CICS Transaction Server for z/OS

CICS DB2 Guide

Version 3 Release 1

SC34-6457-05

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Note!
Before using this information and the product it supports, be sure to read the general information under “Notices” on page 213.

Sixth edition (July 2010)

This edition applies to Version 3 Release 1 of CICS Transaction Server for z/OS, program number 5655-M15, and to all subsequent versions, releases, and modifications until otherwise indicated in new editions. Make sure you are using the correct edition for the level of the product.

Contents

Preface

What this book is about

This book is for anyone who uses, or is considering using, the CICS® Transaction Server for z/OS®, Version 3 Release 1 DB2® interface. It is intended to be used in conjunction with existing manuals in the CICS and DB2 libraries. These are referred to where appropriate.

The aim of this book is to give introductory and guidance information on evaluating, installing, and using the CICS DB2 attachment facility, and on defining and maintaining your CICS DB2 environment.

What you need to know to understand this book

Before you read this book, you need a general understanding of CICS. You can find general introductory information in the *CICS Family: General Information*. You should also have some knowledge of the concepts of data management and databases. For guidance on these topics, see the *DB2 Universal Database for OS/390 and z/OS Administration Guide*.

Notes on terminology

When the term "CICS" is used without any qualification, it refers to the CICS element of IBM® CICS Transaction Server for z/OS.

"DB2" without any qualification refers to DB2 Universal Database™ Server for OS/390® and z/OS.

CICSPlex® SM is used for CICSPlex System Manager.

"MVS™" is used for the operating system, which can be an element of z/OS, OS/390, or MVS/Enterprise System Architecture System Product (MVS/ESA SP).

Summary of changes

This book is based on the CICS DB2 Guide for CICS Transaction Server for z/OS, Version 2 Release 3. Changes from that edition are marked by vertical bars in the left margin.

This part lists briefly the changes that have been made for the following releases:

For most items in each of the lists above, there is a link to the part of the book where there is more detail.

Changes for CICS Transaction Server for z/OS, Version 3 Release 1

The more significant changes for this edition are:

Technical changes

- Because of the removal of run-time support for Java program objects and hot-pooling (HPJ), information about using this type of Java program to access DB2 is removed from Chapter 8, “Using JDBC and SQLJ to access DB2 data from Java programs and enterprise beans written for CICS,” on page 117. If you have any Java program objects that access DB2, and need to migrate them to run in a JVM, “Requirements to support Java programs in the CICS DB2 environment” on page 119 has information on the requirements for Java programs that run in a JVM and access DB2.

Changes for CICS Transaction Server for z/OS, Version 2 Release 3

The more significant changes for this edition are:

Technical changes

- There are changes to the samples that are provided to set up a CICS-compatible DataSource. Chapter 8, “Using JDBC and SQLJ to access DB2 data from Java programs and enterprise beans written for CICS,” on page 117 has information on using the DataSource interface to acquire connections.

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

The more significant changes for this edition are:

Technical changes: Open transaction environment (OTE) exploitation

- If your CICS system is connected to DB2 Version 6 or later, CICS now exploits the open transaction environment (OTE) to improve performance by reducing TCB switching. For full details of the CICS DB2 configuration needed to exploit the open transaction environment, see “Migrating to a different release of DB2” on page 15.
- For an overview of the effects of this change, see the *CICS Transaction Server for z/OS Release Guide* for CICS Transaction Server for z/OS, Version 2 Release 2. Chapter 1, “Overview of the CICS DB2 interface,” on page 1, has explanations of the important differences in the way CICS connects to DB2 in the open transaction environment, including the use of open TCBs instead of subtask TCBs to run threads (see “Overview: How threads work” on page 2). “Thread TCBs (task control blocks)” on page 177 has further information on open TCBs being used as thread TCBs, and on the new modules used to control CICS DB2

connection processing. “How threads are created, used, and terminated” on page 55 explains the differences in thread use when using open TCBs.

- When using the open transaction environment, to be sure that you have enough open TCBs available to process your DB2 workload, ensure that the limit set in your MAXOPENTCBS system initialization parameter is greater than the limit set in the TCBLIMIT attribute of your DB2CONN definition. For more information, see “The MAXOPENTCBS system initialization parameter and TCBLIMIT” on page 52.
- To gain the performance benefits of the open transaction environment, application programs must be threadsafe. See “Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming” on page 106 for information.
- OTE exploitation is particularly important for enterprise beans that make DB2 requests. See “Using JDBC and SQLJ in enterprise beans: special considerations” on page 130 for information.
- There is a new wait type for the open transaction environment, CDB2CONN, and some of the existing wait types only apply when CICS is not using the open transaction environment (when it is connected to DB2 Version 5 or earlier). See “Wait types for CICS DB2” on page 178 for information.
- The use of the open transaction environment affects how you can purge CICS DB2 transactions. See “Purging CICS DB2 transactions” on page 30 for information.
- There are differences to the tracing performed for the CICS DB2 attachment facility in the open transaction environment. Among other things, the CICS DB2 connection program DFHD2D2, which replaces DFHD2EX3 in the open transaction environment, makes new entries in the CSUB trace table. See “Trace for CICS DB2” on page 182 for information.
- There are changes to accounting and performance monitoring as a result of the availability of the open transaction environment. See Chapter 10, “Accounting and monitoring in a CICS DB2 environment,” on page 145 for information.

Technical changes: Group attach

- If your CICS system is connected to DB2 Version 7 or later, you can now use the DB2 group attach facility, which allows CICS to connect to any one member of a data sharing group of DB2 subsystems, rather than to a specific DB2 subsystem. For full details of the CICS DB2 configuration needed to use the DB2 group attach facility, see “Migrating to a different release of DB2” on page 15.
- See “Using the DB2 group attach facility” on page 51 for more information about the group attach facility. Group attach is controlled by the new DB2GROUPID and RESYNCMEMBER attributes of the DB2CONN definition — see the *CICS Resource Definition Guide* for full descriptions of these attributes. If you are using group attach, this affects the resolution of indoubt units of work, and you need to decide on the strategy that CICS adopts — see “Resolving indoubt units of work (UOWs)” on page 26 for details.
- If you are using group attach, the output from, and use of, the DSNC STRT command is affected — see “DSNC STRT” on page 48 for information. If you specify a DB2ID on a DSNC STRT command, this overrides and blanks out a DB2GROUPID set in the installed DB2CONN definition. You cannot specify a DB2GROUPID on a DSNC STRT command.

Other technical changes

- When running with DB2 Version 7 or later, Java applications and enterprise beans for CICS can use the new Java Database Connectivity (JDBC) driver

provided by DB2, that supports a selected subset of the JDBC 2.0 API, including support for the DataSource interface. A DataSource is an alternative way of obtaining a JDBC connection to a database. Chapter 8, “Using JDBC and SQLJ to access DB2 data from Java programs and enterprise beans written for CICS,” on page 117 has information on the requirements for the JDBC 2.0 driver, and on using the DataSource interface to acquire connections. Samples are provided to set up a CICS-compatible DataSource.

- In this release of CICS, PLAN and PLANEXITNAME options are added to the INQUIRE DB2TRAN command, so you can find out in a single step which plan is used by a specified transaction or set of transactions, or which transactions use a specified plan. See the *CICS System Programming Reference* for information.
- The output from the DSNC DISPLAY PLAN or TRAN command now distinguishes between a thread that is active and currently executing in DB2, and a thread that is active but is not currently executing in DB2. See “DSNC DISPLAY” on page 38 for information.
- When preparing CICS programs that access DB2, you can now use Language Environment-conforming language compilers (COBOL and PL/I) that support the integrated CICS translator and, depending on your release of DB2, an SQL statement coprocessor. See “CICS DB2 program preparation steps” on page 134 for more information on the changes to the program preparation process.

Structural changes

- Chapter 1, “Overview of the CICS DB2 interface,” on page 1, has been rewritten, and now includes information on
  - how threads and thread TCBs work
  - how the DB2CONN, DB2ENTRY and DB2TRAN definitions work together
  - how plans, packages and dynamic plan exits work
- Chapter 7, “Application design and development considerations for CICS DB2,” on page 87 and Chapter 9, “Preparing CICS DB2 programs for execution and production,” on page 133 have been reorganised. In particular, Chapter 8, “Using JDBC and SQLJ to access DB2 data from Java programs and enterprise beans written for CICS,” on page 117 is now a separate chapter.
- Chapter 2, “Installation and migration notes for CICS DB2,” on page 15 and Chapter 5, “Defining the CICS DB2 connection,” on page 51 have been reorganised.
- The chapter 'Customization: dynamic plan exits' has been removed, and the information it contained is now in “Dynamic plan exits” on page 96 and “Dynamic plan switching” on page 100.
- The chapter 'Monitoring, tuning and handling deadlocks' has been removed. The information it contained is now in Chapter 10, “Accounting and monitoring in a CICS DB2 environment,” on page 145, Chapter 9, “Preparing CICS DB2 programs for execution and production,” on page 133, Chapter 11, “Problem determination for CICS DB2,” on page 177, and the *CICS Performance Guide*.

Changes for CICS Transaction Server for z/OS, Version 2 Release 1

The more significant changes for this edition are:

- Information is provided on support for Java programs for CICS and enterprise beans accessing DB2 (see “Requirements to support Java programs in the CICS DB2 environment” on page 119 and “Using JDBC and SQLJ in enterprise beans: special considerations” on page 130. “Dynamic plan exits” on page 96 explains the consequences of these changes for dynamic plan exits.

- Information has been added on a safer way to purge CICS DB2 transactions using the DB2 CANCEL THREAD command (see “Purging CICS DB2 transactions” on page 30 and “Wait types for CICS DB2” on page 178).
- Information has been added on DB2 thread identification by a correlation ID (see “DB2 thread identification” on page 194 and the note in “DSNC DISPLAY” on page 38).
- Further information on the changes to the INITPARM system initialization parameter has been added to “Effect of migration to RDO on the INITPARM system initialization parameter” on page 21 and “DSNC STRT” on page 48.
- In “Migrating RCTs to the CSD using DFHCSDUP” on page 23, a note has been added about the effect on CICS DB2 statistics when you use wildcard characters in defining transaction IDs.
- A new parameter, CPRMAPPL, containing the 8 byte character name of the application program issuing an SQL request, is now passed to the sample dynamic plan exit DSNCUEXT — see “Dynamic plan exits” on page 96, table Table 4 on page 97.
- In “Wait types for CICS DB2” on page 178, information is given on a new wait added to DFHD2EX2, to wait until the TERM process is complete (see Table 15 on page 182).

For most items in each of the lists above, there is a reference to the part of the book where there is more detail.

Earlier releases

Changes for CICS Transaction Server for OS/390 Version 1 Release 3

Major changes for this edition provide information on the changes to the INITPARM system initialization parameter now that CICS no longer supports running the CICS DB2 attachment facility with a macro RCT. See “Effect of migration to RDO on the INITPARM system initialization parameter” on page 21 and “Migrating to RDO for DB2 resource definition” on page 21.

Chapter 1. Overview of the CICS DB2 interface

This chapter gives an overview of the CICS interface to DB2 (Database 2).

This chapter includes the following topics:

Overview: How CICS connects to DB2

A CICS DB2 attachment facility is provided with CICS. The CICS DB2 attachment facility provides CICS applications with access to DB2 data while operating in the CICS environment. CICS applications, therefore, can access both DB2 data and CICS data. CICS coordinates recovery of both DB2 and CICS data if transaction or system failure occurs.

The CICS DB2 attachment facility creates an overall connection between CICS and DB2. CICS applications use this connection to issue commands and requests to DB2. The connection between CICS and DB2 can be created or terminated at any time, and CICS and DB2 can be started and stopped independently. You can name an individual DB2 subsystem to which CICS connects, or (if you have DB2 Version 7 or later) you can use the group attach facility to let DB2 choose any active member of a data-sharing group of DB2 subsystems for the connection. You also have the option of CICS automatically connecting and reconnecting to DB2. A DB2 system can be shared by several CICS systems, but each CICS system can be connected to only one DB2 subsystem at a time.

Attachment commands display and control the status of the CICS DB2 attachment facility, and are issued using the CICS supplied transaction DSNC. The attachment commands are:
- STRT - start the connection to DB2
- STOP - stop the connection to DB2
- DISP - display the status of threads, and display statistics
- MODI - modify characteristics of the connection to DB2
- DISC - disconnect threads

The connection between CICS and DB2 is a multithread connection. Within the overall connection between CICS and DB2, there is a thread—an individual connection into DB2—for each active CICS transaction accessing DB2. Threads allow each CICS transaction to access DB2 resources, such as a command processor or an application plan (the information that tells DB2 what the application program's SQL requests are, and the most efficient way to service them). See "Overview: How threads work" on page 2 below for a full explanation of how threads work.

When an application program operating in the CICS environment issues its first SQL request, CICS and DB2 process the request as follows:
- A language interface, or stub, DSNCLI, that is link-edited with the application program calls the CICS resource manager interface (RMI).
- The RMI processes the request, and passes control to the CICS DB2 attachment facility's task-related user exit (TRUE), the module that invokes DB2 for each task.

- The CICS DB2 attachment facility schedules a thread for the transaction. At this stage, DB2 checks authorization, and locates the correct application plan.
- DB2 takes control, and the CICS DB2 attachment facility waits while DB2 services the request.
- When the SQL request completes, DB2 passes the requested data back to the CICS DB2 attachment facility.
- CICS now regains control, and the CICS DB2 attachment facility passes the data and returns control to the CICS application program.

The DB2 address spaces

DB2 requires several different address spaces. Figure 1 shows these address spaces.

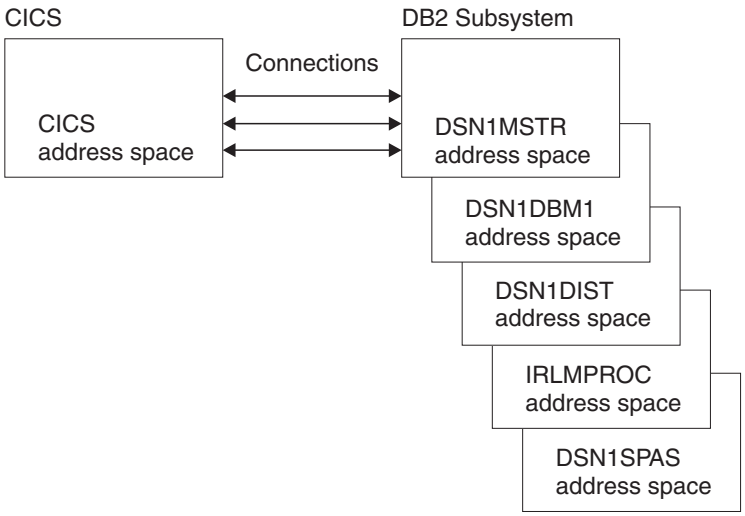


Figure 1. The DB2 address spaces

Various tasks are performed in the different address spaces, as follows:

DSN1MSTR
for system services that perform a variety of system-related functions.

DSN1DBM1
for database services that manipulate most of the structures in user-created databases.

DSN1DIST
for distributed data facilities that provide support for remote requests.

IRLMPROC
for the internal resource lock manager (IRLM), which controls DB2 locking.

DSN1SPAS
for stored procedures, which provide an isolated execution environment for user-written SQL.

Overview: How threads work

Within the overall connection between CICS and DB2, each CICS transaction that accesses DB2 needs a thread, an individual connection into DB2. Threads are created when they are needed by transactions, at the point when the application issues its first SQL or command request. The transaction uses the thread to access

resources managed by DB2. When a thread is no longer needed by the transaction, because the transaction has accessed all the resources it needs to use, the thread is released (typically after syncpoint completion). It takes processor resources to create a thread, so when a thread is released, the CICS DB2 attachment facility checks to see if another transaction needs a thread. If another transaction is waiting for a thread, the CICS DB2 attachment facility reuses the existing thread for that transaction to access DB2. If the thread is no longer needed by any transaction, it is terminated, unless you have requested that it should be protected (kept) for a period of time. A protected thread is reused if another transaction requests it within that period of time; if not, it is terminated when the protection time expires.

There are different types of thread, and you can set a limit on the number of each type of thread that can be active at any one time. This prevents the overall CICS DB2 connection from becoming overloaded with work. A special type of thread is used for DB2 commands issued using the DSNC transaction, and you can also define special threads for CICS transactions with particular requirements, such as transactions that require a fast response time. You can define what a transaction must do if no more threads of the type it needs are available — it can wait until a thread of the right type is available; it can use a general-purpose thread, called a pool thread; or it can abend.

The types of thread provided by the CICS DB2 attachment facility are:

Command threads
: Command threads are reserved by the CICS DB2 attachment facility for issuing commands to DB2 using the DSNC transaction. They are not used for commands acting on the CICS DB2 attachment facility itself, because these commands are not passed to DB2. When a command thread is not available, commands automatically overflow to the pool, and use a pool thread. Command threads are defined in the command threads section of the DB2CONN definition.

Entry threads
: Entry threads are specially defined threads intended for transactions with special requirements, such as transactions that require a fast response time, or transactions with special accounting needs. You can instruct the CICS DB2 attachment facility to give entry threads to particular CICS transactions. You define the different types of entry threads that are needed for different transactions, and you can set a limit on the number of each of these types of entry thread. If a transaction is permitted to use an entry thread, but no suitable entry thread is available, the transaction can overflow to the pool and use a pool thread, or wait for a suitable entry thread, or abend, as you have chosen in the definition for the entry thread.

  A certain number of each type of entry thread can be protected. When an entry thread is released, if it is protected it is not terminated immediately. It is kept for a period of time, and if another CICS transaction needs the same type of entry thread during that period, it is reused. This avoids the overhead involved in creating and terminating the thread for each transaction. An entry thread that is unprotected is terminated immediately, unless a CICS transaction is waiting to use it the moment it is released.

  Entry threads are defined using a DB2ENTRY definition.

Pool threads
: Pool threads are used for all transactions and commands that are not using an entry thread or a DB2 command thread. Pool threads are intended for low volume transactions, and for overflow transactions that could not obtain

an entry thread or a DB2 command thread. A pool thread is terminated immediately if no CICS transaction is waiting to use it. Pool threads are defined in the pool threads section of the DB2CONN definition.

For more detailed information on how the different types of thread are created, used and terminated, see “How threads are created, used, and terminated” on page 55.

Each thread runs under a thread task control block (thread TCB) that belongs to CICS. CICS and DB2 both have connection control blocks linked to the thread TCB. They use these connection control blocks to manage the thread into DB2, and to communicate information to each other about the thread. The DB2 connection control block controls the thread within DB2. The CICS connection control block, called the CSUB, acts as a pointer to the DB2 connection control block, and contains the information CICS requires to call the DB2 connection control block when the thread is needed. DB2 calls these connection control blocks “agent structures”.

The nature of the thread TCBs, and the way in which they are linked to the DB2 connection control block (and therefore to the thread), differs depending on the version of DB2 to which CICS is connected.

While CICS is connecting to a DB2 subsystem, it checks the DB2 release level of the subsystem. If CICS is connecting to DB2 Version 6 or later, the CICS DB2 task-related user exit (the module that invokes DB2 for each task) is automatically enabled as open API, so it can use the open transaction environment (OTE). If CICS is connecting to DB2 Version 5 or earlier, the task-related user exit is not enabled as open API, and does not use the open transaction environment.

Thread TCBs in a non-open transaction environment

When CICS is connected to DB2 Version 5 or earlier, and so is not using the open transaction environment, the thread TCBs are subtasks created by the CICS DB2 attachment facility to run each thread that is requested by transactions or DB2 commands. The CICS DB2 task-related user exit itself remains on the CICS main TCB, the QR TCB.

Once created, the subtask thread TCBs are permanently associated with a particular CSUB and DB2 connection control block. When the process for which a subtask thread TCB was created is complete, the subtask thread TCB, CSUB, DB2 connection control block and thread are released, and the whole assembly can be reused by another CICS transaction to access DB2 resources. So to reuse an existing thread, the CICS DB2 attachment facility must also reuse the subtask thread TCB associated with it.

If the thread is terminated before it is reused, the subtask thread TCB and its associated CSUB and DB2 connection control block remain available in the system. Like the threads themselves, it takes processor resource to create these, so the CICS DB2 attachment facility reuses them. If a thread is requested and no existing threads are available, the CICS DB2 attachment facility looks for an unused subtask thread TCB, CSUB and DB2 connection control block, and reuses them to run a new thread into DB2.

Figure 2 on page 5 summarizes how thread TCBs operate in a non-open transaction environment.

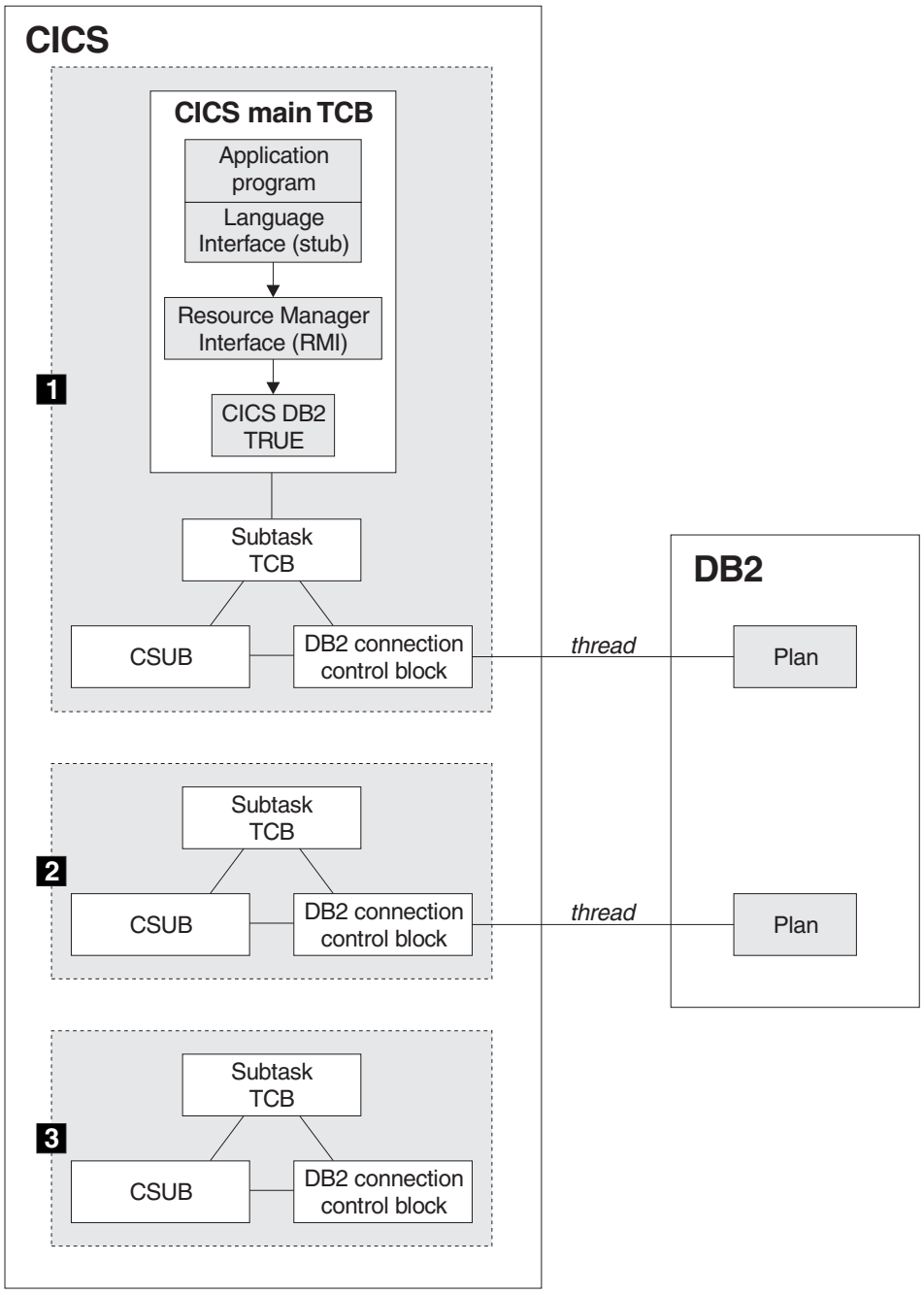


Figure 2. Thread TCBs in a non-open transaction environment

In Figure 2, situation **1** shows CICS using a thread to access DB2. On the CICS main TCB, the language interface that is link-edited with the application program calls the Resource Manager Interface (RMI), which invokes the CICS DB2 attachment facility's task-related user exit. The CICS DB2 task-related user exit, operating on the CICS main TCB, uses an assembly consisting of a subtask TCB, a CSUB, and a DB2 connection control block to run a thread into DB2. The plan associated with the thread is held in DB2.

Situation **2** shows a thread that is not currently in use, but is protected. The subtask TCB, CSUB and DB2 connection control block are still assembled together, and the thread runs into DB2. The thread is available for reuse.

Situation **3** shows an assembly that is left after a thread was terminated. The assembly, consisting of the subtask TCB, CSUB and DB2 connection control block, is available for reuse. It needs a new thread.

Thread TCBs in the open transaction environment

When CICS is connected to DB2 Version 6 or later, it is using the open transaction environment. (This situation therefore applies to users with DB2 Version 7 or later and JDBC 2.0.) In this environment, the CICS DB2 attachment facility uses open TCBs (L8 mode) as the thread TCBs, rather than using specially created subtask TCBs. Open TCBs perform other tasks besides accessing DB2 resources. In the open transaction environment, the CICS DB2 task-related user exit runs on an open TCB rather than on the CICS main TCB. If the application program that made the DB2 request is threadsafe, it can also run on the open TCB. (See “Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming” on page 106 for more information on application programs in the open transaction environment.)

Open TCBs are not permanently associated with a CSUB and DB2 connection control block. The CICS DB2 attachment facility can associate them with any CSUB and DB2 connection control block that are available, and therefore with any thread that is available. When the open TCB no longer needs the connection to DB2, it dissociates from, or releases, the thread, CSUB and DB2 connection control block. The thread, CSUB and DB2 connection control block can then be used by a different open TCB for the tasks it wishes to perform in DB2.

If the thread is terminated before it is reused, the CSUB and DB2 connection control block remain available in the system. If no existing threads are available, and an open TCB needs a connection to DB2, the CICS DB2 attachment facility can associate the unused CSUB and DB2 connection control block with the open TCB, and reuse them to run a new thread into DB2.

Figure 3 on page 7 summarizes how thread TCBs operate in the open transaction environment.

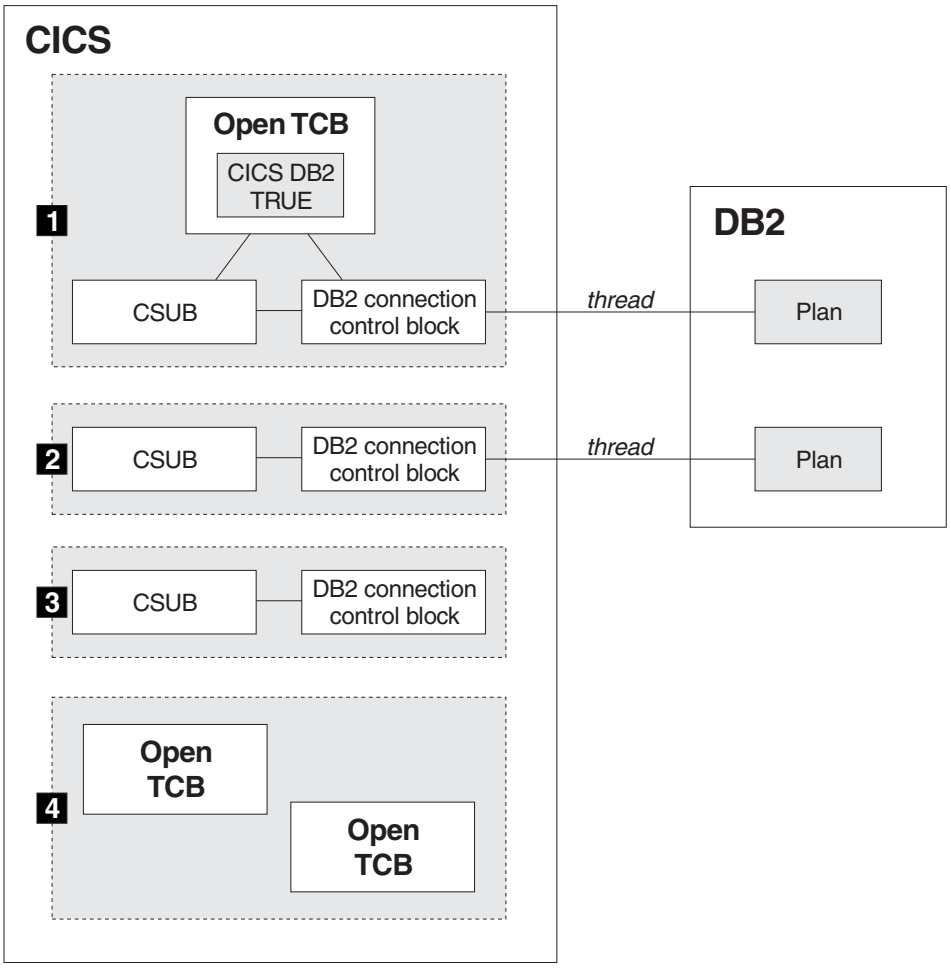


Figure 3. Thread TCBs in the open transaction environment

In Figure 3, situation **1** shows CICS using a thread to access DB2 in the open transaction environment. The CICS DB2 task-related user exit has been invoked by the Resource Manager Interface (RMI), and it is operating on an open TCB. The CICS DB2 attachment facility has associated a CSUB and a DB2 connection control block with the open TCB. The DB2 connection control block has a thread into DB2. The plan associated with the thread is held in DB2.

Situation **2** shows a thread that is not currently in use, but is protected. The CSUB and DB2 connection control block are still linked to each other and have a thread, but no open TCB is attached to them. The thread is available for reuse.

Situation **3** shows an assembly that is left after a thread was terminated. The CSUB and DB2 connection control block are available for reuse. They need a new thread.

Situation **4** shows open TCBs that are available for reuse. The CICS DB2 attachment facility can use these open TCBs and associate CSUB and DB2 connection control block assemblies with them to run threads into DB2.

Both types of TCB that the CICS DB2 attachment facility uses to run the threads, the open TCBs and the subtask TCBs, are referred to in this documentation as “thread TCBs”. In many situations, the different nature of the two types of thread TCB does not lead to any differences in the operation of the CICS DB2 connection.

Where the different types of thread TCB do cause the CICS DB2 connection to behave differently, a distinction is made between the two types. For more technical information on thread TCBs, see “Thread TCBs (task control blocks)” on page 177.

Overview: How you can define the CICS DB2 connection

You use resource definition online (RDO) to define the CICS DB2 connection. If you are migrating from an earlier release of CICS and have not used RDO before, read “Migrating from a CICS release that used RCT definitions for CICS DB2 resources” on page 17. If your CICS system is connected to DB2 Version 6 or later, the MAXOPENTCBS system initialization parameter also influences the CICS DB2 connection — for more information, see “The MAXOPENTCBS system initialization parameter and TCBLIMIT” on page 52.

As we have read in “Overview: How CICS connects to DB2” on page 1, the CICS DB2 connection consists of an overall connection between CICS and DB2, and individual connections known as threads. You can define the attributes of the overall connection, and the attributes of the different types of thread. If you have specially defined entry threads for key transactions, you can tell the CICS DB2 attachment facility which CICS transactions can use those threads. Defining the CICS DB2 connection involves three different objects: DB2CONN (the DB2 connection definition), DB2ENTRY (the DB2 entry definition), and DB2TRAN (the DB2 transaction definition). The scope of each object is as follows:

DB2CONN

DB2CONN is the main definition for the CICS DB2 connection. You need to install a DB2CONN before you can start the CICS DB2 connection. In the DB2CONN definition, you:

- Define the attributes of the overall CICS DB2 connection, which are:
  - the DB2 subsystem that CICS connects to, or the data-sharing group of DB2 subsystems from which DB2 picks an active member for CICS to connect to
  - if the connection to DB2 fails, whether CICS reconnects automatically or not, and, if you are using the group attach facility, whether CICS reconnects to the same DB2 subsystem or not
  - a general-purpose authorization ID for the CICS DB2 attachment facility to sign on to a thread, if no other authorization is needed for the thread
  - the limit on the total number of TCBs that CICS can use to run threads into DB2 at any one time
  - how long protected threads are kept before termination
  - how error messages are communicated to CICS, and what transactions should do if their thread fails
  - where messages and statistics are sent
- Define the attributes of command threads (the special threads used by the DSNC transaction for issuing DB2 commands), which are:
  - the limit on the number of command threads that CICS can use at any one time
  - what type of authorization ID DB2 checks when a command thread is requested (for example, the ID of the user, the ID of the transaction, the general-purpose CICS DB2 attachment facility ID)
- Define the attributes of pool threads (the general-purpose threads used when transactions do not need a special command or entry thread, or when there are no special threads left for a transaction to use), which are:

- what type of authorization ID DB2 checks when a pool thread is requested (for example, the ID of the user, the ID of the transaction, the general-purpose CICS DB2 attachment facility ID)
- what the priority of the thread TCBs is relative to the CICS main TCB
- the limit on the number of pool threads that CICS can use at any one time
- if a transaction cannot get a pool thread, whether it should wait for one, or be abended
- what application plan or dynamic plan exit is used for the pool threads (see "Plans, packages and dynamic plan exits" on page 13)
- at what point during a transaction's use of the thread DB2 accounting records are produced
- if there is a deadlock, whether changes made by the transaction using the thread are rolled back

You can have only one DB2CONN definition installed in a CICS system at one time, and all the DB2ENTRY and DB2TRAN definitions that you install in the system are associated with the DB2CONN definition. If you discard a DB2CONN definition, all the DB2ENTRY and DB2TRAN definitions are discarded as well. You cannot discard a DB2CONN definition and install another one while CICS is connected to DB2.

You can start the CICS DB2 connection with only a DB2CONN installed—you do not need any DB2ENTRY and DB2TRAN definitions to make the connection. If you do this, there are no special threads for key transactions (entry threads). All transactions use general-purpose threads from the pool, and the most important transactions have to wait just as long as the least important transactions to get their individual connection into DB2. To ensure that your important transactions are prioritized, create DB2ENTRY and, if necessary, DB2TRAN definitions for them.

DB2ENTRY

You can set up many DB2ENTRY definitions to define different types of entry threads. The entry threads can be used by the transactions that you specify, to gain priority access (or specialized access) to DB2 resources. In effect, you are reserving a certain number of threads that can only be used by those transactions. You can also protect a number of each type of entry thread, which improves performance for heavily-used transactions. In a DB2ENTRY definition, you can specify a particular transaction, or (by using a wildcard) a group of transactions, that are associated with the DB2ENTRY and can use the type of entry thread that it defines. When those transactions request a thread, the CICS DB2 attachment facility gives them that type of entry thread, if one is available. If you want other transactions to use the same type of entry thread, you can create a DB2TRAN definition for those transactions, which simply tells CICS that the transactions are associated with a particular DB2ENTRY.

In each DB2ENTRY definition, you:

- Specify a transaction, or (by using a wildcard in the name) a group of transactions, that can use this type of entry thread
- Define the attributes of this type of entry thread, which are:
  - what type of authorization ID DB2 checks when this type of entry thread is requested (for example, the ID of the user, the ID of the transaction, the general-purpose CICS DB2 attachment facility ID)
  - what the priority of the thread TCBs is relative to the CICS main TCB
  - the limit on the number of this type of entry thread that CICS can use at any one time

- the number of this type of entry thread that are protected for a period of time while they are not being used
- if a transaction associated with the DB2ENTRY cannot get this type of entry thread, whether it should wait for this type of entry thread, overflow to use a pool thread, or be abended
- what application plan or dynamic plan exit is used for this type of entry thread (see “Plans, packages and dynamic plan exits” on page 13)
- at what point during a transaction's use of the thread DB2 accounting records are produced
- if there is a deadlock, whether changes made by the transaction using the thread are rolled back

You cannot discard a DB2ENTRY while transactions are using that type of entry thread — you must disable it first, to quiesce activity on the DB2ENTRY, and then discard it. If you discard a DB2ENTRY, the DB2TRANs associated with it are “orphaned”, and the transactions listed in them will use pool threads.

If you are using CECI, the command-level interpreter transaction, to test the syntax of CICS commands in an application program, be aware that in this situation, CICS uses the transaction ID CECI to check for matching DB2ENTRY definitions. If you have set up a DB2ENTRY for your application program and you want to replicate it when using CECI, set up a DB2ENTRY with the same properties for the CECI transaction.

DB2TRAN

You can use DB2TRAN definitions to associate additional transactions with a particular DB2ENTRY — the transactions will then use that type of entry thread. Only one DB2TRAN definition can be installed for a specific transaction. In each DB2TRAN definition, you simply:

- Specify the name of a DB2ENTRY
- Specify a transaction, or (by using a wildcard in the name) a group of transactions, that are associated with the particular DB2ENTRY and can use this type of entry thread

When those transactions request a thread, the CICS DB2 attachment facility sees that they are associated with the particular DB2ENTRY, and treats them like the transaction or transactions named on the DB2ENTRY definition itself.

You can define and install DB2CONN, DB2ENTRY and DB2TRAN objects using RDO. The objects can also be defined in batch using DFHCSDUP. CICSplex SM uses EXEC CICS CREATE to install these objects. For detailed information about how to define each of these objects, see the CICS Resource Definition Guide.

Overview: Enabling CICS application programs to access DB2

A CICS application program that accesses DB2 must be prepared in the same way as a normal CICS application program, and also go through DB2's bind process. The bind process is a DB2 process that produces an application plan (often just called a “plan”). Each plan contains the bound form of all the SQL statements from the application programs that use it, and it allows those application programs to access DB2 data at execution time.

The plans are held within DB2, and each thread into DB2 relates to a plan. The plan that each type of thread uses is named on the DB2CONN definition (for pool threads) or the thread's DB2ENTRY definition (for entry threads). The plan for a particular type of thread must contain the bound form of the SQL statements from

all the application programs that use that type of thread to access DB2. You can either name the plan explicitly, or name a dynamic plan exit, a routine that determines which plan to use for the transaction that has requested a thread of that type.

For more information, read the following sections:

- "Preparing a CICS application program that accesses DB2"
- "The bind process" on page 12
- "Plans, packages and dynamic plan exits" on page 13

Preparing a CICS application program that accesses DB2

Figure 4 on page 12 shows the steps in preparing a CICS application program to access DB2.

The first step is to put the program through the DB2 precompiler. The DB2 precompiler builds a database request model (DBRM) that contains information about each of the program's SQL statements.

The second, third and fourth steps are the normal process for preparing any CICS application program, whether or not it accesses DB2. The second step is to put the program through the CICS command language translator. The third step is to compile or assemble the program. The fourth step is to link-edit the program with the necessary interfaces (including the CICS DB2 language interface module DSNCLI). The end product of Steps 2, 3 and 4 is an application load module that enables the program to run. For more information on these steps, see "CICS DB2 program preparation steps" on page 134.

An extra step is required to enable the program to use the information in the DBRM that was created in Step 1. This fifth step is the bind process. The bind process requires DB2, and it uses the DBRM to produce an application plan that enables the program to access DB2 data. See "The bind process" on page 12 for an explanation of the bind process.

If you are using one of the Language Environment®-conforming compilers for COBOL and PL/I, you can combine some of these steps into a single task, because these compilers have integrated the CICS command language translator, and (depending on your version of DB2) an SQL statement coprocessor. See "CICS DB2 program preparation steps" on page 134 for more information.

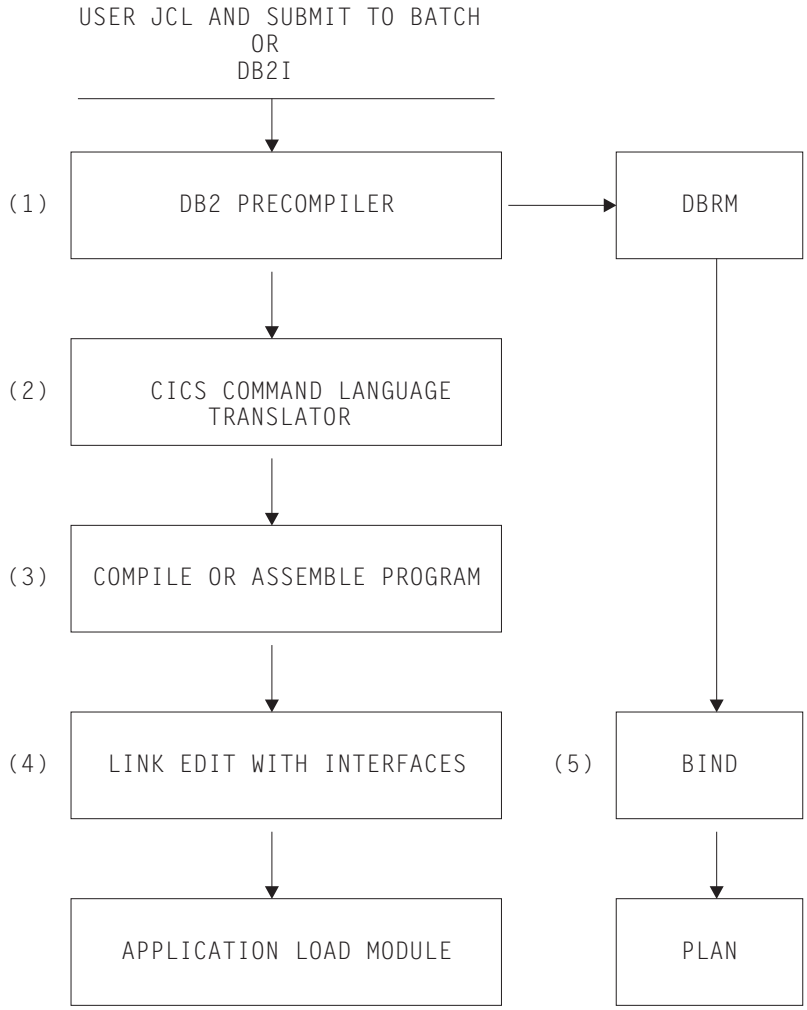


Figure 4. Steps to prepare a CICS application program that accesses DB2

The bind process

Before any CICS application that accesses DB2 can run, it needs to go through the bind process. For the bind process, you require:

- DB2
- The DBRM (database request module) produced by the DB2 precompiler for each program in the application.

The DBRM contains the SQL statements that the DB2 precompiler has extracted from the application program. In the bind process, the SQL statements in the DBRM are put into an operational ("bound") form, by being translated into the control structures that DB2 uses when it runs SQL statements. The resulting material can be made into a package, or it can be placed straight into an application plan (see "Plans, packages and dynamic plan exits" on page 13). The whole process is called "binding" the DBRM. For more information on binding, see the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide*. See "Bind options and considerations for programs" on page 138 for more detail on options you should choose during the bind process in the CICS DB2 environment..

Plans, packages and dynamic plan exits

An application plan allows application programs to access DB2 data at execution time. It contains the bound (operational) form of the SQL statements from the DBRMs that were built from the application programs. It also relates the whole application process to the local instance of DB2 where it will be used.

The operational SQL statements from a DBRM can be placed straight into the plan, in which case we say that the DBRM is bound into a plan. Alternatively, you can bind a DBRM into a package (using the BIND PACKAGE command), which contains the operational SQL statements from a single DBRM. You can group related packages into collections. You can then include the package name or collection name in a list of packages, and bind the list of packages into the plan. A single plan can contain both a package list, and DBRMs bound directly into the plan. You can create a plan using the DBRMs from a single CICS application, or you can use the DBRMs from more than one application to create a single plan.

As well as being created, application plans need to be maintained. If the SQL statements change in one or more of the application programs using a plan, you need to rebuild the DBRMs for the changed application programs. If you bound the old versions of those DBRMs directly into your plan, you need to identify all the DBRMs that are bound directly into that plan, for both the changed programs and any unchanged programs, and bind them all into the plan again. While you are binding the DBRMs into the plan, applications cannot use the plan to access DB2. However, if you bound the old versions of the DBRMs for the changed application programs into packages, and then included the names of the packages (or of the collections containing them) on the package list in the plan, you do not need to bind any other packages or directly-bound DBRMs into the plan again. You simply bind the new versions of the DBRMs for the changed application programs into packages with the same names as the old versions. You do not need to bind the plan again—it locates the new versions of the packages. While you are changing the packages, application programs can still use the other packages and directly-bound DBRMs in the plan. See “What to bind after a program change” on page 137 for more information on maintaining plans.

Each thread into DB2 relates to a plan—see “Overview: How threads work” on page 2 for more information about threads. The plan that each type of thread uses is named on the DB2CONN definition (for pool threads) or the thread's DB2ENTRY definition (for entry threads). When CICS requests the use of a thread for an application to access DB2, it tells DB2 the name of the plan associated with that type of thread, and DB2 locates the plan. The definition for each type of thread can either name a specific plan, or it can name a dynamic plan exit, a routine that determines which plan to use for the transaction that has requested the thread.

If the definition of the pool thread or entry thread names a specific plan, all the transactions that use that type of thread must use that plan. The transactions that can use a type of entry thread are specified in the DB2ENTRY and DB2TRAN definitions for the thread. If the DB2ENTRY definition for the thread names a specific plan, the DBRMs from all the application programs that could run under all those transaction IDs must be bound into the same plan, or bound into packages that are then listed in the same plan. If the DBRMs from any of the application programs that run under those transaction IDs are bound directly into the plan, and you change the SQL statements in any of those application programs, the whole plan will be inaccessible while you bind all the directly-bound DBRMs into the plan again. This means that no transaction can use that type of entry thread while you are maintaining the plan. Pool threads could be used by *any* of your CICS

applications that access DB2, so if the DB2CONN definition names a specific plan for the pool threads, the plan needs to be prepared and maintained using the DBRMs from all those applications. If any of the DBRMs have been bound directly into the plan, the whole plan will be inaccessible during maintenance, and no transaction will be able to use a pool thread.

There are two ways to avoid making types of thread unavailable while you are maintaining plans. The best solution is to avoid binding DBRMs directly into plans, by using packages instead. If you bind each separate DBRM as a package and include them in package lists in plans, the plans are still accessible while you are maintaining individual packages. While you are carrying out maintenance work on a particular program, the pool threads or entry threads related to plans involving that program are still available, because the plans are still accessible. This means that you can safely name a specific plan for each thread. If you want to start using packages, see “Using packages” on page 90 and the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide* for details of how to implement packages.

An alternative solution, developed before packages were available in DB2, is to use a dynamic plan exit. Using a dynamic plan exit means that you do not have to name a specific plan for each type of thread, so even when a particular plan is inaccessible during maintenance, the threads are still available. To implement this solution, you create many small plans for your CICS applications, each containing the DBRMs from a few closely-related programs. Then, instead of specifying a plan name in the PLAN attribute of the DB2CONN or DB2ENTRY definition for each type of thread, you specify an exit program in the PLANEXITNAME attribute. When an application program issues its first SQL statement and a certain type of thread is requested, the exit program that you have specified in the thread definition selects the plan to use for that application program. If a particular plan is inaccessible during maintenance, the application programs requiring that plan cannot use a thread, but other application programs can use the same type of thread with their own plans. However, note that once a particular instance of a type of thread has been created for an application program to use, that thread instance is associated with the plan that the dynamic plan exit selected. For another application program to reuse the thread, it must use the same plan. If the dynamic plan exit selects a different plan for the application program, it must find or create a different thread with the correct plan. This reduces the opportunities for thread reuse. See “Dynamic plan exits” on page 96 for more information on dynamic plan exits.

Chapter 2. Installation and migration notes for CICS DB2

This chapter provides information you should know when you are planning and carrying out installation or migration procedures in the CICS DB2 environment.

CICS startup JCL requirements for connection to DB2

The CICS DB2 attachment facility has to load the DB2 program request handler, DSNAPRH. To do this, the DB2 library, *db2hlq*.SDSNLOAD, should be placed in the MVS linklist, or added to the STEPLIB concatenation of your CICS job (where *db2hlq* is your chosen high-level qualifier for DB2 libraries).

To use the DB2 JDBC driver shipped with DB2 Versions 7 or 8, the *db2hlq*.SDSNLOD2 library also needs to be added to the CICS STEPLIB concatenation. The DB2 JDBC drivers shipped with DB2 Versions 5 and 6 do not require this library.

To modify your CICS startup JCL you should concatenate the following libraries on the STEPLIB DD statement as follows:

- *db2hlq*.SDSNLOAD (after the CICS libraries)
- *db2hlq*.SDSNLOD2 (after the CICS libraries)

There should be no DB2 libraries in the DFHRPL DD statement. If DB2 libraries are required in the DFHRPL concatenation by an application, or by another product, they should be placed after the CICS libraries.

Supported releases of DB2

CICS supports the following releases of DB2:

- DB2 Universal Database Server for OS/390 Version 6
- DB2 Universal Database Server for OS/390 and z/OS Version 7
- DB2 Universal Database Server for OS/390 and z/OS Version 8

CICS provides a CICS DB2 attachment facility (the CICS DB2 adaptor) that works with all supported releases of DB2. The CICS DB2 attachment facility is shipped on the CICS Transaction Server product tape, and you must use this version of the attachment facility to connect a CICS Transaction Server region to DB2.

The CICS DB2 attachment facility has been supplied by CICS since CICS/ESA 4.1. Always use the correct CICS DB2 attachment facility for the release of CICS under which a region is running—the CICS 4.1 attachment facility for a CICS 4.1 region, and so on.

Migrating to a different release of DB2

When you are planning migration to a newer DB2 release, consider the following information:

To use the DB2 group attach facility with CICS, CICS must be connected to DB2 Version 7 or later. You must also use DB2 Version 7 or later "early" (ERLY) code, meaning that the DB2 Version 7 or later version of *db2hlq*.SDSNLINK must be present in the MVS link list (where *db2hlq* is your chosen high-level qualifier for DB2 libraries). You must also apply APARS PQ44614, PQ45691, and PQ45692. (An MVS IPL is required for these DB2 APARS to take effect.)

With the group attach facility, instead of connecting to a specific DB2 subsystem, you can choose to connect to any one member of a data-sharing group of DB2 subsystems which is active on an MVS image. This allows you to use a common DB2CONN definition, specifying a group ID, across multiple cloned AORs, and to reconnect rapidly if the connection to DB2 fails. See "Using the DB2 group attach facility" on page 51 for more information.

For the CICS DB2 attachment facility to use the open transaction environment (OTE), CICS must be connected to DB2 Version 6 or later. You must also use DB2 Version 6 or later "early" (ERLY) code, meaning that the DB2 Version 6 or later version of *db2hlq*.SDSNLINK must be present in the MVS link list. If you are using DB2 Version 6 early code, you must apply APARS PQ43242 and PQ50703. If you are using DB2 Version 7 early code, you must apply APARS PQ46501 and PQ50703. (An MVS IPL is required for these DB2 APARS to take effect.)

The open transaction environment enables the CICS DB2 task-related user exit to execute on an open TCB. Open TCBs, unlike the QR TCB or subtask thread TCBs, may be used for both non-CICS API requests (including requests to DB2) and threadsafe application code. Because threadsafe application code can be executed on the open TCB, a threadsafe CICS DB2 application should not need to switch between different TCBs several times during the execution of a CICS DB2 application. This situation produces a significant performance improvement where an application program issues multiple SQL calls. See "Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming" on page 106 for more information on the open transaction environment and its performance benefits.

If you are migrating to DB2 Version 6 or later, note that with effect from DB2 Version 6, the CICS-DB2 language interface module, DSNCLI, is no longer shipped by the DB2 product. CICS ships the language interface stub in both the SDFHLOAD and SDFHAUTH libraries as a CICS named module, but also with appropriate aliases for compatibility. In SDFHLOAD, the stub is called DFHD2LI, with aliases of DSNCLI, DSNHLI, and DSNWLI. In SDFHAUTH, the stub is called DFHD2LIX, with aliases DSNCLI, DSNHLI, and DSNWLI. Ensure that the library concatenation for the DB2 library SDSNLOAD and the CICS library SDFHLOAD are correct for your site, because both libraries contain the DSNHLI alias.

If you are migrating to DB2 Version 6 or later, and using the open transaction environment, ensure that the limit set in your MAXOPENTCBS system initialization parameter is greater than the limit set in the TCBLIMIT attribute of your DB2CONN definition. In the open transaction environment, MAXOPENTCBS defines the total number of open TCBs allowed in the CICS system, and TCBLIMIT defines the number of these open TCBs that can be used to connect to DB2. If your MAXOPENTCBS limit is lower than your TCBLIMIT, a warning message is issued when CICS connects to DB2, and you may find that you do not have enough open TCBs available to process your DB2 workload. In addition, when running with Transaction Isolation active and connected to DB2 Version 6 or later, set MAXOPENTCBS to the value of max tasks (MXT) or higher. This will minimise the

possibility of TCB stealing due to a TCB being allocated to the wrong subspace. For more information, see “The MAXOPENTCBS system initialization parameter and TCBLIMIT” on page 52.

Migrating from a CICS release that used RCT definitions for CICS DB2 resources

In releases of CICS earlier than CICS Transaction Server for OS/390, Version 1 Release 2, the connection between CICS and DB2 was defined in the resource control table (RCT). The RCT described the relationship between CICS transactions and DB2 resources (application plans and command processors) and was generated using the DSNCRCT macro provided by the CICS DB2 attachment facility. Versions and releases of CICS from CICS Transaction Server for OS/390, Version 1 Release 3 onwards do not support running the CICS DB2 attachment facility using the macro DSNCRCT.

If you are migrating from a CICS release that defined the CICS DB2 connection using a resource control table, you now need to define DB2 resource definitions using CICS resource definition online (RDO). Macro RCTs can still be assembled for the purpose of migrating them to the DFHCSD file only. The DSNCRCT macro is shipped with CICS to allow migration of RCT tables to the CSD. It is now wholly owned by, and incorporated in, CICS . For more information about DSNCRCT, see *CICS Resource Definition Guide*.

When describing parameters of the CICS DB2 connection, the names of the parameters of the RDO objects are now used, not the DSNCRCT macro parameter names. The *CICS Resource Definition Guide* describes which DSNCRCT macro parameter applies to which RDO parameter, and which RDO parameter applies to which DSNCRCT macro parameter.

All changes made to DB2 resource definitions installed directly from the CSD, or made by using EXEC CICS CREATE commands, are cataloged and recovered in a CICS restart. Also, the DB2 objects installed from the CSD remain installed after the CICS DB2 attachment facility is stopped.

This topic provides information to assist you with the migration process, as follows:

If you have not used CICS resource definition online (RDO) before

Using online CICS DB2 resource definition means that you do not have to shut down the interface between CICS and DB2 when adding, deleting, or changing CICS DB2 resource definitions. The benefits of using online definition for DB2 resources are discussed in the following sections:

- Function
- System availability

- Performance

Function

The function of the CICS DB2 attachment facility is enhanced by using online resource definition in the following ways:

- Existing macro-defined RCT load modules can be easily migrated to the CICS system definition file (CSD) using an RCT migration utility.
- The CICS DB2 attachment facility is fully integrated into CICS providing enhanced first failure data capture, enhanced messages with NLS support, more tracing including exception tracing, and system dump support with formatting integrated into the CICS IPCS verbexit.
- It enables management of the CICS DB2 interface by CICSplex SM, including single system image and single point of definition across a CICSplex.
- The CICS DB2 definitions become a CICS-managed resource which provides a consistent end user interface:
  - CEDA and DFHCSDUP for defining and installing entries
  - EXEC CICS CREATE for installing entries
  - CEMT/EXEC CICS INQUIRE, CEMT/EXEC CICS SET, and CEMT/EXEC CICS DISCARD for manipulating installed entries.

  Enhancements made to the CICS DB2 attachment facility before CICS Transaction Server for OS/390, Version 1 Release 3 included:
  - Improved CICS DB2 statistics integrated with CICS
  - Improved attachment facility shutdown coordinated with CICS shutdown
  - Improved TCB management
  - Improved thread management and displays
  - A new accounting option

System availability

Online CICS DB2 resource definition allows you to add, delete or change definitions without the need to shut down the interface between CICS and DB2. You are therefore provided with continuous availability.

Performance

Online CICS DB2 resource definition provides benefits to performance as follows:

- CICS DB2 control blocks are moved above the 16MB line providing virtual storage constraint relief (VSCR).
- Online CICS DB2 resource definition provides the ability to specify generic transaction names, using wildcard symbols, which can reduce the number of definitions required in CICS.

Effect of migration to RDO on CICS DB2 attachment facility operations

Changes to the CICS DB2 attachment facility affect the operation of the facility in the following ways:

Attachment startup and shutdown

You can use the DSNC STRT command to start the CICS DB2 attachment facility.

The syntax of the DSNC STRT command is DSNC STRT *yyyy*. Any value specified after the STRT is treated as a DB2ID. This overrides any DB2ID or DB2GROUPID specified in the DB2CONN definition. If no value is specified, the value from the installed DB2CONN is used. If you want to use group attach, do not specify a value on the DSNC STRT command.

CICS obtains the ID of the DB2 subsystem to which it connects from one of the following sources, in the order of priority shown:

1. A subsystem ID in a DSNC STRT command, if specified.
2. A DB2ID in the installed DB2CONN resource definition, if not blank.
3. A DB2GROUPID in the installed DB2CONN for group attach, if specified.
4. A subsystem ID specified on the INITPARM system initialization parameter, when the DB2ID and DB2GROUPID in the installed DB2CONN resource definition are blank (or have subsequently been set to blanks). On any startup, INITPARM is always used if the last installed DB2CONN contained a blank DB2ID and a blank DB2GROUPID, even if the DB2ID or DB2GROUPID were subsequently changed using a SET command.
5. A default subsystem ID of DSN.

You can use the DSNC STOP <QUIESCE|FORCE> command to stop the CICS DB2 attachment facility. The QUIESCE option now waits for all active transactions to complete, that is, new UOWs can start and acquire threads. In releases of CICS earlier than CICS Transaction Server for OS/390, Version 1 Release 2, a quiesce would only wait for active transactions to release their thread, which, typically, was at the end of a unit of work (UOW).

During shutdown of the CICS DB2 attachment facility initiated by DSNC STOP, the terminal remains locked until the stop is complete, when message DFHDB2025 is issued.

As an alternative to the DSNC command, you can start and stop the CICS DB2 attachment facility using the EXEC CICS SET DB2CONN CONNECTED|NOTCONNECTED commands. You can also stop the CICS DB2 attachment facility by starting the CICS-supplied transactions CDBQ and CDBF from an application program, using an EXEC CICS START command. CDBQ causes a quiesce close and CDBF causes a force close.

CICS DB2 attachment facility command changes

The pool section of the DB2CONN resource definition does not have a TXID parameter associated with it. To modify the number of threads allowed on the pool, use reserved name CEPL on the DSNC MODIFY TRANS command. For example, issue the following command (where *n* is the new number of threads).

```
DSNC MODIFY TRANS CEPL n
```

The DSNC DISP TRAN *tttt* command now displays all threads running for a particular transid, instead of all the transactions associated with an RCT entry. In earlier releases, CICS uses the *tttt* operand to locate an RCT entry and then displays all the threads for that entry.

When you use the DSNC DISP STAT command, CICS displays statistics for DSNC commands on a line beginning `'*COMMAND'`. Pool thread statistics are displayed on a line beginning `'*POOL'`.

When modifying an RCT entry using the DSNC MODIFY TRANS *tttt* command, specify *tttt* exactly as it was defined in the RCT. If you defined a generic TXID, you must refer to the generic name when modifying it with a DSNC command. For example, if you have transactions called TAB and TAC, but they are defined generically as TA*, you can modify these on a DSNC command only by their generic name:

```
DSNC MODIFY TRANS TA*
```

and not by their specific names TAB and TAC.

SQL processing
User application programs do not need to be reassembled or rebound.

Dynamic plan exits
Dynamic plan exits can run unchanged and they do not need to be reassembled. The parameters passed to the exits are unchanged. However, you should be aware that dynamic plan switching can occur in new circumstances, and this could affect the operation of your dynamic plan exits.

A dynamic plan exit is invoked to determine which plan to use at the start of the first unit-of-work (UOW) of the transaction. This is referred to as *dynamic plan selection*.

A dynamic plan exit can also be invoked at the start of a subsequent UOW within the same transaction (provided the thread was released at syncpoint) to determine what plan to use for the next UOW. The plan exit can then decide to use a different plan. For this reason, this is referred to as *dynamic plan switching*.

In releases of CICS earlier than CICS Transaction Server for OS/390, Version 1 Release 2, dynamic plan switching can occur only for the pool, or for RCT entries defined with THRDA (THREADLIMIT) specified as zero; that is, overflowed to the pool. A consequence of using DSNC MODIFY to modify THRDA to zero is that it makes dynamic plan switching effective. An RCT with THRDA greater than 0 is not capable of dynamic plan switching in earlier releases, and the plan selected for the first UOW is used for all subsequent UOWs of the transaction.

In CICS Transaction Server for OS/390, Version 1 Release 2 and later versions and releases, dynamic plan switching can occur for DB2ENTRYs as well as for the pool, irrespective of the THREADLIMIT parameter. If you have coded your own dynamic plan exit, check that the logic can handle subsequent invocations for the same task. Your user application program, or the dynamic plan exit, must be written to tolerate consequences of additional calls to the exit. If the dynamic plan exit would change the plan when you do not want it to, the application program can avoid this by ensuring the thread is not released at syncpoint. However, the recommended method is to release the thread and ensure that the dynamic plan exit provides the correct plan for the new circumstances in which it is called.

Messages
The CICS message domain processes all attachment message requests. As a result, all previous DSNC messages now have the form DFHDB2*nnn*. You can use the DB2CONN MSGQUEUE1, MSGQUEUE2, and MSGQUEUE3 parameters to specify where the messages should be sent. This may have an impact on automation products, for example with NetView®.

Protected threads
If you use protected threads on DB2ENTRYs, note that a thread is no longer flagged as protected for its lifetime. Instead, a thread is protected only when it is not being used. If a new transaction reuses the thread, the thread is in use, and no longer requires protection. Therefore, the current number of protected threads for that DB2ENTRY is decremented. This allows for more effective protection of threads for a DB2ENTRY.

Effect of migration to RDO on application programs

The removal of support for macro RCTs after creating the new type of DB2 resource definition means that application programs cannot access the RCT load module to obtain information about the connection, as in earlier releases of CICS .

Application programs running in earlier releases can find the address of the RCT by means of an EXEC CICS EXTRACT EXIT command that specifies the DB2 task-related user exit on the PROGRAM option, and specifies the GASET(*ptr_ref*) option to get the address of the global work area (GWA). The address of the RCT is stored by releases of the attachment facility earlier than CICS Transaction Server for OS/390, Version 1 Release 2 at offset 8 in the GWA. Because the RCT is no longer available, the CICS DB2 attachment facility now sets offset 8 in the GWA to the address of fetch-protected storage, causing programs that use this address to fail with an ASRE abend. CICS issues message DFHSR0619 to the console and transient data queue CDB2 when an ASRE abend occurs.

You can use the DISMACP system initialization parameter to disable transactions that abend with an ASRE abend.

Effect of migration to RDO on the INITPARM system initialization parameter

CICS no longer supports running the CICS DB2 attachment facility by specifying the DSNCRCT macro in the PARM statement, and a suffix should no longer be specified on the INITPARM parameter. The INITPARM parameter is now solely used to supply a DB2 subsystem override. The syntax of the INITPARM parameter is INITPARM=(DFHD2INI='*yyyy*') where *yyyy* is the (optional) 1–4 character DB2 subsystem identifier.

The DB2 subsystem identifier specified on the INITPARM system initialization parameter does not override a DB2 ID or DB2GROUPID specified in the DB2CONN definition. For a description of the sequence in which the DB2 subsystem identifier is determined, see "DSNC STRT" on page 48.

Effect of migration to RDO on defaults for resource definition parameters

The defaults for many of the new DB2 resource definition parameters are different from the defaults of their macro equivalents.

Most of the defaults of the DSNCRCT macro supplied in CICSTS31.CICS.SDFHMAC are unchanged from the DSNCRCT macro supplied in previous releases. If the DSNCRCT macro generates a default value that is changed from a previous release, it flags it with an MNOTE 5 during table assembly. The default parameters generated in an assembled RCT are migrated unchanged to the CSD.

Migrating to RDO for DB2 resource definition

Migrate your existing RCT load modules into the CSD using the DFHCSDUP MIGRATE command. After migration, maintain the CSD definitions using RDO instead of maintaining the DSNCRCT macro definitions. To use the new CSD definitions, install the DB2 RDO definitions before the CICS DB2 attachment facility is actually started. You can dynamically modify most parameters of the DB2 resource definitions, and you can add new DB2ENTRY and DB2TRAN definitions while the CICS DB2 attachment facility is active.

To use the CICS DB2 attachment facility, the minimum migration requirements are:

1. **Reassemble your existing RCTs** with the DSNCRCT macro from CICSTS31.CICS.SDFHMAC.

2. **Migrate the reassembled RCTs** to the CSD using DFHCSDUP (see “Migrating RCTs to the CSD using DFHCSDUP” on page 23)
3. **Add the migrated GROUPs** to a suitable list specified on the GRPLIST system initialization parameter
4. **Change any INITPARM definitions** in the SIT or SIT overrides to remove any RCT suffix specified. The syntax of the INITPARM is INITPARM=(DFHD2INI='yyyy') (where yyyy is the 1–4 character DB2 subsystem ID). The INITPARM parameter is used to specify a DB2 ID. If the DB2CONN definition contains a non-blank DB2 ID or DB2GROUPID attribute this value is always used, regardless of the INITPARM specification.
5. **Upgrade the CSD** Run a DFHCSDUP job to upgrade the CICS DB2 definitions in the IBM-supplied group, DFHDB2. If you are migrating from CICS/ESA Version 3 or earlier, ensure that no previous user-defined group of CICS DB2 attach definitions is installed — use the IBM-supplied group DFHDB2.
6. **Change the PLTPI** Change and reassemble the PLTPI table to specify program DFHD2CM0.

   This module replaces the DSN2COM0, DSN2COM1, DSNCCOM0, or DSNCCOM1 modules used in earlier releases to connect CICS to DB2 during startup.

   Alternatively, avoid specifying DFHD2CM0 in a PLTPI table altogether by specifying system initialization parameter DB2CONN=YES. This causes CICS to invoke the CICS DB2 attachment facility startup module automatically without requiring an entry in the PLTPI for the CICS DB2 adaptor module.
7. **Change the PLTSD table** to remove either DSN2COM0, DSN2COM1, DSNCCOM0, or DSNCCOM1, the modules used in earlier releases to disconnect CICS from DB2 during warm shutdown.

   The CICS DB2 attachment facility now uses the RMI shutdown function, meaning that it is called automatically to shut down the interface when CICS is shut down, as follows:

   - The CICS DB2 interface is closed normally during a warm shutdown of CICS.
   - The CICS DB2 interface is force closed during an immediate shutdown of CICS.
   - Shutdown of the CICS DB2 interface is not initiated if CICS is cancelled or terminates abnormally.
8. **Change programs that START or STOP the CICS DB2 connection** Change application programs that start or stop the DB2 connection by linking to DSN2COM0, DSNCCOM0, DSN2COM1, or DSNCCOM1 (start) or DSN2COM1, DSNCCOM1, DSN2COM2, or DSNCCOM2 (stop).

   To start the CICS DB2 connection, change application programs to either:

   - Issue an EXEC CICS SET DB2CONN CONNECTED command (this is the recommended programming interface).
   - Link to DFHD2CM0 instead of DSN2COM0 or DSNCCOM0.

   To stop the CICS DB2 connection, change applications to either:

   - Issue an EXEC CICS SET DB2CONN NOTCONNECTED command (this is the recommended programming interface).
   - Link to DFHD2CM2 or DFHD2CM3 instead of DSN2COM2 or DSNCCOM2.
9. **Check the use of EXTRACT EXIT PROGRAM(...) for DB2 interface** Applications issuing the EXEC CICS EXTRACT EXIT PROGRAM(...) ENTRYNAME(DSNCSQL) command, where the program name is DSNCEXT1 or DSN2EXT1, continue to work correctly. CICS dynamically substitutes

program name DFHD2EX1, the CICS DB2 task-related user exit. Note that the entryname is still DSNCSQL. New application programs should use a program name of DFHD2EX1.

Similarly, application programs that issue the EXEC CICS INQUIRE EXITPROGRAM(DSN2EXT1) ENTRYNAME(DSNCSQL) command continue to work correctly. CICS automatically substitutes name DFHD2EX1. New application programs should use the exit program name DFHD2EX1.

In earlier releases of the CICS DB2 attachment facility, more than one task-related user exit is enabled. In addition to the exit with entryname DSNCSQL, earlier releases also support exits with entrynames DSNCIFC and DSNCCMD. Now, all requests through the CICS DB2 attachment facility are handled by a single task-related user exit program, DFHD2EX1, with entryname DSNCSQL. EXTRACT or INQUIRE EXITPROGRAM commands using entry names of DSNCIFC or DSNCCMD fail with INVEXITREQ (on the EXTRACT command) and PGMIDERR (on the INQUIRE command).

Migrating RCTs to the CSD using DFHCSDUP

You can migrate existing RCTs to the CSD with the DFHCSDUP MIGRATE option using the following conventions:

- The utility migrates DSNCRCT TYPE=INIT, TYPE=POOL, and TYPE=COMD macro definitions to a DB2CONN definition with a default name of "RCT*xx*" where *xx* is the value of the SUFFIX= parameter.

  You can override the default DB2CONN name (RCT*xx*) by specifying your own name on the RDONAME parameter on the DSNCRCT TYPE=INIT macro definition. If RDONAME is specified on the TYPE=INIT macro, the DB2CONN is named by the RDONAME value.
- The utility migrates RCT TYPE=ENTRY to a DB2ENTRY definition named by the first non-generic transaction identifier on the TXID parameter.

  You can override the default DB2ENTRY name by specifying your own name on the RDONAME parameter on the TYPE=ENTRY macro definition. If RDONAME is specified on the TYPE=ENTRY, the DB2ENTRY is created with the RDONAME value.
- The utility creates a DB2TRAN definition that references the DB2ENTRY for each transaction identifier specified on the TXID parameter, using the TXID as the name of the DB2TRAN.

  You can override the default DB2TRAN name by specifying your own name on the RDONAME parameter on the TYPE=ENTRY macro definition. If the RDONAME is present on the TYPE=ENTRY and there is only one transaction ID specified for that entry, the DB2TRAN is created with the RDONAME value.
- You can change the RCT source statements to define transaction IDs with generic names, using wildcard characters—the asterisk (*) and plus (+) symbols. However, CSD objects cannot have names that contain these generic symbols, so you must ensure that:
  – Each generic TXID is defined on a separate TYPE=ENTRY macro
  – The RDONAME parameter is specified to supply a valid CSD object name.

  For example, if you define:

```
DSNCRCT TYPE=ENTRY,TXID=J+++,RDONAME=J
DSNCRCT TYPE=ENTRY,TXID=D*,RDONAME=D
DSNCRCT TYPE=ENTRY,TXID=(ANDY,BILL,CARL),RDONAME=A
```

  the following equivalent RDO definitions are generated:

```
DB2ENTRY(J)
DB2TRAN(J)    TRANSID(J+++) DB2ENTRY(J)
```

```
DB2ENTRY(D)
DB2TRAN(D)    TRANSID(D*)   DB2ENTRY(D)
DB2ENTRY(A)
DB2TRAN(ANDY) TRANSID(ANDY) DB2ENTRY(A)
DB2TRAN(BILL) TRANSID(BILL) DB2ENTRY(A)
DB2TRAN(CARL) TRANSID(CARL) DB2ENTRY(A)
```

You cannot define multiple generic transids referring to the same entry in the DSNCRCT macro, and these must be defined explicitly in the CSD using the DEFINE command.

Note that defining transaction IDs using wildcard characters removes the ability to collect CICS DB2 statistics on a per transaction basis, as statistics are now collected for each DB2ENTRY, which represents a group of transactions.

- You can edit the DSNCRCT source macros to include a TYPE=GROUP, GROUP=*groupname*, to specify the group in which the utility should create the DB2 objects. All objects are created in the specified group until another TYPE=GROUP is encountered. If you omit the GROUPNAME parameter, DFHCSDUP uses a default group name of RCT*xx* where *xx* is the 1 or 2 character RCT suffix.

Chapter 3. Operations with CICS DB2

This chapter discusses operating the CICS DB2 attachment facility. It includes the following topics:

Starting the CICS DB2 attachment facility

The CICS DB2 attachment facility can be started automatically at initialization, or manually using the commands described in "Manual connection."

Automatic connection at CICS initialization

Connection between CICS and DB2 can be established automatically at CICS initialization by any one of the following methods:

- Specifying DB2CONN=YES in the SIT, or as a SIT override
- Specifying program DFHD2CM0 after the DFHDELIM statement of your PLTPI
- Specifying a user-written program that issues an EXEC CICS SET DB2CONN CONNECTED command, after the DFHDELIM statement of your PLTPI

Manual connection

Connection between CICS and DB2 can be established manually by any one of the following methods:

- Using the DSNC STRT command.

  For information on the DSNC STRT command see "DSNC STRT" on page 48.
- Using a CEMT SET DB2CONN CONNECTED command.

  For information on the SET DB2CONN CONNECTED command, see *CICS Supplied Transactions*.
- Running a user application that issues an EXEC CICS SET DB2CONN CONNECTED command. For more information about the EXEC CICS SET DB2CONN CONNECTED command, see the *CICS System Programming Reference*.

Stopping the CICS DB2 attachment facility

The CICS DB2 attachment facility, and hence the CICS-DB2 connection, can be quiesce stopped or force stopped. A quiesce stop waits for all CICS transactions currently using DB2 to complete. A force stop causes all CICS transactions currently using DB2 to be forcepurged.

Automatic disconnection at CICS termination

During startup of the CICS DB2 attachment facility, the CICS DB2 task-related user exit (TRUE) is enabled with the SHUTDOWN option. This means that CICS

automatically invokes the TRUE when CICS is shut down, so as to shut down the CICS DB2 connection. When invoked during a quiesce shutdown of CICS, the CICS DB2 TRUE initiates a quiesce stop of the attachment facility. Likewise an immediate shutdown of CICS causes a force shutdown of the attachment facility to be initiated by the TRUE. If CICS is cancelled, no shutdown of the attachment facility is initiated by the TRUE.

Manual disconnection

The connection between CICS and DB2 can be stopped or disconnected by using any one of the following methods:

- Using the DSNC STOP command.

  For information on the DSNC STOP command see “DSNC STOP” on page 46.
- Using a CEMT SET DB2CONN NOTCONNECTED command.
- Running the CICS-supplied CDBQ transaction that issues an EXEC CICS SET DB2CONN NOTCONNECTED command.

  The CDBQ transaction runs program DFHD2CM2. The transaction can be run directly from the terminal or by using the EXEC CICS START command. No messages are output to the terminal. The CICS DB2 adapter however outputs messages to transient data as part of its shutdown procedure.
- Running the CICS supplied CDBF transaction that issues an EXEC CICS SET DB2CONN NOTCONNECTED FORCE command.

  The CDBF transaction runs program DFHD2CM3. The transaction can be run directly from the terminal or EXEC CICS STARTed. No messages are output to the terminal. The CICS DB2 adapter, however, outputs messages to transient data as part of its shutdown procedure.
- Running a user application that issues an EXEC CICS SET DB2CONN NOTCONNECTED command.

Resolving indoubt units of work (UOWs)

Indoubt units of work (UOWs) can occur when CICS, DB2, or the whole system fails whilst a transaction is carrying out syncpoint processing, that is, during processing of an EXEC CICS SYNCPOINT or EXEC CICS RETURN command. CICS is the coordinator of the UOW, and if more than one recoverable resource is involved uses the two-phase commit protocol when trying to commit the UOW. Between replying “yes” to the phase 1 prepare call, and before receiving the commit or backout call at phase 2 time, DB2 is indoubt as to the outcome of the UOW. If a failure occurs at this time, DB2 remains indoubt about the UOW; it has an indoubt UOW and must ask CICS to resynchronize.

In situations where only DB2 and a single CICS system are involved with the unit of work, CICS is always the coordinator. If further parties are involved—for example, by means of a LU6.2 communication link—it is possible that the local CICS system is not the overall coordinator of the unit of work; for example, a remote CICS system might be the coordinator instead. In this situation, it is possible that both DB2 and the local CICS system are indoubt about the outcome of the UOW. If a failure occurs in this situation, the local CICS system might shunt the unit of work, depending on the definition for the transaction. The unit of work is then considered to be shunted indoubt.

Indoubt UOWs are normally resolved automatically when the connection between CICS and DB2 is reestablished. CICS and DB2 exchange information regarding the indoubt UOWs; that is, CICS informs DB2 whether the UOW was backed out or

committed. If a UOW is shunted indoubt, this exchange of information is deferred until the remote coordinator has informed CICS of the outcome. However, if you are using group attach, CICS might reconnect to a different DB2 subsystem, and be unable to exchange information about the indoubt UOWs held by the previously connected DB2 subsystem. The RESYNCMEMBER attribute of the DB2CONN definition is used to solve this problem—see "Resolving indoubt UOWs when using group attach."

Resolving indoubt UOWs when using group attach

See "Using the DB2 group attach facility" on page 51 for an explanation of how the DB2 group attach facility works. If you are using group attach and the connection between CICS and DB2 is broken, CICS might not reconnect to the same DB2 subsystem—it might choose a different member of the data-sharing group of DB2 subsystems. This means that if indoubt UOWs are being held by the first DB2 subsystem to which CICS connected, they cannot be resolved.

To solve this problem, CICS maintains a history of the last DB2 data-sharing group member to which it connected, which is cataloged and maintained across warm, emergency and cold starts (but not initial starts). During connection or reconnection to DB2, the CICS DB2 attachment facility checks this history to see if any outstanding UOW information is being held for the last DB2 data-sharing group member to which it connected, and acts as follows:

- If no outstanding UOW information is being held, group attach operates normally and chooses any active member of the data-sharing group for the connection.
- If outstanding UOW information is being held, the next action depends on the setting you have chosen for the RESYNCMEMBER attribute of the DB2CONN definition.
  - If RESYNCMEMBER is set to YES, indicating that you require resynchronisation with the last recorded DB2 data-sharing group member, CICS ignores the group attach facility, and the CICS DB2 attachment facility waits until it can reconnect to that last connected DB2 data sharing group member, to resolve the indoubt units of work. UOWs which are shunted indoubt are not included in this process, because CICS itself is unable to resolve those UOWs at this time. Resynchronization for those UOWs will occur when CICS has resynchronized with its remote coordinator.
  - If RESYNCMEMBER is set to NO, perhaps because you want to reconnect as fast as possible, CICS makes one attempt to reconnect to the last recorded DB2 data-sharing group member. If this attempt is successful, the indoubt UOWs (with the exception of UOWs that are shunted indoubt) can be resolved. If it is unsuccessful, CICS uses group attach to connect to any active member of the DB2 data-sharing group, and the warning message DFHDB2064 is issued stating that there may be unresolved indoubt UOWs with the last recorded member.

See the *CICS Resource Definition Guide* for information on setting RESYNCMEMBER. The RESYNCMEMBER option can also be set using a CEMT/EXEC CICS SET DB2CONN RESYNCMEMBER RESYNC/NORESYNC command—see *CICS Supplied Transactions* for the CEMT command, and the *CICS System Programming Reference* for the EXEC CICS command.

Resolving indoubt units of work using DB2 restart-light

CICS supports the enhanced DB2 restart-light capability provided in DB2 Version 8. Restart-light mode is intended for a cross-system restart in the event of an MVS system failure, where the CICS systems are configured to use group attach (see

"Using the DB2 group attach facility" on page 51). In DB2 Version 7, the DB2 restart-light capability allowed a DB2 data-sharing member to restart with a minimal storage footprint, free retained locks, and then terminate normally. However, this only applied to in-flight units of work, and not indoubt units of work. For DB2 Version 8, this capability was extended to encompass indoubt units of work. This enables a CICS system to connect to a DB2 restart-light subsystem for the purpose of resynchronizing indoubt units of work. This capability is especially useful because DB2 does not support peer recovery; that is, one DB2 subsystem cannot resynchronize indoubt units of work on behalf of another DB2 subsystem.

In a typical scenario, if an MVS LPAR fails, a cross-system restart can be initiated which involves restarting the failed CICS systems on another LPAR, and bringing up the failed DB2 subsystem on that LPAR in restart-light mode. Assume that the CICS systems have been configured to use group attach, with RESYNCMEMBER(YES) and STANDBYMODE(RECONNECT) on the DB2CONN definition, and there are indoubt units of work outstanding in DB2. The DB2 restart-light subsystem initializes, frees retained locks for any in-flight UOWs, and then awaits resynchronization with CICS for the indoubt UOWs. Each CICS system initializes, and detects whether it has outstanding units of work and whether RESYNCMEMBER(YES) has been specified. Where both these conditions are true, the CICS system ignores group attach and reconnects back to the last DB2 subsystem, which is the DB2 restart-light subsystem. The indoubt UOWs are now resynchronized, but no new transactions are allowed to access DB2. When all the indoubt UOWs have been resolved in the DB2 restart-light subsystem, it terminates. Because the CICS systems are defined with STANDBYMODE(RECONNECT), when the DB2 restart-light subsystem terminates, they drop into standby mode and attempt a reconnection to DB2. Now, because all the indoubt units of work have been resolved, RESYNCMEMBER does not apply and group attach can be used. The CICS systems will reconnect to a normal, active DB2 subsystem.

Recovery of resynchronization information for indoubt UOWs

CICS maintains information about UOWs needed for resynchronization on its system log. Resynchronization information is maintained by CICS across warm, emergency, and cold starts. **Resynchronization information is lost if an initial start of CICS is performed as the system log is initialized and all information is lost, deleting all information about previous units of work.**

You should rarely need to initial start CICS. If you simply want to reinstall resources from the CSD, a cold start should be used, which allows any resynchronization information to be recovered. In particular, an initial start of CICS should be avoided if the previous warm shutdown of CICS issued message DFHRM0131 indicating that resynchronization is outstanding.

If CICS is initial started when DB2 resynchronization was required, when the CICS DB2 connection is re-established, message DFHDB2001 is output for each UOW that failed to be resynchronized, and the UOW must be resynchronized in DB2 using the DB2 RECOVER INDOUBT command. CICS Transaction Server has no equivalent to the DFH$INDB utility that was available in CICS/ESA Version 4 and earlier, which allowed scanning of the system log to ascertain the outcome of the UOW. The MVS system log, and hence all the UOW information on it, has been lost by initial starting of CICS .

Managing the CICS DB2 attachment facility

You can manage the status of the connection between CICS and DB2 using CEMT commands and commands provided by the CICS DB2 attachment facility. The same function provided by CEMT is also available via EXEC CICS INQUIRE and SET commands. Below is a summary of the functions available:

CEMT INQUIRE and SET DB2CONN
The global status of the connection and its attributes along with attributes of pool threads and command threads can be inquired upon and set using these commands. See *CICS Supplied Transactions* .

CEMT INQUIRE and SET DB2ENTRY
The attributes of a particular DB2ENTRY defining threads to be be used by a specific transaction or set of transactions can be inquired upon and set using these commands. See *CICS Supplied Transactions* .

CEMT INQUIRE and SET DB2TRAN
Use these commands to find out and alter which transaction IDs use which DB2ENTRYs. See *CICS Supplied Transactions* .

DSNC DISC (disconnect)
This CICS DB2 attachment command can be used to cause currently connected threads to be terminated as soon as they are not being used by a transaction. For active threads, that means when the transaction releases the thread, which is typically at syncpoint time. Protected threads are threads that currently are not being used by a transaction and normally are released if they have not been reused after two protected thread purge cycles. A DSNC DISCONNECT command pre-empts the purge cycles and causes them to be terminated immediately. For more information on the DSNC DISCONNECT command see “DSNC DISCONNECT” on page 36.

DSNC DISP (display)
This CICS DB2 attachment command can be used to display the status of active threads for a particular plan, for a particular transaction, or for all plans and transactions. For more information, see “DSNC DISPLAY” on page 38.

The DSNC DISP command also displays CICS DB2 statistics to a CICS terminal. These statistics are only a subset of the CICS DB2 statistics that you can obtain using the CICS COLLECT STATISTICS and PERFORM STATISTICS commands. These statistics are subject to the same resetting characteristics as all CICS statistics.

For more information on the DSNC DISP STAT command, see “DISPLAY STATISTICS output” on page 40. For more information on the full CICS DB2 statistics available, see the *CICS Performance Guide*.

DSNC MODI (modify)
This CICS DB2 attachment command can be used to modify where unsolicited messages are sent and the number of threads allowed for a DB2ENTRY or for the pool or command threads. This function is superseded by the CEMT commands described which allow these attributes to be modified and all other attributes of a DB2CONN, DB2ENTRY or DB2TRAN. For more information, see “DSNC MODIFY” on page 43.

Entering DB2 commands

Once the connection between CICS and DB2 has been established, terminal users authorized by CICS can use the DSNC transaction to route commands to the DB2 subsystem. These commands are defined as follows:

```
DSNC -DB2command
```

The command is routed to DB2 for processing. DB2 checks that the user is authorized to issue the command entered. Responses are routed back to the originating CICS user. The command recognition character (CRC) of "-" must be used to distinguish DB2 commands from CICS DB2 attachment facility commands. This command recognition character is not used to identify the DB2 subsystem to which the command is to be sent. The command is sent to the DB2 subsystem to which CICS is currently connected. Figure 5 shows the CICS DB2 attachment facility commands. These require CICS authorization to use the DSNC transaction and the DB2 commands. For more information about the DSNC -DB2COMMAND, see "Issuing commands to DB2 using DSNC" on page 34.

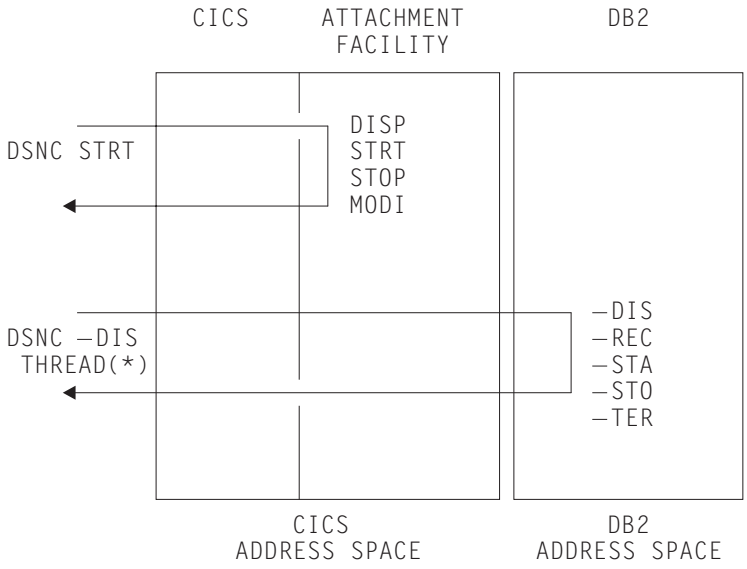


Figure 5. Examples of CICS DB2 attachment facility commands and some DB2 commands

Purging CICS DB2 transactions

When CICS is connected to DB2 Version 5 or earlier, CICS applications that access DB2 will enter a CICS wait, with a resource type of "DB2" and a resource name of "LOT_ECB", while they wait for the CICS DB2 task to access DB2 and complete the request. A CICS task in this wait cannot be purged, but forcepurge is supported. However, there is a risk when forcepurging a CICS task in this state, in that it can cause the associated CICS DB2 task to be terminated during a "must complete" activity in DB2, which would cause termination of the DB2 subsystem.

When CICS is connected to DB2 Version 6 or later, CICS applications that access DB2 do not enter a CICS wait state, because the CICS DB2 task-related user exit and the request into DB2 run on an L8 open TCB. In this environment, both purge and forcepurge of the CICS task are supported. However, with both of these there is again a risk of terminating a DB2 request during a "must complete" activity in DB2.

DB2 “must complete” activities are short-lived, but to avoid this risk, a safer way to terminate a CICS DB2 application is to use the DB2 CANCEL THREAD command. If the CICS DB2 task is active in DB2 at the time, then the thread is terminated, and “must complete” activity is either avoided, or completed before termination. If the task is not active in DB2 at the time of the cancel, then the cancel is deferred until DB2 is next accessed using that thread. Once the DB2 CANCEL THREAD command has been issued, you can safely issue a forcepurge of the CICS transaction, if needed (because the task is currently active in CICS rather than in DB2).

To determine which DB2 thread is associated with a CICS task, use the DSNC DISPLAY TRAN command (see “DSNC DISPLAY” on page 38), which shows the CICS task number, transaction id, and the 12–byte DB2 correlation id of the associated DB2 thread used by the CICS DB2 task. This correlation id uniquely identifies a thread. A DSNC —DIS THD(*), issues a DB2 display thread command showing all threads used by this CICS system identified by correlation id, and gives a unique token that can be used with a DB2 CANCEL THREAD command to cancel the thread.

Starting SMF for DB2 accounting, statistics and tuning

Through its instrumentation facility, DB2 produces a system management facility (SMF) type 101 accounting record at each CICS DB2 thread termination and at each CICS DB2 signon. DB2 also produces an SMF type 100 record to hold DB2 statistics on a DB2 sub system basis. Performance and global trace records are produced as SMF type 102 records. These records can be directed to an SMF data set by:

- Specifying at DB2 installation that accounting or statistics data or both are required.

  To do this the MON,SMFACCT and/or SMFSTAT of the initialization macro DSN6SYSP are set to YES. See the *DB2 Universal Database for OS/390 and z/OS Administration Guide* for more details.
- Activating SMF to write the records.

  Add entries for type 100, 101, and 102 records to the existing SMF member (SMFPRM*xx*) entry in SYS1.PARMLIB.
- Starting DB2 trace.

  Starting DB2 trace can be done at DB2 startup time by setting the parameters of the initialization macro DSN6SYSP, or by using the DB2 -START TRACE command giving the specific trace and classes to be started. The latter is the way to start recording accounting, statistics and performace data on a periodic basis.

DB2 does not produce any reports from the recorded data for accounting, monitoring, or performance purposes. To produce your own reports you can write your own programs to process this data, or use the DB2 Performance Monitor (DB2PM) Program Product.

Starting GTF for DB2 accounting, statistics and tuning

Instead of, or in addition to, recording accounting, statistics and performance data to SMF, DB2 allows you to send this data to generalized trace facility (GTF). DB2 provides -START TRACE and -STOP TRACE commands which you can issue from a CICS terminal using the DSNC transaction. The commands can be used to specify:

Trace scope
either GLOBAL for DB2 subsystem activity, PERF for performance, ACCTG for accounting, STAT for statistics, or MONITOR for monitoring activity.

Trace destination
GTF, in main storage, or SMF.

Trace constraints
specific plans, authorization IDs, classes, location and resource managers.

Chapter 4. CICS-supplied transactions for CICS DB2

Information about the system programming function provided by CEMT for the following commands can be seen in *CICS Supplied Transactions*:

- INQUIRE DB2CONN
- SET DB2CONN
- INQUIRE DB2ENTRY
- SET DB2ENTRY
- INQUIRE DB2TRAN
- SET DB2TRAN

Information about the EXEC CICS INQUIRE and EXEC CICS SET commands is in the *CICS System Programming Reference*.

PLAN and PLANEXITNAME options are available on the INQUIRE DB2TRAN command, so you can find out in a single step which plan is used by a specified transaction or set of transactions, or which transactions use a specified plan.

The DSNC transaction can be used to perform the following:

- Enter DB2 commands from a CICS terminal.
- Cause threads to be terminated when they are released (DSNC DISCONNECT).
- Display information about transactions using the CICS DB2 interface, and display statistics (DSNC DISPLAY).
- Modify the unsolicited message destinations, and modify the number of active threads used by a DB2ENTRY, the pool, or for commands (DSNC MODIFY).
- Shut down the CICS DB2 interface (DSNC STOP).
- Start the CICS DB2 interface (DSNC STRT).

The DSNC transaction executes program DFHD2CM1, which handles both CICS DB2 attachment facility and DB2 commands. You can distinguish DB2 commands from CICS DB2 attachment facility commands by the hyphen (**-**) character, which is entered with DB2 commands. This character is not a DB2 subsystem recognition character, but a command recognition character. It is always a **-**, independent of the character actually defining the DB2 subsystem, since CICS can only connect to one DB2 subsystem at a time. There is no need to use different DB2 subsystem recognition characters from CICS, and thus we use only the default **-** character.

DFHD2CM1 can also be activated by transactions other than DSNC. Thus you can give a different transaction code to each CICS DB2 attachment facility command, and to each DB2 command. This enables you to apply different levels of security to each command.Alternative transaction definitions for CICS DB2 attachment facility commands are supplied in sample group DFH$DB2, using the following names:

DISC
DISP
STRT
STOP
MODI

Alternative transaction definitions for DB2 commands are also supplied in sample group DFH$DB2, using the following names:

-ALT	-CAN	-ARC
-DIS	-MOD	-REC
-RES	-SET	-STA

-STO -TER

This chapter contains the following topics:

Issuing commands to DB2 using DSNC

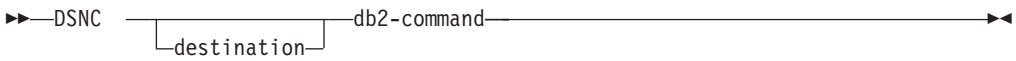
The CICS DB2 attachment facility DSNC command allows you to enter DB2 commands from CICS .

Environment

This command can be issued only from a CICS terminal

Syntax

DSNC syntax



Abbreviation

You can omit DSNC from the DB2 command if the relevant transaction definition is installed from the CICS DB2 sample group, DFH$DB2. For example, if you are installing the -DIS transaction definition.

```
DSNC -DIS THD(*)
```

can be abbreviated to:

```
-DIS THD(*)
```

The sample CICS DB2 group, DFH$DB2, contains the following transaction definitions for issuing DB2 commands:

-ALT	-ARC	-CAN
-DIS	-MOD	-REC
-RES	-SET	-STA
-STO	-TER	

Authorization

Issuing DB2 commands using DSNC does not require any authorization from CICS over and above transaction attach security required to run the DSNC transaction. It does, however, require DB2 privileges. For more information about CICS security, see Chapter 6, "Security in a CICS DB2 environment," on page 65.

Parameter description

destination
Identifies another terminal to receive display information. It must be a valid terminal that is defined to CICS and supported by basic mapping support (BMS).

db2-command
Specifies the exact DB2 command that you want to enter from a CICS terminal It must be preceded by a hyphen.

Usage note

Screen scrolling
The SIT keywords SKR*xxxx* can be used to support the scrolling of DSNC DB2 commands from your terminal. For further information about the SIT keywords and parameters, see the *CICS System Definition Guide*.

Example

Issue the DB2 command -DISPLAY THREAD from a CICS terminal to display threads for a CICS with applid IYK4Z2G1.

```
DSNC -DISPLAY THREAD(IYK4Z2G1)
```

```
DSNV401I : DISPLAY THREAD REPORT FOLLOWS -
DSNV402I : ACTIVE THREADS -
NAME     ST A   REQ ID           AUTHID   PLAN     ASID TOKEN
IYK4Z2G1 N        3              JTILLI1           00BA     0
IYK4Z2G1 T        3 ENTRXC060001 CICSUSER TESTC06  00BA    16
IYK4Z2G1 T        3 POOLXP050002 CICSUSER TESTP05  00BA    17
IYK4Z2G1 T  *     6 COMDDSNC0003 JTILLI1           00BA    18
DISPLAY ACTIVE REPORT COMPLETE
DSN9022I : DSNVDT '-DIS THREAD' NORMAL COMPLETION
DFHDB2301 07/09/98 13:36:36 IYK4Z2G1 DSNC DB2 command complete.
```

Figure 6. Sample output from DSNC -DISPLAY command

DSNC DISCONNECT

The CICS DB2 attachment facility command DSNC DISCONNECT disconnects threads.

The command provides manual control to release resources being shared by normal transactions so that special purpose processes, such as DB2 utilities, can have exclusive access to the resources.

Environment

This command can be issued only from a CICS terminal.

Syntax

DISC syntax

Abbreviation

DSNC DISC or DISC (using the DISC transaction from the CICS DB2 sample group DFH$DB2).

Authorization

Access to this command can be controlled using the following CICS authorization checks:

- Transaction attach security for transaction DSNC
- Command security for resource DB2CONN. This command requires READ access. For more information about CICS security, see Chapter 6, “Security in a CICS DB2 environment,” on page 65.

Parameter description

plan-name
Specifies a valid application plan.

Usage notes

Preventing creation of threads
The command DSNC DISCONNECT does not prevent threads from being created on behalf of transactions. The command only causes currently connected threads to be terminated as soon as they are not being used by a transaction. To interrupt a transaction and cancel a thread faster, you can use the DB2 CANCEL THREAD command.

You can stop the transactions associated with a particular plan ID in CICS with the MAXACTIVE setting for TRANCLASS. This prevents new instances of the transaction from causing a re-creation of a thread.

Alternative for protected threads
You may want to deallocate a plan for rebinding or for running a utility against the database. If you are using a protected thread use EXEC CICS SET DB2ENTRY(*entryname*) THREADLIMIT(0), or DSNC MODIFY rather than

DSNC DISCONNECT, to send all the threads to the pool. The protected thread terminates on its own within two purge cycles. See the PURGECYCLE attribute of DB2CONN.

Example

Disconnect active and protected threads for plan TESTP05:

```
DSNC DISC TESTP05
```

```
DFHDB2021 07/09/98 13:46:29 IYK4Z2G1 The disconnect command is complete.
```

Figure 7. Sample output from DSNC -DISCONNECT command

DSNC DISPLAY

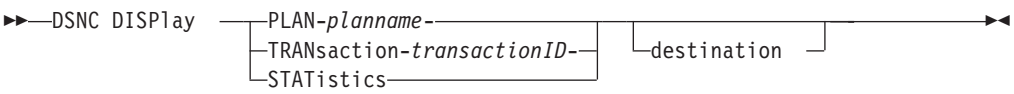
The CICS DB2 attachment facility command DSNC DISPLAY displays information on active CICS DB2 threads and the corresponding CICS transaction using them, or statistical information associated with DB2ENTRYs and the DB2CONN.

Environment

This command can be issued only from a CICS terminal.

Syntax

DISPLAY syntax



Abbreviation

DSNC DISP or DISP (using the DISP transaction from the CICS DB2 sample group DFH$DB2).

Authorization

Access to this command can be controlled using the following CICS authorization checks:

- Transaction attach security for transaction DSNC
- Command security for resource DB2CONN. This command requires READ access. For more information about CICS security, see Chapter 6, “Security in a CICS DB2 environment,” on page 65.

Parameter description

planname

Displays information about threads by *planname*. *Planname* is a valid plan name for which information is displayed.

If you do not specify *planname* (or if you specify an asterisk, *), information is displayed for all active threads.

Example

Display information on all active plan IDs listed in the resource control table. The display information is to be sent to another terminal designated as MTO2.

```
DSNC DISP PLAN * MTO2
```

Parameter description

transactionID

A valid transaction ID for which thread information is displayed.

If you do not specify a transaction ID, information is displayed for all active threads.

Example

Display information about all active transactions listed in the resource control table.

```
DSNC DISP TRAN
```

Parameter description

Displays the statistical counters associated with each entry in the resource control table. The counters concern the usage of the available connections of the CICS DB2 attachment facility to DB2.

Usage notes

If you issue this command from CICS while the CICS DB2 attachment facility is active but the DB2 subsystem is not, a statistics display is produced with no obvious indication that the subsystem is not operational. Message DFHDB2037 appears in the CICS message log to indicate that the attachment facility is waiting for DB2 to start.

Example

Display statistical counters associated with each entry in the resource control table.

```
DSNC DISP STAT
```

Note that a more detailed set of CICS DB2 statistics can be obtained using standard CICS statistics interfaces, for example, the commands EXEC CICS COLLECT STATISTICS and EXEC CICS PERFORM STATISTICS, or using the DFH0STAT sample program.

Alternative destination

destination

The identifier of another terminal to receive the requested display information. It must be a valid terminal that is defined to CICS and supported by basic mapping support (BMS).

Because the optional destination is sometimes preceded by an optional plan name or transaction ID in the command, each parameter must be unique and separately identifiable as either a name or a terminal identifier. If only one parameter is entered, it is first checked to see whether it is a plan name or a transaction ID, and it is then checked as a destination. To use a character string that is both a plan name or transaction ID and also a valid terminal identifier, you must use both the name and destination parameters to display the required information at the required terminal.

When an alternate destination is specified to receive the requested display information, the following message is sent to the requesting terminal:

```
DFHDB2032 date time applid alternate destination display command complete
```

DISPLAY PLAN or TRAN

Figure 8 on page 40 shows an example of the output for the DSNC DISPLAY (PLAN or TRANSACTION) command. For each created thread the output shows the name of the DB2ENTRY or '*POOL' for the pool, or the '*COMMAND' for which it has been created.

```
DFHDB2013 07/09/98 15:26:47 IYK4Z2G1 Display report follows for threads
accessing DB2 DB3A
DB2ENTRY S PLAN     PRI-AUTH SEC-AUTH CORRELATION  TRAN TASK  UOW-ID
*POOL    A TESTC05  JTILLI1           POOLXC050001 XC05 01208 AEEEC0321ACDCE00
XC06     * TESTC06  JTILLI1           ENTRXC060003 XC06 01215 AEEEC0432F8EFE01
XP05     A TESTP05  JTILLI1           ENTRXP050002 XP05 01209 AEEEC03835230C00
XP05     I TESTP05  JTILLI1           ENTRXP050004
DFHDB2020 07/09/98 15:26:47 IYK4Z2G1 The display command is complete.
```

Figure 8. Sample output from DSNC DISPLAY (PLAN or TRANSACTION) command

The column named 'S' denotes the status of the thread, and can take the following values:

***** The thread is active within a unit of work, and is currently executing in DB2.

A The thread is active within a unit of work, but is not currently executing in DB2.

I The thread is inactive; it is a protected thread that is waiting for new work.

The PLAN associated with the thread is displayed (there is no plan for command threads).

The PRI-AUTH field shows the primary authorization ID used for the thread. The SEC-AUTH field shows the secondary authorization ID (if any) for the thread.

The CORRELATION fields shows the 12-byte thread correlation ID which is made up as *eeeetttnnnn* where *eeee* is either COMD, POOL or ENTR indicating whether it is a command, pool or DB2ENTRY thread; *tttt* is the transid, and *nnnn* is a unique number.

Note: A correlation ID passed to DB2 can be changed only by the CICS Attachment Facility issuing a signon to DB2. If signon reuse occurs by a thread using a primary authorization ID which remains constant across multiple transactions (for example, by using AUTHID(name)) only one signon will occur. In this instance the *tttt* in the correlation ID does not match the running transaction ID. It is the ID of the transaction for which the initial signon occurred.

If the thread is active within a unit of work, the CICS transaction name, its task number and finally the CICS local unit of work ID is displayed.

The correlation ID used in this display is also output on DB2 commands such as DISPLAY LOCK. For example, by using this display in conjunction with a display locks command you can find out which CICS task is holding a lock within DB2.

DISPLAY STATISTICS output

Output of a DSNC DISPLAY STATISTICS command is as follows:

```
DFHDB2014 07/09/98 14:35:45 IYK4Z2G1 Statistics report follows for RCTJT
accessing DB2 DB3A
                                                                -----COMMITS----
DB2ENTRY PLAN        CALLS    AUTHS    W/P HIGH   ABORTS   1-PHASE  2-PHASE
*COMMAND               1        1      1    1       0          0       0
*POOL    ********      4        1      0    1       0          2       0
XC05     TESTP05      22        1     11    2       0          7       5
XP05     ********      5        2      0    1       0          1       1
DFHDB2020 01/17/98 15:45:27 IYKA4Z2G1  The display command is complete.
```

Figure 9. Sample output from DSNC DISPLAY STATISTICS command

DB2ENTRY
Name of the DB2ENTRY, or "*COMMAND" for DSNC command calls, or "*POOL" for pool statistics.

PLAN
The plan name associated with this entry. Eight asterisks in this field indicate that this transaction is using dynamic plan allocation. The command processor transaction DSNC does not have a plan associated with it.

If a plan name associated with an entry is dynamically changed, the last plan name is the one put into use.

CALLS
The total number of SQL statements issued by transactions associated with this entry.

AUTHS
The total number of signon invocations for transactions associated with this entry. A signon does not indicate whether a new thread is created or an existing thread is reused. If the thread is reused, a signon occurs only if the authorization ID or transaction ID has changed.

W/P
The number of times that all available threads for this entry were busy. This value depends on the value of THREADWAIT for the entry. If THREADWAIT is set to POOL, W/P indicates the number of times the transaction overflowed to the pool. An overflow to the pool only shows up in the statistics for the individual DB2ENTRY, and is not reflected in the pool statistics.

If THREADWAIT is set to YES, this reflects the number of times that either the transaction had to wait for a thread (because the number of active threads had reached THREADLIMIT), or the transaction could not use a new thread TCB (because the number of TCBs in use running threads had reached TCBLIMIT).

HIGH
The maximum number of threads acquired by transactions associated with this entry at any time since the connection was started, that is, a high watermark of threads.

Note: In releases of CICS before CICS Transaction Server for OS/390, Version 1 Release 2, the HIGH value also included the transactions forced to wait for a thread or those diverted to the pool. From CICS Transaction Server for OS/390, Version 1 Release 2 onwards, the HIGH value *only* represents threads actually created on the entry.

ABORTS
The total number of units of recovery which were rolled back. It includes both abends and syncpoint rollbacks, including syncpoint rollbacks generated by -911 SQL codes.

COMMITS
One of the following two fields is incremented each time a DB2 transaction associated with this entry has a real or implied (such as EOT) syncpoint. Units of recovery that do not process SQL calls are not reflected here.

1-PHASE
The total number of single-phase commits for transactions associated with this entry. This total does not include any two-phase commits (see the explanation for 2-PHASE below). This total does include read-only commits as well as single- phase commits for units of recovery which have performed updates. A two-phase commit is needed only when the application has updated recoverable resources other than DB2.

2-PHASE
The total number of two-phase commits for transactions associated with this entry. This number does not include single phase commit transactions.

DSNC MODIFY

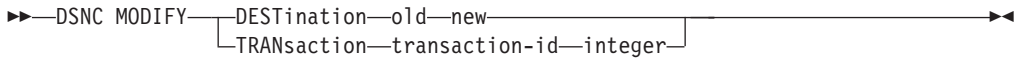
The CICS DB2 attachment facility command DSNC MODIFY modifies the message queue destinations of the DB2CONN, THREADLIMIT value for the pool, for DSNC commands, or for DB2ENTRYs. The same function can also be achieved using CEMT/EXEC CICS SET DB2CONN or DB2ENTRY commands.

Environment

This command can be issued only from a CICS terminal.

Syntax

MODIFY syntax



Abbreviation

DSNC MODI or MODI (using the MODI transaction from the CICS DB2 sample group DFH$DB2).

Authorization

Access to this command can be controlled using the following CICS authorization checks:

- Transaction attach security for transaction DSNC.
- Command security for resource DB2CONN. This command requires UPDATE access.
- For DSNC MODIFY TRANSACTION commands modifying the attributes of a DB2ENTRY. There are also command security checks for resources DB2ENTRY and DB2TRAN and resource security for the DB2ENTRY. The command requires READ access to resource DB2TRAN, and UPDATE access to resource DB2ENTRY for command security. In addition, the resource security command requires UPDATE access to the particular DB2ENTRY involved. For more information about CICS security, see Chapter 6, “Security in a CICS DB2 environment,” on page 65.

Parameter description

DESTination

Specifies that the MSGQUEUE parameter of the DB2CONN table is to be changed, replacing the "old" destination ID with the "new" destination ID.

old Any destination ID currently set in the MSGQUEUE of the DB2CONN.

new A new destination identifier.

TRANsaction

Specifies that the THREADLIMIT value associated with the given transaction or group is to be modified.

transaction-ID

The command uses a transaction ID to identify either the pool, command, or the DB2ENTRY THREADLIMIT value to be modified.

- To change the THREADLIMIT value of the pool, a transaction ID of CEPL must be used.
- To change the THREADLIMIT for command threads, a transaction ID of DSNC must be used.
- To change the THREADLIMIT for a DB2ENTRY, use the transaction ID of any transaction that is defined to use the DB2ENTRY.

integer
Is a new maximum value.

Usage notes

The integer specified in the command DSNC MODIFY TRANSACTION cannot be larger than the value specified for the TCBLIMIT parameter of the DB2CONN. The lowest possible value is zero.

Examples

Example 1
To change the specification of the MSGQUEUE parameter in the DB2CONN from MTO1 to MTO2 as follows:

```
DSNC MODI DEST MTO1 MTO2
```

```
DFHDB2039 07/09/98 14:47:17 IYK4Z2G1 The error destinations are: MT02 ****
****.
```

Figure 10. Sample output from DSNC MODIFY DESTINATION command

Example 2
To change the pool thread limit to 12:

```
DSNC MODI TRAN CEPL 12
```

```
DFHDB2019 07/09/98 14:49:28 IYK4Z2G1 The modify command is complete.
```

Figure 11. Sample output from DSNC MODIFY TRANSACTION command (pool thread)

Example 3
To change the command thread limit to 3:

```
DSNC MODI TRAN DSNC 3
```

```
DFHDB2019 07/09/98 14:49:28 IYK4Z2G1 The modify command is complete.
```

Figure 12. Sample output from DSNC MODIFY TRANSACTION command (for a command thread)

Example 4

To change the thread limit of the DB2ENTRY used by transaction XP05 to 8:

```
DSNC MODI TRAN XP05 8
```

```
DFHDB2019 07/09/98 14:49:28 IYK4Z2G1 The modify command is complete.
```

Figure 13. Sample output from DSNC MODIFY TRANSACTION command (changing DB2ENTRY thread limit)

DSNC STOP

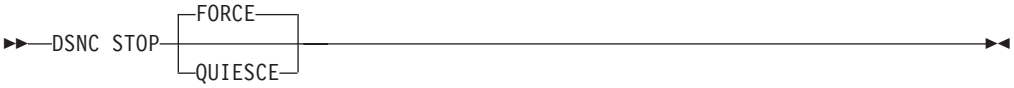
The CICS DB2 attachment facility command DSNC STOP stops the attachment facility. The same function can also be achieved by issuing a CEMT or EXEC CICS SET DB2CONN NOTCONNECTED command.

Environment

This command can be issued only from a CICS terminal.

Syntax

STOP syntax



Abbreviation

DSNC STOP or STOP (using the STOP transaction from the CICS DB2 sample group DFH$DB2).

Authorization

Access to this command can be controlled using the following CICS authorization checks:

- Transaction attach security for transaction DSNC
- Command security for resource DB2CONN. This command requires UPDATE access. For more information about CICS security, see Chapter 6, “Security in a CICS DB2 environment,” on page 65.

Parameter description

QUIESCE
Specifies that the CICS DB2 attachment facility is to be stopped after CICS transactions currently running complete. QUIESCE waits for all active transactions to complete, so new UOWs can start and acquire threads.

FORCE
Specifies that the CICS DB2 attachment facility is to be stopped immediately by forcing disconnection with DB2, regardless of any transactions that are running. Currently running transactions that have accessed DB2 are forcepurged. This includes transactions that may have committed updates to DB2 in a previous UOW, but have not yet accessed DB2 in their current UOW.

Usage notes

For a DSNC STOP QUIESCE, message DFHDB2012 is output to the terminal. The terminal then remains locked until shutdown is complete, when message DFHDB2025 is output.

For a DSNC STOP FORCE, message DFHDB2022 is output to the terminal. The terminal then remains locked until shutdown is complete, when message DFHDB2025 is output.

Examples

Example 1

To quiesce stop the CICS DB2 attachment facility:

```
DSNC STOP
```

```
DFHDB2012 07/09/98 14:54:28 IYK4Z2G1 Stop quiesce of the CICS-DB2 attachment
facility from DB2 subsystem DB3A is proceeding.
```

Figure 14. Sample output from DSNC STOP command

The message resulting from the DSNC STOP command shown in Figure 14 is replaced by the message shown in Figure 15 when shutdown is complete.

```
DFHDB2025I 07/09/98 14:58:53 IYK4Z2G1 The CICS-DB2 attachment has disconnected
from DB2 subsystem DB3A
```

Figure 15. Sample output from DSNC STOP when shutdown is complete

Example 2

To force stop the CICS DB2 attachment facility:

```
DSNC STOP FORCE
```

```
DFHDB2022 07/09/98 15:01:51 IYK4Z2G1 Stop force of the CICS-DB2 attachment
facility from DF2D is proceeding.
```

Figure 16. Sample output from DSNC STOP FORCE command

The message resulting from the DSNC STOP FORCE command shown in Figure 16 is replaced by the message shown in Figure 17 when shutdown is complete.

```
DFHDB2025I 07/09/98 15:10:55 IYK4Z2G1 The CICS-DB2 attachment has disconnected
from DB2 subsystem DF2D group DFP2
```

Figure 17. Sample output from DSNC STOP FORCE when shutdown is complete

In this example, group attach was used, so the name of the DB2 subsystem and the name of its group are shown.

DSNC STRT

The DSNC STRT command starts the CICS DB2 attachment facility, which allows CICS application programs to access DB2 databases. The same function can also be achieved by issuing a CEMT or EXEC CICS SET DB2CONN CONNECTED command.

Environment

This command can be issued only from a CICS terminal.

Syntax

STRT syntax

Abbreviation

DSNC STRT or STRT (using the STRT transaction from the CICS DB2 sample group DFH$DB2).

Authorization

Access to this command can be controlled using the following CICS authorization checks:

- Transaction attach security for transaction DSNC
- Command security for resource DB2CONN. This command requires UPDATE access. For more information about CICS security, see Chapter 6, “Security in a CICS DB2 environment,” on page 65.

Parameter description

ssid
Specifies a DB2 subsystem ID to override the DB2 subsystem ID (DB2ID) or DB2 data-sharing group ID (DB2GROUPID) specified in the DB2CONN. You cannot specify a DB2 data-sharing group ID in a DSNC STRT command.

Usage notes

If a DB2CONN is not installed when the DSNC STRT command is issued, error message DFHDB2031 is produced, indicating that no DB2CONN is installed. Resource definitions must be installed from the CSD before attempting to start the CICS DB2 attachment facility.

If you issue a DSNC STRT command and specify a DB2 subsystem ID, any DB2GROUPID in the installed DB2CONN definition is blanked out, and needs to be set again (using CEDA INSTALL or a SET DB2CONN command) to use group attach on subsequent occasions.

The hierarchy for determining the DB2 subsystem to use is as follows:
1. Use the subsystem ID if specified in a DSNC STRT command.
2. Use the DB2ID in the installed DB2CONN if not blank.
3. Use the DB2GROUPID in the installed DB2CONN for group attach.

4. Use the subsystem ID if specified on the INITPARM when the DB2ID and DB2GROUPID in the last installed DB2CONN are blank (or have subsequently been set to blanks). On any startup, INITPARM is always used if the last installed DB2CONN contained a blank DB2ID and a blank DB2GROUPID, even if the DB2ID or DB2GROUPID were subsequently changed using a SET command.
5. Use a default subsystem ID of DSN.

Examples

Example 1

To start the CICS DB2 attachment facility using the DB2 subsystem ID (DB2ID) or DB2 data-sharing group ID (DB2GROUPID) from an installed DB2CONN:

```
DSNC STRT
```

In this example, group attach is used, so the name of the DB2 subsystem and the name of its group are shown.

```
DFHDB2023I 07/09/98 15:06:07 IYK4Z2G1 The CICS DB2 attachment has connected to
DB2 subsystem DF2D group DFP2
```

Figure 18. Sample output from DSNC STRT command

Example 2

To start the CICS DB2 attachment facility, using an installed DB2CONN, but overriding the DB2 subsystem ID (DB2ID) or DB2 data-sharing group ID (DB2GROUPID) in the DB2CONN with the DB2 subsystem ID DB3A:

```
DSNC STRT DB3A
```

```
DFHDB2023I 07/09/97 15:06:07 IYK4Z2G1 The CICS DB2 attachment has connected to
DB2 subsystem DB3A
```

Figure 19. Sample output from DSNC STRT using DB3A

If you are not using group attach, and the DB2 subsystem is not active when an attempt is made to start the CICS DB2 attachment facility, the following output is received if STANDBYMODE=NOCONNECT is specified in the DB2CONN:

```
DFHDB2018 07/09/98 15:14:10 IYK4Z2G1 DB3A DB2 subsystem is not active.
```

Figure 20. Sample output from DSNC STRT when DB2 is not active and STANDBYMODE=NOCONNECT

If STANDBYMODE=CONNECT or RECONNECT, the following output is received:

```
DFHDB2037 07/09/98 15:15:42 IYK4Z2G1 DB2 subsystem DB3A is not active.
The CICS DB2 attachment facility is waiting.
```

Figure 21. Sample output from DSNC STRT when DB2 is not active and STANDBYMODE=CONNECT or RECONNECT

If you are using group attach, and no DB2 subsystems in the data-sharing group are active when an attempt is made to start the CICS DB2 attachment facility, the following output is received if STANDBYMODE=NOCONNECT is specified in the DB2CONN:

```
DFHDB2037 07/09/01 12:30:10 IYK2ZFV1 DB2 group DFP2 has no active members.
```

Figure 22. Sample output from DSNC STRT with group attach when no DB2 subsystems in the data-sharing group are active and STANDBYMODE=NOCONNECT

If STANDBYMODE=CONNECT or RECONNECT, the following output is received:

```
DFHDB2037 07/09/01 12:55:00 IYK2ZFV1 DB2 group DFP2 has no active members.
The CICS DB2 attachment facility is waiting.
```

Figure 23. Sample output from DSNC STRT with group attach when no DB2 subsystems in the data-sharing group are active and STANDBYMODE=CONNECT or RECONNECT

Chapter 5. Defining the CICS DB2 connection

The structure and performance of your CICS DB2 connection is determined when you define the DB2CONN, DB2ENTRY and DB2TRAN objects. These objects describe the global attributes of the CICS DB2 connection, the relationship between CICS transactions and DB2 resources (including application plans and command processors), the attributes of each type of thread, and the type of thread that each transaction can use. See “Overview: How you can define the CICS DB2 connection” on page 8 for an overview of the DB2CONN, DB2ENTRY and DB2TRAN objects. For information about how to define the DB2CONN, DB2ENTRY and DB2TRAN objects using resource definition online (RDO), and a full list of their attributes, see the *CICS Resource Definition Guide*.

When CICS is connected to DB2 Version 6 or later, and you are exploiting the open transaction environment, you also need to synchronize your setting for the system initialization parameter MAXOPENTCBS with the TCBLIMIT value on your DB2CONN definition. “The MAXOPENTCBS system initialization parameter and TCBLIMIT” on page 52 has more information about this.

This chapter provides further information to help you decide on your DB2CONN, DB2ENTRY and DB2TRAN definitions. The topics “What happens during SQL processing” on page 53 and “How threads are created, used, and terminated” on page 55 provide more detail about the CICS DB2 environment to help you understand the effects of your choices. To optimize the performance of your CICS DB2 connection, “Selecting thread types for optimum performance” on page 61, “Selecting BIND options for optimum performance” on page 62 and “Coordinating your DB2CONN, DB2ENTRY, and BIND options” on page 62 provide advice on coordinating your DB2CONN and DB2ENTRY definitions with the options you choose during the bind process.

Using the DB2 group attach facility

When you are defining the connection between CICS and DB2, you can choose to have CICS connect to a specific DB2 subsystem. You can specify the name of this DB2 subsystem using the DB2ID attribute of the DB2CONN definition. However, if you have multiple DB2 subsystems that are using DB2 Version 7 or later, you might want to use DB2's group attach facility to make it possible for CICS to connect to any of your subsystems, rather than just one named subsystem. (Group attach for CICS is not available in releases of DB2 earlier than Version 7.) For full details of the CICS DB2 configuration needed to use the DB2 group attach facility, see “Migrating to a different release of DB2” on page 15.

Group attach is a DB2 facility that allows CICS to connect to any one member of a data-sharing group of DB2 subsystems, rather than to a specific DB2 subsystem. The group attach facility chooses any one member of the group that is active on the local MVS image for the connection to CICS (members that are active on other MVS images are not eligible for selection). If you use the DB2GROUPID attribute of the DB2CONN definition to specify the ID for the group of DB2 subsystems, instead

of using the DB2ID attribute to specify the ID of an individual DB2 subsystem, you will activate the group attach facility. This means that you can use a common DB2CONN definition, specifying a group ID, across multiple cloned AORs, and CICS will connect to any active member of that data-sharing group. See the *CICS Resource Definition Guide* for information on how to define and install a DB2CONN definition.

If you are using group attach and the connection between CICS and DB2 is broken, CICS might not reconnect to the same DB2 subsystem—it might choose a different member of the data-sharing group of DB2 subsystems. This means that if indoubt UOWs are being held by the first DB2 subsystem to which CICS connected, they cannot be resolved. The RESYNCMEMBER attribute of the DB2CONN definition can be used to solve this problem. See "Resolving indoubt units of work (UOWs)" on page 26 for information on the RESYNCMEMBER attribute and how to set it.

After the connection has been established, you can use the CEMT or EXEC CICS INQUIRE DB2CONN DB2ID() command to find out which member of the data-sharing group has been chosen for the current connection. See *CICS Supplied Transactions* for the CEMT command, and the *CICS System Programming Reference* for the EXEC CICS command.

If group attach is set but you want CICS to connect to a specific DB2 subsystem, you can override group attach. For example, if you want CICS to connect to the DB2 subsystem with an ID of "xyz", you can specify the DB2ID using:

- a CEMT or EXEC CICS SET DB2CONN DB2ID(xyz) command (see *CICS Supplied Transactions* for the CEMT command, and the *CICS System Programming Reference* for the EXEC CICS command)
- a DSNC STRT xyz command (see "DSNC STRT" on page 48)

Each of these methods overrides group attach by setting a DB2ID in the installed DB2CONN definition.

Specifying a DB2ID by any of these methods causes the DB2GROUPID attribute of the installed DB2CONN definition to be blanked out. If you want to revert to using group attach, set the DB2GROUPID attribute again using a CEMT or EXEC CICS SET DB2CONN DB2GROUPID() command.

Specifying a DB2ID on the INITPARM=(DFHD2INI=*db2id*) system initialization parameter does not override group attach—if a DB2GROUPID is set in the DB2CONN definition, the INITPARM setting is ignored. See the *CICS System Definition Guide* for more information on using INITPARM.

You cannot specify a DB2GROUPID using the INITPARM system initialization parameter, or using the DSNC STRT command.

The MAXOPENTCBS system initialization parameter and TCBLIMIT

As well as the DB2CONN, DB2ENTRY, and DB2TRAN objects you define, the CICS DB2 connection is affected by a system initialization parameter, MAXOPENTCBS. MAXOPENTCBS controls the total number of L8 mode TCBs that the CICS region can have in operation at any time, so it is relevant when CICS is connected to DB2 Version 6 or later (when open TCBs are used to run threads into DB2). L8 mode open TCBs are reserved for use by task-related user exits that are enabled with the OPENAPI option. These include the CICS DB2 task-related user exit, when CICS is connected to DB2 Version 6 or later.

In the open transaction environment (when CICS is connected to DB2 Version 6 or later), the TCBLIMIT attribute of the DB2CONN definition controls how many of the L8 mode open TCBs can be used by the CICS DB2 task-related user exit to run threads into DB2. If the TCBLIMIT is reached, the CICS DB2 task-related user exit can obtain an open TCB from the pool controlled by MAXOPENTCBS, but it must wait before it can use the open TCB to run a thread into DB2. When another task stops using its open TCB to run a thread into DB2, and so the number of open TCBs in use running threads falls below TCBLIMIT, the waiting task is allowed to use its own open TCB to run a thread into DB2. However, if MAXOPENTCBS is reached, no more open TCBs are allowed in the CICS region, and the CICS DB2 task-related user exit cannot even obtain an open TCB for its use. It must wait until an open TCB is released by another task and returned to the pool controlled by MAXOPENTCBS, when it can use the released open TCB. For more information about how L8 mode TCBs are managed, and the effects of a shortage of open TCBs, see the *CICS Performance Guide*.

To ensure that you have enough open TCBs available to meet your DB2 workload, set the limit in your MAXOPENTCBS system initialization parameter to a value greater than the limit set in the TCBLIMIT attribute of your DB2CONN definition. If MAXOPENTCBS is lower than TCBLIMIT, the system may run out of open TCBs before it reaches TCBLIMIT. When CICS connects to DB2, a warning message, DFHDB2211, is issued if the CICS DB2 attachment facility detects that CICS is connecting to DB2 Version 6 or higher, and that the setting of MAXOPENTCBS in the SIT is lower than the TCBLIMIT setting in the DB2CONN definition. If you receive this warning message, adjust your MAXOPENTCBS limit.

In addition, when running with Transaction Isolation active and connected to DB2 Version 6 or later, set MAXOPENTCBS to the value of max tasks (MXT) or higher. This will minimise the possibility of TCB stealing due to a TCB being allocated to the wrong subspace. The *CICS Performance Guide* explains how this happens.

When CICS is connected to DB2 Version 5 or earlier, and is not exploiting the open transaction environment, the CICS DB2 task-related user exit uses its own specially created subtask thread TCBs to run threads, rather than using open TCBs. In this environment, the TCBLIMIT attribute of the DB2CONN definition simply controls how many subtask thread TCBs the CICS DB2 attachment facility can create. MAXOPENTCBS is not relevant when CICS is connected to DB2 Version 5 or earlier, as it only applies to open TCBs. If TCBLIMIT is reached in this environment, the CICS DB2 task-related user exit must wait until another task stops using a subtask thread TCB, and it can then use the released subtask thread TCB.

What happens during SQL processing

The main DB2 activities involved in processing CICS transactions with SQL calls are:

- Create a thread or reuse an existing thread (see “Thread creation” on page 54).
- Process the SQL statements (see “SQL processing” on page 54).
- Perform commit processing (see “Commit processing” on page 54).
- Release the thread (see “Thread release” on page 55).
- Terminate the thread or keep it (see “Thread termination” on page 55).

These main activities are performed for each transaction. The exact work involved in each activity depends on the DB2CONN and DB2ENTRY options, the BIND options, and whether packages are used.

Thread creation

The following activities can occur at thread creation time, depending on the BIND options (the authorization check is always performed at thread creation time):

- Sign on.
- Check the maximum number of threads.
- For an application plan, load the skeleton cursor table (SKCT) and header, if not already in the environmental description manager (EDM) pool.
- Create a copy of the SKCT header in the cursor table (CT).
- Perform the plan authorization check.
- If ACQUIRE(ALLOCATE) is specified:
  - Acquire table space (TS) locks for all TSs referenced in the plan.
  - Load all database descriptors (DBDs) referenced in the plan.

The control block for an application plan, the SKCT, is divided into sections. The header and directory of an SKCT contain control information; SQL sections contain SQL statements from the application. A copy of the SKCT, the CT, is made for each thread executing the plan. Only the header and directory are loaded when the thread is created, if they are not already in the EDM pool.

The SQL sections of the plan segments are never copied into the CT at thread creation time. They are copied in, section by section, when the corresponding SQL statements are executed. For a protected thread with RELEASE(DEALLOCATE), the CT increases in size until all segments have been copied into the CT.

If the SQL statements for the transaction are bound to a package rather than a plan, DB2 uses a skeleton package table (SKPT) rather than an SKCT, and a package table (PT) rather than a CT. The SKPT is allocated when the first SQL statement is executed; it is not allocated when the thread is created.

SQL processing

The following activities can occur for each SQL statement processed, depending on thread reuse and the BIND options.

- For the first SQL call in a transaction reusing a thread with a new authorization ID:
  - Signon
  - Authorization check
- Load the SKCT SQL section, if it is not already in the EDM pool.
- Create a copy of the SKCT SQL section in the CT, if it is not already there.
- If ACQUIRE(USE) is specified:
  - Acquire referenced TS locks, if not already taken.
  - Load DBDs in the EDM pool, if they are not already there.
- Process the SQL statement.

If the SQL statement is in a package, the SKPT directory and header are loaded. The PT is allocated at statement execution time, rather than at thread creation time, as in the case with the SKCT and the CT for plans bound using ACQUIRE(ALLOCATE).

Commit processing

The following activities can occur at commit time, depending on your BIND options:

- Release the page locks

- If RELEASE(COMMIT) is specified:
  - Release the TS locks
  - Free the CT pages.

Thread release

Transactions release the thread they are using at different times. If the transaction is terminal-oriented, or non-terminal-oriented and NONTERMREL=YES is specified in the DB2CONN, the thread is released at SYNCPOINT as well as at end of task (EOT). This makes it efficient to use a protected thread for transactions issuing many SYNCPOINTS, if combined with the BIND options ACQUIRE(ALLOCATE) and RELEASE(DEALLOCATE). In this case the resources to do the following activities are saved for each syncpoint:

- Terminate and start the thread.
- Release and acquire the TS locks.
- Release and copy segments of the plan into the CT.

Threads are not released at SYNCPOINT time if:

- Held cursors are open.
- Certain DB2 modifiable special registers are not at their initial value. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* lists these special registers.
- The DB2 modifiable special register, CURRENT DEGREE, is ever changed during the lifetime of the CICS task.

If the transaction is not terminal-oriented and you specify NONTERMREL=NO, the thread is released at EOT only. You do not need to use a protected thread to get thread reuse after an EXEC CICS SYNCPOINT command. You may still want to use a protected thread if this is a frequently used transaction. The BIND options ACQUIRE(ALLOCATE) and RELEASE(DEALLOCATE) give the same advantages as for the terminal-oriented transactions with many syncpoints.

Thread termination

The following activities can occur at thread termination time, depending on the BIND options:

- If RELEASE(DEALLOCATE) is specified:
  - Release TS locks
  - Free CT pages
- Free work storage.

How threads are created, used, and terminated

There are three main types of threads that can be used by the CICS DB2 attachment facility: command threads, entry threads, and pool threads. See “Overview: How threads work” on page 2for an overview of how threads work, and an explanation of the different thread types. This section deals in more detail with the processes involved in creating, using, and terminating the different types of thread, and attaching thread TCBs, and the implications of these on specifying DB2CONN and DB2ENTRY parameters. Overflow to the pool is also discussed. The section looks closely at thread creation and termination for:

- Protected entry threads (see “Protected entry threads” on page 57)
- Unprotected entry threads for critical transactions (see “Unprotected entry threads for critical transactions” on page 58)
- Unprotected entry threads for background transactions (see “Unprotected entry threads for background transactions” on page 59)

- Pool threads (see “Pool threads” on page 60)

You define the relationship between CICS transactions and DB2 plans using DB2CONN for pool threads, and DB2ENTRY for entry threads. See “Overview: How you can define the CICS DB2 connection” on page 8 for an overview of the attributes of DB2CONN and DB2ENTRY.

The CICS DB2 attachment facility uses different types of thread TCB to run threads, depending on whether CICS is connected to DB2 Version 5 or earlier, or to DB2 Version 6 or later. See “Overview: How threads work” on page 2 for a full explanation.

When CICS is connected to DB2 Version 5 or earlier, the thread TCB is a subtask TCB created specially by the CICS DB2 attachment facility to run the thread. This subtask TCB remains permanently attached to the DB2 connection control block and thread. In this environment, to reuse the thread, the CICS DB2 attachment facility must reuse the subtask TCB attached to the thread.

When CICS is connected to DB2 Version 6 or later, the thread TCB is the open TCB on which the CICS DB2 attachment facility is already running. When it needs to run a thread, the CICS DB2 attachment facility associates the open TCB with the DB2 connection control block and thread it wants to use, and the open TCB then runs the thread. When the thread is no longer needed, the open TCB dissociates from it, and the DB2 connection control block and thread becomes available for reuse by another open TCB.

The following general rules apply to thread creation, use, and termination.

When CICS is connected to DB2 Version 5 or earlier, and is using specially created subtask TCBs as the thread TCBs, these rules apply to the thread TCBs:

- When the CICS DB2 attachment facility is started no subtask thread TCBs are started. They are started as needed when work arrives.
- Before an SQL request can be passed to DB2, a subtask thread TCB and a thread must be available for the transaction.
- Once attached, a subtask thread TCB is normally available until the CICS DB2 attachment facility is stopped.

When CICS is connected to DB2 Version 6 or later, and is using open TCBs as the thread TCBs, the rules above do not apply. In this environment, the following rule applies to the thread TCBs:

- Before an SQL request can be passed to DB2, a thread must be available for the transaction. The open TCB associates itself with the thread, and becomes the thread TCB until it dissociates from the thread.

In both environments, when CICS is connected to DB2 Version 5 or earlier and when it is connected to DB2 Version 6 or later, the following rules apply to the threads:

- When a thread is created and another transaction with a new authorization ID is reusing a thread, DB2 makes an authorization check for the new authorization ID.
- A terminal-oriented transaction usually releases the thread at syncpoint and end-of-task. The thread is *not* released at syncpoint if held cursors are open or any modifiable special registers are not in their initial state.
- A non-terminal-oriented transaction releases the thread at end-of-task only, unless NONTERMREL=YES is specified in the DB2CONN.

- When a transaction releases a thread, the thread can be reused by another transaction specifying the same plan and defined in the same DB2ENTRY. Pool threads can be reused by any waiting (queued) transaction specifying the same plan and using a pool thread.
- An unprotected thread is terminated immediately it is released, unless another transaction is waiting (queued) for the thread.
- A protected thread is terminated if not used during two consecutive purge cycles. With default settings, this averages about 45 seconds. This value can be modified by the PURGECYCLE parameter of the DB2CONN.
- The THREADWAIT parameter defines whether the requests for a thread should be queued, abended, or overflowed to the pool in case of entry thread shortage.

Protected entry threads

These threads are defined with the following DB2ENTRY parameters:

```
PROTECTNUM(n)
THREADLIMIT(n)
```

Protected entry threads are recommended for:

- High-volume transactions of any type
- Terminal-oriented transactions with many commits
- Non-terminal-oriented transactions with many commits (if NONTERMREL=YES is specified in the DB2CONN)

Protected entry threads are created, used, and terminated as follows:

TCB attach

When CICS is connected to DB2 Version 5 or earlier, the CICS DB2 attachment facility attaches a subtask thread TCB when required. The subtask thread TCB normally remains available for reuse until the CICS DB2 attachment facility is stopped.

When CICS is connected to DB2 Version 6 or later, and is using the open transaction environment, a new or existing open TCB is allocated to the CICS task prior to calling the CICS DB2 attachment facility. If MAXOPENTCBS is reached, no more open TCBs can be created, and the task enters a CICS dispatcher wait until an open TCB is available. At the end of the task, the open TCB is returned to the pool of open TCBs managed by the CICS dispatcher.

Thread creation

A thread is created only if an existing thread is not available.

When CICS is connected to DB2 Version 5 or earlier, if no thread is available, but an unused subtask thread TCB exists for this DB2ENTRY, a new thread is created and related to the TCB, provided THREADLIMIT is not exceeded. If no thread is available and no unused TCB is available, a new TCB is created, and a new thread is built, provided the TCBLIMIT and THREADLIMIT are not exceeded.

When CICS is connected to DB2 Version 6 or later (and so is using the open transaction environment), if no thread is available for a task, a new thread is created and related to the task's open TCB, provided THREADLIMIT is not exceeded. If TCBLIMIT is reached, no more open TCBs can be used as thread TCBs for the DB2ENTRY.

Thread termination
If the current number of protected threads is less than the PROTECTNUM value when the thread is released and there is no new work queued, the thread is marked as protected. Otherwise it is terminated. A protected thread is terminated if it is unused for two consecutive purge cycles.

Thread reuse
Other transactions using the same DB2ENTRY may reuse a thread, if it is available. This is likely because the threads remain active for about 45 seconds after being released, depending on the PURGECYCLE value.

Overflow to pool
If THREADWAIT=POOL is specified, requests for threads are transferred to the pool when the value of THREADLIMIT is exceeded. When a transaction overflows to the pool, the transaction is now controlled by the PRIORITY, THREADLIMIT, and THREADWAIT attributes that are specified for pool threads in the DB2CONN definition, and those attributes in the DB2ENTRY definition are ignored. The remaining attributes that are specified in the DB2ENTRY definition for the entry thread still apply to the transaction, that is, ACCOUNTREC, AUTHID or AUTHTYPE, DROLLBACK, and PLAN or PLANEXITNAME. The PROTECTNUM attribute in the DB2ENTRY definition is no longer relevant for a transaction that overflows to the pool, so this setting is ignored.

Unprotected entry threads for critical transactions

These threads are defined with the following DB2ENTRY parameters:

```
PROTECTNUM(0)
THREADLIMIT(n)
```

This is the recommended type of definition for:

- Critical transactions requiring a fast response time, but with a volume so low that a protected thread cannot be used
- Limited concurrency transactions

You could use a protected thread for limited concurrency transactions, if the transaction rate makes it possible to reuse the thread.

Unprotected entry threads for critical transactions are created, used, and terminated as follows:

TCB attach
No thread TCBs are attached when the CICS DB2 attachment facility is started.

A TCB is attached only if needed by a thread. When CICS is connected to DB2 Version 5 or earlier, the subtask thread TCB normally remains available for reuse until the CICS DB2 attachment facility is stopped.

Thread creation
A thread is created only when needed by a transaction.

When CICS is connected to DB2 Version 5 or earlier, if no thread is available, but an unused subtask thread TCB exists for this DB2ENTRY, a new thread is created and related to the TCB, provided THREADLIMIT is not exceeded. If no thread is available and no unused TCB is available, a new TCB is created, and a new thread is built, provided the TCBLIMIT and THREADLIMIT are not exceeded.

When CICS is connected to DB2 Version 6 or later (and so is using the open transaction environment), if no thread is available, but an open TCB can be used as a thread TCB for this DB2ENTRY, a new thread is created and related to the TCB, provided THREADLIMIT is not exceeded. If TCBLIMIT is reached, no more open TCBs can be used as thread TCBs for the DB2ENTRY.

Thread termination
The thread is terminated immediately after it is released, unless it has a transaction queued for it.

Thread reuse
Other transactions specified to use the same DB2ENTRY can reuse a thread, if it is available. This happens only if a transaction is waiting for the thread when the thread becomes available.

Overflow to pool
If THREADWAIT=POOL is specified, requests for threads are transferred to the pool when the value of THREADLIMIT is exceeded. When a transaction overflows to the pool, the transaction is now controlled by the PRIORITY, THREADLIMIT, and THREADWAIT attributes that are specified for pool threads in the DB2CONN definition, and those attributes in the DB2ENTRY definition are ignored. The remaining attributes that are specified in the DB2ENTRY definition for the entry thread still apply to the transaction, that is, ACCOUNTREC, AUTHID or AUTHTYPE, DROLLBACK, and PLAN or PLANEXITNAME. The PROTECTNUM attribute in the DB2ENTRY definition is no longer relevant for a transaction that overflows to the pool, so this setting is ignored.

Note that you should not allow overflow to the pool for limited concurrency transactions.

Unprotected entry threads for background transactions

These threads are defined with the following DB2ENTRY parameters:

```
PROTECTNUM(0)
THREADLIMIT(0)
THREADWAIT(POOL)
```

This is the recommended type of definition for transactions with low volume that do not require a fast response time. All transactions are forced to use pool threads.

Unprotected entry threads for background transactions are created, used, and terminated as follows:

TCB attach
No subtask thread TCB is ever attached for this thread definition because THREADLIMIT=0. A pool thread TCB (or, in the open transaction environment, an open TCB) is used. All activity related to this entry definition is forced to a thread and a TCB in the pool. A transaction is then under the control of the PRIORITY, THREADLIMIT, and THREADWAIT parameters for the pool. The transaction keeps the PLAN and the AUTHID/AUTHTYPE values you specified for the entry thread.

Thread creation
A thread is created in the pool when needed by a transaction unless the THREADLIMIT value for the pool was reached.

Thread termination
The thread is terminated when it is released, unless it has a transaction queued for it.

Thread reuse
Other transactions using the same plan can reuse the thread, when it becomes available.

Pool threads

These threads are defined with the following DB2CONN parameter:

```
THREADLIMIT(n)
```

There are four cases when a pool thread can be used:

1. A transaction is not specified in any DB2ENTRY or DB2TRAN, but issues SQL requests. This transaction defaults to the pool and uses the plan specified for the pool.
2. A transaction is specified in a DB2ENTRY or DB2TRAN referencing a DB2ENTRY, but is forced to the pool because the DB2ENTRY specifies THREADLIMIT(0) and THREADWAIT(POOL). This transaction uses the plan specified in the DB2ENTRY.
3. A transaction is specified in a DB2ENTRY or DB2TRAN referencing a DB2ENTRY, but overflows to the pool (THREADWAIT=POOL) when the THREADLIMIT value is exceeded. This transaction uses the plan specified in the DB2ENTRY.
4. A transaction is specified in a DB2ENTRY or a DB2TRAN referencing a DB2ENTRY, but the DB2ENTRY is disabled. The DISABLEDACT keyword is set to POOL, therefore a pool thread is used. This transaction uses the plan specified for the pool.

Pool threads are always unprotected threads.

Pool threads are created, used, and terminated as follows:

TCB attach
No thread TCBs are attached when the CICS DB2 attachment facility is started.

A TCB is attached only if needed by a thread. When CICS is connected to DB2 Version 5 or earlier, the subtask thread TCB normally remains available for reuse until the CICS DB2 attachment facility is stopped.

Thread creation
A thread is created only when needed by a transaction.

Thread termination
The thread is terminated immediately after it is released, unless it has a transaction queued for it.

Thread reuse
Other transactions using the same plan can reuse a thread when it becomes available. In the pool this happens only if there is a queue for threads and the first transaction in the queue requests the same plan used by the thread being released.

Selecting thread types for optimum performance

You should select the thread type to use for a given set of transactions together with the BIND parameters for the corresponding plan. This is because the BIND parameters determine whether a number of activities are related to the thread or to the transactions. For advice on selecting BIND parameters, see “Selecting BIND options for optimum performance” on page 62.

As we have read in “How threads are created, used, and terminated” on page 55, **protected entry threads** are recommended for:

- High-volume transactions of any type
- Terminal-oriented transactions with many commits
- Non-terminal-oriented transactions with many commits (if NONTERMREL=YES is specified in the DB2CONN)

Unprotected entry threads for critical transactions are recommended for:

- Critical transactions requiring a fast response time, but with a volume so low that a protected thread cannot be used
- Limited concurrency transactions

You could use a protected thread for limited concurrency transactions, if the transaction rate makes it possible to reuse the thread.

Unprotected entry threads for background transactions are recommended for transactions with low volume that do not require a fast response time. All transactions are forced to use pool threads.

Using protected threads (by specifying PROTECTNUM=n on the DB2ENTRY definition for an entry thread) is a performance option that reduces the resources involved in creating and terminating a thread. A protected thread is not terminated when a transaction ends, and the next transaction associated with the same DB2ENTRY reuses the thread. By using protected threads, you eliminate much of the work required for thread creation and termination for individual transactions. For performance reasons, it is recommended that you use protected entry threads whenever possible, and especially where a transaction is frequently used, or issues many SYNCPOINTS. The main exception is when a transaction is infrequently used, because even a protected thread is likely to terminate between such transactions.

From an accounting viewpoint, the situation is different. An accounting record is produced for each thread termination and for each new user signon. This means that only one accounting record is produced if the thread stays alive and the user ID does not change. This record contains summarized values for all transactions using the same thread, but it is not possible to assign any value to a specific transaction. This can be overcome by specifying ACCOUNTREC(UOW) to make sure an accounting record is cut per unit of work, or by specifying ACCOUNTREC(TASK) to make sure there is an accounting record cut per CICS task. See Chapter 10, “Accounting and monitoring in a CICS DB2 environment,” on page 145 for more information about accounting in a CICS DB2 environment.

Several transactions can be specified to use the same DB2ENTRY. Ideally, they should all use the same plan. Each low-volume transaction can have its own DB2ENTRY. In this case thread reuse is not likely and you should specify

PROTECTNUM=0. An alternative is to group a number of low-volume transactions in the same DB2ENTRY and specify PROTECTNUM=n. This gives better thread utilization and less overhead.

Authorization checks take place when a thread is created and when a thread is reused with a new user. Avoiding the overhead in the security check is part of the performance advantage of using protected threads. This means that from a performance viewpoint all transactions defined to use the same DB2ENTRY with PROTECTNUM>0 should use the same authorization ID. At least they should avoid specifying TERM, OPID, and USERID for the AUTHTYPE parameter, because these values often vary among instances of a transaction.

It is important that you coordinate your DB2CONN, DB2ENTRY, and BIND options. For more information, see “Coordinating your DB2CONN, DB2ENTRY, and BIND options.”

Selecting BIND options for optimum performance

For an overview of the bind process, see “The bind process” on page 12. The BIND options that you select for a plan should be coordinated with the thread types used by the transactions associated with that plan. For advice on selecting thread types, see “Selecting thread types for optimum performance” on page 61.

We recommend that transactions using protected threads should use a plan bound with ACQUIRE(ALLOCATE) and RELEASE(DEALLOCATE) to reduce the amount of work done. Although ACQUIRE(ALLOCATE) and RELEASE(DEALLOCATE) reduce the amount of processing for a protected thread, there are some locking considerations (for more information, see “Developing a locking strategy in the CICS DB2 environment” on page 105). The plans for infrequently used transactions that do not use a protected thread should not typically use ACQUIRE(ALLOCATE), unless most of the SQL statements in the plan are used in each transaction.

Using ACQUIRE(ALLOCATE) minimizes the work done at SQL processing time. Using RELEASE(DEALLOCATE) minimize the work done at commit time. RELEASE(DEALLOCATE) optimizes performance if there are many commits in the program and if the thread is to be reused, because the work associated with releasing the TS locks and freeing the CT pages is done once, when the thread terminates, and not for each SYNCPOINT statement.

Packages do not have a separate ACQUIRE option. ACQUIRE(USE) is implicit when a program is executed from a package.

The bind option VALIDATE can also affect performance. You should use VALIDATE(BIND) in a CICS environment. For more information, see “Bind options and considerations for programs” on page 138.

It is important that you coordinate your DB2CONN, DB2ENTRY, and BIND options. For more information, see “Coordinating your DB2CONN, DB2ENTRY, and BIND options.”

Coordinating your DB2CONN, DB2ENTRY, and BIND options

You can create many different combinations of DB2CONN, DB2ENTRY, and BIND options. As we have read, one of the most important things you need to do to optimize performance is to define whether a given set of transactions should use one or more protected threads. “Selecting thread types for optimum performance” on page 61

on page 61 has more detailed advice about this. You should then define the BIND parameters ACQUIRE and RELEASE to minimize the total amount of work related to the main activities involved in processing SQL transactions. “Selecting BIND options for optimum performance” on page 62 has more detailed advice about this.

In general it is recommended that you initially set your DB2CONN, DB2ENTRY and BIND options to the values shown in Table 1. You may find that you get better performance from other combinations for your own transactions. For each transaction type a recommended thread type and BIND option are shown. There are also recommendations for whether transactions should overflow to the pool.

Table 1. Recommended combinations of DB2CONN, DB2ENTRY and BIND options

Transaction Description	Thread Type	Overflow	ACQUIRE	RELEASE
High volume (all types)	Protected Entry	Note 1	ALLOCATE	DEALLOCATE
Terminal-oriented with many commits (plus non-terminal if NONTERMREL=YES)	Protected Entry	Note 2	Note 3	DEALLOCATE
Low volume, requires fast response time	Unprotected Entry	Yes	USE	COMMIT
Low volume, limited concurrency	Unprotected Entry	Never	USE	COMMIT
Low volume, does not require fast response time	Pool	Not Applicable	USE	COMMIT
Non-terminal-oriented with many commits (NONTERMREL=NO)	Note 4	Note 4	Note 3	DEALLOCATE

Notes:
1. Yes, but define enough entry threads so this happens infrequently.
2. Yes, but if it overflows to the pool no protected thread is used.
3. ALLOCATE if most of the SQL in the plan is used. Otherwise use ACQUIRE(USE).
4. Threads are held until EOT. Use pool threads for a short transaction. Consider entry threads for longer running transactions.

In Table 1 limited concurrency means only a limited number (n) of transactions are allowed to execute at the same time. A special case exists when n=1. In that case the transactions are serialized. You can still use a protected thread if the transaction rate is high enough to make it worthwhile. The transactions cannot be controlled, if overflow to the pool is allowed. You should normally use the CICS mechanism for limiting the number of transactions running in a specific class, rather than forcing transactions to queue for a limited number of threads.

As Table 1 shows, only a few combinations of DB2CONN, DB2ENTRY, and BIND options are generally recommended. However, in specific situations other combinations can be used.

Table 2 on page 64 shows a summary of the activities involved in processing SQL requests for the three recommended sets of DB2CONN, DB2ENTRY, and BIND specifications. An “X” indicates a required activity. The table also demonstrates the performance advantage of using protected threads without changing the authorization ID.

Table 2. Activities involved in processing SQL requests for different DB2CONN, DB2ENTRY, and BIND specifications

Activity	Protected Threads		Unprotected Threads	
	ACQUIRE(ALLOCATE) RELEASE(DEALLOCATE)		(USE) (COMMIT)	(USE) (DEALLOCATE)
	Activity for each thread	Activity for each transaction	Activity for each transaction	Activity for each transaction
Create thread:	X		X	X
SIGNON	X	(1)	X	X
Authorization Check	X	(1)	X	X
Load SKCT Header	X		X	X
Load CT Header	X		X	X
Acquire all TS locks	X			
Load all DBDs	X			
For each SQL statement:				
Load SKCT SQL section		(2)	(2)	(2)
Create CT copy		(3)	X	X
Acquire all TS locks			X	X
Load all DBDs			X	X
Commit:				
Release page locks		X	X	X
Release TS locks			X	
Free CT pages			X	
Terminate Thread:	X		X	X
Release TS locks	X		X	X
Free CT pages	X			X
Free work storage	X		X	X

Notes:
X. Required activity
1. Only if new authorization ID
2. Only if SQL section is not already in EDM pool
3. Only if SQL section is not already in Cursor Table

Chapter 6. Security in a CICS DB2 environment

In the CICS DB2 environment, there are four main stages at which you can implement security checking. These are:

- When a CICS user signs on to a CICS region. CICS sign-on authenticates users by checking that they supply a valid user ID and password. This chapter does not deal with this process; you can find more information about it in "Verifying CICS users" in the *CICS RACF® Security Guide*.
- When a CICS user tries to use or modify a CICS resource that is related to DB2. This could be a DB2CONN, DB2ENTRY or DB2TRAN resource definition; or a CICS transaction that accesses DB2 to obtain data; or a CICS transaction that issues commands to the CICS DB2 attachment facility or to DB2 itself. At this stage, you can use CICS' own security mechanisms, which are managed by RACF or an equivalent external security manager, to control the CICS user's access to the resource. "Controlling access to DB2 resources in CICS" on page 66 tells you how to implement security at this stage.
- When the CICS region connects to DB2, and when a transaction acquires a thread into DB2. Both the CICS region and the transaction must provide authorization IDs to DB2, and these authorization IDs are validated by RACF or an equivalent external security manager. "Providing authorization IDs to DB2 for the CICS region and for CICS transactions" on page 74 tells you how to choose and provide these authorization IDs.
- When a CICS user tries to use a CICS transaction to execute or modify a DB2 resource. This could be a plan, or a DB2 command, or a resource that is needed to execute dynamic SQL. At this stage, you can use DB2's security checking, which is managed either by DB2 itself, or by RACF or an equivalent external security manager, to control the CICS user's access to the resource. "Authorizing users to access resources within DB2" on page 81 tells you how to implement security at this stage.

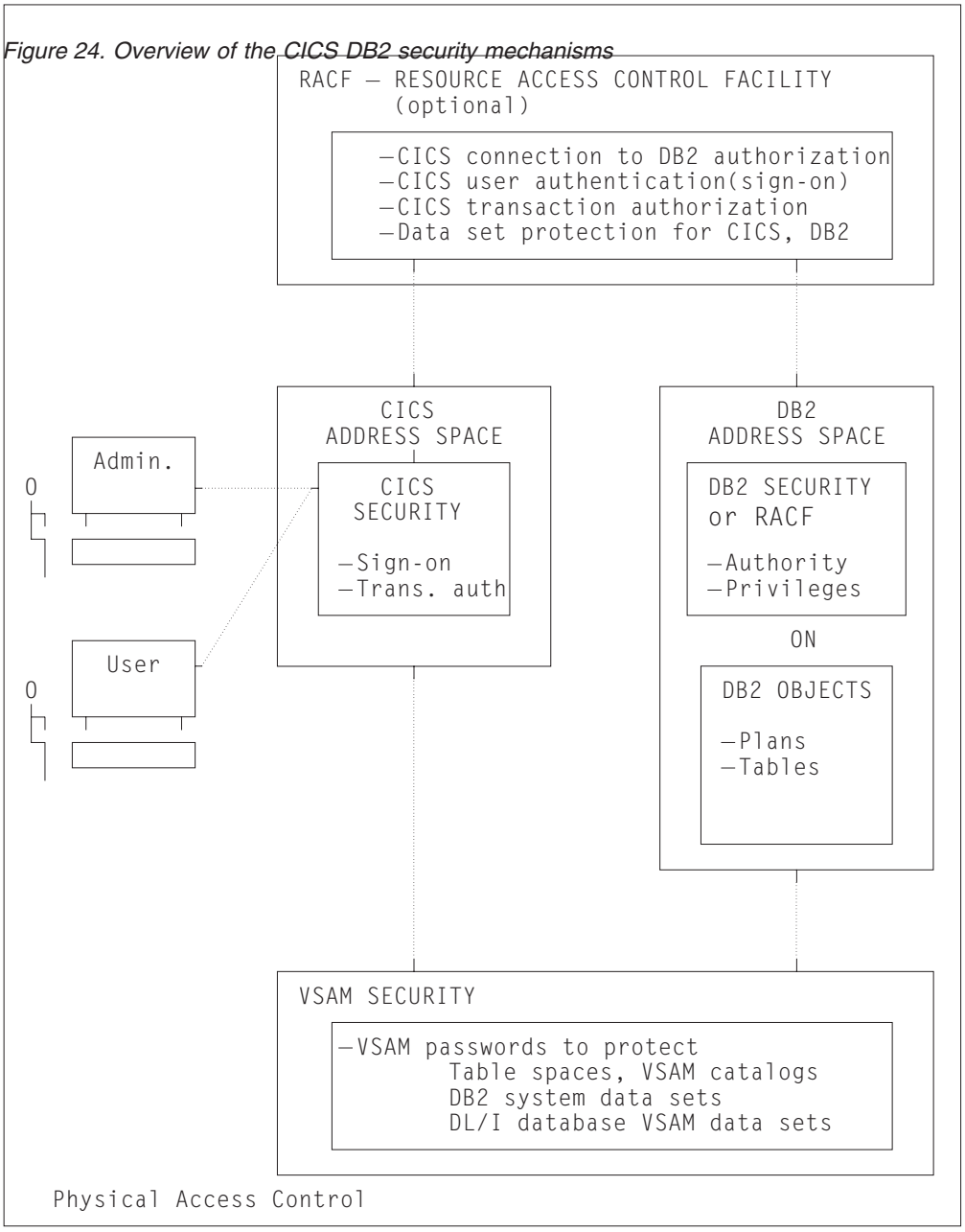
You can also use RACF, or an equivalent external security manager, to protect the components that make up CICS and DB2 from unauthorized access. You can apply this protection to DB2 databases, logs, bootstrap data sets (BSDSs), and libraries outside the scope of DB2, and to CICS data sets and libraries. You can use VSAM password protection as a partial replacement for the protection provided by RACF. "CICS system resource security" in the *CICS RACF Security Guide* gives you more information about this.

DB2 Version 8 introduced support for multilevel security. "Multilevel security and row-level security" on page 85 explains what to do if multilevel security is active in your DB2 environment.

Note: In this chapter, we refer to RACF as the external security manager used by CICS. Except for the explicit RACF examples, the general discussion applies equally to any functionally equivalent non-IBM external security manager.

Figure 24 shows the security mechanisms involved in a CICS DB2 environment.

Figure 24. Overview of the CICS DB2 security mechanisms



Controlling access to DB2 resources in CICS

In the CICS region, CICS users might need to perform the following DB2–related activities:

- Inquire on, modify, create or discard DB2CONN, DB2ENTRY, and DB2TRAN resource definitions.
- Use a transaction that accesses DB2 to obtain data, or issue CICS DB2 attachment facility commands or DB2 commands using the DSNC transaction.

As far as the CICS region is concerned, you can control access to all these resources and initiate security checking for them, by enabling RACF, or an equivalent external security manager, for the CICS region, and enabling the

appropriate CICS security mechanism (transaction-attach security, resource security, command security, or surrogate security). When a user tries to access protected resources, CICS calls the external security manager to perform security checking. RACF makes security checks using the CICS user's ID, which is authenticated when the user signs on to CICS. If a user does not sign on to CICS, they are given the default user ID, unless a user ID has been permanently associated with a terminal using preset security.

This topic describes how to control users' access to DB2–related resources in the CICS region, as follows:

- "Controlling access to DB2CONN, DB2TRAN, and DB2ENTRY resources" tells you how to control access to resource definitions.
- "Controlling access to DB2 CICS transactions" on page 73 tells you how to control access to transactions.

Some of the DB2-related resources in the CICS region are subject to further security checking by DB2's security mechanisms, and this topic tells you where this applies.

For wider information about the CICS security topics discussed here, such as command and resource security in general, see the *CICS RACF Security Guide*.

Controlling access to DB2CONN, DB2TRAN, and DB2ENTRY resources

You can control users' access to DB2CONN, DB2TRAN, and DB2ENTRY resource definitions on several levels, by enabling different CICS security mechanisms:

- Control users' ability to access particular resources by using the CICS **resource security** mechanism. Resource security is implemented at the transaction level. For example, you could prevent some users from modifying a particular DB2ENTRY definition. "Using resource security to control access to DB2ENTRY and DB2TRAN resources" tells you how to use this security mechanism.
- Control users' ability to issue particular SPI commands against DB2-related resources by using the CICS **command security** mechanism. Command security is also implemented at the transaction level. For example, you could permit only certain users to issue CREATE and DISCARD commands against DB2ENTRY resource definitions. "Using command security to control using SPI commands for DB2 resources" on page 69 tells you how to use this security mechanism.
- Control users' ability to modify the authorization IDs that CICS provides to DB2, by using the CICS **surrogate security and AUTHTYPE security** mechanisms. The authorization IDs are used for DB2's own security checking, and they are set by the AUTHID, COMAUTHID, AUTHTYPE and COMAUTHTYPE attributes on DB2-related resource definitions, and by the SIGNID attribute on the DB2CONN definition for the CICS region. CICS checks that the user who wants to modify the authorization ID, is permitted to act on behalf of the existing authorization ID that is specified in the resource definition. "Using surrogate security and AUTHTYPE security to control access to authorization IDs" on page 71 tells you how to use these security mechanisms.

Using resource security to control access to DB2ENTRY and DB2TRAN resources

The CICS resource security mechanism controls users' access to named CICS resources. For example, you can use it to protect certain resources — such as a particular DB2ENTRY definition — from being modified by particular users. CICS command security, which is also described in this section, can prevent users from

performing certain actions on types of resources, such as “all DB2ENTRY definitions”, but it cannot protect individual items within the resource type.

Because your CICS region only has one DB2CONN definition, you do not need to use resource security to protect it; you can control access to the DB2CONN definition using command security. Also, DB2TRAN definitions, for the purpose of resource security, are treated as extensions of the DB2ENTRY definition to which they refer, and are not defined for resource security in their own right. If you give a user permission to access a DB2ENTRY definition, you also give them permission to access the DB2TRAN definitions that refer to it.[1] For resource security, you therefore only need to define your DB2ENTRY definitions to RACF.

When resource security is enabled for a transaction, the external security manager checks that the user ID associated with the transaction is authorized to modify the resource that is involved. “Resource security” in the *CICS RACF Security Guide* has more information about this process.

To protect your DB2-related resources using resource security, complete these steps:

1. To enable RACF, or an equivalent external security manager, and make resource security available for a CICS region, specify SEC=YES as a system initialization parameter for the CICS region.
2. In RACF, create general resource classes to contain your DB2-related resources. You need a member class and a grouping class. Unlike the RACF default resource class names for CICS, there are no IBM-supplied default class names for DB2ENTRYs. Create your own installation-defined class names by adding new class descriptors to the installation-defined part (module ICHRRCDE) of the RACF class descriptor table (CDT). For an example of how to do this, see the IBM-supplied sample job, RRCDTE, supplied in member DFH$RACF of CICSTS31.CICS.SDFHSAMP. This gives an example of a member class called XCICSDB2, and a grouping class called ZCICSDB2. This example uses the same naming convention as the default resource class names for CICS. Do not use existing CICS class names for DB2-related resource definitions; instead, create new class names using a similar naming convention.
3. Define profiles for your DB2ENTRY definitions in the resource classes that you have created. For example, to add a number of DB2ENTRY names to the XCICSDB2 resource class, use the RDEFINE command as follows:

   ```
   RDEFINE  XCICSDB2  (db2ent1, db2ent2, db2ent3.., db2entn) UACC(NONE)
                    NOTIFY(sys_admin_userid)
   ```

   Protecting DB2ENTRY resource definitions also protects access to associated DB2TRAN definitions, because a DB2TRAN is considered to be an extension to the DB2ENTRY to which it refers. You do not need to protect your DB2CONN definition using resource security.
4. To activate resource security for your DB2-related resources, specify XDB2=*name* as a system initialization parameter for the CICS region, where *name* is the general resource class name that you defined for your DB2-related resources.
5. Specify RESSEC=YES in the resource definition for any transactions involving DB2-related resources for which you want to enable resource security. Now,

1. In the case where a transaction changes the name of the DB2ENTRY with which a DB2TRAN definition is associated, a double security check is performed, to verify the user's authority to modify both the old DB2ENTRY to which the definition referred, and the new DB2ENTRY to which it will refer.

when a user tries to use one of these transactions to access one of the DB2-related resources that you have protected, RACF checks that the user ID is authorized to access that resource.

6. Give permission to your CICS users, or groups of users, to perform appropriate actions on each DB2-related resource that you have protected. Remember that if a user has permission to perform actions on a DB2ENTRY definition, they are automatically authorized to perform the same actions on DB2TRAN definitions associated with it.

   The access that users need to perform certain actions is as follows:

   INQUIRE command
   Requires READ authority

   SET command
   Requires UPDATE authority

   CREATE command
   Requires ALTER authority

   DISCARD command
   Requires ALTER authority

   For example, you can use the PERMIT command to authorize a group of users to modify a protected DB2ENTRY, `db2ent1` in class XCICSDB2, with UPDATE authority, as follows:

   ```
   PERMIT db2ent1 CLASS(XCICSDB2) ID(group1) ACCESS(UPDATE)
   ```

Using command security to control using SPI commands for DB2 resources

The CICS command security mechanism controls users' ability to issue particular SPI commands against types of DB2-related resource. For example, you can use it to control which users are allowed to issue CREATE and DISCARD commands against DB2ENTRY resource definitions. Unlike resource security, CICS command security cannot protect individual named resources; it is designed to protect types of resource. You can use command security to protect DB2CONN, DB2ENTRY, and DB2TRAN resource definitions.

When command security is enabled for a transaction, the external security manager checks that the user ID associated with the transaction is authorized to use that command to modify the type of resource that is involved. “CICS command security” in the *CICS RACF Security Guide* has more information about this process.

If you have both resource security and command security enabled for a particular transaction, RACF performs two security checks against the user ID. For example, if a transaction involves the user issuing a DISCARD command against DB2ENTRY definition `db2ent1`, RACF checks:

1. That the user ID is authorized to issue the DISCARD command (ALTER authority) against the DB2ENTRY resource type.
2. That the user ID is authorized to access the DB2ENTRY definition `db2ent1` with ALTER authority.

To protect your DB2-related resources using command security, complete these steps:

1. To enable RACF, or an equivalent external security manager, for a CICS region, specify SEC=YES as a system initialization parameter for the region.

2. Add the DB2 resource names DB2CONN, DB2ENTRY, and DB2TRAN as resource identifiers in one of the IBM-supplied RACF resource classes for CICS commands, CCICSCMD or VCICSCMD. Alternatively, you can use a user-defined general resource class for your CICS commands. “CICS resources subject to command security checking” in the *CICS RACF Security Guide* tells you more about this. For example, you can use the REDEFINE command to define a profile named CMDSAMP in the default class VCICSCMD, and use the ADDMEM operand to specify that the DB2 resource types are to be protected by this profile, as follows:

   ```
   RDEFINE  VCICSCMD CMDSAMP UACC(NONE)
                     NOTIFY(sys_admin_userid)
                     ADDMEM(DB2CONN, DB2ENTRY, DB2TRAN)
   ```

3. To make command security available for a CICS region:
   a. If you have used the IBM-supplied RACF resource classes CCICSCMD or VCICSCMD for CICS command profiles, specify XCMD=YES as a system initialization parameter for the region. Specifying YES means that CCICSCMD and VCICSCMD are used to build RACF's in-storage profiles.
   b. If you have used a user-defined general resource class for CICS commands, specify XCMD=*user_class* as a system initialization parameter for the region, where *user_class* is the name of the user-defined general resource class.
4. Specify CMDSEC=YES in the resource definition for any transactions involving DB2-related resources for which you want to enable command security. Now, when a user tries to use one of these transactions to issue a command to modify one of the DB2-related resources that you have protected, RACF checks that the user ID is authorized to issue that command against that type of resource.
5. Give permission to your CICS users, or groups of users, to issue appropriate commands against each type of DB2-related resource. For command security, you need to give separate permissions relating to the DB2TRAN resource type, as well as to the DB2ENTRY resource type. You can also protect the DB2CONN resource type (that is, the CICS region's DB2CONN definition).

   The access that users need to issue certain commands is as follows:

   INQUIRE command
   Requires READ authority

   SET command
   Requires UPDATE authority

   CREATE command
   Requires ALTER authority

   DISCARD command
   Requires ALTER authority

   For example, if you have defined the DB2 resource types in the CMDSAMP profile as in the example in Step 2, you can use the PERMIT command to authorize a group of users to issue EXEC CICS INQUIRE commands against the DB2 resource types as follows:

   ```
   PERMIT CMDSAMP CLASS(VCICSCMD) ID(operator_group) ACCESS(READ)
   ```

   Within a transaction, you can query whether a user ID has access to DB2 resource types by using the EXEC CICS QUERY RESTYPE(SPCOMMAND) command, with the RESID parameter specifying DB2CONN, DB2ENTRY, or DB2TRAN.

Using surrogate security and AUTHTYPE security to control access to authorization IDs

The CICS surrogate security and AUTHTYPE security mechanisms control users' ability to modify the authorization IDs that CICS provides to DB2. You can use it to ensure that only certain users are permitted to change these authorization IDs, which are used for DB2's own security checking. Surrogate security and AUTHTYPE security are set for the whole CICS region, and any transactions that involve changes to the authorization IDs are subject to them.

"Providing authorization IDs to DB2 for the CICS region and for CICS transactions" on page 74 explains how to select and change these authorization IDs. To summarize, the authorization IDs that CICS provides to DB2 are set by the AUTHID, COMAUTHID, AUTHTYPE and COMAUTHTYPE attributes on DB2-related resource definitions, and by the SIGNID attribute on the DB2CONN definition for the CICS region. To change the authorization IDs, you first need authority to modify the DB2CONN and DB2ENTRY definitions, which might be protected by command security or resource security. Surrogate security provides an extra layer of protection, because it involves CICS acting on DB2's behalf to check that the user modifying the authorization ID, is permitted to act as a surrogate for the existing authorization ID that is specified in the resource definition.

True surrogate security provides security checking when a user attempts to change the SIGNID, AUTHID or COMAUTHID attributes on a DB2CONN or DB2ENTRY definition, all of which specify an authorization ID that is used when a process signs on to DB2. CICS uses the surrogate user facility of RACF to perform this checking. A surrogate user is one who has the authority to do work on behalf of another user, without knowing that other user's password. When a user attempts to change one of the SIGNID, AUTHID or COMAUTHID attributes, CICS calls RACF to check that the user is authorized as a surrogate of the authorization ID that is presently specified on the SIGNID, AUTHID or COMAUTHID attribute.

For the AUTHTYPE and COMAUTHTYPE attributes, which give a type of authorization ID to be used rather than specifying an exact authorization ID, CICS cannot use true surrogate security. Instead, it uses a mechanism called AUTHTYPE security. When a user attempts to change one of the AUTHTYPE or COMAUTHTYPE attributes, CICS calls RACF to check that the user is authorized through a profile that you have defined for the resource definition in the RACF FACILITY general resource class. Although AUTHTYPE security is not true surrogate security, it is enabled by the same system initialization parameter, and you will probably want to use it in addition to surrogate security, so the instructions in this topic tell you how to set up both types of security.

Note that when DB2CONN and DB2ENTRY resource definitions are installed as part of a cold or initial start of CICS, if surrogate security and AUTHTYPE security are enabled, RACF makes surrogate security and AUTHTYPE security checks for the CICS region user ID. If you install DB2CONN and DB2ENTRY resource definitions in this way, ensure that the CICS region user ID is defined as a surrogate user for any authorization IDs specified in the resource definitions, and also that it is authorized through the correct profiles in the RACF FACILITY general resource class.

To implement surrogate security and AUTHTYPE security to protect the authorization IDs that CICS provides to DB2, complete the following steps:

1. To enable RACF, or an equivalent external security manager, for a CICS region, specify SEC=YES as a system initialization parameter for the region.

2. To activate surrogate security and AUTHTYPE security for a CICS region, specify XUSER=YES as a system initialization parameter for the region. This system initialization parameter enables both the security mechanisms. When the security mechanisms are enabled, CICS calls RACF to perform security checks whenever a transaction involves EXEC CICS SET, CREATE, and INSTALL commands that operate on the SIGNID, AUTHID, COMAUTHID, AUTHTYPE and COMAUTHTYPE attributes of DB2CONN and DB2ENTRY resource definitions. For the SIGNID, AUTHID and COMAUTHID attributes, RACF performs the surrogate security check, and for the AUTHTYPE or COMAUTHTYPE attributes, RACF performs the AUTHTYPE security check.
3. For the purpose of surrogate security, you need to define appropriate CICS users, or groups of users, as surrogates of any authorization IDs that are specified on the SIGNID, AUTHID or COMAUTHID attributes of your DB2CONN and DB2ENTRY definitions. To define a user ID as a surrogate of an authorization ID:
   a. Create a profile for the authorization ID in the RACF SURROGAT class, with a name of the form *authid*.DFHINSTL, with the authorization ID defined as the owner. For example, if you have specified DB2AUTH1 as an authorization ID on a SIGNID, AUTHID or COMAUTHID attribute, use the following command to create a profile:

      ```
      RDEFINE  SURROGAT  DB2AUTH1.DFHINSTL  UACC(NONE) OWNER(DB2AUTH1)
      ```

   b. Permit appropriate CICS users to act as a surrogate for the authorization ID, by giving them READ authority to the profile you have created. For example, to permit a user with the ID CICSUSR1 to act as a surrogate for the authorization ID DB2AUTH1, and therefore to install or modify any SIGNID, AUTHID or COMAUTHID attributes that specify DB2AUTH1 as the existing authorization ID, use the following command:

      ```
      PERMIT   DB2AUTH1.DFHINSTL  CLASS(SURROGAT) ID(CICSUSR1)  ACCESS(READ)
      ```

   Repeat this process for all the authorization IDs that you have specified on SIGNID, AUTHID or COMAUTHID attributes. Also, if you might need to install DB2CONN and DB2ENTRY resource definitions containing SIGNID, AUTHID or COMAUTHID attributes as part of a cold or initial start of CICS, permit the CICS region user ID to act as a surrogate for any authorization IDs specified by those attributes. (The defaults for DB2CONN and DB2ENTRY resource definitions do not involve the AUTHID and COMAUTHID attributes. The default SIGNID for an installed DB2CONN definition is the applid of the CICS region.)
4. For the purpose of AUTHTYPE security, you need to create a profile for each of your DB2CONN or DB2ENTRY resource definitions in the RACF FACILITY general resource class, and give appropriate CICS users, or groups of users, READ authority to the profiles. (This process imitates the true surrogate security mechanism, but does not involve the use of a specific authorization ID; instead, it protects each resource definition.) To do this:
   a. Create a profile for the DB2CONN or DB2ENTRY resource definition in the RACF FACILITY general resource class, with a name of the form DFHDB2.AUTHTYPE.*authname*, where *authname* is the name of the DB2CONN or DB2ENTRY resource definition. For example, to define a profile for a DB2CONN resource definition named DB2CONN1, use the following command:

      ```
      RDEFINE  FACILITY  DFHDB2.AUTHTYPE.DB2CONN1   UACC(NONE)
      ```

   b. Give appropriate CICS users READ authority to the profile you have created. For example, to permit a user with the ID CICSUSR2 to install or modify the AUTHTYPE or COMAUTHTYPE attributes on a DB2CONN resource definition named DB2CONN1, use the following command:

```
PERMIT  DFHDB2.AUTHTYPE.DB2CONN1 CLASS(FACILITY) ID(CICSUSR2) ACCESS(READ)
```

Repeat this process for each of your DB2CONN and DB2ENTRY resource definitions. Also, if you might need to install DB2CONN and DB2ENTRY resource definitions containing AUTHTYPE or COMAUTHTYPE attributes as part of a cold or initial start of CICS, give READ authority to the CICS region user ID on the profiles for those resource definitions.

Controlling access to DB2 CICS transactions

You can control users' access to

- CICS transactions that access DB2 to obtain data
- The DSNC transaction, and any other transactions that you have set up, to issue CICS DB2 attachment facility commands and DB2 commands

by using the CICS transaction-attach security mechanism. When transaction-attach security is enabled, RACF, or an equivalent external security manager, checks that the CICS user is authorized to run the transaction that they have requested.

To protect DB2-related transactions using transaction-attach security, follow the instructions in “Transaction security” in the *CICS RACF Security Guide*. The process is the same for all CICS transactions; there are no special considerations for DB2-related transactions as far as the transaction-attach security mechanism is concerned. The instructions tell you how to:

- Set up appropriate system initialization parameters for the CICS region to activate transaction-attach security (see “CICS parameters controlling transaction-attach security” in the *CICS RACF Security Guide*).
- Define transaction profiles to RACF for the transactions that you want to protect (see “Defining transaction profiles to RACF” in the *CICS RACF Security Guide*).

If you have defined transactions other than DSNC to issue CICS DB2 attachment facility commands and DB2 commands (for example, if you have created a separate transaction to run each command), remember to define these transactions to RACF as well.

You can now control which CICS users can use transactions that access DB2. Add the appropriate users or groups of users to the access list for the transaction profiles, with READ authority. “Defining transaction profiles to RACF” in the *CICS RACF Security Guide* has some recommendations about this.

For transactions that issue CICS DB2 attachment facility commands and DB2 commands, bear in mind that:

- CICS DB2 attachment facility commands operate on the connection between CICS and DB2, and they run entirely within CICS. DB2 commands operate in DB2 itself, and they are routed to DB2. You can distinguish DB2 commands from CICS DB2 attachment facility commands by the hyphen (**-**) character, which is entered with DB2 commands.
- If you have access to the DSNC transaction, CICS allows you to issue all of the CICS DB2 attachment facility commands and DB2 commands.
- If you have defined separate transactions to run individual CICS DB2 attachment facility commands and DB2 commands, you can give different CICS users authorization to subsets of these transaction codes, and therefore to subsets of the commands. For example, you could give some users authority to issue CICS DB2 attachment facility commands, but not DB2 commands. Chapter 4, “CICS-supplied transactions for CICS DB2,” on page 33 has the names of the

separate transaction definitions that CICS supplies for the CICS DB2 attachment facility commands and the DB2 commands.

CICS DB2 attachment facility commands do not flow to DB2, so they are not subject to any further security checking. They are only protected by CICS transaction-attach security. However, DB2 commands, and CICS transactions that access DB2 to obtain data, are subject to further stages of security checking by DB2's own security mechanisms, as follows:

- When a transaction signs on to DB2, it must provide valid authorization IDs to DB2. The authorization IDs are checked by RACF or an equivalent external security manager.
- Because the transaction is issuing a DB2 command or accessing DB2 data, the authorization IDs that it has provided must have permission to perform these actions within DB2. In DB2, you can use GRANT statements to give the authorization IDs permission to perform actions.

In addition, the CICS region itself must be authorized to connect to the DB2 subsytem.

"Providing authorization IDs to DB2 for the CICS region and for CICS transactions" tells you how to authorize the CICS region to connect to the DB2 subsystem, and how to provide valid authorization IDs for transactions.

"Authorizing users to access resources within DB2" on page 81 tells you how to grant permissions to the authorization IDs that the transactions have provided to DB2.

Providing authorization IDs to DB2 for the CICS region and for CICS transactions

For the purposes of security, DB2 uses the term "process" to represent all forms of access to data, either by users interacting directly with DB2, or by users interacting with DB2 by way of other programs, including CICS. A process that connects to or signs on to DB2 must provide one or more DB2 short identifiers, called authorization IDs, that can be used for security checking in the DB2 address space. Every process must provide a primary authorization ID, and it can optionally provide one or more secondary authorization IDs. DB2 privileges and authority can be granted to either primary or secondary authorization IDs. For example, users can create a table using their secondary authorization ID. The table is then owned by that secondary authorization ID. Any other user that provides DB2 with the same secondary authorization ID has associated privileges over the table. To take privileges away from a user, the administrator can simply disconnect the user from that authorization ID.

CICS has two types of process that need to provide DB2 with authorization IDs:

- The overall connection between a CICS region and DB2, which is created by the CICS DB2 attachment facility. This process has to go through DB2's connection processing to provide DB2 with authorization IDs.
- CICS transactions that acquire a thread into DB2. These could be, for example, a transaction that is retrieving data from a DB2 database, or the DSNC transaction that is issuing a DB2 command. For each CICS transaction, the actual process that DB2 sees is the thread TCB, which CICS uses to control a transaction's thread into DB2. These processes have to go through DB2's sign-on processing to provide DB2 with authorization IDs.

During connection processing and sign-on processing, DB2 sets the primary and secondary authorization IDs for the process to use in the DB2 address space. By default, DB2 uses the authorization IDs that the process has provided. However, both connection processing and sign-on processing involve exit routines, and these exit routines allow you to influence the setting of the primary and secondary authorization IDs. DB2 has a default connection exit routine and a default sign-on exit routine. You can replace these with your own exit routines, and a sample connection exit routine and sign-on exit routine are supplied with DB2 to assist you with this.

"Providing authorization IDs to DB2 for a CICS region" tells you how to set up authorization IDs for a CICS region to connect to DB2.

"Providing authorization IDs to DB2 for CICS transactions" on page 77 tells you how to set up authorization IDs for CICS transactions.

Providing authorization IDs to DB2 for a CICS region

When the CICS DB2 attachment facility creates the overall connection between a CICS region and DB2, the process goes through DB2's connection processing. The CICS region can provide:

- A primary authorization ID. The primary authorization ID becomes the CICS region's primary ID in DB2. For the connection between a CICS region and DB2, you cannot choose the primary authorization ID that is initally passed to DB2's connection processing; it is the user ID for the CICS region. However, it is possible to change the primary ID that DB2 sets during connection processing, by writing your own connection exit routine. If RACF, or an equivalent external security manager, is active, the user ID for the CICS region must be defined to it. "Providing a primary authorization ID for a CICS region" tells you about the possible primary authorization IDs for a CICS region.
- One or more secondary authorization IDs. You can use the name of a RACF group, or list of groups, as secondary authorization IDs for the CICS region. If you do this, you need to replace the default DB2 connection exit routine DSN3@ATH, which only passes primary authorization IDs to DB2. The sample DB2 connection exit routine DSN3SATH passes the names of RACF groups to DB2 as secondary authorization IDs. Alternatively, you can write your own connection exit routine that sets secondary IDs for the CICS region. "Providing secondary authorization IDs for a CICS region" on page 76 tells you how to set up secondary authorization IDs for a CICS region.

Providing a primary authorization ID for a CICS region

The connection type that CICS requests from DB2 is single address space subsystem (SASS). For the connection between a CICS region and DB2, you cannot choose the primary authorization ID that is initially passed to DB2's connection processing. The ID that is passed to DB2 as the primary authorization ID for the CICS region is one of the following:

- The user ID taken from the RACF started procedures table, ICHRIN03, if CICS is running as a started task.
- The user parameter of the STDATA segment in a STARTED general resource class profile, if CICS is running as a started job.
- The user ID specified on the USER parameter of the JOB card, if CICS is running as a job.

The user ID that a CICS region might use must be defined to RACF, or your equivalent external security manager, if the external security manager is active. Define the user ID to RACF as a USER profile. It is not sufficient to define it as a RESOURCE profile.

Once you have defined the CICS region's user ID to RACF, permit it to access DB2, as follows:

1. Define a profile for the DB2 subsystem with the single address space subsystem (SASS) type of connection, in the RACF class DSNR. For example, the following RACF command creates a profile for SASS connections to DB2 subsystem DB2A in class DSNR:

   ```
   RDEFINE DSNR (DB2A.SASS) OWNER(DB2OWNER)
   ```

2. Permit the user ID for the CICS region to access the DB2 subsystem. For example, the following RACF command permits a CICS region with a user ID of CICSHA11 to connect to DB2 subsystem DB2A:

   ```
   PERMIT DB2A.SASS CLASS(DSNR) ID(CICSHA11) ACCESS(READ)
   ```

DB2's connection exit routine takes the primary authorization ID (the user ID) provided by the CICS region, and sets it as the primary ID for the CICS region in DB2. The default DB2 connection exit routine DSN3@ATH, and the sample DB2 connection exit routine DSN3SATH, both behave in this way. It is possible to change the primary ID that DB2 sets, by writing your own connection exit routine. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has more information about the sample connection exit routine and about writing exit routines. However, you might find it more straightforward to provide secondary authorization IDs for the CICS region, and grant permissions to the CICS region based on these, rather than on the primary authorization ID.

Providing secondary authorization IDs for a CICS region

When a CICS region connects to DB2, it can provide one or more secondary authorization IDs to DB2, in addition to the primary authorization ID. You can use the name of the RACF group, or list of groups, to which the CICS region is connected, as secondary authorization IDs. This enables you to grant DB2 privileges and authority to RACF groups, and then connect multiple CICS regions to the same groups, instead of granting DB2 privileges to all the possible primary authorization IDs for each CICS region.

To provide the name of the RACF group, or list of groups, to which a CICS region is connected, to DB2 as secondary authorization IDs, complete the following steps:

1. Specify SEC=YES as a system initialization parameter for the CICS region, to ensure that CICS uses RACF.
2. Connect the CICS region to the appropriate RACF group or list of groups. “RACF group profiles” in the *CICS RACF Security Guide* has more information about this.
3. Replace the default DB2 connection exit routine DSN3@ATH. This exit routine is driven during connection processing. The default connection exit routine does not support secondary authorization IDs, so you need to replace it with the sample connection exit routine DSN3SATH, which is provided with DB2, or with your own routine. DSN3SATH is shipped in source form in the DB2 SDSNSAMP library, and you can use it as a basis for your own routine. DSN3SATH passes the names of the RACF groups to which the CICS region is connected, to DB2 as secondary authorization IDs. If the RACF list of groups option is active, DSN3SATH obtains all the group names to which the CICS region is connected, and uses these as secondary authorization IDs. If the RACF list of groups

option is not active, DSN3SATH uses the name of the CICS region's current connected group as the only secondary authorization ID.

When the CICS region connects to DB2, the sample connection exit routine sets the CICS region's primary authorization ID (the region's user ID) as the primary ID, and sets the names of the RACF groups to which the CICS region is connected, as secondary IDs.

As an alternative to providing the names of RACF groups as secondary authorization IDs to DB2, you can write your own connection exit routine that sets secondary IDs for the CICS region. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has information about writing connection exit routines.

Providing authorization IDs to DB2 for CICS transactions

When a CICS transaction's thread TCB signs on to DB2 and goes through DB2's sign-on processing, it can provide:

- A primary authorization ID. For CICS transactions, you can choose the primary authorization ID. It can be the user ID or operator ID of the CICS user, or a terminal ID, or a transaction ID; or it can be an ID that you have specified. The ID that is used as the primary authorization ID is determined by attributes in the DB2ENTRY definition (for entry threads), or in the DB2CONN definition (for pool threads and command threads). "Providing a primary authorization ID for CICS transactions" on page 78 tells you how to choose the primary authorization ID for a CICS transaction.
- One or more secondary authorization IDs. You can use the name of a RACF group, or list of groups, as secondary authorization IDs. This has the advantage that you can grant DB2 privileges and authority to RACF groups, rather than to each individual CICS user. To use secondary authorization IDs, use the AUTHTYPE attribute in the DB2ENTRY definition (for entry threads), or the AUTHTYPE or COMAUTHTYPE attributes in the DB2CONN definition (for pool threads or command threads), to specify the GROUP option. You also need to replace the default DB2 sign-on exit routine DSN3@SGN, because the default routine does not pass secondary authorization IDs to DB2. When you specify the GROUP option, the primary authorization ID is automatically defined as the user ID of the CICS user associated with the transaction. "Providing secondary authorization IDs for CICS transactions" on page 80 tells you how to set up and use secondary authorization IDs.

A key consideration for choosing the authorization IDs that CICS transactions provide to DB2 is the security mechanism that you have chosen for security checking in the DB2 address space. This security checking covers access to DB2 commands, plans, and dynamic SQL. In DB2 Version 5 or later, you can choose to have this security checking carried out by:

- DB2's own internal security.
- RACF, or an equivalent external security manager.
- Partly DB2, and partly RACF.

If you are using RACF for some or all of the security checking in your DB2 address space, CICS transactions that sign on to DB2 **must** provide an authorization ID by one of the following methods:

- Specify AUTHTYPE(USERID) or COMAUTHTYPE(USERID) in the appropriate definition for the thread (DB2ENTRY or DB2CONN), to provide the user ID of the CICS user associated with the transaction to DB2 as the primary authorization ID.

- Specify AUTHTYPE(GROUP) or COMAUTHTYPE(GROUP) in the appropriate definition for the thread (DB2ENTRY or DB2CONN), to provide the user ID of the CICS user associated with the transaction to DB2 as the primary authorization ID, and the name of a RACF group or list of groups as the secondary authorization IDs.

CICS must also be using RACF (SEC=YES must be specified in the SIT). These conditions apply because when RACF is used for security checking in the DB2 address space, CICS needs to pass a RACF access control environment element (ACEE) to DB2. CICS can only produce an ACEE if it has RACF active, and only threads defined with the USERID or GROUP option can pass the ACEE to DB2.

Note that if the RACF access control environment element (ACEE) in the CICS region is changed in a way that affects the CICS DB2 attachment facility, DB2 is not aware of the change until a sign-on occurs. You can use the CEMT or EXEC CICS SET DB2CONN SECURITY(REBUILD) command to cause the CICS DB2 attachment facility to issue a DB2 sign-on the next time a thread is reused, or when a thread is built on an already signed-on TCB. This ensures that DB2 is made aware of the security change.

Providing a primary authorization ID for CICS transactions

When a CICS transaction's thread TCB signs on to DB2, it must provide a primary authorization ID to DB2. The ID that a transaction uses as its primary authorization ID is determined by an attribute in the resource definition for the thread that the transaction uses to access DB2. This means that all transactions that use the same type of thread (either the same type of entry thread, or pool threads, or command threads) must use the same type of primary authorization ID. In each CICS region, you need to set a primary authorization ID for:

- Each type of entry thread, using your DB2ENTRY definitions.
- The pool threads, using your DB2CONN definition.
- The command threads (used for the DSNC transaction), using your DB2CONN definition.

Before you start to set primary authorization IDs, ensure that you have authority to do so. As well as having authority to change your DB2CONN or DB2ENTRY definitions, if surrogate user checking is in force for the CICS region (that is, the system initialization parameter XUSER is set to YES), you need to obtain special authority to perform operations involving DB2 authorization IDs. These operations are modifying the AUTHID, COMAUTHID, AUTHTYPE, or COMAUTHTYPE attributes on a DB2ENTRY or DB2CONN definition, and modifying the SIGNID attribute on a DB2CONN definition. “Using surrogate security and AUTHTYPE security to control access to authorization IDs” on page 71 tells you how to grant users authority to perform these operations.

There are two methods of setting the primary authorization ID for a particular type of thread:

1. Use the AUTHID attribute in the DB2ENTRY definition (for entry threads), or the AUTHID or COMAUTHID attribute in the DB2CONN definition (for pool threads or command threads), to specify a primary authorization ID. For example, you could define `AUTHID=test2`. In this case, the CICS DB2 attachment facility passes the characters `TEST2` to DB2 as the primary authorization ID.

   Using AUTHID or COMAUTHID does not permit the use of secondary authorization IDs, and also is not compatible with the use of RACF, or an equivalent external security manager, for security checking in the DB2 address space.

2. Use the AUTHTYPE attribute in the DB2ENTRY definition (for entry threads), or the AUTHTYPE or COMAUTHTYPE attribute in the DB2CONN definition (for pool threads or command threads), to instruct CICS to use an existing ID that is relevant to the transaction as the primary authorization ID. This ID can be a CICS user ID, operator ID, terminal ID, or transaction ID; or it can be an ID that you have specified in the DB2CONN definition for the CICS region.

   Using AUTHTYPE or COMAUTHTYPE is compatible with the use of RACF (or an equivalent external security manager) for security checking in the DB2 address space, if you use the USERID or GROUP options, and with the use of secondary authorization IDs, if you use the GROUP option.

The two methods of determining the primary authorization ID are mutually exclusive; you cannot specify both AUTHID and AUTHTYPE, or COMAUTHID and COMAUTHTYPE, in the same resource definition.

Remember that all IDs that you select as primary authorization IDs must be defined to RACF, or your equivalent external security manager, if the security manager is active for the DB2 subsystem. For RACF, the primary authorization IDs must be defined as RACF USER profiles, not just as RESOURCE profiles (for example, as a terminal or transaction).

Follow the instructions in the *CICS Resource Definition Guide* to set up or modify DB2CONN and DB2ENTRY definitions. If you are using the AUTHTYPE or COMAUTHTYPE attributes to determine the primary authorization ID for a type of thread, use Table 3 on page 80 to identify the options that provide the desired authorization ID and support the facilities you want. The key points to consider are:

- If you want to provide secondary authorization IDs to DB2 as well as a primary authorization ID, you need to select the GROUP option. When you specify the GROUP option, your primary authorization ID is automatically defined as your CICS user ID, but you can base your security checking on the secondary authorization IDs instead.
- If you are using RACF for security checking in the DB2 address space, you need to select either the GROUP option, or the USERID option. Only these options can pass the RACF access control environment element (ACEE) to DB2, which is required when RACF is used for security checking.
- Think about the performance and maintenance implications of your choice of authorization ID. The *CICS Performance Guide* outlines these. With the USERID, OPID, TERM, TX or GROUP options, sign-on processing occurs more frequently, and maintenance also takes more time, because you need to grant permissions to a greater number of authorization IDs. With the SIGN option, or using the AUTHID attribute instead of the AUTHTYPE attribute, sign-on processing is decreased, and maintenance is less complicated. However, using standard authorization IDs makes DB2's security checking less granular.
- Think about the accounting implications of your choice of authorization ID. The authorization ID is used in each DB2 accounting record. From an accounting viewpoint, the most detailed information is obtained if using USERID, OPID, GROUP or TERM. However, depending on the ACCOUNTREC specification, it may not be possible to account at the individual user level in any case. For more information about accounting in a CICS DB2 environment, see Chapter 10, “Accounting and monitoring in a CICS DB2 environment,” on page 145.

Table 3 on page 80 shows the primary authorization IDs that the CICS DB2 attachment facility passes to DB2 when you select each option for the AUTHTYPE or COMAUTHTYPE attributes.

Table 3. Options available on the AUTHTYPE and COMAUTHTYPE attributes

Option	Primary authorization ID passed to DB2	Supports RACF checking for DB2?	Supports secondary auth IDs?
USERID	User ID associated with the CICS transaction, as defined to RACF and used in CICS sign-on	Yes	No
OPID	User's CICS operator ID, defined in the CICS segment of the RACF user profile	No	No
SIGN	An ID you specified in the SIGNID attribute of the DB2CONN definition for the CICS region. Defaults to the applid of the CICS region	No	No
TERM	Terminal ID of the terminal associated with the transaction	No	No
TX	Transaction ID	No	No
GROUP	User's CICS RACF user ID used in CICS sign-on	Yes	Yes

If you are not planning to provide secondary authorization IDs for your CICS transactions, you do not need to replace the default DB2 sign-on exit routine DSN3@SGN. The default sign-on exit routine handles primary authorization IDs. However, the DB2 subsystem to which you are connecting might use a different sign-on exit routine for some other reason. If the DB2 subsystem uses the sample sign-on exit routine DSN3SSGN, you might need to make a change to DSN3SSGN, if **all** of the following conditions are true:

- You have chosen an AUTHID or AUTHTYPE option other than GROUP.
- RACF list of groups processing is active.
- You have transactions whose primary authorization ID is not defined to RACF.

If this is the case, the *DB2 Universal Database for OS/390 and z/OS Administration Guide* tells you the change you need to make to the sample sign-on exit routine.

Providing secondary authorization IDs for CICS transactions

When a CICS transaction's thread TCB signs on to DB2, it can provide one or more secondary authorization IDs to DB2, in addition to the primary authorization ID. You can provide DB2 with the name of a CICS user's RACF group, or list of groups, as secondary authorization IDs. This has the advantage that you can grant DB2 privileges and authority to RACF groups, rather than to each individual CICS user. CICS users can then be connected to, or removed from, RACF groups as required. “RACF group profiles” in the *CICS RACF Security Guide* explains how users can be placed into RACF groups.

You can only provide secondary authorization IDs to DB2 for CICS transactions if you specify the GROUP option for the AUTHTYPE attribute in the DB2ENTRY definition (for entry threads), or the AUTHTYPE or COMAUTHTYPE attributes in the DB2CONN definition (for pool threads or command threads). If you specify any other option for AUTHTYPE or COMAUTHTYPE, the secondary authorization ID is set to blanks. When you specify the GROUP option, you cannot choose the primary authorization ID for the thread type; it is automatically defined as the user ID of the CICS user associated with the transaction. You should base your security checking on the secondary authorization IDs instead.

To provide the names of a user's RACF groups to DB2 as secondary authorization IDs, complete the following steps:

1. Specify SEC=YES as a system initialization parameter for the CICS region, to ensure that CICS uses RACF. If your CICS transaction profile names are defined with a prefix, also specify the system initialization parameter SECPRFX=YES or SECPRFX=*prefix*.
2. If the CICS region is using MRO:
   a. Ensure that each connected CICS region is also using RACF security (SEC=YES).
   b. Specify ATTACHSEC=IDENTIFY on the CONNECTION definition for the TOR, to ensure that sign-on information is propagated from the TOR to the AORs.
3. Replace the default DB2 sign-on exit routine DSN3@SGN. This sign-on exit routine is driven during sign-on processing. The default sign-on exit routine does not support secondary authorization IDs, so you need to replace it with the sample sign-on exit routine DSN3SSGN, which is provided with DB2, or with your own routine. DSN3SSGN is shipped in source form in the DB2 SDSNSAMP library, and you can use it as a basis for your own routine. (The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has more information about sign-on exits and about writing exit routines.) If the RACF list of groups option is not active, DSN3SSGN passes the name of the current connected group as the secondary authorization ID. If the RACF list of groups is active, DSN3SSGN obtains the names of all the groups to which the user is connected, and passes them to DB2 as secondary authorization IDs.
4. Use the AUTHTYPE attribute in the DB2ENTRY definition (for entry threads), or the AUTHTYPE or COMAUTHTYPE attribute in the DB2CONN definition (for pool threads or command threads), to specify the GROUP option as the authorization type for each type of thread for which you want to provide secondary authorization IDs. If surrogate user checking is in force for the CICS region (that is, the system initialization parameter XUSER is set to YES), you need to obtain special authority to perform operations involving DB2 authorization IDs. “Using surrogate security and AUTHTYPE security to control access to authorization IDs” on page 71 tells you how to do this.

If you have successfully completed all the steps listed above, when a CICS transaction's thread TCB signs on to DB2 with the types of thread that you have defined with the GROUP option, the CICS user's user ID will be passed to DB2 as the primary authorization ID, and the user's RACF group or list of groups will be passed to DB2 as secondary authorization IDs. If you have not successfully completed all the steps, the CICS DB2 attachment facility will issue an authorization failed message.

As an alternative to providing the names of RACF groups as secondary authorization IDs to DB2, you can write your own sign-on exit routine that sets secondary IDs for CICS transactions. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has information about writing sign-on exit routines.

Authorizing users to access resources within DB2

“Controlling access to DB2 resources in CICS” on page 66 tells you how to control CICS users' access to resources that are held in the CICS address space. Once the user has accessed the DB2 address space from a CICS transaction, either to issue a DB2 command (using DSNC or a similar transaction) or to obtain data, they might need permission to perform the following actions:

- Issue DB2 commands.

- Execute a plan, which might include dynamic SQL.

Access to the DB2 resources that a CICS user needs to perform these actions is subject to security checking by DB2's security mechanisms. In DB2 Version 5 or later, you can choose to have this security checking carried out by:

- DB2's own internal security.
- RACF, or an equivalent external security manager.
- Partly DB2, and partly RACF.

The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has more information about setting up RACF to perform security checking in the DB2 address space.

If you are using RACF for some or all of the security checking in your DB2 address space, remember that CICS transactions that sign on to DB2 **must** provide an authorization ID by using the USERID or GROUP option on the AUTHTYPE or COMAUTHTYPE attribute in the resource definition for the thread that they use. (“Providing authorization IDs to DB2 for CICS transactions” on page 77 describes how to do this.) CICS must also be using RACF (SEC=YES must be specified in the SIT). This is because when RACF is used for security checking in the DB2 address space, CICS needs to pass a RACF access control environment element (ACEE) to DB2. CICS can only produce an ACEE if it has RACF active, and only threads defined with the USERID or GROUP option can pass the ACEE to DB2.

When the ACEE is passed to DB2, it is used by the DB2 exit DSNX@XAC, which determines whether RACF, or an equivalent non-IBM external security manager, or DB2 internal security is used for security checking. DSNX@XAC is driven when a transaction whose thread has signed on to DB2, issues API requests. You can modify DSNX@XAC — the *DB2 Universal Database for OS/390 and z/OS Administration Guide* has more information about this.

DB2, or the external security manager, performs security checking using the authorization IDs that the CICS transaction provided to DB2 when the thread that it was using signed on to DB2. The authorization IDs could be related to the individual CICS user (for example, the CICS user's user ID and the RACF groups to which the user is connected), or they could be related to the transaction (for example, the terminal ID or transaction ID), or they could be related to the whole CICS region. “Providing authorization IDs to DB2 for the CICS region and for CICS transactions” on page 74 tells you how to choose these authorization IDs and provide them to DB2.

DB2, or the external security manager, checks that you have given the authorization IDs permission to perform the relevant actions in DB2. You can give the authorization IDs this permission by using GRANT statements in DB2. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has full information on how to grant, and revoke, DB2 permissions for authorization IDs.

This topic tells you how to control access to resources in the DB2 address space, as follows:

- “Controlling access to DB2 commands” on page 83 tells you how to control users' ability to issue DB2 commands.
- “Controlling access to plans” on page 84 tells you how to control users' ability to execute plans, and dynamic SQL.

Controlling access to DB2 commands

For CICS users, the first security checking related to DB2 commands is performed in the CICS address space, when the user tries to access a CICS transaction that issues DB2 commands. This could be DSNC, or a user-defined transaction that invokes DFHD2CM1 and runs an individual DB2 command. “Controlling access to DB2 CICS transactions” on page 73 describes how to control users' access to these transactions in the CICS address space.

When a user issues a DB2 command through a CICS transaction, they are also subject to DB2's own security checking, which verifies that they are authorized to DB2 to issue the command. This security checking uses the authorization IDs (primary or secondary) that the transaction has passed from CICS. “Providing authorization IDs to DB2 for the CICS region and for CICS transactions” on page 74 tells you how to choose these authorization IDs and provide them to DB2. For transactions that use DFHD2CM1 to issue DB2 commands, the authorization IDs are set by the COMAUTHID or COMAUTHTYPE attribute of the CICS region's DB2CONN definition. For other applications that issue DB2 commands, the authorization IDs are set by the AUTHID or AUTHTYPE attribute for the CICS region's resource definition for the type of thread used by the transaction (pool thread or entry thread). These attributes control the authorization ID, or type of authorization ID, that is passed to DB2 by a transaction that is using that type of thread.

DB2 commands are therefore subject to two security checks, one in the CICS address space and one in the DB2 address space. Figure 25 illustrates the process.

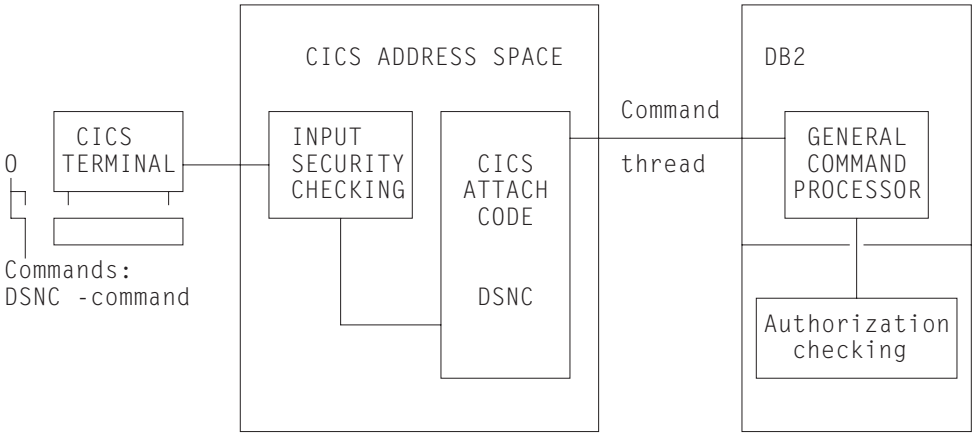


Figure 25. Security mechanisms for DB2 commands

In most cases, only a limited number of users are permitted to execute DB2 commands. A convenient solution can be to specify COMAUTHTYPE(USERID) on the DB2CONN definition, which resolves to the 8-byte CICS user ID as the authorization ID in DB2. Using this method, you can give different DB2 privileges explicitly to CICS user IDs. For example, you can use GRANT DISPLAY to give specific CICS user IDs permission to use only the -DIS command.

To authorize a user to issue a DB2 command, use a GRANT command to grant DB2 command privileges to the authorization ID that the transaction has passed from CICS. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has full information on how to grant, and revoke, DB2 permissions for authorization IDs.

Controlling access to plans

As for DB2 commands, the first security check for users' access to plans takes place in the CICS address space, when CICS verifies that the user is permitted to access the transaction that will execute the plan. The second security check takes place in the DB2 address space, when DB2 verifies that the authorization ID provided by the transaction, is authorized to execute the plan. Figure 26 illustrates this process.

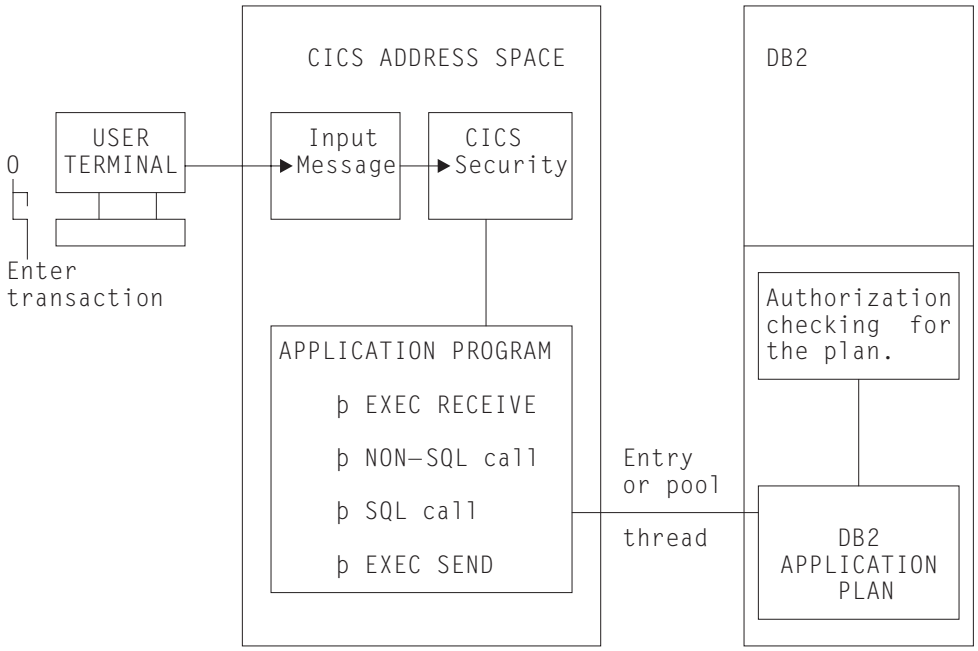


Figure 26. Security mechanisms for executing a plan

To authorize a user to execute a plan, use a GRANT command to grant DB2 command privileges to the authorization ID that the transaction has passed from CICS. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has full information on how to grant, and revoke, DB2 permissions for authorization IDs.

If a plan includes dynamic SQL

When using static SQL, the binder of the plan must have the privileges needed to access the data, and the authorization ID passed from CICS to DB2 need only have the privileges to execute the plan.

However, if a plan includes the use of dynamic SQL, the authorization ID passed from CICS to DB2 must possess the privileges required to access all the DB2 resources involved, both the plan and the data. For example, if you specify AUTHTYPE(USERID), the CICS user ID must be granted DB2 privileges to the DB2 resources involved in the dynamic SQL. If this user ID is also a TSO user ID, it has access to the DB2 resources directly from SPUFI, QMF™, and other utilities.

If you do not want to spend too much time granting DB2 privileges, where a transaction executes a plan that involves the use of dynamic SQL, consider using one of the following methods of supplying an authorization ID to DB2:

- Use the SIGN option on the AUTHTYPE attribute of the DB2ENTRY definition for the thread used by the transaction. This results in the transaction having the primary authorization ID that you specified in the SIGNID attribute of the

DB2CONN definition for the CICS region. (This method is not suitable where RACF is used for security checking in the DB2 address space.)

- Use the AUTHID attribute of the DB2ENTRY definition for the thread used by the transaction, to specify a standard authorization ID. Use the same authorization ID for all the transactions that need to access dynamic SQL. (This method is not suitable where RACF is used for security checking in the DB2 address space.)
- Create a RACF group, and connect your CICS users to this RACF group. Use the GROUP attribute of the DB2ENTRY definition for the thread used by the transaction, so that the RACF group is one of the secondary IDs that is passed to DB2.

In each case, you can then grant DB2 privileges for DB2 resources involved in all dynamic SQL to a single ID, either the standard authorization ID from the DB2CONN definition or the AUTHID attribute, or the name of the RACF group. "Providing authorization IDs to DB2 for the CICS region and for CICS transactions" on page 74 tells you how to provide authorization IDs by all these methods.

Multilevel security and row-level security

DB2 Version 8 introduced support for multilevel security. CICS does not provide specific support for multilevel security, but you can use CICS in a multilevel-secure environment provided that you take care with the configuration.

For more information about multilevel security, see:

- *DB2 Universal Database for OS/390 and z/OS Administration Guide*.
- *Planning for Multilevel Security and the Common Criteria*, GA22-7509.
- The IBM Redbook *Multilevel Security and DB2 Row-Level Security Revealed*, SG24-6480.

When multilevel security is implemented at row level (row-level security) for data in DB2 Version 8 or later, the RACF SECLABEL class is activated, and a set of security labels is defined for users and for the DB2 table rows. The RACF options SETR MLS and MLACTIVE are not required to be active. You can use DB2 row-level security without impact on the rest of the MVS system.

CICS is able to access DB2 rows secured in this way. For CICS, you need to ensure that the RACF user profile for a CICS user that needs access to the DB2 rows is defined in RACF to include a default SECLABEL. The *z/OS Security Server RACF Security Administrator's Guide*, SA22-7683, explains how to do this.

When a CICS user signs on to a CICS region with SEC=YES specified in the SIT, RACF associates the default SECLABEL with the RACF access control environment element (ACEE) for the user. The DB2ENTRY definition (or DB2CONN definition if the pool is being used) needs to specify AUTHTYPE=USERID or AUTHTYPE=GROUP, which ensures the ACEE is passed on to DB2 for further security checking. An individual CICS user can therefore only have one associated SECLABEL.

For non-terminal tasks or programs, such as PLT programs, if the PLTPIUSR system initialization parameter is not specified and the PLTPISEC=NONE system initialization parameter is specified, PLT programs are run under the CICS region userid. In this case, you need to define the CICS region userid with a default SECLABEL. If you need to define different SECLABELS for a transaction, you would need to run each transaction in a separate CICS region which has a different CICS region userid and associated SECLABEL.

Chapter 7. Application design and development considerations for CICS DB2

This chapter contains information primarily for the CICS application developer, the CICS application reviewer, and those involved in defining standards for application design.

Note that this chapter deals only with the design recommendations that are unique to the CICS DB2 environment. The general considerations that apply only to CICS applications, or only to DB2 applications, are not covered. See the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide* for more information on DB2 application design, and the *CICS Application Programming Guide* for more information on CICS application design.

In the design process, decisions can be taken that have consequences related not only to the application being developed now, but also to future applications. Some of the key aspects of the design process are as follows:

- Design the relationship between CICS applications and DB2 plans and packages (see "Designing the relationship between CICS applications and DB2 plans and packages" on page 88). To gain the greatest benefits for the performance and administration of your system, the relationship between DB2 plans, transactions, and application programs must be defined while you are designing applications.
- Develop a locking strategy (see "Developing a locking strategy in the CICS DB2 environment" on page 105). Locking is affected by options you choose when creating tables in DB2, by the design of your application programs, and by options you choose when binding plans, so you need to take it into account throughout the development process.
- Consider the security aspects of both the CICS DB2 test system and the CICS DB2 production system. The considerations for security in a CICS DB2 system are described in Chapter 6, "Security in a CICS DB2 environment," on page 65.
- When developing the application programs, note the considerations in "SQL, threadsafe and other programming considerations for CICS DB2 applications" on page 105. The use of certain commands and programming techniques can improve the performance of your application and avoid some potential problems. Whether you use qualified or unqualified SQL influences many other aspects of the CICS DB2 environment. And to gain the performance benefits of the open transaction environment (OTE), your application programs must be threadsafe.
- If you are using Java™ programs and enterprise beans in the CICS DB2 environment, note the support and programming considerations in Chapter 8, "Using JDBC and SQLJ to access DB2 data from Java programs and enterprise beans written for CICS," on page 117.
- Plan the further steps to be taken when application development is complete and the application is put into production. Chapter 9, "Preparing CICS DB2 programs for execution and production," on page 133 gives information on this process, including the use of different BIND options.
- Define your CICS DB2 connection to benefit the application's performance. For example, using protected entry threads for the application programs to access DB2 improves performance for heavily-used applications. Chapter 5, "Defining the CICS DB2 connection," on page 51 gives information on your CICS DB2 connection.

The design that you implement can influence:

- Performance
- Concurrency

- Operation
- Security
- Accounting
- The development environment

A well-designed CICS DB2 application should work properly when set into production for the first time. However, certain factors can affect the application's performance later on. These factors include:
- Increased transaction rate
- Continued development of existing applications
- More people involved in developing CICS DB2 applications
- Existing tables used in new applications
- Integration of applications

It is therefore important to develop a consistent set of standards on using DB2 in the CICS environment.

If you have previously developed applications with data stored in VSAM and DL/I, be aware that there are several differences between those applications and CICS DB2 applications. Some of the main differences to consider are:
- Locking mechanism
- Security
- Recovery and restart
- BIND process
- Operational procedures
- Performance
- Programming techniques

One of the major differences between batch and online program design is that online systems should be designed for a high degree of concurrency. At the same time, no compromise should be made to data integrity. In addition, most online systems have design criteria about performance.

Designing the relationship between CICS applications and DB2 plans and packages

When CICS applications use DB2 data, the application architecture must take account of design aspects related to the CICS DB2 attachment facility. One of the most important aspects to consider is the relationship between transaction IDs, DB2 plans and packages, and program modules. If any of the program modules uses SQL calls, a corresponding DB2 plan or package must be available. The plan to be used for a transaction ID is specified in the DB2CONN or DB2ENTRY definition for the thread that the transaction uses to access DB2. The plan can be named explicitly, or a plan exit routine can be named that selects the plan name. The plan must include the DBRMs from all modules that could possibly run under this transaction ID. The DBRMs can be bound directly into the plan, or they can be bound as packages and named in a package list in the plan. See “Overview: Enabling CICS application programs to access DB2” on page 10 for a more detailed overview of this topic.

To control the characteristics of the plan and the CICS DB2 attachment facility threads, the relationship between transaction IDs, DB2 plans, and the program modules must be defined in the design step. Some characteristics of the threads, environmental description manager (EDM) pool, and plans that depend on the design are the:
- Plan sizes

- Number of different plans concurrently in use
- Number of threads concurrently in use
- Possibility of reusing a thread
- Size of the EDM pool
- I/O activity in the EDM pool
- Overall page rate in the system
- Authorization granularity
- Use of DB2 packages

There are various design techniques for combining CICS transactions with DB2 plans, as follows:

- The best technique is to use plans based on packages (see “Using packages” on page 90).
- If you choose not to use packages, you can use one of the following design techniques for your plans:
  - “Using one large plan for all transactions” on page 93
  - “Using many small plans” on page 94
  - “Using plans based on transaction grouping” on page 95

  If you then find that some threads need to be associated with more than one of your plans (as the pool threads will, unless you have one large plan), you can use “Dynamic plan exits” on page 96 to achieve this.
- If you need to create the plans for an application after the design and development process has finished, see “If you need to create plans for an application that has already been developed” on page 99.
- If a transaction needs to use a program that is not in its plan (perhaps because the application has changed), see “If you need to switch plans within a transaction” on page 99.

“A sample application” gives an example of a CICS application accessing DB2, and this example is used in discussion of the various design techniques.

A sample application

A simple example can be used to explain the consequences of different application design techniques. Figure 27 on page 90 shows how CICS MAPs and transaction IDs are correlated, and how the transactions should work, without DB2 considerations.

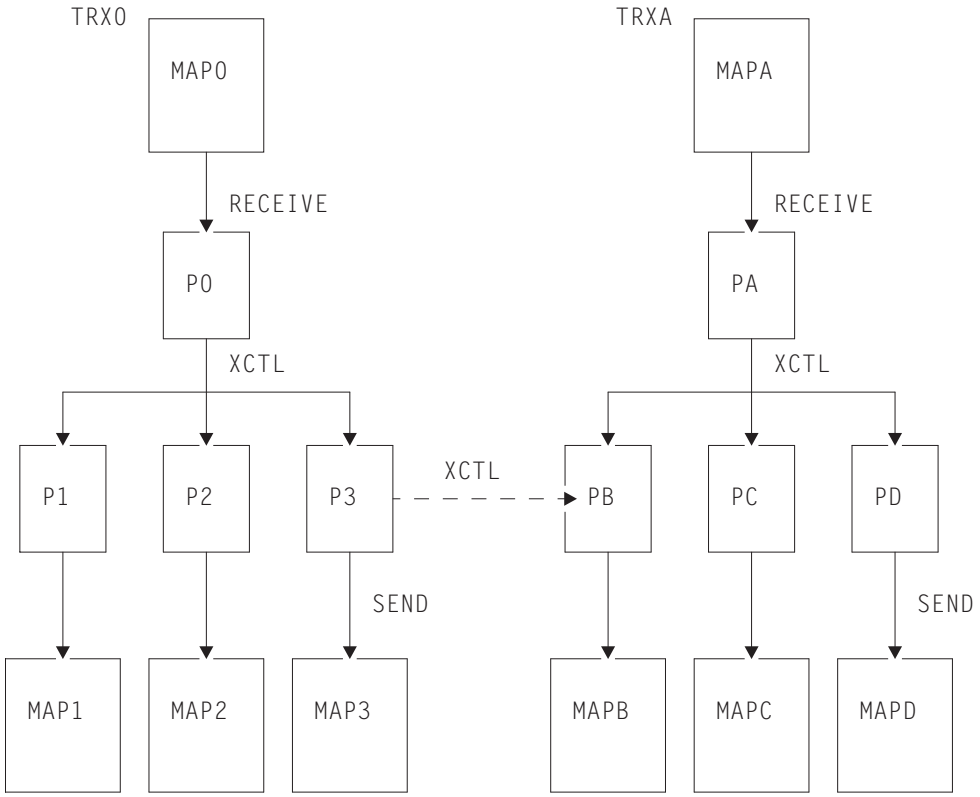


Figure 27. Example of a typical application design

In this example:

- The transaction ID, TRX0, is specified in the EXEC CICS RETURN TRANSID(TRX0) command, when a program (not shown) returns control after displaying MAP0.
- The next transaction then uses the transaction ID, TRX0, independent of what the terminal user decided to do.
- Program P0 is the initial program for transaction TRX0.
- We assume that all programs shown are issuing SQL calls.
- Depending on the option chosen by the terminal user, program P0 performs a CICS transfer control (XCTL) to one of the programs: P1, P2, or P3.
- After issuing some SQL calls, these programs display one of the maps: MAP1, MAP2, or MAP3.
- The example shown on the right side of the figure works in the same way.
- In some situations, program P3 transfers control to program PB.

Using packages

Using packages is the best way to ensure that the relationship between CICS transactions and DB2 plans is easy to manage. See “Plans, packages and dynamic plan exits” on page 13 for an overview of plans and packages.

In early releases of DB2, before packages were available, the DBRMs from all the programs that could run under a particular CICS transaction had to be directly bound into a single plan. Changing one DBRM in a plan (because the SQL calls for that program had changed) required all the DBRMs in the plan to be bound again. Binding a large plan can be very slow, and the entire transaction is unavailable for

processing during the operation. Just quiescing an application can be very difficult for a highly used one, but to leave the plan out of commission for an extended time while it is being rebound is usually unacceptable.

Dynamic plan exits (see “Dynamic plan exits” on page 96) were an interim solution designed to address this problem. The dynamic plan exit is an exit program that you specify in the DB2CONN or DB2ENTRY definition instead of specifying a plan name. You create many small plans for your CICS applications, each containing the DBRMs from a few programs, and the exit program selects the correct plan when each unit of work begins. You can also use the dynamic plan exit to switch between plans within a transaction (see “Dynamic plan switching” on page 100). However, each small plan must still be rebound and taken out of commission every time an SQL statement changes in one of the programs that uses it. Also, the use of dynamic plan switching requires an implicit or explicit CICS SYNCPOINT to allow switching between plans.

Now that packages are available in DB2, using them is the best way to manage your plans. With packages, you can break the program units into much smaller parts, which you can rebind individually without affecting the entire plan, or even affecting the current users of the particular package you are rebinding.

Since updating a plan is easier with packages, you can build much larger applications without the need to switch transactions, programs, or plans to accommodate DB2 performance or availability. This also means that you do not have to maintain as many RDO definitions. You can also avoid situations where you might otherwise use dynamic SQL to obtain program flexibility. In a plan, you can even specify packages that do not exist yet, or specify package collections to which you can add packages. This means that DBRMs from new programs could be added without disturbing the existing plan at all.

The qualifier option on packages and plans to reference different table sets can give you more flexibility to avoid plan switching.

In summary, packages:

- Minimize plan outage time, processor time, and catalog table locks

during bind for programs that are logically linked together with START, LINK, or RETURN TRANSID and have DBRMs bound together to reduce DB2ENTRY definitions.

- Reduce CICS STARTS or exits.
- Avoid cloning CICS and DB2ENTRY definitions.
- Provide the ability to bind a plan with null packages for later inclusion in the plan.
- Allow you to specify collection at execution time using SET CURRENT PACKAGESET=*variable*, which is a powerful feature when used with QUALIFIER
- Provide the QUALIFIER parameter, which adds flexibility to:
  - Allow you to reference different table sets using unqualified SQL
  - Reduce the need for synonyms and aliases
  - Lessen the need for dynamic SQL

There are other benefits that using packages can provide in a CICS environment:

- It allows you to use fewer plans.
- It allows you to bind low-use transactions into a single plan.
- It increases thread reuse potential.

You can also optimize your application by using package lists that order their entries to reduce search time or by keeping package list entries to a minimum.

DB2 also provides accounting at the package level. For more information about packages, refer to the discussions of planning to bind and preparing an application program to run in the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide* and *DB2 Packages: Implementation and Use*.

Converting to packages

A transaction that currently uses a dynamic plan exit or dynamic plan switching techniques can be converted to use packages as follows:

- Bind all of the DBRMs contained in the plan associated with the transaction into packages in a single collection.
- Bind a new plan with a PKLIST containing a single wildcard entry for this collection.
- Modify the DB2ENTRY entry for this transaction to use the new plan. Protected threads can now be used for this transaction to optimize thread reuse.

You could choose to have a single plan for the whole application, or one plan per transaction. The following sections give more detailed instructions for converting your transactions, based on this choice.

A similar approach can be taken for converting all CICS applications, whether they use a dynamic plan exit or not.

Note that high-usage packages can be bound with RELEASE(DEALLOCATE), with low-usage packages bound with RELEASE(COMMIT). This results in the high-usage packages being retained in the plan's package directory until plan deallocation, while the low-usage packages are removed from the directory, and the space in the EDM pool is released. The disadvantage of this approach is that if you use RELEASE(DEALLOCATE) and then need to rebind a highly-used package, you must intervene to force deallocation of the package if it is allocated to a long-running thread. Consider that to rebind a package is less expensive than to rebind a plan, in terms of the time spent doing it.

Using one plan for the application: This approach gives greatest flexibility in defining the DB2ENTRYs and DB2TRANs for the application, because the transactions involved can be grouped to better utilize protected threads and optimize thread reuse. The steps in converting to this environment are:

1. Bind all DBRMs for the transactions in the application into packages using a single collection such as COLLAPP1.
2. Bind a new plan, PLANAPP1, with a package list consisting of a single entry, COLLAPP1.*.

   ```
   BIND PLAN (PLANAPP1) ..... PKLIST (COLLAPP1.*) ..
   ```

3. In the DB2ENTRY, replace the dynamic plan exit program name with the name of this new plan. For example, replace:

   ```
   PLANEXITNAME=DSNCUEXT
   ```

   with

   ```
   PLAN=PLANAPP1
   ```

Using one plan per transaction: This approach was preferable prior to DB2 Version 3 because accounting at the individual package level was not possible, which forced accounting to be done by plan name. However, current releases of DB2 provide accounting at the package level, which allows for plans to be made up of a large number of packages whilst still providing the required accounting granularity.

The steps in using this approach are:

1. Bind the DBRMs for groups of transactions or all transactions into packages. The collections to be used could be based on the transactions being converted, such as TRAN1, or on the application, as above. The latter approach is preferable because creating and maintaining collections on a transaction basis requires greater administrative effort, particularly if there are many common routines.
2. Bind a new plan for each transaction with a package list referring to a single wildcard package list entry that would depend on the approach taken. Use `TRAN1.*` if the collections were based on transactions or `COLLAPP1.*` if a single collection was set up for all transactions:

   ```
   BIND PLAN (TRAN1) .... PKLIST (TRAN1.*) ...
   ```

   or

   ```
   BIND PLAN (TRAN1) .... PKLIST (COLLAPP1.*) ...
   ```
3. Modify the DB2ENTRY definitions to replace the dynamic plan exit with the plan names associated with the transactions.

If you have packages and still want to use dynamic plan switching techniques

For dynamic plan switching users, if the value of a modifiable special register (for example, the CURRENT PACKAGESET register) is changed during processing and not reset to the initial state before the SYNCPOINT is taken, the following occur:

- The thread is not released by the CICS DB2 attachment facility.
- Thread reuse does not occur because the task continues to use this thread with the same plan allocated.
- Dynamic plan switching does not occur because the same thread and plan are used; that is, the dynamic plan switching exit is not taken on the first SQL statement issued following the SYNCPOINT.

Therefore you should take care to ensure that any modifiable special register is reset to its initial value before the SYNCPOINT is taken if you want to use dynamic plan switching. The *DB2 Universal Database for OS/390 and z/OS Administration Guide* lists the modifiable special registers.

Using one large plan for all transactions

Using one large plan for all CICS transactions that issue SQL calls is an easy strategy. For the example in Figure 27 on page 90:

- There is one plan, PLAN0, using the DBRMs from P0, P1, P2, P3, PA, PB, PC, and PD
- In CICS, define one DB2ENTRY specifying PLAN0 plus a DB2TRAN per transaction ID required (unless a wildcard transaction ID can be specified). One DB2ENTRY gives the best overall thread utilization if protected threads are used.

Advantages

- There are no restrictions regarding which program modules can be executed under any transaction ID. For example, it is possible that program P3 can transfer control to program PB. This does not require any changes for the plan or the definition in CICS.
- Each DBRM exists in only one plan (PLAN0).
- Thread reuse is easy to obtain. All transactions could use the same DB2ENTRY.

Disadvantages

- The complete plan must be rebound for any DB2 program modification.
- BIND can be time-consuming for large plans.
- The BIND process cannot take place while the plan is in use. The plan is likely to be in use in a production system most of the time due to normal activity. In a test environment, the transaction rate is normally low, but programmers can use debugging tools that make the response times longer with conversational programs. This can effectively keep the thread and plan busy.
- DB2-invoked REBIND (due to plan invalidation) allows no DB2 transactions to execute this plan.
- There is no real information value in messages and statistics pointing out the plan name, because there is only one plan.
- EDMPOOL must be large enough to cope with DBDs, SKCTs, and CTs and must allow some fragmentation. Remember that the plan segmentation feature allows DB2 to load into CTs only parts of the application plans being executed. Nevertheless, the header and directory parts of an application plan are loaded in their entirety into the SKCT (if not already loaded), then copied from the SKCT to CTs. This happens at thread creation time.

  Because the application plan directory size is directly dependent on the number of segments in the plan, using a large plan influences the EDMPOOL size and the number of I/O operations needed to control it.

Using many small plans

This technique requires many transaction IDs, each of which has a corresponding plan. The technique can minimize both plan sizes and plan overlap.

We recommend that you use packages rather than using many small plans.

Using many small plans implies either that the program flow follows a narrow path with limited possibilities for branching out, or that plan switching takes place frequently.

In the example in Figure 27 on page 90, the switching could take place between program P0 and the programs at the next lower level, or between program PA and the programs at the next lower level.

- PLAN1 for (TRX0) using the DBRMs from programs P0, P1, P2, and P3.
- PLANA for (TRXA) using the DBRMs from programs PA, PB, PC, and PD.

However, program P3 can transfer control (using the XCTL command) to program PB. A plan switching technique must then be used. These techniques are described in “If you need to switch plans within a transaction” on page 99.

A special variation of using small plans exists. In some applications, it can be convenient to have the terminal user specify the transaction ID for the next transaction. It is typically in read-only applications, where the user can choose

between many different information panels by entering a systematically built 1- to 4-character transaction ID. The advantage for the user is the ability to jump from any panel to any other panel without passing a hierarchy of submenus.

If a DB2 plan is associated with each transaction ID, the application ends up with many small plans.

Advantages

- Plan maintenance is relatively simple, because little overlap exists between plans.
- High information value in messages, statistics, and so on, pointing out the plan name.

Note: Packages offer these advantages, too.

Disadvantages

- Plan switching occurs often, unless the application flow follows a narrow path.
- It is difficult to use protected threads, because the transactions are spread over many sets of transaction IDs, plans, and threads.
- Resource consumption can be high, due to plan switching and low thread reuse.

Note: Packages avoid these disadvantages.

Using plans based on transaction grouping

Transaction grouping can produce a number of midsize independent plans, where a plan switch can occur if necessary.

It is often possible to define such groups of programs, where the programs inside a group are closely related. That means that they are often executed in the same transaction, or in different transactions being executed consecutively. One separate plan should then be used for each group.

In the example in Figure 27 on page 90 two plans could be built:

- PLAN1 for (TRX0) using the DBRMs from programs P0, P1, P2, and P3.
- PLANA for (TRXA) using the DBRMs from programs PA, PB, PC, and PD.

However, program P3 can transfer control to program PB. A plan switching technique could then be used. These techniques are described in section “If you need to switch plans within a transaction” on page 99. It is recommended that plan switching is an exception and not the normal case, mainly due to additional processor overhead.

In this case, the result of the transaction grouping technique matches the result for the technique of using many small plans. This is because of the simplicity of the example used. Normally the transaction grouping technique should produce a larger plan.

Advantages

- The plan size and the number of different plans can be controlled by the user.
- Thread reuse is likely, depending on the transaction rate within the group.

Disadvantages

- Plan overlap can occur.
- The optimum grouping can change over time.
- Plan switching may be necessary.

- Plan switching is handled in the application code.

Dynamic plan exits

You can design CICS applications around numerous small plans and select the plan dynamically at execution time. A small plan is not the same as a package, which has a strictly one-to-one correspondence to a database request module (DBRM). The use of packages is recommended rather than the use of dynamic plan exits, as packages have additional advantages over dynamic plan exits — see “Using packages” on page 90 for more information. The use of dynamic plan exits was an interim solution that was designed to address problems in the CICS DB2 environment before packages were available in DB2.

Normally, a dynamic plan exit is driven to determine which plan to use at the start of the first unit of work (UOW) of the transaction. This is referred to as *dynamic plan selection*.

A dynamic plan exit can also be driven at the start of a subsequent UOW (assuming the thread was released at syncpoint) to determine what plan to use for the next UOW. The plan exit can decide to use a different plan. This is referred to as *dynamic plan switching*. See “Dynamic plan switching” on page 100 for more information.

When a dynamic plan exit is used, DB2 plan allocation occurs only upon execution of the first SQL statement in a program, or after the program issues a syncpoint and links or transfers control to another program with a separate DBRM.

This is accomplished by using an exit program specified in:

- DB2ENTRY, exit for a specific transaction code specified in the keyword PLANEXITNAME
- DB2CONN, exit for transactions using the pool specified in the keyword PLANEXITNAME.

IBM supplies two sample assembler language exit programs, DSNCUEXT and DFHD2PXT, in both source and object code form. You can also write other exit programs.

Note that the use of the following items within the dynamic exit program is not supported:

- SQL commands.
- IFI calls.
- EXEC CICS SYNCPOINT commands.

The sample exit programs, DSNCUEXT and DFHD2PXT

IBM supplies two sample assembler language exit programs, DSNCUEXT and DFHD2PXT, in both source and object code form. DSNCUEXT and DFHD2PXT are functionally identical, but the CICS-supplied program definition for DSNCUEXT specifies CONCURRENCY(QUASIRENT), while the CICS-supplied program definition for DFHD2PXT specifies CONCURRENCY(THREADSAFE).

The two programs are supplied because as explained in “Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming” on page 106, when CICS is connected to DB2 Version 6 or later and exploits the open transaction environment (OTE), the CICS DB2 task-related user exit operates as a threadsafe program and is able to receive control on an open

TCB (L8 mode). If the application program that made the DB2 request is threadsafe, it can also run on the open TCB. In this situation, no TCB switching should be needed. However, if a dynamic plan exit is used that is defined with CONCURRENCY(QUASIRENT), like DSNCUEXT, this causes a switch back to the QR TCB, incurring an additional cost. Dynamic plan exits that are defined with CONCURRENCY(THREADSAFE) and are coded to threadsafe standards, like DFHD2PXT, can run on the open TCB, and do not incur the additional cost.

When CICS is connected to DB2 Version 6 or later, you should therefore use DFHD2PXT as your dynamic plan exit in preference to DSNCUEXT. However, note that if you add logic that is not threadsafe to the supplied sample program, or issue non-threadsafe CICS commands in the exit, this will cause a switch back to the QR TCB, and the additional cost is incurred. To gain the performance benefits resulting from the avoidance of TCB switching, you must use a dynamic plan exit that is defined as threadsafe, code logic that is threadsafe, and ensure that the program contains only threadsafe commands.

The object code (load module) for the sample plan exits, DSNCUEXT and DFHD2PXT, are included in the SDFHLOAD library. DSNCUEXT is the default dynamic plan exit, and it is invoked as a CICS user-replaceable program. The source code for both sample programs is written in assembler language and supplied in the SDFHSAMP library. The sample programs show how to address the parameter list but do not change the plan name.

A parameter list is passed to DSNCUEXT (or DFHD2PXT) through a COMMAREA, and has the following format in the Assembler version:

Table 4. Example of a parameter list passed to DSNCUEXT (or DFHD2PXT) through a COMMAREA

CPRMPLAN	DS	CL8	The DBRM/plan name of the first SQL statement on entry to DSNCUEXT (or DFHD2PXT). The field can be modified to establish a new plan.
CPRMAUTH	DS	CL8	The current authorization ID that is passed to DB2 at signon time. This is for information only. Any changes made to it are ignored.
CPRMUSER	DS	CL4	A user area that is reserved for use by DSNCUEXT (or DFHD2PXT). The CICS DB2 attachment preserves this field across invocations of DSNCUEXT (or DFHD2PXT).
CPRMAPPL	DS	CL8	The name of the application program that issued the SQL call.

The Assembler version of the parameter list is shipped as member DSNCPRMA in SDFHMAC library. The COBOL version is DSNCPRMC in SDFHCOB library. The PL/I version is DSNCPRMP in SDFHPLI library.

Before calling the dynamic plan exit, the CICS DB2 attachment facility sets CPRMPLAN to the name of the DBRM set in the parameter list of the first EXEC SQL statement executed in the unit of work. As supplied by CICS, the dynamic plan exits DSNCUEXT and DFHD2PXT do not modify the plan name as input in CPRMPLAN by the CICS DB2 attachment facility, but return immediately, leaving the plan name as that chosen by the CICS DB2 attachment facility.

As a consequence of adding support for JDBC and SQLJ support for Java applications for CICS, the CICS-supplied dynamic plan exits have been changed.

SQLJ and JDBC require that DB2 produce four DBRMs for each application program in order to support dynamic change of isolation levels. For JDBC and SQLJ applications, the DBRM name is restricted to seven characters, the eighth character being used as a suffix of 1,2,3 or 4. Hence for JDBC and SQLJ applications it is not possible to use a default naming convention of program name = dbrm name = plan name, as the DBRM name being used will contain a suffix of 1,2,3 or 4.

For JDBC applications, SQLJ applications, and mixed JDBC and SQLJ applications, the DB2 JDBC driver uses information from the JDBC profile to set the name of the DBRM in the parameter list of the first EXEC SQL statement executed. The first SQL issued will always have the DBRM name set to the JDBC base program with the default isolation level appended. That is, DSNJDBC2 by default, or if, for example, the JDBC profile was generated using *pgmname=OTHER*, the DBRM name will be OTHER2. For example, if dynamic plan exits are not used, the plan name is always obtained from the DB2CONN or DB2ENTRY definition, the plan name in the properties file is ignored.

In order to support a default naming convention for JDBC 1.2 and 2.0 and SQLJ, the CICS-supplied dynamic plan exits DSNCUEXT and DFHD2PXT have been changed to detect an input CPRMPLAN name whose first seven characters are “DSNJDBC” or “DSNSQLJ”. If such a plan name is detected, the plan name is changed to “DSNJDBC ” (with the eighth character set to blanks). Users wishing to use the default dynamic plan exits with Java applications for CICS should bind the multiple DBRMs into a plan called DSNJDBC.

For the support of the DB2 Universal JDBC Driver, the CICS-supplied dynamic plan exits DSNCUEXT and DFHD2PXT have been changed to detect an input CPRMPLAN name whose first characters are “SYSSTAT”, “SYSLH” or “SYSLN”. If such a plan name is detected, the plan name is changed to “DSNJCC ” (with the seventh and eighth characters set to blanks). Users wishing to use the default dynamic plan exits with Java applications for CICS should bind the multiple DBRMs into a plan called DSNJCC.

Writing your own exit program

The exit program can be written in assembler language, COBOL, or PL/I. The program is a CICS program, which means it must:

- Adhere to normal CICS conventions.
- Be defined to CICS (unless program autoinstall is being used.
- Use CICS command level statements.
- Return to CICS using an EXEC CICS RETURN command.

The CICS DB2 attachment facility program passes a parameter list to the exit program using a COMMAREA. The exit program can change the default plan name (DBRM name) supplied in the parameter list, when the first SQL statement is processed by the CICS DB2 attachment facility. The name specifies the plan name for this execution of the transaction.

If CICS is connected to DB2 Version 6 or later, then as explained in “Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming” on page 106, you should ensure that the logic in your dynamic plan exit is coded to threadsafe standards, and that the program is defined as threadsafe (like the sample exit program DFHD2PXT). If the program is not defined as threadsafe, each use of the program causes a switch back to the QR TCB, incurring an additional cost. If the program is defined as threadsafe but uses

non-threadsafe CICS commands (which is permitted), each non-threadsafe command causes a switch back to the QR TCB and incurs the additional cost.

If you need to create plans for an application that has already been developed

You can use this technique if the applications were developed with little attention to the DB2 plan aspects. After the application is completely developed, the plans are defined to match the transaction.

In general, defining plans after the application has already been developed is not recommended, but this technique is useful for *conversion projects*, where the application design is unchanged but the application now uses DB2.

When defining the DB2 plans and the DB2ENTRY specifications, you can perform the following steps:

1. For each program module with SQL calls, analyze under which CICS transaction codes they might run. It is likely that a given program module is used under more than one CICS transaction code.

   The output from this step is a list of DBRMs for each transaction.
2. For each CICS transaction code, decide on a plan that it should use. (Only one plan may be specified in the DB2ENTRY for a given CICS transaction code. More than one transaction may use the same plan).

   For this step you have many alternatives. The possible number of plans to use is between one and the number of different transaction IDs. The best way to manage the plans is to use packages, binding all the DBRMs into packages that are then listed in plans (see “Using packages” on page 90). If you do not use packages, alternative techniques are described in “Using one large plan for all transactions” on page 93, “Using many small plans” on page 94 and “Using plans based on transaction grouping” on page 95.

Applied to the example in Figure 27 on page 90, a possible solution would be:

- One plan, PLAN0, using the DBRMs from P0, P1, P2, P3, and PB, used by the transaction ID TRX0
- One plan, PLANA, using the DBRMs from PA, PB, PC, and PD, used by the transaction ID TRXA
- Two DB2ENTRY definitions, one for each plan

The advantages and disadvantages of this technique completely depend on the actual application design and the result of the above-mentioned steps.

If you need to switch plans within a transaction

Ideally, the plan that a transaction uses to access DB2 should contain or reference the DBRMs from all the application programs that could operate under that transaction ID. However, you might find that if the design of your applications has changed, some of your older plans now do not contain all the relevant DBRMs. In this case, the application design could require a switch to a different plan in the course of a transaction, if the transaction requires that a program not included in the current plan must be executed. This situation could also occur if the structure of the DB2 plans was imperfectly considered during the design of the application.

The best solution to this problem is to use packages. You can bind the DBRM from the missing program into a package, and add the package to a package list in the

existing plan. The transaction can now access the missing program without needing to switch plans. There are two other possible solutions, which are discussed below, as follows:

- “Dynamic plan switching”
- “Switching transaction IDs in order to switch plans”

Dynamic plan switching

Dynamic plan switching (DPS) allows you to use more than one plan in a transaction. However, as noted above, switching plans within a CICS transaction instance should be a rare occurrence. The dynamic plan exit was designed to select a plan dynamically at the start of the transaction (dynamic plan selection), not to change plans frequently within transactions.

To do dynamic plan switching, the thread must be released at syncpoint and reacquired, to drive the dynamic plan exit. The dynamic plan exit can then be used to select the plan for the program you need to execute. This enables the use of a different plan for different UOWs within a transaction.

In releases of CICS before CICS Transaction Server for OS/390, Version 1 Release 2, dynamic plan switching could only occur for the pool threads, or for RCT entries that specified THRDA=0, that is, overflowed to the pool. An RCT entry with THRDA > 0 was not capable of dynamic plan switching. In CICS Transaction Server for OS/390, Version 1 Release 2 and later versions and releases, dynamic plan switching can occur for entry threads as well as for the pool, irrespective of the THREADLIMIT parameter.

If you have coded your own dynamic plan exit, check that the logic copes with subsequent invocations for the same task. Either the user application or the dynamic plan exit must be written to tolerate consequences of additional calls to the exit. If the dynamic plan exit would change the plan when not wanted, the user application can avoid this by ensuring the thread is not released at syncpoint. Preferably, if the thread is released, the dynamic plan exit must provide the proper plan for the new cases when it is called, that is, a DB2ENTRY with THREADLIMIT > 0.

To invoke the dynamic plan exit to do plan switching after the end of a UOW, your transaction must release the thread at syncpoint. A transaction releases a thread at syncpoint only if:

- It is a terminal driven task, or a nonterminal driven task and NONTERMREL=YES is set in the DB2CONN
- No held cursors are open
- Any DB2 special registers modified have been set back the their initial state.
- DB2 special register CURRENT DEGREE has ever been modified by this transaction.

Switching transaction IDs in order to switch plans

Once a transaction has started, the application programmer cannot control the plan used by the transaction ID, but they can control the transaction ID itself. So, from a programmer viewpoint, a possible way to switch plans would be to switch transaction IDs. However, it is strongly recommended that you bind the DBRM from the missing program into a package, and add the package to a package list in the existing plan, rather than changing the transaction ID just to switch to a new plan.

If you have to switch transaction IDs, note that in most cases, the first program transfers data to the next program. The preferred method of doing this is to use an EXEC CICS RETURN IMMEDIATE command. Alternatively, you can start a new CICS task against the same terminal, using an EXEC CICS START command, or using a transient data queue with a trigger level of one. The old program should issue RETURN to CICS to make the new task start. For both of these switching techniques, the work done in one user transaction is split up into more than one UOW. If the new task is backed out, the work done in the first task remains committed.

If you switch transaction IDs in order to switch plans, the application programs contain the logic to decide when to switch transaction ID. This means that if you want to change the plan structure (for example for performance and operational reasons), you need to change the application programs as well.

A different technique is to have the program flow controlled by a table, instead of having code to do this in several programs. The main idea is that it is simpler to maintain the relationship between the plans, programs, and transaction IDs in a table than to maintain code in each application program to do the logic. Developing the application programs is also simpler if a standard interface is provided.

Using a control table to control program flow

The design principle presented below is an example of a standard method that can be used to implement different types of application design. It allows the use of, for example, one large plan or many small plans *without* changing the programs.

Note: It is recommended that you use packages rather than this technique to control program flow.

Table 5 shows an example of the contents of a control table. The example is based on the design situations described in Figure 27 on page 90.

Table 5. Control table for sample application

Function name	Program	Transaction	Plan name	New TRANS ID
	P0	TRX0	PLAN0	*
Sales	P1	TRX0	PLAN0	
Order	P2	TRX0	PLAN0	
Pay	P3	TRX0	PLAN0	
	PA	TRXA	PLANA	*
Price	PB	TRXA	PLANA	
Order	PC	TRXA	PLANA	
Parts	PD	TRXA	PLANA	
Price	PB	TEMP	PLANX	*

Function name

The function name field of the table supplements the program field. It works in exactly the same way. It is used in the cases where the terminal user enters a function name in a command field, eventually supplied with a key. The PFCP program can accept either a function name or a program name.

PFCP then uses the function column to search for a valid transaction.

In this way, the logic to interpret the user's choices is also removed from the programs and placed in the table, where it is easy to maintain.

Program
The name of the program described in this row.

Transaction
The transaction ID name under which the program in the program column can be executed.

Plan name
The plan name field is not used. It is shown for illustration purposes only. It shows the plan name used by the corresponding transaction.

New TRANS ID
An * in this column of the table means that the corresponding row can be used when searching for a new transaction ID to start a given program.

The control table reflects the following main relationships:

- Relationships between plans and programs/DBRMs, which are described in the DB2 catalog table SYSIBM.SYSDBRM
- Relationships between transaction codes and plans, which are described using the DB2ENTRY and DB2TRAN CICS definitions

When implementing the definitions in CICS, you should consider the following:

- Previously, many different macro RCTs could be used by a CICS system over a period of time. Therefore, different RCT names could be used at different times. The same RCT name could be used by different CICS systems.
- With RDO-defined CICS DB2 definitions, the need for multiple RCTs is removed, because DB2ENTRYs and DB2TRANS can be installed or discarded as required using the same DB2CONN.

Multiple “logical RCTs” could be maintained in an RDO environment by placing a DB2CONN definition and its associated DB2ENTRYs and DB2TRANs in a list, and installing the required list. Two additional columns would be added to the control table:

1. DB2CONN name
2. CICS APPLID

At execution time, the PFCP can determine the applid and DB2CONN name using an EXEC CICS INQUIRE SYSTEM command. It then searches for rows belonging to the current applid and DB2CONN.

The disadvantage, however of multiple “logical RCTs” is that a DB2CONN cannot be discarded and replaced without shutting down the CICS DB2 attachment facility. A solution is to have one DB2CONN definition and to change “RCTs” by discarding and installing different sets of DB2ENTRYs and DB2TRANS to work with it. These can be discarded and installed without shutting down the attachment facility.

In this case, the control table could contain a DB2ENTRY name instead of the DB2CONN. At execution time, the PFCP can use the CICS DB2 SPI commands to inquire whether this DB2ENTRY was installed. In this way using the name of one DB2ENTRY to identify the set of definitions installed, identifies the “logical RCTs”.

The control table can be implemented in different ways. The most useful solutions are probably either a DB2 table or a main storage table.

A *DB2 table* is the simplest to develop and maintain. One or two SELECT calls are needed for each invocation of PFCP. These SELECTs should return only one row and indexes can be used. The data and index pages are referenced often and probably stay in the buffer pool. The response time impact is thus minimal.

A *main storage table* is faster to access, at least until a certain number of rows in the table is reached. It is more complicated to maintain.

The principle in the program flow is shown in Figure 28.

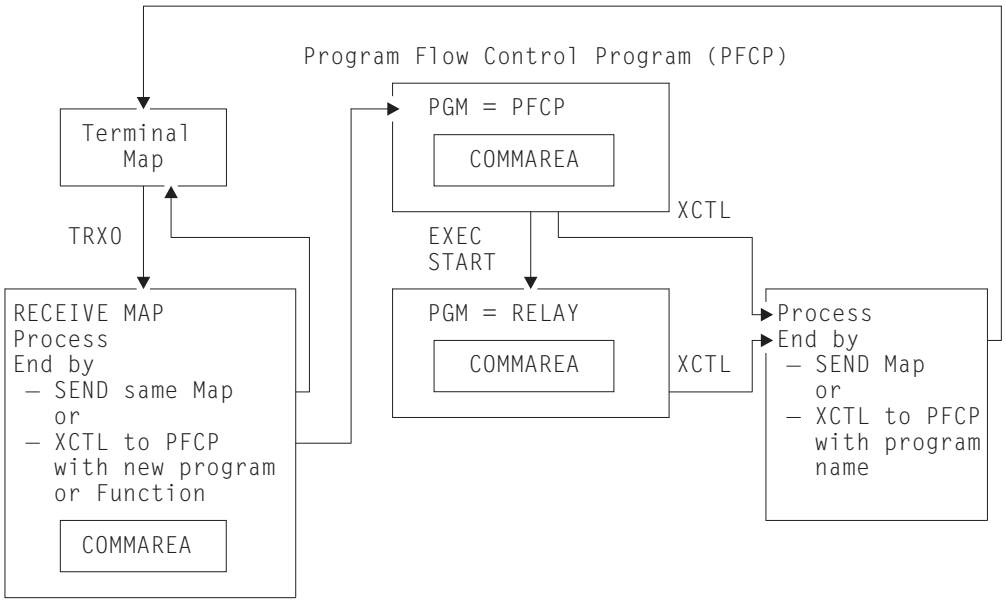


Figure 28. Table-controlled program flow

The flow for the application design used in Figure 27 on page 90 is explained below:

1. The terminal user sends a transaction to CICS. The transaction ID is TRX0.
2. The transaction definition points to program P0.
3. Program P0 receives the map, does some processing, and decides that program P3 is needed.
4. Instead of transferring control to program P3 (the DBRM for P3 could be part of another plan), P0 transfers control to the program flow control program (PFCP in this example). P0 also passes a COMMAREA.
5. PFCP does a table lookup in the control table to see if program P3 is included in the plan currently in use (PLAN0). This is done by checking if P3 is specified in the same row as the current transaction ID (TRX0). In the example, this is the case (line 4 in the table).
6. PFCP then transfers control to program P3. It also passes the COMMAREA it received from P0 to P3.
7. P3 processes the necessary SQL calls and finishes either by sending a map to the terminal or by transferring control to PFCP (not shown) to execute another program.
8. Assuming that this other program is PB, PFCP again checks whether PB is allowed to run under the current transaction ID, which still is TRX0.

   The table shows that PB must not be executed under TRX0. PFCP then examines the table to find a transaction ID under which program PB can be

executed. In the example, both TRXA and TEMP are valid transaction IDs. However, TRXA is pointing to program PA in the transaction definition. The New_TRANS_ID column of the table shows that only the rows with an * can be used when searching for a new transaction ID to start a given program. In this case, it is the TEMP transaction.

There are two possibilities for program names in the RDO transaction definition entry for the TEMP transaction ID:

- The RDO transaction definition can point directly to the new program (PB). In this case, there must be a transaction ID for each program that could be started in this way. Also, to use the COMMAREA, the program being started must contain logic to find out whether it is being started by START or by gaining control from an XCTL.
- The RDO transaction definition can point to a common program, here called the RELAY program. In this case, one or more transaction IDs can be used. All of them point to the RELAY program in the RDO transaction definition. The purpose of the RELAY is to transfer control to the appropriate program. All these programs are then never begun with START and do not need to handle this situation.

  The solution with the RELAY program is shown in Figure 28 on page 103.

9. PFCP starts the transaction TEMP, passing the COMMAREA.
10. The RELAY program is started. It must use an EXEC CICS RETRIEVE command to retrieve the COMMAREA.
11. From the COMMAREA, RELAY picks up the program name PB.
12. RELAY transfers control to PB, passing the COMMAREA.
13. The plan switch is completed.

Advantages

- This method allows you to implement different types of application design, such as using one large plan or many small plans.
- The decision of when to switch plans is taken away from the development process, and is not part of the coding.
- Only the control table needs to be updated when new programs are set into production. The existing programs do not need to be changed, even if they can call the new functions.
- The relationship between the transaction IDs, the DB2 plans, and the programs can be changed without changing the programs. However, the control table must then be changed.
- Information from the DB2 catalog (SYSPLAN and SYSDBRM) can be used to build the control table.
- Alternatively, the control table can be used to generate information about the DBRM structure of the plans.
- The control table contains information that can assist in defining the DB2ENTRYs and DB2TRANs in CICS, (if the plan name column is available).
- Other functions can be included in a control table structure, for example information about which transaction ID to use in the TRANSID option of the EXEC CICS RETURN command.

Disadvantages

The two major disadvantages of this technique are the costs of designing and developing the solution and the execution time overhead.

The cost of getting from program to program is approximately doubled. However, this should normally not correspond to more than a few percent increase in the processor time for the transaction. To decide whether or not to use such a solution, you should balance these disadvantages against the advantages.

Developing a locking strategy in the CICS DB2 environment

DB2 uses a lock mechanism to allow concurrency while maintaining data integrity.

In a CICS environment, concurrency is likely to be high. To give maximum concurrency, you should use row level locking or page locking instead of table space locking. You can do this by defining LOCKSIZE(PAGE), LOCKSIZE(ROW) or LOCKSIZE(ANY) when creating the table space, and by defining the isolation level as cursor stability at BIND time. For more information, see *DB2 Universal Database for OS/390 and z/OS SQL Reference*.

Specifying LOCKSIZE(ANY) allows DB2 to decide if lock escalation can take place for the table space. The DB2 parameter NUMLKTS is the number of concurrent locks for a table space. If the number of locks exceeds NUMLKTS, lock escalation takes place. NUMLKTS should then be set to a value so high that lock escalation does not take place for normal CICS operation.

If a table space lock is achieved and the plan was bound with RELEASE(DEALLOCATE), the table space is not released at COMMIT time, as only page locks are released. This can mean that a thread and plan monopolizes use of the table space.

Using ANY instead of PAGE gives DB2 the option to use lock escalation for programs that require many page locks before committing. This is typically the case in batch programs. DB2 also provides the ability to lock at the row level rather than the page or tablespace level, thus providing better granularity and reducing lock contention.

You can override DB2 rules for choosing initial lock attributes by using the SQL statement LOCK TABLE in an application program. However, you should avoid using the LOCK TABLE statement, unless it is strictly necessary. If the LOCK TABLE statement is used in an online program, it can prevent the use of RELEASE(DEALLOCATE) and of protected threads. If you do use a LOCK TABLE statement, your plan should use the bind option RELEASE(COMMIT).

In general, it is recommended that you design CICS programs so that:
- Locks are kept as short as possible.
- The number of concurrent locks is minimized.
- The access order of the tables is the same for all transactions.
- The access order of the rows inside a table is the same for all transactions.

SQL, threadsafe and other programming considerations for CICS DB2 applications

This section describes the following SQL and general programming considerations, and programming techniques:

- “Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming” on page 106
- “SQL language” on page 109
- “Using qualified and unqualified SQL” on page 109

Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming

The CICS DB2 attachment facility includes a CICS DB2 task-related user exit, DFHD2EX1, that is invoked when an application program makes an SQL request. It manages the process of acquiring a thread connection into DB2, and of returning control to the application program when the DB2 processing is complete.

When CICS is connected to DB2 Version 5 or earlier, the CICS DB2 task-related user exit operates as a quasi-reentrant task-related user exit program. It runs on the CICS main TCB (the QR TCB) and uses its own subtask thread TCBs to run threads, switching to and from the subtask thread TCBs for each DB2 request. However, when CICS is connected to DB2 Version 6 or later, the CICS DB2 attachment facility exploits the open transaction environment (OTE), to enable the CICS DB2 task-related user exit to invoke and return from DB2 without switching TCBs. In the open transaction environment, the CICS DB2 task-related user exit operates as a threadsafe and open API task-related user exit program—it is automatically enabled using the OPENAPI option on the ENABLE PROGRAM command during connection processing. This enables it to receive control on an open L8 mode TCB. Requests to DB2 are also issued on the L8 TCB, so it acts as the thread TCB, and no switch to a subtask TCB is needed. For full details of the CICS DB2 configuration needed to support the open transaction environment, see “Migrating to a different release of DB2” on page 15.

In the open transaction environment, if the user application program that invoked the task-related user exit conforms to threadsafe coding conventions and is defined to CICS as threadsafe, it can also run on the L8 TCB. Before its first SQL request, the application program runs on the CICS main TCB, the QR TCB. When it makes an SQL request and invokes the task-related user exit, control passes to the L8 TCB, and DB2 processing is carried out. On return from DB2, if the application program is threadsafe, it now continues to run on the L8 TCB.

Where the correct conditions are met, the use of open TCBs for CICS DB2 applications decreases usage of the QR TCB, and avoids TCB switching. An ideal CICS DB2 application program for the open transaction environment is a threadsafe program, containing only threadsafe EXEC CICS commands, and using only threadsafe user exit programs. An application like this will move to an L8 TCB when it makes its first SQL request, and then continue to run on the L8 TCB through any amount of DB2 requests and application code, requiring no TCB switching. This situation produces a significant performance improvement where an application program issues multiple SQL calls. The gains are also significant when using an enterprise bean, because when enterprise beans make DB2 requests, they require additional TCB switches to and from the enterprise bean's own TCB (see “Using JDBC and SQLJ in enterprise beans: special considerations” on page 130). If the application program does not issue many SQL calls, the performance benefits might not be as significant.

If the execution of the program involves any actions that are not threadsafe, CICS switches back to the QR TCB at that point. Such actions are non-threadsafe CICS requests issued by the program, the use of non-threadsafe dynamic plan exits, the use of non-threadsafe task-related user exits, and the involvement of non-threadsafe global user exits. Switching back and forth between the open TCB and the QR TCB is detrimental to the application's performance.

In order to gain the performance benefits of the open transaction environment for CICS DB2 applications, you *must* meet the following conditions:

1. CICS must be connected to DB2 Version 6 or later. “Migrating to a different release of DB2” on page 15 has full details of the CICS DB2 configuration needed to support the open transaction environment, including APARs that must be applied for DB2 and for CICS.
2. The system initialization parameter FORCEQR must not be set to YES. FORCEQR forces programs defined as threadsafe to run on the QR TCB, and it might be set to YES as a temporary measure while problems connected with threadsafe-defined programs are investigated and resolved.
3. The CICS DB2 application must have threadsafe application logic (that is, the native language code in between the EXEC CICS commands must be threadsafe), use only threadsafe EXEC CICS commands, and be defined to CICS as threadsafe. Only code that has been identified as threadsafe is permitted to execute on open TCBs. If your CICS DB2 application is not defined as threadsafe, or if it uses EXEC CICS commands which are not threadsafe, TCB switching will take place and some or all of the performance benefits of OTE exploitation will be lost.
4. Any dynamic plan exits used by the CICS DB2 attachment facility must be coded to threadsafe standards and defined to CICS as threadsafe. The default dynamic plan exit DSNCUEXT, which is invoked as a CICS user-replaceable program, is not defined to CICS as threadsafe, but the alternative CICS-supplied sample dynamic plan exit DFHD2PXT is so defined. See “Dynamic plan exits” on page 96 for more information.
5. Any global user exits on the execution path used by the application must be coded to threadsafe standards and defined to CICS as threadsafe (for CICS DB2 applications, note in particular the global user exits XRMIIN and XRMIOUT).
6. Any other task-related user exits used by the application must be defined to CICS as threadsafe, or as OPENAPI.

See the *CICS Application Programming Guide* for information on how to make application programs and user exit programs threadsafe. By defining a program to CICS as threadsafe, you are only specifying that the application logic is threadsafe, not that all the EXEC CICS commands included in the program are threadsafe. CICS can ensure that EXEC CICS commands are processed safely by switching to the QR TCB for those commands not yet converted that still rely on quasi-reentrancy. In order to permit your program to run on an open TCB, CICS needs you to guarantee that your application logic is threadsafe.

The EXEC CICS commands that are threadsafe, and so do not involve TCB switching, are indicated in the command syntax diagrams in the *CICS Application Programming Reference* and the *CICS System Programming Reference* with the statement “This command is threadsafe”, and are listed in "Threadsafe command list" in the *CICS Application Programming Reference* and Appendix D of the *CICS System Programming Reference*.

If a user application program in the open transaction environment is not defined as threadsafe, the CICS DB2 task-related user exit still runs on an L8 TCB, but the application program runs on the QR TCB throughout the task. Every time the program makes an SQL request, CICS switches from the QR TCB to the L8 TCB and back again, so the performance benefits of the open transaction environment are negated.

The table below shows what happens when application programs with different concurrency attributes invoke the CICS DB2 task-related user exit when CICS is connected to different versions of DB2.

Table 6. Combinations of application programs and the CICS DB2 task-related user exit

Program's concurrency attribute	**CICS DB2 task-related user exit's operation**	**Effect**
QUASIRENT or THREADSAFE	Quasi-reentrant (when connected to DB2 Version 5 or earlier)	Application program and task-related user exit run under the CICS QR TCB. The task-related user exit manages its own TCBs, switching to and from them for each DB2 request.
QUASIRENT	Threadsafe and open API (when connected to DB2 Version 6 or later)	Application program runs under the CICS QR TCB. Task-related user exit runs under an L8 TCB, and DB2 requests are executed under the L8 TCB. CICS switches to and from the CICS QR TCB and the L8 TCB for each DB2 request.
THREADSAFE	Threadsafe and open API (when connected to DB2 Version 6 or later)	OTE exploitation. Task-related user exit runs under an L8 TCB, and DB2 requests are executed under the L8 TCB. The application program also runs on the L8 TCB when control is returned to it. No TCB switches are needed until the task terminates, or if it issues a non-threadsafe CICS request which forces a switch back to the QR TCB.

In summary, to gain the performance benefits of the open transaction environment:

1. CICS must be connected to DB2 Version 6 or later. If CICS is connected to DB2 Version 5 or earlier, the CICS DB2 task-related user exit operates as a quasi-reentrant task-related user exit, switching TCBs for every DB2 request.
2. FORCEQR must not be set to YES.
3. The CICS DB2 application must have threadsafe application logic (that is, the native language code in between the EXEC CICS commands must be threadsafe), use only threadsafe EXEC CICS commands, and be defined to CICS as threadsafe. If the application program is not defined as threadsafe, and so must operate on the CICS QR TCB, TCB switching occurs for every DB2 request, even if the task-related user exit is running on an open TCB. If the application program is defined as threadsafe but uses non-threadsafe EXEC CICS commands, TCB switching occurs for every non-threadsafe EXEC CICS command.
4. The CICS DB2 application must use only threadsafe or open API dynamic plan exits, task-related user exits and global user exits. If any non-threadsafe exits are used, this forces a switch back to the QR TCB.

If all these conditions are met, you can gain the performance benefits of the open transaction environment.

SQL language

The complete SQL language is available to the CICS programmer with only minor restrictions. For a detailed description on using the SQL language in a CICS program, see the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide*.

In a CICS program, it is possible to use:
- Data manipulating language (DML)
- Data description language (DDL)
- GRANT and REVOKE statements

CICS also supports both dynamic and static SQL statements.

However, for performance and concurrency reasons, it is recommended that in general you do not issue DDL and GRANT and REVOKE statements in CICS. You should also limit dynamic SQL use.

The reason for these recommendations is that the DB2 catalog pages can be locked, with a lower concurrency level as a consequence. Also the resource consumption for these types of SQL statements is typically higher than resource consumption for static DML SQL statements.

Using qualified and unqualified SQL

Programmers writing CICS DB2 programs can use qualified and unqualified SQL. In qualified SQL, the creator is specified in front of the table or view name. In unqualified SQL, the creator is not specified.

When programmers develop CICS DB2 standards, it is important to determine the use of qualified and unqualified SQL. This decision influences many other aspects of the DB2 environment. The main relationships to other DB2 areas and some consequences for the two types of SQL statements are shown in Table 7.

Table 7. Qualified and unqualified SQL

Relationship to other DB2 areas	Qualified SQL	Unqualified SQL
Use of synonyms	Not possible	Possible
Binder ID	Any	Same as creator
Number of creators for tables and table spaces	Any	One
Use of VALIDATE(RUN)	Is qualified	Uses binder to qualify
Use of dynamic SQL	Is qualified	Uses executor to qualify
Require a separate test DB2 subsystem	Yes	No
Require same creator in test DB2 and production DB2	Yes	No
Possibility of using multiple versions of the test tables in the same test DB2 subsystem	No	Yes

Some of the limitations shown in Table 7 on page 109 can be bypassed if you develop your own preprocessor to modify the source code before invoking the DB2 precompiler. This allows you, for example, to change the creator in the SQL statements.

It is recommended that you use qualified SQL for dynamic SQL statements, because it is easier to administer.

If you use unqualified SQL, you must decide how to supply the CREATOR to fully identify the tables and views. There are two possibilities:

- You can use synonyms. The synonym must be created by the authorization id specified in the DB2ENTRY and DB2CONN. Synonyms can only be created by the authorization ID itself. That means that you must develop a method to create the synonyms. You can use a TSO ID with the same ID as the authorization ID specified in the DB2ENTRY or DB2CONN. Another possibility is to design a CICS transaction ID (using the same authorization ID) that itself could do the CREATE SYNONYM statement. However, neither of these methods is advisable.
- If you do not use synonyms, the CREATOR used in the bind process is the authorization ID of the binder. All tables and views referenced in the dynamic SQL must then be created with this ID. All transactions using dynamic SQL to access a common set of DB2 resources must then have the same authorization ID specified in the DB2ENTRY or DB2CONN. In most cases, it must be the SIGNID, or a character string. This restriction is normally not acceptable.

For these reasons, the use of unqualified SQL in dynamic SQL statements is not recommended.

Views

It is generally recommended that you use views where appropriate. Some views, however, cannot be updated.

In a real-time, online system, you often need to update rows you have retrieved using views. If the view update restriction forces you to update the base table directly (or by using another view), you should consider only views that can be updated. In most cases this makes the program easier to read and modify.

Updating index columns

When updating columns that are used in one or more indexes, consider the following:

- When updating a field in a table, DB2 does not use any index containing this field to receive the rows. This includes the fields listed in the FOR UPDATE OF list in the DECLARE CURSOR statement. It is independent of whether the field is actually updated.
- A table space that today is nonpartitioned can be recreated with more than one partition. SQL updates are not allowed against a partitioning key field. That means that programs doing updates of these fields must be changed to use DELETE and INSERT statements instead.

Dependency of unique indexes

A programmer can take advantage of the fact that DB2 returns only one row from a table with a unique index, if the full key is supplied in the SELECT statement. A cursor is not needed in this case. However, if at a later time the index is changed

and the uniqueness is dropped, then the program does not execute correctly when two or more rows are returned. The program then receives an SQL error code.

Commit processing

CICS ignores any EXEC SQL COMMIT statement in your application programs. The DB2 commit must be synchronized with CICS, which means that your program must issue an EXEC CICS SYNCPOINT command. CICS then performs the commit processing with DB2. An implicit SYNCPOINT is always invoked by the EXEC CICS RETURN at EOT.

You should be aware of the actions taken at SYNCPOINT:

- The UOW is completed. This means that all updates are committed in both CICS and in DB2.
- The thread is released for terminal-oriented transactions (unless a held cursor is open). If the thread is released and there is no use for it, it is terminated unless it is a protected thread.
- The thread is not released for non-terminal-oriented transactions, unless NONTERMREL=YES is specified in the DB2CONN. It first happens when the transaction is finished.
- All opened cursors are closed.
- All page locks are released.
- If RELEASE(COMMIT) was specified in the BIND process:
  - Table space locks are released
  - The cursor table segments of the plan in the EDM pool are released.
- Table space locks obtained by dynamic SQL are released independently of the BIND parameters.

Serializing transactions

You may need to serialize the execution of one or more transactions. This typically occurs when the application logic was not designed to deal with concurrency and in cases where the risk of deadlocks is too high.

You should allow serialization only for low-volume transactions because of potential queueing time.

The following methods each have different serialization start and end times:

- *CICS transaction classes*. The CICS facility of letting only one transaction execute at a time in a CLASS is useful to serialize the complete transaction.
- *DB2 thread serialization*. In cases where the serialization may be limited to an interval from the first SQL call to syncpoint (for terminal-oriented transactions, and nonterminal-oriented transactions if NONTERMREL=YES is defined), you can use your DB2ENTRY specifications to ensure that only one thread of a specific type is created at one time. This technique allows concurrency for the first part of the transaction, and is useful if the first SQL call is not in the beginning of the transaction. Do not use this technique if your transaction updated other resources before it issues its first SQL statement.
- *CICS enqueue and dequeue*. If you know that the serialization period necessary is only a small part of the programs, then the CICS enqueue and dequeue technique can be useful. The advantage is that only the critical part of the transaction is serialized. This part can be as small as just one SQL statement. It allows a higher transaction rate than the other methods, because the serialization is kept to a minimum.

The disadvantage compared to the other techniques is that the serialization is done in the application code and requires the programs to be changed.

- *LOCK TABLE statement*. It is recommended that you do *not* use the LOCK TABLE statement.

  The LOCK TABLE statement can be used to serialize CICS transactions and other programs, if EXCLUSIVE mode is specified. Note that it is the whole table space that is locked, not the table referenced in the statement.

  The serialization starts when the LOCK statement is executed. The end time for the serialization is when the table space lock is released. This can be at syncpoint or at thread deallocation time.

  Use this technique with care, because of the risk of locking the table space until thread deallocation time. However, this technique is the only one that works across the complete DB2 system. The other techniques are limited to controlling serialization of only CICS transactions.

Page contention

When designing applications and databases, consider the impact of having many transactions accessing the same part of a table space. The term “hot spot” is often used to describe a small part of the table space, where the access density is significantly higher than the access density for the rest of the table space.

If the pages are used for SELECT processing only, there is no concurrency problem. The pages are likely to stay in the buffer pool, so little I/O activity takes place. However, if the pages are updated frequently, you may find that you have concurrency problems, because the pages are locked from first update until syncpoint. Other transactions using the same pages have to wait. Deadlocks and timeouts often occur in connection with hot spots.

Two examples of hot spots are sequential number allocation and insert in sequence.

Sequential number allocation

If you use one or more counters to supply your application with new sequential numbers, consider the following:

- You should calculate the frequency of updates for each counter. You should also calculate the elapsed time for the update transaction, measured from update of the counter until commit. If the update frequency multiplied by the calculated elapsed time exceeds about 0.5 in peak hours, the queue time can be unacceptable.
- If you are considering having more than one counter in the same table space, you should calculate the total counter busy time.
- If the counters are placed in the same row, they are always locked together.
- If they are placed in different rows in the same table space, they can be in the same page. Since the locks are obtained at the page level, the rows are also locked together in this case.
- If the rows are forced to different pages of the same table space (for example by giving 99% free space) it is still possible that the transactions can be queued.

  When for example row 2 in page 2 is accessed, a table space scan can occur. The scan stops to wait at page number 1, if this page is locked by another transaction. You should therefore avoid a table space scan.
- If an index is defined to avoid the table space scan, it is uncertain whether it can be used. If the number of pages in the table space is low, the index is not used.

- A solution is then to have only one counter in each table space. This solution is preferred, if more than one CICS system is accessing the counters.
- If only one CICS system is accessing the counters, a BDAM file can be an alternative solution. However, the possibility of splitting the CICS system into two or more CICS systems at a later time can make this solution less attractive.

Insert in sequence

In situations where many transactions are inserting rows in the same table space, you should consider the sequence of the inserted rows. If you base a clustering index on a field with a time stamp, or a sequential number, DB2 tries to insert all rows adjacent to each other. The pages where the rows are inserted can then be considered a hot spot.

Note that in the clustering index, all inserts are also in the same page, within a given period.

If there is more than one index and the nonclustering index is used for data retrieval, the risk of deadlock between index and data is increased. In general terms, the INSERT obtains the X-locks (exclusive locks) in the following order:

1. Clustering index leaf page
2. Data page
3. Nonclustering index leaf page

When the SELECT statement uses the nonclustered index, the S-locks (shared locks) are obtained in this order:

1. Nonclustering index leaf page
2. Data page

This is the opposite order to the order of the INSERT locks. Often the SELECT rate is higher for the new rows. This means that the data pages are common for the INSERT and the SELECT statements. Where the index page is also the same, a deadlock can occur.

A solution to the deadlock risk is to spread the rows by choosing another index as clustering.

The general methods of how to handle deadlock situations are described in “Handling deadlocks in the CICS DB2 environment” on page 196.

CICS and CURSOR WITH HOLD option

The WITH HOLD option on a CURSOR declaration in a CICS program causes the following effects during a SYNCPOINT:

- The cursor is kept open.
- The cursor is left in position after the last row which was retrieved, and before the next row in the results table.
- Dynamic SQL statements are still prepared.

All locks are released, except for those required to maintain the cursor's position. Any exclusive page locks are downgraded to shared locks.

In conversational CICS applications, you can use DECLARE CURSOR...WITH HOLD to request that the cursor is not closed at syncpoint time. However, all cursors are *always* closed at end of task (EOT) and on SYNCPOINT ROLLBACK. Across EOTs, a cursor declared WITH HOLD must be reopened and repositioned just as if the WITH HOLD option were not specified. The scope of the held cursor is a single task.

In summary:

- The next FETCH following a syncpoint must come from the same task.
- You cannot hold a cursor across end of task.
- Therefore, cursors are *not* held across the EOT portions of pseudoconversational transactions.

If you try to hold a cursor across EOT, the cursor is closed and you get an SQLCODE -501 when you execute the next FETCH. The precompiler cannot detect this and you do not get a warning message notifying you of this situation.

In general, threads can become candidates for reuse at each syncpoint. When you use DECLARE CURSOR...WITH HOLD in the CICS applications, consider the following recommendations:

- Close held cursors as soon as they are no longer needed. Once all held cursors are closed, syncpoint can free the thread for thread reuse.
- Always close held cursors before EOT. If you do not close your held cursors, the CICS DB2 attachment facility forces signon to restore the thread to the initial state, and this incurs additional processor time.

EXEC CICS RETURN IMMEDIATE command

When the TRANSID option is specified in conjunction with the IMMEDIATE option, CICS avoids sending an end bracket (EB) to the terminal during the termination of the transaction that issued the RETURN command, and immediately initiates the transaction designated by the TRANSID option. The keyboard remains locked during this transaction, since no EB was sent to the terminal.

The new transaction behaves as if it were started by input from the terminal. You can pass data to the transaction designated by the TRANSID option, using a COMMAREA. If you choose to, the transaction issuing the RETURN command can also pass a terminal input message using the INPUTMSG and INPUTMSGLEN options. This facility allows you to immediately initiate a transaction that expects to be initiated as a result of terminal input.

This facility provides the same general capability as that achieved by issuing an EXEC CICS START TRANSID(....) with TERMID(....) set to the EIBTRMID value, but with much less overhead and without the momentary keyboard unlocking. The EXEC CICS RETURN TRANSID() IMMEDIATE command permits a pseudoconversational transaction to switch transaction codes. This could be advisable, for example, to keep DB2 plan sizes smaller or to have better accounting statistics for charge-back purposes.

Avoiding AEY9 abends

You can use the following CICS command to detect whether the CICS DB2 attachment facility is enabled:

```
EXEC CICS EXTRACT EXIT PROGRAM('DFHD2EX1')
         ENTRY('DSNCSQL')
         GASET(name1)
         GALENGTH(name2)
```

If you specify a program name of DSNCEXT1 or DSN2EXT1 CICS dynamically changes it to the required name DFHD2EX1. If you get the INVEXITREQ condition, the CICS DB2 attachment facility is not enabled.

When the CICS DB2 attachment facility is enabled it is not necessarily connected to DB2. It can be waiting for DB2 to initialize. When this occurs, and an application issues an EXEC SQL command when CONNECTERROR=ABEND is specified in the DB2CONN, an AEY9 abend would result. CONNECTERROR=SQLCODE would result in a -923 SQL code being returned to the application.

You can use the INQUIRE EXITPROGRAM command with the CONNECTST keyword in place of the EXTRACT EXIT command to determine whether the CICS is connected to DB2.

The CONNECTST keyword of the INQUIRE EXITPROGRAM command returns values:

- CONNECTED, when the CICS DB2 attachment facility is ready to accept SQL requests
- NOTCONNECTED, when the CICS DB2 attachment facility is not ready to accept SQL requests.

If the command fails with PGMIDERR, this is the same as NOTCONNECTED.

Figure 29 shows an example of assembler code using the INQUIRE EXITPROGRAM command.

```
CSTAT    DS    F
ENTNAME  DS    CL8
EXITPROG DS    CL8
         ...
         MVC   ENTNAME,=CL8'DSNCSQL'
         MVC   EXITPROG,=CL8'DFHD2EX1'
         EXEC CICS INQUIRE EXITPROGRAM(EXITPROG)               X
               ENTRYNAME(ENTNAME) CONNECTST(CSTAT) NOHANDLE
         CLC   EIBRESP,DFHRESP(NORMAL)
         BNE   NOTREADY
         CLC   CSTAT,DFHVALUE(CONNECTED)
         BNE   NOTREADY
```

Figure 29. Example of the INQUIRE EXITPROGRAM command

If you specify a program name of DSN2EXT1, CICS dynamically changes it to the required name, DFHD2EX1.

Further consideration on the use of the EXTRACT EXIT or INQUIRE EXITPROGRAM commands by applications has to be made when running in an environment where dynamic workload balancing using the MVS workload manager is taking place.

If an application avoids making DB2 calls because it knows the CICS DB2 connection is not active, but issues an error message instead and returns normally, it could delude the workload manager into routing more work to the CICS region. This is called the “storm drain effect”. Because the application did not abend, the workload manager believes that good response times are being achieved by this CICS region for DB2 work, and routes more work down the “storm drain”.

This effect can be avoided by ensuring the application abends. Alternatively, it can
be avoided by running with STANDBYMODE=RECONNECT and
CONNECTERROR=SQLCODE in the DB2CONN. In this situation, applications
should not use the Extract or Inquire Exitprogram commands to test whether DB2
work is possible. Instead, a test should be made for -923 SQLcode to be returned if

CICS is not connected to DB2. At the time of returning the -923 SQLcode, the CICS DB2 attachment facility informs the MVS workload manager that the request has failed. A dynamic routing program can subsequently use this information to avoid the “storm drain effect”. The CICSPlex SM dynamic routing program implements this function to avoid routing more DB2 work to the affected CICS region. No notification occurs when the condition causing the -923 SQLcode has passed. Because of this, after a given time, CICSPlex SM reactivates the CICS region in terms of its eligibility to receive work, and sends a test item known as a “sacrificial lamb” to the CICS region to test whether the problem still exists.

You are, therefore, advised to do the following:

- Specify STANDBYMODE=RECONNECT in the DB2CONN. This ensures that the CICS DB2 attachment facility waits (in standby mode) for DB2 to initialize and connect automatically, should DB2 be down when connection is first attempted. Also, if DB2 subsequently fails, the CICS DB2 attachment facility reverts again to standby mode and wait for DB2. It then automatically connects when DB2 returns.
- Use CONNECTERROR=SQLCODE provided applications handle the -923 code correctly.
- Avoid using EXTRACT EXIT or INQUIRE EXITPROGRAM commands if CONNECTERROR=SQLCODE can be used.
- Use CONNECTERROR=ABEND if an AEY9 abend is required. Use the INQUIRE EXITPROGRAM command instead of the EXTRACT EXIT command.
- It is worth noting that AEY9 abends can still occur even when STANDBYMODE=RECONNECT and CONNECTERROR=SQLCODE are specified if:
  - The CICS DB2 attachment facility is never started. An AEY9 results if an application issues an EXEC SQL command. You should always specify DB2CONN=YES in the SIT, or program DFHD2CM0 in PLTPI. Therefore the CICS DB2 attachment is at minimum in standby mode.
  - The CICS DB2 attachment is shut down using a DSNC STOP or CEMT/EXEC CICS SET DB2CONN NOTCONNECTED command.

It is advisable to avoid shutting down the attachment. The CICS DB2 SPI commands allow dynamic modification of the environment without shutting down the attachment.

Chapter 8. Using JDBC and SQLJ to access DB2 data from Java programs and enterprise beans written for CICS

Java programs and enterprise beans written for CICS can use several methods to access data held in a DB2 database. They can:

- Use a JCICS LINK command, or the CCI Connector for CICS TS, to link to a CICS program that uses Structured Query Language (SQL) commands to access the data. For more information about using the CCI Connector for CICS TS, see *Java Applications in CICS*.
- Use a bean to access the data. The bean could be a Data Access bean; a JavaBean that uses JDBC or SQLJ to access the data; or an entity bean running on another EJB server. For more information about using beans to access data, see *Java Applications in CICS*.
- Directly access the data by using the Java Data Base Connectivity (JDBC) or Structured Query Language for Java (SQLJ) application programming interfaces. This chapter tells you how to do this.

This chapter covers:

Making JDBC and SQLJ work in the CICS DB2 environment

When a Java application for CICS makes JDBC and SQLJ requests, the requests are processed by a JDBC driver supplied by DB2. In a CICS environment, the DB2-supplied JDBC driver is link-edited with the CICS DB2 language interface (stub) DSNCLI. The driver converts the JDBC or SQLJ requests into their EXEC SQL equivalents. The converted requests from the DB2-supplied JDBC driver flow into the CICS DB2 attachment facility in exactly the same way as EXEC SQL requests from any other program (for example, a COBOL program). So there are no operational differences between Java programs for CICS DB2 and other programs for CICS DB2, and all customization and tuning options available using RDO apply to Java programs for CICS DB2.

DB2 Version 6 provides the JDBC 1.2 driver, that supports the JDBC 1.2 application programming interface. DB2 Version 7 provides three levels of the JDBC driver, the 1.2 level, the 2.0 level, and the DB2 Universal JDBC Driver. DB2 Version 8 provides two levels of the JDBC driver, the 2.0 level and the DB2 Universal JDBC Driver. Java programs and enterprise beans written for CICS can use any of these JDBC drivers.

The JDBC 2.0 driver supports a selected subset of the JDBC 2.0 application programming interface, and it is downward compatible, so it supports the JDBC 1.2 API as well. Existing Java applications and enterprise beans that were written using the JDBC 1.2 API and that run in a JVM, can run using the JDBC 2.0 driver, and can benefit from performance improvements made in the JDBC 2.0 driver. If you create new Java applications and enterprise beans that use the JDBC 2.0 API, you need to use the JDBC 2.0 driver or the DB2 Universal JDBC Driver.

The DB2 Universal JDBC Driver provides enhanced support for the JDBC 2.0 # programming interface and most of the JDBC 3.0 application programming # interface. Like the JDBC 2.0 driver, it is downward compatible, so it supports the # JDBC 1.2 API as well. Because it is an entirely new driver, rather than a follow-on # to the JDBC 2.0 driver, you can expect some differences in behavior between this # driver and the JDBC 1.2 and 2.0 drivers. For more information about the DB2 # Universal JDBC Driver, see the the *DB2 Universal Database for OS/390 and z/OS # Application Programming Guide and Reference for Java* which is appropriate to # your version of DB2. The document number for DB2 Version 7 is SC26-9932, and # the document number for DB2 Version 8 is SC18-7414.

To use a JDBC driver provided by DB2, CICS must be connected to a DB2 subsystem that supports the appropriate level of JDBC driver. For example, when CICS is connected to a DB2 Version 6 subsystem, you cannot use the JDBC 2.0 driver provided by DB2 Version 7 or by DB2 Version 8.

The following table summarizes which level of the JDBC driver is supported by which versions and releases of CICS and DB2.

Table 8. Support for the JDBC driver in CICS and DB2

Product	**JDBC driver supported**
DB2 Version 6 (with APAR PQ84783)	1.2 level
DB2 Version 7 (with APAR PQ84783)	1.2 level and 2.0 level
# DB2 Version 7 (with APAR PQ86525)	DB2 Universal JDBC Driver
DB2 Version 8 (with APAR PQ84783)	2.0 level
# DB2 Version 8 (with APAR PQ86525)	DB2 Universal JDBC Driver
CICS TS for OS/390 Version 1 Release 3 (with APAR PQ34321)	1.2 level
# CICS TS for z/OS Version 2 Release 2 (with APARs # PQ57455 and PQ85283)	1.2 level, 2.0 level and DB2 Universal JDBC Driver
# CICS TS for z/OS Version 2 Release 3 (with APAR # PQ85283)	1.2 level, 2.0 level and DB2 Universal JDBC Driver
CICS TS for z/OS Version 3 Release 1	1.2 level, 2.0 level and DB2 Universal JDBC Driver

“Requirements to support Java programs in the CICS DB2 environment” on page 119 has information on the system requirements to support each level of the JDBC driver.

Full details of how to code and build Java applications that use the JDBC and SQLJ application programming interfaces can be found in the *DB2 Universal Database for OS/390 and z/OS Application Programming Guide and Reference for Java* that applies to your version of DB2. The document number for DB2 Version 6 is SC26-9018, the document number for DB2 Version 7 is SC26-9932, and the

document number for DB2 Version 8 is SC18-7414. Particular programming features apply to JDBC and SQLJ when they are used in a CICS environment, so read “Programming with JDBC and SQLJ in the CICS DB2 environment” on page 121 for more specific guidance before developing your Java application.

Requirements to support Java programs in the CICS DB2 environment

To use Java programs in the CICS DB2 environment, you need to apply the following system and setup requirements:

Requirements for Java programs and enterprise beans, which run in a JVM

- For Java programs and enterprise beans, which run in the IBM Java Virtual Machine (JVM), the following APARs are required on DB2:
  - PQ84783 on DB2 6.1
  - PQ84783 (JDBC 1.2 and 2.0 drivers) and PQ86525 (DB2 Universal JDBC Driver) on DB2 7.1
  - PQ84783 (JDBC 2.0 driver) and PQ86525 (DB2 Universal JDBC Driver) on DB2 8.1
- To use the DB2-supplied JDBC drivers with Java programs and enterprise beans, you need to amend the JVM profiles that are used by the Java programs or enterprise beans. You need to add a DB2-supplied zip file (or for the DB2 Universal JDBC Driver, three DB2-supplied jar files) to the trusted middleware class path, and a DB2-supplied directory containing dynamic load libraries to the library path for the JVM. (Note that if the JVM is a worker JVM that uses the shared class cache, its trusted middleware class path and library path are taken from the JVM profile for the master JVM that initializes the shared class cache, not from the JVM profile for the worker JVM itself.)
  - The CICS-supplied sample JVM profiles contain commented-out examples of how to amend the trusted middleware class path and library path to add these files for the JDBC 1.2 driver.
  - If you want to use the JDBC 2.0 driver instead, follow the supplied example for the library path setting, but for the trusted middleware class path, add the zip file `db2j2classes.zip` instead of the file named in the example.
  - For the DB2 Universal JDBC Driver, the appropriate settings are in the CICS-supplied sample JVM profiles as commented-out examples. You need to specify the library path setting as `/usr/lpp/db2710/db2710/jcc/lib`, where `db2710` is the high-level qualifier for your DB2 libraries (note the additional subdirectory `jcc`). The DB2-supplied jar files `db2jcc.jar`, `db2jcc_javax.jar`, and `db2jcc_license_cisuz.jar` need to be added to the trusted middleware classpath following this example:

    ```
    TMSUFFIX=/usr/lpp/db2710/db2710/jcc/classes/db2jcc.jar:\
     /usr/lpp/db2710/db2710/jcc/classes/db2jcc_javax.jar:\
     /usr/lpp/db2710/db2710/jcc/classes/db2jcc_license_cisuz.jar
    ```

    where `db2710` is the high-level qualifier for your DB2 libraries.

  Java Applications in CICS tells you how to locate and customize JVM profiles. If you have any applications that use the JDBC 2.0 API, you must use either the JDBC 2.0 driver (which supports a subset of the JDBC 2.0 application programming interface), or the DB2 Universal JDBC driver. The JDBC 2.0 driver and the DB2 Universal JDBC Driver also support applications written using the JDBC 1.2 API.
- For the JDBC 1.2 driver, the JDBC 2.0 driver, and the DB2 Universal JDBC Driver, you also need to add the DB2 directory containing the serialized profile `DSNJDBC_JDBCProfile.ser` either to the JVM's standard class path (the

CLASSPATH option in the JVM profile), or to its shareable application class path (the `ibm.jvm.shareable.application.class.path` option in the JVM properties file). If the JVM is a worker JVM that uses the shared class cache, its shareable application class path is taken from the JVM profile for the master JVM that initializes the shared class cache, but its standard class path is taken from the JVM profile for the worker JVM itself. The serialized profile is initially created in the DB2 directory where the command `db2genjdbc` was issued, but it might have been subsequently moved to another location. The directory that needs to be added to the JVM's class path is the directory that currently contains the serialized profile. When you have added the directory to the JVM's class path, you also need to ensure that the DB2 system property `db2sqljjdbcprogram=dsnjdbc` is set in the JVM properties file for the JVM. This system property is the default, so it does not need to be added to the JVM properties file if it is not present. For full details, see the *DB2 Universal Database for OS/390 and z/OS Application Programming Guide and Reference for Java* which is appropriate to your version of DB2.

Requirements for the DB2-supplied JDBC drivers

- To use the JDBC 1.2 driver or the JDBC 2.0 driver shipped with DB2 Version 7 or later, or the DB2 Universal JDBC Driver, you need to add the SDSNLOD2 library to the CICS STEPLIB concatenation. The JDBC 1.2 driver shipped with DB2 Version 6 does not require this library.
- To enable your applications to use the DB2-supplied JDBC drivers, you need to name the drivers by using the `jdbc.drivers` system property in the JVM properties files that are referenced by the JVM profiles used by your applications. The CICS-supplied sample JVM properties files contain commented-out examples of how to do this. *Java Applications in CICS* tells you how to locate and customize JVM properties files. Naming the JDBC drivers removes the need for applications to load the drivers themselves using the `Class.forName()` method. Instead, the DriverManager class loads the required class for the application. The name of the driver is the same for the JDBC 1.2 driver, the JDBC 2.0 driver, and the DB2 Universal JDBC Driver, so if you follow this method, you do not need to change your existing applications or your JVM properties files when you migrate from one driver to another.
- When running the JDBC driver in a CICS environment, you might want to alter the system properties in your JVM properties files to tailor your environment. With CICS, the DB2 environment variable DB2SQLJPROPERTIES, which names a system properties file to be used by the JDBC driver, is not used. Instead, you can set system properties related to the JDBC driver in the JVM properties files. These are the files named by the JVMPROPS parameter in your JVM profiles. If you want to alter the system properties, note that most DB2 JDBC driver system properties are not used in a CICS environment.The appendixes of the *DB2 Universal Database for OS/390 and z/OS Application Programming Guide and Reference for Java* have a list of the properties that are not used or have a different meaning in a CICS environment, and the document also contains the full list of DB2 JDBC driver properties. For DB2 Version 6, the document number is SC26-9018, the full list of driver properties is in Chapter 7, and the changes to properties in a CICS environment are in Appendix B. For DB2 Version 7, the document number is SC26-9932, the full list of driver properties is in Chapter 6, and the changes to properties in a CICS environment are in Appendix B. For DB2 Version 8, the document number is SC18-7414, the full list of driver properties is in Chapter 7, and the changes to properties in a CICS environment are in Appendix A.
- If you want to use the DataSource interface, which is supported by the JDBC 2.0 driver provided by DB2 Version 7 or later or the DB2 Universal JDBC Driver, to

connect to a database, you need a suitably configured naming server. If you need to configure a naming server, see *Java Applications in CICS*, in particular the topics Defining name servers, Enabling JNDI references, Setting up an LDAP server, and Setting up a COS Naming Directory Server.

Requirements for using Java 2 security with JDBC or SQLJ

- To use JDBC or SQLJ from a Java program or enterprise bean with a Java 2 security policy mechanism active, you must use the JDBC 2.0 driver or the DB2 Universal JDBC Driver. The JDBC 1.2 driver does not support Java 2 security, and will fail with a security exception.
- To activate a Java 2 security policy mechanism, you need to amend your JVM properties files. These are the files named by the JVMPROPS parameter in your JVM profiles. *Java Applications in CICS* has more information about setting up a Java 2 security policy mechanism. In summary, to use the default Java 2 security manager for a JVM with a particular JVM profile, include the following statement in the JVM properties file that is referenced by that JVM profile:

  ```
  java.security.manager=default
  ```

  You also need to name your Java 2 security policy file in the JVM properties file, using the following statement:

  ```
  java.security.policy= /directory/tree/file.name
  ```

  CICS supplies an example Java 2 security policy for use with Java programs or enterprise beans in the CICS environment, and you can find the example file at `/usr/lpp/cicsts/cicsts31/lib/security/dfjejbpl.policy`, where cicsts31 is your chosen value for the USSDIR installation parameter that you defined when you installed CICS TS.
- To use JDBC and SQLJ, you need to amend your Java 2 security policy to grant permissions to the JDBC driver, by adding the following lines:

  ```
  grant codeBase "file:/usr/lpp/db2710/-" {
    permission java.security.AllPermission;
  };
  ```

  In place of `db2710`, specify a directory below which all your DB2 Version 7 libraries are located. The permissions are applied to all the directories and files below this level. The example Java 2 security policy `dfjejbpl.policy` does not contain this statement, so you need to add it.
- In your Java 2 security policy, you also need to grant read permissions, by adding the following lines:

  ```
  grant {

  // allows anyone to read properties
  permission java.util.PropertyPermission "*", "read";

  };
  ```

  If you do not do this, running a Java program produces AccessControlExceptions and unpredictable results. The example Java 2 security policy `dfjejbpl.policy` already contains this statement.

Programming with JDBC and SQLJ in the CICS DB2 environment

The JDBC 1.2 driver supports the JDBC 1.2 level application programming interface. The JDBC 2.0 driver supports the JDBC 1.2 API and a subset of the JDBC 2.0 API.The DB2 Universal JDBC Driver provides enhanced support for the JDBC 2.0 API and most of the JDBC 3.0 API, and also supports the JDBC 1.2 API.

All three drivers support the SQLJ Part 0 (ANSI 98) level API. Java programs for
CICS must adhere to the programming rules of these application programming
interfaces, which are more restrictive than the general CICS programming model.

You can find more information about the JDBC APIs at the JDBC Web site, http://java.sun.com/products/jdbc. For information about the features of the JDBC APIs that are supported by the DB2-supplied JDBC drivers, and how to code and build Java applications that use the JDBC and SQLJ APIs, see the *DB2 Universal Database for OS/390 and z/OS Application Programming Guide and Reference for Java* which is appropriate for your version of DB2. The document number for DB2 Version 6 is SC26-9018, the document number for DB2 Version 7 is SC26-9932, and the document number for DB2 Version 8 is SC18-7414.

The particular programming features that apply to JDBC and SQLJ when used in a CICS environment are described in the following sections:

Acquiring a connection to a database

Before executing SQL statements, a JDBC or SQLJ application has to acquire a connection or connection context to a database. The database is identified by a database Uniform Resource Locator (URL) that is provided to the JDBC driver. The JDBC driver recognizes two types of URL:

Default URL

A default URL does not include the location name of a DB2 subsystem. A default URL for DB2 for OS/390 and z/OS can be specified in one of two formats:

```
jdbc:db2os390sqlj:
```
or
```
jdbc:default:connection
```

When a default URL is specified, the application is given a connection to the local DB2 to which CICS is connected. If your installation uses DB2 data sharing, you can access all the data in your sysplex from the local DB2.

Explicit URL

An explicit URL includes the location name of a DB2 subsystem. The basic structure of an explicit URL for DB2 for OS/390 and z/OS is:

```
jdbc:db2os390:<location-name>
```
or
```
jdbc:db2os390sqlj:<location-name>
```

Typically, the location name is the name of the local DB2 to which CICS is connected. However, you can specify the name of a remote DB2 to access.

In this case, CICS uses the local DB2 as a pass-through, and uses DB2 Distributed Data Facilities to access the remote DB2.

It is recommended that you use a default URL in a CICS environment. The use of an explicit URL causes particular behaviours at the close of a connection, that could be inconvenient when multiple programs are used in the same application suite. Also, when a default URL is used, the connection behaves in the same way using the JDBC 1.2 driver, the JDBC 2.0 driver, or the DB2 Universal JDBC Driver. See "Committing a unit of work" on page 129 for further information.

To acquire a connection to a database, applications need to provide the default or explicit URL of the database to the JDBC driver. The application can provide this URL using one of two methods, depending on the level of JDBC driver that is provided by your DB2 system. It can use the JDBC DriverManager interface, which is supported by the JDBC 1.2 driver, the JDBC 2.0 driver, and the DB2 Universal JDBC Driver; or it can use the DataSource interface, which is supported by the JDBC 2.0 driver and the DB2 Universal JDBC Driver. For descriptions of these two methods, see:

- "Acquiring a connection using the JDBC DriverManager interface"
- "Acquiring a connection using the DataSource interface" on page 124

If you can use the JDBC 2.0 driver or the DB2 Universal JDBC Driver, the DataSource interface is the recommended method of acquiring a connection, because applications are then isolated from the platform-specific and JDBC driver-specific mechanisms for obtaining a connection to a database.

How many connections can you have?

A Java application for CICS can have at most one JDBC connection or SQLJ connection context open at a time. Although JDBC allows an application to have multiple connections at the same time, CICS does not permit this. However, an application can close an existing connection and open a connection to a new DB2 location.

An application that has an open connection should close the connection before linking to another application that wants to use JDBC or SQLJ. For Java programs that are part of an application suite, you need to consider the implications of closing the connection, because if you are using an explicit URL, closing the connection can cause a syncpoint to be taken. If you are using a default URL, a syncpoint does not have to be taken when the connection is closed. See "Committing a unit of work" on page 129 for more information about this.

Acquiring a connection using the JDBC DriverManager interface

The JDBC DriverManager interface is supported by the JDBC 1.2 driver, the JDBC 2.0 driver, and the DB2 Universal JDBC Driver.

To use this method of acquiring a connection, your Java application needs to invoke the `DriverManager.getConnection` method to specify a default URL or an explicit URL, to connect to a DB2 subsystem. (For more information about default and explicit URLs, see "Acquiring a connection to a database" on page 122.) In a CICS DB2 environment, you do not need to specify a userid and password on the `DriverManager.getConnection` request. If you do specify these, they are ignored for DB2 Version 6, but cause an error for DB2 Version 7. The existing CICS DB2 security procedures are used instead.

For more information on using the JDBC DriverManager interface to acquire a connection, and sample code that you can use in your application, see the *DB2 Universal Database for OS/390 and z/OS Application Programming Guide and Reference for Java* which is appropriate for your version of DB2.

Acquiring a connection using the DataSource interface

The DataSource interface is supported by the JDBC 2.0 driver provided by DB2 Version 7 or later, and the DB2 Universal JDBC Driver. To use this method of acquiring a connection, CICS must be connected to a DB2 Version 7, or later, subsystem, and must be set up to use the JDBC 2.0 driver or the DB2 Universal JDBC Driver, with the appropriate zip file or jar files on the trusted middleware class path in the JVM profiles used by your applications (see “Requirements to support Java programs in the CICS DB2 environment” on page 119). You also need a suitably configured naming server. If you need to configure a naming server, see *Java Applications in CICS*, in particular the topics Defining name servers, Enabling JNDI references, Setting up an LDAP server, and Setting up a COS Naming Directory Server.

Instead of specifying a default or explicit URL in the program itself, an application can use the Java Naming and Directory Interface (JNDI) to look up a reference to a previously deployed DataSource. You can create, deploy and manage a DataSource separately from the applications that use it, and it acts as a “connection factory”. The DataSource provides all the necessary information to generate the JDBC connection, so the application programmer does not need to provide the correct URL (as required by the DriverManager interface).

CICS provides sample Java applications to enable you to:

- Publish a CICS-compatible DataSource to a JNDI Namespace (CICSDataSourcePublish.java).
- Retract a CICS-compatible DataSource from a JNDI Namespace (CICSDataSourceRetract.java).
- Look up a CICS-compatible DataSource from a JNDI Namespace, and use it to obtain a JDBC connection with default URL characteristics to the local DB2 subsystem to which CICS is connected (CICSjdbcDataSource.java).

Currently, only DataSources published using either the CICS-supplied sample CICSDataSourcePublish.java, or code similar to this sample, are supported.

The DataSource in the sample applications does not specify the database name, so it generates connections with default URL characteristics. A DataSource that specified the database name would generate connections with an explicit URL. It is recommended that you do not specify the database name in your DataSource, so that it generates JDBC connections with a default URL. Using a default URL ensures the correct behaviour at the close of a connection. See “Committing a unit of work” on page 129 for further information.

JDBC connection pooling is a technology used by JDBC 2.0 to optimize the acquisition of JDBC connections. The CICS DB2 attachment facility already has its own mechanism to manage, protect and reuse threads, so the JDBC connection pooling mechanism is superseded in the CICS DB2 environment by CICS' own mechanism, which provides an equivalent functionality. For this reason, a DataSource that is created in CICS to access DB2 uses the `com.ibm.db2.jcc.DB2SimpleDataSource` class, which does not contain support for JDBC connection pooling, rather than the `com.ibm.db2.jcc.DB2DataSource` class, which does contain that support. The DB2-supplied JDBC driver ensures that the

correct class is used. Note that the CICSjdbcDataSource.java sample application uses a standard JDBC DataSource object to look up the DataSource, and the DB2 JDBC driver converts this to a CICS-compatible DataSource object that uses the `com.ibm.db2.jcc.DB2SimpleDataSource` class.

"Setting up the sample applications to publish, look up and retract a DataSource" tells you how to set up the CICS-supplied sample applications. "Publishing a DataSource using CICSDataSourcePublish.java" on page 126, "Looking up a DataSource using CICSjdbcDataSource.java" on page 127, and "Retracting a DataSource using CICSDataSourceRetract.java" on page 128 tell you how to use the sample applications. For further technical background on the DataSource, see the *DB2 Universal Database for OS/390 and z/OS Application Programming Guide and Reference for Java* which is appropriate for your version of DB2.

Setting up the sample applications to publish, look up and retract a DataSource

CICS provides the file `CICSDB2DataSource.jar` in the directory `/usr/lpp/cicsts/cicsts31/samples/jdbc`. This file contains the object (.class) files for the sample applications CICSDataSourcePublish.java, CICSjdbcDataSource.java, and CICSDataSourceRetract.java. The source code (.java) for these files is also in the directory `/usr/lpp/cicsts/cicsts31/samples/jdbc`.

To set up the sample applications, follow these steps:

1. The sample applications use the CICS-supplied sample JVM profile DFHJVMPR, which is a HFS file. When you install CICS, the CICS-supplied sample JVM profiles are placed in the HFS directory `/usr/lpp/cicsts/cicsts31/JVMProfiles`, where `cicsts31` is the value that you chose for the CICS_DIRECTORY variable used by the DFHIJVMJ job during CICS installation. CICS actually looks for the JVM profiles in the HFS directory that is specified by the JVMPROFILEDIR system initialization parameter, which might or might not be the directory containing the CICS-supplied sample JVM profiles. If the location of the JVM profiles has been changed for your CICS region, you can use the EXEC CICS INQUIRE JVMPROFILE command to find the full path name of the HFS file that CICS is using, provided that DFHJVMPR has been used during the lifetime of the CICS region. (Note that there is no CEMT equivalent for this command.) Locate the JVM profile DFHJVMPR and add classes to the classpaths as follows:
   - On the CLASSPATH option in the JVM profile (which specifies the standard class path), specify the .jar file containing the sample applications, `/usr/lpp/cicsts/cicsts31/samples/jdbc/CICSDB2DataSource.jar`.
   - On either the TMSUFFIX statement or the TMPREFIX statement (which are used as part of the trusted middleware class path), specify the DB2 JDBC 2.0 classes file required by the JDBC 2.0 driver, `/usr/lpp/db2710/db2710/classes/db2j2classes.zip` (where `db2710` is the high-level qualifier for your DB2 libraries).

   Java Applications in CICS has more information about locating and customizing JVM profiles.
2. Use CEDA to install transactions DSDB, DSPU, and DSRE from group DFH$DB2.
3. Use CEDA to install programs DFJ$DSDB, DFJ$DSPU, and DFJ$DSRE from group DFH$DB2.

4. The default name is jdbc/CICSDB2DataSource. You can change the name of the DataSource, or the subContext to where the DataSource will be published. There are two ways to do this:
   a. You can change the sample programs CICSDataSourcePublish.java, CICSDataSourceRetract.java, and CICSjdbcDataSource.java as required. If you change the name or subContext for the DataSource, remember to make the same change in all three of the sample programs. Put the new classes for the sample programs on your CLASSPATH option in the JVM profile DFHJVMPR.
   b. Alternatively, you can add the system property `com.ibm.cics.datasource.path` to the JVM properties file that is referenced by the JVMPROPS statement in the JVM profile DFHJVMPR. When you install CICS, the CICS-supplied sample JVM properties files are placed in the directory `/usr/lpp/cicsts/cicsts31/props/`, where `cicsts31` is the value that you chose for the CICS_DIRECTORY variable used by the DFHIJVMJ job during CICS installation. The CICS-supplied sample profile DFHJVMPR references the JVM properties file `dfjjvmpr.props`. Include the following statement in the JVM properties file:

      ```
      com.ibm.cics.datasource.path=subContext/DataSourcename
      ```

      Specify the subContext and name that you want to use for the DataSource.

   If the `com.ibm.cics.datasource.path` system property is present in the JVM properties file, the sample applications use the values specified by that property. Otherwise, they default to the DataSource name specified in the sample programs.
5. Before you use the sample applications, ensure that your user ID is authorized to access DB2 resources. “Authorizing users to access resources within DB2” on page 81 tells you how to ensure that your user ID has the correct authorization.

Although the sample applications use the CICS-supplied sample JVM profile DFHJVMPR, which is a profile for a standalone JVM (that does not use the shared class cache), DataSource lookup classes based on the sample application CICSjdbcDataSource.java can also be used by worker JVMs (that do use the shared class cache). Bear in mind that for a worker JVM, the CLASSPATH option in the JVM profile and the `com.ibm.cics.datasource.path` system property in the JVM properties file are taken from the JVM profile and JVM properties file for the worker JVM itself. However, the trusted middleware class path (including the TMSUFFIX statement or the TMPREFIX statement, where you need to specify the `db2j2classes.zip` file) is taken from the JVM profile for the master JVM.

Publishing a DataSource using CICSDataSourcePublish.java

To publish a CICS-compatible DataSource to your JNDI server using the sample program CICSDataSourcePublish.java, enter transaction DSPU at a terminal. By default, the DataSource will be named CICSDB2DataSource, and it will be published to subContext `jdbc` in the JNDI initial context. The location of the initial context is determined by the parameters specified in your LDAP or JNDI server configuration, in the JVM properties file for the JVM. You can change the sample program, or use the `com.ibm.cics.datasource.path` system property, to specify a different DataSource name and subContext; see “Setting up the sample applications to publish, look up and retract a DataSource” on page 125 for instructions.

The following messages are displayed on the screen:

```
DSPU - CICSDataSourcePublish: Transaction starting

DSPU - CICSDataSourcePublish: Datasource jdbc/CICSDB2DataSource published
```

If the DataSource has already been published, the following message is displayed on the screen:

```
DSPU - CICSDataSourcePublish: Datasource jdbc/CICSDB2DataSource already published
```

The following output appears in stdout:

```
********************************************************************************
**** CICSDataSourcePublish: started
**** CICSDataSourcePublish: Looking up DataSource jdbc/CICSDB2DataSource
**** CICSDataSourcePublish: DataSource jdbc/CICSDB2DataSource not found
**** CICSDataSourcePublish: Binding DataSource jdbc/CICSDB2DataSource
**** CICSDataSourcePublish: DataSource bound to JNDI
**** CICSDataSourcePublish: ended
********************************************************************************
```

Figure 30. Stdout output from transaction DSPU to publish a DataSource with default name and subContext

The sample program publishes a DataSource that provides the information needed to generate default URL connections. Now, instead of specifying a URL in a `DriverManager.getConnection` request (the JDBC DriverManager interface), your application programs can use the Java Naming and Directory Interface (JNDI) to look up a reference to the DataSource, as described in "Looking up a DataSource using CICSjdbcDataSource.java." Remember that CICS must be using the JDBC 2.0 driver (provided by DB2 Version 7 or later) or the DB2 Universal JDBC Driver to use the DataSource interface.

It is not recommended that you use CICSDataSourcePublish.java as a PLTPI program. Though this is possible, it severely impacts the time taken for control to be given to CICS. If you want to use the program in PLTPI processing, then you should have a PLTPI program start transaction DSPU.

Looking up a DataSource using CICSjdbcDataSource.java

To look up a DataSource to test that it has been published correctly, enter transaction DSDB at a terminal. The following messages are displayed on the screen:

```
DSDB - DataSource JDBC transaction starting.

DSDB - DataSource JDBC transaction finished. See stdout
```

The following output appears in stdout:

```
********************************************************************************
**** CICSjdbcDataSource: started
**** CICSjdbcDataSource: Looking up CICS datasource jdbc/CICSDB2DataSource
**** CICSjdbcDataSource: DataSource Connection created.
**** CICSjdbcDataSource: AutoCommit is false
**** CICSjdbcDataSource: First Select Statement created
**** CICSjdbcDataSource: First Result Set created
**** CICSjdbcDataSource: Table name = SYSCOPY
**** CICSjdbcDataSource: Table name = SYSCOLAUTH
**** CICSjdbcDataSource: Table name = SYSCOLUMNS
.
. a list of table names defined to DB2
.
**** CICSjdbcDataSource: Table name = SYSSEQUENCESDEP
**** CICSjdbcDataSource: Result Set output completed
**** CICSjdbcDataSource: ended
********************************************************************************
```

Figure 31. Stdout output from transaction DSDB to look up a DataSource with default name and subContext

To acquire a connection for a Java application program using your published DataSource, use the sample code provided in the CICSjdbcDataSource.java sample. The sample code shows you how your application can look up the DataSource and make an SQL query.

The CICSjdbcDataSource.java sample gets a DB2SimpleDataSource instance from JNDI, but treats it as a DataSource, making it vendor and platform independent. It is possible to bypass this lookup by instantiating a DB2SimpleDataSource directly. You can do this by coding:

```
.
.
DataSource ds = new DB2SimpleDataSource():

Connection con1 = ds.getConnection();
.
.
```

You should be aware that if you do this, the code will no longer be portable in the true sense, as it is now platform and vendor specific.

Retracting a DataSource using CICSDataSourceRetract.java

To retract (unBind) a DataSource that you have published, enter transaction DSRE at a terminal.

The following messages are displayed on the screen:

```
DSRE - CICSDataSourceRetract: Transaction starting

DSRE - CICSDataSourceRetract: Datasource jdbc/CICSDB2DataSource retracted
```

If the DataSource has not been published or has already been retracted, the following message is displayed on the screen:

```
DSRE - CICSDataSourceRetract: Datasource jdbc/CICSDB2DataSource not found
```

The following output appears in stdout:

```
********************************************************************************
**** CICSDataSourceRetract: started
**** CICSDataSourceRetract: unbinding jdbc/CICSDB2DataSource
**** CICSDataSourceRetract: jdbc/CICSDB2DataSource unbound
**** CICSDataSourceRetract: ended
********************************************************************************
```

Figure 32. Stdout output from transaction DSRE to retract a DataSource with default name and subContext

Committing a unit of work

To commit a unit of work, your JDBC and SQLJ applications can issue JDBC and SQLJ commit and rollback method calls. The DB2 JDBC driver converts these calls into a JCICS commit or a JCICS rollback call, resulting in a CICS syncpoint being taken. A JDBC or SQLJ commit therefore results in the whole CICS unit of work being committed, not just the updates made to DB2. CICS does not support committing work done using a JDBC connection independently of the rest of the CICS unit of work.

A JDBC or SQLJ application can also issue JCICS commit or rollback directly, and this has the same result as issuing a JDBC or SQLJ commit or rollback method call. The whole unit of work is committed or rolled back together, both DB2 updates and updates to CICS controlled resources.

When you are working with JDBC connections, there are some circumstances in which you cannot avoid a syncpoint being taken, and the unit of work being committed, when the connection to the DB2 database is closed. This applies in either of the following circumstances:

- You have used the autocommit property of a JDBC connection. (See "Autocommit.")
- You have acquired the connection using an explicit URL. (See "Syncpoint issues for explicit and default URLs" on page 130.)

For a stand-alone application, these rules do not cause a problem, as CICS ensures that an end of task syncpoint is taken in addition to any syncpoint that is taken when the connection is closed. However, the JDBC and SQLJ application programming interfaces do not support the concept of multiple application programs for each unit of work. If you have a number of programs that make up an application, one program might access DB2, then call another program that also accesses DB2, in the course of a single unit of work. If you want these programs to be Java programs that use JDBC or SQLJ, you need to ensure that the unit of work is **not** committed when the connection to DB2 is closed, or else the application will not operate as planned. You should be particularly aware of this requirement if you are replacing programs in an existing application with Java programs that use JDBC or SQLJ, and you want to share the same CICS-DB2 thread between the programs. Using a default URL to acquire the connection, rather than an explicit URL, addresses this issue (see "Syncpoint issues for explicit and default URLs" on page 130).

Autocommit

JDBC applications can use the autocommit property of a JDBC connection. The autocommit property causes a commit after each update to DB2. This commit is a CICS commit, and results in the whole unit of work being committed.

Using the autocommit property also causes a commit to be taken when a connection is closed, both for connections obtained using an explicit URL, and connections obtained using a default URL.

The use of autocommit in a CICS environment is not recommended, and for this reason the DB2 JDBC driver sets a default of autocommit(false) when running in a CICS environment, which differs from non-CICS environments where the default is autocommit(true).

Autocommit(true) **must not** be used in an enterprise bean running as part of an OTS transaction. This causes an ASPD abend, because it causes a CICS syncpoint to be taken, which is not allowed in an OTS transaction.

Syncpoint issues for explicit and default URLs

When a Java application for CICS that uses JDBC or SQLJ acquires a connection using an explicit URL, it operates in an environment similar to that of a DPL server program linked to with the SYNCONRETURN attribute. When the application program closes the explicit URL connection:

- If CICS is using the JDBC 1.2 driver, an implicit syncpoint is taken.
- If CICS is using the JDBC 2.0 driver or the DB2 Universal JDBC Driver, no implicit syncpoint is taken. However, with these drivers, the close of an explicit URL connection is only successful when on a unit of work boundary. The application must therefore take a syncpoint, by issuing a JDBC or SQLJ commit method call or a JCICS commit, prior to closing the connection. (The application could use autocommit(true) to ensure that a syncpoint is taken, but the use of this property is discouraged in the CICS environment.)

So with all levels of the JDBC driver, when the application program closes an explicit URL connection, that is the end of the unit of work.

You can overcome this restriction by acquiring the connection using a **default** URL instead of an explicit URL, or by using a DataSource that provides a default URL connection (see “Acquiring a connection to a database” on page 122). When a default URL is used, the Java application does not have to close the connection on a unit of work boundary, and no syncpoint is taken when the connection is closed (provided that autocommit(true) has not been specified).

It is recommended that you always use default URL connections in a CICS environment.

CICS abends during JDBC or SQLJ requests

CICS abends issued whilst processing an EXEC SQL request built by the DB2-supplied JDBC driver are not converted into Java Exceptions, and therefore are not catchable by a Java application for CICS. The CICS transaction will abend and rollback to the last syncpoint.

Using JDBC and SQLJ in enterprise beans: special considerations

From CICS enterprise beans, you can use the JDBC 1.2 driver, the JDBC 2.0 driver, or the DB2 Universal JDBC Driver supplied by DB2. As the JDBC 2.0 driver and the DB2 Universal JDBC Driver are downward compatible, enterprise beans that were written using the JDBC 1.2 API can run using the newer drivers, and can benefit from performance improvements made in those drivers.

Open transaction environment (OTE) exploitation also benefits the performance of enterprise beans that make DB2 requests. (See “Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming” on page 106 for an full explanation of how application programs can exploit the open transaction environment.) With DB2 Version 5 and earlier, CICS did not exploit the open transaction environment, and four TCB switches were needed for each DB2 request made by an enterprise bean:

1. A switch from the enterprise bean's TCB to the CICS QR TCB, where the CICS DB2 task-related user exit was invoked.
2. A switch to one of the TCBs managed by the task-related user exit, where the DB2 subtask was carried out.
3. A switch to return to the task-related user exit on the CICS QR TCB.
4. A final switch to return to the enterprise bean on its TCB.

When CICS is connected to DB2 Version 6 or later, it exploits the open transaction environment, and only two TCB switches are needed for each DB2 request:

1. A switch from the enterprise bean's TCB to the L8 TCB, where the task-related user exit is invoked, and on which the DB2 requests are made.
2. A switch back to the enterprise bean's TCB.

When using JDBC and SQLJ in enterprise beans, bear in mind the following considerations:

- To use JDBC, the DB2 libraries and files required by the DB2-supplied JDBC drivers must be added to the LIBPATH and TMPREFIX settings for the JVM profile used by the request processor program. “Requirements to support Java programs in the CICS DB2 environment” on page 119 explains how to do this. The default request processor program DFJIIRP (used by the CICS-supplied CIRP request processor transaction) uses the JVM profile DFHJVMCD.
- As for all Java programs in the CICS environment, it is better to use a default URL, rather than an explicit URL, when obtaining a JDBC connection or an SQLJ connection context (see “Committing a unit of work” on page 129 for more information).
- For enterprise beans, it is particularly important to avoid using the autocommit property of a JDBC connection. Autocommit(true) **must not** be used in an enterprise bean running as part of an OTS transaction; this causes an ASPD abend, because it causes a CICS syncpoint to be taken, which is not allowed in an OTS transaction. For the same reason, do not use EXEC CICS SYNCPOINT, JCICS commit, or JDBC or SQLJ commit commands in any program or enterprise bean running as part of an OTS transaction.
- Remember that only one connection or connection context can be open at a time. An enterprise bean using JDBC or SQLJ should close the JDBC connection or SQLJ connection context before invoking methods on another enterprise bean that also wishes to use JDBC or SQLJ within the same CICS transaction context. Using a default URL ensures that no syncpoint is taken when the close occurs.
- DROLLBACK(YES) should not be specified on a DB2ENTRY definition or the DB2CONN pool definition used by transactions running enterprise beans as part of an OTS transaction. With this attribute, if a deadlock is detected, the CICS DB2 attachment facility issues a CICS syncpoint rollback request, which is not allowed in an OTS transaction, and an ASPD abend results. Enterprise beans should use DROLLBACK(NO), and test for an SQLException with an SQLCODE of —913 and issue an OTS rollback request.

Chapter 9. Preparing CICS DB2 programs for execution and production

This chapter discusses program preparation in a CICS DB2 environment:
- "The CICS DB2 test environment"
- "CICS DB2 program preparation steps" on page 134
- "What to bind after a program change" on page 137
- "Bind options and considerations for programs" on page 138
- "CICS DB2 program testing and debugging" on page 139
- "Going into production: checklist for CICS DB2 applications" on page 139
- "Tuning a CICS application that accesses DB2" on page 142

For information on support for Java programs and enterprise beans in the CICS DB2 environment, see Chapter 8, "Using JDBC and SQLJ to access DB2 data from Java programs and enterprise beans written for CICS," on page 117.

This chapter contains Diagnosis, Modification or Tuning information.

The CICS DB2 test environment

You can connect more than one CICS system to the same DB2 system. However, the CICS DB2 attachment facility does not allow you to connect one CICS system to more than one DB2 system at a time.

You can set up production and test environments with:
- A single CICS system connected to one DB2 system
- Two or more CICS systems for production and test, connected to the same DB2 system
- Two or more CICS systems, as above, connected to two or more different DB2 systems

The first alternative, using a single CICS system for both production and test, is not recommended. In releases of CICS before CICS Transaction Server for OS/390, Version 1 Release 2, this was not recommended because the RCT could not be dynamically changed. You can now change the CICS DB2 definitions using RDO without stopping the attachment facility. Programs, transactions, maps, terminals and DB2 definitions can all be dynamically added to a running system. However, this environment is still not recommended, because applications in test could affect the performance of the production system.

The second alternative, with just one DB2 system, could be used for both test and production. Whether it is suitable depends on the development and production environments involved. Running a test CICS system and a production CICS system separately allows test failures without impacting production.

The third alternative, with, for example, one test and one production DB2 system, is the most flexible. Two CICS subsystems can run with one or more DB2 systems. Where the CICS systems are attached to different DB2 systems:
- User data and the DB2 catalog are not shared. This is an advantage if you want to separate test data from production data.
- Wrong design or program errors in tested applications do not affect the performance in the production system.

- Authorization within the test system can be less strict because production data is not available. When two CICS systems are connected to the same DB2 system, authorization must be strictly controlled, both in terms of the functions and the data that are available to programmers.

CICS DB2 program preparation steps

The steps shown in Figure 33 summarize how to prepare your program for execution after your application program design and coding is complete.

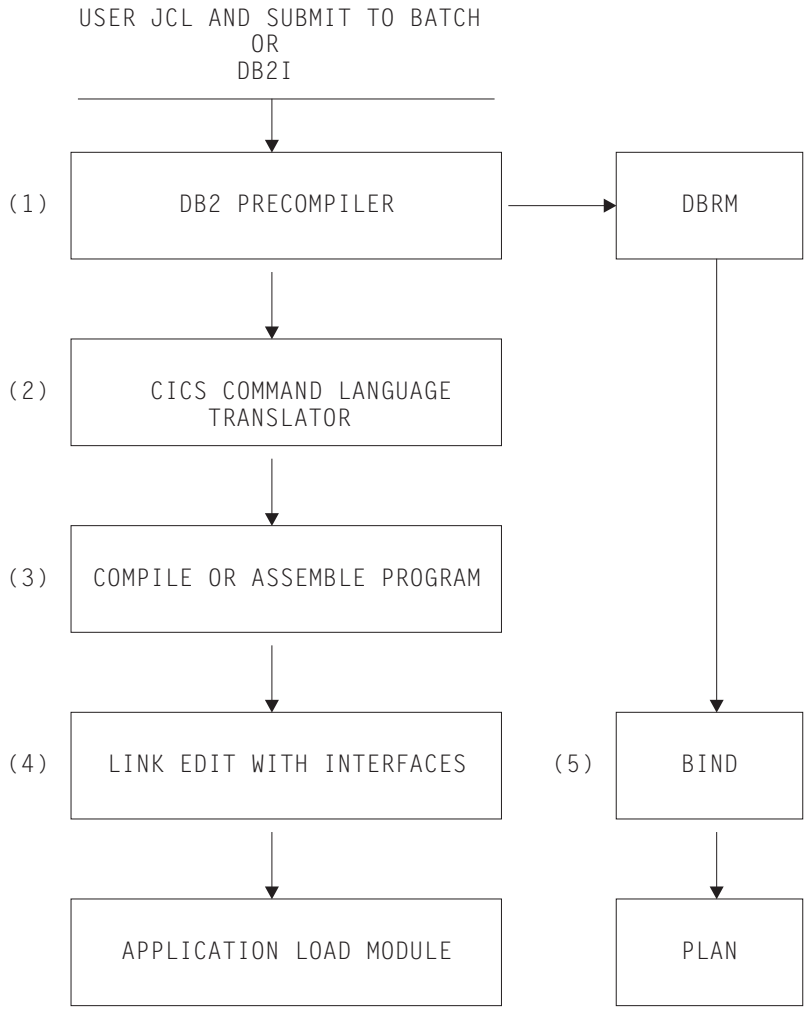


Figure 33. Steps to prepare a CICS application program that accesses DB2

For an overview of the stages in this process, see “Preparing a CICS application program that accesses DB2” on page 11.

When you prepare CICS application programs that access DB2:

- The DB2 precompiler (Step 1) builds a DBRM that contains information about each of the program's SQL statements. It also validates SQL statements in the program. For more information about using the DB2 precompiler, see the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide*.

- If the source program is written in PL/I, the input to Step 1, the DB2 precompiler, is the output from the PL/I macro phase (if used).
- You can run Step 1, the DB2 precompiler, and Step 2, the CICS command language translator, in either sequence. The sequence shown is the preferred method, and it is the method supported by the DB2I program preparation panels. If you run the CICS command language translator first, it produces a warning message for each EXEC SQL statement it encounters, but these messages have no effect on the result.
- If you use one of the Language Environment-conforming compilers (COBOL and PL/I) that has integrated the CICS translator, translation of the EXEC CICS commands (Step 2) takes place during program compilation (Step 3). See the *CICS Application Programming Guide* for more information on the integrated CICS translator and the compilers that support it.
- If you are running DB2 Version 7 or later and preparing a COBOL or PL/I program using one of the Language Environment-conforming COBOL or PL/I compilers, the compiler also provides an SQL statement coprocessor (which produces a DBRM), so you do not need to use the separate DB2 precompiler (Step 1). See the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide* for more information on using the SQL statement coprocessor.
- If you are running DB2 Version 6 or earlier and preparing a COBOL or PL/I program, use the separate DB2 precompiler. For a COBOL program, ensure that you specify a string delimiter that is the same for the DB2 precompiler and the integrated CICS translator. The default delimiters are not compatible.
- In the link edit of the program (Step 4), include both the appropriate CICS EXEC interface module, or stub, for the language in which you are coding, and the CICS DB2 language interface module DSNCLI. The CICS EXEC interface module *must* be included first in the load module. (For more information on the CICS EXEC interface modules, see the *CICS Application Programming Guide*.) You can link DSNCLI with your program in either 24-bit or 31-bit addressing mode (AMODE=31). If your application program runs in 31-bit addressing mode, you should link-edit the DSNCLI stub to your application with the attributes AMODE=31 and RMODE=ANY so that your application can run above 16MB.
- The bind process (Step 5) requires DB2. The bind process uses the DBRM to produce an application plan (often just called a plan) which enables the program to access DB2 data. See “The bind process” on page 12 for more information on the bind process. Note that a group of transactions using the same entry thread (in other words, specified in the same DB2ENTRY) must use the same application plan. Their DBRMs must be bound into the same application plan, or bound into packages that are then listed in the same application plan.

Table 9 shows the tasks that you need to perform to prepare a CICS DB2 program, depending on the language of the program and on your version of DB2:

Table 9. Tasks to prepare a CICS program that accesses DB2

DB2 version and program language	Step 1 (SQL statement processing)	Step 2 (CICS command translation)	Step 3 (Program compile)	Step 4 (Link-edit)	Step 5 (Bind)
DB2 V6 and Assembler	DB2 precompiler	CICS-supplied separate translator	Language compiler	Link-edit with EXEC interface and DSNCLI	Bind process

Table 9. Tasks to prepare a CICS program that accesses DB2 (continued)

DB2 version and program language	Step 1 (SQL statement processing)	Step 2 (CICS command translation)	Step 3 (Program compile)	Step 4 (Link-edit)	Step 5 (Bind)
DB2 V6 and PL/I	DB2 precompiler	Language compiler that supports integrated CICS translator		Link-edit with EXEC interface and DSNCLI	Bind process
DB2 V6 and COBOL	DB2 precompiler	Language compiler that supports integrated CICS translator		Link-edit with EXEC interface and DSNCLI	Bind process
DB2 V6 and other languages	DB2 precompiler	CICS-supplied separate translator	Language compiler	Link-edit with EXEC interface and DSNCLI	Bind process
DB2 V7 or V8 and Assembler	DB2 precompiler	CICS-supplied separate translator	Language compiler	Link-edit with EXEC interface and DSNCLI	Bind process
DB2 V7 or V8 and PL/I	Language compiler that supports integrated CICS translator and SQL statement coprocessor			Link-edit with EXEC interface and DSNCLI	Bind process
DB2 V7 or V8 and COBOL	Language compiler that supports integrated CICS translator and SQL statement coprocessor			Link-edit with EXEC interface and DSNCLI	Bind process
DB2 V7 or V8 and other languages	DB2 precompiler	CICS-supplied separate translator	Language compiler	Link-edit with EXEC interface and DSNCLI	Bind process

You can perform this program preparation using the DB2 Interactive Interface (DB2I) or by submitting your own JCL for batch execution.

- DB2 Interactive Interface (DB2I): DB2I provides panels to precompile, compile or assemble, and link-edit an application program and to bind the plan. For details about application program preparation, see the *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide*.
- User JCL submitted to batch execution: Members DSNTEJ5C and DSNTEJ5P in the DB2 library, SDSNSAMP, contain samples of the JCL required to prepare COBOL and PL/I programs for CICS.

If you perform this process while CICS is running, you may need to issue a CEMT NEWCOPY command to make the new version of the program known to CICS.

CICS SQLCA formatting routine

DSNTIAR, the IBM-supplied SQLCODE message formatting procedure, lets you send a sort of "SQL messages online" to your application.

With DB2 Version 3 Release 1, DSNTIAR was split into two front-end modules (DSNTIAC and DSNTIAR) and a run-time module (DSNTIA1). DSNTIAC is used for CICS applications and DSNTIAR for other DB2 interfaces. This change removed the need, previous to DB2 3.1, to relink-edit your application modules every time a change is made to DSNTIAR, either by change of release or by applying maintenance. If you have applications that have previously been link-edited with DSNTIAR, you should consider link-editing them again using DSNTIAC instead, which will provide performance improvments and isolate them from changes to DSNTIAR.

The CICS front-end part, DSNTIAC, is supplied as a source member in the DB2 library SDSNSAMP.

The necessary program definitions for DSNTIAC and DSNTIA1 are provided in IBM supplied group DFHDB2 on the CSD. You must add the SDSNLOAD library to the CICS DFHRPL concatenation (after the CICS libraries) so that DSNTIA1 can be loaded.

What to bind after a program change

For an overview of the bind process, see “The bind process” on page 12. For an overview of plans and packages, see “Plans, packages and dynamic plan exits” on page 13.

The example in Figure 34 shows a CICS transaction consisting of four program modules. It is not unusual that the number of modules is high in a real transaction. This section describes what you must do if one module is changed.

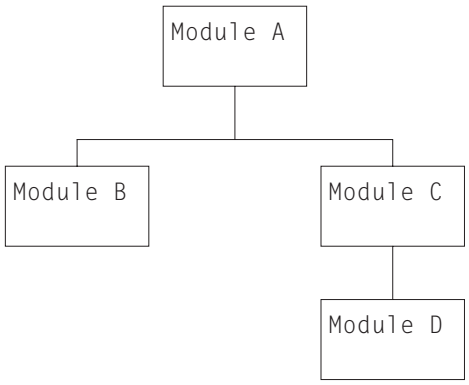


Figure 34. Application consisting of four program modules

Assuming that at least one SQL statement changed in program C, you must perform the following steps to prepare the program and to make the transaction executable again:

1. Precompile the program on DB2.
2. Translate the program using the CICS translator.
3. Compile the host language source statements.
4. Link-edit.
5. **If the DBRM for program C was bound into a package**, bind that package using the new DBRM, and all the application plans that use program C will automatically locate the new package.
6. **If the DBRM for program C was bound directly into any application plans**, locate all the application plans that include the DBRM for program C. Bind all the application plans again, using the DBRMs for all the programs directly bound into them, to get new application plans. For the programs that were not changed, use their old DBRMs. Note that you *cannot* use the REBIND subcommand, because input to REBIND is the plan and *not* the DBRMs.

If you have not used packages before, note that using packages simplifies the rebinding process. You can bind each separate DBRM as a package and include them in a package list. The package list can be included in a PLAN. You can then use the BIND PACKAGE command to bind the DBRMs for any changed programs,

instead of using the BIND PLAN command to bind the whole application plan. This provides increased transaction availability and better performance. See section “Using packages” on page 90 for more information on using packages.

Bind options and considerations for programs

See “The bind process” on page 12 for an overview of the bind process.

When binding multiple programs into an application plan, be aware of the way in which DB2 uses time stamps. For each program, the DB2 precompiler:

- Creates a DBRM with a time stamp of Td*x* (for example Td1 for the first program, Td2 for the second program, and so on).
- Creates a modified source program with a time stamp of Ts*x* in the SQL parameter list (for example Ts1 and Ts2, if two programs are involved).

At bind time, the DBRM for each program is bound into the package or plan that you have specified. In addition, DB2 updates its catalog table SYSIBM.SYSDBRM with one line for each DBRM, together with its time stamp. At execution time, DB2 checks the time stamps for each SQL statement, and returns a -818 SQL code if the time stamp for the DBRM and the time stamp it has placed in the source program are different (in our example, if Td1 and Ts1 are different, or Td2 and Ts2 are different). To avoid -818 SQL codes, use one of the following strategies:

- Bind all programs into packages, and list these packages in the application plan. When a program changes, simply precompile, compile, and link-edit the program, and bind it into a package again.
- If you bind any programs directly into application plans, ensure that for every new or changed program, you precompile, compile, and link-edit the program, then bind all the application plans that involve that program, using the DBRMs from all the programs directly bound into those plans. Use the BIND command, not the REBIND command, to do this.

When you bind a plan, a number of options are available. Almost all bind options are application dependent and should be taken into account during the application design. You should develop procedures to handle different BIND options for different plans. Also, the procedures should be able to handle changes in BIND options for the same plan over time.

The following sections describe some specific recommendations for BIND options with CICS:

RETAIN

RETAIN® means that BIND and EXECUTE authorities from the old plan are not changed.

When the RETAIN option is not used, all authorities from earlier GRANTs are REVOKED. The user executing the BIND command becomes the creator of the plan, and all authorities must be reestablished by new GRANT commands.

This is why it is recommended that you use the RETAIN option when binding your plans in the CICS environment.

Isolation level

It is recommended that you use *Cursor Stability (CS)* unless there is a specific need for using Repeatable Read (RR). This is recommended to allow a high level of concurrency and to reduce the risk of deadlocks.

Note that the isolation level is specified for the complete plan. This means that if RR is necessary for a specific module in CICS, then all the DBRMs included in the plan must also use RR.

Also, if for performance reasons you decide to group a number of infrequently used transactions together to use the same DB2ENTRY and let them use a common plan, then this new plan must also use RR, if just one of the transactions requires RR.

Plan validation time

A plan is bound with VALIDATE(RUN) or VALIDATE(BIND). VALIDATE(RUN) is used to determine how to process SQL statements that cannot be bound.

If a statement must be bound at execution time, it is rebound for each execution. This means that the statement is rebound for every new unit of work (UOW).

Binding a statement at execution time can affect performance. A statement bound at execution time is rebound for each execution. That is, the statement must be rebound after each syncpoint. It is not recommended that you use this option with CICS.

Note that using dynamic SQL does not require VALIDATE(RUN). Nevertheless, dynamic SQL implies that a statement is bound at execution.

You should use VALIDATE(BIND) in a CICS DB2 environment.

ACQUIRE and RELEASE

The general recommendations for these parameters are described in “Selecting BIND options for optimum performance” on page 62. The parameters change from plan to plan and over time, because they are related to the transaction rate.

CICS DB2 program testing and debugging

The tools that can be used in testing and debugging a CICS application program that accesses DB2 are those normally used in a CICS environment. These include:

- The execution diagnostic facility (EDF)
- The CICS auxiliary trace
- Transaction dumps.

For information about these and other problem determination processes, see Chapter 11, “Problem determination for CICS DB2,” on page 177.

Going into production: checklist for CICS DB2 applications

This checklist shows the tasks you need to perform after designing, developing, and testing an application, in order to put the application into production.

These tasks are highly dependent on the standards you have used in the test system. For example, the tasks to be performed are different if:

- There are separate DB2 systems for test and production

- Only one DB2 is used for both test and production.

The following discussion assumes that you use separate DB2 and CICS subsystems for test and production.

Going into production implies performing the following activities:

Use DDL to prepare production databases
All DDL operations must run on the production DB2 system, using DDL statements from the test system as a base. Some modifications are probably needed, for example, increasing the primary and secondary allocations, as well as defining other volume serial numbers and defining a new VCAT in the CREATE STOGROUP statements.

Migrate DCLGEN
For COBOL and PL/I programs, you may have to run DCLGEN operations on the production DB2 system, using DCLGEN input from the test DB2 system.

Depending on the option taken for compilations (if no compilations are run on the production system), an alternative could be to copy the DCLGEN output structures from the test libraries into the production libraries. This keeps all information separate between test and production systems.

Precompile for the production system
If you have bound your programs into packages on the test system, you do not need to perform this step. You can migrate the packages straight to the production system. See "Produce an application plan for the production system" below for details of how to do this. However, if you want to bind your programs directly into application plans, or if you want to bind the programs into packages on the production system, you need to put the DBRMs for the programs on the production system. You can either:

- Precompile CICS modules containing EXEC SQL statements on the production system, or
- Copy DBRMs from the test system to the production system libraries.

Compile and link-edit for the production system
To produce load modules:

- If the DBRMs were produced by precompiling on the production system, compile and link-edit the CICS modules on the production system; or
- If the DBRMs were copied, or if you are migrating packages from the test system to the production system, copy the load modules from the test system to the production system libraries.

Table 10 shows a procedure you can use to copy a changed load module from a test system to a production system library, replacing the old version of the load module.

Table 10. Migrating a changed program from the test environment to the production environment

Test system	Production system	Notes
	USER.PROD.LOADLIB(PGM3)	The original load module
USER.TEST.LOADLIB(PGM3)		The test load module
	USER.OLD.PROD.LOADLIB(PGM3)	The old version of the program is placed in other production library
	USER.PROD.LOADLIB(PGM3)	The new version of the program is placed in the production library

By selecting the production run library using the proper JCL, you can run either the old version or the new version of the program. Then the correct version of the package is run, determined by the consistency token embedded in the program load module.

Produce an application plan for the production system

If you have bound your programs into packages on the test system, you can copy the packages to the production system, including them in a collection that is listed in the application plan. When you copy a package to the production system, you do not need to bind the application plan on the production system again, as long as the package is included in a collection that is already listed in the application plan.

Table 11 shows a procedure you can use to copy a changed package from a test system to a production system library, replacing the old version of the package. This example uses the VERSION keyword at precompile time to distinguish the different versions of the packages. For a full explanation and use of the VERSION keyword, refer to *DB2 Packages: Implementation and Use*.

Table 11. Migrating a changed package from the test environment to the production environment

Test system	Production system	Notes
	location_name. PROD_COLL.PRG3.VER1	The old version of the package
location_name. TEST_COLL.PRG3.VER2		A new version of the package is bound on the test system and then copied to the production system
	location_name. PROD_COLL.PRG3.VER1	The old version is still in the production collection
	location_name. PROD_COLL.PRG3.VER2	The new version is placed in the production collection

If you want to bind your programs directly into application plans, or if you want to bind the programs into packages on the production system, you must perform the bind process on the DBRMs that you have placed on the production system. If you are binding your programs directly into application plans, you must then bind all the application plans on the production system that involve those programs. See “The bind process” on page 12 for more information on the bind process. Note that due to various factors, such as the sizes of tables and indexes, comparing the EXPLAIN output between test and production systems can be useless. Nevertheless, it is recommended that you run EXPLAIN when you first bind a plan on the production system, to check the DB2 optimizer decisions.

GRANT EXECUTE

You must grant users EXECUTE authority for the DB2 application plans on the production system.

Tests Although no further tests should be necessary at this point, stress tests are useful and recommended to minimize the occurrence of resource contention, deadlocks, and timeouts and to check that the transaction response time is as expected.

CICS definitions

To have new application programs ready to run, update the following RDO definitions on the CICS production system.

- RDO transaction definitions for new transaction codes
- RDO program definitions for new application programs and maps

- SIT for specific DB2 requirements, if it is the first DB2-oriented application going into production
- RDO DB2ENTRY and DB2TRAN definitions for the applications. RDO DB2CONN definition if it is the first DB2-oriented application going into production. When defining the new transactions and application plans in the DB2ENTRY you can use unprotected threads to get detailed accounting and performance information in the beginning. Later, you can use protected threads as needed.

In addition, if RACF is installed, you need to define new users and DB2 objects.

Tuning a CICS application that accesses DB2

Tuning a CICS application must be done in two phases:
1. Before moving an application to production
2. On a periodical basis when in production.

When moving a CICS application that accesses DB2 to production, add these checks to those already performed for CICS:

- If you are connecting CICS to DB2 Version 6 or later, check that all the application programs that make DB2 requests are threadsafe. If they are, you will be exploiting the open transaction environment (OTE), and improving the performance of the application. See “Enabling CICS DB2 applications to exploit the open transaction environment (OTE) through threadsafe programming” on page 106 for an explanation of how application programs work in the open transaction environment.
- Ensure that the number and type of SQL statements used meet the program specifications (use the DB2 accounting facility).
- Check if the number of get and updated pages in the buffer pool is higher than expected (use the DB2 accounting facility).
- Check that planned indexes are being used (use EXPLAIN), and that inefficient SQL statements are not being used.
- Check if DDL is being used and, if so, the reasons for using it (use the DB2 accounting facility).
- Check if conversational transactions are being used.

  Determine whether pseudoconversational transactions can be used instead. If conversational design is needed, check the DB2 objects that are locked across conversations. Check also that the number of new threads needed because of this conversational design is acceptable.
- Check the locks used and their duration.

  Make sure that tablespace locks are not being used because of incorrect or suboptimal specification of, for example:
  – LOCK TABLE statement
  – LOCKSIZE=TS specification
  – ISOLATION LEVEL(RR) specification
  – Lock escalation.

  This information is available in the catalog tables, except for lock escalation, which is an installation parameter (DSNZPARM).
- Check the plans used and their sizes. Even though the application plans are segmented, the more DBRMs used in the plan, the longer the time needed to BIND and REBIND the plans in case of modification. Try to use packages whenever possible. Packages were designed to solve the problems of:

  - Binding the whole plan again after modifying your SQL application. (This was addressed by dynamic plan selection, at the cost of performance.)
  - Binding each application plan if the modified SQL application is used by many applications.

When this tuning is complete, use the expected transaction load to decide on the DB2ENTRY definitions required, and the number of threads required. Check also the impact of these transactions on the DB2 and CICS subsystems.

When tuning a CICS application that accesses DB2 in production:

- Check that the CICS applications use the planned indexes by monitoring the number of GET PAGES in the buffer pool (use the DB2 accounting facility). The reasons for an index not being used may be that the index has been dropped, or that the index was created after the plan was bound.
- Use the lock manager data from the accounting facility to check on suspensions, deadlocks, and timeouts.

Chapter 10. Accounting and monitoring in a CICS DB2 environment

This chapter deals with accounting and monitoring in a CICS DB2 environment. It covers:

For advice on tuning the CICS DB2 attachment facility, see the *CICS Performance Guide*.

CICS-supplied accounting and monitoring information

CICS includes several facilities to perform the tasks of accounting and monitoring. These facilities can be used to measure the use of different resources within a CICS system. The most frequently used tools are:

- *Statistics* data. CICS statistics are the simplest tool for monitoring a CICS system. They contain information about the CICS system as a whole, such as its performance and use of resources. This makes CICS statistics suitable for performance tuning and capacity planning. CICS collects statistics during online processing, and processes them offline later. The statistics domain collects this data and then writes records to the System Management Facility (SMF) data set provided by MVS. The records are of SMF type 110. You can process these records offline using the DFHSTUP program.
- *Monitoring* data. CICS monitoring collects data about all user and CICS-supplied transactions during online processing for later offline analysis. The records produced by CICS monitoring are also of SMF type 110 and are written to the SMF data sets. Data provided by CICS monitoring is useful for performance tuning and for charging your users for the resources they use. Monitoring provides three classes of data:
  - Performance class for detailed transaction level information
  - Transaction resource data for additional transaction-level information about individual resources accessed by a transaction
  - Exception class for exceptional conditions

CICS is a multitasking address space, and CICS monitoring facilities are generally used to determine the processor time and other resources consumed by the individual transactions or functions performed by CICS.

For a full description of the CICS monitoring facilities, and details on activating, collecting, and processing this information, see the *CICS Performance Guide*, and the *CICS Customization Guide*.

For both statistics data and monitoring data, you can use an offline processing facility. CICS Performance Analyzer and Tivoli® Decision Support for OS/390 are two tools that collect and analyze data from CICS and other IBM systems and products. They can build reports that help you with:

- Systems overview
- Service levels
- Availability
- Performance and tuning
- Capacity planning

For more information on CICS Performance Analyzer and Tivoli Decision Support for OS/390, see the *CICS Performance Guide*.

DB2-supplied accounting and monitoring information

The instrumentation facility component of DB2 enables you to use six types of traces. For each trace type, you can activate a number of trace classes. You can use SMF as the trace output destination. Another alternative is to externalize the trace output under control of GTF. The types of traces are statistics, accounting, audit, performance, monitor, and global.

Statistics

Describe the total work executed in DB2. This information is not related to any specific end user. The main purposes of the DB2 statistics trace are to:

- Supply data for DB2 capacity planning.
- Assist with monitoring and tuning at the DB2 subsystem level.
- Assist in accounting for DB2 activity.

The statistics records are written at user-defined intervals. You can reset the statistical collection interval and the origination time without stopping and starting the trace by using the MODIFY TRACE command. All DB2 activity for the statistical collection interval is reported in the record. This can make it difficult to directly relate the activity to specific end users.

The DB2 statistics trace can be activated for several classes. If the statistics records are written to SMF, the SMF types are 100 and 102.

Accounting

Describes the work performed on behalf of a particular user (authorization ID from the DB2CONN or DB2ENTRY). The main purposes of the accounting records are to charge the DB2 cost to the authorization ID and perform monitoring and tuning at the program level. DB2 produces an accounting record at thread termination or when a transaction is reusing a thread with a new authorization ID. That means that if a thread is defined as protected (PROTECTNUM>0) and all transactions with the same transaction code for this DB2ENTRY use the same authorization ID, only one accounting record is produced, describing all activity done in the thread. Additionally, accounting records are written if you set ACCOUNTREC in your DB2ENTRY or DB2CONN definitions to UOW, TASK, or TXID. Setting ACCOUNTREC to these options is considered a signon, even if you use the same authorization ID.

You can activate the DB2 accounting trace for several classes. If the accounting records are written to SMF, the SMF type is 101 and 102.

Audit Collects information about DB2 security controls and is used to ensure that data access is allowed only for authorized purposes. If the audit records are written to SMF, the SMF type is 102.

Performance

Records information for a number of different event classes. The information is intended for:

- Program-related monitoring and tuning
- Resource-related monitoring and tuning
- User-related monitoring and tuning
- System-related monitoring and tuning
- Accounting-related profile creation

You can activate the DB2 performance trace for several classes. If the performance records are written to SMF, the SMF type is 102.

Monitor
Records data for *online* monitoring with user written programs

Global
Aids serviceability. If the global trace records are written to SMF, the SMF type is 102.

Monitoring a CICS DB2 environment: Overview

The objective of monitoring the CICS DB2 attachment facility is to provide a basis for accounting and tuning. To achieve this objective, you can obtain the following data:

- The number of transactions accessing DB2 resources.
- The average number of SQL statements issued by a transaction.
- The average processor usage for a transaction.
- The average response time for a transaction.
- The cost associated with particular transactions.
- Buffer pool activity associated with a transaction.
- Locking activity associated with a transaction. This includes whether table space locks are used instead of page locks, and whether lock escalation occurs, for example due to repeatable read.
- The level of thread usage for DB2ENTRYs and the pool.
- The level of thread reuse for protected threads in DB2ENTRYs.

You should also monitor your test environment to:

- Check that new programs function correctly (that is, use the correct call sequence) against test databases.
- Detect any performance problems due to excessive I/O operations or inefficient SQL statements.
- Detect bad design practices, such as holding DB2 resources across screen conversations.
- Set up optimum locking protocols to balance application isolation needs with those of existing applications.

Include monitoring in the acceptance procedures for new applications, so that any problems not detected during the test period can be quickly identified and corrected.

You can use some, or all, of the following tools to monitor the CICS DB2 attachment facility and CICS transactions that access DB2 resources. You can:

- Monitor the CICS DB2 attachment facility using:
  - CICS DB2 attachment facility commands
  - DB2 commands
  - CICS DB2 statistics

  See “Monitoring the CICS DB2 attachment facility” on page 148.
- Monitor CICS transactions using:
  - CICS monitoring facility (CMF)
  - CICS auxiliary trace

  See “Monitoring CICS transactions that access DB2 resources” on page 151.
- Monitor DB2 using:
  - DB2 statistics records
  - DB2 accounting records

– DB2 performance records

See “Monitoring DB2 when used with CICS” on page 152.

- Monitor the CICS system (for example, the dispatcher) with CICS statistics. See “Monitoring the CICS system in a CICS DB2 environment” on page 156.

Monitoring the CICS DB2 attachment facility

You monitor the CICS DB2 attachment facility by using commands addressed to both DB2 and the CICS DB2 attachment facility itself.

Monitoring the CICS DB2 attachment facility using CICS DB2 attachment facility commands

You can monitor the status of CICS-DB2 threads, and the corresponding CICS transactions using them, using the DSNC DISPLAY PLAN or TRAN command provided by the CICS DB2 attachment facility. For more information, see Chapter 4, “CICS-supplied transactions for CICS DB2,” on page 33. You can also use commands provided by CICS, such as the CEMT or EXEC CICS INQUIRE command, on the DB2CONN or on individual DB2ENTRYs. Used on the DB2CONN, the commands enable you to monitor the status of the overall connection between CICS and DB2, as well as the use of the pool. Used on an individual DB2ENTRY, the commands enable you to monitor the use of the DB2ENTRY.

Monitoring the CICS DB2 attachment facility using DB2 commands

Once a connection between CICS and DB2 is established, terminal users authorized by CICS security can use the DSNC transaction to route commands to the DB2 system. These commands are of the form:

DSNC-*DB2command*

For example, the DSNC -DIS THREAD command can show CICS DB2 threads.

The command is routed to DB2 for processing. DB2 checks that the authorization ID passed from CICS is authorized to issue the command entered.

Responses are routed back to the originating CICS user. The command recognition character (CRC) of a hyphen, (-), must be used to distinguish DB2 commands from CICS DB2 attachment facility commands. For DB2 commands issued from CICS, the CRC is always **-**, regardless of the subsystem recognition character.

Both CICS and DB2 authorization are required to issue DB2 commands from a CICS terminal:

- CICS authorization is required to use the DSNC transaction, and
- DB2 authorization is required to issue DB2 commands.

For more information see Chapter 4, “CICS-supplied transactions for CICS DB2,” on page 33.

Monitoring the CICS DB2 attachment facility using CICS DB2 statistics

In addition to the limited statistics output by the DSNC DISP STAT command and those output to the STATSQUEUE destination of the DB2CONN during attachment facility shutdown, a more comprehensive set of CICS DB2 statistics can be collected using standard CICS statistics interfaces:

- The EXEC CICS COLLECT statistics command accepts the DB2CONN keyword to allow CICS DB2 global statistics to be collected. CICS DB2 global statistics are mapped by the DFHD2GDS DSECT.
- The EXEC CICS COLLECT statistics command accepts the DB2ENTRY() keyword to allow CICS DB2 resource statistics to be collected for a particular DB2ENTRY. CICS DB2 resource statistics are mapped by the DFHD2RDS DSECT.
- The EXEC CICS PERFORM STATISTICS command accepts the DB2 keyword to allow the user to request that CICS DB2 global and resource statistics to be written out to SMF.

The CICS DB2 global and resource statistics are described in detail in the *CICS Performance Guide*.

CICS DB2 statistics are supported for all types of CICS statistics, namely:

- Requested statistics - CICS DB2 statistics are written as a result of an EXEC CICS PERFORM STATISTICS RECORD command with the DB2 keyword.
- Requested reset statistics - a special case of requested statistics in which the statistics counters are reset after collection.
- Interval statistics - statistics written when a requested interval expires.
- End of day statistics - a special case of interval statistics.
- Unsolicited statistics - CICS writes DB2 global and resource statistics to SMF when the attachment facility is shut down. Also, DB2 resource statistics are written to SMF when a DB2ENTRY is discarded.

The CICS sample statistics program, DFH0STAT, supports DB2 statistics. It uses EXEC CICS COLLECT STATISTICS commands with the DB2CONN and DB2ENTRY keywords to collect statistics. It also uses EXEC CICS INQUIRE commands for the DB2CONN and DB2ENTRYs to collect data. An example of the output from DFH0STAT is shown in Figure 35 on page 150.

DB2 Connection

```
  DB2 Connection Name. . . . . . . . . . . :  RCTJT
  DB2 Group ID . . . . . . . . . . . . . . :                        Resync Group Member. . . . . . . . . . . : N/A
  DB2 Sysid. . . . . . . . . . . . . . . . :  DE2D
  DB2 Release. . . . . . . . . . . . . . . :   6.2.0

  DB2 Connection Status. . . . . . . . . . :  CONNECTED             DB2 Connect Date and Time . . . :  09/09/2001  10:37:19.21354
  DB2 Connection Error . . . . . . . . . . :  SQLCODE
  DB2 Standby Mode . . . . . . . . . . . . :  RECONNECT

  DB2 Pool Thread Plan Name. . . . . . . . :
  DB2 Pool Thread Dynamic Plan Exit Name . :  DSNCUEXT

  Pool Thread Authtype . . . . . . . . . . :  USERID              Command Thread Authtype. . . . . . . . . :  N/A
  Pool Thread Authid . . . . . . . . . . . :                      Command Thread Authid. . . . . . . . . . :  JTILLI1

  Signid for Pool/Entry/Command Threads. . :  SSSSSSSS

  Create Thread Error. . . . . . . . . . . :  ABEND               Message TD Queue 1. . . . . . . . . . . :  CDB2
  Protected Thread Purge Cycle . . . . . . :  00.30               Message TD Queue 2. . . . . . . . . . . :
  Deadlock Resolution. . . . . . . . . . . :  ROLLBACK           Message TD Queue 3. . . . . . . . . . . :
  Non-Terminal Intermediate Syncpoint. . . :  NORELEASE
  Pool Thread Wait Setting . . . . . . . . :  WAIT                Statistics TD Queue . . . . . . . . . . :  CDB2

  Pool Thread Priority . . . . . . . . . . :  HIGH                DB2 Accounting records by . . . . . . . :  NONE

  Current TCB Limit. . . . . . . . . . . . :        100
  Current number of TCBs . . . . . . . . . :         10
  Peak number of TCBs. . . . . . . . . . . :         10

  Current number of free TCBs. . . . . . . :          5

  Current number of tasks on TCB Readyq. . :          0
  Peak number of tasks on TCB Readyq . . . :          0

  Pool Thread Limit. . . . . . . . . . . . :          3          Number of Calls using Pool Threads. . . . . :        0
  Current number of Pool Threads . . . . . :          0          Number of Pool Thread Signons . . . . . . . :        0
  Peak number of Pool Threads. . . . . . . :          2          Number of Pool Thread Partial Signons . . . :        0
  Number of Pool Thread Waits. . . . . . . :          0          Number of Pool Thread Commits . . . . . . . :        0
                                                                 Number of Pool Thread Aborts. . . . . . . . :        0
  Current number of Pool Tasks . . . . . . :          0          Number of Pool Thread Single Phase. . . . . :        0
  Peak number of Pool Tasks. . . . . . . . :          0          Number of Pool Thread Reuses. . . . . . . . :        0
  Current Total number of Pool Tasks . . . :          0          Number of Pool Thread Terminates. . . . . . :        0

  Current number of Tasks on Pool Readyq . :          0
  Peak number of Tasks on Pool Readyq. . . :          0

  Current number of DSNC Command threads . :          0          Number of DSNC Command Calls. . . . . . . . :        0
  Peak number of DSNC Command threads. . . :          0          Number of DSNC Command Signons. . . . . . . :        0
  DSNC Command Thread Limit. . . . . . . . :          2          Number of DSNC Command Thread Terminates. . :        0
                                                                 Number of DSNC Command Thread Overflows . . :        0
```

Figure 35. Example output from DFH0STAT: the DB2 Connection report

```
Applid IYK2Z2G1  Sysid JOHN  Jobname CI13JTD5    Date 09/09/2001  Time 10:38:50              CICS 6.2.0              PAGE     3

DB2 Entries

  DB2Entry Name. . . . . . . . . . . . . . :  XP05                DB2Entry Status . . . . . . . . . . . . :  ENABLED
  DB2Entry Static Plan Name. . . . . . . . :  TESTP05            DB2Entry Disabled Action. . . . . . . . :  POOL
  DB2Entry Dynamic Plan Exit Name. . . . . :                     DB2Entry Deadlock Resolution. . . . . . :  ROLLBACK

  DB2Entry Authtype. . . . . . . . . . . . :  N/A               DB2Entry Accounting records by. . . . . :  NONE
  DB2Entry Authid. . . . . . . . . . . . . :  JTILLI1

                                                                 Number of Calls using DB2Entry. . . . . . . :      16,500
  DB2Entry Thread Wait Setting . . . . . . :  WAIT               Number of DB2Entry Signons. . . . . . . . . :          10
                                                                 Number of DB2Entry Partial Signons. . . . . :           0
  DB2Entry Thread Priority . . . . . . . . :  HIGH               Number of DB2Entry Commits. . . . . . . . . :           0
  DB2Entry Thread Limit. . . . . . . . . . :          10         Number of DB2Entry Aborts . . . . . . . . . :           0
  Current number of DB2Entry Threads . . . :           0         Number of DB2Entry Single Phase . . . . . . :       5,500
  Peak number of DB2Entry Threads. . . . . :          10         Number of DB2Entry Thread Reuses. . . . . . :       5,031
                                                                 Number of DB2Entry Thread Terminates. . . . :         464
  DB2Entry Protected Thread Limit. . . . . . . . . . :         5 Number of DB2Entry Thread Waits/Overflows . :         306
  Current number of DB2Entry Protected Threads . . . :         5
  Peak number of DB2Entry Protected Threads. . . . . :         5

  Current number of DB2Entry Tasks . . . . . . . . . :         0
  Peak number of DB2Entry Tasks. . . . . . . . . . . :        28
  Current Total number of DB2Entry Tasks . . . . . . :     5,500

  Current number of Tasks on DB2Entry Readyq . . . . :         0
  Peak number of Tasks on DB2Entry Readyq. . . . . . :        18
```

Figure 36. Example output from DFH0STAT: the DB2 Entries report

Important statistics fields to look at as regards performance and tuning are:

- The number of calls made using a thread from a DB2ENTRY or the pool, and the number of thread reuses (that is, the number of times an existing thread was reused). Thread reuse is reported for each DB2ENTRY, and (in the DB2 Connection statistics) for the pool. Thread reuse is good for performance, because it avoids the overhead of creating a thread for each CICS transaction or each unit of work. The use of protected threads can increase thread reuse.
- If THREADWAIT(YES) is specified, the peak number of tasks on the readyq waiting for a thread. It is better to limit transactions using a transaction class rather than allow them to queue for threads.
- In the DB2 Connection statistics, check the field “Peak number of tasks on Pool Readyq”, and also the field “Peak number of Tasks on TCB Readyq”. If the latter is nonzero, tasks were queued waiting to use a TCB (or, when CICS is connected to DB2 Version 6 or later, waiting for a DB2 connection to use with their open TCBs), rather than waiting for a thread. The tasks were queued because the TCBLIMIT, the maximum number of TCBs that can be used to control threads into DB2, had been reached. This shows that the number of threads available (the sum of the THREADLIMIT values for the pool, for command threads and for all DB2ENTRYs) exceeds the number of TCBs allowed. TCBLIMIT or the THREADLIMIT values should be adjusted in this case.

Monitoring CICS transactions that access DB2 resources

CICS provides accounting and monitoring facilities for the resources needed by CICS transactions within the CICS address space. Three types of records can be produced:

- Performance records that record the resources used by each transaction in the CICS address space.
- Transaction resource data to record additional information about individual resources accessed by a transaction
- Exception records that record shortages of resources.

The CICS performance class monitoring records include the following DB2-related data fields, in the group DFHDATA:

DB2REQCT (180)

The total number of DB2 EXEC SQL and instrumentation facility interface (IFI) requests issued by a transaction.

DB2RDYQW (187)

The elapsed time the transaction waited for a DB2 thread to become available.

DB2CONWT (188)

When CICS is connected to DB2 Version 5 or earlier, the elapsed time the transaction waited for a CICS DB2 subtask to become available; or, when CICS is connected to DB2 Version 6 or later, the elapsed time the transaction waited for a DB2 connection to become available to use with its open TCB.

DB2WAIT (189)

The elapsed time the transaction waited for DB2 to service the DB2 requests issued by the transaction. When CICS is connected to DB2 Version 6 or later, this figure does not apply and is zero.

CICS monitoring is used in the CICS DB2 environment with the DB2 accounting facility, to monitor performance and to collect accounting information.

For more information about matching up CICS performance class records and DB2 accounting records, see “Relating DB2 accounting records to CICS performance class records” on page 161. For more information about calculating processor consumption, see “Accounting for processor usage in a CICS DB2 environment” on page 167.

You can use the CICS auxiliary trace facility to trace SQL calls issued by a CICS application program.

For more information about trace output by the CICS DB2 attachment facility, see Chapter 11, “Problem determination for CICS DB2,” on page 177.

Monitoring DB2 when used with CICS

Using SMF and/or GTF records produced by DB2, the user can monitor DB2 when used with CICS . The DB2 performance monitor (DB2PM) program product is useful to provide reports based on:

- Statistics records
- Accounting records
- Performance records

The reports in this topic are shown as examples. Refer to the documentation of the DB2PM release you are using for the format and meaning of the fields involved in the reports.

Monitoring DB2 using the DB2 statistics facility

DB2 produces statistical data on a subsystem basis at the end of each time interval, as specified at installation time. This data is collected and written to the SMF and GTF data set only if the facility is active. For more information about activating these facilities and directing the output to SMF and GTF, see “Issuing

commands to DB2 using DSNC" on page 34, and "Starting GTF for DB2 accounting, statistics and tuning" on page 31.

Data related to the system services address space is written as SMF instrumentation facility component identifier (IFCID) 0001 records. Data related to the database services address space is written as SMF IFCID 0002 records. Refer to the *DB2 Universal Database for OS/390 and z/OS Administration Guide* for a description of these records.

These statistics are useful for tuning the DB2 subsystem, since they reflect the activity for all subsystems connected to DB2.

It is difficult to interpret this data when more than one subsystem is connected to DB2 (that is, both CICS and TSO). However, the counts obtained while running the CICS DB2 attachment facility in a controlled environment (that is, with CICS as the only subsystem connected, or with limited TSO activity) can be very useful.

The *DB2 Universal Database for OS/390 and z/OS Administration Guide* shows and analyzes, from a DB2 viewpoint, the statistical data reported for the database and system services address spaces. Included here is a reduced version of the statistics report. You can use this report to monitor the average CICS transaction. Figure 37 on page 154 shows a small part of the report provided by DB2PM. Refer to the *DB2 Universal Database for OS/390 and z/OS Administration Guide* for additional information on these reports.

```
   LOCATION: DSN710P2              DB2 PERFORMANCE MONITOR (V7)
      GROUP: DSN710P2              STATISTICS REPORT - LONG
     MEMBER: DF2D
  SUBSYSTEM: DF2D
DB2 VERSION: V7                                  SCOPE: MEMBER

SQL DML                      QUANTITY  /SECOND  /THREAD  /COMMIT
---------------------------  --------  -------  -------  -------
SELECT                           1.00     0.00     0.05     0.02
INSERT                           9.00     0.00     0.41     0.21
UPDATE                           0.00     0.00     0.00     0.00
DELETE                           0.00     0.00     0.00     0.00

PREPARE                         17.00     0.00     0.77     0.40
DESCRIBE                        34.00     0.00     1.55     0.79
DESCRIBE TABLE                   0.00     0.00     0.00     0.00
OPEN                            31.00     0.00     1.41     0.72
CLOSE                           26.00     0.00     1.18     0.60
FETCH                          827.00     0.00    37.59    19.23

TOTAL                          945.00     0.00    42.95    21.98


SQL DCL                      QUANTITY  /SECOND  /THREAD  /COMMIT
---------------------------  --------  -------  -------  -------
LOCK TABLE                       0.00     0.00     0.00     0.00
GRANT                            0.00     0.00     0.00     0.00
REVOKE                           0.00     0.00     0.00     0.00
SET HOST VARIABLE                0.00     0.00     0.00     0.00
SET CURRENT SQLID                0.00     0.00     0.00     0.00
SET CURRENT DEGREE               0.00     0.00     0.00     0.00
SET CURRENT RULES                0.00     0.00     0.00     0.00
SET CURRENT PATH                 0.00     0.00     0.00     0.00
SET CURRENT PRECISION            0.00     0.00     0.00     0.00

CONNECT TYPE 1                   0.00     0.00     0.00     0.00
CONNECT TYPE 2                  29.00     0.00     1.32     0.67
RELEASE                          0.00     0.00     0.00     0.00
SET CONNECTION                   0.00     0.00     0.00     0.00

ASSOCIATE LOCATORS               0.00     0.00     0.00     0.00
ALLOCATE CURSOR                  0.00     0.00     0.00     0.00

HOLD LOCATOR                     0.00     0.00     0.00     0.00
FREE LOCATOR                     0.00     0.00     0.00     0.00

TOTAL                           29.00     0.00     1.32     0.67
```

Figure 37. Sample statistics report from DB2PM (Part 1 of 2)

```
SUBSYSTEM SERVICES           QUANTITY  /SECOND  /THREAD  /COMMIT
--------------------------  --------  -------  -------  -------
IDENTIFY                       23.00     0.00     1.05     0.53
CREATE THREAD                  22.00     0.00     1.00     0.51
SIGNON                         39.00     0.00     1.77     0.91
TERMINATE                      57.00     0.00     2.59     1.33
ROLLBACK                        8.00     0.00     0.36     0.19

COMMIT PHASE 1                  0.00     0.00     0.00     0.00
COMMIT PHASE 2                  0.00     0.00     0.00     0.00
READ ONLY COMMIT                0.00     0.00     0.00     0.00

UNITS OF RECOVERY INDOUBT       0.00     0.00     0.00     0.00
UNITS OF REC.INDBT RESOLVED     0.00     0.00     0.00     0.00

SYNCHS(SINGLE PHASE COMMIT)    35.00     0.00     1.59     0.81
QUEUED AT CREATE THREAD         0.00     0.00     0.00     0.00
SUBSYSTEM ALLIED MEMORY EOT     0.00     0.00     0.00     0.00
SUBSYSTEM ALLIED MEMORY EOM     0.00     0.00     0.00     0.00
SYSTEM EVENT CHECKPOINT         3.00     0.00     0.14     0.07


CPU TIMES                              TCB TIME         SRB TIME       TOTAL TIME          /THREAD          /COMMIT
-----------------------------  ---------------  ---------------  ---------------  ---------------  ---------------
SYSTEM SERVICES ADDRESS SPACE      17:40.602755      1:09.182200     18:49.784954        51.353862        26.274069
DATABASE SERVICES ADDRESS SPACE        6.100449        11.626277        17.726726         0.805760         0.412249
IRLM                                   0.051894      2:43.867972      2:43.919867         7.450903         3.812090
DDF ADDRESS SPACE                      1.195607         0.212343         1.407950         0.063998         0.032743

TOTAL                              17:47.950705      4:04.888792     21:52.839497        59.674523        30.531151
```

Figure 37. Sample statistics report from DB2PM (Part 2 of 2)

Figure 37 on page 154 includes information about:

- *SQL DML*. This information can be used to monitor the SQL requests issued.
- *SQL DCL*. This information can be used to check whether the application is using LOCK statements.
- *Subsystem Services*. This section provides information on thread usage and signon activity. For performance reasons, thread reuse is recommended in CICS environments, to avoid the overhead of creating a thread for each CICS transaction.

Further useful information in the statistics reports, not shown in Figure 37 on page 154, is:

- *Locking* can be used to monitor the number of timeouts and deadlocks. For more information about deadlocks, see “Handling deadlocks in the CICS DB2 environment” on page 196.
- *Buffer Pool* provides information on:
  - The number of data sets opened (Data sets Opened)
  - The number of pages retrieved (GETPAGE Requests)
  - Number of I/Os (Read Operations and Write I/O Operations)

This statistical data is not checkpointed and is not retained by DB2 across restarts.

Monitoring DB2 using the DB2 accounting facility

The DB2 accounting facility output for a single transaction can be used for monitoring and tuning purposes. For information on using the DB2 accounting facility, see “DB2 accounting reports” on page 160.

Monitoring DB2 using the DB2 performance facility

The DB2 performance facility trace provides detailed information on the flow of control inside DB2. While the main purpose of this trace is to supply debugging information, it can also be used as a monitoring tool because of the timing data provided with each entry.

Due to high resource consumption, the DB2 performance trace should be used only in specific cases, where it becomes difficult to use any other tool to monitor DB2-oriented transactions.

Even in this case, only the needed classes of performance trace should be started, for only a limited time and for only the transactions that need to be carefully monitored.

Monitoring the CICS system in a CICS DB2 environment

You can monitor the activity of the CICS DB2 TCBs using the CICS dispatcher statistics. For more information, see the *CICS Performance Guide*.

For example, data in the dispatcher statistics section provides the accumulated time for each of the CICS TCBs. The field Accum/TCB is the total processor time used by the corresponding TCB. For more information about the CICS Dispatcher statistics, see the *CICS Performance Guide*.

You can obtain the total processor time used by the CICS address space from RMF™ Monitor II reports. This time is usually greater than the sum of all CICS task TCBs.

The difference between the processor time reported by RMF and the sum of CICS TCBs in the CICS dispatcher statistics report is the processor time consumed by all the other subtask TCBs. The subtasks are used for:

- DB2 threads (when CICS is connected to DB2 Version 5 or earlier)
- If DBCTL is used, processor time consumed in the DBCTL threads
- If MQSeries® is used, processor time consumed by the MQSeries threads

These are global performance reports and can help you determine how much of your processor time is being used by CICS.

Accounting in a CICS DB2 environment: Overview

Accounting in a CICS DB2 environment can be used to:

- Analyze the transactions being executed in the system.
- Charge back the total amount of resources consumed for a given set of transactions to a well-defined set of end users. (For simplification, the term end user is used in this chapter as the target for charging resources. The end user can be real end users, groups of end users, transactions, or any other expression for the unit to which the resources must be appointed.)

Normally the units of consumption are the processor, I/O, main storage, and so on, in some weighted proportion. A typical CICS transaction that accesses DB2, consumes resources in the operating system, the CICS system, the application code, and the DB2 address spaces. Each of these components can produce data, which can be used as input to the accounting process. You can combine the output from the different sources to create a complete picture of resource usage for a transaction.

A normal requirement of an accounting procedure is that the results calculated are repeatable, which means that the cost of a transaction accessing a set of data should be the same whenever the transaction is executed. In most cases, this means that the input data to the accounting process should also be repeatable.

When planning the accounting strategy for your CICS DB2 environment, you need to:

- Decide the types of DB2 accounting data to use in your accounting process (processor usage, I/O, calls, and so on). “Accounting information provided by the DB2 accounting facility” tells you about the accounting data that you can obtain from the DB2 accounting facility.
- Decide how you are going to relate the data from the DB2 accounting record for each transaction to the CICS performance class data for that transaction, to create a complete picture of resource usage for the transaction. “Relating DB2 accounting records to CICS performance class records” on page 161 tells you how you can match up the two types of data.
- Decide whether you are going to relate the CICS performance records and the DB2 accounting records for each transaction back to the specific end user, or whether you are going to define and calibrate a number of model transactions, measure these transactions in a controlled environment, and count only the number of model transactions executed by each end user. “Matching DB2 accounting records and CICS performance class records to the end user” on page 164 gives suggestions for when each method is most appropriate.

If you have decided to use processor usage as the basis for your accounting, “Accounting for processor usage in a CICS DB2 environment” on page 167 has more information on the different classes of processor time that are reported in the DB2 accounting records, and on how to calculate the total processor time used by a transaction.

Accounting information provided by the DB2 accounting facility

The DB2 accounting facility provides detailed statistics on the use of DB2 resources by CICS transactions. You can use DB2 accounting records as the basis for the accounting and tuning of DB2 resources used by CICS transactions. “Data types in DB2 accounting records” discusses the types of data in DB2 accounting records.

DB2 gathers accounting data on an authorization ID within thread basis. When requested, the accounting facility collects this data and directs it to SMF, GTF, or both when the thread is terminated or when the authorization ID is changed. For information about activating the DB2 accounting facility and directing the output to SMF and GTF, see “Starting SMF for DB2 accounting, statistics and tuning” on page 31, and “Starting GTF for DB2 accounting, statistics and tuning” on page 31. See the *DB2 Universal Database for OS/390 and z/OS Administration Guide* for information on the general structure of DB2 SMF and GTF records.

The identification section of each DB2 accounting record written to SMF and GTF provides a number of keys on which the data can be sorted and summarized. These include the authorization ID, the transaction ID, the plan name, and the package name.

The DB2 Performance Monitor (DB2PM) program product provides accounting reports taken from the DB2 accounting records. “DB2 accounting reports” on page 160 shows examples of these reports.

Data types in DB2 accounting records

The *DB2 Universal Database for OS/390 and z/OS Administration Guide* has details on the individual fields in the DB2 accounting record. This section provides an overview of the different types of data in DB2 accounting records.

The following data types can be used for accounting:

You have several possibilities for defining a cost formula based on the DB2 accounting records.

- Where repeatability combined with a reasonable expression for the complexity of the transactions has high priority, then the processor usage, the GETPAGE count, and the set write intents count are good candidates.
- If the purpose of the accounting process is to analyze the behavior of the CICS transactions, then any information in the DB2 accounting records can be used.

Processor usage

The processor usage information given in the DB2 accounting record shows in most cases the greater part of the total processor time used for the SQL calls. The DB2 statistics records report processor time used in the DB2 address spaces that could not be related directly to the individual threads.

You should consider distributing the processor time reported in the DB2 statistics records proportionally between all users of the DB2 subsystem (transactions, batch programs, TSO users).

The amount of processor time reported in the DB2 accounting records is (for the same work) relatively repeatable over time.

See "Accounting for processor usage in a CICS DB2 environment" on page 167 for more detail on reporting processor usage in a CICS DB2 environment.

I/O

In a DB2 system, the I/O can be categorized in these types:
Synchronous read I/O
Sequential prefetch (asynchronous reads)
Asynchronous writes
EDM pool reads (DBDs and plan segments)
Log I/O (mainly writes).

Of these five I/O types, only the synchronous read I/O is recorded in the DB2 accounting record.

The number of sequential prefetch read requests is also reported, but the number of read requests is not equal to the number of I/O.

None of the I/O types should be considered as repeatable over time. They all depend on the buffer sizes and the workload activity.

DB2 is not aware of any caches being used. That means that DB2 reports an I/O occurrence, even if the cache buffer satisfies the request.

GETPAGE

GETPAGE represents a number in the DB2 accounting record that is fairly constant over time for the same transaction. It shows the number of times DB2 requested a

page from the buffer manager. Each time DB2 has to read or write data in a page, the page must be available, and at least one GETPAGE is counted for the page. This is true for both index and data pages. How often the GETPAGE counter is incremented for a given page used several times depends on the access path selected. However, for the same transaction accessing the same data, the number of GETPAGEs remains fairly constant over time, but the GETPAGE algorithm can change between different releases of DB2.

If the buffer pool contains the page requested, no I/O occurs. If the page is not present in the buffer, the buffer manager requests the page from the media manager, and I/O occurs.

The GETPAGE number is thus an indicator of the activity in DB2 necessary for executing the SQL requests.

Write intents

The number of set write intents is present in the QBACSWS field of the DB2 accounting record, but the number is not related to the actual number of write I/Os from the buffer pools. The number represents the number of times a page has been marked for update. Even in a read-only transaction this number can be present, because the intended writes to the temporary work files used in a DB2 sort are also counted.

The typical case is that the number of set write intents is much higher than the number of write I/Os. The ratio between these two numbers depends on the size of the buffer pool and the workload. It is not a good measurement for write I/O activity, but does indicate the complexity of the transactions.

SQL call activity

The number and type of SQL calls executed in a transaction are reported in the DB2 accounting record. The values are repeatable over time, unless there are many different paths possible through a complex program, or the access path changes. The access path chosen can change over time (for example by adding an index).

A given SQL call can be simple or complex, depending on factors such as the access path chosen and the number of tables and rows involved in the requests.

The number of GETPAGEs is in most cases a more precise indicator of DB2 activity than the number of different SQL calls.

Transaction occurrence

A straightforward way of accounting is to track the number and type of transactions executed. Your accounting is then based on these values.

Storage

The DB2 accounting record does not contain any information about real or virtual storage related to the execution of the transactions. One of the purposes of the DB2 subsystem is to optimize the storage use. This optimization is done at the DB2 level, not at the transaction level.

A transaction uses storage from several places when requesting DB2 services. The most important places are the thread, the EDM pool, and the buffer pools.

Because no information is given in the DB2 accounting record about the storage consumption and because the storage use is optimized at the subsystem level, it is difficult to account for storage in a DB2 environment.

DB2 accounting reports

The DB2 Performance Monitor (DB2PM) program product provides accounting reports taken from the DB2 accounting records. Figure 38 and Figure 39 show examples of long and short accounting reports for a CICS transaction accessing DB2 resources.

```
   LOCATION: DSN710P2                      DB2 PERFORMANCE MONITOR (V7)                          PAGE: 1-1
      GROUP: DSN710P2                        ACCOUNTING REPORT - LONG                  REQUESTED FROM: NOT SPECIFIED
     MEMBER: DF2D                                                                                  TO: NOT SPECIFIED
  SUBSYSTEM: DF2D                           ORDER: PRIMAUTH-PLANNAME                   INTERVAL FROM: 11/05/01 10:42:31.25
DB2 VERSION: V7                                 SCOPE: MEMBER                                     TO: 11/05/01 10:51:03.70

PRIMAUTH: JTILLI1  PLANNAME: DSNJDBC

ELAPSED TIME DISTRIBUTION                                                CLASS 2 TIME DISTRIBUTION
-------------------------------------------------------------------      ------------------------------------------------------------
APPL   |================================================> 98%          CPU    |=> 3%
DB2    |                                                                 NOTACC |=> 2%
SUSP   |=> 2%                                                            SUSP   |==============================================> 95%

AVERAGE       APPL(CL.1)  DB2 (CL.2)  IFI (CL.5)    CLASS 3 SUSPENSIONS   AVERAGE TIME  AV.EVENT    HIGHLIGHTS
------------  ----------  ----------  ----------    --------------------  ------------  --------    --------------------------
ELAPSED TIME   25.435644    0.504442         N/P    LOCK/LATCH(DB2+IRLM)      0.000000      0.00    #OCCURRENCES    :        2
 NONNESTED     25.435644    0.504442         N/A    SYNCHRON. I/O             0.085908      6.50    #ALLIEDS        :        2
 STORED PROC    0.000000    0.000000         N/A     DATABASE I/O             0.085908      6.50    #ALLIEDS DISTRIB:        0
 UDF            0.000000    0.000000         N/A     LOG WRITE I/O            0.000000      0.00    #DBATS          :        0
 TRIGGER        0.000000    0.000000         N/A    OTHER READ I/O            0.042337      1.00    #DBATS DISTRIB. :        0
                                                    OTHER WRTE I/O            0.000000      0.00    #NO PROGRAM DATA:        2
CPU TIME        0.016663    0.015404         N/P    SER.TASK SWTCH            0.352902      4.00    #NORMAL TERMINAT:        2
 AGENT          0.016663    0.015404         N/A     UPDATE COMMIT            0.000000      0.00    #ABNORMAL TERMIN:        0
  NONNESTED     0.016663    0.015404         N/P     OPEN/CLOSE               0.206822      1.50    #CP/X PARALLEL. :        0
  STORED PRC    0.000000    0.000000         N/A     SYSLGRNG REC             0.024259      1.00    #IO PARALLELISM :        0
  UDF           0.000000    0.000000         N/A     EXT/DEL/DEF              0.121821      1.50    #INCREMENT. BIND:        0
  TRIGGER       0.000000    0.000000         N/A     OTHER SERVICE            0.000000      0.00    #COMMITS        :        3
 PAR.TASKS      0.000000    0.000000         N/A    ARC.LOG(QUIES)            0.000000      0.00    #ROLLBACKS      :        0
                                                    ARC.LOG READ              0.000000      0.00    #SVPT REQUESTS  :        0
SUSPEND TIME         N/A    0.481147         N/A    STOR.PRC SCHED            0.000000      0.00    #SVPT RELEASE   :        0
 AGENT               N/A    0.481147         N/A    UDF SCHEDULE              0.000000      0.00    #SVPT ROLLBACK  :        0
 PAR.TASKS           N/A    0.000000         N/A    DRAIN LOCK                0.000000      0.00    MAX SQL CASC LVL:        0
                                                    CLAIM RELEASE             0.000000      0.00    UPDATE/COMMIT   :     0.00
NOT ACCOUNT.         N/A    0.007891         N/A    PAGE LATCH                0.000000      0.00    SYNCH I/O AVG.  : 0.013217
DB2 ENT/EXIT         N/A       35.00         N/A    NOTIFY MSGS               0.000000      0.00
EN/EX-STPROC         N/A        0.00         N/A    GLOBAL CONT.              0.000000      0.00
EN/EX-UDF            N/A        0.00         N/A    FORCE-AT-COMMIT           0.000000      0.00
DCAPT.DESCR.         N/A         N/A         N/P    ASYNCH IXL REQUESTS       0.000000      0.00
LOG EXTRACT.         N/A         N/A         N/P    TOTAL CLASS 3             0.481147     11.50
```

Figure 38. Accounting long report for a CICS transaction accessing DB2 resources

```
   LOCATION: DSN710P2                      DB2 PERFORMANCE MONITOR (V7)                          PAGE: 1-1
      GROUP: DSN710P2                        ACCOUNTING REPORT - SHORT                 REQUESTED FROM: NOT SPECIFIED
     MEMBER: DF2D                                                                                  TO: NOT SPECIFIED
  SUBSYSTEM: DF2D                               ORDER: PLANNAME                        INTERVAL FROM: 11/05/01 10:42:31.25
DB2 VERSION: V7                                 SCOPE: MEMBER                                     TO: 11/05/01 10:50:14.53

                          #OCCURS #ROLLBK SELECTS INSERTS UPDATES DELETES CLASS1 EL.TIME CLASS2 EL.TIME GETPAGES SYN.READ LOCK SUS
PLANNAME                  #DISTRS #COMMIT FETCHES   OPENS  CLOSES PREPARE CLASS1 CPUTIME CLASS2 CPUTIME BUF.UPDT TOT.PREF #LOCKOUT
------------------------- ------- ------- ------- ------- ------- ------- -------------- -------------- -------- -------- --------

DSNJDBC                         1       0    0.00    0.00    0.00    0.00       1.706541       1.003194   249.00    13.00     0.00
                                0       2    4.00    2.00    2.00    2.00       0.027471       0.025984     0.00     5.00        0

TESTP05                         2       0    0.00    0.50    0.00    0.00      33.283119       0.215656     7.00     0.00     0.00
                                0       2    1.50    0.50    0.00    0.00       0.001908       0.001389     1.00     0.00        0

***  GRAND TOTAL  ***
                                3       0    0.00    0.33    0.00    0.00      22.757593       0.478169    87.67     4.33     0.00
                                0       4    2.33    1.00    0.67    0.67       0.010429       0.009587     0.67     1.67        0
```

Figure 39. Accounting short report for a CICS transaction accessing DB2 resources

Relating DB2 accounting records to CICS performance class records

To see a complete picture of the usage of resources by each CICS transaction in both the CICS and DB2 address spaces, you need to match up the data in the DB2 accounting records with the data in the CICS performance class records. When you have a complete picture, you can analyze the resources used by individual transactions, and also charge back to the end user the total amount of resources consumed for a given set of transactions, using whatever data types you have decided to include in your cost formula.

If you are examining resource usage because you are carrying out performance analysis, rather than accounting, then you always need to match up the DB2 accounting records and the CICS performance class records. However, if you are examining resource usage for accounting purposes, you might not need to match up the DB2 accounting records and the CICS performance class records. You do **not** need to match up the records if:

- You are using DB2 Version 6 or later
- **and** You have chosen to use processor time consumption as the basis for your accounting

and

- You are not using DB2 sysplex query parallelism (parallel query).

In this situation, the processor time consumed in DB2 is reported by the CICS performance class records as well as by the DB2 accounting records, so the CICS performance class record for a transaction gives you all the information on processor time that you need to charge the resources for that transaction back to the end user. If you are in this situation, skip the rest of this section, and instead read the sections “Accounting for processor usage in a CICS DB2 environment” on page 167 (to understand how processor time consumption is reported), and “Calculating CICS and DB2 processor times for DB2 Version 6 or later” on page 174 (to find out how to use the information on processor time that is available to you).

If you are using DB2 Version 5 or earlier, or you have chosen to use data as well as, or other than, processor time consumption as the basis for your accounting, read the rest of this section to find out how to match up the DB2 accounting records and the CICS performance class records. If you are using processor time consumption for your accounting, you can then read the section “Accounting for processor usage in a CICS DB2 environment” on page 167 to find out how to calculate your processor time consumption using your matched-up DB2 accounting records and CICS performance class records.

What are the issues when matching DB2 accounting records and CICS performance records?

Because CICS and DB2 have different accounting needs, it is not always easy to match up DB2 accounting records and CICS performance class records. There are two main issues involved:

1. There is not necessarily a one-to-one relationship between the CICS performance class records and the DB2 accounting records. A DB2 accounting record can contain information about one CICS transaction, multiple CICS transactions, or part of a CICS transaction.
2. The DB2 accounting records do not have a field that matches exactly with the corresponding CICS performance records.

For the purpose of charging resources back to end users, it is possible to give each end user a different authorization ID from a DB2 viewpoint, by specifying the DB2ENTRY or DB2CONN parameter AUTHTYPE as OPID, USERID, GROUP, or TERM. In this case, a DB2 accounting record is generated that contains data only for the authorization ID. You can then collect together all the DB2 accounting records by authorization ID, and charge the resources consumed directly to the end user. This method means that you do not need to match the DB2 accounting records with the CICS performance class records. However, from a usability and performance viewpoint, using OPID, USERID, GROUP, and TERM is not an attractive solution, for the reasons discussed in “Controlling access to plans” on page 84. For large networks, specifying these authorization IDs can complicate maintenance and result in performance overhead. It is preferable to plan your use of authorization IDs with performance in mind, and assign DB2 accounting records to the end user by matching them to the CICS performance class records.

This section tells you:

- What you can do to make the relationship between DB2 accounting records and CICS performance class records more straightforward.
- What information in a DB2 accounting record can be used to identify the corresponding CICS performance class records.
- What strategies you can use to match DB2 accounting records and CICS performance class records in four typical scenarios.

Controlling the relationship between DB2 accounting records and CICS performance class records

By default, DB2 always writes its accounting records at thread termination, or at the signon of a new authorization ID that is reusing the thread. If a thread is reused by a transaction that has the same CICS transaction ID and the same DB2 authorization ID as the previous transaction that used the thread, DB2 does not write an accounting record at that point. (See “Providing authorization IDs to DB2 for the CICS region and for CICS transactions” on page 74 for information about the relationship between the CICS transaction ID and the DB2 authorization ID.) This means that each DB2 accounting record for the thread can contain information about multiple CICS transactions. In addition, if different types of CICS transactions use the same transaction ID to access DB2, the DB2 accounting record can contain information about different types of CICS transactions.

There are three ways in which you can influence the relationship between DB2 accounting records and CICS performance class records, to deal with these issues:

- You could design your CICS applications so that each CICS transaction ID and DB2 authorization ID always represents the same piece of work, that consumes the same resources. This ensures that each DB2 accounting record contains either a single piece of work, or more than one occurrence of the same piece of work, and it will not contain different items. If such a DB2 accounting record contains multiple items, because the items are identical you can divide the resources used equally between them. However, it might not be practical to design your applications in this way. For example, take the case where a terminal user has a menu displayed at the terminal, and can choose different options (involving different pieces of work) for the next transaction. If the previous transaction ended by setting up the CICS transaction ID with the EXEC CICS RETURN TRANSID(zzzz) command, the next transaction runs under the transaction ID zzzz, no matter what piece of work the terminal user chooses. You might not want to re-design this application simply for accounting purposes.

- You could avoid reusing threads. This ensures that the thread terminates, and DB2 writes an accounting record, after each task, so each DB2 accounting record represents a single task. However, by doing this, you would lose the significant performance advantages of thread reuse. Also, if different types of transaction used the same transaction ID to access DB2, each DB2 accounting record could still refer to one of several possible tasks.
- You can make DB2 produce an accounting record each time a CICS task finishes using DB2 resources, by specifying ACCOUNTREC(TASK) in the DB2CONN or DB2ENTRY definition. ACCOUNTREC(TASK) is recommended rather than ACCOUNTREC(UOW). This ensures that there is at least one identifiable DB2 accounting record for each task, and the DB2 accounting record will not contain multiple tasks. Also, to solve the issue of different types of transaction using the same transaction ID to access DB2, when you specify ACCOUNTREC(TASK), CICS passes its LU6.2 token to DB2 to be included in the accounting record. You can use this token to match each DB2 accounting record to the relevant CICS transaction. Using ACCOUNTREC(TASK) is generally the most practical and complete solution to control the relationship between DB2 accounting records and CICS performance class records. It carries an overhead for each transaction, but its usefulness for accounting purposes normally outweighs this overhead.

Even if you specify ACCOUNTREC(TASK), note that DB2 can only recognize a single CICS task as long as the task continues to use the same thread. If a transaction contains more than one UOW, assuming that it releases the thread at the end of the UOW, it could use a different thread for each of its UOWs. This can happen with terminal-oriented transactions issuing multiple syncpoints (commit or rollback), and also non-terminal-oriented transactions if NONTERMREL(YES) is set in the DB2CONN. In these cases, DB2 produces an accounting record for each UOW, because it does not recognize them as a single task. So for this kind of transaction, each DB2 accounting record can contain information about only a part of the transaction, and you need to ensure that all the relevant DB2 accounting records for the transaction are identified.

Using data in the DB2 accounting record to identify the corresponding CICS performance class records

Certain fields in DB2 accounting records can help you match them to the corresponding CICS performance records. In order of usefulness, these fields are:

- The CICS LU6.2 token. If you specify either ACCOUNTREC(TASK) or ACCOUNTREC(UOW) in the DB2ENTRY or DB2CONN, CICS passes its LU6.2 token to DB2 to be included in the DB2 trace records. The token is written to QWHCTOKN in the correlation header. The presence of this token makes matching the two sets of records much more simple.
- The thread correlation ID, which contains the CICS 4-character transaction ID. Remember that if you **have not** specified ACCOUNTREC(TASK) or ACCOUNTREC(UOW), the DB2 accounting record might contain information about more than one transaction that used this ID. If you **have** specified ACCOUNTREC(TASK) or ACCOUNTREC(UOW), the DB2 accounting record might only contain part of a transaction (a single UOW), and you need to locate the other records relating to the transaction. If different types of CICS transaction use the same transaction ID, you cannot make a positive identification from this item alone.
- The authorization ID field. As for the thread correlation ID, the DB2 accounting record might contain information about more than one transaction that used this authorization ID, or it might only contain part of a transaction. The authorization ID that a CICS transaction uses is determined by the AUTHID or AUTHTYPE

parameter in the DB2CONN or DB2ENTRY. If different types of CICS transaction use the same authorization ID, you cannot make a positive identification from this item alone

- The timestamp fields. The start and end time for the thread can help identify the CICS transactions that the DB2 accounting record covers.

Matching DB2 accounting records and CICS performance class records to the end user

There is not a single ideal way of matching DB2 accounting records and CICS performance class records. In a few cases, it might be impossible to make the matching correct, because transactions are being run concurrently. In most situations, though, there are strategies you can use to match up the two types of records with reasonable accuracy.

If the resources used in the individual transaction are the basis for accounting, then when you have matched up the CICS performance records and the DB2 accounting records, you can relate them back to the specific end user. Alternatively, you can define and calibrate a number of model transactions, measure these transactions in a controlled environment, and count only the number of model transactions executed by each end user.

The two main factors that determine what strategies you should use are:

- Whether each CICS transaction ID represents only one possible transaction path (and so it always represents the same amount of resources consumed), or whether many different transaction paths share the same CICS transaction ID (so it can represent different amounts of resources consumed.
- Whether each DB2 accounting record relates to only one transaction or a part of one transaction (because you have taken one of the measures described in “Controlling the relationship between DB2 accounting records and CICS performance class records” on page 162), or whether it contains information about more than one transaction.

Figure 40 on page 165 shows how these factors combine to create four typical scenarios that you might encounter when matching DB2 accounting records and CICS performance class records. The following sections suggest strategies for matching the records in each case, and for charging the resources used back to the end user.

	One transaction in each DB2 accounting record	Many transactions in each DB2 accounting record
Each transaction path has its own transaction ID	A	B
Many different transaction paths share the same transaction ID	C	D

Figure 40. Different accounting scenarios

Scenario A: One transaction in each DB2 accounting record, with its own transaction ID

In this scenario, you know that each DB2 accounting record contains information relating to a single, identifiable CICS transaction. If the transaction accessed DB2 resources more than once, DB2 might have created more than one accounting record for it. You simply need to match the DB2 accounting records relating to the transaction, to the CICS performance record for the transaction.

The end user for the transaction can be identified from the CICS performance record. This record contains the CICS activities related to this transaction. You can identify the DB2 accounting records that apply to this transaction by using any of the data items listed in “Using data in the DB2 accounting record to identify the corresponding CICS performance class records” on page 163.

As all these transactions are identical, you can expect that they consume comparable amounts of resources. For accounting purposes, you could create model transactions for each transaction type. Because you can identify which DB2 accounting records apply to which CICS transactions, you can match up the DB2 accounting records and the CICS performance record for one transaction, and then simply assign the amount of DB2 resources used in those accounting records, to each subsequent transaction of that type. You should validate the correctness of your models on a regular basis, in case the resource usage changes.

Scenario B: Several transactions in each DB2 accounting record, but each type of transaction has its own transaction ID

In this scenario, each DB2 accounting record can contain information relating to more than one transaction, so you can't simply match each DB2 accounting record directly to the relevant CICS performance record. However, you can identify the types of transaction that are present in the DB2 accounting record, because each transaction ID only refers to one type of transaction.

If only one type of CICS transaction is present in a particular DB2 accounting record, then for accounting purposes, the resources consumed in DB2 can be split equally between each transaction. This is reasonable, because the transactions are

(by definition) almost identical. The number of commits and backouts in the DB2 accounting record indicates the number of units of work covered in this record. However, as noted in “Controlling the relationship between DB2 accounting records and CICS performance class records” on page 162, units of work in the same transaction might use a different thread, and so not be present in the same DB2 accounting record. Make sure that you have assigned all the relevant DB2 resources to each transaction; this may involve examining more than one DB2 accounting record.

If two or more different types of CICS transaction are present in a particular DB2 accounting record (because they use the same DB2ENTRY and hence the same thread), you cannot use the method of distributing the resources equally, because the different types of transaction might use different resources. In this case, you can create model transactions by periodically measuring the amount of DB2 resources used by each type of CICS transaction. Take these measurements by temporarily disallowing thread reuse, and looking at the resulting DB2 accounting records, which will contain information relating to only one transaction. Use these model transactions to charge back the resources to the end user. You should periodically validate the correctness of the model transactions.

Scenario C: One transaction in each DB2 accounting record, but several types of transaction use the same transaction ID

In this scenario, you know that each DB2 accounting record contains information relating to a single CICS transaction, but because several types of transaction use the same transaction ID, you can't be sure which type of transaction is shown by a particular DB2 accounting record.

You won't be able to match up a set of records for one instance of a transaction and then re-use those figures, as you could in Scenario A. You will need to match all the individual CICS performance records with their corresponding DB2 accounting records. Unless you do this, you won't know what type of transaction is represented by each DB2 record.

You can match each of the DB2 accounting records to the relevant CICS performance record by using the data items listed in “Using data in the DB2 accounting record to identify the corresponding CICS performance class records” on page 163. If you have specified either ACCOUNTREC(TASK) or ACCOUNTREC(UOW) in the DB2ENTRY or DB2CONN, so that CICS passes its LU6.2 token to DB2, then you can match the records together easily. If not, you will need to match the records based on their time stamps. In this case, the matching may not be accurate if transactions are being run simultaneously.

You can then use your matched sets of records to charge back the resources used for each transaction, to the end user identified by the CICS performance record.

Scenario D: Several transactions in each DB2 accounting record, and several types of transaction use the same transaction ID

In this scenario, each DB2 accounting record can contain information relating to more than one transaction, and also you can't use the transaction IDs to identify which types of transaction are present in the accounting record.

This situation is best avoided, because you are unlikely to be able to match records accurately. If you do find yourself in this situation, the best solution is to create model transactions, as described for Scenario B. Next, find a way to mark the CICS performance records with an identifier that is unique to each transaction. For example, the user could supply information in a user field in the performance

records that identifies the transaction being executed. Now you can use this field to identify which of the model transactions should be used for accounting in this case.

Accounting for processor usage in a CICS DB2 environment

This section tells you about the information on processor time consumption that is provided in the DB2 accounting and statistics trace records, and about how to calculate the total processor time used in CICS and DB2.

The DB2 *accounting trace* can be started with CLASS 1, CLASS 2, or CLASS 3. However, CLASS 1 must always be active to externalize the information collected by activating CLASS 2, CLASS 3, or both classes.

The processor times reported in the DB2 accounting records are the TCB time for the thread TCB running code in CICS or in the DB2 address space, using cross-memory services; and the SRB time for work scheduled in CICS.

CLASS 1 (the default) results in accounting data being accumulated by several DB2 components during normal execution. This data is then collected to write the DB2 accounting record. The data collection does not involve any overhead of individual event tracing.

CLASS 2 and CLASS 3 activate many additional trace points. Every occurrence of these events is traced internally, but is *not* written to an external destination. Rather, the accounting facility uses these traces to compute the additional total statistics that appear in the accounting record when CLASS 2 or CLASS 3 is activated. Accounting CLASS 1 must be active to externalize the information.

CLASS 2 collects the delta elapsed and processor times spent 'IN DB2' and records this in the accounting record.

CLASS 3 collects the I/O elapsed time and lock and latch suspension time spent 'IN DB2' and records this in the accounting record.

CLASS 7 and CLASS 8 in DB2 collect package level accounting in DB2 and package level accounting wait in DB2. For information on package level accounting, refer to the *DB2 Universal Database for OS/390 and z/OS Administration Guide*.

The *statistics trace* reports processor time in the statistics records. The processor times reported are:

- Time under a DB2 address space TCB running asynchronous of the CICS address space. Examples of this are the DB2 log and writes from the buffer pools.
- Time under SRBs scheduled under the DB2 address spaces. An example is the asynchronous read engine for sequential prefetch.

The DB2 address spaces reported in the statistics record are:

- Database manager address space
- System services address space
- IRLM.

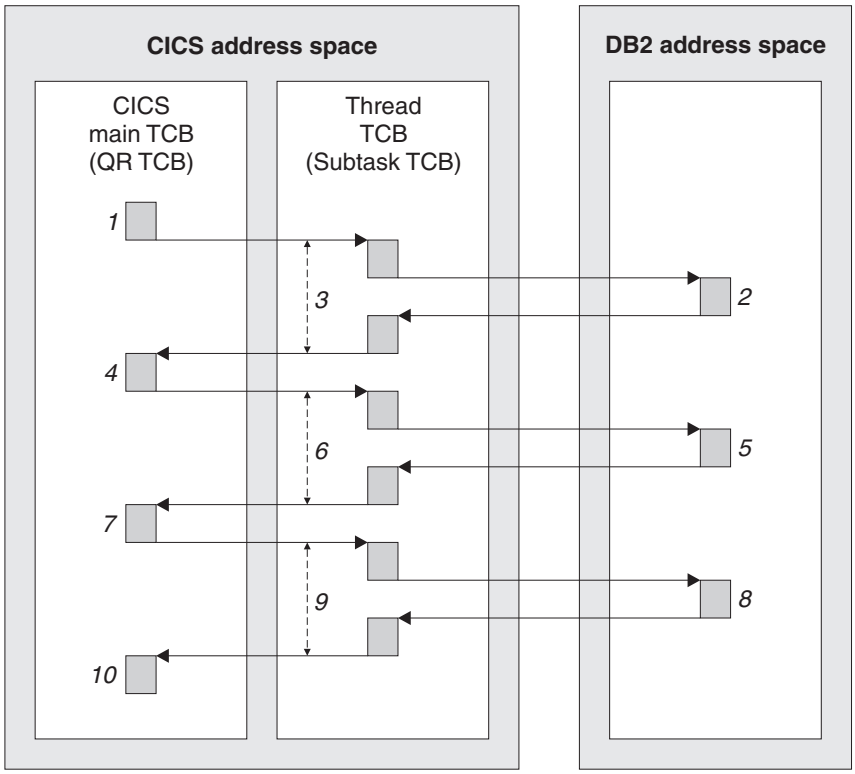
In a CICS DB2 environment, the processor time from the DB2 accounting records is typically much greater than the processor time reported in the DB2 statistical records, because most of the processor time used is in the thread TCB itself and in the DB2 address spaces using cross memory services.

DB2 accounting records are produced when a thread is terminated or signon occurs. This means that the period reported in the DB2 accounting record is the time between thread start or user signon (if reusing a thread previously used by another user) and thread termination or another signon. If several different transactions are specified for the same DB2ENTRY, and they use the same CICS transaction ID and the same DB2 authorization ID to sign on to the thread, then the DB2 accounting record for this thread can include data for more than one transaction. Also, if a transaction releases its DB2 thread at syncpoint, and the thread is terminated or re-used by another transaction, then the original transaction has to use a different thread. A single transaction can therefore be associated with multiple DB2 threads during the life of its execution. As DB2 produces accounting records for each thread, this can mean that multiple accounting records are produced for the transaction. See “Controlling the relationship between DB2 accounting records and CICS performance class records” on page 162 for information on how you can determine the transactions that are included in each DB2 accounting record.

The processor time is accurately obtainable by authorization ID within the transaction by aggregating all the accounting records for this authorization ID and transaction. Note, however, that the elapsed times associated with the accounting record would be of little value in this case, because the sum of the elapsed times does not include the time from one commit point to the first SQL call in the next UOW. The elapsed time for a thread is associated with the thread and not with the transaction.

Figure 41 on page 169 and Figure 42 on page 171 show each period of processor time that is reported by CICS and DB2, and where it takes place. The location of processing differs depending on the version of DB2 to which CICS is connected, and whether or not the application accessing DB2 is threadsafe. This is because when CICS is connected to DB2 Version 6 or later, and is exploiting the open transaction environment, the CICS DB2 attachment facility uses CICS-managed open TCBs rather than CICS DB2 subtask TCBs.

Figure 41 on page 169 shows the situation when CICS is connected to DB2 Version 5 or earlier, or when the application accessing DB2 is not threadsafe.




```
This picture shows the environment when CICS is connected
to DB2 Version 5 or earlier, or when the application
accessing DB2 is not threadsafe.

Times 3 + 6 + 9 are reported as CLASS 1 processor time
(time spent under the thread TCB)
Times 2 + 5 + 8 are reported as CLASS 2 processor time
(time spent in DB2)
Times 1 + 4 + 7 + 10 are reported as CICS processor time
(time spent on the CICS main TCB)
```

Figure 41. CICS with DB2 Version 5 or non-threadsafe application: Processor times recorded

If CICS is connected to DB2 Version 5 or earlier, it is using a subtask TCB to run the thread into DB2. If CICS is connected to DB2 Version 6 or later but the application accessing DB2 is not threadsafe, then CICS is using an open TCB to run the thread into DB2, but it is using the open TCB in the same way as it would use a subtask TCB. The TCB that CICS uses to run the thread into DB2 is called the thread TCB.

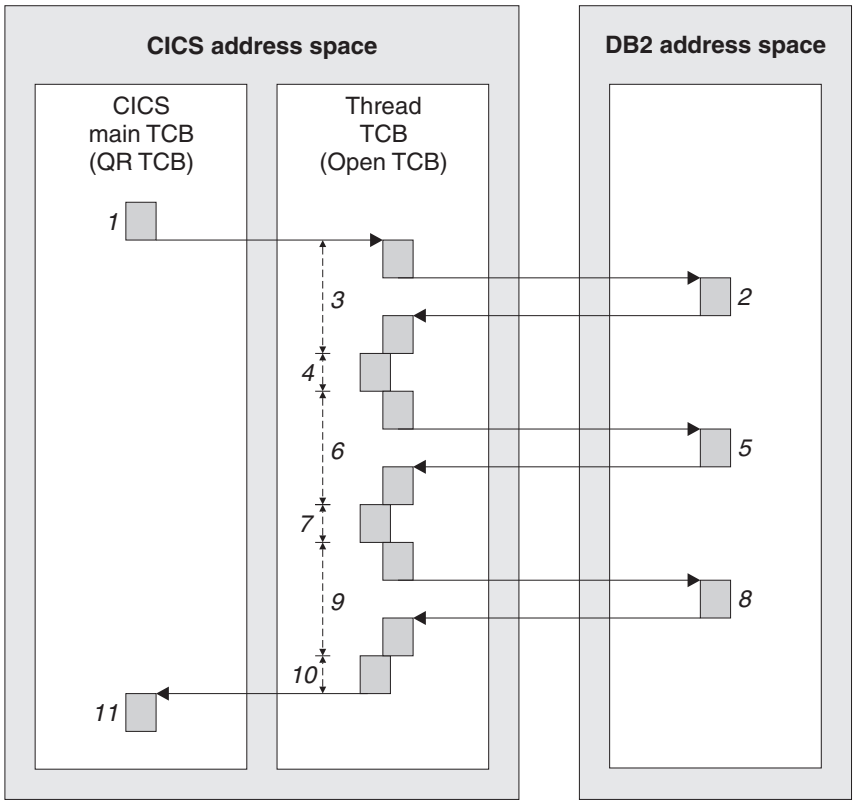
The periods of processor time shown in the figure are as follows:

- Time 1: The application starts on the CICS main TCB. At the end of Time 1, the application issues an EXEC SQL request.
- Time 2: DB2 is fulfilling the application's request. This processor time is spent in the DB2 address space. At the end of Time 2, DB2 passes its response to the CICS DB2 attachment facility.
- Time 3: The CICS DB2 attachment facility is carrying out processing on the thread TCB. This covers both the processing needed for the application to access DB2, and the processing needed to pass DB2's response back to the

application. It also includes the processor time taken for DB2 to fulfil the request and respond. Time 2 is therefore nested within Time 3. At the end of Time 3, DB2's response is passed to the application, and the access to DB2 is complete.

- Time 4: The application has finished with DB2 for the moment. The application code runs on the CICS main TCB, until the application needs to access DB2 again. At the end of Time 4, the application issues a second EXEC SQL request.
- Time 5: As for Time 2, DB2 is fulfilling the second request from the application.
- Time 6: The CICS DB2 attachment facility is carrying out processing on the thread TCB related to this second request, or waiting for a response from DB2.
- Time 7: The application code runs again on the CICS main TCB. It issues a third EXEC SQL request.
- Time 8: As for Time 2, DB2 is fulfilling a third request from the application.
- Time 9: The CICS DB2 attachment facility is carrying out processing on the thread TCB related to this third request, or waiting for a response from DB2.
- Time 10: The application has now made all its EXEC SQL requests. The application code continues to run on the CICS main TCB until it terminates.

Figure 42 on page 171 shows the situation when CICS is connected to DB2 Version 6 or later, and the application accessing DB2 is threadsafe.




```
This picture shows the environment when CICS is connected to DB2
Version 6 or later, and when the application accessing DB2 is threadsafe.

Times 3 + 4 + 6 + 7 + 9 + 10 are reported as CLASS 1 processor time
(time spent under the open TCB, processing access to DB2
and running application code)
Times 2 + 5 + 8 are reported as CLASS 2 processor time
(time spent in DB2)
Times 1 + 11 are reported as CICS processor time
(time spent on the CICS main TCB)
```

Figure 42. CICS with DB2 Version 6 and threadsafe application: Processor times recorded

Here, CICS is using an open TCB to run the thread into DB2. As the application is threadsafe, the application code can also run on the open TCB. The periods of processor time shown in the figure are as follows:

- Time 1: The application starts on the CICS main TCB. At the end of Time 1, the application issues an EXEC SQL request.
- Time 2: DB2 is fulfilling the application's request. This processor time is spent in the DB2 address space. At the end of Time 2, DB2 passes its response to the CICS DB2 attachment facility.
- Time 3: The CICS DB2 attachment facility is carrying out processing on the thread TCB. This covers both the processing needed for the application to access DB2, and the processing needed to pass DB2's response back to the application. It also includes the processor time taken for DB2 to fulfil the request and respond. Time 2 is therefore nested within Time 3. At the end of Time 3, DB2's response is passed to the application, and the access to DB2 is complete.

- Time 4: The application has finished with DB2 for the moment. As the application is threadsafe, the application code now runs on the thread TCB (the open TCB). At the end of Time 4, the application issues a second EXEC SQL request.
- Time 5: As for Time 2, DB2 is fulfilling the second request from the application.
- Time 6: The CICS DB2 attachment facility is carrying out processing on the thread TCB related to this second request, or waiting for a response from DB2.
- Time 7: The application code runs again on the thread TCB. It issues a third EXEC SQL request.
- Time 8: As for Time 2, DB2 is fulfilling a third request from the application.
- Time 9: The CICS DB2 attachment facility is carrying out processing on the thread TCB related to this third request, or waiting for a response from DB2.
- Time 10: The application has now made all its EXEC SQL requests. The application code runs again on the thread TCB.
- Time 11: The application has completed its processing. The application terminates, and processing returns to the CICS main TCB.

Note that an application that is defined as threadsafe (that is, you have told CICS that the application code is threadsafe), can still issue CICS commands that are not threadsafe. These commands force a switch back to the CICS main TCB, and the application code then continues to run on the CICS main TCB until the application makes its next EXEC SQL request. The activity associated with the non-threadsafe CICS command, and with the application code that runs on the CICS main TCB, is reported as CICS processor time, and not as CLASS 1 processor time. Once the EXEC SQL request is issued, the application code can run on the open TCB again, and is reported from then on as CLASS 1 processor time.

Accounting CLASS 1 processor time

In Figure 41 on page 169, when CICS is connected to DB2 Version 5 or earlier, CLASS 1 is the sum of the times 3, 6, and 9. In Figure 42 on page 171, when CICS is connected to DB2 Version 6 or later, CLASS 1 is the sum of the times 3, 4, 6, 7, 9, and 10.

For CLASS 1, a task processor timer is created when the TCB is attached. When a thread to DB2 starts, the timer value is saved. When the thread is terminated (or the authorization ID is changed), then the timer is checked again, and both the timer start and end values are recorded in the SMF type 101 record (the DB2 accounting record). The fields in the SMF type 101 record used for accounting CLASS 1 processor time are:

- QWACBJST for begin thread TCB time
- QWACEJST for end thread TCB time
- QWACBSRB for begin ASCB SRB time
- QWACESRB for end ASCB SRB time.

You can find a description of the contents of the DB2 accounting record in the *DB2 Universal Database for OS/390 and z/OS Administration Guide*. There is also the description of accounting record fields in member DSNWMSGS, which is shipped in SDSNSAMP.

When CICS is connected to DB2 Version 6 or later, when the CLASS 1 recording becomes active for a thread, it is recording time spent on the L8 open TCB. Because the L8 TCB is used for both CICS activity and DB2 activity, this includes processor time spent in the CICS-DB2 attachment facility, including trace calls. It also includes processor time spent running application code (if the application is threadsafe) and threadsafe CICS commands on the open TCB. If a thread is reused, the thread housekeeping processor time is also included in the CLASS 1

processor time. As in previous releases, there is a proportion of thread creation and thread termination processing that is not captured by CLASS 1 time. The CLASS 1 processor time does not include any time spent running application code on the QR TCB, which happens as follows:

- In the initial period before the application issues its first EXEC SQL request and moves on to the open TCB (time 1 in the figure). This initial application code runs on the CICS main TCB, and is not seen by DB2 accounting.
- If the application issues a CICS command that is not threadsafe. This forces processing to move back to the CICS main TCB. The application code then continues to run on the CICS main TCB, where it cannot be seen by DB2 accounting, until the application issues its next EXEC SQL request. At this point, processing can move back onto the open TCB.

When CICS is connected to DB2 Version 5 or earlier, CLASS 1 processor time does not include any processor time spent in application code, because all application code is executed under the QR TCB.

When CICS is connected to DB2 Version 6 or later, unless you are using DB2
sysplex query parallelism (parallel query), you do not need to use the DB2 CLASS
1 processor time for accounting purposes. The processor time recorded in the CICS SMF type 110 record is all that is required to give a complete account of the processor time consumed by an application. This record includes the time spent in the application code, the thread creation and termination costs, and the time covered by the DB2 CLASS 1 processor time. For more information, see "Calculating CICS and DB2 processor times for DB2 Version 6 or later" on page 174.

Accounting CLASS 2 processor time

In Figure 41 on page 169 and Figure 42 on page 171, CLASS 2 is the sum of the times 2, 5, and 8.

For accounting CLASS 2, the timer is checked on every entry and exit from DB2 to record the 'IN DB2' time in the SMF type 101 record. In this case, it is the difference that is stored in the record. The fields in the SMF type 101 record used for accounting CLASS 2 processor time are QWACAJST for CICS attach TCB time and QWACASRB for CICS ASCB SRB time.

For a description of the contents of the DB2 statistics records, see the *DB2 Universal Database for OS/390 and z/OS Administration Guide*.

The elapsed time (start and end times between the above defined points) is also reported in the SMF type 101 record (QWACASC).

When CICS is connected to DB2 Version 5 or earlier, the CLASS 2 processor time is not significantly different from the CLASS 1 processor time, in contrast to IMS™ and TSO. However, when CICS is connected to DB2 Version 6 or later, there can be a significant difference between CLASS 1 and CLASS 2 processor time, as there is for IMS and TSO. This is because when CICS is connected to DB2 Version 6 or later, the CLASS 1 processor time includes processor time spent in the CICS-DB2 attachment facility, including trace calls, and also includes processor time spent running threadsafe application code and threadsafe CICS commands on the open TCB. All this processor time occurs in the CICS address space, and so is not reported for accounting CLASS 2. The CLASS 2 processor time itself is not affected by the open transaction environment.

Unlike accounting CLASS 1, the CLASS 2 elapsed times and processor times accurately reflect the elapsed times and processor times spent 'IN DB2', whether CICS is connected to DB2 Version 5 or earlier, or to DB2 Version 6 or later. Accounting CLASS 2 information is therefore very useful for monitoring the performance of SQL execution. However, the processor overhead associated with having class accounting is quite considerable.

To reduce the overhead, it was usually recommended that the CLASS 2 trace be limited to trace data for plans and locations of specific authorization IDs. The processor overhead is 0-5%, with 2% being typical.

Calculating CICS and DB2 processor times for DB2 Version 5 or earlier

When your CICS system is connected to DB2 Version 5 or earlier, the CICS performance class record does not include processor time consumed in DB2. To estimate the total processor time for a single transaction, you could add information from the corresponding CICS performance record and DB2 accounting record (SMF type 101 record). For information about matching CICS performance records with DB2 accounting records, see "Relating DB2 accounting records to CICS performance class records" on page 161.

You should take the CPU field from the CICS performance class record. Using the DB2 accounting record, you can calculate the DB2 thread processor time (T1) as:

```
T1 = QWACEJST - QWACBJST
```

This calculates the CLASS 1 TCB processor time. The sum of the processor time from the CICS CPU field and the calculated value of T1 is an expression for the processor time spent in CICS and DB2.

Notes:

- The CLASS 2 processor time is part of the CLASS 1 processor time and should not be added to the sum.
- If the CLASS 2 processor time is subtracted from the CLASS 1 processor time, this gives an approximation of CPU utilization of the CICS DB2 attachment facility. This is a useful tuning aid.
- The processor time used in the DB2 address spaces and recorded in the DB2 statistics records is not related to any specific thread. It can be distributed proportionally to the CPU time recorded in the DB2 accounting records.
- Processor time used in the CICS address space under the subtask TCBs cannot easily be distributed to the CICS performance records, because it includes the processor times for the DB2 subtasks, which are already contained in the calculated T1 value. It means that processor time used in subtasks other than the thread subtasks is not included in the addition.
- Most of the processor time used in the thread TCB to create the thread is not included in any DB2 accounting records associated with this thread, because this processor time is spent before the thread is created.
- The capture ratio for CICS and DB2 should be taken into account. Capture ratio is the ratio of reported CPU time to total used CPU time (for more information, see the *z/OS Resource Measurement Facility (RMF) Performance Management Guide (SC28–1951)*).

Calculating CICS and DB2 processor times for DB2 Version 6 or later

When CICS is connected to DB2 Version 6 or later, and is exploiting the open transaction environment, the CICS DB2 attachment facility uses CICS-managed

open TCBs rather than CICS DB2 subtask TCBs. This means the CICS monitoring facility can measure activity that was previously only reported in the DB2 accounting record (the SMF type 101 record). For example, CICS can now measure the processor time consumed on the DB2 thread and the processor time consumed in DB2 (the CLASS 1 and CLASS 2 CPU time). When CICS is using L8 open TCBs, the CPU time reported for these TCBs by the CICS monitoring facility includes the DB2 CLASS 1 processor time.

In the open transaction environment, the CICS L8 task processor time can also include the cost of creating a DB2 thread. When CICS is connected to DB2 Version 5 or earlier, this time is unaccounted for in the CICS and DB2 SMF records. When CICS is connected to DB2 Version 6 or later, if a transaction causes a DB2 thread to be created, you can expect the total task processor time accounted for to be higher than that accounted for by a CICS system running with earlier DB2 releases. Correspondingly, if at the end of a transaction, the thread is terminated (because it is unprotected and no other task is waiting to use it), then the cost of thread termination is included in the CICS L8 task processor time. Again, this cost is not accounted for by a CICS system connected to DB2 Version 5 or earlier.

Unless you are using DB2 parallel query, when CICS is connected to DB2 Version 6 or later, **do not** add together the processor time from the CICS records (SMF type 110 records) and the DB2 accounting records (SMF type 101 records) when calculating the total processor time for a single transaction, because the DB2 processor time would then be included twice. The total processor time for a single transaction is recorded in the USRCPUT field in the CICS records (performance class data field 008 from group DFHTASK). This field includes all processor time used by the transaction when it was executing on any TCB managed by the CICS dispatcher. CICS-managed TCBs include the QR, RO, CO, J8, and L8 mode TCBs.

If you are using DB2 parallel query, you do need to add some of the processor time from the DB2 accounting records. With DB2 sysplex query parallelism, DB2 might use multiple TCBs within the DB2 address space to service a query. (For more information about when DB2 does or does not parallelize a query, see the section "Enabling Sysplex query parallelism" in *DB2 UDB for OS/390 and z/OS Data Sharing: Administration and Planning*.) The TCBs used for this purpose are non-CICS TCBs, so any processor time that they consume is not accounted for in the CICS SMF type 110 records. To obtain the total amount of processor time used for a parallel query, you therefore need to add the PAR.TASKS processor time recorded in the DB2 SMF type 101 record that applies to the transaction, to the processor time recorded in the USRCPUT field in the CICS SMF type 110 record.

Chapter 11. Problem determination for CICS DB2

Problem determination for CICS DB2 is discussed in this chapter under the following headings:

This chapter contains Diagnosis, Modification or Tuning information.

Thread TCBs (task control blocks)

In the CICS DB2 environment, each thread into DB2 runs under a thread task control block (TCB). The nature of these TCBs differs depending on whether CICS is connected to DB2 Version 5 or earlier (and so is not using the open transaction environment), or to DB2 Version 6 or later (and so is using the open transaction environment). See "Overview: How threads work" on page 2 for an overview of thread TCBs and an explanation of the difference. This section provides further technical information about thread TCBs, to assist with problem determination.

When CICS is connected to DB2 Version 5 or earlier, the thread TCBs are specially created "daughter" subtasks of a CICS DB2 attachment facility subtask (the MSUB TCB) that is established when CICS connects to DB2. The MSUB TCB is a subtask of the main CICS TCB (the QR TCB), and hence the thread TCBs are "grand daughters" of the main CICS TCB. The CICS DB2 attachment facility runs on the QR TCB. It uses module DFHD2MSB, running on the MSUB TCB, to control the subtask thread TCBs.

The number of subtask thread TCBs allowed is controlled using the TCBLIMIT attribute of the DB2 connection definition (DB2CONN). A subtask thread TCB is not terminated when the thread is terminated. A subtask thread TCB can be terminated if:

- A CICS transaction is force purged from CICS and the thread is still active in DB2. In this case, the subtask is terminated as a means of flushing the request out of DB2. The current UOW in DB2 is backed out.
- The TCBLIMIT value of the DB2CONN is lowered. When a thread is terminated, the CICS DB2 attachment facility recognises that the current number of TCBs exceeds the TCBLIMIT, and terminates the TCB as well.
- CICS is indoubt as to the outcome of a UOW because it has lost contact with its coordinator. Terminating the subtask causes DB2 to release the thread, but maintain the UOW as indoubt and maintain its locks. The UOW is completed by a later resynchronization when CICS reestablishes contact with its coordinator.
- The CICS DB2 attachment facility is shut down.

When CICS is connected to DB2 Version 6 or later, the thread TCBs are open L8 mode TCBs. The open TCBs are "daughters" of the main CICS TCB (the QR TCB). The CICS DB2 task-related user exit itself runs on the open TCB, as well as using it to run the thread. The task-related user exit uses the CICS DB2 attach

module DFHD2D2 to invoke DB2 when it needs to acquire a thread. Another module, DFHD2CO, running on a different TCB, deals with aspects of the overall CICS DB2 connection, including identifying to DB2 and disconnecting CICS from DB2.

The maximum number of open TCBs that can be running threads into DB2 at any one time is controlled using the TCBLIMIT parameter of the DB2CONN. An open TCB running a thread is not terminated when the thread is terminated. An open TCB can be terminated if:

- A CICS transaction is force purged from CICS and the thread is still active in DB2. In this case the TCB is terminated as a means of flushing the request out of DB2. The current UOW in DB2 is backed out.
- CICS is indoubt as to the outcome of a UOW because it has lost contact with its coordinator. Terminating the TCB causes DB2 to release the thread, but maintain the UOW as indoubt and maintain its locks. The UOW is completed by a later resynchronization when CICS reestablishes contact with its coordinator.
- The CICS dispatcher, where open TCBs are returned if they are not being used by the CICS DB2 attachment facility, cleans up the unused open TCBs after a period of time.

Wait types for CICS DB2

The CICS DB2 task-related user exit, DFHD2EX1, issues WAIT_MVS calls for different purposes, and these are distinguished by different resource name and resource type values. The resource name and resource type values are visible in the dispatcher section of a CICS system dump, and also appear on the CEMT INQUIRE TASK panel as Hty and Hva values respectively.

When CICS is connected to DB2 Version 5 or earlier, DFHD2EX1 runs on the CICS main TCB (the QR TCB). It uses the WAIT_MVS function of CICS dispatcher domain to put the running CICS task into a CICS dispatcher wait while the DB2 request is run on a subtask TCB. This wait is represented by a resource type of “DB2“.

When CICS is connected to DB2 Version 6 or later, the CICS DB2 task-related user exit and the request into DB2 run on an L8 open TCB. The CICS task is not put into a CICS dispatcher wait when active in DB2, so there is no related information in the dispatcher section of the CICS system dump. The CEMT INQUIRE TASK panel shows that the CICS DB2 task is running on an open TCB. To find out if the task is active in DB2, use the DSNC DISPLAY TRAN command (see “DSNC DISPLAY” on page 38). This command displays all the threads currently in use, and the task with which each thread is associated. See “DISPLAY PLAN or TRAN” on page 39 for an example of the output from the command. If the thread associated with the task has a status of ‘*’ in the ‘S’ field, this shows that the thread is currently active in DB2. The task is therefore either running or waiting in DB2.

As an example, take a situation that can occur when CICS is connected to DB2 Version 5 or earlier. When a CICS system dump is taken, a CICS task is waiting for the CICS DB2 task to complete its work in DB2. This wait is represented by a resource type of “DB2” and a resource name of “LOT_ECB”. The examples shown in Figure 43 on page 179, Figure 44 on page 179, and Figure 45 on page 179 show how this would appear in the dispatcher section of CICS system dump, and using the CEMT inquire task panels.

```
DS_TOKEN KE_TASK  TY S   P PS TT RESOURCE   RESOURCE ST   TIME OF
                                  TYPE       NAME          SUSPEND
00020003 029D7C80 SY SUS N OK -  TIEXPIRY   DS_NUDGE SUSP 18:50:29
000C0005 029CAC80 SY SUS N OK -                     SUSP 18:11:22
000E0005 02B99080 SY SUS N OK -  JCJOURDS   DFHJ01A  SUSP 18:39:39
00120007 02B99780 SY SUS N OK -  KCCOMPAT   SINGLE   OLDW 17:02:12
00160005 02B99B00 SY SUS N OK -  JCTERMN    SUBTASK  OLDW 17:01:56
00180003 029CA580 SY SUS N OK -  ICMIDNTE   DFHAPTIM SUSP 08:00:00
001A0003 029CA200 SY SUS N OK -  TCP_NORM   DFHZDSP  OLDW 18:51:27
001C0003 03F03900 SY SUS N OK -  ICEXPIRY   DFHAPTIX SUSP 18:50:29
008A0005 02B92080 SY SUS N OK -  JCJOURDS   DFHJ02A  SUSP 17:02:04
008E0001 02B13080 SY SUS N OK IN SMSYSTEM             SUSP 18:47:49
0102006F 02BA9080 NS SUS Y OK -  DB2        LOT_ECB  MVS  18:51:22
01040031 02BA9780 NS RUN
01060009 02B13B00 NS SUS Y OK -                       MVS  18:50:29
```

Figure 43. CICS-formatted dump: dispatcher domain

```
 INQUIRE TASK
 STATUS:  RESULTS - OVERTYPE TO MODIFY
  Tas(0000151) Tra(DSNC)           Sus Tas Pri( 255 )
? Tas(0000161) Tra(XC05) Fac(1303) Sus Ter Pri( 001 )
  Tas(0000162) Tra(CEMT) Fac(1302) Run Ter Pri( 255 )
```

Figure 44. CICS CEMT INQUIRE command for a CICS DB2 wait transaction

```
 INQUIRE TASK
 SYNTAX OF SET COMMAND
  Tas(0000161) Tra(XC05) Fac(1303) Sus Ter Pri( 001 )
     Hty(DB2     ) Hva(LOT_ECB ) Hti(000018) Sta(TO)
     Use(SYSADM  ) Rec(X'A8B5FE112D54CA85')
  CEMT  Set TAsk() | < All >
   < PRiority() >
   < PUrge | FOrcepurge >
```

Figure 45. CICS CEMT INQUIRE command after question mark (?)

The full list of waits issued from the CICS DB2 task-related user exit DFHD2EX1, their meanings, and whether the task can be purged or forcepurged out of this wait is given in Table 12. A fuller explanation of each wait follows the table.

Table 12. WAITs issued from the CICS DB2 TRUE

Resource type or Hty value	Resource name or Hva value	Meaning	Purge and forcepurge
DB2	LOT_ECB	CICS task is waiting for DB2, that is, waiting for the CICS DB2 task to complete the request. Used when CICS is connected to DB2 Version 5 or earlier.	Purge: No. Forcepurge: Yes (but see below).
CDB2RDYQ	name of DB2ENTRY or *POOL	CICS task is waiting for a thread to become available. The resource name details for which DB2ENTRY or the pool has a shortage of threads.	No

Table 12. WAITs issued from the CICS DB2 TRUE (continued)

Resource type or Hty value	Resource name or Hva value	Meaning	Purge and forcepurge
CDB2TCB		Used instead of CDB2CONN when CICS is connected to DB2 Version 5 or earlier. The CICS task is waiting for a CICS DB2 subtask to become available. This indicates that TCBLIMIT has been reached, and all subtask TCBs are in use running threads.	No
CDB2CONN		Used instead of CDB2TCB when CICS is connected to DB2 Version 6 or later. The CICS task has an open TCB but is waiting for a DB2 connection to become available to use with the open TCB. This indicates that TCBLIMIT has been reached, and the maximum permitted number of open TCBs (and hence connections) are being used to access DB2.	No

A resource type of DB2 is only used when CICS is connected to DB2 Version 5 or earlier. It indicates that the task is waiting for DB2 or, more specifically, the task is waiting for its associated CICS DB2 task to complete the DB2 request and post it back. The task can be forcepurged when in this state, in which case the CICS task abends and backout occurs. In addition, the CICS DB2 task is detached, causing DB2 to back out as well. Forcepurging a task in this state can cause termination of the DB2 subsystem, if the CICS DB2 task is terminated during a “must complete” activity in DB2. To avoid this risk, use the DB2 CANCEL THREAD command before issuing the forcepurge—see “Purging CICS DB2 transactions” on page 30 for the procedure.

CDB2RDYQ indicates that the THREADLIMIT value of a DB2ENTRY or the pool has been exceeded, and that THREADWAIT is set to YES, indicating that the task should wait. Purge of the task in this state is not allowed. If you attempt to forcepurge the task, message DFHAP0604 is issued to the console, and forcepurge is deferred until a thread has been acquired and the task is no longer queued waiting for a thread. Instead of purging the task, you can use a SET DB2ENTRY() THREADLIMIT(*n*) command to increase the number of threads available for the DB2ENTRY, or a SET DB2CONN THREADLIMIT(*n*) if it is the pool. CICS posts tasks to try again to acquire a thread if the threadlimit is increased.

CDB2TCB is used instead of CDB2CONN when CICS is connected to DB2 Version 5 or earlier. It indicates that the task is allowed a thread, but all the existing CICS DB2 subtask TCBs are in use, and the TCBLIMIT specified in the DB2CONN has been reached, so no new TCBs can be attached. Purge of the task is not allowed. If you attempt to forcepurge the task, message DFHAP0604 is issued to the console, and forcepurge is deferred until a TCB has been acquired and the task is no longer queued waiting for a TCB. Instead of purging the task, you can use a SET DB2CONN TCBLIMIT command to increase TCBLIMIT, which increases the number of subtask TCBs allowed. If you increase TCBLIMIT, CICS posts tasks to try again to acquire a CICS DB2 subtask.

CDB2CONN is used instead of CDB2TCB when CICS is connected to DB2 Version 6 or later. It indicates that the CICS task has obtained an open TCB from the pool of open TCBs, but is waiting for a DB2 connection to become available to use with the open TCB. This shows that the TCBLIMIT specified in the DB2CONN has been reached, which limits the number of open TCBs (and hence connections) that can be used to access DB2. (See "The MAXOPENTCBS system initialization parameter and TCBLIMIT" on page 52 for an explanation of the role of TCBLIMIT in the open transaction environment.) The CICS task must wait for a connection to be freed by another TCB running on behalf of another CICS task, after which it may use the freed DB2 connection with its own TCB. Purge of the task is not allowed. If you attempt to forcepurge the task, message DFHAP0604 is issued to the console, and forcepurge is deferred until a DB2 connection has been acquired. Instead of purging the task, you can use a SET DB2CONN TCBLIMIT command to increase TCBLIMIT, which increases the number of open TCBs permitted to access DB2. If you increase TCBLIMIT, CICS posts tasks to try again to acquire a DB2 connection.

Table 13 gives details of WAITS issued using WAIT_OLDC dispatcher calls where the ECB is hand posted:

Table 13. WAITS issued using WAIT_OLDC dispatcher calls

Resource type or Hty value	Resource name or Hva value	Meaning	Purge and forcepurge
DB2_INIT		CICS DB2 initialization program DFHD2IN1 issues the wait to wait for the CICS initialization task running program DFHD2IN2 to complete.	Yes
DB2CDISC	name of DB2CONN	A SET DB2CONN NOTCONNECTED command has been issued with the WAIT or FORCE option. DFHD2TM waits for the count of tasks using DB2 to reach zero.	Yes
DB2EDISA	name of DB2ENTRY	A SET DB2ENTRY DISABLED command has been issued with the WAIT or FORCE option. DFHD2TM waits for the count of tasks using the DB2ENTRY to reach zero.	Yes

Table 14 shows details of EXEC CICS WAIT EXTERNAL requests issued by the CICS DB2 attachment facility.

Table 14. EXEC CICS WAIT EXTERNAL requests issued by the attachment facility

Resource type or Hty value	Resource name or Hva value	Meaning	Purge and forcepurge
USERWAIT	CDB2TIME	The CICS DB2 service task program DFHD2EX2 is in its timer wait cycle either waiting for the protected thread purge cycle to pop or to be posted for another event.	Yes
USERWAIT	DB2START	The CICS DB2 service program DFHD2EX2 is waiting for DB2 to post it when it becomes active.	Yes

Table 15 gives details of EXEC CICS WAIT EVENT requests issued by the CICS DB2 attachment facility:

Table 15. EXEC CICS WAIT EVENT requests

Module	Resource name	Meaning
DFHD2EX2	PROTTERM	A TERM call has been issued for a protected thread during the protected thread purge cycle.
DFHD2STR	ATCHMSUB	The CICS DB2 startup program DFHD2STR has attached the master subtask program DFHD2MSB and is waiting for it to identify to DB2. (Only applies when CICS is connected to DB2 Version 5 or earlier.)
DFHD2STR	DTCHMSUB	The CICS DB2 startup program is waiting for the master subtask program DFHD2MSB to terminate. (Only applies when CICS is connected to DB2 Version 5 or earlier.)
DFHD2STP	MSBRETRN	The CICS DB2 shutdown program is waiting for the master subtask program DFHD2MSB to terminate. (Only applies when CICS is connected to DB2 Version 5 or earlier.)
DFHD2STP	CEX2TERM	The CICS DB2 shutdown program is waiting for the CICS DB2 service task CEX2 running program DFHD2EX2 to terminate all subtasks and terminate itself.

Messages for CICS DB2

Messages issued by the CICS DB2 attachment facility use the DFHDB prefix which is also used for CICS DBCTL messages. Message numbers are in the range 2000 through 2999 and are reserved for CICS DB2. Thus CICS DB2 attachment messages are of the form DFHDB2xxx.

Where possible, message numbers have been maintained from previous releases of the attachment. For example, message DFHDB2023 documents the same condition as old messages DSN2023 or DSNC023. However, the contents of the message have changed. For example, all messages contain the date, time, and applid.

The destination for transient data messages output by the CICS DB2 attachment facility is controlled using the MSGQUEUE1, MSGQUEUE2 and MSGQUEUE3 parameters of the DB2CONN definition. The same message can be routed to three transient data queues. By default, messages are sent to a single queue called CDB2 which is defined as indirect to queue CSSL.

All messages are documented in the *CICS Messages and Codes* manual and are available using the CMAC CICS-supplied transaction.

Trace for CICS DB2

In releases of CICS before CICS Transaction Server for OS/390, Version 1 Release 2, the user could specify the trace points to be used by the CICS DB2 attachment facility using parameters in the RCT. Trace points can no longer be user specified. The CICS DB2 attachment facility uses AP domain trace points in the range 3100 to 33FF. The contents of all trace points issued by the CICS DB2 attachment facility are documented in *CICS Trace Entries*.

Standard tracing performed by the CICS DB2 attachment facility is controlled by the FC (File Control) and RI (RMI) trace flags. RMI trace controls:

- Trace output from the CICS DB2 task-related user exit, DFHD2EX1
- Trace output from the CICS DB2 attach module, DFHD2D2 (when CICS is connected to DB2 Version 6 or later)
- GTF trace from the CICS DB2 subtask program DFHD2EX3 (when CICS is connected to DB2 Version 5 or earlier).

All other standard tracing from the attachment is controlled using File Control tracing. A large proportion of the possible trace issued from the CICS DB2 attachment facility is exception tracing which is output irrespective of RI or FC tracing being active, but is issued independently. The levels of FC and RI trace required can be set using the CICS-supplied transaction, CETR, or using SIT parameters STNTRFC= and STNTRRI=.

Figure 46 and Figure 47 on page 187 show examples of the trace output from the RMI and the CICS DB2 task-related user exit, DFHD2EX1, when level 1 and level 2 RI tracing is active. In both examples, the trace shows one SQL statement being executed. The example trace in Figure 46 was output when CICS was connected to DB2 Version 5 or earlier. In this environment, the CICS DB2 task-related user exit runs on the CICS QR TCB (the main TCB), and creates subtask TCBs to run threads into DB2. The example trace in Figure 47 on page 187 was output when CICS was connected to DB2 Version 6, and was using the open transaction environment. In this environment, the CICS DB2 task-related user exit runs on an open L8 mode TCB, and uses that same TCB to run threads into DB2.

CICS DB2 trace output is written to the CICS internal trace table and auxiliary trace and GTF trace destinations if active.

```
AP 2520 ERM ENTRY PLI-APPLICATION-CALL-TO-TRUE(DSNCSQL )

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-99902F92 TIME-08:39:21.5717947197 INTERVAL-00.0000141562        =000166=
               1-0000  01                                                                    *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                     *DSNCSQL                        *
               3-0000  B60AF1D6 427901C0                                                     *..1O...{                       *
               4-0000  E3C5E2E3 D7F0F540 00000001 00100000  19900000 999000E0 000114E0 00000000  *TESTP05 ............r..\...\....*
                 0020  00000020 00007BB0 00000000 98400000  0040000A 00101100 00000000 00000000  *.....#.....q ... ..............*
                 0040  00000000 00000000 00000000                                           *............                    *

AP 2522 ERM EVENT PASSING-CONTROL-TO-QR-TRUE(DSNCSQL )

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-99902F92 TIME-08:39:21.5718005166 INTERVAL-00.0000057968        =000167=
               1-0000  01                                                                    *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                     *DSNCSQL                        *
               3-0000  B60AF1D6 427901C0                                                     *..1O...{                       *
               4-0000  18CCB654 00042004 19044204 00000000  007A8000 007A8000 18F0005C 18F0CCD0  *................:...:...0.*.0.}*
                 0020  190441C0 19044210 19044206 18F000D0  19044200 18CCB490 190441C8 190441B0  *...{.........0.}...........H....*
                 0040  190441AC 190441EC 18CCB5F3 190441FD  18CCB5F4 190441B4 190441B2 00020000  *...........3.......4............*
               5-0000  D8D9                                                                 *QR                             *

AP 3180 D2EX1 ENTRY - APPLICATION REQUEST - EXEC SQL FETCH

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-8009E4D0 TIME-08:39:21.5718055947 INTERVAL-00.0000050781        =000168=
               1-0000  02000000 00280800 001EE3C5 E2E3D7F0  F5401663 1BA501CD D1DC0002 18F0BA40  *..........TESTP05 ...v..J....0. *
                 0020  00000000 18F0CDB0 018D0004                                           *.....0......                   *
               2-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AA680 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.$w.......}.*
                 0020  00000000 00041FF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                 0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 000C010C  *....................TESTP05 ....*
                 0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF1D6 427901C0  *..{.............IYK2Z2G1..1O...{*
                 0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                 00A0  C9E8C1D8 E3C3F0F3 0AF1D642 7901C6D9  C2400003 000118F0 CD680000 00000000  *IYAQTC03.1O...FRB .....0........*
                 00C0  00000000 00000000 30050001 04000000  00000000 00000000 00000000 0000      *............................  *
```

Figure 46. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 5 or earlier (Part 1 of 4)

```
AP 3182 D2EX1 EVENT - POST D2EX3 THREAD TCB  FOR DB2ENTRY XP05     USING PLAN TESTP05

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-8009E4D0 TIME-08:39:21.5719012041 INTERVAL-00.0000956093        =000169=
               1-0000  010C010C A000C000 00000000                                          *......{.....                    *
               2-0000  E3C5E2E3 D7F0F540                                                  *TESTP05                         *
               3-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AA680 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.$w.......}.*
                 0020  00000000 00041FF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                 0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                 0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF1D6 427901C0  *..{.............IYK2Z2G1..1O...{*
                 0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                 00A0  C9E8C1D8 E3C3F0F3 0AF1D642 7901C6D9  C2400003 000118F0 CD680000 00000000  *IYAQTC03.1O...FRB .....0........*
                 00C0  00000000 00000000 30050001 04000000  00000000 00000000 00000000 0000      *............................  *
               4-0000  00C86EC4 C6C8C4F2 C5D5E340 40404040  E7D7F0F5 40404040 B60AF017 63D17AC6  *.H>DFHD2ENT     XP05    ..0..J:F*
                 0020  E3C5E2E3 D7F0F540 00000000 00000000  00000000 00000000 D1E3C9D3 D3C9F140  *TESTP05 ................JTILLI1 *
                 0040  00808080 80000000 67E939C4 B0188B86  B60AF017 63D17AC6 0000000C 00000003  *.........Z.D...f..0..J:F........*
                 0060  00000001 00000001 00000000 00000000  00000001 00000001 00000000 00000000  *................................*
                 0080  00000000 00000002 00000001 00000000  00000000 00000000 00000000 00000000  *................................*
                 00A0  00000000 00000000 00000000 00000000  18DCD030 00000000 00000000 19044210  *..................}.............*
                 00C0  00000000 00000000                                                    *........                        *
               5-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF1D7 B18F4081 18D305E0 18DF2D78  *..>DFHD2CSB     ..1P.. a.L.\....*
                 0020  19044210 007C6420 00000000 00000000  00000000 00000000 807A7858 00000000  *.....@.....................:......*
                 0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                 0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                 0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF1D7 C3208E08 C7C2C9C2  *    ENTRXP050001......1PC...GBIB*
                 00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF1D642  79010020 44000000 003C0001 00000000  *MIYAIYAQTC03.1O.................*
                 00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *............                 .%Q.*
                 00E0  C6D9C240 00030001 18F0CD68 00000000  00000000 00000000 00003005 00010400  *FRB .....0......................*
                 0100  00000000 00000000 00000000 00000000  00000000 00010320 00010250 9838A2F2  *.........................&q.s2*
                 0120  8000A118 18DCD110 18DCD188 18F0CD68  1838AEA2 18D305F8 18DCD110 19044210  *......J...Jh.0.....s.L.8..J.....*
                 0140  18D305E0 18DF2D78 18DCD030 98389A78  1838AA78 9838A0C2 98389E62 00000000  *.L.\......}.q.......q..Bq.......*
                 0160  C1D7C940 184AA680 003400EF 18DCD1A0  4C6E0034 00103220 6BC4C2F2 00000000  *API .$w.......J.<>......,DB2....*
                 0180  0028C4F0 F0F0F180 007C6420 1838AE4A  B60AF1D7 C330BB88 00040000 041C0004  *..D0001..@.....$..1PC..h........*
                 01A0  19044244 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                 01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
                 01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0220  00000000 00000000 00000000 00000000  00000000 00000000 00000004 18DCD2B0  *............................K.*
                 0240  6E6EE399 81838540 E2A38199 A3406E6E  0100041C C9C4C5D5 00000000 00000000  *>>Trace Start >>....IDEN........*
                 0260  0200041C E2C9C7D5 00000000 00000000  0300041C C3E3C8C4 00000000 00000000  *....SIGN............CTHD........*
                 0280  0400041C C1D7C940 00000000 00000000  00000000 00000000 00000000 00000000  *....API ........................*
                 02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*

DS 0004 DSSR  ENTRY - FUNCTION(WAIT_MVS) RESOURCE_TYPE(DB2) ECB_ADDRESS(19044244) PURGEABLE(YES) WLM_WAIT_TYPE(OTHER_PRODUCT)
                   RESOURCE_NAME(LOT_ECB)

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-98E36990 TIME-08:39:21.5719126416 INTERVAL-00.0000114375        =000170=
               1-0000  00680000 00000014 00000001 00000000  B1242040 00000000 060A0160 18DCD030  *.................. .......-..}.*
                 0020  C4F2C3E2 18DCD030 180864CE 180874CD  C4C2F240 40404040 00000028 00000000  *D2CS..}.........DB2     ........*
                 0040  19044244 A5200000 00010000 01000A00  00000000 18CCBB19 D3D6E36D C5C3C240  *....v...................LOT_ECB *
                 0060  40404040 40404040                                                      *                            *
```

Figure 46. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 5 or earlier (Part 2 of 4)

```
DS 0005 DSSR  EXIT - FUNCTION(WAIT_MVS) RESPONSE(OK)

              TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-98E36990 TIME-08:39:22.4099274553 INTERVAL-00.2535246579*       =000175=
                1-0000  00680000 00000014 00000001 00000000  B1242040 00000000 060A0160 18DCD030  *.................. .......-..}.*
                  0020  C4F2C3E2 18DCD030 180864CE 180874CD  C4C2F240 40404040 00000028 00000000  *D2CS..}.........DB2     ........*
                  0040  19044244 A5200000 00010000 01000A00  00000000 18CCBB19 D3D6E36D C5C3C240  *....V..................LOT_ECB *
                  0060  40404040 40404040                                                        *                               *

AP 3183 D2EX1 EVENT - AWOKEN BY D2EX3 THREAD TCB  FOR DB2ENTRY XP05     USING PLAN TESTP05

              TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-8009E4D0 TIME-08:39:22.4099330334 INTERVAL-00.0000055781        =000176=
                1-0000  010C010C A000C000 00000000 00000000  00000000                          *......{.............            *
                2-0000  E3C5E2E3 D7F0F540                                                      *TESTP05                        *
                3-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AA680 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.$w.......}.*
                  0020  00000000 00041FF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                  0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                  0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF1D6 427901C0  *..{.............IYK2Z2G1..1O...{*
                  0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                  00A0  C9E8C1D8 E3C3F0F3 0AF1D642 7901C6D9  C2400003 000118F0 CDE00000 00000000  *IYAQTC03.1O...FRB .....0.\......*
                  00C0  00000000 00000000 30050001 04000000  00000000 00000000 00000000 0000      *............................    *
                4-0000  00C86EC4 C6C8C4F2 C5D5E340 40404040  E7D7F0F5 40404040 B60AF017 63D17AC6  *.H>DFHD2ENT     XP05    ..0..J:F*
                  0020  E3C5E2E3 D7F0F540 00000000 00000000  00000000 00000000 D1E3C9D3 D3C9F140  *TESTP05 ................JTILLI1 *
                  0040  00808080 80000000 67E939C4 B0188B86  B60AF017 63D17AC6 0000000C 00000003  *.........Z.D...f..0..J:F........*
                  0060  00000001 00000001 00000000 00000000  00000001 00000001 00000000 00000000  *................................*
                  0080  00000000 00000002 00000001 00000000  00000000 00000000 00000000 00000000  *................................*
                  00A0  00000000 00000000 00000000 00000000  18DCD030 00000000 00000000 19044210  *..................}.............*
                  00C0  00000000 00000000                                                        *........                       *
                5-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF1D7 B18F4081 18D305E0 18DF2D78  *..>DFHD2CSB     ..1P.. a.L.\....*
                  0020  19044210 007C6420 00000000 00000000  00000000 00000000 807A7858 00000000  *.....@.................:......*
                  0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                  0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                  0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF1D7 C3208E08 C7C2C9C2  *    ENTRXP050001......1PC...GBIB*
                  00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF1D642  79010020 44000000 003C0001 00000000  *MIYAIYAQTC03.1O.................*
                  00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *............                .%Q.*
                  00E0  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003005 00010400  *FRB .....0.\....................*
                  0100  00000000 00000000 00000000 00000000  00000000 00010320 00010250 9838A2F2  *.........................&q.s2*
                  0120  8000A118 18DCD110 18DCD188 18F0CDE0  1838AEA2 18D305F8 18DCD110 19044210  *......J...Jh.0.\...s.L.8..J.....*
                  0140  18D305E0 18DF2D78 18DCD030 98389A78  1838AA78 9838A0C2 98389E62 00000000  *.L.\......}.q.......q..Bq.......*
                  0160  C1D7C940 184AA680 003400EF 18DCD1A0  4C6E0034 00103220 6BC4C2F2 00000000  *API .$w.......J.<>......,DB2....*
                  0180  0028C4F0 F0F0F180 007C6420 1838AE4A  B60AF1DF BEC73D08 00040000 041C0004  *..D0001..@.....$..1..G..........*
                  01A0  19044244 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                  01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
                  01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0220  00000000 00000000 00000000 00000000  00000000 00000000 00000005 18DCD2C0  *.............................K{*
                  0240  6E6EE399 81838540 E2A38199 A3406E6E  0100041C C9C4C5D5 00000000 00000000  *>>Trace Start >>....IDEN........*
                  0260  0200041C E2C9C7D5 00000000 00000000  0300041C C3E3C8C4 00000000 00000000  *....SIGN............CTHD........*
                  0280  0400041C C1D7C940 00000000 00000000  0500041C C1D7C940 00000000 00000000  *....API ............API ........*
                  02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*
```

Figure 46. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 5 or earlier (Part 3 of 4)

```
AP 3181 D2EX1 EXIT - APPLICATION REQUEST - EXEC SQL FETCH

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-8009E4D0 TIME-08:39:22.4100164084 INTERVAL-00.0000833750        =000177=
               1-0000  02000000 00280800 001EE3C5 E2E3D7F0  F5401663 1BA501CD D1DC0002 18F0BA40  *.........TESTP05 ...v..J....0. *
                 0020  00000000 18F0CDB0 018D0004                                              *.....0......                   *
               2-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AA680 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.$w.......}.*
                 0020  00000000 00041FF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                 0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                 0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF1D6 427901C0  *..{.............IYK2Z2G1..1O...{*
                 0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                 00A0  C9E8C1D8 E3C3F0F3 0AF1D642 7901C6D9  C2400003 000118F0 CDE00000 00000000  *IYAQTC03.1O...FRB .....0.\......*
                 00C0  00000000 00000000 30050001 04000000  00000000 00000000 00000000 0000      *............................    *
               3-0000  00                                                                        *.                              *
               4-0000  E2D8D3C3 C1404040 00000088 00000000  00004040 40404040 40404040 40404040  *SQLCA   ...h......              *
                 0020  40404040 40404040 40404040 40404040  40404040 40404040 40404040 40404040  *                                *
                 0040  40404040 40404040 40404040 40404040  40404040 40404040 C4E2D540 40404040  *                          DSN     *
                 0060  00000000 00000000 00000000 FFFFFFFF  00000000 00000000 40404040 40404040  *........................        *
                 0080  404040F0 F0F0F0F0                                                        *   00000                        *
               5-0000  00C86EC4 C6C8C4F2 C5D5E340 40404040  E7D7F0F5 40404040 B60AF017 63D17AC6  *.H>DFHD2ENT     XP05    ..0..J:F*
                 0020  E3C5E2E3 D7F0F540 00000000 00000000  00000000 00000000 D1E3C9D3 D3C9F140  *TESTP05 ..............JTILLI1 *
                 0040  00808080 80000000 67E939C4 B0188B86  B60AF017 63D17AC6 0000000C 00000003  *.........Z.D...f..0..J:F........*
                 0060  00000001 00000001 00000000 00000000  00000001 00000001 00000000 00000000  *................................*
                 0080  00000000 00000002 00000001 00000000  00000000 00000000 00000000 00000000  *................................*
                 00A0  00000000 00000000 00000000 00000000  18DCD030 00000000 00000000 19044210  *.................}.............*
                 00C0  00000000 00000000                                                        *........                       *
               6-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF1D7 B18F4081 18D305E0 18DF2D78  *..>DFHD2CSB     ..1P.. a.L.\....*
                 0020  19044210 007C6420 00000000 00000000  00000000 00000000 807A7858 00000000  *.....@.....................:......*
                 0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                 0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                 0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF1D7 C3208E08 C7C2C9C2  *    ENTRXP050001......1PC...GBIB*
                 00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF1D642  79010020 44000000 003C0001 00000000  *MIYAIYAQTC03.1O.................*
                 00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *....................         .%Q.*
                 00E0  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003005 00010400  *FRB .....0.\....................*
                 0100  00000000 00000000 00000000 00000000  00000000 00010320 00010250 9838A2F2  *.........................&q.s2*
                 0120  8000A118 18DCD110 18DCD188 18F0CDE0  1838AEA2 18D305F8 18DCD110 19044210  *......J...Jh.0.\...s.L.8..J.....*
                 0140  18D305E0 18DF2D78 18DCD030 98389A78  1838AA78 9838A0C2 98389E62 00000000  *.L.\......}.q.......q..Bq.......*
                 0160  C1D7C940 184AA680 003400EF 18DCD1A0  4C6E0034 00103220 6BC4C2F2 00000000  *API .$w.....J.<>......,DB2....*
                 0180  0028C4F0 F0F0F180 007C6420 1838AE4A  B60AF1DF BEC73D08 00040000 041C0004  *..D0001..@.....$..1..G..........*
                 01A0  19044244 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                 01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                              ....*
                 01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0220  00000000 00000000 00000000 00000000  00000000 00000000 00000005 18DCD2C0  *.............................K{*
                 0240  6E6EE399 81838540 E2A38199 A3406E6E  0100041C C9C4C5D5 00000000 00000000  *>>Trace Start >>....IDEN........*
                 0260  0200041C E2C9C7D5 00000000 00000000  0300041C C3E3C8C4 00000000 00000000  *....SIGN............CTHD........*
                 0280  0400041C C1D7C940 00000000 00000000  0500041C C1D7C940 00000000 00000000  *....API .............API ........*
                 02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*

AP 2523 ERM EVENT REGAINING-CONTROL-FROM-QR-TRUE(DSNCSQL )

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-99902F92 TIME-08:39:22.4100237365 INTERVAL-00.0000073281        =000178=
               1-0000  01                                                                        *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                         *DSNCSQL                        *
               3-0000  B60AF1D6 427901C0                                                         *..1O...{                       *
               4-0000  18CCB654 00042004 19044204 00000000  007A8000 007A8000 18F0005C 18F0CCD0  *.................:...:...0.*.0.}*
                 0020  190441C0 19044210 19044206 18F000D0  19044200 18CCBCA0 190441C8 190441B0  *...{.........0.}...........H....*
                 0040  190441AC 190441EC 18CCB5F3 190441FD  18CCB5F4 190441B4 190441B2 00020000  *...........3.......4............*
               5-0000  D8D9                                                                      *QR                             *

AP 2521 ERM EXIT PLI-APPLICATION-CALL-TO-TRUE(DSNCSQL )

             TASK-00041 KE_NUM-003F TCB-QR   /007C5B60 RET-99902F92 TIME-08:39:22.4100312365 INTERVAL-00.0000075000        =000179=
               1-0000  01                                                                        *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                         *DSNCSQL                        *
               3-0000  B60AF1D6 427901C0                                                         *..1O...{                       *
               4-0000  E3C5E2E3 D7F0F540 00000001 00100000  19900000 999000E0 000114E0 00000000  *TESTP05 ............r..\...\....*
                 0020  00000020 00007BB0 00000000 98400000  0040000A 00101100 00000000 00000000  *......#.....q ... ..............*
                 0040  00000000 00000000 00000000                                               *............                    *
```

Figure 46. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 5 or earlier (Part 4 of 4)

The example trace in Figure 47 was produced when CICS was connected to DB2 Version 6.

```
AP 2520 ERM ENTRY PLI-APPLICATION-CALL-TO-TRUE(DSNCSQL )

             TASK-00035 KE_NUM-003F TCB-QR   /007C5B60 RET-99902F92 TIME-08:32:00.7673270795 INTERVAL-00.0000135312        =000162=
               1-0000  01                                                                  *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                   *DSNCSQL                        *
               3-0000  B60AF030 A54A8EC0                                                   *..0.v$.{                       *
               4-0000  E3C5E2E3 D7F0F540 00000001 00100000  19900000 999000E0 000114E0 00000000  *TESTP05 ............r..\...\....*
                 0020  00000020 00007BB0 00000000 98400000  0040000A 00101100 00000000 00000000  *......#.....q ... ..............*
                 0040  00000000 00000000 00000000                                           *............                    *

DS 0002 DSAT  ENTRY - FUNCTION(CHANGE_MODE) MODENAME(L8)

             TASK-00035 KE_NUM-003F TCB-QR   /007C5B60 RET-8009E318 TIME-08:32:00.7673341108 INTERVAL-00.0000070312        =000163=
               1-0000  00980000 00000003 00000001 00000000  A0000040 00000000 05000102 01000002  *.q.................. ............*
                 0020  01007450 00000000 000002B0 18CCB490  18CCB6D8 9801014C 01031498 18220F30  *...&..............Qq..<...q....*
                 0040  18CCBB70 1833E000 9800E8F0 00007000  190441EC 18CCBB70 00000008 D3F8D8D9  *......\.q.Y0..............L8QR*
                 0060  18CCB638 FFFFFFFF 18CB4B00 987D9520  00000001 18DEA4A0 18DEA010 00000001  *............q'n.......u.........*
                 0080  00007550 18CCB776 00000000 0000E8F0  18CCBA28 18CCBA28                    *...&..........Y0........       *

DS 0003 DSAT  EXIT - FUNCTION(CHANGE_MODE) RESPONSE(OK)

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-8009E318 TIME-08:32:00.7673710483 INTERVAL-00.0000369375        =000164=
               1-0000  00980000 00000003 00000001 00000000  A0000040 00000000 05000102 01000002  *.q.................. ............*
                 0020  01007450 00000000 000002B0 18CCB490  18CCB6D8 9801014C 01031498 18220F30  *...&..............Qq..<...q....*
                 0040  18CCBB70 1833E000 9800E8F0 00007000  190441EC 18CCBB70 00000001 D3F8D8D9  *......\.q.Y0..............L8QR*
                 0060  18CCB638 FFFFFFFF 18CB4B00 987D9520  00000001 18DEA4A0 18DEA010 00000001  *............q'n.......u.........*
                 0080  00007550 18CCB776 00000000 0000E8F0  18CCBA28 18CCBA28                    *...&..........Y0........       *

AP 2522 ERM EVENT PASSING-CONTROL-TO-OPENAPI-TRUE(DSNCSQL )

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-99902F92 TIME-08:32:00.7673729077 INTERVAL-00.0000018593        =000165=
               1-0000  01                                                                  *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                   *DSNCSQL                        *
               3-0000  B60AF030 A54A8EC0                                                   *..0.v$.{                       *
               4-0000  18CCB654 0006F004 19044204 00000000  007A8000 007A8000 18F0005C 18F0CCD0  *......0.........:...:...0.*.0.}*
                 0020  190441C0 19044210 19044206 18F000D0  19044200 18CCB490 190441C8 190441B0  *...{.........0.}...........H....*
                 0040  190441AC 190441EC 18CCB5F3 190441FD  18CCB5F4 190441B4 190441B2 00020000  *...........3.......4...........*
               5-0000  D3F8                                                                 *L8                             *

AP 3180 D2EX1 ENTRY - APPLICATION REQUEST - EXEC SQL FETCH

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-8009E4D0 TIME-08:32:00.7673780483 INTERVAL-00.0000051406        =000166=
               1-0000  02000000 00280800 001EE3C5 E2E3D7F0  F5401663 1BA501CD D1DC0002 18F0BA40  *.........TESTP05 ...v..J....0. *
                 0020  00000000 18F0CDB0 018D0004                                           *.....0......                   *
               2-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AC080 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.${.......}.*
                 0020  00000000 0006EFF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                 0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 000C010C  *....................TESTP05 ....*
                 0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF030 A54A8EC0  *..{.............IYK2Z2G1..0.v$.{*
                 0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                 00A0  C9E8C1D8 E3C3F0F3 0AF030A5 4A8EC6D9  C2400003 000118F0 CD680000 00000000  *IYAQTC03.0.v$.FRB .....0........*
                 00C0  00000000 00000000 39050001 04000000  00000000 00000000 00000000 0000      *............................  *
```

Figure 47. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 6 or later (Part 1 of 4)

```
AP 3250 D2D2 ENTRY - FUNCTION(DB2_API_CALL) CSUB_TOKEN(18DCD030)

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-98E3321C TIME-08:32:00.7674652827 INTERVAL-00.0000872343        =000167=
               1-0000  00200000 00000034 00000000 00000000  B8000000 00000000 03000100 18DCD030  *............................}.*
               2-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF031 FAD0CB43 18D305E0 18DF2D78  *..>DFHD2CSB     ..0..}...L.\....*
                 0020  19044210 007C6B90 00000000 00000000  B60AF030 A54A8EC0 00000000 00000000  *.....@,...........0.v$.{........*
                 0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                 0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                 0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF032 01359743 C7C2C9C2  *    ENTRXP050001......0...p.GBIB*
                 00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF030A5  4A8E0000 44800000 00000001 00000000  *MIYAIYAQTC03.0.v$..............*
                 00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *............                .%Q.*
                 00E0  C6D9C240 00030001 18F0CD68 00000000  00000000 00000000 00003905 00010400  *FRB .....0.....................*
                 0100  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0120  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0140  00000000 00000000 00000000 00000000  00000000 00000000 98DCD110 00000000  *........................q.J.....*
                 0160  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0180  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 01A0  00000000 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                 01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
                 01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0220  00000000 00000000 00000000 00000000  00000000 00000000 00000004 18DCD2B0  *............................K.*
                 0240  6E6EE399 81838540 E2A38199 A3406E6E  0100035C C9C4C5D5 00000000 00000000  *>>Trace Start >>...*IDEN........*
                 0260  0200035C E2C9C7D5 00000000 00000000  0300035C C3E3C8C4 00000000 00000000  *...*SIGN...........*CTHD........*
                 0280  0400035C C1D7C940 00000000 00000000  00000000 00000000 00000000 00000000  *...*API .......................*
                 02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*
               3-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AC080 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.${.......}.*
                 0020  00000000 0006EFF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                 0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                 0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF030 A54A8EC0  *..{.............IYK2Z2G1..0.v$.{*
                 0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                 00A0  C9E8C1D8 E3C3F0F3 0AF030A5 4A8EC6D9  C2400003 000118F0 CD680000 00000000  *IYAQTC03.0.v$.FRB .....0........*
                 00C0  00000000 00000000 39050001 04000000  00000000 00000000 00000000 0000      *............................  *

AP 326C D2D2 EVENT - ABOUT_TO_ISSUE_DB2_API_REQUEST

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-98E3321C TIME-08:32:00.7674700952 INTERVAL-00.0000048125        =000168=
               1-0000  98DCD110 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *q.J............................*
               2-0000  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003905 00010400  *FRB .....0.\...................*
                 0020  00000000 00000000 00000000 00000000                                      *.................               *
               3-0000  E3C5E2E3 D7F0F540                                                        *TESTP05                        *
               4-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF031 FAD0CB43 18D305E0 18DF2D78  *..>DFHD2CSB     ..0..}...L.\....*
                 0020  19044210 007C6B90 00000000 00000000  B60AF030 A54A8EC0 00000000 00000000  *.....@,...........0.v$.{........*
                 0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                 0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                 0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF032 01359743 C7C2C9C2  *    ENTRXP050001......0...p.GBIB*
                 00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF030A5  4A8E0000 44800000 00000001 00000000  *MIYAIYAQTC03.0.v$..............*
                 00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *............                .%Q.*
                 00E0  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003905 00010400  *FRB .....0.\...................*
                 0100  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0120  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0140  00000000 00000000 00000000 00000000  00000000 00000000 98DCD110 00000000  *........................q.J.....*
                 0160  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0180  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 01A0  00000000 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                 01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
                 01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0220  00000000 00000000 00000000 00000000  00000000 00000000 00000004 18DCD2B0  *............................K.*
                 0240  6E6EE399 81838540 E2A38199 A3406E6E  0100035C C9C4C5D5 00000000 00000000  *>>Trace Start >>...*IDEN........*
                 0260  0200035C E2C9C7D5 00000000 00000000  0300035C C3E3C8C4 00000000 00000000  *...*SIGN...........*CTHD........*
                 0280  0400035C C1D7C940 00000000 00000000  00000000 00000000 00000000 00000000  *...*API .......................*
                 02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*
               5-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AC080 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.${.......}.*
                 0020  00000000 0006EFF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                 0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                 0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF030 A54A8EC0  *..{.............IYK2Z2G1..0.v$.{*
                 0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                 00A0  C9E8C1D8 E3C3F0F3 0AF030A5 4A8EC6D9  C2400003 000118F0 CD680000 00000000  *IYAQTC03.0.v$.FRB .....0........*
                 00C0  00000000 00000000 39050001 04000000  00000000 00000000 00000000 0000      *............................  *
```

Figure 47. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 6 or later (Part 2 of 4)

```
AP 326D D2D2 EVENT - RETURN_FROM_DB2_API_REQUEST

              TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-98E3321C TIME-08:32:00.7678738139 INTERVAL-00.0004037187        =000169=
                1-0000  98DCD110 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *q.J............................*
                2-0000  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003905 00010400  *FRB .....0.\...................*
                  0020  00000000 00000000 00000000 00000000                                      *.................               *
                3-0000  E3C5E2E3 D7F0F540                                                        *TESTP05                        *
                4-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF031 FAD0CB43 18D305E0 18DF2D78  *..>DFHD2CSB     ..0..}...L.\....*
                  0020  19044210 007C6B90 00000000 00000000  B60AF030 A54A8EC0 00000000 00000000  *.....@,...........0.v$.{........*
                  0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                  0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                  0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF032 01359743 C7C2C9C2  *    ENTRXP050001......0...p.GBIB*
                  00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF030A5  4A8E0000 44800000 00000001 00000000  *MIYAIYAQTC03.0.v$..............*
                  00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *............                .%Q.*
                  00E0  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003905 00010400  *FRB .....0.\...................*
                  0100  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0120  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0140  00000000 00000000 00000000 00000000  00000000 00000000 98DCD110 00000000  *.......................q.J.....*
                  0160  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0180  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  01A0  00000000 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                  01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
                  01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0220  00000000 00000000 00000000 00000000  00000000 00000000 00000005 18DCD2C0  *............................K{*
                  0240  6E6EE399 81838540 E2A38199 A3406E6E  0100035C C9C4C5D5 00000000 00000000  *>>Trace Start >>...*IDEN........*
                  0260  0200035C E2C9C7D5 00000000 00000000  0300035C C3E3C8C4 00000000 00000000  *...*SIGN...........*CTHD........*
                  0280  0400035C C1D7C940 00000000 00000000  0500035C C1D7C940 00000000 00000000  *...*API ...........*API ........*
                  02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*

                5-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AC080 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.${.......}.*
                  0020  00000000 0006EFF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                  0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                  0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF030 A54A8EC0  *..{.............IYK2Z2G1..0.v$.{*
                  0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                  00A0  C9E8C1D8 E3C3F0F3 0AF030A5 4A8EC6D9  C2400003 000118F0 CD680000 00000000  *IYAQTC03.0.v$.FRB .....0........*
                  00C0  00000000 00000000 39050001 04000000  00000000 00000000 00000000 0000      *............................  *

AP 3251 D2D2 EXIT - FUNCTION(DB2_API_CALL) RESPONSE(OK)

              TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-98E3321C TIME-08:32:00.7697274233 INTERVAL-00.0018536093        =000170=
                1-0000  00200000 00000034 00000000 00000000  B8000000 00000000 03000100 18DCD030  *............................}.*
                2-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF031 FAD0CB43 18D305E0 18DF2D78  *..>DFHD2CSB     ..0..}...L.\....*
                  0020  19044210 007C6B90 00000000 00000000  B60AF030 A54A8EC0 00000000 00000000  *.....@,...........0.v$.{........*
                  0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                  0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                  0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF032 01359743 C7C2C9C2  *    ENTRXP050001......0...p.GBIB*
                  00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF030A5  4A8E0000 44800000 00000001 00000000  *MIYAIYAQTC03.0.v$..............*
                  00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *............                .%Q.*
                  00E0  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003905 00010400  *FRB .....0.\...................*
                  0100  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0120  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0140  00000000 00000000 00000000 00000000  00000000 00000000 98DCD110 00000000  *.......................q.J.....*
                  0160  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0180  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  01A0  00000000 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                  01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
                  01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  0220  00000000 00000000 00000000 00000000  00000000 00000000 00000005 18DCD2C0  *............................K{*
                  0240  6E6EE399 81838540 E2A38199 A3406E6E  0100035C C9C4C5D5 00000000 00000000  *>>Trace Start >>...*IDEN........*
                  0260  0200035C E2C9C7D5 00000000 00000000  0300035C C3E3C8C4 00000000 00000000  *...*SIGN...........*CTHD........*
                  0280  0400035C C1D7C940 00000000 00000000  0500035C C1D7C940 00000000 00000000  *...*API ...........*API ........*
                  02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                  02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*
                3-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AC080 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.${.......}.*
                  0020  00000000 0006EFF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                  0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                  0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF030 A54A8EC0  *..{.............IYK2Z2G1..0.v$.{*
                  0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                  00A0  C9E8C1D8 E3C3F0F3 0AF030A5 4A8EC6D9  C2400003 000118F0 CDE00000 00000000  *IYAQTC03.0.v$.FRB .....0.\......*
                  00C0  00000000 00000000 39050001 04000000  00000000 00000000 00000000 0000      *............................  *
```

Figure 47. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 6 or later (Part 3 of 4)

```
AP 3181 D2EX1 EXIT - APPLICATION REQUEST - EXEC SQL FETCH

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-8009E4D0 TIME-08:32:00.7697348608 INTERVAL-00.0000074375        =000171=
               1-0000  02000000 00280800 001EE3C5 E2E3D7F0  F5401663 1BA501CD D1DC0002 18F0BA40  *.........TESTP05 ...v..J....0. *
                 0020  00000000 18F0CDB0 018D0004                                              *.....0......                   *
               2-0000  00DE6EC4 C6C8C4F2 D3D6E340 40404040  E7D7F0F5 184AC080 18DF2D78 18DCD030  *..>DFHD2LOT     XP05.${.......}.*
                 0020  00000000 0006EFF0 00000000 18DF2E0C  18F0CDE0 00000000 00000000 FF6CD800  *.......0.........0.\.........%Q.*
                 0040  00000000 00000000 00000000 00000000  00000000 E3C5E2E3 D7F0F540 010C010C  *....................TESTP05 ....*
                 0060  A000C000 00000000 00000000 00000000  C9E8D2F2 E9F2C7F1 B60AF030 A54A8EC0  *..{.............IYK2Z2G1..0.v$.{*
                 0080  D1E3C9D3 D3C9F140 40404040 40404040  00000000 00000000 C7C2C9C2 D4C9E8C1  *JTILLI1         ........GBIBMIYA*
                 00A0  C9E8C1D8 E3C3F0F3 0AF030A5 4A8EC6D9  C2400003 000118F0 CDE00000 00000000  *IYAQTC03.0.v$.FRB .....0.\......*
                 00C0  00000000 00000000 39050001 04000000  00000000 00000000 00000000 0000      *............................    *
               3-0000  00                                                                        *.                              *
               4-0000  E2D8D3C3 C1404040 00000088 00000000  00004040 40404040 40404040 40404040  *SQLCA   ...h......              *
                 0020  40404040 40404040 40404040 40404040  40404040 40404040 40404040 40404040  *                                *
                 0040  40404040 40404040 40404040 40404040  40404040 40404040 C4E2D540 40404040  *                          DSN     *
                 0060  00000000 00000000 00000000 FFFFFFFF  00000000 00000000 40404040 40404040  *........................        *
                 0080  404040F0 F0F0F0F0                                                        *   00000                        *
               5-0000  00C86EC4 C6C8C4F2 C5D5E340 40404040  E7D7F0F5 40404040 B60AF017 63D17AC6  *.H>DFHD2ENT     XP05    ..0..J:F*
                 0020  E3C5E2E3 D7F0F540 00000000 00000000  00000000 00000000 D1E3C9D3 D3C9F140  *TESTP05 ................JTILLI1 *
                 0040  00808080 80000000 67E939C4 B0188B86  B60AF017 63D17AC6 0000000C 00000003  *.........Z.D...f..0..J:F........*
                 0060  00000001 00000001 00000000 00000000  00000001 00000001 00000000 00000000  *................................*
                 0080  00000000 00000002 00000001 00000000  00000000 00000000 00000000 00000000  *................................*
                 00A0  00000000 00000000 00000000 00000000  18DCD030 00000000 00000000 19044210  *..................}.............*
                 00C0  00000000 00000000                                                        *........                       *
               6-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF031 FAD0CB43 18D305E0 18DF2D78  *..>DFHD2CSB     ..0..}...L.\....*
                 0020  19044210 007C6B90 00000000 00000000  B60AF030 A54A8EC0 00000000 00000000  *.....@,...........0.v$.{........*
                 0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
                 0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
                 0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF032 01359743 C7C2C9C2  *    ENTRXP050001......0...p.GBIB*
                 00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF030A5  4A8E0000 44800000 00000001 00000000  *MIYAIYAQTC03.0.v$...............*
                 00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *....................        .%Q.*
                 00E0  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003905 00010400  *FRB .....0.\....................*
                 0100  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0120  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0140  00000000 00000000 00000000 00000000  00000000 00000000 98DCD110 00000000  *........................q.J.....*
                 0160  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0180  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 01A0  00000000 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
                 01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                               ....*
                 01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 0220  00000000 00000000 00000000 00000000  00000000 00000000 00000005 18DCD2C0  *............................K{*
                 0240  6E6EE399 81838540 E2A38199 A3406E6E  0100035C C9C4C5D5 00000000 00000000  *>>Trace Start >>...*IDEN........*
                 0260  0200035C E2C9C7D5 00000000 00000000  0300035C C3E3C8C4 00000000 00000000  *...*SIGN...........*CTHD........*
                 0280  0400035C C1D7C940 00000000 00000000  0500035C C1D7C940 00000000 00000000  *...*API ...........*API ........*
                 02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
                 02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*

AP 2523 ERM EVENT REGAINING-CONTROL-FROM-OPENAPI-TRUE(DSNCSQL )

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-99902F92 TIME-08:32:00.7697405327 INTERVAL-00.0000056718        =000172=
               1-0000  01                                                                        *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                        *DSNCSQL                        *
               3-0000  B60AF030 A54A8EC0                                                        *..0.v$.{                       *
               4-0000  18CCB654 0006F004 19044204 00000000  007A8000 007A8000 18F0005C 18F0CCD0  *......0.........:...:...0.*.0.}*
                 0020  190441C0 19044210 19044206 18F000D0  19044200 18CCBCA0 190441C8 190441B0  *...{.........0.}...........H....*
                 0040  190441AC 190441EC 18CCB5F3 190441FD  18CCB5F4 190441B4 190441B2 00020000  *...........3.......4............*
               5-0000  D3F8                                                                    *L8                             *

AP 2521 ERM EXIT PLI-APPLICATION-CALL-TO-TRUE(DSNCSQL )

             TASK-00035 KE_NUM-003F TCB-L8000/007C6B90 RET-99902F92 TIME-08:32:00.7697463608 INTERVAL-00.0000058281        =000173=
               1-0000  01                                                                        *.                              *
               2-0000  C4E2D5C3 E2D8D340                                                        *DSNCSQL                        *
               3-0000  B60AF030 A54A8EC0                                                        *..0.v$.{                       *
               4-0000  E3C5E2E3 D7F0F540 00000001 00100000  19900000 999000E0 000114E0 00000000  *TESTP05 ............r..\...\....*
                 0020  00000020 00007BB0 00000000 98400000  0040000A 00101100 00000000 00000000  *......#.....q ... ..............*
                 0040  00000000 00000000 00000000                                              *............                    *
```

Figure 47. Sample trace output from the RMI and the CICS DB2 TRUE — CICS connected to DB2 Version 6 or later (Part 4 of 4)

CSUB trace

The CSUB is the connection control block that CICS uses to manage, and exchange information about, a thread into DB2. It is the CICS equivalent to the DB2 connection control block. The CSUB is linked to the thread TCB that CICS uses to run the thread. See “Overview: How CICS connects to DB2” on page 1 for a full explanation of the relationship between the CSUB, the DB2 connection control block and the thread TCB.

When CICS is connected to DB2 Version 5 or earlier, the thread TCB is a subtask TCB owned by the CICS DB2 attachment facility and not known to the CICS dispatcher or kernel. This means that CICS tracing cannot be performed in the subtask program, DFHD2EX3. DFHD2EX3 does issue one GTF trace to record the point in time it posts back the CICS task on completion of the DB2 request. In addition to this, DFHD2EX3 maintains its own trace table at the end of the CSUB control block to record the requests it makes to DB2, and the responses to those requests.

When CICS is connected to DB2 Version 6 or later, and is using the open transaction environment, the thread TCB is an open TCB known to the CICS dispatcher and kernel. The CICS DB2 thread processor DFHD2D2, which replaces DFHD2EX3 in the open transaction environment, can therefore use CICS tracing. As well as using CICS tracing, DFHD2D2, like DFHD2EX3, maintains a trace table at the end of the CSUB control block to record the requests it makes to DB2, and the responses to those requests.

The CSUB trace table is 160 bytes in length allowing ten entries of 16 bytes to be written. The trace table wraps when all ten entries have been used. The format of each trace entry is shown in Table 16.

Table 16. Layout of CSUB trace table entry

Bytes	Content	Information
Bytes 0-3	Trace request number	Fullword number of the trace entry written. The number is used to find the latest entry written.
Bytes 4-7	Trace request	Four-character representation of the DB2 request issued. Possible values are: ABRT - Abort request API - SQL or IFI request ASSO - Associate request COMM - Commit request CTHD - Create thread request DISS - Dissociate request ERRH - Error handler request IDEN - Identify request PREP - Prepare request PSGN - Partial signon request SIGN - Full signon request SYNC - Single phase request TERM - Terminate thread request TIDN - Terminate identify request TSGN - Terminate signon request *REC - Recovery routine entered
Bytes 8-9	reserved	
Bytes 10-11	frb return code	Two-byte frb return code
Bytes 12-15	frb reason code	Four-byte frb reason code

The CSUB control block is formatted in a CICS system dump. It is also output if RI (RMI) level 2 trace is active in traces output from the CICS task-related user exit DFHD2EX1, plus all exception traces from DFHD2EX1.

In the trace example Figure 47 on page 187, output when CICS is connected to DB2 Version 5 or earlier, DATA6 from trace point 3181 is the CSUB, and this section is shown in Figure 48. Looking at the character representation on the right hand side, the trace table is delimited by >>Trace Start >> and <<Trace End <<. In this example you can see that an identify, signon, create thread, followed by two API requests have been issued to DB2, and all requests were successful and the FRB return code and reason codes for each request are zeros.

```
6-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B60AF031 FAD0CB43 18D305E0 18DF2D78  *..>DFHD2CSB     ..0..}...L.\....*
  0020  19044210 007C6B90 00000000 00000000  B60AF030 A54A8EC0 00000000 00000000  *.....@,.....0.v$.{........*
  0040  18DF2DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U...........................*
  0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
  0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B60AF032 01359743 C7C2C9C2  *    ENTRXP050001......0...p.GBIB*
  00A0  D4C9E8C1 C9E8C1D8 E3C3F0F3 0AF030A5  4A8E0000 44800000 00000001 00000000  *MIYAIYAQTC03.0.v$..............*
  00C0  00000000 00000000 00000000 40404040  40404040 40404040 40404040 FF6CD800  *............                .%Q.*
  00E0  C6D9C240 00030001 18F0CDE0 00000000  00000000 00000000 00003905 00010400  *FRB .....0.\...................*
  0100  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0120  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0140  00000000 00000000 00000000 00000000  00000000 00000000 98DCD110 00000000  *.......................q.J.....*
  0160  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0180  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  01A0  00000000 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
  01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
  01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0220  00000000 00000000 00000000 00000000  00000000 00000000 00000005 18DCD2C0  *.............................K{*
  0240  6E6EE399 81838540 E2A38199 A3406E6E  0100035C C9C4C5D5 00000000 00000000  *>>Trace Start >>...*IDEN.......*
  0260  0200035C E2C9C7D5 00000000 00000000  0300035C C3E3C8C4 00000000 00000000  *...*SIGN..........*CTHD........*
  0280  0400035C C1D7C940 00000000 00000000  0500035C C1D7C940 00000000 00000000  *...*API ..........*API ........*
  02A0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  02C0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<<Trace End   <<*
```

Figure 48. Sample CSUB trace — CICS connected to DB2 Version 5 or earlier

Figure 49 on page 193 shows the same situation when CICS is connected to DB2 Version 6 or later. In this example you can see that an identify, signon, and create thread have been issued to DB2. There is an API request, followed by a syncpoint and a dissociate (which dissociates the DB2 connection control block from the L8 TCB). The transaction now makes another API request, starting another unit of work, and the DB2 connection control block is reassociated (ASSO) with the L8 TCB. A partial signon occurs to create an accounting record for the previous unit of work. The API request is now issued to DB2.

```
5-0000  03006EC4 C6C8C4F2 C3E2C240 40404040  B6AD65D0 21D3EAC2 19335860 193F3D78  *..>DFHD2CSB     ...}.L.B...-....*
  0020  1956D210 007C9A60 00000000 00000000  B6AD65D2 9A2090C6 00000000 00000000  *..K.@.-...........K...F........*
  0040  193F3DE4 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *...U............................*
  0060  00000000 00000000 00000000 E3C5E2E3  D7F0F540 D1E3C9D3 D3C9F140 40404040  *............TESTP05 JTILLI1     *
  0080  40404040 C5D5E3D9 E7D7F0F5 F0F0F0F1  00000000 B6AD65D0 287EBD02 C7C2C9C2  *    ENTRXP050001.......}.=..GBIB*
  00A0  D4C9E8C1 C9E8C3E7 E3C3F0F7 AD65CE96  02B68000 44800000 00000001 D1E3C9D3  *MIYAIYCXTC07...o............JTIL*
  00C0  D3C9F140 40404040 40404040 40404040  40404040 40404040 40404040 FF6D6400  *LI1                            ._..*
  00E0  C6D9C240 00030001 1940CDF0 00000000  00000000 00000000 00004005 00010000  *FRB ..... .0.............. .....*
  0100  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0120  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0140  00000000 00000000 00000000 00000000  00000000 00000000 9954B110 00000000  *........................r.......*
  0160  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0180  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  01A0  00000000 00000000 40404040 40404040  40404040 40404040 40404040 40404040  *........                        *
  01C0  40404040 40404040 40404040 40404040  40404040 40404040 40404040 00000000  *                            ....*
  01E0  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0200  00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000  *................................*
  0220  00000000 00000000 00000000 00000000  00000000 00000000 00000009 1954B300  *................................*
  0240  6E6EE399 81838540 E2A38199 A3406E6E  0100057C C9C4C5D5 00000000 00000000  *>>Trace Start >>...@IDEN........*
  0260  0200057C E2C9C7D5 00000000 00000000  0300057C C3E3C8C4 00000000 00000000  *...@SIGN...........@CTHD........*
  0280  0400057C C1D7C940 00000000 00000000  0500057C E2E8D5C3 00000000 00000000  *...@API ...........@SYNC........*
  02A0  0600057C C4C9E2E2 00000000 00000000  0700057C C1E2E2D6 00000000 00000000  *...@DISS...........@ASSO........*
  02C0  0800057C D7E2C7D5 00000000 00000000  0900057C C1D7C940 00000000 00000000  *...@PSGN...........@API ........*
  02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<
  02E0  00000000 00000000 00000000 00000000  4C4CE399 81838540 C5958440 40404C4C  *................<
```

Figure 49. Sample CSUB trace — CICS connected to DB2 Version 6 or later

CSUB Abend information

If a CICS-DB2 subtask abends, part of the recovery process is to save information from the MVS SDWA in the CSUB control block, for example CSB_SDWA_REGS (regs 0 - 15) and CSB_SDWA_PSW. Although the CSUB is typically freemained following the failure, the exception trace written at the time of failure (AP 319D) captures the CSUB control block containing the SDWA information.

Dump for CICS DB2

Control blocks from the CICS DB2 attachment facility are formatted out in a CICS system dump under the control of the DB2 keyword of the CICS IPCS verbexit. The DB2 keyword may specify the following values:

- 0 - no DB2 output
- 1 - summary information only
- 2 - control blocks only
- 3 - summary and control blocks

In a CICS transaction dump, no summary or control blocks appear but the trace table contains the CICS DB2 trace entries.

A sample showing CICS DB2 summary information from a CICS system dump is shown in Figure 50 on page 194. It gives information on the global state of the CICS DB2 connection, and a summary of transactions (under the headings "Tran id", "Task num", "TcaAddr", "TieAddr", "LotAddr", "Rctename", "RcteAddr", "CsubAddr", "Correlation id", "Uowid", "Subtask running", and "TCB in DB2"). This sample was output when CICS was connected to DB2 Version 6, so using the open transaction environment.

```
===DB2: CICS/DB2 - SUMMARY
==DB2: GLOBAL STATE SUMMARY
   Db2conn name:                          RCTJT
   Connection status:                     Connected
   In standby mode:                       No
   DB2 id:                                DE2D
   DB2 Group id:
   DB2 release:                           0610
   Operating in OpenAPI mode:             Yes
   Service task started:                  Yes
   Master subtask started:                No - not required
   Tcb limit:                             12
   Currently active tcbs:                 2
   Message Queue1:                        CDB2
   Message Queue2:
   Message Queue3:
   Statistics Queue:                      CDB2
   Standbymode:                           Reconnect
   Connecterror:                          Sqlcode
==DB2: TRANSACTION SUMMARY
Tran Task  TcaAddr  TieAddr  LotAddr  Rctename RcteAddr CsubAddr Correlation  Uowid            Subtask  TCB
id   num                                                  id                               running  in DB2
-------------------------------------------------------------------------------------------------------------
XP05 00050 184AB680 190442F0 19044370 XP05     18DF2D78 18D10330 ENTRXP050002 B60A17A16316E1C7 N/A      Yes
XP05 00048 184AC680 19044190 19044210 XP05     18DF2D78 18D10030 ENTRXP050001 B60A1794A7A9E7C4 N/A      No
```

Figure 50. Dump example

DB2 thread identification

A thread executing in DB2 on behalf of a CICS transaction is identified by its *correlation ID* set by the CICS DB2 Attachment Facility. DB2 allows up to 12 bytes to be used for the correlation ID. In releases of CICS before CICS Transaction Server for OS/390, Version 1 Release 2, only 8 bytes were used.

The format 12 byte correlation ID is made up as as *eeeetttnnnn* where *eeee* is either COMD, POOL or ENTR indicating whether it is a command, pool or DB2ENTRY thread; *tttt* is the transid, and *nnnn* is a unique number.

Note: A correlation ID passed to DB2 can be changed only by the CICS Attachment Facility issuing a signon to DB2. If signon reuse occurs by a thread using a primary authorization ID which remains constant across multiple transactions (for example, by using AUTHID(name)) only one signon will occur. In this instance the *tttt* in the correlation ID does not match the running transaction ID. It is the ID of the transaction for which the initial signon occurred.

Transaction abend codes for CICS DB2

In releases of CICS before CICS Transaction Server for OS/390, Version 1 Release 2, the CICS DB2 attachment facility used a single transaction abend code DSNC for various error situations relying on state left in control blocks to distinguish between the error cases. The CICS DB2 attachment facility now uses multiple abend codes. Each abend code is unique to a particular error. The transaction abend codes are AD2x or AD3x and are documented in the *CICS Messages and Codes* manual and are available using the CICS-supplied transaction, CMAC.

Execution Diagnostic Facility (EDF) for CICS DB2

The CICS DB2 task-related user exit, DFHD2EX1, is enabled with the FORMATEDF keyword and is called by CICS to format the screen for SQL API requests when the transaction is being run under EDF.

In EDF mode, the CICS DB2 attachment facility:

- Stops on every EXEC SQL command and deciphers the SQL statement showing it in a file on the panel
- Shows the results before and after SQL calls are processed
- Displays the following:
  - The type of SQL statement.
  - Any input and output variables.
  - The contents of the SQLCA.
  - Primary and secondary authorization IDs. (This helps diagnose SQLCODE -922.)

An EDF panel displays a maximum of 55 variables, which is about ten screens. Each EDF SQL session requires 12KB of CICS temporary storage, which is freed on exit from EDF.

EDF screens for SQL statements are shown in Figure 51, and Figure 52 on page 196.

```
TRANSACTION: XC05 PROGRAM: TESTC05 TASK:0000097 APPLID: CICS41 DISPLAY:00
 STATUS:  ABOUT TO EXECUTE COMMAND

 EXEC SQL OPEN
  DBRM=TESTC05,  STMT=00221, SECT=00001









 OFFSET: X'001692'    LINE: UNKNOWN        EIBFN=X'0E0E'


ENTER:
PF1 : UNDEFINED          PF2 : UNDEFINED          PF3 : UNDEFINED
PF4 :                    PF5 :                    PF6 :
PF7 :                    PF8 :                    PF9 :
PF10:                    PF11: UNDEFINED          PF12:
```

Figure 51. EDF example of the "before" SQL EXEC panel

```
TRANSACTION: XC05 PROGRAM: TESTC05 TASK:0000097 APPLID: CICS41 DISPLAY:00
 STATUS:  COMMAND EXECUTION COMPLETE
 CALL TO RESOURCE MANAGER DSNCSQL
 EXEC SQL OPEN                              P.AUTH=SYSADM  , S.AUTH=
 PLAN=TESTC05,  DBRM=TESTC05,  STMT=00221, SECT=00001
 SQL COMMUNICATION AREA:
  SQLCABC      = 136                                          AT X'03907C00'
  SQLCODE      =   -923                                       AT X'03907C04'
  SQLERRML     = 070                                          AT X'03907C08'
  SQLERRMC     = ' ACCESS,00000000,00000000,              '... AT X'03907C0A'
  SQLERRP      = 'DSNAET03'                                   AT X'03907C50'
  SQLERRD(1-6) =  000,  000, 00000, 0000000000, 00000,  000   AT X'03907C58'
  SQLWARN(0-A) = '_ _ _ _ _ _ _ _ _ _ _'                      AT X'03907C70'
  SQLSTATE     = 57015                                        AT X'03907C7B'


 OFFSET: X'001692'    LINE: UNKNOWN        EIBFN=X'0E0E'


ENTER:  CONTINUE
PF1 : UNDEFINED           PF2 : UNDEFINED           PF3 : END EDF SESSION
PF4 : SUPPRESS DISPLAYS   PF5 : WORKING STORAGE     PF6 : USER DISPLAY
PF7 : SCROLL BACK         PF8 : SCROLL FORWARD      PF9 : STOP CONDITIONS
PF10: PREVIOUS DISPLAY    PF11: UNDEFINED           PF12: ABEND USER TASK
```

Figure 52. EDF example of the "after" SQL EXEC panel

Handling deadlocks in the CICS DB2 environment

Deadlocks can occur in a CICS DB2 system between two or more transactions or between one transaction and another DB2 user. Deadlocks can involve two resources or only one resource — see “Two deadlock types” on page 197.

This section covers deadlocks only within DB2. If DB2 resources are involved in this type of deadlock, one of the partners in the deadlock times out according to the user-defined IRLM parameters. Other possible deadlocks are where resources outside DB2 are involved.

Deadlocks are expected to occur, but not too often. You should give special attention to deadlock situations if:

- Other transactions are often delayed because they access resources held by the partners in the deadlock. This increases the response times for these transactions. A cascade effect can then be the result.
- The resources involved in the deadlock are expected to be used more intensively in the future, because of an increased transaction rate either for the transactions involved in the deadlock or for other transactions.

The IRLM component of the DB2 subsystem performs deadlock detection at user-defined intervals. One of the partners in the deadlock is the victim and receives a -911 or a -913 return code from DB2. The actual return code is determined by the DROLLBACK parameter for the DB2CONN (if a transaction is using a pool thread) or the DB2ENTRY used by the transaction. The other partner continues processing after the victim is rolled back.

To solve deadlock situations, you must perform a number of activities. Solving deadlocks means applying changes somewhere in the system to reduce the deadlock likelihood.

The following steps are often necessary for solving a deadlock situation:

1. Detect the deadlock (see “Deadlock detection”).
2. Find the resources involved (see “Finding the resources involved” on page 198).
3. Find the SQL statements involved (see “Finding the SQL statements involved” on page 198).
4. Find the access path used (see “Finding the access path used” on page 198).
5. Determine why the deadlock occurred (see “Determining why the deadlock occurred” on page 198).
6. Make changes to avoid it (see “Making changes” on page 198).

Two deadlock types

A deadlock within DB2 can occur when two transactions are both holding a lock wanted by the other transaction. In a DB2 environment, two deadlock types can occur when:

- Two resources are involved. Each transaction has locked one resource and wants the other resource in an incompatible mode. The resources are typically index pages and data pages. This is the classic deadlock situation.
- Only one resource is involved. DB2 Release 2 introduced the concept of update (U) locks. The main purpose was to reduce the number of situations where a *lock promotion* caused the deadlock. The U-lock has solved most of these situations, but it is still possible in specific situations to have a deadlock with only one resource involved, because the resource can be locked in more than one way.

  A typical example of this is when a transaction opens a cursor with the ORDER BY option and uses an index to avoid the sort. When a row in a page is fetched, DB2 takes a share (S) lock at that page. If the transaction then issues an update without a cursor for the row last fetched, the S-lock is promoted to an exclusive (X) lock.

  If two of these transactions run concurrently and both get the S-lock at the same page before taking the X-lock, a deadlock occurs.

Deadlock detection

In a normal production environment running without DB2 performance traces activated, the easiest way to get information about a deadlock is to scan the MVS log to find the messages shown in Figure 53.
From these messages, both partners in the deadlock are identified. The partners

```
DSNT375I PLAN p1 WITH CORRELATION ID id1
AND CONNECTION ID id2 IS DEADLOCKED with
PLAN p2 WITH CORRELATION ID id3
AND CONNECTION ID id4.

DSNT501I DSNILMCL RESOURCE UNAVAILABLE
         CORRELATION-ID=id1,CONNECTION-ID=id2
         REASON=r-code
         TYPE name
         NAME name
```

Figure 53. Deadlock messages

are given by both plan name and correlation ID.

Also, a second message identifies the resource that the victim could not obtain. The other resource (whether it is the same or not) is not displayed in the message.

Finding the resources involved

To find the other resources involved in a deadlock, you may have to activate a DB2 performance trace and recreate the deadlock. Suppose that the reason for solving the deadlock is that the number of deadlocks is too high. Normally recreating the deadlock after the trace is started is a minor problem.

You should limit the DB2 performance trace to the two plans indicated in the MVS log message. The "AUTH RCT" parameter specifies the CICS transaction ID; so limiting the trace to the two transaction IDs (authorization IDs) involved can also be reasonable. The performance trace to be started should include *class(06)* for general locking events and *class(03)* for SQL events. The Database 2 Performance Monitor (DB2PM) is a useful tool to format the trace output. The DB2PM lock contention report and the lock suspension report can assist in determining the resources involved in the deadlock.

If the output from the DB2PM reports is too large, you can develop a user program to analyze the output from the traces. The goal is to find the resources involved in the deadlock and all the SQL statements involved.

Finding the SQL statements involved

A deadlock can involve many SQL statements. Often solving the deadlock requires finding all SQL statements. If the resources involved are identified from the lock traces, you can find the involved SQL statements in an SQL trace report by combining the timestamps from both traces.

Finding the access path used

To find the access path used by the SQL statements involved in the deadlock, use the EXPLAIN option of DB2 for the corresponding plans.

Determining why the deadlock occurred

Identifying both the SQL statements and the resources involved in the deadlock and finding the access path should show you why the deadlock occurred. This knowledge is often necessary to be able to develop one or more solutions. However, the process can be time-consuming.

Making changes

In general, a deadlock occurs because two or more transactions both want the same resources in opposite order at the same time and in a conflicting mode. The actions taken to prevent a deadlock must deal with these characteristics.

Table 17 shows a list of preventive actions and the corresponding main effects.

Table 17. Deadlock prevention

Actions	Spread Resources	Change the Locking Order	Decrease Concurrency	Change Locking Mode
Increase Index Freespace	X			
Increase Index Subpage Size	X			
Increase TS Freespace	X			
Change Clustering Index	X	X		
Reorg the Table Space	X	X	X	
Add an Index		X	X (1)	
Drop an Index		X		

Table 17. Deadlock prevention (continued)

Actions	Spread Resources	Change the Locking Order	Decrease Concurrency	Change Locking Mode
Serialize the Transactions			X	
Use additional COMMITS			X	
Minimize the Response Time			X	
Change Isolation Level (2)			X	X
Redesign Application	X	X	X	X
Redesign Database	X	X	X	X
Notes: 1. Due to changes in access path. 2. Cursor stability is usually better than repeatable read.				

To choose the right action, you must first understand why the deadlock occurred. Then you can evaluate the actions to make your choices. These actions can have several effects. They can:

- Solve the deadlock problem as desired
- Force a change in access path for other transactions causing new deadlocks
- Cause new deadlocks in the system.

It is therefore important that you carefully monitor the access path used by the affected transactions, for example by the EXPLAIN facility in DB2. In many cases, solving deadlocks is an iterative process.

Bibliography

The CICS Transaction Server for z/OS library

The published information for CICS Transaction Server for z/OS is delivered in the following forms:

The CICS Transaction Server for z/OS Information Center

The CICS Transaction Server for z/OS Information Center is the primary source of user information for CICS Transaction Server. The Information Center contains:

- Information for CICS Transaction Server in HTML format.
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CICSPlex SM Messages and Codes, GC34-6471
CICSPlex SM Problem Determination, GC34-6472

CICS family books

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CICS Family: Communicating from CICS on System/390, SC34-6474

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CICS Debugging Tools Interfaces Reference, GC34-6908

Other CICS books

The following publications contain further information about CICS, but are not provided as part of CICS Transaction Server for z/OS, Version 3 Release 1.

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 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

Books from related libraries

DB2

- *DB2 Universal Database for OS/390 and z/OS Administration Guide*, SC26-9931
- *DB2 Universal Database for OS/390 and z/OS Application Programming and SQL Guide*, SC26-9933
- *DB2 Universal Database for OS/390 and z/OS Command Reference*, SC26-9934
- *DB2 Universal Database for OS/390 and z/OS Data Sharing: Planning and Administration*, SC26-9935
- *DB2 Universal Database Server for z/OS Data Sharing Quick Reference Card*, SX26-3846
- *DB2 Universal Database for OS/390 and z/OS Diagnosis Guide and Reference*, LY37-3740
- *DB2 Universal Database for OS/390 and z/OS Diagnostic Quick Reference*, LY37-3741
- *DB2 Universal Database for OS/390 and z/OS Installation Guide*, GC26-9936
- *DB2 Universal Database for OS/390 and z/OS Messages and Codes*, GC26-9940
- *DB2 Universal Database for OS/390 and z/OS Reference for Remote DRDA® Requesters and Servers*, SC26-9942
- *DB2 Universal Database for OS/390 and z/OS Reference Summary*, SX26-3847
- *DB2 Universal Database for OS/390 and z/OS Release Planning Guide*, SC26-9943

- *DB2 Universal Database for OS/390 and z/OS SQL Reference*, SC26-9944
- *DB2 Universal Database for OS/390 and z/OS Utility Guide and Reference*, SC26-9945
- *DB2 Universal Database Server for OS/390 and z/OS What's New?*, GC26-9946
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- *DB2 Universal Database for OS/390 and z/OS Text Extender Administration and Programming*, GC26-9941
- *DB2 Universal Database for OS/390 and z/OS XML Administration and Programming*, GC26-9941
- *An Introduction to DB2 Universal Database for z/OS*, GC26-9937
- *DB2 for OS/390 DB2 Packages: Implementation and Use*, GG24-4001

DB2 Performance Monitor (DB2 PM)

- *DB2 Performance Monitor for OS/390: Report Reference*, SC27-0853

Resource Management Facility (RMF)

- *z/OS Resource Management Facility (RMF) Performance Management Guide*, SC33–7992
- *z/OS Resource Management Facility (RMF) Report Analysis*, SC33–7991

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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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This book also documents Diagnosis, Modification or Tuning Information provided by CICS.

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