm.cics.iiop.RequestProcessor**. The following default resource definitions are provided by CICS in the DFHIIOP group:

```
DEFINE TRANSACTION(CIRP)    GROUP(DFHIIOP)
     PROGRAM(DFJIIRP)       TWASIZE(0)
     PROFILE(DFHCICST)      STATUS(ENABLED)
     TASKDATALOC(ANY)       TASKDATAKEY(USER)
     RUNAWAY(SYSTEM)        SHUTDOWN(ENABLED)
     PRIORITY(1)            TRANCLASS(DFHTCL00)
     DTIMOUT(NO)            TPURGE(NO)
     SPURGE(YES)            ISOLATE(YES)
     RESSEC(YES)            CMDSEC(YES)
     RESTART(NO)
     DESCRIPTION(Default CICS IIOP Request Processor transaction)


DEFINE PROGRAM(DFJIIRP)       GROUP(DFHIIOP)
     DESCRIPTION(CICS IIOP Request Processor)
     JVM(YES)
     JVMCLASS(com.ibm.cics.iiop.RequestProcessor)
     JVMPROFILE(DFHJVMCD)
```

```
LANGUAGE(LE370)       RELOAD(NO)            EXECKEY(USER)
RESIDENT(NO)          USAGE(NORMAL)         USELPACOPY(NO)
STATUS(ENABLED)       CEDF(NO)              DATALOCATION(ANY)
DYNAMIC(NO)
```

See “Dynamic routing” on page 387 if the request is to be routed to an AOR.

- The name of the CorbaServer that will process the request

See the *CICS Resource Definition Guide* for full details of the REQUESTMODEL resource definition.

Note: To simplify the process of creating REQUESTMODEL definitions for enterprise beans, use the CREA CICS-supplied transaction.

Pattern matching:

All requests are compared with installed REQUESTMODEL values for CORBASERVER and TYPE.

A TYPE value of CORBA indicates a request for a stateless CORBA object; a TYPE value of EJB indicates a request for an enterprise bean, and a TYPE value of GENERIC can indicate either type of request. Further matching is then performed, based on the TYPE value:

Stateless CORBA objects

For stateless CORBA objects, (TYPE=CORBA, or GENERIC), the matching process compares the **MODULE** name, **INTERFACE** and **OPERATION** fields contained within the IIOP message, against the patterns defined in each installed REQUESTMODEL, until the closest match is found. INTERFACE, MODULE, and OPERATION can be defined as generic patterns. The rules for pattern matching are summarized as follows:

- Double colons are used as component separators. Each component must be between 1 and 16 characters long
- Generic patterns can consist of zero or more characters followed by *.

If several different generic patterns match a given string, the longest generic pattern results in the most specific match.

Enterprise beans

For enterprise beans, the matching process compares the BEANNAME, OPERATION, and INTFACETYPE fields within the IIOP message, against those defined in each installed REQUESTMODEL.

Name-mangling of the OPERATION field:

The OPERATION field of the REQUESTMODEL definition is used to supply the name of the remote method that is to be matched by this request model.

The GIOP request received at run-time includes an operation field which is compared to the OPERATION field on the request model. However, the value of the operation field is not always the same as the method name, as used on the stateless CORBA object or enterprise bean. If RMI-IIOP is being used (as always happens with enterprise beans and may happen with stateless CORBA objects), the method name undergoes a process known as “*mangling*” to change the method name into a canonical form suitable for transmission using IIOP. This mangled method name may not be the same as the original method name. The operation field in the REQUESTMODEL must supply the mangled version of the method name (or a pattern, using wildcard characters, that matches it).

The CICS-supplied CREA transaction can be used to create REQUESTMODEL definitions for enterprise beans that automatically deal with this name-mangling issue.

This mangling and de-mangling knowledge is compiled into the application's stub and tie classes generated using the RMI compiler (RMIC).

For more information about mangling, see "Name mangling for Java."

REQUESTMODEL examples:

This is an example of a stateless CORBA object REQUESTMODEL:

```
DEFINE REQUESTMODEL(DFJ$IIRH)  GROUP(DFH$IIOP)
       CORBASERVER(IIOP)
       TYPE(Corba)
       MODULE(hello)
       INTERFACE(HelloWorld)
       OPERATION(*)
       TRANSID(IIHE)
       DESCRIPTION(Hello world java server sample)
```

Dynamic routing:

If the method invocation is to be routed to another region (AOR), you must define the TRANSID specified in the REQUESTMODEL as dynamically routable in the Listener region (using the DYNAMIC parameter). If you use the supplied default TRANSACTION definition, CIRP, then you will need to change it.

Name mangling for Java

Name mangling is a term that denotes the process of mapping a name that is valid in a particular programming language to a name that is valid in the CORBA Interface Definition Language (IDL). This section explains why mangling is necessary for Java names, how the names are mangled, and how mangling affects your CICS system.

Why mangling is necessary for Java names:

Java client programs use Java Remote Method Invocation (RMI) to invoke methods in a server.

RMI in turn uses one of two communication protocols between client and server:

Java Remote Method Protocol (JRMP)
: RMI uses JRMP when both client and server applications are written in Java. CICS does not use JRMP.

Internet Inter-ORB Protocol (IIOP)
: RMI uses in an environment when client and server applications may be written in different languages. When IIOP is used as the communications protocol, Java client applications can use the RMI to invoke server programs in another language (C++, for example), as well as to invoke remote Java programs.

IIOP uses Interface Definition Language (IDL) to specify interfaces between objects in a language-independent way. When a Java client makes a remote method call, the Java method name, and its arguments, are converted to the equivalent IDL for transmission to the server using IIOP. It is at this point that mangling may be necessary, because there are many differences in the rules for Java names and IDL names. Some of these differences are:

- Java names are case-sensitive, IDL names are not
- Java supports overloaded methods, IDL does not
- Java names can contain Unicode characters, IDL names cannot
- Some valid Java names may collide with IDL keywords
- Java names can start with a leading underscore, IDL names cannot

In these cases, and others, Java names that are not permitted in IDL, or that are permitted but may be ambiguous, are mangled into an acceptable form.

How Java names are mangled:

The rules by which a Java method call is mapped to an IDL name are not simple, and depend upon the circumstances.

Here is one example:

A Java remote interface has methods save, Save and SAVE. These names are distinct in Java, but - because IDL names are not case sensitive - IDL cannot distinguish between them. Therefore, the names are mangled to make them distinct. The mangled names are save_, Save_0 and SAVE_0_1_2_3. However, if the Java remote interface had just one method - save - the name would not be mangled, because there is no possibility of ambiguity.

This example illustrates two important principles:

- It is not possible to determine the mangled name of a given method without knowing what other methods exist.
- Adding or removing a method can affect the mangled names of other methods.

Other cases where mangling is necessary are handled differently. For detailed information about the mapping between Java and IDL, see *Java Language to IDL Mapping*, which is published by the Object Management Group (OMG) (`http://www.omg.org`).

How mangling affects CICS:

Although the support for IIOP within CICS contains code that implements the mangling rules, there is very little visible effect on the way you configure and use your CICS system.

There are just two situations in which you need to be aware that mangling takes place. They are:

When defining REQUESTMODELs

REQUESTMODEL resource definitions map inbound IIOP request to CICS transactions. When an inbound request initiated by a Java remote method invocation is received, the OPERATION attribute in the REQUESTMODEL is compared with the mangled name in the inbound request to determine if the REQUESTMODEL matches the request. If it is possible that mangling can take place, do not specify a method name in the OPERATION attribute of the REQUESTMODEL, but specify a generic operation instead.

When creating debugging profiles for Java programs

Debugging profiles specify which program instances are to run under the control of a debugger. When an inbound request initiated by a Java remote method invocation is received, the method field of the debugging profile is compared with the mangled name in the inbound request to determine if the profile matches the request. If it is possible that mangling can take place, do not specify a method name in the debugging profile, but specify a generic method instead.

CAUTION: Although - in theory - its is possible to deduce the mangled names corresponding to each method, it is not a simple task, and is not advisable. To do so, you will need a thorough knowledge of the mangling rules, and of all the method names used in your application. There is also a risk that small changes to an application can change a mangled name.

Handling IIOP diagnostics

If a remote method that is invoked over IIOP fails, the client code will receive a CORBA exception. This includes all enterprise bean exceptions.

CORBA exceptions are defined in the CORBA documentation, which can be obtained from the CORBA Web site: `http://www.omg.org`.

In many instances, the exception includes a CICS specific minor code to aid in problem determination. CICS currently uses the following minor codes:

Table 23. CICS specific CORBA minor codes

Code	CICS component detecting problem
1229111296	CICS IIOP request receiver
1229111297	Elsewhere in CICS II domain
1229111298	ORB component of CICS OT domain
1229111299	JTS component of CICS OT domain
1229111300	CSI component of CICS OT domain
1229111301	CSI component of CICS EJ domain

If the client receives a CORBA exception containing any of the CICS minor codes, you should examine the CICS message logs for further information about the error.

Notices

Trademarks

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General

CICS Transaction Server for z/OS Program Directory, GI13-0565
CICS Transaction Server for z/OS What's New, GC34-7192
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CICS Transaction Server for z/OS Installation Guide, GC34-7171

Access to CICS

CICS Internet Guide, SC34-7173

CICS Web Services Guide, SC34-7191

Administration

CICS System Definition Guide, SC34-7185
CICS Customization Guide, SC34-7161
CICS Resource Definition Guide, SC34-7181
CICS Operations and Utilities Guide, SC34-7213
CICS RACF Security Guide, SC34-7179
CICS Supplied Transactions, SC34-7184

Programming

CICS Application Programming Guide, SC34-7158
CICS Application Programming Reference, SC34-7159
CICS System Programming Reference, SC34-7186
CICS Front End Programming Interface User's Guide, SC34-7169
CICS C++ OO Class Libraries, SC34-7162
CICS Distributed Transaction Programming Guide, SC34-7167
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Diagnosis

CICS Problem Determination Guide, GC34-7178
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CICS Diagnosis Reference, GC34-7166
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CICS Data Areas, GC34-7163
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CICSPlex SM Resource Tables Reference Vol 2, SC34-7205
CICSPlex SM Messages and Codes, GC34-7201
CICSPlex SM Problem Determination, GC34-7203

Other CICS publications

The following publications contain further information about CICS, but are not provided as part of CICS Transaction Server for z/OS, Version 4 Release 2.

Designing and Programming CICS Applications, SR23-9692

CICS Application Migration Aid Guide, SC33-0768

CICS Family: API Structure, SC33-1007

CICS Family: Client/Server Programming, SC33-1435

CICS Family: Interproduct Communication, SC34-6853

CICS Family: Communicating from CICS on System/390, SC34-6854

CICS Transaction Gateway for z/OS Administration, SC34-5528

CICS Family: General Information, GC33-0155

CICS 4.1 Sample Applications Guide, SC33-1173

CICS/ESA 3.3 XRF Guide , SC33-0661

Other IBM publications

The following publications contain information about related IBM products.

IBM Developer Kit and Runtime Environment, Java 2 Technology Edition Diagnostics Guide, SC34-6358
Persistent Reusable Java Virtual Machine User's Guide, SC34-6201

Accessibility

Accessibility features help a user who has a physical disability, such as restricted mobility or limited vision, to use software products successfully.

You can perform most tasks required to set up, run, and maintain your CICS system in one of these ways:
- using a 3270 emulator logged on to CICS
- using a 3270 emulator logged on to TSO
- using a 3270 emulator as an MVS system console

IBM Personal Communications provides 3270 emulation with accessibility features for people with disabilities. You can use this product to provide the accessibility features you need in your CICS system.

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CICS Transaction Server for z/OS
Version 4 Release 2
Java Applications in CICS

Publication No. SC34-7174-02

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