CICS Transaction Server for z/OS

Web Services Guide

Version 3 Release 2

SC34-6838-04

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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 305.

This edition applies to Version 3 Release 2 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.

Contents

Preface

What this book is about

This book describes how to use Web Services in CICS®.

Who should read this book

This book is for:

- Planners and architects considering deploying CICS applications in a Web services environment.
- Systems programmers who are responsible for configuring CICS to support Web services
- Applications programmers who are responsible for applications that will be deployed in a Web services environment.

Chapter 1. CICS and Web services

What the World Wide Web did for interactions between programs and end users, Web services can do for program-to-program interactions. With Web services, you can integrate applications more rapidly, efficiently, and cheaply than ever before.

CICS Transaction Server for z/OS® provides comprehensive support for Web services:

- A CICS application can participate in a heterogeneous Web services environment as a service requester, as a service provider, or both.
- CICS supports the HTTP and WebSphere MQ transport protocols.
- CICS Transaction Server for z/OS includes the CICS Web services assistant, a set of utility programs that help you map WSDL service descriptions into high-level programming language data structures, and *vice versa*. The utility programs support these programming languages:

  COBOL

  PL/I

  C

  C++
- The CICS support for Web services conforms to open standards including:

  SOAP 1.1 and 1.2

  HTTP 1.1

  | WSDL 1.1 and 2.0
- CICS support for Web services ensures maximum interoperability with other Web services implementations by conditionally or fully complying with many Web Service specifications, including the "WS-I Basic Profile Version 1.1" on page 31. The profile is a set of non-proprietary Web services specifications, along with clarifications and amendments to those specifications, which, taken together, promote interoperability between different implementations of Web services.

What is a Web service?

A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically, Web Service Definition Language, or WSDL).

Web services fulfill a specific task or a set of tasks. A Web service is described using a standard, formal XML notion, called its service description, that provides all of the details necessary to interact with the service, including message formats (that detail the operations), transport protocols, and location.

The nature of the interface hides the implementation details of the service so that it can be used independently of the hardware or software platform on which it is implemented and independently of the programming language in which it is written.

This allows and encourages Web service based applications to be loosely coupled, component oriented, cross-technology implementations. Web services can be used alone or in conjunction with other Web services to carry out a complex aggregation or a business transaction.

How Web services can help your business

Web services is a technology for deploying, and providing access to, business functions over the World Wide Web. Web services make it possible for applications to be integrated more rapidly, easily, and cheaply than ever before.

Web services can help your business by:

- Reducing the cost of doing business
- Making it possible to deploy solutions more rapidly
- Opening up new opportunities.

The key to achieving all these things is a common program-to-program communication model, built on existing and emerging standards such as HTTP, XML, SOAP, and WSDL.

The support that CICS provides for Web services makes it possible for your existing applications to be deployed in new ways, with the minimum amount of reprogramming.

Web services terminology

Extensible Markup Language (XML)
A standard for document markup, which uses a generic syntax to mark up data with simple, human-readable tags. The standard is endorsed by the World Wide Web Consortium (W3C) (http://www.w3.org).

Initial SOAP sender
The SOAP sender that originates a SOAP message at the starting point of a SOAP message path.

Service provider
The collection of software that provides a Web service.

Service provider application
An application that is used in a service provider. Typically, a service provider application provides the business logic component of a service provider.

Service requester
The collection of software that is responsible for requesting a Web service from a service provider.

Service requester application
An application that is used in a service requester. Typically, a service requester application provides the business logic component of a service requester.

Simple Object Access Protocol
See SOAP.

SOAP Formerly an acronym for *Simple Object Access Protocol*. A lightweight protocol for exchange of information in a decentralized, distributed environment. It is an XML based protocol that consists of three parts:

- An envelope that defines a framework for describing what is in a message and how to process it.
- A set of encoding rules for expressing instances of application-defined data types.
- A convention for representing remote procedure calls and responses.

SOAP can be used with other protocols, such as HTTP.

The specification for SOAP 1.1 is published at http://www.w3.org/TR/SOAP.

The specification for SOAP 1.2 is published at:

http://www.w3.org/TR/soap12-part0

http://www.w3.org/TR/soap12-part1

http://www.w3.org/TR/soap12-part2

SOAP intermediary
A SOAP node that is both a SOAP receiver and a SOAP sender and is targetable from within a SOAP message. It processes the SOAP header blocks targeted at it and acts to forward a SOAP message towards an ultimate SOAP receiver.

SOAP message path
The set of SOAP nodes through which a single SOAP message passes. This includes the initial SOAP sender, zero or more SOAP intermediaries, and an ultimate SOAP receiver.

SOAP node
Processing logic which operates on a SOAP message.

SOAP receiver
A SOAP node that accepts a SOAP message.

SOAP sender
A SOAP node that transmits a SOAP message.

Ultimate SOAP receiver
The SOAP receiver that is a final destination of a SOAP message. It is responsible for processing the contents of the SOAP body and any SOAP header blocks targeted at it.

UDDI Universal Description, Discovery and Integration

Universal Description, Discovery and Integration
Universal Description, Discovery and Integration (UDDI) is a specification for distributed Web-based information registries of Web services. UDDI is also a publicly accessible set of implementations of the specification that allow businesses to register information about the Web services they offer so that other businesses can find them. The specification is published by OASIS (http://www.oasis-open.org)

Web service
A software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically, Web Service Description Language, or WSDL).

Web Services Atomic Transaction
A specification that provides the definition of an atomic transaction coordination type used to coordinate activities having an "all or nothing" property.

The specification is published at http://www.ibm.com/developerworks/library/specification/ws-tx/#atomhttp://www.ibm.com/developerworks/library/specification/ws-tx/#atom.

Web service binding file
A file, associated with a WEBSERVICE resource, which contains

information that CICS uses to map data between input and output messages, and application data structures.

Web service description
An XML document by which a service provider communicates the specifications for invoking a Web service to a service requester. Web service descriptions are written in Web Service Description Language (WSDL).

Web Service Description Language
An XML application for describing Web services. It is designed to separate the descriptions of the abstract functions offered by a service, and the concrete details of a service, such as how and where that functionality is offered.

The specification is published at http://www.w3.org/TR/wsdlhttp://www.w3.org/TR/wsdl.

Web Services Security
A set of enhancements to SOAP messaging that provides message integrity and confidentiality. The specification is published by OASIS (http://www.oasis-open.org) at http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-soap-message-security-1.0.pdf.

WS-Atomic Transaction
Web Services Atomic Transaction

WS-I Basic Profile
A set of non-proprietary Web services specifications, along with clarifications and amendments to those specifications, which, taken together, promote interoperability between different implementations of Web services. The profile is defined by the Web Services Interoperability Organization (WS-I) and version 1.0 is available at http://www.ws-i.org/Profiles/BasicProfile-1.0.html.

WSDL Web Service Description Language.

WSS Web Services Security

XML Extensible Markup Language.

The specifications for XML are published at:

http://www.w3.org/TR/soap12-part0

http://www.w3.org/TR/soap12-part1

http://www.w3.org/TR/soap12-part2

XML namespace
A collection of names, identified by a URI reference, which are used in XML documents as element types and attribute names.

XML schema
An XML document that describes the structure, and constrains the contents of other XML documents.

XML schema definition language
An XML syntax for writing XML schemas, recommended by the World Wide Web Consortium (W3C).

Chapter 2. The Web services architecture

The Web services architecture is based on interactions between three components: a service provider, a service requester, and an optional service registry.

The service provider
The collection of software that provides a Web service. It includes:

- The application program
- The middleware
- The platform on which they run

The service requester
The collection of software that is responsible for requesting a Web service from a service provider. It includes:

- The application program
- The middleware
- The platform on which they run

The service registry
A place where service providers publish descriptions of the services they provide, and where service requesters find them.

The registry is an optional component of the Web services architecture, because there are many situations where service requesters and providers can communicate without it. For example, the organization that provides a service can distribute the service description directly to the users of the service, using an attachment in an e-mail, or a download from an FTP site, or even a CD-ROM distribution.

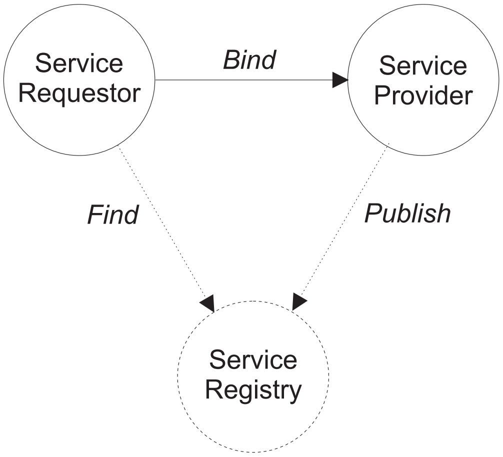


Figure 1. Web service components and interactions

CICS provides direct support for implementing the requester and provider components; you will need additional software to deploy a service registry in CICS. But, because the Web service architecture is platform-independent, you can, if you need a service registry, deploy it on another platform.

The interactions between the components involve the following operations:

Bind The service requester uses the service description to bind with the service provider and interact with the Web service implementation.

Publish
When a service registry is used, a service provider publishes its description in a registry so that the requester can find it.

Find When a service registry is used, a service requester finds the service description in the registry.

The Web service description

A Web service description is a document by which the *service provider* communicates the specifications for invoking the Web service to the *service requester*. Web service descriptions are expressed in the XML application known as Web Service Description Language (WSDL).

The service description describes the Web service in such a way as to minimize the amount of shared knowledge and customized programming that is needed to ensure communication between the service provider and the service requester. For example, neither the requester nor the provider needs to be aware of the platform on which the other runs, nor of the programming language in which the other is written.

A service description can conform to either the WSDL 1.1 or WSDL 2.0 specification, and there are differences in both the terminology and major elements that can be included in the service description. The following information uses WSDL 1.1 terminology and elements to explain the purpose of the service description.

The structure of WSDL allows a service description to be partitioned into:
- An abstract *service interface definition* that describes the interfaces of the service, and makes it possible to write programs that implement, and invoke, the service.
- A concrete *service implementation definition* that describes the location on the network (or *endpoint*) of the provider's Web service, and other implementation specific details, and that makes it possible for a service requester to connect to the service provider.

This is illustrated in Figure 2 on page 7.

A WSDL 1.1 document uses the following major elements in the definition of network services:

`<types>`
A container for data type definitions using some type system (such as XML Schema). Defines the data types used within the message. The `<types>` element is not required when all messages consist of simple data types.

`<message>`
Specifies which XML data types are used to define the input and output parameters of an operation.

`<portType>`
Defines the set of operations supported by one or more endpoints. Within a `<portType>` element, each operation is described by an `<operation>` element.

<operation>
Specifies which XML messages can appear in the input and output data flows. An operation is comparable with a method signature in a programming language.

<binding>
Describes the protocol, data format, security and other attributes for a particular `<portType>` element.

<port> Specifies the network address of an endpoint, and associates it with a `<binding>` element.

<service>
Defines the Web service as a collection of related endpoints. A `<service>` element contains one or more `<port>` elements.

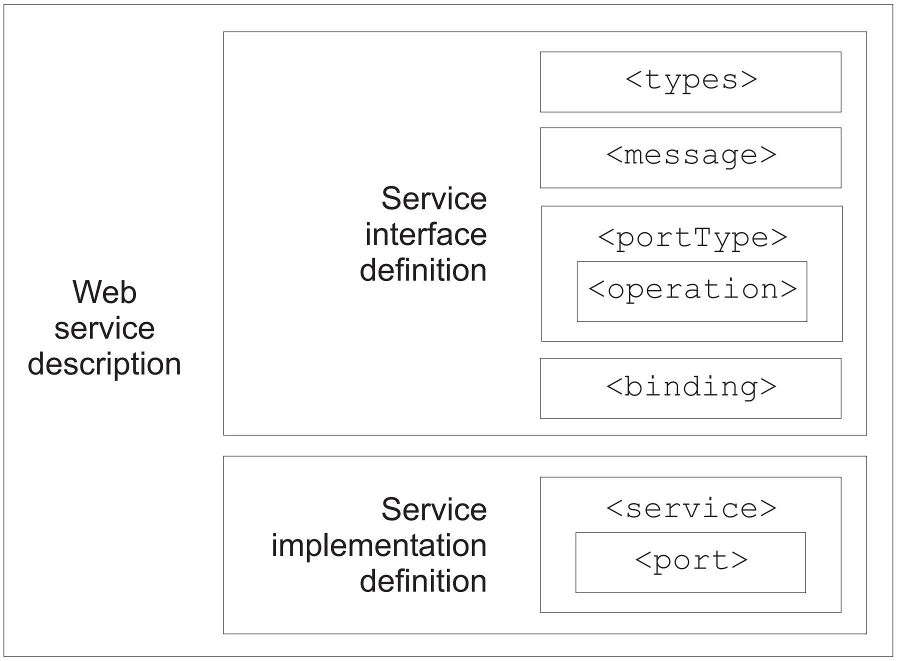


Figure 2. Structure of a Web service description

The ability to partition the Web service description makes it possible to divide responsibility for creating a complete service description. As an illustration, consider a service which is defined by a standards body for use across an industry, and implemented by individual companies within that industry:

- The standards body provides a service interface definition, containing the following elements:

  `<types>`

  `<message>`

  `<portType>`

  `<binding`

- A service provider who wishes to offer an implementation of the service provides a service implementation definition, containing the following elements:

  `<port>`

  `<service>`

Service publication

A service description can be published using a number of different mechanisms; each mechanism has different capabilities, and is suitable for use in different situations. When necessary, a service description can be published in more than one way. Although CICS does not provide direct support for service publication, any of the mechanisms described can be used with CICS.

Direct publishing
This is the simplest mechanism for publishing service descriptions: the service provider sends the service description directly to the service requester. Ways to accomplish this include using an e-mail attachment, an FTP site, or a CD ROM distribution.

Advertisement and Discovery of Services (ADS)
DISCO
These proprietary protocols provide a dynamic publication mechanism. The service requester uses a simple HTTP GET mechanism to retrieve a Web service descriptions from a network location that is specified by the service provider, and identified with a URL.

Universal Description, Discovery and Integration (UDDI)
A specification for distributed Web-based information registries of Web services. UDDI is also a publicly accessible set of implementations of the specification that allow businesses to register information about the Web services they offer so that other businesses can find them.

Chapter 3. What is SOAP?

SOAP is a protocol for the exchange of information in a distributed environment. SOAP messages are encoded as XML documents and can be exchanged using a variety of underlying protocols.

Formerly an acronym for *Simple Object Access Protocol*, SOAP is developed by the World Wide Web Consortium (W3C), and is defined in the following documents issued by W3C. Consult these documents for complete, and authoritative, information about SOAP.

Simple Object Access Protocol (SOAP) 1.1 (W3C note)

SOAP Version 1.2 Part 0: Primer (W3C recommendation)

SOAP Version 1.2 Part 1: Messaging Framework (W3C recommendation)

SOAP Version 1.2 Part 2: Adjuncts (W3C recommendation)

The SOAP specifications describe a distributed processing model in which a *SOAP message* is passed between *SOAP nodes*. The message originates at a *SOAP sender* and is sent to a *SOAP receiver*. Between the sender and the receiver, the message might be processed by one or more *SOAP intermediaries*.

A SOAP message is a one-way transmission between SOAP nodes, from a SOAP sender to a SOAP receiver, but messages can be combined to construct more complex interactions, such as request and response, and peer-to-peer conversations.

The specification also describes:

- A set of encoding rules for expressing instances of application-defined data types.
- A convention for representing remote procedure calls and responses.

The structure of a SOAP message

A SOAP message is encoded as an XML document, consisting of an `<Envelope>` element, which contains an optional `<Header>` element, and a mandatory `<Body>` element. The `<Fault>` element, contained within the `<Body>`, is used for reporting errors.

The SOAP envelope

The SOAP `<Envelope>` is the root element in every SOAP message, and contains two child elements, an optional `<Header>` and a mandatory `<Body>`.

The SOAP header

The SOAP `<Header>` is an optional sub-element of the SOAP envelope, and is used to pass application-related information that is to be processed by SOAP nodes along the message path.

The SOAP body

The SOAP `<Body>` is a mandatory sub-element of the SOAP envelope, which contains information intended for the ultimate recipient of the message.

The SOAP fault

The SOAP `<Fault>` is a sub-element of the SOAP body, which is used for reporting errors.

With the exception of the `<Fault>` element, which is contained in the `<Body>` of a SOAP message, XML elements within the `<Header>` and the `<Body>` are defined by the applications that make use of them, although the SOAP specification imposes some constraints on their structure.

Figure 3 shows the main elements of a SOAP message.
Figure 4 on page 11 is an example of a SOAP message that contains header blocks (the `<m:reservation>` and `<n:passenger>` elements) and a body (containing the `<p:itinerary>` and `<q:lodging>` elements).

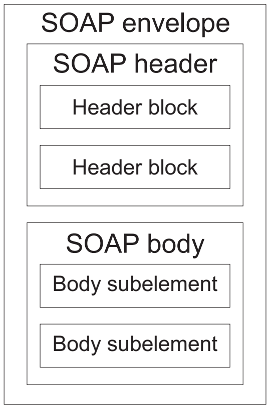


Figure 3. The structure of a SOAP message

```
<?xml version='1.0' ?>
<env:Envelope xmlns:env="http://www.w3.org/2003/05/soap-envelope">
 <env:Header>
  <m:reservation xmlns:m="http://travelcompany.example.org/reservation"
          env:role="http://www.w3.org/2003/05/soap-envelope/role/next"
           env:mustUnderstand="true">
   <m:reference>uuid:093a2da1-q345-739r-ba5d-pqff98fe8j7d</m:reference>
   <m:dateAndTime>2001-11-29T13:20:00.000-05:00</m:dateAndTime>
  </m:reservation>
  <n:passenger xmlns:n="http://mycompany.example.com/employees"
          env:role="http://www.w3.org/2003/05/soap-envelope/role/next"
           env:mustUnderstand="true">
   <n:name>Åke Jõgvan Øyvind</n:name>
  </n:passenger>
 </env:Header>
 <env:Body>
  <p:itinerary
    xmlns:p="http://travelcompany.example.org/reservation/travel">
   <p:departure>
     <p:departing>New York</p:departing>
     <p:arriving>Los Angeles</p:arriving>
     <p:departureDate>2001-12-14</p:departureDate>
     <p:departureTime>late afternoon</p:departureTime>
     <p:seatPreference>aisle</p:seatPreference>
   </p:departure>
   <p:return>
     <p:departing>Los Angeles</p:departing>
     <p:arriving>New York</p:arriving>
     <p:departureDate>2001-12-20</p:departureDate>
     <p:departureTime>mid-morning</p:departureTime>
     <p:seatPreference/>
   </p:return>
  </p:itinerary>
  <q:lodging
   xmlns:q="http://travelcompany.example.org/reservation/hotels">
   <q:preference>none</q:preference>
  </q:lodging>
 </env:Body>
</env:Envelope>
```

Figure 4. An example of a SOAP 1.2 message

The SOAP header

The SOAP `<Header>` is an optional element within a SOAP message. It is used to pass application-related information that is to be processed by SOAP nodes along the message path.

The immediate child elements of the `<Header>` element are called header blocks; a header block is an application-defined XML element, and represents a logical grouping of data which can be targeted at SOAP nodes that might be encountered in the path of a message from a sender to an ultimate receiver.

SOAP header blocks can be processed by SOAP intermediary nodes, and by the ultimate SOAP receiver node; however, in a real application, not every node will process every header block. Rather, each node is typically designed to process particular header blocks, and - conversely - each header block is intended to be processed by particular nodes.

The SOAP header allows features to be added to a SOAP message in a decentralized manner without prior agreement between the communicating parties.

SOAP defines a few attributes that can be used to indicate who should deal with a feature and whether it is optional or mandatory. Such "control" information includes, for example, passing directives or contextual information related to the processing of the message. This allows a SOAP message to be extended in an application-specific manner.

Although the header blocks are application-defined, SOAP-defined attributes on the header blocks indicate how the header blocks are to be processed by the SOAP nodes. Some of the important attributes are:

`encodingStyle`
Indicates the rules used to encode the parts of a SOAP message: SOAP defines a narrower set of rules for encoding data than the very flexible encoding that XML allows.

`role (SOAP 1.2)`
`actor (SOAP 1.1)`

In SOAP 1.2, the **role** attribute specifies whether a particular node will operate on a message. If the role specified for the node matches the role attribute of the header block, the node processes the header; if the roles do not match, the node does not process the header block. In SOAP 1.1, the **actor** attribute performs the same function.

Roles can be defined by the application, and are designated by a URI. For example, `http://example.com/Log` might designate the role of a node which performs logging. Header blocks which are to be processed by this node specify `env:role="http://example.com/Log"` (where the namespace prefix `env` is associated with the SOAP namespace name of `http://www.w3.org/2003/05/soap-envelope`).

The SOAP 1.2 specification defines three standard roles in addition to those which are defined by the application:

`http://www.w3.org/2003/05/soap-envelope/none`
None of the SOAP nodes on the message path should process the header block directly. Header blocks with this role can be used to carry data that is required for processing of other SOAP header blocks.

`http://www.w3.org/2003/05/soap-envelope/next`
All SOAP nodes on the message path are expected to examine the header block (provided that the header has not been removed by a node earlier in the message path).

`http://www.w3.org/2003/05/soap-envelope/ultimateReceiver`
Only the ultimate receiver node is expected to examine the header block.

`mustUnderstand`
This attribute is used to ensure that SOAP nodes do not ignore header blocks which are important to the overall purpose of the application. If a SOAP node determines (using the **role** or **actor** attribute) that it should process a header block, and the **mustUnderstand** attribute has a value of `"true"`, then the node must either process the header block in a manner consistent with its specification, or not at all (and throw a fault). But if the attribute has a value of `"false"`, the node is not obliged to process the header block.

In effect, the **mustUnderstand** attribute indicates whether processing of the header block is mandatory or optional.

Values of the **mustUnderstand** attribute are:

`true (SOAP 1.2)`

1 (SOAP 1.1)
the node must either process the header block in a manner consistent with its specification, or not at all (and throw a fault).

false (SOAP 1.2)
0 (SOAP 1.1)
the node is not obliged to process the header block.

relay (SOAP 1.2 only)
When a SOAP intermediary node processes a header block, it removes it from the SOAP message. By default, it also removes any header blocks that it ignored (because the **mustUnderstand** attribute had a value of "false"). However, when the **relay** attribute is specified with a value of "true", the node retains the unprocessed header block in the message.

The SOAP body

The <Body> is the mandatory element within the SOAP envelope in which the main end-to-end information conveyed in a SOAP message is carried.

The <Body> element and its associated child elements are used to exchange information between the initial SOAP sender and the ultimate SOAP receiver. SOAP defines one child element for the <Body>: the <Fault> element is used for reporting errors. Other elements within the <Body> are defined by the Web service that uses them.

The SOAP fault

The SOAP <Fault> element is used to carry error and status information within a SOAP message.

If present, the SOAP <Fault> element must appear as a body entry and must not appear more than once within a Body element. The subelements of the SOAP <Fault> element are different in SOAP 1.1 and SOAP 1.2.

SOAP 1.1

In SOAP 1.1, the SOAP <Fault> element contains the following subelements:

<faultcode>
The <faultcode> element is a mandatory element within the <Fault> element. It provides information about the fault in a form that can be processed by software. SOAP defines a small set of SOAP fault codes covering basic SOAP faults, and this set can be extended by applications.

<faultstring>
The <faultstring> element is is a mandatory element within the<Fault> element. It provides information about the fault in a form intended for a human reader.

<faultactor>
The <faultactor> element contains the URI of the SOAP node that generated the fault. A SOAP node that is not the ultimate SOAP receiver must include the <faultactor> element when it creates a fault; an ultimate SOAP receiver is not obliged to include this element, but may do so.

<detail>
The <detail> element carries application-specific error information related to the <Body> element. It must be present if the contents of the <Body> element could not be successfully processed; it must not be used to carry

information about error information belonging to header entries - detailed error information belonging to header entries must be carried within header entries.

SOAP 1.2

In SOAP 1.2, the SOAP `<Fault>` element contains the following subelements:

`<Code>`
The `<Code>` element is a mandatory element within the `<Fault>` element. It provides information about the fault in a form that can be processed by software. It contains a `<Value>` element and an optional `<Subcode>` element.

`<Reason>`
The `<Reason>` element is a mandatory element within the `<Fault>` element. It provides information about the fault in a form intended for a human reader. The `<Reason>` element contains one or more `<Text>` elements, each of which contains information about the fault in a different language.

`<Node>`
The `<Node>` element contains the URI of the SOAP node that generated the fault. A SOAP node that is not the ultimate SOAP receiver must include the `<Node>` element when it creates a fault; an ultimate SOAP receiver is not obliged to include this element, but may do so.

`<Role>`
The `<Role>` element contains a URI that identifies the role the node was operating in at the point the fault occurred.

`<Detail>`
The `<Detail>` element is an optional element, which contains application-specific error information related to the SOAP fault codes describing the fault. The presence of the `<Detail>` element has no significance as to which parts of the faulty SOAP message were processed.

SOAP nodes

A SOAP node is the processing logic which operates on a SOAP message.

A SOAP node can:

- transmit a SOAP message
- receive a SOAP message
- process a SOAP message
- relay a SOAP message.

A SOAP node can be:

SOAP sender
A SOAP node that transmits a SOAP message.

SOAP receiver
A SOAP node that accepts a SOAP message.

Initial SOAP sender
The SOAP sender that originates a SOAP message at the starting point of a SOAP message path.

SOAP intermediary
A SOAP intermediary is both a SOAP receiver and a SOAP sender and is targetable from within a SOAP message. It processes the SOAP header blocks targeted at it and acts to forward a SOAP message towards an ultimate SOAP receiver.

Ultimate SOAP receiver

The SOAP receiver that is a final destination of a SOAP message. It is responsible for processing the contents of the SOAP body and any SOAP header blocks targeted at it. In some circumstances, a SOAP message might not reach an ultimate SOAP receiver, for example because of a problem at a SOAP intermediary.

The SOAP message path

The SOAP message path is the set of SOAP nodes through which a single SOAP message passes. This includes the initial SOAP sender, zero or more SOAP intermediaries, and an ultimate SOAP receiver

In the simplest case, a SOAP message is transmitted between two nodes, that is from a *SOAP sender* to a *SOAP receiver*. However, in more complex cases, messages can be processed by *SOAP intermediary* nodes, which receive a SOAP message, and then send it to the next node. Figure 5 shows an example of a SOAP message path, in which a SOAP message is transmitted from the initial SOAP sender node, to the ultimate SOAP receiver node, passing through two SOAP intermediary nodes on its route.

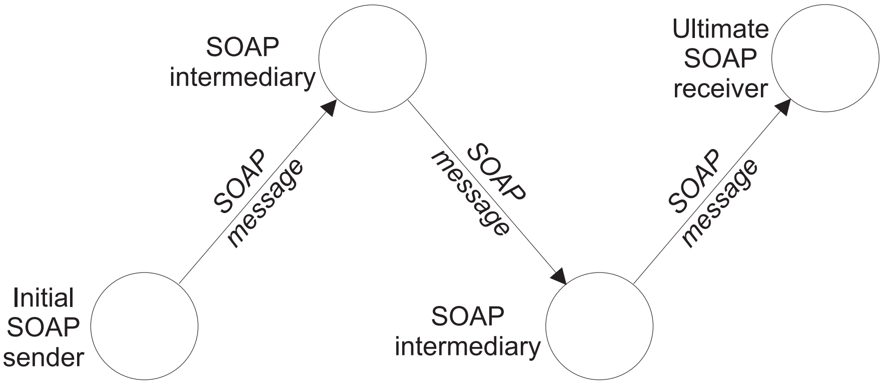


Figure 5. An example of a SOAP message path

A SOAP intermediary is both a SOAP receiver and a SOAP sender. It can (and in some cases must) process the header blocks in the SOAP message, and it forwards the SOAP message towards its ultimate receiver.

The *ultimate SOAP receiver* is the final destination of a SOAP message. As well as processing the header blocks, it is responsible for processing the SOAP body. In some circumstances, a SOAP message might not reach an ultimate SOAP receiver, for example because of a problem at a SOAP intermediary.

Chapter 4. How CICS supports Web services

CICS supports two different approaches to the deployment of your CICS applications in a Web services environment. One approach enables rapid deployment, with the least amount of programming effort; the other approach gives you complete flexibility and control over your Web service applications, using code that you write to suit your particular needs. Both approaches are underpinned by an infrastructure consisting of one or more *pipelines* and *message handler* programs that operate on Web service requests and responses.

When you deploy your CICS applications in a Web services environment you can choose from the following options:

- Use the CICS Web services assistant to help you deploy an application with the least amount of programming effort.

  For example, if you want to expose an existing application as a Web service, you can start with a high-level language data structure and generate the Web services description. Alternatively, if you want to communicate with an existing Web service, you can start with its Web service description and generate a high-level language structure that you can use in your program.

  The CICS Web services assistant also generates the CICS resources that you need to deploy your application. And when your application runs, CICS transforms your application data into a SOAP message on output and transforms the SOAP message back to application data on input.
- Take complete control over the processing of your data by writing your own code to map between your application data and the message that flows between the service requester and provider.

  For example, if you want to use non-SOAP messages within the Web service infrastructure, you can write your own code to transform between the message format and the format used by your application.

Whichever approach you follow, you can use your own message handlers to perform additional processing on your request and response messages, or use CICS-supplied message handlers that are designed especially to help you process SOAP messages.

Message handlers and pipelines

A *message handler* is a program in which you can perform your own processing of Web service requests and responses. A *pipeline* is a set of message handlers that are executed in sequence.

There are two distinct phases in the operation of a pipeline:

1. The *request phase*, during which CICS invokes each handler in the pipeline in turn. Each message handler can process the request before returning control to CICS.
2. This is followed by the *response phase*, during which CICS again invokes each handler in turn, but with the sequence reversed. That is, the message handler that is invoked first in the request phase, is invoked last in the response phase. Each message handler can process the response during this phase.

   Not every request is succeeded by a response; some applications use a one-way message flow from service requester to provider. In this case, although there is no message to be processed, each handler is invoked in turn during the response phase.

Figure 6 shows a pipeline of three message handlers:

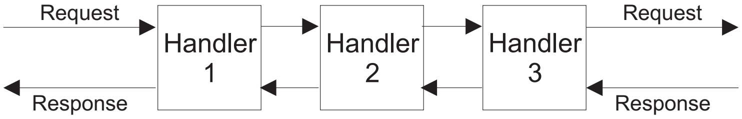


Figure 6. A generic CICS pipeline

In this example, the handlers are executed in the following sequence:

In the request phase

1. Handler 1
2. Handler 2
3. Handler 3

In the response phase

1. Handler 3
2. Handler 2
3. Handler 1

In a service provider, the transition between the phases normally occurs in the last handler in the pipeline (known as the *terminal handler*) which absorbs the request, and generates a response; in a service requester, the transition occurs when the request is processed in the service provider. However, a message handler in the request phase can force an immediate transition to the response phase, and an immediate transition can also occur if CICS detects an error.

A message handler can modify the message, or can leave it unchanged. For example:

- A message handler that performs encryption and decryption will receive an encrypted message on input, and pass the decrypted message to the next handler. On output, it will do the opposite: receive a plain text message, and pass an encrypted version to the following handler.
- A message handler that performs logging will examine a message, and copy the relevant information from that message to the log. The message that is passed to the next handler is unchanged.

Important: If you are familiar with the SOAP feature for CICS TS, you should be aware that the structure of the pipeline in this release of CICS is not the same as that used in the feature.

Transport-related handlers

CICS supports the use of two transport mechanisms between the Web service requester and the provider. In some cases, you might require different message handlers to be invoked, depending upon which transport mechanism is in use. For example, you might wish to include message handlers that perform encryption of parts of your messages when you are using the HTTP transport to communicate on an external network. But encryption might not be required when you are using the MQ transport on a secure internal network.

To support this, you can configure your pipeline to specify handlers that are invoked only when a particular transport (HTTP or MQ) is in use. For a service provider, you can be even more specific, and specify handlers that are invoked only when a particular named resource (a TCPIPSERVICE for the HTTP transport, a QUEUE for the MQ transport) is in use.

This is illustrated in Figure 7:

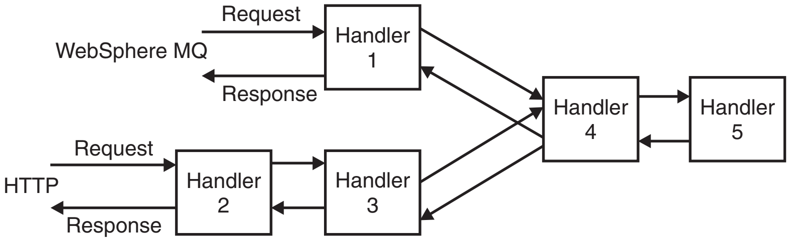


Figure 7. Pipeline with transport-related handlers

In this example, which applies to a service provider:

- Handler 1 is invoked for messages that use the MQ transport.
- Handlers 2 and 3 are invoked for messages that use the HTTP transport.
- Handlers 4 and 5 are invoked for all messages.
- Handler 5 is the terminal handler.

Interrupting the flow

During processing of a request, a message handler can decide not to pass a message to the next handler, but can, instead, generate a response. Normal processing of the message is interrupted, and some handlers in the pipeline are not invoked. For example, suppose that handler 2 in Figure 8 is responsible for performing security checks.

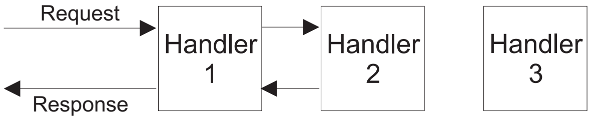


Figure 8. Interrupting the pipeline flow

If the request does not bear the correct security credentials, then, instead of passing the request to handler 3, handler 2 suppresses the request and constructs a suitable response. The pipeline is now in the response phase, and when handler 2 returns control to CICS, the next handler invoked is handler 1, and handler 3 is bypassed altogether.

A handler that interrupts the normal message flow in this way must only do so if the originator of the message expects a response; for example, a handler should not generate a response when an application uses a one-way message flow from service requester to provider.

A service provider pipeline

In a service provider pipeline, CICS receives a request, which is passed through a pipeline to the target application program. The response from the application is returned to the service requester through the same pipeline.

When CICS is in the role of service provider, it performs the following operations:

1. Receive the request from the service requester.
2. Examine the request, and extract the contents that are relevant to the target application program.

3. Invoke the application program, passing data extracted from the request.
4. When the application program returns control, construct a response, using data returned by the application program.
5. Send a response to the service requester.

Figure 9 illustrates a pipeline of three message handlers in a service provider setting:

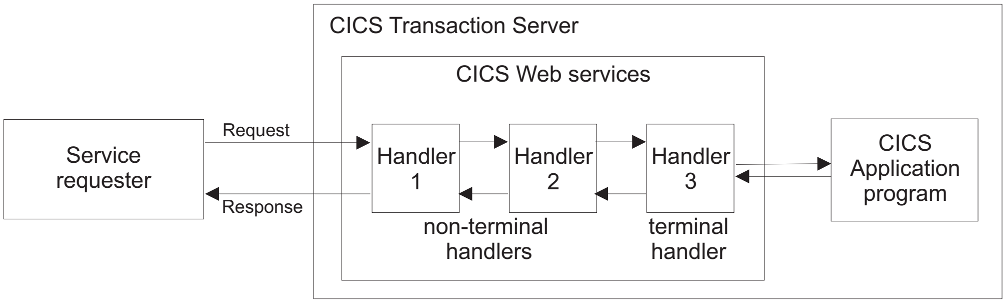


Figure 9. A service provider pipeline

1. CICS receives a request from the service requester. It passes the request to message handler 1.
2. Message handler 1 performs some processing, and passes the request to handler 2 (To be precise, it returns control to CICS, which manages the pipeline. CICS then passes control to the next message handler).
3. Message handler 2 receives the request from handler 1, performs some processing, and passes the request to handler 3.
4. Message handler 3 is the terminal handler of the pipeline. It uses the information in the request to invoke the application program. It then uses the output from the application program to generate a response, which it passes back to handler 2.
5. Message handler 2 receives the response from handler 3, performs some processing, and passes it to handler 1.
6. Message handler 1 receives the response from handler 2, performs some processing, and returns the response to the service requester.

A service requester pipeline

In a service requester pipeline, an application program creates a request, which is passed through a pipeline to the service provider. The response from the service provider is returned to the application program through the same pipeline.

When CICS is in the role of service requester, it performs the following operations:

1. Use data provided by the application program to construct a request.
2. Send the request to the service provider.
3. Receive a response from the service provider.
4. Examine the response, and extract the contents that are relevant to the original application program.
5. Return control to the application program.

Figure 10 on page 21 illustrates a pipeline of three message handlers in a service requester setting:

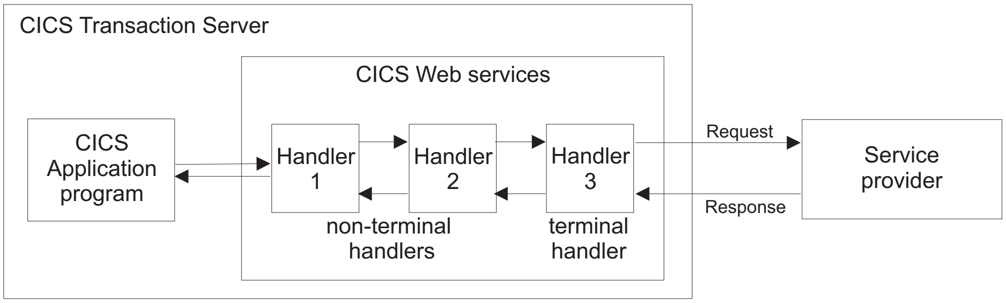


Figure 10. A service requester pipeline

1. An application program creates a request.
2. Message handler 1 receives the request from the application program, performs some processing, and passes the request to handler 2 (To be precise, it returns control to CICS, which manages the pipeline. CICS then passes control to the next message handler).
3. Message handler 2 receives the request from handler 1, performs some processing, and passes the request to handler 3.
4. Message handler 3 receives the request from handler 2, performs some processing, and passes the request to the service provider.
5. Message handler 3 receives the response from the service provider, performs some processing, and passes it to handler 2.
6. Message handler 2 receives the response from handler 3, performs some processing, and passes it to handler 1.
7. Message handler 1 receives the response from handler 2, performs some processing, and returns the response to the application program.

CICS pipelines and SOAP

The pipeline which CICS uses to process Web service requests and responses is generic, in that there are few restrictions on what processing can be performed in each message handler. However, many Web service applications use SOAP messages, and any processing of those messages should comply with the SOAP specification. Therefore, CICS provides special *SOAP message handler* programs that can help you to configure your pipeline as a SOAP node.

- A pipeline can be configured for use in a service requester, or in a service provider:
  - A service requester pipeline is the initial SOAP sender for the request, and the ultimate SOAP receiver for the response
  - A service provider pipeline is the ultimate SOAP receiver for the request, and the initial SOAP sender for the response

  You cannot configure a CICS pipeline to function as a SOAP intermediary.
- A service requester pipeline can be configured to support SOAP 1.1 or SOAP 1.2, but not both. However, a service provider pipeline can be configured to support both SOAP 1.1 and SOAP 1.2. Within your CICS system, you can have many pipelines, some of which support SOAP 1.1 or SOAP 1.2 and some of which support both.
- You can configure a CICS pipeline to have more than one SOAP message handler.
- The CICS-provided SOAP message handlers can be configured to invoke one or more user-written header-handling routines.

- The CICS-provided SOAP message handlers can be configured to enforce some aspects of compliance with the WS-I Basic Profile Version 1.1, and to enforce the presence of particular headers in the SOAP message.

The SOAP message handlers, and their header handling routines are specified in the pipeline configuration file.

SOAP messages and the application data structure

In many cases, the CICS Web services assistant can generate the code to transform the data between a high-level data structure used in an application program, and the contents of the `<Body>` element of a SOAP message. In these cases, when you write your application program, you do not need to parse or construct the SOAP body; CICS will do this for you.

In order to transform the data, CICS needs information, at run time, about the application data structure, and about the format of the SOAP messages. This information is held in two files:

- The Web service binding file

  This file is generated by the CICS Web services assistant from an application language data structure, using utility program DFHLS2WS, or from a Web service description, using utility program DFHWS2LS. CICS uses the binding file to generate the resources used by the Web service application, and to perform the mapping between the application's data structure and the SOAP messages.
- The Web service description

  This may be an existing Web service description, or it may be generated from an application language data structure, using utility program DFHLS2WS. CICS uses the Web service description to perform full validation of SOAP messages.

Figure 11 shows where these files are used in a service provider.

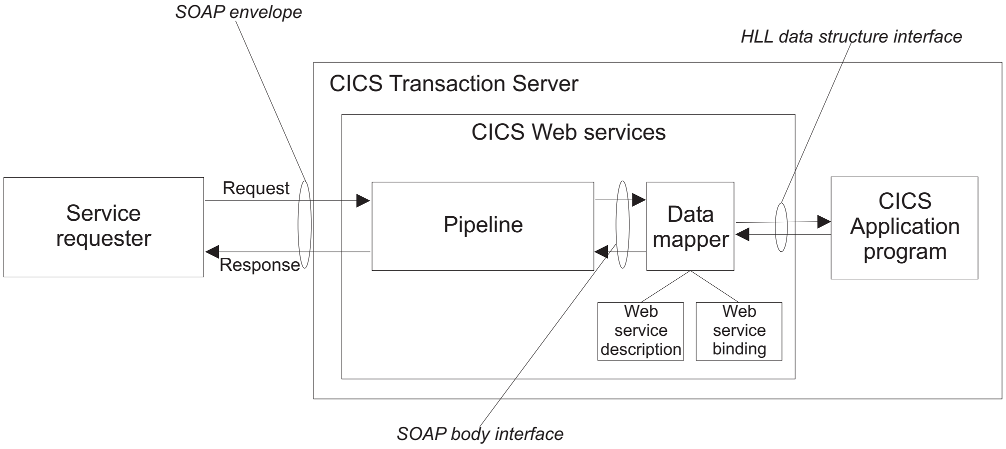


Figure 11. Mapping the SOAP body to the application data structure in a service provider

A message handler in the pipeline (typically, a CICS-supplied SOAP message handler) removes the SOAP envelope from an inbound request, and passes the SOAP body to the data mapper function. This uses the Web service binding file to map the contents of the SOAP body to the application's data structure. If full validation of the SOAP message is active, then the SOAP body is validated against the Web service description. If there is an outbound response, the process is reversed.

Figure 12 shows where these files are used in a service requester.

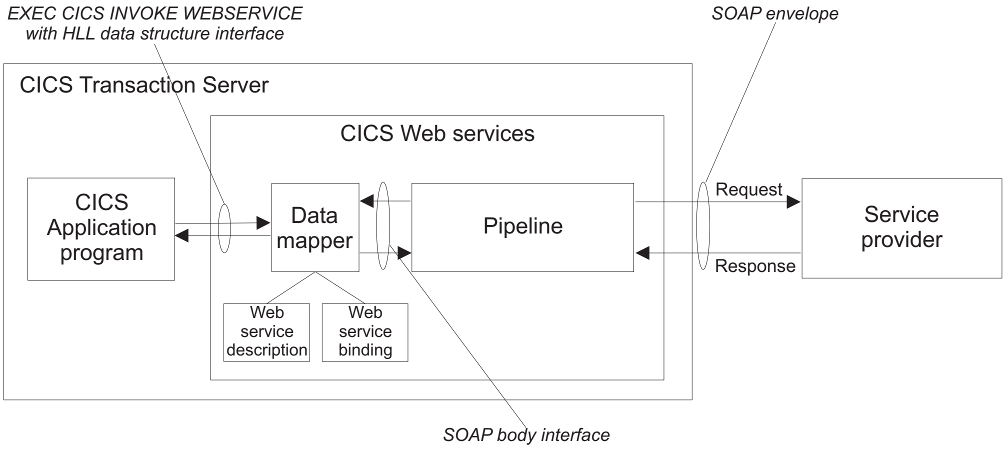


Figure 12. Mapping the SOAP body to the application data structure in a service requester

For an outbound request, the data mapper function constructs a SOAP body from the application's data structure, using information from the Web service binding file. A message handler in the pipeline (typically, a CICS-supplied SOAP message handler) adds the SOAP envelope. If there is an inbound response, the process is reversed. If full validation of the SOAP message is active, then the inbound SOAP body is validated against the Web service description.

In both cases, the execution environment that allows a particular CICS application program to operate in a Web services setting is defined by three objects. These are the pipeline, the Web service binding file, and the Web service description. The three objects are defined to CICS as attributes of the WEBSERVICE resource definition.

There are some situations in which, even though you are using SOAP messages, you cannot use the transformation that the CICS Web services assistant generates:

- When the same data cannot be represented in the SOAP message and in the high-level language.

  All the high-level languages that CICS supports, and XML Schema, support a variety of different data types. However, there is not a one-to-one correspondence between the data types used in the high-level languages, and those used in XML Schema, and there are cases where data can be represented in one, but not in the other. In this situations, you should consider one of the following:

  – Change your application data structure. This may not be feasible, as it might entail changes to the application program itself.

  – Construct a wrapper program, which transforms the application data into a form that CICS can then transform into a SOAP message body. If you do this, you can leave your application program unchanged. In this case CICS Web service support interacts directly with the wrapper program, and only indirectly with the application program.

- When your application program is in a language which is not supported by the CICS Web services assistant.

  In this situation, you should consider one of the following:

  – Construct a wrapper program that is written in one of the languages that the CICS Web services assistant does support (COBOL, PL/I, C or C++).

- Instead of using the CICS Web services assistant, write your own program to perform the mapping between the SOAP messages and the application program's data structure.

WSDL and the application data structure

A Web service description contains abstract representations of the input and output messages used by the service. CICS uses the Web service description to construct the data structures used by application programs. At run time, CICS performs the mapping between the application data structures and the messages.

The description of a Web service contains, among other things:

- One or more operations
- For each operation, an input message and an optional output message
- For each message, the message structure, defined in terms of XML data types. Complex data types used in the messages are defined in an XML schema which is contained in the `<types>` element within the Web service description. Simple messages can be described without using the `<types>` element.

WSDL contains an abstract definition of an operation, and the associated messages; it cannot be used directly in an application program. To implement the operation, a service provider must do the following:

- It must parse the WSDL, in order to understand the structure of the messages
- It must parse each input message, and construct the output message
- It must perform the mappings between the contents of the input and output messages, and the data structures used in the application program

A service requester must do the same in order to invoke the operation.

When you use the the CICS Web services assistant, much of this is done for you, and you can write your application program without detailed understanding of WSDL, or of the way the input and output messages are constructed.

The CICS Web services assistant consists of two utility programs:

DFHWS2LS
This utility program takes a Web service description as a starting point. It uses the descriptions of the messages, and the data types used in those messages, to construct high-level language data structures that you can use in your application programs.

DFHLS2WS
This utility program takes a high-level language data structure as a starting point. It uses the structure to construct a Web services description that contains descriptions of messages, and the data types used in those messages derived from the language structure.

Both utility programs generate a Web services binding file that CICS uses at run time to perform the mapping between the application program's data structures and the SOAP messages.

An example of COBOL to WSDL mapping

This example shows how the data structure used in a COBOL program is represented in the Web services description that is generated by the CICS Web services assistant.

Figure 13 shows a simple COBOL data structure:

```
  *    Catalogue COMMAREA structure
           03 CA-REQUEST-ID            PIC X(6).
           03 CA-RETURN-CODE           PIC 9(2).
           03 CA-RESPONSE-MESSAGE      PIC X(79).
      *    Fields used in Place Order
           03 CA-ORDER-REQUEST.
               05 CA-USERID                PIC X(8).
               05 CA-CHARGE-DEPT           PIC X(8).
               05 CA-ITEM-REF-NUMBER       PIC 9(4).
               05 CA-QUANTITY-REQ          PIC 9(3).
               05 FILLER                   PIC X(888).
```

Figure 13. COBOL record definition of an input message defined in WSDL

The key elements in the corresponding fragment of the Web services description are shown in Figure 14:

```
<xsd:sequence>
    <xsd:element name="CA-REQUEST-ID" nillable="false">
        <xsd:simpleType>
            <xsd:restriction base="xsd:string">
                <xsd:length value="6"/>
                <xsd:whiteSpace value="preserve"/>
            </xsd:restriction>
        </xsd:simpleType>
    </xsd:element>
    <xsd:element name="CA-RETURN-CODE" nillable="false">
        <xsd:simpleType>
            <xsd:restriction base="xsd:short">
                <xsd:maxInclusive value="99"/>
                <xsd:minInclusive value="0"/>
            </xsd:restriction>
        </xsd:simpleType>
    </xsd:element>
    <xsd:element name="CA-RESPONSE-MESSAGE" nillable="false">
        ...
    </xsd:element>
    <xsd:element name="CA-ORDER-REQUEST" nillable="false">
        <xsd:complexType mixed="false">
            <xsd:sequence>
                <xsd:element name="CA-USERID" nillable="false">
                    <xsd:simpleType>
                        <xsd:restriction base="xsd:string">
                            <xsd:length value="8"/>
                            <xsd:whiteSpace value="preserve"/>
                        </xsd:restriction>
                    </xsd:simpleType>
                </xsd:element>
                <xsd:element name="CA-CHARGE-DEPT" nillable="false">
                    ...
                </xsd:element>
                <xsd:element name="CA-ITEM-REF-NUMBER" nillable="false">
                    ...
                </xsd:element>
                <xsd:element name="CA-QUANTITY-REQ" nillable="false">
                    ...
                </xsd:element>
                <xsd:element name="FILLER" nillable="false">
                    ...
                </xsd:element>
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>
</xsd:sequence>
```

Figure 14. WSDL fragment derived from a COBOL data structure

WSDL and message exchange patterns

A WSDL 2.0 document contains a message exchange pattern (MEP) that defines the way that SOAP 1.2 messages should be exchanged between the Web service requester and Web service provider.

CICS supports four out of the eight message exchange patterns that are defined in the WSDL 2.0 Part 2: Adjuncts specification for both service provider and service requester applications. These are:

In-Only
A request message is sent to the Web service provider, but the provider is not allowed to send any type of response to the Web service requester.

In-Out
A request message is sent to the Web service provider, and a response message is returned to the Web service requester. The response message could be a normal SOAP message or a SOAP fault.

In-Optional-Out
A request message is sent to the Web service provider, and a response message is optionally returned to the Web service requester. If there is a response, it could be either a normal SOAP message or a SOAP fault.

Robust In-Only
A request message is sent to the Web service provider, and no response message is returned to the Web service requester unless an error occurs. If there is an error, a SOAP fault message is sent to the requester.

The Web service binding file

The *Web service binding file* contains information that CICS uses to map data between input and output messages, and application data structures.

A Web service description contains abstract representations of the input and output messages used by the service. When a service provider or service requester application executes, CICS needs information about how the contents of the messages maps to the data structures used by the application. This information is held in a Web service binding file.

Web service binding files are created:

- By utility program DFHWS2LS when language structures are generated from WSDL.
- By utility program DFHLS2WS when WSDL is generated from a language structure.

At run time, CICS uses information in the Web service binding file to perform the mapping between application data structures and SOAP messages. Web service binding files are defined to CICS in the WSBIND attribute of the WEBSERVICE resource.

Related information

WEBSERVICE resource definitions

External standards

CICS support for Web services conforms to a number of industry standards and specifications.

Extensible Markup Language Version 1.0

Extensible Markup Language (XML) 1.0 is a subset of SGML. Its goal is to enable generic SGML to be served, received, and processed on the Web in the way that is now possible with HTML.

XML has been designed for ease of implementation and for interoperability with both SGML and HTML.

The specification for XML 1.0 and its errata is published by the World Wide Web Consortium (W3C) as a W3C Recommendation at http://www.w3.org/TR/REC-xml.

SOAP 1.1 and 1.2

SOAP is a lightweight, XML-based, protocol for exchange of information in a decentralized, distributed environment.

The protocol consists of three parts:

- An envelope that defines a framework for describing what is in a message and how to process it.
- A set of encoding rules for expressing instances of application-defined data types.
- A convention for representing remote procedure calls and responses.

SOAP can be used with other protocols, such as HTTP.

The specifications for SOAP are published by the World Wide Web Consortium (W3C). The specification for SOAP 1.1 is described as a note at http://www.w3.org/TR/SOAP. This specification has not been endorsed by the W3C, but forms the basis for the SOAP 1.2 specification. It expands the SOAP acronym to Simple Object Access Protocol.

SOAP 1.2 is a W3C recommendation and is published in two parts:

- Part 1: Messaging Framework is published at http://www.w3.org/TR/soap12-part1/ .
- Part 2: Adjuncts is published at http://www.w3.org/TR/soap12-part2/.

The specification also includes a primer that is intended to provide a tutorial on the features of the SOAP Version 1.2 specification, including usage scenarios. The primer is published at http://www.w3.org/TR/soap12-part0/. The specification for SOAP 1.2 does not expand the acronym.

SOAP 1.1 Binding for MTOM 1.0

SOAP 1.1 Binding for MTOM 1.0 is a specification that describes how to use the SOAP Message Transmission Optimization Mechanism (MTOM) and XML-binary Optimized Packaging (XOP) specifications with SOAP 1.1.

The aim of this specification is to define the minimum changes to MTOM and XOP to enable these facilities to be used interoperably with SOAP 1.1 and to largely reuse the SOAP 1.2 MTOM/XOP implementation.

The SOAP 1.1 Binding for MTOM 1.0 specification is published as a formal submission by theWorld Wide Web Consortium (W3C) at http://www.w3.org/Submission/soap11mtom10/.

Related concepts

"XML-binary Optimized Packaging (XOP)" on page 32
XML-binary Optimized Packaging (XOP) is one of a related pair of specifications that defines how to efficiently serialize XML Infosets that have certain types of content.

"SOAP Message Transmission Optimization Mechanism (MTOM)"
SOAP Message Transmission Optimization Mechanism (MTOM) is one of a related pair of specifications that defines conceptually how to optimize the transmission and format of a SOAP message.

SOAP Message Transmission Optimization Mechanism (MTOM)

SOAP Message Transmission Optimization Mechanism (MTOM) is one of a related pair of specifications that defines conceptually how to optimize the transmission and format of a SOAP message.

MTOM defines:

1. how to optimize the transmission of base64binary data in SOAP messages in abstract terms
2. how to implement optimized MIME multipart serialization of SOAP messages in a binding independent way using XOP

The implementation of MTOM relies on the related XML-binary Optimized Packaging (XOP) specification. As these two specifications are so closely linked, they are normally referred to as MTOM/XOP.

The specification is published by the World Wide Web Consortium (W3C) as a W3C Recommendation at http://www.w3.org/TR/soap12-mtom/.

Related concepts

"XML-binary Optimized Packaging (XOP)" on page 32
XML-binary Optimized Packaging (XOP) is one of a related pair of specifications that defines how to efficiently serialize XML Infosets that have certain types of content.

"SOAP 1.1 Binding for MTOM 1.0" on page 27
SOAP 1.1 Binding for MTOM 1.0 is a specification that describes how to use the SOAP Message Transmission Optimization Mechanism (MTOM) and XML-binary Optimized Packaging (XOP) specifications with SOAP 1.1.

Web Services Atomic Transaction Version 1.0

Web Services Atomic Transaction Version 1.0 (or WS-AtomicTransaction) is a protocol that defines the atomic transaction coordination type for transactions of a short duration. It is used with the extensible coordination framework described in the Web Services Coordination Version 1.0 (or WS-Coordination) specification.

The WS-AtomicTransaction specification and the WS-Coordination specification define protocols for short term transactions that enable transaction processing systems to interoperate in a Web services environment. Transactions that use WS-AtomicTransaction have the *ACID* properties of atomicity, consistency, isolation, and durability.

The specification for WS-AtomicTransaction is published at http://www.ibm.com/developerworks/library/specification/ws-tx/.

Web Services Coordination Version 1.0

Web Services Coordination Version 1.0 (or WS-Coordination) is an extensible framework for providing protocols that coordinate the actions of distributed applications. These coordination protocols are used to support a number of applications, including those that need to reach consistent agreement on the outcome of distributed activities.

The framework enables an application service to create a context needed to propagate an activity to other services and to register for coordination protocols. The framework enables existing transaction processing, workflow, and other systems for coordination to hide their proprietary protocols and to operate in a heterogeneous environment.

The specification for WS-Coordination is published at http://www.ibm.com/developerworks/library/specification/ws-tx/.

Web Services Description Language Version 1.1 and 2.0

Web Services Description Language (WSDL) is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information.

The operations and messages are described abstractly, and then bound to a concrete network protocol and message format to define an endpoint. Related concrete end points are combined into abstract endpoints (services).

WSDL is extensible to allow the description of endpoints and their messages regardless of what message formats or network protocols are used to communicate. The WSDL 1.1 specification only defines bindings that describe how to use WSDL in conjunction with SOAP 1.1, HTTP GET and POST, and MIME.

WSDL 2.0 provides a model as well as an XML format for describing Web services. It enables you to separate the description of the abstract functionality offered by a service from the concrete details of a service description, such as "how" and "where" that functionality is offered. It also describes extensions for Message Exchange Patterns, SOAP modules, and a language for describing such concrete details for SOAP 1.2 and HTTP. The WSDL 2.0 specification also resolves many technical issues and limitations that are present in WSDL 1.1.

The specification for WSDL 1.1 is published by the World Wide Web Consortium (W3C) as a W3C Note at http://www.w3.org/TR/wsdl.

The latest specification for WSDL 2.0 is published as a W3C candidate recommendation at http://www.w3.org/TR/wsdl20.

Related concepts

"How CICS complies with WSDL 2.0" on page 33
CICS conditionally complies with WSDL 2.0, and support is subject to the following restrictions.

Web Services Security: SOAP Message Security

Web Services Security (WSS): SOAP Message Security is a set of enhancements to SOAP messaging that provides message integrity and confidentiality. WSS: SOAP Message Security is extensible, and can accommodate a variety of security models and encryption technologies.

WSS: SOAP Message Security provides three main mechanisms that can be used independently or together. They are:

- The ability to send security tokens as part of a message, and for associating the security tokens with message content
- The ability to protect the contents of a message from unauthorized and undetected modification (message integrity)
- The ability to protect the contents of a message from unauthorized disclosure (message confidentiality).

WSS: SOAP Message Security can be used in conjunction with other Web service extensions and application-specific protocols to satisfy a variety of security requirements.

The specification is published by the Organization for the Advancement of Structured Information Standards (OASIS) at http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-soap-message-security-1.0.pdf.

Related concepts

"How CICS complies with Web Services Security specifications" on page 33
CICS conditionally complies with Web Services Security: SOAP Message Security and related specifications by supporting the following aspects.

Web Services Trust Language

Web Services Trust Language (or WS-Trust) defines extensions that build on Web Services Security to provide a framework for requesting and issuing security tokens, and to broker trust relationships.

WS-Trust describes:

1. Methods for issuing, renewing, and validating security tokens.
2. Ways to establish, access the presence of, and broker trust relationships.

CICS supports the February 2005 version of the specification that is published at http://www-128.ibm.com/developerworks/library/specification/ws-trust/.

Related concepts

"How CICS complies with WS-Trust" on page 36
CICS conditionally complies with WS-Trust, and support is subject to the following restrictions.

WSDL 1.1 Binding Extension for SOAP 1.2

WSDL 1.1 Binding Extension for SOAP 1.2 is a specification that defines the binding extensions that are required to indicate that Web service messages are bound to the SOAP 1.2 protocol.

The aim of this specification is to provide functionality that is comparable with the binding for SOAP 1.1.

This specification is published as a formal submission request by the World Wide Web Consortium (W3C) at http://www.w3.org/Submission/wsdl11soap12/.

WS-I Basic Profile Version 1.1

WS-I Basic Profile Version 1.1 (WS-I BP 1.1) is a set of non-proprietary Web services specifications, along with clarifications and amendments to those specifications, which together promote interoperability between different implementations of Web services.

The WS-I BP 1.1 is derived from Basic Profile Version 1.0 by incorporating its published errata and separating out the requirements that relate to the serialization of envelopes and their representation in messages. These requirements are now part of the Simple SOAP Binding Profile Version 1.0.

To summarize, the WS-I Basic Profile Version 1.0 has now been split into two separately published profiles. These are:

- WS-I Basic Profile Version 1.1
- WS-I Simple SOAP Binding Profile Version 1.0

Together, these two Profiles supersede the WS-I Basic Profile Version 1.0.

The reason for this separation is to enable the Basic Profile 1.1 to be composed with any profile that specifies envelope serialization, including the Simple SOAP Binding Profile 1.0.

The specification for WS-I BP 1.1 is published by the Web Services Interoperability Organization (WS-I), and can be found at http://www.ws-i.org/Profiles/BasicProfile-1.1.html.

Related concepts

"How CICS complies with WS-I Basic Profile 1.1" on page 37
CICS conditionally complies with WS-I Basic Profile 1.1 in that it adheres to all the *MUST* level requirements. However, CICS does not specifically implement support for UDDI registries, and therefore the points relating to this in the specification are ignored. Also the Web services assistant jobs and associated runtime environment are not fully compliant with this Profile, as there are limitations in the support of mapping certain schema elements.

WS-I Simple SOAP Binding Profile Version 1.0

WS-I Simple SOAP Binding Profile Version 1.0 (SSBP 1.0) is a set of non-proprietary Web services specifications, along with clarifications and amendments to those specifications which promote interoperability.

The SSBP 1.0 is derived from the WS-I Basic Profile 1.0 requirements that relate to the serialization of the envelope and its representation in the message.

WS-I Basic Profile 1.0 has now been split into two separately published profiles. These are:

- WS-I Basic Profile Version 1.1
- WS-I Simple SOAP Binding Profile Version 1.0

Together, these two Profiles supersede the WS-I Basic Profile Version 1.0.

The specification for SSBP 1.0 is published by the Web Services Interoperability Organization (WS-I), and can be found at http://www.ws-i.org/Profiles/SimpleSoapBindingProfile-1.0.html.

XML-binary Optimized Packaging (XOP)

XML-binary Optimized Packaging (XOP) is one of a related pair of specifications that defines how to efficiently serialize XML Infosets that have certain types of content.

XOP does this by:

1. packaging the XML in some format. This is called the *XOP package*. The specification mentions MIME Multipart/Related but does not limit it to this format.
2. Re-encoding all or part of base64binary content to reduce its size.
3. Placing the base64binary content elsewhere in the package and replacing the encoded content with XML that references it.

XOP is used as an implementation of the MTOM specification, which defines the optimization of SOAP messages. As these two specifications are so closely linked, they are normally referred to as MTOM/XOP.

The specification is published by the World Wide Web Consortium (W3C) as a W3C Recommendation at http://www.w3.org/TR/xop10/

Related concepts

"SOAP Message Transmission Optimization Mechanism (MTOM)" on page 28
SOAP Message Transmission Optimization Mechanism (MTOM) is one of a related pair of specifications that defines conceptually how to optimize the transmission and format of a SOAP message.

"SOAP 1.1 Binding for MTOM 1.0" on page 27
SOAP 1.1 Binding for MTOM 1.0 is a specification that describes how to use the SOAP Message Transmission Optimization Mechanism (MTOM) and XML-binary Optimized Packaging (XOP) specifications with SOAP 1.1.

XML Encryption Syntax and Processing

XML Encryption Syntax and Processing specifies a process for encrypting data and representing the result in XML. The data may be arbitrary data (including an XML document), an XML element, or XML element content. The result of encrypting data is an XML Encryption element which contains or references the cipher data.

XML Encryption Syntax and Processing is a recommendation of the World Wide Web Consortium (W3C) and is published at http://www.w3.org/TR/xmlenc-core.

XML-Signature Syntax and Processing

XML-Signature Syntax and Processing specifies processing rules and syntax for XML digital signatures.

XML digital signatures provide integrity, message authentication, and signer authentication services for data of any type, whether located within the XML that includes the signature or elsewhere.

The specification for XML-Signature is published by World Wide Web Consortium (W3C) at http://www.w3.org/TR/xmldsig-core.

CICS compliance with Web services standards

CICS is compliant with the supported Web services standards and specifications, in that it allows you to generate and deploy Web services that are compliant.

It should be noted that CICS does not enforce this compliancy. For example, in the case of support for the WS-I Basic Profile 1.1 specification, CICS allows you to apply additional qualities of service to your Web service that could break the interoperability outlined in this Profile.

How CICS complies with WSDL 2.0

CICS conditionally complies with WSDL 2.0, and support is subject to the following restrictions.

Mandatory requirements

- Only the message exchange patterns in-only, in-out, robust in-only, and in-optional-out may be used in the WSDL.
- Only one Endpoint is allowed for each Service.
- There must be at least one Operation.
- Endpoints may only be specified with a URI.
- There must be a SOAP binding
- The XML schema type system must be used.

Aspects that are tolerated

- The following HTTP binding properties are ignored:
  - whttp:location
  - whttp:header
  - whttp:transferCodingDefault
  - whttp:transferCoding
  - whttp:cookies
  - whttp:authenticationType
  - whttp:authenticationRealm
- SOAP header information is ignored by DFHWS2LS. However, you can add your own message handlers to the pipeline to create and process the required SOAP header information for inbound and outbound messages.

Aspects that are not supported

- The #any and #other message content models.
- The out-only, robust-out-only, out-in and out-optional-in message exchange patterns.
- WS-Addressing for Endpoints.
- HTTP GET is not supported. This is defined using the soap-response message exchange pattern in the WSDL document. If your WSDL defines this message exchange pattern, DFHWS2LS issues an error message.

Related concepts

“Web Services Description Language Version 1.1 and 2.0” on page 29
Web Services Description Language (WSDL) is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information.

How CICS complies with Web Services Security specifications

CICS conditionally complies with Web Services Security: SOAP Message Security and related specifications by supporting the following aspects.

Compliance with Web Services Security: SOAP Message Security

Security header

The <wsse:Security> header provides a mechanism for attaching security-related information targeted at a specific recipient in the form of a SOAP actor or role. This could be the ultimate recipient of the message or an intermediary. The following attributes are supported in CICS:

- S11:actor (for an intermediary)
- S11:mustUnderstand
- S12:role (for an intermediary)
- S12:mustUnderstand

Security tokens

The following security tokens are supported in the security header:

- User name and password
- Binary security token (X.509 certificate)

Token references

A security token conveys a set of claims. Sometimes these claims reside elsewhere and need to be accessed by the receiving application. The <wsse:SecurityTokenReference> element provides an extensible mechanism for referencing security tokens. The following mechanisms are supported:

- Direct reference
- Key identifier
- Key name
- Embedded reference

Signature algorithms

This specification builds on XML Signature and therefore has the same algorithm requirements as those specified in the XML Signature specification. CICS supports:

Algorithm type	Algorithm	URI
Digest	SHA1	`http://www.w3.org/2000/09/xmldsig#sha1`
Signature	DSA with SHA1 (validation only)	`http://www.w3.org/2000/09/xmldsig#dsa-sha1`
Signature	RSA with SHA1	`http://www.w3.org/2000/09/xmldsig#rsa-sha1`
Canonicalization	Exclusive XML canonicalization (without comments)	`http://www.w3.org/2001/10/xml-exc-c14n#`

Signature signed parts

CICS allows the following SOAP elements to be signed:

- the SOAP message body
- the identity token (a type of security token), that is used as an asserted identity

Encryption algorithms

The following data encryption algorithms are supported:

Algorithm	URI
Triple Data Encryption Standard algorithm (Triple DES)	`http://www.w3.org/2001/04/xmlenc#tripledes-cbc`
Advanced Encryption Standard (AES) algorithm with a key length of 128 bits	`http://www.w3.org/2001/04/xmlenc#aes128-cbc`
Advanced Encryption Standard (AES) algorithm with a key length of 192 bits	`http://www.w3.org/2001/04/xmlenc#aes192-cbc`
Advanced Encryption Standard (AES) algorithm with a key length of 256 bits	`http://www.w3.org/2001/04/xmlenc#aes256-cbc`

The following key encryption algorithm is supported:

Algorithm	URI
Key transport (public key cryptography) RSA Version 1.5:	`http://www.w3.org/2001/04/xmlenc#rsa-1_5`

Encryption message parts

CICS allow the following SOAP elements to be encrypted:

- the SOAP body

Timestamp

The `<wsu:Timestamp>` element provides a mechanism for expressing the creation and expiration times of the security semantics in a message. CICS tolerates the use of timestamps within the Web services security header on inbound SOAP messages.

Error handling

CICS generates SOAP fault messages using the standard list of response codes listed in the specification.

Compliance with Web Services Security: UsernameToken Profile 1.0

The following aspects of this specification are supported:

Password types

Text

Token references

Direct reference

Compliance with Web Services Security: X.509 Certificate Token Profile 1.0

The following aspects of this specification are supported:

Token types

- X.509 Version 3: Single certificate. See http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-x509- token-profile-1.0#X509v3.
- X.509 Version 3: X509PKIPathv1 without certificate revocation lists (CRL). See http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-x509- token-profile-1.0#X509PKIPathv1.

- X.509 Version 3: PKCS7 with or without CRLs. The IBM® software development kit (SDK) supports both. The Sun Java Development Kit (JDK) supports PKCS7 without CRL only.

Token references

- Key identifier - subject key identifier
- Direct reference
- Custom reference - issuer name and serial number

Aspects that are not supported

The following items are not supported in CICS:

- Validation of Timestamps for freshness
- Nonces
- Web services security for SOAP attachments
- Security Assertion Markup Language (SAML) token profile, WS-SecurityKerberos token profile, and XrML token profile
- Web Services Interoperability (WS-I) Basic Security Profile
- XML enveloping digital signature
- XML enveloping digital encryption
- The following transport algorithms for digital signatures are not supported:
  - XSLT: `http://www.w3.org/TR/1999/REC-xslt-19991116`
  - SOAP Message Normalization. For more information, see http://www.w3.org/TR/2003/NOTE-soap12-n11n-20031008/
- The Diffie-Hellman key agreement algorithm for encryption is not supported. For more information, see http://www.w3.org/TR/2002/REC-xmlenc-core-20021210/Overview.html#sec-DHKeyValue.
- The following canonicalization algorithm for encryption, which is optional in the XML encryption specification, is not supported:
  - Canonical XML with or without comments
  - Exclusive XML canonicalization with or without comments
- In the Username Token Version 1.0 Profile specification, the digest password type is not supported.

Related concepts

"Web Services Security: SOAP Message Security" on page 29
Web Services Security (WSS): SOAP Message Security is a set of enhancements to SOAP messaging that provides message integrity and confidentiality. WSS: SOAP Message Security is extensible, and can accommodate a variety of security models and encryption technologies.

How CICS complies with WS-Trust

CICS conditionally complies with WS-Trust, and support is subject to the following restrictions.

Aspects that are supported

- Validation binding
- Issuance binding where one token is returned
- AppliesTo in the Issuance binding

Aspects that are tolerated

- Requested references

- Keys and entropy
- Returning computed keys

Aspects that are not supported

- Returning multiple security tokens
- Returning security tokens in headers
- Renewal bindings
- Cancel bindings
- Negotiation and challenge extensions
- Key and Token parameter extensions
- Key exchange token binding

Related concepts

"Web Services Trust Language" on page 30
Web Services Trust Language (or WS-Trust) defines extensions that build on Web Services Security to provide a framework for requesting and issuing security tokens, and to broker trust relationships.

How CICS complies with WS-I Basic Profile 1.1

CICS conditionally complies with WS-I Basic Profile 1.1 in that it adheres to all the *MUST* level requirements. However, CICS does not specifically implement support for UDDI registries, and therefore the points relating to this in the specification are ignored. Also the Web services assistant jobs and associated runtime environment are not fully compliant with this Profile, as there are limitations in the support of mapping certain schema elements.

See "High-level language and XML schema mapping" on page 150 for a list of unsupported schema elements.

Conformance targets identify what artifacts (e.g. SOAP message, WSDL description) or parties (e.g. SOAP processor, end user) that the requirements apply to. The conformance targets supported by CICS are:

MESSAGE
Protocol elements that transport the ENVELOPE (e.g. SOAP over HTTP messages).

ENVELOPE
The serialization of the `soap:Envelope` element and its content.

DESCRIPTION
The description of types, messages, interfaces and their protocol and data format bindings, and network access points associated with Web services (e.g. WSDL descriptions).

INSTANCE
Software that implements a `wsdl:port`.

CONSUMER
Software that invokes an INSTANCE.

SENDER
Software that generates a message according to the protocol associated with it

RECEIVER
Software that consumes a message according to the protocol associated with it.

Related concepts

"WS-I Basic Profile Version 1.1" on page 31
WS-I Basic Profile Version 1.1 (WS-I BP 1.1) is a set of non-proprietary Web services specifications, along with clarifications and amendments to those specifications, which together promote interoperability between different implementations of Web services.

Chapter 5. Getting started with Web services

There are several ways to get started with Web services in CICS. The most appropriate way for you will depend upon how much you already know about the subject and upon how well advanced your plans are for using Web services.

Here are some starting points for Web services in CICS:

- Install the example application. CICS provides an example of a catalog management application, which can be enabled as a Web service provider. The example includes all the code and resource definitions that you need to get the application working in CICS with the minimum amount of work. It also includes code to interact with the service that runs on a number of common Web service clients.

  Use the example application if you want a rapid “proof-of-concept” demonstration that you can deploy a Web service in CICS or if you want a “hands-on” way to learn about Web services in CICS.

  The example application is described in Chapter 14, “The CICS catalog manager example application,” on page 257
- Get straight to work planning to deploy an application as a service provider or a requester. You might already know enough about how you will use Web services in CICS to start planning your applications and the related infrastructure.
- Migrate from the SOAP feature for CICS. If you have an existing application that uses the feature, you might be ready to start planning how you will redeploy the application.

Planning to use Web services

Before you can plan to use Web services in CICS, you need to consider these questions for each application:

Do you plan to deploy your CICS application in the role of a service provider or a service requester?

You may have a pair of applications that you want to connect using CICS support for Web services. In this case, one application will be the service provider; the other will be the service requester.

Do you plan to use your existing application programs, or write new ones?

If your existing applications are designed with a well defined interface to the business logic, you will probably be able to use them in a Web services setting, either as a service provider or a service requester. However, in most cases, you will need to write a wrapper program that connects your business logic to the Web services logic.

If you plan to write new applications, you should aim to keep your business logic separated from your Web services logic, and, once again, you will need to write a wrapper program to provide this separation. However, if your application is designed with Web services in mind, the wrapper may prove to be simpler to write.

Do you intend to use SOAP messages?

SOAP is fundamental to the Web services architecture, and much of the support that is provided in CICS assumes that you will use SOAP. However, there may be situations where you wish to use other message formats. For example, you may have developed your own message formats that you want to deploy with the CICS Web services infrastructure. CICS allows you to do this, but you will not be able to use some of the functions that CICS provides, such as the Web services assistant, and the SOAP message handlers.

If you decide not to use SOAP, your application programs will be responsible for parsing inbound messages, and constructing outbound messages.

Do you intend to use the CICS Web services assistant to generate the mappings between your data structures and SOAP messages?

The assistant provides a rapid deployment of many applications into a Web services setting with little or no additional programming. And when additional programming is required, it is usually straightforward, and can be done without changing existing business logic.

However, there are cases which are better handled without using the Web services assistant. For example, if you have existing code that maps data structures to SOAP messages, there is no advantage in reengineering your application with the Web services assistant.

Although the CICS Web services assistant supports the most common data types and structures, there are some which are not supported. In this situation, you should check the list of unsupported data types and structures for the language in question, and consider providing a program layer that maps your application's data to a format that the assistant can support. If this is not possible, you will need to parse the message yourself. For details on what the assistant can and can't support, see “High-level language and XML schema mapping” on page 150.

If you decide not to use the CICS Web services assistant, you can use a tool such as WebSphere Developer for System z to create the necessary artifacts, and provide your own code for parsing inbound messages, and constructing outbound messages. You can also use the provided vendor interface API.

Do you intend to use an existing service description, or create a new one?

In some situations, you will be obliged to use an existing service description as a starting point. For example:

- Your application is a service requester, and it is designed to invoke an existing Web service.
- Your application is a service provider, and you want it to conform to an existing industry-standard service description.

In other situations, you may need to create a new service description for your application.

Next steps:

- Planning a service provider
- Planning a service requester

Related information

Chapter 14, “The CICS catalog manager example application,” on page 257
The CICS catalog example application is a working COBOL application that is designed to illustrate best practice when connecting CICS applications to external clients and servers.

Planning a service provider application

In general, CICS applications should be structured to ensure separation of business logic and communications logic. Following this practice will help you to deploy new and existing applications in a Web service provider in a straightforward way. You will, in some situations, need to interpose a simple wrapper program between your application program and CICS Web service support.

Figure 15 shows a typical application which is partitioned to ensure a separation between communication logic and business logic.

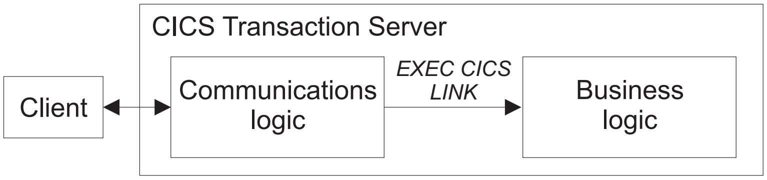


Figure 15. Application partitioned into communications and business logic

In many cases, you can deploy the business logic directly as a service provider application. This is illustrated in Figure 16.

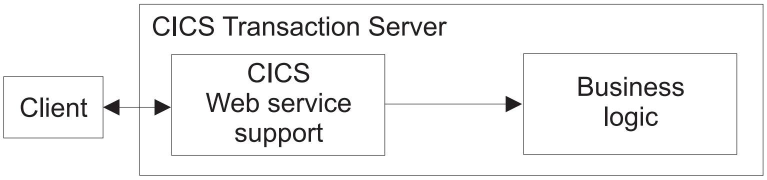


Figure 16. Simple deployment of CICS application as a Web service provider

To use this simple model, the following conditions apply:

When you are using the CICS Web services assistant to generate the mapping between SOAP messages and application data structures:

The data types used in the interface to the business logic must be supported by the CICS Web services assistant. If this is not the case, you must interpose a wrapper program between CICS Web service support and your business logic.

You will also need a wrapper program when you deploy an existing program to provide a service that conforms to an existing Web service description: if you process the Web service description using the assistant, the resulting data structures are very unlikely to match the interface to your business logic.

When you are not using the CICS Web services assistant:

Message handlers in your service provider pipeline must interact directly with your business logic.

Using a wrapper program

Use a wrapper program when the CICS Web services assistant cannot generate code to interact directly with the business logic. For example, the interface to the business logic might use a data structure which the CICS Web services assistant cannot map directly into a SOAP message. In this situation, you can use a wrapper program to provide any additional data manipulation that is required:

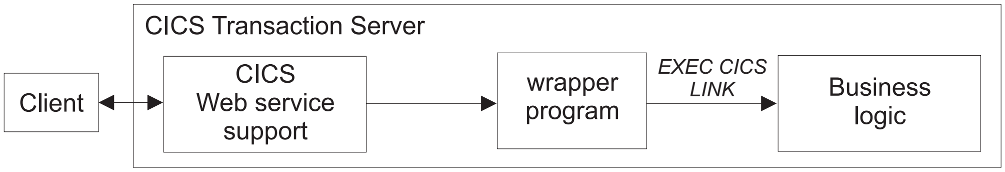


Figure 17. Deployment of CICS application as a Web service provider using a wrapper program

You will need to design a second data structure that the assistant can support, and use this as the interface to your wrapper program. The wrapper program then has two simple functions to perform:

- move data between the two data structures
- invoke the business logic using its existing interface

Error handling

If you are planning to use the CICS Web services assistant, you should also consider how to handle rolling back changes when errors occur. When a SOAP request message is received from a service requester, the SOAP message is transformed by CICS just before it is passed to your application program. If an error occurs during this transformation, CICS does not automatically roll back any work that has been performed on the message. For example, if you plan to add some additional processing on the SOAP message using handlers in the pipeline, you need to decide if they should roll back any recoverable changes that they have already performed.

On outbound SOAP messages, for example when your service provider application program is sending a response message to a service requester, if CICS encounters an error when generating the response SOAP message, all of the recoverable changes made by the application program are automatically backed out. You should consider whether adding synchronization points is appropriate for your application program.

If you are planning to use Web service atomic transactions in your provider application, and the Web service requester also supports atomic transactions, any error that causes CICS to roll back a transaction would also cause the remote requester to roll back its changes.

Planning a service requester application

In general, CICS applications should be structured to ensure separation of business logic and communications logic. Following this practice will help you to deploy new and existing applications in a Web service requester in a straightforward way. You will, in almost every situation, need to interpose a simple wrapper program between your application program and CICS Web service support.

Figure 18 shows a typical application which is partitioned to ensure a separation between communication logic and business logic. The application is ideally structured for reuse of the business logic in a Web service requester.

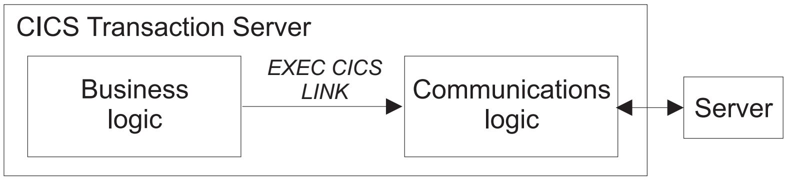


Figure 18. Application partitioned into communications and business logic

You cannot use the existing **EXEC CICS LINK** command to invoke CICS Web services support in this situation:

- When you are using the CICS Web services assistant to generate the mapping between SOAP messages and application data structures, you must use an **EXEC CICS INVOKE WEBSERVICE** command, and pass the application's data structure to CICS Web services support. Also, the data types used in the interface to the business logic must be supported by the CICS Web services assistant.

  However, if the target WEBSERVICE that your application program invokes is provider mode, i.e. a value has been defined for the PROGRAM attribute, CICS automatically optimizes the request using the **EXEC CICS LINK** command.
- When you are not using the CICS Web services assistant, you must construct your own messages, and link to program DFHPIRT.

Either way, it follows that your business logic cannot invoke a Web service directly unless you are prepared to change the program. For the Web services assistant, this option is shown in Figure 19, but it is not advisable in either case.

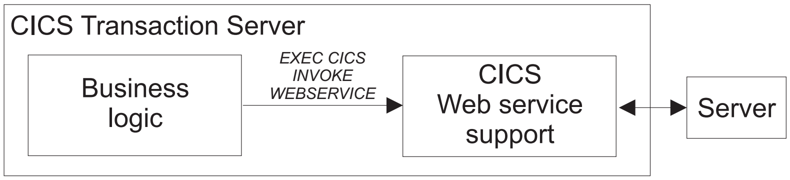


Figure 19. Simple deployment of CICS application as a Web service requester

Using a wrapper program

A better solution, which keeps the business logic almost unchanged, is to use a wrapper program. The wrapper, in this case, has two purposes:

- It issues an **EXEC CICS INVOKE WEBSERVICE** command, or an **EXEC CICS LINK PROGRAM(DFHPIRT)**, on behalf of the business logic. The only change in the business logic is the name of the program to which it links.
- It can, if necessary, provide any data manipulation that is required if your application uses a data structure which the CICS Web services assistant cannot map directly into a SOAP message.

For the case when the Web services assistant is used, this structure is illustrated in Figure 20 on page 44.

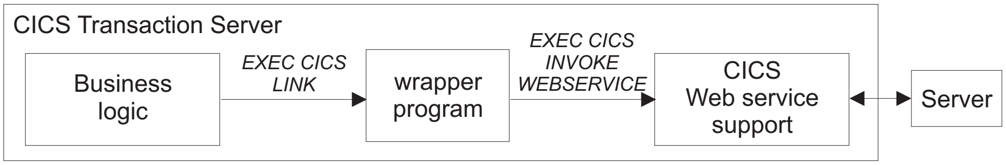


Figure 20. Deployment of CICS application as a Web service requester using a wrapper program

Error handling

If you are planning to use the CICS Web services assistant, you should also consider how to handle rolling back changes when errors occur. If your service requester application receives a SOAP fault message from the service provider, you need to decide how your application program should handle the fault message. CICS does not automatically roll back any changes when a SOAP fault message is received.

If you are planning to implement Web service atomic transactions in your requester application program, the error handling is different. If the remote service provider encounters an error and rolls back its changes, a SOAP fault message is returned and the local transaction in CICS also rolls back. If local optimization is in effect, the service requester and provider use the same transaction. If the provider encounters an error, any changes made by the transaction in the requester are also rolled back.

Migrating from the SOAP for CICS feature

If you use the SOAP for CICS feature, you must perform a number of tasks to migrate applications that use the feature. The support for Web services provided in CICS Transaction Server is substantially different from that provided in the feature.

The SOAP for CICS feature relies to a considerable extent upon user-written code, and therefore it is not possible to set out a step-by-step migration task. However, here are some of the things you will need to think about.

- Consider using the Web services assistant to construct and parse SOAP messages. If you decide to do so, you are advised to discard your existing message adapters, and design new wrapper programs to replace them, as it is unlikely that you will be able to reuse significant amounts of code in your adapters.
- If you use SOAP messages, but decide not to use the Web services assistant, you may be able to reuse your existing code for constructing and parsing the messages. However, you should consider whether to use the CICS-provided SOAP message handlers, because they are designed to work with SOAP 1.1 and SOAP 1.2 messages.
- Review your use of containers. The SOAP for CICS feature uses BTS containers, whereas CICS Transaction Server uses channel containers. You will need to review your programs and change any BTS-related commands required by the feature. You will also need to review the name and usage of each container, as most of these have changed.
- Consider how to migrate the function that was provided by your pipeline programs. The pipeline in the SOAP for CICS feature has a fixed number of user-written programs, each with a designated purpose. The function provided by

some of these programs is provided in CICS Transaction Server by the CICS-provided SOAP message handlers, so you may be able to dispense with these programs altogether.

On the other hand, CICS Transaction Server lets you define as many programs in your pipeline as you need. Therefore, you should consider whether the function performed by your pipeline programs should be restructured to take advantage of the new framework.

In any case, the way that pipeline programs communicate with CICS, and with one another, has changed, so you will need to review these programs to see if they can be reused in the new environment.

In the SOAP for CICS feature, you could have just one pipeline for all your service provider applications, and one for all your service requesters. In CICS Transaction Server, you can configure many different pipelines. Therefore, it is possible that the logic you provided in your pipeline programs to distinguish one application from another can be replaced by CICS resource definitions. For example, in a service provider, code that distinguishes between applications based upon a URI, can be replaced with a suitable set of URIMAP resources

Chapter 6. Configuring your CICS system for Web services

Before you can use Web services, your CICS system must be correctly configured.

1. Ensure that you have installed Language Environment® support for PL/I. For more information, see the *CICS Transaction Server for z/OS Installation Guide*.
2. Activate z/OS Support for Unicode. You must enable the z/OS conversion services and install a conversion image that specifies the data conversions that you want CICS to perform between SOAP messages and an application program. For more information, see *z/OS Support for Unicode: Using Conversion Services*.

CICS resources for Web services

The following CICS resources support Web services in CICS:

PIPELINE

A PIPELINE resource definition is required in every case. It provides information about the message handler programs that act on a service request and on the response. Typically, a single PIPELINE definition defines an infrastructure that can be used by many applications. The information about the message handlers is supplied indirectly: the PIPELINE specifies the name of a z/OS UNIX file which contains an XML description of the handlers and their configuration.

A PIPELINE resource that is created for a service requester cannot be used for a service provider, and vice versa. The two sorts of PIPELINE are distinguished by the contents of the pipeline configuration file that is specified in the CONFIGFILE attribute: for a service provider, the top level element is `<provider_pipeline>`; for a service requester it is `<requester_pipeline>`.

WEBSERVICE

A WEBSERVICE resource definition is required only when the mapping between application data structure and SOAP messages has been generated using the CICS Web services assistant. It defines aspects of the run time environment for a CICS application program deployed in a Web services setting.

Although CICS provides the usual resource definition mechanisms for WEBSERVICE resources, they are typically created automatically from a Web service binding file when the PIPELINE's pickup directory is scanned. This happens when the PIPELINE resource is installed, or as a result of a PERFORM PIPELINE SCAN command. The attributes applied to the WEBSERVICE resource in this case come from a Web services binding file, which is created by the Web services assistant; information in the binding file comes from the Web service description, or is supplied as a parameter of the Web services assistant.

A WEBSERVICE resource that is created for a service requester cannot be used for a service provider, and vice versa. The two sorts of WEBSERVICE are distinguished by the PROGRAM attribute: for a service provider, the attribute must be specified; for a service requester it must be omitted.

URIMAP

A URIMAP definition is required only in a service provider, and contains information that maps the URI of an inbound Web service request to the other resources (such as the PIPELINE) that will service the request.

Although CICS provides the usual resource definition mechanisms, for service providers deployed using the CICS Web services assistant the URIMAP resources are typically created automatically from a Web service binding file when the PIPELINE's pickup directory is scanned. This happens when the PIPELINE resource is installed, or as a result of a PERFORM PIPELINE SCAN command. The attributes applied to the URIMAP resource in this case come from a Web services binding file, which is created by the Web services assistant; information in the binding file comes from the Web service description, or is supplied as a parameter of the Web services assistant.

TCPIPSERVICE

A TCPIPSERVICE definition is required in a service provider that uses the HTTP transport, and contains information about the port on which inbound requests are received.

The resources that are required to support a particular application program depends upon the following:

- Whether the application program is a service provide or a service requester.
- Whether the application is deployed with the CICS Web services assistant.

Service requester or provider	CICS Web services assistant used	PIPELINE required	WEBSERVICE required	URIMAP required	TCPIPSERVICE required
Provider	Yes	Yes	Yes (but see note 1)	Yes (but see note 1)	See note 2
	No	Yes	No	Yes	See note 2
Requester	Yes	Yes	Yes	No	No
	No	Yes	No	No	No

Notes:

1. When the CICS Web service assistant is used to deploy an application program, the WEBSERVICE and URIMAP resources can be created automatically when the PIPELINE's pickup directory is scanned. This happens when the PIPELINE resource is installed, or as a result of a PERFORM PIPELINE SCAN command.
2. A TCPIPSERVICE resource is required when the HTTP transport is used. When the WebSphere® MQ transport is used, a TCPIPSERVICE resource is not required.

Typically, when you deploy many Web services applications in a CICS system, you will have more than one of each type of resource. In this case, you can share some resources between applications.

For each ...	You can have ...
Pipeline configuration file	• More than one PIPELINE resource that refers to the file
PIPELINE resource	• More than one URIMAP resource that refers to the PIPELINE • More than one WEBSERVICE resource that refers to the PIPELINE • More than one Web service binding file in the PIPELINE's pickup directory

For each ...	You can have ...
Web service binding file	• Just one URIMAP resource that is automatically generated from the binding file. But you can define further URIMAPs using RDO. • Just one WEBSERVICE resource that is automatically generated from the binding file. But you can define further WEBSERVICEs using RDO.
WEBSERVICE	• More than one URIMAP resource. If the WEBSERVICE resource is automatically generated from the binding file, there is just one corresponding URIMAP resource. But you can define further URIMAP resources using RDO.
URIMAP	• Just one TCPIPSERVICE when it is explicitly named in the URIMAP resource.
TCPIPSERVICE	• Many URIMAP resources.

Configuring CICS to use the WebSphere MQ transport

To use the WebSphere MQ (WMQ) transport with Web services in CICS, you must configure your CICS region accordingly.

1. Include the following libraries in the STEPLIB concatenation. Note that they must be included after the CICS libraries to ensure that the correct Adapter, trigger monitor and bridge code is used.

   thlqual.SCSQANL*x*

   thlqual.SCSQAUTH

   where:

   thlqual is the high-level qualifier for the WMQ libraries.

   x is the language letter for national language.

2. Include the following libraries in the DFHRPL concatenation. Note that they must be included after the CICS libraries to ensure that the correct Adapter, trigger monitor and bridge code is used.

   thlqual.SCSQLOAD

   thlqual.SCSQANL*x*

   thlqual.SCSQCICS

   thlqual.SCSQAUTH

   thlqual is the high-level qualifier for the WMQ libraries.

   x is the language letter for national language.

   The SCSQANLx and SCSQCICS libraries are required only if you are running WebSphere MQ V531 and wish to use the MQ Bridge function, or if you wish to run WebSphere MQ supplied samples. Otherwise they can be removed from the CICS procedure. When using the bridge function with WebSphere MQ V531, the CICS shipped bridge transfers control to the WebSphere MQ V531 bridge contained in the SCSQCICS library

3. Specify the following CICS system initialization parameters.

```
INITPARM=(DFHMQPRM='SN=queuemanager,IQ=initiation_queue')
MQCONN=YES
```

where:

queuemanager is the subsystem name.

initiation_queue is the name of the default initiation queue.

4. Ensure that the coded character set identifiers (CCSIDs) used by your queue manager and by CICS, and the UTF-8 and UTF-16 code pages are configured to z/OS conversion services. The CICS code page is specified in the **LOCALCCSID** system initialization parameter.
5. Update your CSD as appropriate.
   - If you want to share a CICS TS 3.2 CSD with earlier CICS releases, ensure that the groups CSQCAT1 and CSQCKB are not installed for CICS TS 3.2. Delete the CKQQ TDQUEUE definition from group CSQCAT1, and then install the group as part of a group list for earlier CICS releases, after installing DFHLIST. This overrides group DFHMQ and correctly installs the required definitions.
   - If you do not need to share your CSD with earlier releases of CICS, remove the existing groups CSQCAT1 and CSQCKB from your CSD.

You can find more detailed information in the *WebSphere MQ z/OS System Setup Guide*.

The WebSphere MQ transport

CICS can receive and send SOAP messages to WebSphere MQ (WMQ) using the WMQ transport, both in the role of service provider and service requester.

As a **service provider**, CICS uses WMQ triggering to process SOAP messages from an application queue. Triggering works by using an initiation queue and local queues. A local (application) queue definition includes:

- The criteria for when a trigger message should be generated. For example, when the first message arrives on the local queue, or for every message that arrives on the local queue. For CICS SOAP processing, you should specify that triggering occurs when the first message arrives on the local queue.

  The local queue definition can also specify that trigger data should be passed to the target application, and in the case of CICS SOAP processing (transaction CPIL), this specifies the default target URL to be used if this is not passed with the inbound message.
- The *process name* that identifies the *process definition*. The process definition describes how the message should be processed. In the case of CICS SOAP processing, specify the CPIL transaction.
- The name of the initiation queue that the trigger message should be sent to.

When a message arrives on the local queue, the Queue Manager generates and sends a trigger message to the specified initiation queue. The trigger message includes the information from the process definition. The trigger monitor retrieves the trigger message from the initiation queue and schedules the CPIL transaction to start processing the messages on the local queue. For more information about triggering, see the *CICS integration with WebSphere MQ* manual.

You can configure CICS, so that when a message arrives on a local queue, the trigger monitor (provided by WMQ) schedules the CPIL transaction to process the messages on the local queue and drive the CICS SOAP pipeline to process the SOAP messages on the queue.

When CICS constructs a response to a SOAP message that is received from WebSphere MQ, the correlation ID field is populated with the message ID of the input message, unless the report option MQRO_PASS_CORREL_ID has been set. If this report option has been set, the correlation id is propagated from the input message to the response.

As a **service requester**, on outbound requests you can specify that the responses for the target Web service should be returned on a particular reply queue.

In both cases, CICS and WMQ require configuration to define the necessary resources and queues.

Defining local queues in a service provider

To use the WebSphere MQ transport in a service provider, you must define one or more local queues that store request messages until they are processed, and one trigger process that specifies the CICS transaction that will process the request messages.

1. Define an initiation queue. Use the following command:

   ```
   DEFINE
   QLOCAL('initiation_queue')
   DESCR('description')
   ```

   where *initiation_queue* is the same as the value specified in IQ= in DFHMQPRM in the **INITPARM** system initialization parameter.
2. For each local request queue, define a QLOCAL object. Use the following command:

   ```
   DEFINE
   QLOCAL('queuename')
   DESCR('description')
   PROCESS(processname)
   INITQ('initiation_queue')
   TRIGGER
   TRIGTYPE(FIRST)
   TRIGDATA('default_target_service')
   BOTHRESH(nnn)
   BOQNAME('requeuename')
   ```

   where:

   queuename is the local queue name.

   processname is the name of the process instance that identifies the application started by the queue manager when a trigger event occurs. Specify the same name on each QLOCAL object.

   initiation_queue is the name of the initiation queue to be used (e.g. as specified in IQ= in the DFHMQPRM **INITPARM** system initialization parameters for Websphere MQ).

   default_target_service is the default target service to be used if a service is not specified on the request . The target service is of the form '/string' and is used to match the path of a URIMAP definition. for example '/SOAP/test/test1'. Note that the first character must be '/' .

nnn is the number of retries that will be attempted.

requeuename is the name of the queue to which failed messages will be sent.

3. Define a PROCESS object that specifies the trigger process. Use the following command:

   ```
   DEFINE
   PROCESS(processname)
   APPLTYPE(CICS)
   APPLICID(CPIL)
   ```

   where:

   processname is the name of the process, and must be the same as the name that is used when defining the request queues.

Defining local queues in a service requester

When you use the WebSphere MQ transport for outbound requests in a service requester, you can specify in the URI for the target Web service that your responses should be returned on a predefined reply queue. If you do so, you must define each reply queue with a QLOCAL object.

If the URI associated with a request does not specify a reply queue, CICS will use a dynamic queue for the reply.

Optional: To define each QLOCAL object that specifies a predefined reply queue, use the following command.

```
DEFINE
QLOCAL('reply_queue')
DESCR('description')
BOTHRESH(nnn)
```

where:

reply_queue is the local queue name.

nnn is the number of retries that will be attempted.

The URI for the WMQ transport

When communication between the service requester and service provider uses WMQ, the URI of the target is in a form that identifies the target as a queue and includes information to specify how the request and response should be handled by WMQ.

Syntax

```
              ┌─&───────────────────────────────────────────┐
              ▼                                             │
►►──jms:/queue?───┬─destination=queuename─┬─────────────────────┬─┬┴──────────────────►◄
                  │                       └─@queuemanagername─┘ │
                  ├─persistence=message_persistence─────────────┤
                  ├─priority=message_priority───────────────────┤
                  ├─replyDestination=reply_queue────────────────┤
                  ├─timeout=timeout─────────────────────────────┤
                  ├─timeToLive=expiry_time──────────────────────┤
                  └─targetService=string────────────────────────┘
```

CICS uses the following options; other Web service providers might use further options that are not described here. The entire URI is passed to the service provider, but CICS ignores any options that it does not support and that are coded in the URI. CICS is not sensitive to the case of the option names. However, some other implementations that support this style of URI are case-sensitive.

destination=*queuename* [@*queuemanagername*]

queuename is the name of the input queue in the target queue manager

queuemanagername is the name of the target queue manager

persistence=*message_persistence*

Specify one of the following:

0 Persistence is defined by the default queue persistence.

1 Messages are not persistent.

2 Messages are persistent.

If the option is not specified or is specified incorrectly, the default queue persistence is used.

priority=*message_priority*

Specifies the message priority as an integer in the range 0 to 99999999.

replyDestination=*reply_queue*

Specifies the queue to be used for the response message. If this option is not specified, CICS will use a dynamic queue for the response message. You must define the reply queue in a QLOCAL object before using this option.

timeout=*timeout*

The timeout in milliseconds for which the service requester will wait for a response. If a value of zero is specified, or if this option is omitted, the request will not time out.

timeToLive=*expiry-time*

Specifies the expiry time for the request in milliseconds. If the option is not specified or is specified incorrectly, the request will not expire.

targetService=*string*

Identifies the target service. If CICS is the service provider, then the target service should be of the form '/string', as CICS will use this as the path when attempting to match with URIMAP. If not specified, the value specified in TRIGDATA on the input queue at the service provider is used.

This example shows a URI for the WMQ transport:

```
jms:/queue?destination=queue01@cics007&timeToLive=10&replyDestination=rqueue05&targetService=/myservice
```

Configuring CICS to support persistent messages

CICS provides support for sending persistent messages using the WMQ transport protocol to a Web service provider application that is deployed in a CICS region.

CICS uses Business Transaction Services (BTS) to ensure that persistent messages are recovered in the event of a CICS system failure. For this to work correctly, follows these steps:

1. Use IDCAMS to define the local request queue and repository file to MVS. You must specify a suitable value for STRINGS for the file definition. The default value of 1 is unlikely to be sufficient, and you are recommended to use 10 instead.
2. Define the local request queue and repository file to CICS. Details of how to define the local request queue to CICS are described in “Defining local queues in a service provider” on page 51. You must specify a suitable value for STRINGS in the file definition. The default value of 1 is unlikely to be sufficient, and it is recommended that you use 10 instead.
3. Define a PROCESSTYPE resource with the name DFHMQSOA, using the repository file name as the value for the FILE option.
4. Ensure that during the processing of a persistent message, a program issues an **EXEC CICS SYNCPOINT** command before the first implicit syncpoint is requested; for example, using an SPI command such as **EXEC CICS CREATE TDQUEUE** implicitly takes a syncpoint. Issuing an **EXEC CICS SYNCPOINT** command confirms that the persistent message has been processed successfully. If a program does not explicitly request a syncpoint before trying to implicitly take a syncpoint, CICS issues an ASP7 abend.

For one way request messages, if the Web service abends or backs out, sufficient information is retained to allow a transaction or program to retry the failing request, or to report the failure appropriately. You need to provide this recovery transaction or program. See “Persistent message processing” for details.

Persistent message processing

When a Web service request is received in a WMQ persistent message, CICS creates a unique BTS process with the process type DFHMQSOA. Data relating to the inbound request is captured in BTS data-containers that are associated with the process.

The process is then scheduled to run asynchronously. If the Web service completes successfully and commits, CICS deletes the BTS process. This includes the case when a SOAP fault is generated and returned to the Web service requester.

Error processing

If an error occurs when creating the required BTS process, the Web service transaction abends, and the inbound Web service request is not processed. If BTS is not usable, message DFHPI0117 is issued, and CICS continues without BTS, using the existing channel-based container mechanism.

If a CICS failure occurs before the Web service starts or completes processing, BTS recovery ensures that the process is rescheduled when CICS is restarted.

If the Web service abends and backs out, the BTS process is marked complete with an ABENDED status. For request messages that require a response, a SOAP fault is returned to the Web service requester. The BTS process is cancelled, and CICS retains no information about the failed request. CICS issues message DFHBA0104 on transient data queue CSBA, and message DFHPI0117 on transient data queue CPIO.

For one way messages, there is no way to return information about the failure to the requester so the BTS process is retained in a COMPLETE ABENDED state. CICS issues message DFHBA0104 on transient data queue CSBA, and DFHPI0116 on transient data queue CPIO.

You can use the CBAM transaction to display any COMPLETE ABENDED processes, or you can supply a recovery transaction to check for COMPLETE ABENDED processes of the DFHMQSOA and take appropriate action.

For example, your recovery transaction could:

1. Reset the BTS process using the **RESET ACQPROCESS** command.
2. Issue the **RUN ASYNC** command to retry the failing Web service. It could keep a retry count in another data-container on the process, to avoid repeated failure.
3. Use information in the associated data-containers to report on the problem:

   The DFHMQORIGINALMSG data-container contains the message received from WMQ, which might contain RFH2 headers.

   The DFHMQMSG data-container contains the WMQ message with any RFH2 headers removed.

   The DFHMQDLQ data-container contains the name of the dead letter queue associated with the original message.

   The DFHMQCONT data-container contains the WMQ MQMD control block relating to the **MQ GET** for the original message.

Chapter 7. Creating the Web services infrastructure

To deploy a Web service to CICS, you must create the necessary transport infrastructure and define one or more pipelines that will process your Web services requests. Typically, one pipeline can process requests for many different Web services, and, when you deploy a new Web service in your CICS system, you can choose to use an existing pipeline.

Creating the CICS infrastructure for a service provider

To create the CICS infrastructure for a service provider, you need to create a pipeline configuration file and define and install a number of CICS resources.

Perform the following steps to create the infrastructure for your service provider:

1. Define the transport infrastructure.
   - If you are using the WMQ transport, you must define one or more local queues that store input messages until they are processed, and one trigger process that specifies the CICS transaction that will process the input messages. See "Configuring CICS to use the WebSphere MQ transport" on page 49 for details.
   - If you are using the HTTP transport, you must define a TCPIPSERVICE resource that defines the port on which inbound requests are received. See "CICS resources for Web services" on page 47 for details.

   Repeat this step for each different transport configuration you need.
2. Create a pipeline configuration file. This is an XML file that is stored in the z/OS UNIX System Services file system. It defines what message handler programs are used to process inbound Web service requests, and the responses. CICS provides a standard set of message handlers that you can use to enable different options in your pipeline. A basic pipeline sample basicsoap11provider.xml, is provided in library `/usr/lpp/cicsts/samples/pipelines`, which you can use as a basis for adding in additional message handlers as appropriate.
   a. Define the message handlers that you want to include in the pipeline configuration file. If you create any custom message handler programs, to optimize performance it is recommended that you make them threadsafe. For more information about the options that you can enable in the pipeline, see "The pipeline configuration file" on page 59.
   b. Copy the pipeline configuration file to a suitable directory in z/OS UNIX.
   c. Change the pipeline configuration file permissions to allow the CICS region to read the file.

   Repeat this step for each different pipeline configuration you need.
3. Define and install a PIPELINE resource. The PIPELINE resource defines the location of the pipeline configuration file. It also specifies a *pickup directory*, which is the z/OS UNIX directory that will contain the Web service binding files and optionally the WSDL.

   Repeat this step for each pipeline configuration you need.
4. Unless you use autoinstalled PROGRAM definitions, you need to supply a PROGRAM resource definition for each program that runs in the pipeline. These include the target application program, which normally run under transaction CPIH. The transaction is defined with the attribute `TASKDATALOC(ANY)`. Therefore, when you link-edit the program, you must specify the `AMODE(31)` option.

Your CICS system now contains the infrastructure needed for each service provider:

- One or more transport infrastructures
- One or more pipelines

You can extend the configuration when you need to do so, to either define additional transport infrastructure, or to create additional pipelines.

Creating the CICS infrastructure for a service requester

To create the CICS infrastructure for a service requester, you need to create a pipeline configuration file and define and install a number of CICS resources.

Perform the following steps to create the CICS infrastructure for your service requester:

1. Create a pipeline configuration file. This is an XML file that is stored in z/OS UNIX System Services file system. It defines what message handler programs and header processing programs are used to process outbound Web service requests, and the responses.

   CICS provides a standard set of message handlers and header processing programs that you can use to enable different options in your pipeline, for example sending SOAP 1.1 or SOAP 1.2 messages. A basic pipeline sample basicsoap11requester.xml is provided in library `/usr/lpp/cicsts/samples/pipelines`, which you can use as a basis for adding in additional message handlers as appropriate.

   a. Review the CICS-supplied message handlers to see if they meet your processing requirements. CICS provides the following handlers and header programs:

      - SOAP message handlers, to process SOAP 1.1 or 1.2 messages. You can only support one level of SOAP in a service requester pipeline.
      - MTOM handler, to process MIME Multipart/Related messages that conform to the MTOM/XOP specifications.
      - Security handler, to process secure Web service messages.
      - WS-AT header processing program, to process atomic transaction messages.

   b. Define the message handlers that you want to include in the pipeline configuration file. For more information about the options that you can enable in the pipeline, see “The pipeline configuration file” on page 59.

      If you want to perform your own processing in the pipeline, you need to create a message handler or header processing program. See “Message handlers” on page 92 for details. If you decide to create custom message handler programs, to optimize performance it is recommended that you make them threadsafe.

   c. Copy the pipeline configuration file to a suitable directory in z/OS UNIX.

   d. Change the pipeline configuration file permissions to allow the CICS region to read the file.

2. Define and install a PIPELINE resource. The PIPELINE resource defines the location of the pipeline configuration file. It also specifies a *pickup directory*, which is the z/OS UNIX directory that will contain the Web service binding files and optionally the WSDL. For a requester mode pipeline, you can also specify a timeout in seconds, which determines how long CICS waits for a response from Web service providers. Repeat this step for each different pipeline configuration

you need. When you install a PIPELINE resource, CICS reads any files in the specified pickup directory, and creates the WEBSERVICE resources dynamically.

3. Unless you use autoinstall PROGRAM definitions, you need to supply a PROGRAM resource definition for each program that runs in the pipeline. These include the service requester application program, which normally run under transaction CPIH. The transaction is defined with the attribute `TASKDATALOC(ANY)`. Therefore, when you link-edit the program, you must specify the `AMODE(31)` option.

Your CICS system now contains the infrastructure needed for each service requester.

You can extend the configuration when you need to do so, to create additional pipelines.

The pipeline configuration file

The configuration of a pipeline used to handle a Web service request is specified in an XML document, known as a *pipeline configuration file*.

The pipeline configuration file is stored in the z/OS UNIX System Services file system, and its name is specified in the CONFIGFILE attribute of a PIPELINE resource definition. Use a suitable XML editor or text editor to work with your pipeline configuration files. When you work with configuration files, ensure that the character set encoding is US EBCDIC (Code page 037).

When CICS processes a Web service request, it uses a pipeline of one or more message handlers to handle the request. A pipeline is configured to provide aspects of the execution environment that apply to different categories of applications, such as support for Web Service Security, and Web Service transactions. Typically, a CICS region that has a large number of service provider or service requester applications will need several different pipeline configurations. However, where different applications have similar requirements, they can share the same pipeline configuration.

There are two kinds of pipeline configuration: one describes the configuration of a service provider pipeline; the other describes a service requester pipeline. Each is defined by its own schema, and each has a different root element.

Pipeline	Schema	Root element
Service provider	`Provider.xsd`	`<provider_pipeline>`
Service requester	`Requester.xsd`	`<requester_pipeline>`

Although many of the XML elements used are common to both kinds of pipeline configuration, others are used only in one or the other, so you cannot use the same configuration file for both a provider and requester.

Restriction: Namespace-qualified element names are not supported in the pipeline configuration file.

The immediate sub-elements of the `<provider_pipeline>` and `<requester_pipeline>` elements are:

- A `<service>` element, which specifies the message handlers that are invoked for every request. This element is mandatory when used within the `<provider_pipeline>` element, and optional within the `<requester_pipeline>` element.
- An optional `<transport>` element, which specifies message handlers that are selected at run time, based upon the resources that are being used for the message transport.
- For the `<provider_pipeline>` only, an `<apphandler>` element, which is used in some cases to specify the target application (or wrapper program) that provides the service.
- An optional `<service_parameter_list>` element, which contains the parameters that are available to the message handlers in the pipeline.

Certain elements can have attributes associated with them. Each attribute value must have quotes around it to produce a valid XML document.

Associated with the pipeline configuration file is a PIPELINE resource. The attributes include CONFIGFILE, which specifies the name of the pipeline configuration file in z/OS UNIX. When you install a PIPELINE definition, CICS reads the information that it needs in order to configure the pipeline from the file.

CICS supplies sample configuration files that you can use as a basis for developing your own. They are provided in library `/usr/lpp/cicts/samples/pipelines`.

File **Description**

`basicsoap11provider.xml`
A pipeline definition for a service provider that uses the CICS-provided SOAP 1.1 handler, for use when the application has been deployed using the CICS Web services assistant.

`basicsoap11requester.xml`
A pipeline definition for a service requester that uses the CICS-provided SOAP 1.1 handler, for use when the application has been deployed using the CICS Web services assistant.

`wsatprovider.xml`
A pipeline definition that adds configuration information for Web Services transactions to `basicsoap11provider.xml`.

`wsatrequester.xml`
A pipeline definition that adds configuration information for Web Services transactions to `basicsoap11requester.xml`.

Example pipeline configuration file

This is a simple example of a configuration file for a service provider pipeline:

```
<?xml version="1.0" encoding="UTF-8"?>
<provider_pipeline
   xmlns="http://www.ibm.com/software/htp/cics/pipeline"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://www.ibm.com/software/htp/cics/pipeline/provider.xsd">
  <service>
    <terminal_handler>
      <cics_soap_1.1_handler/>
    </terminal_handler>
  </service>
  <apphandler>DFHPITP</apphandler>
</provider_pipeline>
```

The pipeline contains just one message handler, the CICS-supplied SOAP 1.1 message handler. The handler links to program DFHPITP.

- The `<provider_pipeline>` element is the root element of the pipeline configuration file for a service provider pipeline.
- The `<service>` element specifies the message handlers that are invoked for every request. In the example, there is just one message handler.
- The `<terminal_handler>` element contains the definition of the terminal message handler of the pipeline.
- The `<cics_soap_1.1_handler>` indicates that the terminal handler of the pipeline is the CICS-supplied handler program for SOAP 1.1 messages.
- The `<apphandler>` element specifies the name of the program to which the terminal handler of the pipeline will link by default. In this case, the program is DFHPITP, which is the CICS-supplied target program for applications deployed with the CICS Web services assistant. For programs that are not deployed with the Web services assistant, this is the name of the target application program.

Transport-related handlers

In the configuration file for each pipeline, you can specify more than one set of message handlers. At run time, CICS selects the message handlers that are called, based upon the resources that are being used for the message transport.

In a service provider, and in a service requester, you can specify that some message handlers should be called only when a particular transport (HTTP or WebSphere MQ) is in use. For example, consider a Web service that you make available to your employees. Those who work at a company location access the service using the WebSphere MQ transport on a secure internal network; however, employees working at a business partner location access the service using the HTTP transport over the internet. In this situation, you might want to use message handlers to encrypt parts of the message when the HTTP transport is used, because of the sensitive nature of the information.

In a service provider, inbound messages are associated with a named resource (a TCPIPSERVICE for the HTTP transport, a QUEUE for the MQ transport). You can specify that some message handlers should be called only when a particular resource is used for an inbound request.

To make this possible, the message handlers are specified in two distinct parts of the pipeline configuration file:

The service section
Specifies the message handlers that are called each time the pipeline executes.

The transport section
Specifies the message handlers that might or might not be called, depending upon the transport resources that are in use.

Remember: At run time, a message handler can choose to curtail the execution of the pipeline. Therefore, even if CICS decides that a particular message handler should be called based on what is in the pipeline configuration file, the decision might be overruled by an earlier message handler.

The message handlers that are specified within the transport section (the *transport-related handlers*) are organized into several lists. At run time, CICS selects the handlers in just one of these lists for execution, based on which transport resources are in use. If more than one list matches the transport resources that are being used, CICS uses the list that is most selective. The lists that are used in both service provider and service requester pipelines are:

<default_transport_handler_list>
This is the least selective list of transport-related handlers; the handlers specified in this list are called when none of the following lists matches the transport resources that are being used.

<default_http_transport_handler_list>
In a service requester pipeline, the handlers in this list are called when the HTTP transport is in use.

In a service provider pipeline, the handlers in this list are called when the HTTP transport is in use, and no <named_transport_entry> names the TCPIPSERVICE for the TCP/IP connection.

<default_mq_transport_handler_list>
In a service requester pipeline, the handlers in this list are called when the WebSphere MQ transport is in use.

In a service provider pipeline, the handlers in this list are called when the WebSphere MQ transport is in use, and no <named_transport_entry> names the message queue on which inbound messages are received.

The following list of message handlers is used only in the configuration file for a service provider pipeline:

<named_transport_entry>
As well as a list of handlers, the <named_transport_entry> specifies the name of a resource, and the transport type.

- For the HTTP transport, the handlers in this list are called when the resource name matches the name of the TCPIPSERVICE for the inbound TCP/IP connection.
- For the WebSphere MQ transport, the handlers in this list are called when the resource name matches the name of the message queue that receives the inbound message.

Example

This is an example of a <transport> element from the pipeline configuration file for a service provider pipeline:

```
<transport>

  <!-- HANDLER1 and HANDLER2 are the default transport handlers -->
  <default_transport_handler_list>
    <handler><program>HANDLER1</program><handler_parameter_list/></handler>
    <handler><program>HANDLER2</program><handler_parameter_list/></handler>
  </default_transport_handler_list>

  <!-- HANDLER3 overrides defaults for MQ transport -->
  <default_mq_transport_handler_list>
    <handler><program>HANDLER3</program><handler_parameter_list/></handler>
  </default_mq_transport_handler_list>

  <!-- HANDLER4 overrides defaults for http transport with TCPIPSERVICE(WS00) -->
  <named_transport_entry type="http">
    <name>WS00</name>
    <transport_handler_list>
      <handler><program>HANDLER4</program><handler_parameter_list/></handler>
    </transport_handler_list>
  </named_transport_entry>

</transport>
```

The effect of this definition is this:

- The <default_mq_transport_handler_list> ensures that messages that use the MQ transport are processed by handler HANDLER3.
- The <named_transport_entry> ensures that messages that use the TCP/IP connection associated with TCPIPSERVICE(WS00) are processed by handler HANDLER4.
- The <default_transport_handler_list> ensures that all remaining messages, that is, those that use the HTTP transport, but not TCPISERVICE(WS00), are processed by handlers HANDLER1 and HANDLER2.

Remember: Any handlers specified in the service section of the pipeline definition will be called in addition to those specified in the transport section.

The pipeline definition for a service provider

The message handlers are defined in an XML document, which is stored in z/OS UNIX. The name of the file that contains the document is specified in the CFGFILE attribute of a PIPELINE definition.

The root element of the pipeline configuration document is the <provider_pipeline> element. The high-level structure of the document is shown in Figure 21 on page 64.

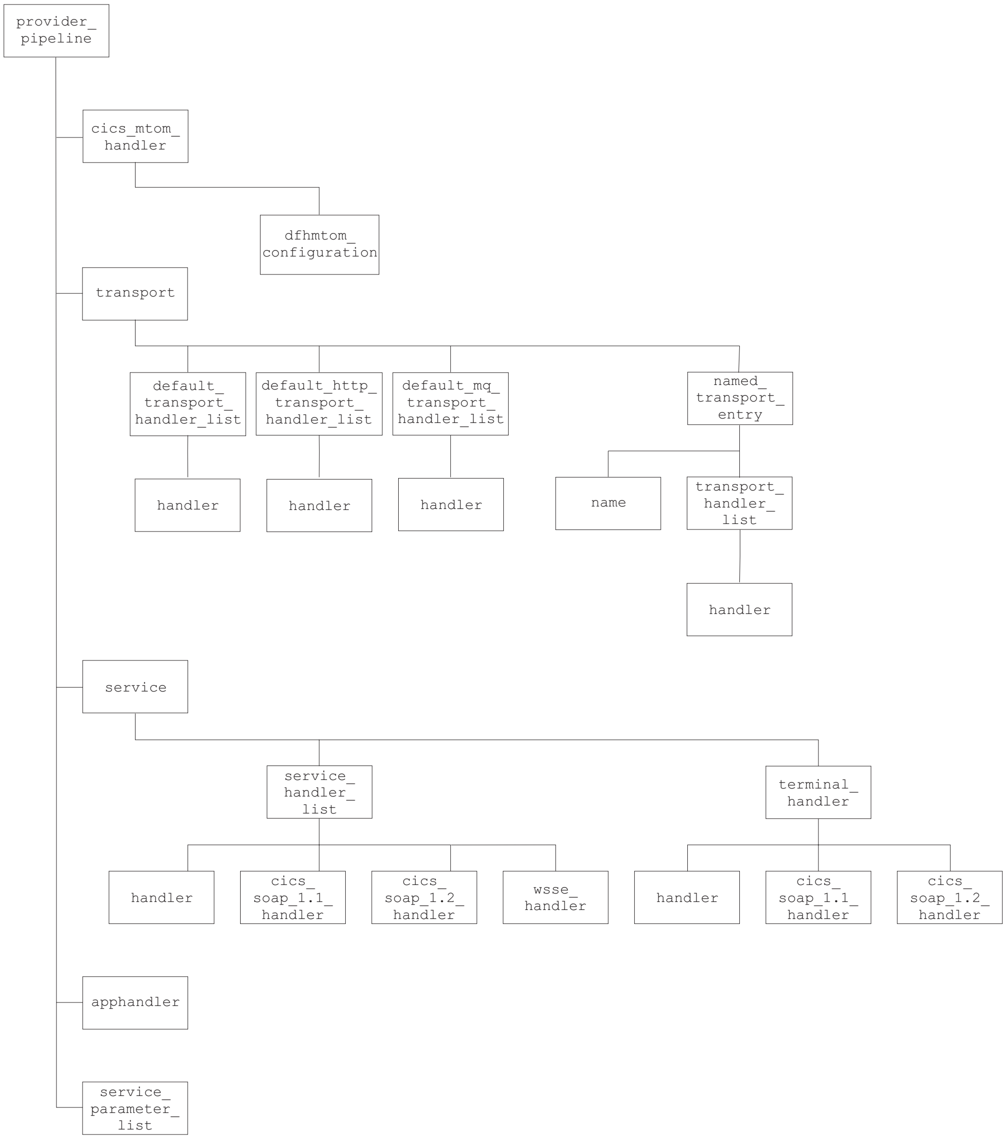


Figure 21. Structure of the pipeline definition for a service provider.

Note: In order to simplify the figure, child elements of the `<handler>`, `<cics_soap_1.1_handler>`, and `<cics_soap_1.2_handler>` elements are not shown.

The following elements are used only in the pipeline configuration for a service provider:

`<named_transport_entry>`

`<terminal_handler>`

Other elements are common to a service provider and a service requester.

The pipeline definition for a service requester

The message handlers are defined in an XML document, which is stored in z/OS UNIX. The name of the file that contains the document is specified in the CFGFILE attribute of a PIPELINE definition.

The root element of the pipeline configuration document is the <requester_pipeline> element. The high-level structure of the document is shown in Figure 22.

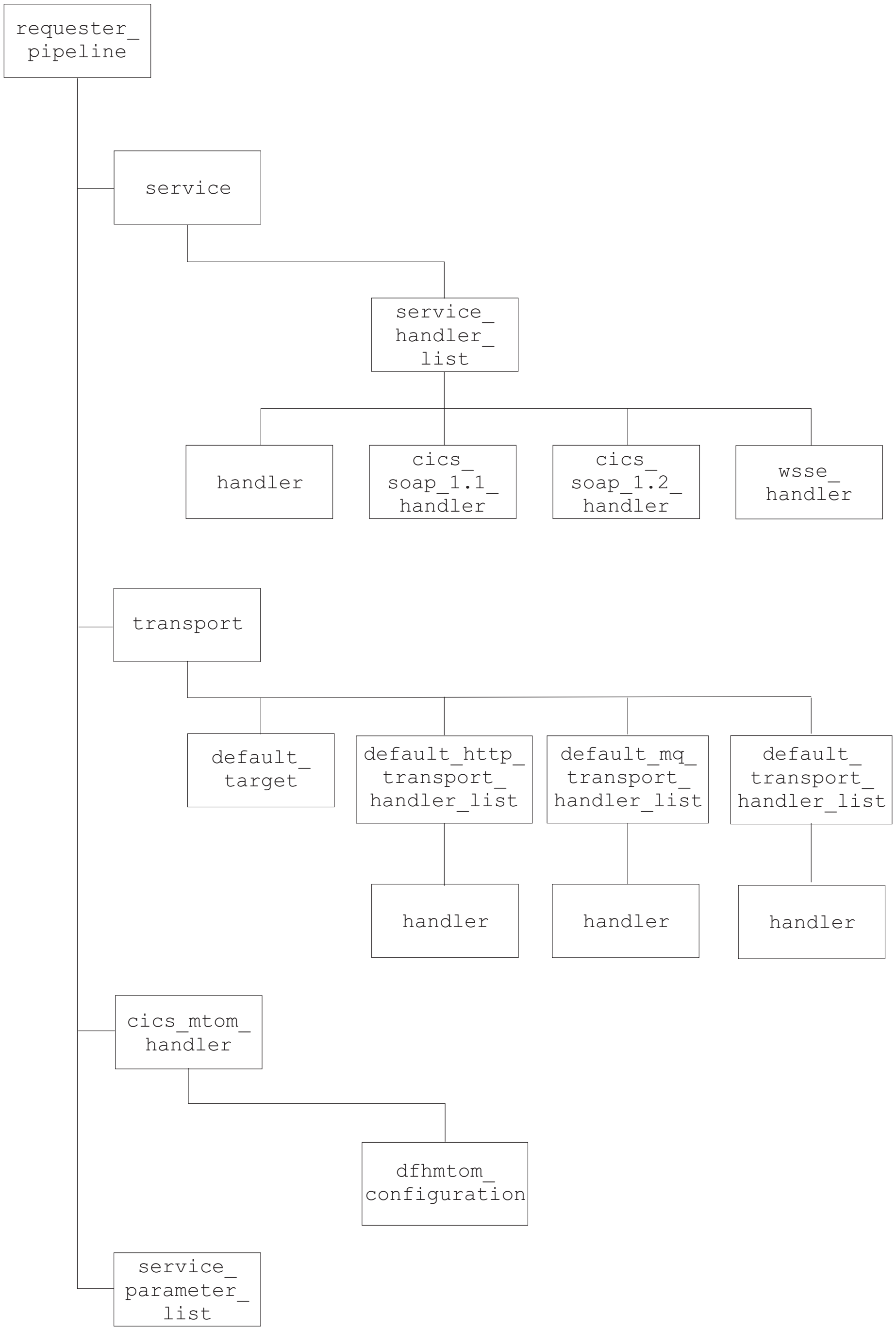


Figure 22. Structure of the pipeline definition for a service requester.

Note: In order to simplify the figure, child elements of the <handler>, <cics_soap_1.1_handler>, and <cics_soap_1.2_handler> elements are not shown.

Some elements used in the pipeline configuration for a service provider are also used in a service requester.

Elements used only in service providers

Some of the XML elements used in a pipeline configuration file apply only to service provider pipelines.

The <named_transport_entry> element

Contains a list of handlers that are to be invoked when a named transport resource is being used by a service provider.

- For the MQ transport, the named resource is the local input queue on which the request is received.
- For the HTTP transport, the resource is the TCPIPSERVICE that defines the port on which the request was received.

Used in:

- Service provider

Contained by:

<transport>

Attributes:

Name	Description
type	The transport mechanism with which the named resource is associated: **wmq** The named resource is a queue **http** The named resource is a TCPIPSERVICE

Contains:

1. A <name> element, containing the name of the resource
2. An optional <transport_handler_list> element. Each <transport_handler_list> contains one or more <handler> elements.

   If you do not code a <transport_handler_list> element, then the only message handlers that are invoked when the named transport is used are those that are specified in the <service> element.

Example

```
<named_transport_entry type="http">
  <name>PORT80</name>
  <transport_handler_list>
    <handler><program>HANDLER1</program><handler_parameter_list/></handler>
    <handler><program>HANDLER2</program><handler_parameter_list/></handler>
  </transport_handler_list>
</named_transport_entry>
```

In this example, the message handlers specified (HANDLER1 and HANDLER2) are invoked for messages received on the TCPIPSERVICE with the name PORT80.

The <provider_pipeline> element

The root element of the XML document that describes the configuration of the CICS pipeline for a Web service provider.

Used in:

- Service provider

Contains:

1. Optional <cics_mtom_handler> element
2. Optional <transport> element
3. <service> element
4. Optional <apphandler> element, that specifies the name of the program that the terminal handler of the pipeline will link to by default.

   Use the <apphandler> when the terminal handler is one of the CICS-supplied SOAP message handlers, that is when the <terminal_handler> element contains a <cics_soap_1.1_handler> element or a <cics_soap_1.2_handler> element.

   Message handlers can specify a different program at run time, so the name coded here is not always the program that is linked to. If you do not code an <apphandler> element, one of the message handlers must use the DFHWS-APPHANDLER container to specify the name of the program at run time.

   Important: When you use the CICS Web services assistant to deploy your service provider, the <apphandler> element (or the DFHWS-APPHANDLER container) must specify DFHPITP, and not the name of your target application or wrapper program. In this case, you specify the name of your program in the PGMNAME parameter when you run DFHWS2LS or DFHLS2WS.
5. Optional <service_parameter_list> element, containing XML elements that are made available to all the message handlers in the pipeline in container DFH-SERVICEPLIST.

Example

```
<provider_pipeline>
  <service>
    ...
  </service>
  <apphandler>DFHPITP</apphandler>
</provider_pipeline>
```

The <terminal_handler> element

Contains the definition of the terminal message handler of the service provider pipeline.

Used in:

- Service provider

Contained by:

- <service> element

Contains:

One of the following elements:

<handler>

<cics_soap_1.1_handler>

<cics_soap_1.2_handler>

However, you should not define <cics_soap_1.1_handler> and <cics_soap_1.2_handler> elements in the same pipeline. If you expect your pipeline to process both SOAP 1.1 and SOAP 1.2 messages, you should use the CICS-supplied SOAP 1.2 message handler.

Remember: In a service provider, you can specify these handlers in the <service_handler_list> element as well as in the <terminal_handler> element.

Example

```
<terminal_handler>
  <cics_soap_1.1_handler>
    ...
  </cics_soap_1.1_handler>
<service_handler_list>
```

The <transport_handler_list> element

Contains a list of message handlers that are invoked when a named resource is used.

- For the MQ transport, the named resource is the name of the local input queue.
- For the HTTP transport, the resource is the TCPIPSERVICE that defines the port on which the request was received.

Used in:

- Service provider

Contained by:

- <named_transport_entry> element

Contains:

- One or more <handler> elements.

Example

```
<transport_handler_list>
  <handler>
    ...
  </handler>
  <handler>
    ...
  </handler>
<transport_handler_list>
```

Elements used in service requesters

Some of the XML elements used in a pipeline configuration file apply only to service requester pipelines.

The <requester_pipeline> element

The root element of the XML document that describes the configuration of a pipeline in a service requester.

Used in:

- Service requester

Contains:

1. Optional <service> element
2. Optional <transport> element
3. Optional <cics_mtom_handler> element

4. Optional <service_parameter_list> element, containing XML elements that are made available to the message handlers in container DFH-SERVICEPLIST.

Example

```
<requester_pipeline>
  <service>
    <service_handler_list>
      <cics_soap_1.1_handler/>
    </service_handler_list>
  </service>
</requester_pipeline>
```

Elements used in service provider and requesters

Some of the XML elements used in a pipeline configuration file apply to both service provider and service requester pipelines.

The <cics_soap_1.1_handler> element

Defines the attributes of the CICS-supplied handler program for SOAP 1.1 messages.

Used in:

- Service requester
- Service provider

Contained by:

<service_handler_list> element

<terminal_handler> element

Contains:

Zero, one, or more <headerprogram> elements. Each <headerprogram> contains:

1. A <program_name> element, containing the name of a header processing program
2. A <namespace> element, which is used with the following <localname> element to determine which header blocks in a SOAP message should be processed by the header processing program. The <namespace> element contains the URI (Universal Resource Identifier) of the header block's namespace.
3. A <localname> element, which is used with the preceding <namespace> element to determine which header blocks in a SOAP message should be processed by the header processing program. The <localname> contains the element name of the header block.

   For example, consider this header block:

   ```
   <t:myheaderblock xmlns:t="http://mynamespace" ...> .... </t:myheaderblock>
   ```

   - The namespace name is http://mynamespace
   - The element name is myheaderblock

   To make a header program match this header block, code the <namespace> and <localname> elements like this:

   ```
   <namespace>http://mynamespace</namespace>
   <localname>myheaderblock</localname>
   ```

   You can code an asterisk (*) in the <localname> element to indicate that all header blocks in the namespace whose names begin with a given character string should be processed. For example:

```
<namespace>http://mynamespace</namespace>
<localname>myhead*</localname>
```

When you use the asterisk in the <localname> element, a header in a message can match more than one <headerprogram> element. For example, this header block

```
<t:myheaderblock xmlns:t="http://mynamespace" ...> .... </myheaderblock>
```

matches all the following <headerprogram> elements:

```
<headerprogram>
  <program_name>HDRPROG1</program_name>
  <namespace>http://mynamespace</namespace>
  <localname>*</localname>
  <mandatory>false</mandatory>
</headerprogram>
<headerprogram>
  <program_name>HDRPROG2</program_name>
  <namespace>http://mynamespace</namespace>
  <localname>myhead*</localname>
  <mandatory>false</mandatory>
</headerprogram>
<headerprogram>
  <program_name>HDRPROG3</program_name>
  <namespace>http://mynamespace</namespace>
  <localname>myheaderblock</localname>
  <mandatory>false</mandatory>
</headerprogram>
```

When this is the case, the header program that runs is the one specified in the <headerprogram> element in which the element name of the header block is most precisely stated. In the example, that is HDRPROG3.

When the SOAP message contains more than one header, the header processing program is invoked once for each matching header, but the sequence in which the headers are processed is undefined.

If you code two or more <headerprogram> elements that contain the same <namespace> and <localname>, but that specify different header programs, only one of the header programs will be called to process the header. The header will be passed in the DFHHEADER container to the selected program. The other header programs will not be called unless they are defined with<mandatory>true</mandatory> in which case they will be called without having the header passed in the DFHHEADER container.

4. A <mandatory> element, containing an XML boolean value (true or false). Alternatively, you can code the values as 1 or 0 respectively.

true

During service request processing in a service provider pipeline, and service response processing in a service requester pipeline, the header processing program is to be invoked at least once, even if none of the headers in the SOAP messages matches the <namespace> and <localname> elements:

- If none of the headers matches, the header processing program is invoked once.
- If any of the headers match, the header processing program is invoked once for each matching header.

During service request processing in a service requester pipeline, and service response processing in a service provider pipeline, the header processing program is to be invoked at least once, even though the SOAP message that CICS creates has no headers initially. If you want to add headers to your message, you must ensure that at least one header processing program is invoked, by specifying <mandatory>true</mandatory> or <mandatory>1</mandatory>.

false
The header processing program is to be invoked only if one or more of the headers in the SOAP messages matches the <namespace> and <localname> elements:

- If none of the headers matches, the header processing program is not invoked.
- If any of the headers match, the header processing program is invoked once for each matching header.

Example

```
<cics_soap_1.1_handler>
  <headerprogram>
    <program_name> ... </program_name>
    <namespace>...</namespace>
    <localname>...</localname>
    <mandatory>true</mandatory>
  </headerprogram>
</cics_soap_1.1_handler>
```

The <cics_soap_1.2_handler> element

Defines the attributes of the CICS-supplied SOAP 1.2 message handler program.

Used in:

- Service requester
- Service provider

Contained by:

<service_handler_list> element

<terminal_handler> element

Contains:

Zero, one, or more <headerprogram> elements. Each <headerprogram> contains:

1. A <program_name> element, containing the name of a header processing program
2. A <namespace> element, which is used with the following <localname> element to determine which header blocks in a SOAP message should be processed by the header processing program. The <namespace> element contains the URI (Universal Resource Identifier) of the header block's namespace.
3. A <localname> element, which is used with the preceding <namespace> element to determine which header blocks in a SOAP message should be processed by the header processing program. The <localname> contains the element name of the header block.

   For example, consider this header block:

   ```
   <t:myheaderblock xmlns:t="http://mynamespace" ...> .... </t:myheaderblock>
   ```

   - The namespace name is http://mynamespace
   - The element name is myheaderblock

   To make a header program match this header block, code the <namespace> and <localname> elements like this:

```
<namespace>http://mynamespace</namespace>
<localname>myheaderblock</localname>
```

You can code an asterisk (`*`) in the `<localname>` element to indicate that all header blocks in the namespace whose names begin with a given character string should be processed. For example:

```
<namespace>http://mynamespace</namespace>
<localname>myhead*</localname>
```

When you use the asterisk in the `<localname>` element, a header in a message can match more than one `<headerprogram>` element. For example, this header block

```
<t:myheaderblock xmlns:t="http://mynamespace" ...> .... </myheaderblock>
```

matches all the following `<headerprogram>` elements:

```
<headerprogram>
  <program_name>HDRPROG1</program_name>
  <namespace>http://mynamespace</namespace>
  <localname>*</localname>
  <mandatory>false</mandatory>
</headerprogram>
<headerprogram>
  <program_name>HDRPROG2</program_name>
  <namespace>http://mynamespace</namespace>
  <localname>myhead*</localname>
  <mandatory>false</mandatory>
</headerprogram>
<headerprogram>
  <program_name>HDRPROG3</program_name>
  <namespace>http://mynamespace</namespace>
  <localname>myheaderblock</localname>
  <mandatory>false</mandatory>
</headerprogram>
```

When this is the case, the header program that runs is the one specified in the `<headerprogram>` element in which the element name of the header block is most precisely stated. In the example, that is HDRPROG3.

When the SOAP message contains more than one header, the header processing program is invoked once for each matching header, but the sequence in which the headers are processed is undefined.

If you code two or more `<headerprogram>` elements that contain the same `<namespace>` and `<localname>`, but that specify different header programs, only one of the header programs will be called to process the header. The header will be passed in the DFHHEADER container to the selected program. The other header programs will not be called unless they are defined with`<mandatory>true</mandatory>` in which case they will be called without having the header passed in the DFHHEADER container.

4. A `<mandatory>` element, containing an XML boolean value (`true` or `false`). Alternatively, you can code the values as `1` or `0` respectively.

   true

   During service request processing in a service provider pipeline, and service response processing in a service requester pipeline, the header processing program is to be invoked at least once, even if none of the headers in the SOAP messages matches the `<namespace>` and `<localname>` elements:

   - If none of the headers matches, the header processing program is invoked once.
   - If any of the headers match, the header processing program is invoked once for each matching header.

During service request processing in a service requester pipeline, and service response processing in a service provider pipeline, the header processing program is to be invoked at least once, even though the SOAP message that CICS creates has no headers initially. If you want to add headers to your message, you must ensure that at least one header processing program is invoked, by specifying `<mandatory>true</mandatory>` or `<mandatory>1</mandatory>`.

false
The header processing program is to be invoked only if one or more of the headers in the SOAP messages matches the `<namespace>` and `<localname>` elements:

- If none of the headers matches, the header processing program is not invoked.
- If any of the headers match, the header processing program is invoked once for each matching header.

Example

```
<cics_soap_1.2_handler>
  <headerprogram>
    <program_name> ... </program_name>
    <namespace>...</namespace>
    <localname>...</localname>
    <mandatory>true</mandatory>
  </headerprogram>
</cics_soap_1.2_handler>
```

The <default_http_transport_handler_list> element

Specifies the message handlers that are invoked by default when the HTTP transport is in use.

In a service provider, message handlers specified in this list are invoked only if the list of handlers defined in a `<named_transport_entry>` element is less specific.

Used in:

- Service provider
- Service requester

Contained by:

- `<transport>` element

Contains:

- One or more `<handler>` elements.

Example

```
<default_http_transport_handler_list>
  <handler>
    ...
  </handler>
  <handler>
    ...
  </handler>
</default_http_transport_handler_list>
```

The <default_mq_transport_handler_list> element

Specifies the message handlers that are invoked by default when the WebSphere MQ transport is in use.

In a service provider, message handlers specified in this list are invoked only if the list of handlers defined in a `<named_transport_entry>` element is less specific.

Used in:

- Service provider
- Service requester

Contained by:

- `<transport>` element

Contains:

- One or more `<handler>` elements.

Example

```
<default_mq_transport_handler_list>
  <handler>
    ...
  </handler>
  <handler>
    ...
  </handler>
</default_mq_transport_handler_list>
```

The `<default_transport_handler_list>` element

Specifies the message handlers that are invoked by default when any transport is in use.

In a service provider, message handlers specified in this list are invoked when the list of handlers defined in any of the following elements is less specific:

`<default_http_transport_handler_list>`

`<default_mq_transport_handler_list>`

`<named_transport_entry>`

Used in:

- Service provider
- Service requester

Contained by:

- `<transport>` element

Contains:

- One or more `<handler>` elements.

Example

```
<default_transport_handler_list>
  <handler>
     <program>HANDLER1</program>
     <handler_parameter_list/>
  </handler>
  <handler>
     <program>HANDLER2</program>
     <handler_parameter_list/>
  </handler>
</default_transport_handler_list>
```

The <handler> element

Defines the attributes of a message handler program.

Some CICS-supplied handler programs do not use the <handler> element. For example, the CICS-supplied SOAP message handler programs are defined using the <cics_soap_1.1_handler> and <cics_soap_1.2_handler> elements.

Used in:

- Service provider
- Service requester

Contained by:

<default_transport_handler_list>

<transport_handler_list>

<service_handler_list>

<terminal_handler>

<default_http_transport_handler_list>

<default_mq_transport_handler_list>

Contains:

1. <program> element, containing the name of the handler program
2. <handler_parameter_list> element, containing XML elements that are made available to the message handlers in container DFH-HANDLERPLIST.

Example

```
<?xml version="1.0"?>
<provider_pipeline>
        xmlns="http://www.ibm.com/software/htp/cics/pipeline">
 <service>
  <service_handler_list>
   <handler>
     <program>MYPROG</program>
     <handler_parameter_list><output print="yes"/></handler_parameter_list>
   </handler>
  </service_handler_list>
  <terminal_handler>
   <cics_soap_1.1_handler>
    ...
   </cics_soap_1.1_handler>
  </terminal_handler>
 </service
 <apphandler>DFHPITP</apphandler>
</provider_pipeline>
```

In this example, the handler program is MYPROG. The handler parameter list consists of a single <output> element; the contents of the parameter list are known to MYPROG.

The <service> element

Specifies the message handlers that are invoked for every request.

Used in:

- Service provider
- Service requester

Contained by:

<provider_pipeline>

<requester_pipeline>

Contains:

1. <service_handler_list> element
2. In a service provider only, a <terminal_handler> element

Example

```
<service>
  <service_handler_list>
  ...
  </service_handler_list>
  <terminal_handler>
  ...
  </terminal_handler>
</service>
```

The <service_handler_list> element

Specifies a list of message handlers that are invoked for every request.

Used in:

- Service provider
- Service requester

Contained by:

- <service> element

Contains:

One or more of the following elements:

<handler>

<cics_soap_1.1_handler>

<cics_soap_1.2_handler>

<wsse_handler>

You determine the order that each handler is called at run time by the order that you specify the handler elements in the <service_handler_list> element. For example, if your pipeline supports WS-Security, encrypted SOAP messages remain encrypted until the <wsse_handler> element is called. Therefore, you must specify the <wsse_handler> element before any other handler program that processes unencrypted messages.

You should not define <cics_soap_1.1_handler> and <cics_soap_1.2_handler> elements in the same pipeline.

If you expect your service provider pipeline to process both SOAP 1.1 and SOAP 1.2 messages, you should use the CICS-supplied SOAP 1.2 message handler. This supports both SOAP 1.1 and SOAP 1.2 messages.

You can use either a SOAP 1.1 or a SOAP 1.2 handler in a service requester pipeline, but in this case the SOAP 1.2 handler does not support SOAP 1.1 messages. Do not specify the SOAP 1.1 or SOAP 1.2 handler in the pipeline if your service requester applications are sending complete SOAP envelopes in the DFHREQUEST container. This avoids duplicating the SOAP message headers in outbound messages.

Remember: In a service provider, you can specify the generic handler and SOAP handlers in the `<terminal_handler>` element as well as in the `<service_handler_list>` element.

Example

```
<service_handler_list>
  <wsse_handler>
    ...
  </wsse_handler>
 <cics_soap_1.1_handler_java>
    ...
 </cics_soap_1.1_handler_java>
 <handler>
    ...
 </handler>
</service_handler_list>
```

The `<service_parameter_list>` element

An optional element containing XML elements that are made available to all the message handlers in the pipeline in container DFH-SERVICEPLIST.

Used in:

- Service requester
- Service provider

Contains:

- If you are using WS-AT: a `<registration_service_endpoint>` element
- In a service requester if you are using WS-AT: an optional `<new_tx_context_required/>` element
- Optional user defined tags

Example

```
<requester_pipeline>
 <service_parameter_list>
  <registration_service_endpoint>
  http://provider.example.com:7160/cicswsat/RegistrationService
  </registration_service_endpoint>
  <new_tx_context_required/>
  <user_defined_tag1>
  ...
  </user_defined_tag1>
 </service_parameter_list>
</requester_pipeline>
```

Related reference

"The `<requester_pipeline>` element" on page 68
The root element of the XML document that describes the configuration of a pipeline in a service requester.

"The `<provider_pipeline>` element" on page 66
The root element of the XML document that describes the configuration of the CICS pipeline for a Web service provider.

The `<transport>` element

Specifies handlers that are to be invoked only when a particular transport is in use.

Used in:

- Service provider
- Service requester

Contained by:

`<provider_pipeline>`

`<requester_pipeline>`

Contains:

In a service provider:

1. An optional `<default_transport_handler_list>` element
2. An optional `<default_http_transport_handler_list>` element
3. An optional `<default_mq_transport_handler_list>` element
4. Zero, one, or more `<named_transport_entry>` elements

In a service requester:

1. An optional `<default_target>` element. The `<default_target>` contains a URI that CICS uses to locate the target Web service when the service requester application does not provide a URI. In many cases, however, the URI of the target will be provided by the service requester application, and whatever you specify in the `<default_target>` will be ignored. For example, service provider applications that are deployed using the CICS Web services assistant normally get the URI from the Web service description.
2. An optional `<default_http_transport_handler_list>` element
3. An optional `<default_mq_transport_handler_list>` element
4. An optional `<default_transport_handler_list>` element

Example

```
<transport>
  <default_transport_handler_list>
  ...
  </default_transport_handler_list>
</transport>
```

Pipeline configuration for WS-Security

In order for Web service requester and provider applications to participate in WS-Security protocols, you must configure your pipelines accordingly, by including message handler DFHWSSE, and by providing configuration information for the handler.

A provider pipeline configuration file that uses WS-Security might take the following form:

```
<?xml version="1.0"?>
<provider_pipeline
        xmlns="http://www.ibm.com/software/htp/cics/pipeline">
   <service>
      <service_handler_list>
         <wsse_handler>
            <dfhwsse_configuration version="1">
               <authentication trust="blind" mode="basic"/>
            </dfhwsse_configuration>
         </wsse_handler>
         <handler>
          ...
         </handler>
      </service_handler_list>
      <terminal_handler>
         <cics_soap_1.2_handler/>
     </terminal_handler>
   </service>
   <apphandler>DFHPITP</apphandler>
</provider_pipeline>
```

The <wsse_handler> element

Specifies parameters used by the CICS-supplied message handler that provides support for WS-Security.

Used in:

- Service provider
- Service requester

Contained by:

`<service_handler_list>`

Contains:

- A `<dfhwsse_configuration>` element.

The <dfhwsse_configuration> element

Specifies configuration information for the security handler DFHWSSE1, which provides support for securing Web services.

Used in:

- Service provider
- Service requester

Contained by:

`<wsse_handler>`

Attributes:

Name	Description
version	An integer denoting the version of the configuration information. The only valid value is 1.

Contains:

1. Either of the following elements:
   - An optional `<authentication>` element.
     - In a service requester pipeline, the `<authentication>` element specifies the type of authentication that the security header of outbound SOAP messages will use.
     - In a service provider pipeline, the element specifies whether CICS will use the security tokens in an inbound SOAP message to determine the user ID under which work will be processed.
   - An optional `<sts_authentication>` element.

The `action` attribute on this element specifies what type of request should be sent to the Security Token Service. If the request is to issue an identity token, then CICS uses the values in the nested elements to request an identity token of the specified type.

2. If you specify an `<sts_authentication>` element, you must also specify an `<sts_endpoint>` element.

   When this element is present, CICS uses the URI in the `<endpoint>` element to send a request to the Security Token Service.
3. An optional, empty `<expect_signed_body/>` element.

   The `<expect_signed_body/>` element indicates that the `<body>` of the inbound message must be signed. If the body of an inbound message is not correctly signed, CICS rejects the message with a security fault.
4. An optional, empty `<expect_encrypted_body/>` element.

   The `<expect_encrypted_body/>` element indicates that the `<body>` of the inbound message must be encrypted. If the body of an inbound message is not correctly encrypted, CICS rejects the message with a security fault.
5. An optional `<sign_body>` element.

   If this element is present, CICS will sign the `<body>` of the outbound message, using the algorithm specified in the `<algorithm>` element contained in the `<sign_body>` element.
6. An optional `<encrypt_body>` element.

   If this element is present, CICS will encrypt the `<body>` of the outbound message, using the algorithm specified in the `<algorithm>` element contained in the `<encrypt_body>` element.
7. In provider pipelines only, an optional `<reject_signature/>` element.

   If this element is present, CICS rejects any message that includes a certificate in its header that signs part or all of the message body. A SOAP fault is issued to the Web service requester.
8. In provider pipelines only, an optional `<reject_encryption/>` element.

   If this element is present, CICS rejects any message that is partially or fully encrypted. A SOAP fault is issued to the Web service requester.

Example

```
<dfhwsse_configuration version="1">
  <sts_authentication action="issue">
    <auth_token_type>
      <namespace>http://example.org.tokens</namespace>
      <element>UsernameToken</element>
    </auth_token_type>
    <suppress/>
  </sts_authentication>
  <sts_endpoint>
    <endpoint>https://example.com/SecurityTokenService</endpoint>
  </sts_endpoint>
  <expect_signed_body/>
  <expect_encrypted_body/>
  <sign_body>
    <algorithm>http://www.w3.org/2000/09/xmldsig#rsa-sha1</algorithm>
    <certificate_label>SIGCERT01</certificate_label>
  </sign_body>
  <encrypt_body>
    <algorithm>http://www.w3.org/2001/04/xmlenc#tripledes-cbc</algorithm>
    <certificate_label>ENCCERT02</certificate_label>
  </encrypt_body>
</dfhwsse_configuration>
```

The <authentication> element

Specifies the use of security tokens in the headers of inbound and outbound SOAP messages.

Used in:

- Service provider
- Service requester

Contained by:

`<dfhwsse_configuration>`

Attributes:

Attribute	Description
trust mode	Taken together, the trust and mode attributes specify: • whether asserted identity is used • the combination of security tokens that are used in SOAP messages. Asserted identity allows a trusted user to assert that work should run under an different identity, the *asserted identity*, without the trusted user having the credentials associated with that identity. When asserted identity is used, messages contain a *trust token* and an *identity token*. The trust token is used to check that the sender has the correct permissions to assert identities, and the identity token holds the asserted identity, that is, the user ID under which the request is executed. Use of asserted identity requires that a service provider trusts the requester to make this assertion. In CICS, the trust relationship is established with security manager surrogate definitions: the requesting identity must have the correct authority to start work on behalf of the asserted identity. The allowable combinations of the these attributes, and their meanings, are described in Table 1 and Table 2 on page 82.

Table 1. The **mode** *and* **trust** *attributes in a service requester pipeline*

trust	mode	Meaning
none	none	No credentials are added to the message
	basic	*Invalid combination of attribute values*
	signature	Asserted identity is not used. CICS uses a single X.509 security token which is added to the message, and used to sign the message body. The certificate is identified with the `<certificate_label>` element, and the algorithm is specified in the `<algorithm>` element.
blind	none	*Invalid combination of attribute values*
	basic	Asserted identity is not used. CICS adds an identity token to the message, but does not provide a trust token. The identity token is a username with no password. The user ID placed in the identity token is the contents of the DFHWS-USERID container (which, by default, contains the running task's user ID).
	signature	*Invalid combination of attribute values*

Table 1. The **mode** *and* **trust** *attributes in a service requester pipeline (continued)*

trust	mode	Meaning
basic	(any)	*Invalid combination of attribute values*
signature	none	*Invalid combination of attribute values*
	basic	Asserted identity is used. CICS adds the following tokens to the message: • The trust token is an X.509 security token. • The identity token is a username with no password. The certificate used to sign the identity token and message body is specified by the `<certificate_label>`. The user ID placed in the identity token is the contents of the DFHWS-USERID container (which, by default, contains the running task's user ID).
	signature	*Invalid combination of attribute values*

Table 2. The **mode** *and* **trust** *attributes in a service provider pipeline*

trust	mode	Meaning
none	none	Inbound messages need not contain any credentials, and CICS does not attempt to extract or verify any credentials that are found in a message. However, CICS will check that any signed elements have been correctly signed.
	basic	Inbound messages must contain a username security token with a password. CICS puts the username in the DFHWS-USERID container.
	signature	Inbound messages must contain an X.509 security token that has been used to sign the message body.
blind	none	*Invalid combination of attribute values*
	basic	Inbound messages must contain an identity token, where the identity token contains a user ID and optionally a password. CICS puts the user ID in the DFHWS-USERID container. If no password is included, CICS uses the user ID without verifying it. If a password is included, the security handler DFHWSSE1 verifies it.
	signature	Inbound messages must contain an identity token, where the identity token is the first X.509 certificate in the SOAP message header. The certificate does not need to have signed the message. The security handler extracts the matching user ID and places it in the DFHWS-USERID container.

Table 2. The **mode** *and* **trust** *attributes in a service provider pipeline (continued)*

trust	mode	Meaning
basic	none	*Invalid combination of attribute values*
	basic	Inbound messages must use asserted identity: • The trust token is a username token with a password • The identity token is a second username token without a password. CICS puts this username in container DFHWS-USERID.
	signature	Inbound messages must use asserted identity: • The trust token is a username token with a password • The identity token is an X.509 certificate. CICS puts the user ID associated with the certificate in container DFHWS-USERID.
signature	none	*Invalid combination of attribute values*
	basic	Inbound messages must use asserted identity: • The trust token is an X.509 certificate • The identity token is a username token without a password. CICS puts the username in container DFHWS-USERID. The identity token and the body must be signed with the X.509 certificate.
	signature	Inbound messages must use asserted identity: • The trust token is an X.509 certificate • The identity token is a second X.509 certificate. CICS puts the user ID associated with this certificate in container DFHWS-USERID. The identity token and the body must be signed with the first X.509 certificate (the trust token).

Notes:

1. The combinations of the trust and mode attribute values are checked when the PIPELINE is installed. The installation will fail if the attributes are incorrectly coded.

Contains:

1. An optional, empty `<suppress/>` element.

   If this element is specified in a service provider pipeline, the handler will not attempt to use any security tokens in the message to determine under which user ID the work will run.

   If this element is specified in a service requester pipeline, the handler will not attempt to add to the outbound SOAP message any of the security tokens that are required for authentication.

2. An optional `<algorithm>` element that specifies the URI of the algorithm used to sign the body of the SOAP message. You must specify this element if the combination of trust and mode attribute values indicate that the messages are signed.

   You can specify the following algorithms:

Algorithm	URI
Digital Signature Algorithm with Secure Hash Algorithm 1 (DSA with SHA1)	`http://www.w3.org/2000/09/xmldsig#dsa-sha1`
Rivest-Shamir-Adleman algorithm with Secure Hash Algorithm 1 (RSA with SHA1)	`http://www.w3.org/2000/09/xmldsig#rsa-sha1`

3. An optional `<certificate_label>` element that specifies the label associated with an X.509 digital certificate installed in RACF®. If this element is specified in a service requester pipeline, and the `<suppress>` element is not specified, the certificate is added to the security header in the SOAP message. If you do not specify a `<certificate_label>` element, CICS uses the default certificate in the RACF key ring.

   This element is ignored in a service provider pipeline.

Example

```
<authentication trust="signature" mode="basic">
  <suppress/>
  <certificate_label>AUTHCERT03</certificate_label>
</authentication>
```

The `<sts_authentication>` element

Specifies that a Security Token Service (STS) should be used for authentication and determines what type of request is sent.

Used in:

- Service provider
- Service requester

Contained by:

`<dfhwsse_configuration>`

Attributes:

Name	Description
action	Specifies what type of request CICS should send to the STS when a message is received in the service provider pipeline. Valid values are: **issue** The STS issues an identity token for the SOAP message. **validate** The STS validates the provided identity token and returns whether the token is valid to the security handler. If you do not specify this attribute, CICS assumes that the action is to request an identity token. In a service requester pipeline, you cannot specify this attribute because CICS always requests that the STS issues a token.

Contains:

1. An <auth_token_type> element. This element is required when you specify a <sts_authentication> element in a service requester pipeline and optional in a service provider pipeline.
   - In a service requester pipeline, the <auth_token_type> element indicates the type of token the STS will issue when CICS sends it the user ID contained in the DFHWS-USERID container. The token that CICS receives from the STS is placed in the header of the outbound message.
   - In a service provider pipeline, the <auth_token_type> element is used to determine which identity token CICS takes from the message header and send to the STS to exchange or validate. CICS uses the first identity token of the specified type in the message header. If you do not specify this element, CICS uses the first identity token that it finds in the message header. CICS does not consider the following as identity tokens:
     - wsu:Timestamp
     - xenc:ReferenceList
     - xenc:EncryptedKey
     - ds:Signature
2. In a service provider pipeline only, an optional, empty <suppress/> element. If this element is specified, the handler does not attempt to use any security tokens in the message to determine under which user ID the work will run, including the identity token that is returned by the STS.

Example

The following example shows a service provider pipeline, where the security handler requests a token from the STS.

```
<sts_authentication action="issue">
   <auth_token_type>
      <namespace>http://example.org.tokens</namespace>
      <element>UsernameToken</element>
   </auth_token_type>
   <suppress/>
</sts_authentication>
```

The <auth_token_type> element

Specifies what type of identity token is required.

This element is mandatory when you specify the <sts_authentication> element in a service requester pipeline, and optional in a service provider.

- In a service requester pipeline, the <auth_token_type> element indicates the type of token the STS will issue when CICS sends it the user ID contained in the DFHWS-USERID container. The token that CICS receives from the STS is placed in the header of the outbound message.
- In a service provider pipeline, the <auth_token_type> element is used to determine which identity token CICS takes from the message header and send to the STS to exchange or validate. CICS uses the first identity token of the specified type in the message header. If you do not specify this element, CICS uses the first identity token that it finds in the message header. CICS does not consider the following as identity tokens:
  - wsu:Timestamp
  - xenc:ReferenceList
  - xenc:EncryptedKey

- `ds:Signature`

Used in:

- Service provider
- Service requester

Contained by:

`<sts_authentication>`

Contains:

1. A `<namespace>` element. This element contains the namespace of the token type that should be validated or exchanged.
2. An `<element>` element. This element contains the local name of the token type that should be validated or exchanged.

The values of these elements form the Qname of the token.

Example

```
<auth_token_type>
   <namespace>http://example.org.tokens</namespace>
   <element>UsernameToken</element>
</auth_token_type>
```

The `<sts_endpoint>` element

Specifies the location of the Security Token Service (STS).

Used in:

- Service provider
- Service requester

Contained by:

`<dfhwsse_configuration>`

Contains:

- An `<endpoint>` element. This element contains a URI that points to the location of the Security Token Service (STS) on the network. You are recommended to use SSL or TLS to keep the connection to the STS secure, rather than using HTTP.

  You can also specify a WebSphere MQ endpoint using the JMS format of URI.

Example

In this example, the endpoint is configured to use a secure connection to the STS that is located at the specified URI.

```
<sts_endpoint>
   <endpoint>https://example.com/SecurityTokenService</endpoint>
</sts_endpoint>
```

The `<sign_body>` element

Directs DFHWSSE to sign the body of outbound SOAP messages, and provides information about how the messages are to be signed.

Used in:

- Service provider
- Service requester

Contained by:

<dfhwsse_configuration>

Contains:

1. An <algorithm> element that contains the URI that identifies the algorithm used to sign the body of the SOAP message.

   You can specify the following algorithms:

Algorithm	URI
Digital Signature Algorithm with Secure Hash Algorithm 1 (DSA with SHA1)	http://www.w3.org/2000/09/xmldsig#dsa-sha1
Rivest-Shamir-Adleman algorithm with Secure Hash Algorithm 1 (RSA with SHA1)	http://www.w3.org/2000/09/xmldsig#rsa-sha1

2. A <certificate_label> element that specifies the label associated with a digital certificate installed in RACF. The digital certificate provides the key that is used to sign the message.

Example

```
<sign_body>
 <algorithm>http://www.w3.org/2000/09/xmldsig#rsa-sha1</algorithm>
 <certificate_label>SIGCERT01</certificate_label>
</sign_body>
```

The <encrypt_body> element

Directs DFHWSSE to encrypt the body of outbound SOAP messages, and provides information about how the messages are to be encrypted.

Used in:

- Service provider
- Service requester

Contained by:

<dfhwsse_configuration>

Contains:

1. An <algorithm> element containing the URI that identifies the algorithm used to encrypt the body of the SOAP message.

   You can specify the following algorithms:

Algorithm	URI
Triple Data Encryption Standard algorithm (Triple DES)	http://www.w3.org/2001/04/xmlenc#tripledes-cbc
Advanced Encryption Standard (AES) algorithm with a key length of 128 bits	http://www.w3.org/2001/04/xmlenc#aes128-cbc

Algorithm	URI
Advanced Encryption Standard (AES) algorithm with a key length of 192 bits	`http://www.w3.org/2001/04/xmlenc#aes192-cbc`
Advanced Encryption Standard (AES) algorithm with a key length of 256 bits	`http://www.w3.org/2001/04/xmlenc#aes256-cbc`

2. A `<certificate_label>` element that specifies the label that is associated with a digital certificate in RACF. The digital certificate provides the key that is used to encrypt the message.

Example

```
<encrypt_body>
  <algorithm>http://www.w3.org/2001/04/xmlenc#aes256-cbc</algorithm>
  <certificate_label>ENCCERT02</certificate_label>
</encrypt_body>
```

Pipeline configuration for MTOM/XOP

To enable Web service requester and provider applications to receive and send MIME messages that include binary attachments, you must configure your pipelines accordingly. This enables an MTOM handler to process MIME messages in the pipeline using the configuration options that you have defined.

The `<cics_mtom_handler>` element

Enables the CICS-supplied MTOM handler program, that provides support for MTOM MIME multipart/related messages that contain XOP documents and binary attachments. MTOM support is enabled for all inbound messages that are received in the pipeline, but MTOM support for outbound messages is conditionally enabled subject to further options.

Used in:

- Service provider
- Service requester

Contained by:

`<provider_pipeline>`

`<requester_pipeline>`

In a provider pipeline configuration file, the `<cics_mtom_handler>` element should be defined before the `<transport>` element. At run time, the MTOM handler program needs to unpackage the inbound MTOM message before other handlers including the transport handler process it. It will also then be invoked as the last handler for the response message, to package an MTOM message to send to the Web service requester.

In a requester pipeline configuration file, `<cics_mtom_handler>` element should be defined after the `<transport>` element. At run time, the outbound request message is not converted into MTOM format until all other handlers have processed it. It will then also be invoked as the first handler for the inbound response message to unpackage the MTOM message before other handlers process it and return to the requesting program.

Contains:

<dfhmtom_configuration> element

Default options can be changed using configuration options specified in the <dfhmtom_configuration> element. If you do not want to change the default options, you can use an empty element.

Example

For a provider mode pipeline, you could specify:

```
<provider_pipeline>
    <cics_mtom_handler/>
    <transport>
    ....
    </transport>
    <service>
    ....
    </service>
</provider_pipeline>
```

The <dfhmtom_configuration> element

Specifies configuration information for the CICS-supplied MTOM handler program, which provides support for MIME messages that contain XOP documents and binary attachments. If you do not specify any configuration for MTOM, CICS assumes default values.

Used in:

- Service provider
- Service requester

Contained by:

<cics_mtom_handler>

Attributes:

Name	Description
version	An integer denoting the version of the configuration information. The only valid value is 1.

Contains:

1. An optional <mtom_options> element
2. An optional <xop_options> element
3. An optional <mime_options> element

Example

```
<dfhmtom_configuration version="1">
  <mtom_options send_mtom="same" send_when_no_xop="no"/>
  <xop_options apphandler_supports_xop="yes"/>
  <mime_options content_id_domain="example.org"/>
</dfhmtom_configuration>
```

The <mtom_options> element

Specifies when to use MTOM for outbound SOAP messages.

Used in:

- Service provider
- Service requester

Contained by:

`<dfhmtom_configuration>`

Attributes:

Attribute	Description
send_mtom	Specifies if MTOM should be used to convert the outbound SOAP message into a MIME message: **no** MTOM is not used for outbound SOAP messages. **same** In service provider mode, MTOM is used for SOAP response messages whenever the requester uses MTOM. This is the default value in a service provider pipeline. In service requester mode, specifying this value is the same as when you specify send_mtom="yes". **yes** MTOM is used for all outbound SOAP messages. This is the default value in a service requester pipeline.
send_when_no_xop	Specifies if an MTOM message should be sent, even when there are no binary attachments present in the message. **no** MTOM is only used when binary attachments are being sent with the message. **yes** MTOM is used for all outbound SOAP messages, even when there are no binary attachments to send in the message. This is the default value, and is primarily used as an indicator to the receiving program that the sender supports MTOM/XOP. This attribute can be combined with any of the send_mtom attribute values, but has no effect if you specify `send_mtom="no"`.

Example

```
<provider_pipeline>
 <cics_mtom_handler>
  <dfhmtom_configuration version="1">
    <mtom_options send_mtom="same" send_when_no_xop="no"/>
  </dfhmtom_configuration>
 </cics_mtom_handler>
...
</provider_pipeline>
```

In this provider pipeline example, SOAP messages are converted into MTOM messages only when binary attachments need to be sent with the message and the service requester sent an MTOM message.

The `<xop_options>` element

Specifies whether XOP processing can take place in direct or compatibility mode.

Used in:

- Service provider
- Service requester

Contained by:

```
<dfhmtom_configuration>
```

Attributes:

Attribute	Description
apphandler_supports_xop	In provider mode, specifies if the application handler is capable of handling XOP documents in direct mode: **no** The application handler cannot handle XOP documents directly. This is the default value if the `<apphandler>` element does not specify DFHPITP. Compatibility mode is used in the pipeline to handle any inbound or outbound messages that are received or sent in MTOM format. **yes** The application handler can handle XOP documents. This is the default value if the `<apphandler>` element specifies DFHPITP. Direct mode is used in the pipeline to handle any inbound or outbound messages that are received or sent in MTOM format. This is subject to restrictions at run time. For example, if you have specified WS-Security related elements in the pipeline configuration file, the MTOM handler determines that the pipeline should use compatibility mode rather than direct mode for processing XOP documents. In requester mode, specifies if service requester applications use the CICS Web services support to create and handle XOP documents in direct mode. **no** Service requester applications do not use the CICS Web services support. Specify this value if your requester application links to DFHPIRT to drive the pipeline, and is therefore not capable of creating and handling XOP documents in direct mode. **yes** Service requester applications do use the CICS Web services support. Specify this value if your requester application uses the **EXEC CICS INVOKE WEBSERVICE** command.

Example

```
<provider_pipeline>
 <cics_mtom_handler>
  <dfhmtom_configuration version="1">
    <xop_options apphandler_supports_xop="no"/>
  </dfhmtom_configuration>
 </cics_mtom_handler>
 ...
</provider_pipeline>
```

In this provider pipeline example, inbound MTOM messages and outbound response messages are processed in the pipeline using compatibility mode.

The `<mime_options>` element

Specifies the domain name that should be used when generating MIME content-ID values, that are used to identify binary attachments.

Used in:

- Service provider
- Service requester

Contained by:

`<dfhmtom_configuration>`

Attributes:

Attribute	Description
content_id_domain	The syntax to use is *domain.name*. To conform to Internet standards, the name should be a valid internet host name and should be unique to the CICS system where the pipeline is installed. Note that this is not checked by CICS. If this element is omitted, CICS uses the value `cicsts`.

Example

```
<provider_pipeline>
<dfhmtom_configuration version="1">
  <mime_options content_id_domain="example.org"/>
</dfhmtom_configuration>
...
</provider_pipeline>
```

In this example, references to binary attachments are created using `cid:`*`unique_value`*`@example.org`.

Message handlers

A message handler is a CICS program that is used to process a Web service request during input and to process the response during output. Message handlers use channels and containers to interact with one another and with the system.

The message handler interface lets you perform the following tasks in a message handler program:

- Examine the contents of an XML request or response, without changing it
- Change the contents of an XML request or response
- In a non-terminal message handler, pass an XML request or response to the next message handler in the pipeline
- In a terminal message handler, call an application program, and generate a response
- In the request phase of the pipeline, force a transition to the response phase, by absorbing the request, and generating a response
- Handle errors

Tip: It is advisable to use the CICS-provided SOAP 1.1 and SOAP 1.2 handlers to work with SOAP messages. These handlers let you work directly with the major elements in a SOAP message (the SOAP headers and the SOAP body).

All programs which are used as message handlers are invoked with the same interface: they are invoked with a *channel* which holds a number of containers. The containers can be categorized as:

Control containers

These are essential to the operation of the pipeline. Message handlers can use the control containers to modify the sequence in which subsequent handlers are processed.

Context containers

In some situations, message handler programs need information about the context in which they are invoked. CICS provides this information in a set of *context containers* which are passed to the programs.

Some of the context containers hold information which you can change in your message handler. For example, in a service provider pipeline, you can change the user ID and transaction ID of the target application program by modifying the contents of the appropriate context containers.

User containers

These contain information which one message handler needs to pass to another. The use of user containers is entirely a matter for the message handlers.

Restriction: Do not use names starting with DFH for user containers.

Message handler protocols

Message handlers in a pipeline process request and response messages. The behavior of the handlers is governed by a set of protocols which describe what actions the message handlers can take in a given situation.

Each non-terminal message handler in a pipeline is invoked twice:

1. The first time, it is driven to process a request (an inbound request for a service provider pipeline, an outbound request for a service requester)
2. The second time, it is driven for one of three reasons:
   - to process a response (an outbound response for a service provider pipeline, an inbound response for a service requester)
   - to perform recovery following an error elsewhere in the pipeline
   - to perform any further processing that is required when there is no response.

The terminal message handler in a service provider pipeline is invoked once, to process a request.

Message handlers may be provided in a pipeline for a variety of reasons, and the processing that each handler performs may be very different. In particular:

- Some message handlers do not change the message contents, nor do they change the normal processing sequence of a pipeline
- Some message handlers change the message contents, but do not change the normal processing sequence of a pipeline
- Some message handlers change the processing sequence of a pipeline.

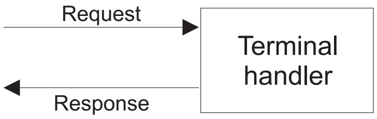
Each handler has a choice of actions that it can perform. The choice depends upon:

- whether the handler is invoked in a service provider or a service requester
- in a service provider, whether the handler is a terminal handler or not
- whether the handler is invoked for a request or a response message.

Terminal handler protocols

Normal request and response

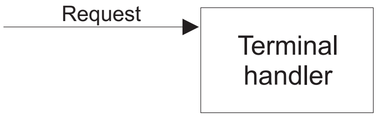
This is the normal protocol for a terminal handler. The handler is invoked for a request message, and constructs a response.



In order to construct the response, a typical terminal handler will link to the target application program, but this is not mandatory.

Normal request, with no response

This is another common protocol for a terminal handler.

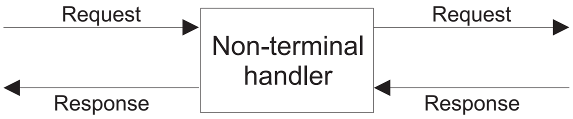


This protocol is usually encountered when the target application determines that there should be no response to the request (although the decision may also be made in the terminal handler).

Non-terminal handler protocols

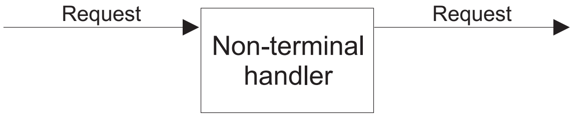
Normal request and response

This is the usual protocol for a non-terminal handler. The handler is invoked for a request message, and again for the response message. In each case, the handler processes the message, and passes it to the next handler in the pipeline.



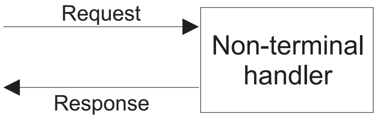
Normal request, no response

This is another common protocol for a non-terminal handler. The handler is invoked for a request message, and after processing it, passes to the next handler in the pipeline. The target application (or another handler) determines that there should be no response. When the handler is invoked for the second time, there is no response message to process.



Handler creates the response

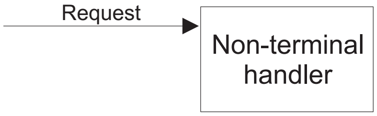
This protocol is typically used in abnormal situations, because the non-terminal handler does not pass the request to the next handler. Instead it constructs a response, and returns it to the pipeline.



This protocol could be used when the handler determines that the request is in some way invalid, and that no further processing of the request should be attempted. In this situation, the handler is **not** invoked a second time.

Handler suppresses the response

This is another protocol that is typically used in abnormal situations, because the non-terminal handler does not pass the request to the next handler. In this protocol, the handler determines that there should be no response to the request.



This protocol could be used when no response is expected to the original request, and, because the request is in some way invalid, no further processing of the request should be attempted.

Supplying your own message handlers

When you want to perform specialized processing on the messages that flow between a service requester and a service provider, and CICS does not supply a message handler that meets your needs, you will need to supply your own.

In most situations, you can perform all the processing you need with the CICS-supplied message handlers. For example, you can use the SOAP 1.1 and 1.2 message handlers which CICS supplies to process SOAP messages. But there are occasions when you will want to perform your own, specialized, operations on Web service requests and responses. To do this, you must supply your own message handlers.

1. Write your message handler program. A message handler is a CICS program with a channel interface. You can write your program in any of the languages which CICS supports, and use any CICS command in the DPL subset within your program.
2. Compile and link-edit your program. Message handler programs normally run under transaction CPIH, which is defined with the attribute `TASKDATALOC(ANY)`. Therefore, when you link-edit the program, you must specify the `AMODE(31)` option.
3. Install the program in your CICS system in the usual way.
4. Define the program in the pipeline configuration file. Use the `<handler>` element to define your message handler. Within the `<handler>` element, code a `<program>` element containing the name of the program.

Working with messages in a non-terminal message handler

A typical non-terminal message handler processes a message, then passes control to another message handler in the pipeline.

In a non-terminal message handler, you can work with a request or response, with or without changing it, and pass it on to the next message handler.

Note: Although Web services typically use SOAP messages which contain XML, your message handlers will work as well with other message formats

1. Using the contents of container DFHFUNCTION, determine if the message passed to this message handler is a request or a response.

DFHFUNCTION	Request or response	Type of message handler	Inbound or outbound
RECEIVE-REQUEST	Request	Non-terminal	Inbound
SEND-RESPONSE	response	Non-terminal	Outbound
SEND-REQUEST	Request	Non-terminal	Outbound
RECEIVE-RESPONSE	response	Non-terminal	Inbound

   Tip:

   - If DFHFUNCTION contains PROCESS-REQUEST, the message handler is a terminal message handler, and these steps do not apply.
   - If DFHFUNCTION contains HANDLER-ERROR, the handler is being called for error processing, and these steps do not apply.
2. Retrieve the request or the response from the appropriate container.
   - If the message is a request, it is passed to the program in container DFHREQUEST. Container DFHRESPONSE is also present, with a length of zero.
   - If the message is a response, it is passed to the program in container DFHRESPONSE.
3. Perform any processing of the message which is required. Depending upon the purpose of the message handler, you might:
   - Examine the message without changing it, and pass it to the next message handler in the pipeline.
   - Change the request, and pass it to the next message handler in the pipeline.
   - If the message is a request, you can bypass the following message handlers in the pipeline, and, instead, construct a response message.

   Note: It is the contents of the containers which a message handler returns that determines which message handler is invoked next. It is an error if a message handler does nothing (that is, it makes no changes to any of the containers passed to it).

Passing a message to the next message handler in the pipeline

In a typical non-terminal message handler, you will process a request or response, with or without changing it, and pass it on to the next message handler.

1. Return the message to the pipeline - changed or unchanged - in the appropriate container.
   - If the message is a request and you have changed it, return it in container DFHREQUEST

   - If the message is a response and you have changed it, put it in container DFHRESPONSE
   - If you have not changed the message, it is already in the appropriate container
2. If the message is a request, delete container DFHRESPONSE. When a message handler is invoked for a request, containers DFHREQUEST and DFHRESPONSE are passed to the program; DFHRESPONSE has a length of zero. However, it is an error to return both DFHREQUEST and DFHRESPONSE.

The message is passed to the next message handler on the pipeline.

Forcing a transition to the response phase of the pipeline

When you are processing a request, there are times when you will want to generate an immediate response, instead of passing the request to the next message handler in the pipeline.

1. Delete container DFHREQUEST.
2. Construct your response, and put it in container DFHRESPONSE.

The response is passed to the next message handler on the response phase of the pipeline.

Suppressing the response

In some situations, you will want to absorb a request without sending a response.

1. Delete container DFHREQUEST.
2. Delete container DFHRESPONSE.

Handling one way messages in a service requester pipeline

When a service requester pipeline sends a request to a service provider, there is normally an expectation that there will be a response, and that, following the sending of the request, the message handlers in the pipeline will be invoked again when the response arrives. Some Web services do not send a response, and so you must take special action to indicate that CICS should not wait for a response before invoking the message handlers for a second time.

To do this, ensure that container DFHNORESPONSE is present at the end of pipeline processing in the request phase. Typically, this is done by application level code, because the knowledge of whether a response is expected is lodged in the application:

- For applications deployed with the CICS Web services assistant, CICS code will create the container.
- Applications that are not deployed with the assistant will typically create the container before invoking the application.

If you create or destroy container DFHNORESPONSE in a message handler, you must be sure that doing so will not disturb the message protocol between the service requester and the provider.

Working with messages in a terminal message handler

A typical terminal handler processes a request, invokes an application program, and generates a response.

Note: Although Web services typically use SOAP messages which contain XML, your message handlers will work as well with other message formats

In a terminal message handler, you can work with a request, and - optionally - generate a response and pass it back along the pipeline. A typical terminal handler will use the request as input to an application program, and use the application program's response to construct the response.

1. Using the contents of container DFHFUNCTION, determine that the message passed to this handler is a request, and that the handler is being called as a terminal handler.

DFHFUNCTION	Request or response	Type of handler	Inbound or outbound
PROCESS-REQUEST	Request	Terminal	Inbound

   Tip:

   - If DFHFUNCTION contains any other value, the handler is not a terminal handler, and these steps do not apply.

2. Retrieve the request from container DFHREQUEST. Container DFHRESPONSE is also present, with a length of zero.
3. Perform any processing of the message which is required. Typically, a terminal handler will invoke an application program.
4. Construct your response, and put it in container DFHRESPONSE. If there is no response, you must delete container DFHRESPONSE.

The response is passed to the next handler in the response phase of the pipeline. The handler is invoked for function SEND-RESPONSE. If there is no response, the next handler is invoked for function NO-RESPONSE.

Handling errors

Message handlers should be designed to handle errors that may occur in the pipeline.

When an error occurs in a message handler program, the program is invoked again for error processing. Error processing always takes place in the response phase of the pipeline; if the error occurred in the request phase, subsequent handlers in the request phase are bypassed.

In most cases, therefore, you should write your handler program to handle any errors that may occur.

1. Check that container DFHFUNCTION contains HANDLER-ERROR, indicating that the message handler has been called for error processing.

   Tip:

   - If DFHFUNCTION contains any other value, the message handler has not been invoked for error processing, and these steps do not apply.

2. Analyze the error information, and determine if the message handler can recover from the error by constructing a suitable response.

   Container DFHERROR holds information about the error. For detailed information about this container, see "Container DFHERROR" on page 106.

   Container DFHRESPONSE is also present, with a length of zero.

3. Perform any recovery processing.
   - If the message handler can recover, construct a response, and return it in container DFHRESPONSE.

- If the message handler can recover, but no response is required, delete container DFHRESPONSE, and return container DFHNORESPONSE instead.
- If the message handler cannot recover, return container DFHRESPONSE unchanged (that is, with a length of zero).

If your message handler is able to recover from the error, pipeline processing continues normally. If not, CICS generates a SOAP fault that contains information about the error. In the case of a transaction abend, the abend code is included in the fault.

The message handler interface

The CICS pipeline links to the message handlers using a channel containing a number of containers. Some containers are optional, others are required by all message handlers, and others are used by some message handlers, and not by others.

Before a handler is invoked, some or all of the containers are populated with information which the handler can use to perform its work. The containers returned by the handler determine the subsequent processing, and are passed on to later handlers in the pipeline.

The SOAP message handlers

The SOAP message handlers are CICS-provided message handlers that you can include in your pipeline to process SOAP 1.1 and SOAP 1.2 messages. You can use the SOAP message handlers in a service requester or in a service provider pipeline.

On input , the SOAP message handlers parse inbound SOAP messages, and extract the SOAP `<Body>` element for use by your application program. On output, the handlers construct the complete SOAP message, using the `<Body>` element which your application provides.

If you use SOAP headers in your messages, the SOAP handlers can invoke user-written header processing programs that allow you to process the headers on inbound messages, and to add them to outbound messages.

SOAP message handlers, and any header processing programs, are specified in the pipeline configuration file, using the `<cics_soap_1.1_handler>` and the `<cics_soap_1.2_handler>` elements, and their sub-elements.

Typically, you will need just one SOAP handler in a pipeline. However, there are some situations where more than one is needed. For example, you can ensure that SOAP headers are processed in a particular sequence by defining multiple SOAP handlers.

Header processing programs

Header processing programs are user-written CICS programs that are linked to from the CICS-provided SOAP 1.1 and SOAP 1.2 message handlers, in order to process SOAP header blocks.

You can write your header processing program in any of the languages that CICS supports, and use any CICS command in the DPL subset. Your header processing program can link to other CICS programs.

The header processing programs have a channel interface; the containers hold information which the header program can examine or modify, including:

The SOAP header block for which the program is invoked

The SOAP message body

This interface and the containers that the header processing program can use are described in "The header processing program interface" on page 101.

Other containers hold information about the environment in which the header program is invoked, such as:

The transaction ID under which the header program was invoked

Whether the program was invoked for a service provider or requester pipeline

Whether the message being processed is a request or response

Header processing programs normally run under transaction CPIH, which is defined with the attribute `TASKDATALOC(ANY)`. Therefore, when you link-edit the program, you must specify the `AMODE(31)` option.

How header processing programs are invoked for a SOAP request

The `<cics_soap_1.1_ handler>` and `<cics_soap_1.2_ handler>` elements in a pipeline configuration contain zero, one, or more, `<headerprogram>` elements, each of which contains the following children:

`<program_name>`

`<namespace>`

`<localname>`

`<mandatory>`

When a pipeline is processing an inbound SOAP message (a request in the case of a service provider, a response in the case of a service requester), the header program specified in the `<program_name>` element is invoked or not, depending upon:

- The contents of the `<namespace>`, `<localname>`, and `<mandatory>` elements
- The value of certain attributes of the root element of the SOAP header itself (the **actor** attribute for SOAP 1.1; the **role** attribute for SOAP 1.2)

The following rules determine if the header program will be invoked in a given case:

The `<mandatory>` element in the pipeline configuration file

If the element contains `true` (or `1`), the header processing program is invoked at least once, even if none of the headers in the SOAP message is selected for processing by the remaining rules:

- If none of the header blocks is selected, the header processing program is invoked once.
- If any of the header blocks is selected by the remaining rules, the header processing program is invoked once for each selected header.

Attributes in the SOAP header block

For SOAP 1.1, a header block is eligible for processing only if the **actor** attribute is absent, or has a value of `http://schemas.xmlsoap.org/soap/actor/next`

For SOAP 1.2, a header block is eligible for processing only if the **role** attribute is absent, or has one of the following values:

```
http://www.w3.org/2003/05/soap-envelope/role/next
http://www.w3.org/2003/05/soap-envelope/role/ultimateReceiver
```

A header block that is eligible for processing is not processed unless it is selected by the next rule.

The `<namespace>` and `<localname>` elements in the pipeline configuration file

A header block that is eligible for processing according to the previous rule is selected for processing only if:

- the name of the root element of the header block matches the `<localname>` element in the pipeline configuration file
- *and* the root element's namespace matches the `<namespace>` element in the pipeline configuration file

For example, consider this header block:

```
<t:myheaderblock xmlns:t="http://mynamespace" ...> .... </t:myheaderblock>
```

Subject to the other rules, the header block will be selected for processing when the following is coded in the pipeline configuration file:

```
<namespace>http://mynamespace</namespace>
<localname>myheaderblock</localname>
```

The `<localname>` can contain an `*` to indicate that all header blocks in the namespace should be processed. Therefore, the same header block will be selected by the following:

```
<namespace>http://mynamespace</namespace>
<localname>*</localname>
```

When the SOAP message contains more than one header, the header processing program is invoked once for each matching header, but the sequence in which the headers are processed is undefined.

The CICS-provided SOAP message handlers select the header processing programs that will be invoked based upon the header blocks that are present in the SOAP message at the time when the message handler receives it. Therefore, a header processing program is never invoked as a result of a header block that is added to a message in the same SOAP message handler. If you want to process the new header (or any modified headers) in your pipeline, you must define another SOAP message handler in your pipeline.

For an outbound message (a request in a service requester, a response in a service provider) the CICS-provided SOAP message handlers create a SOAP message that does not contain any headers. In order to add one or more headers to the message, you must write a header handler program to add the headers. To ensure that this header handler is invoked, you must define it in your pipeline configuration file, and specify `<mandatory>true</mandatory>`.

If a header handler is invoked in the request phase of a pipeline, it will be invoked again in the response phase, even if the message that flows in the response phase does not contain a matching header.

The header processing program interface

The CICS-provided SOAP 1.1 and SOAP 1.2 message handlers link to the header processing programs using channel DFHHHC-V1. The containers that are passed on the channel include several that are specific to the header processing program interface, and sets of *context containers* and *user containers* that are accessible to all the header processing programs and message handler programs in the pipeline.

Container DFHHEADER is specific to the header processing program interface. Other containers are available elsewhere in your pipeline, but have specific uses in a header processing program. The containers in this category are:

DFHWS-XMLNS

DFHWS-BODY

Container DFHHEADER

When the header processing program is invoked, DFHHEADER contains the single header block which caused the header processing program to be driven. When the header program is specified with `<mandatory>true</mandatory>` or `<mandatory>1</mandatory>` in the pipeline configuration file, it is be invoked even when there is no matching header block in the SOAP message. In this case, container DFHHEADER has a length of zero. This will be the case when a header processing program is invoked to add a header block to a SOAP message that does not have header blocks.

The SOAP message that CICS creates has no headers initially. If you want to add headers to your message, you must ensure that at least one header processing program is invoked, by specifying `<mandatory>true</mandatory>` or `<mandatory>1</mandatory>`.

When the header program returns, container DFHHEADER must contain zero, one, or more header blocks which CICS inserts in the SOAP message in place of the original:

- You can return the original header block unchanged.
- You can modify the contents of the header block.
- You can append one or more new header blocks to the original block.
- You can replace the original header block with one or more different blocks.
- You can delete the header block completely.

Container DFHWS-XMLNS

When the header processing program is invoked, DFHWS-XMLNS contains information about XML namespaces that are declared in the SOAP envelope. The header program can use this information:

- to resolve qualified names that it encounters in the header block
- to construct qualified names in new or modified header blocks.

The namespace information consists of a list of namespace declarations, which use the standard XML notation for declaring namespaces. The namespace declarations in DFHWS-XMLNS are separated by spaces. For example:

```
xmlns:na='http://abc.example.org/schema' xmlns:nx='http://xyz.example.org/schema'
```

You can add further namespace declarations to the SOAP envelope by appending them to the contents of DFHWS-XMLNS. However, namespaces whose scope is a SOAP header block or a SOAP body are best declared in the header block or the body respectively. You are advised not to delete namespace declarations from container DFHWS-XMLNS in a header processing program, because XML elements which are not visible in the program may rely on them.

Container DFHWS-BODY

Contains the body section of the SOAP envelope. The header processing program can modify the contents.

When the header processing program is invoked, DFHWS-BODY contains the SOAP `<Body>` element.

When the header program returns, container DFHWS-BODY must again contain a valid SOAP `<Body>`, which CICS inserts in the SOAP message in place of the original:

- You can return the original body unchanged.
- You can modify the contents of the body.

You must not delete the SOAP body completely, as every SOAP message must contain a `<Body>` element.

Context containers and user containers

As well as the containers described, the interface passes the *control containers*, *context containers*, and *user containers* on channel DFHHHC-V1.

For more information about these containers, see “Containers used in the pipeline” on page 105.

The SOAP handler interfaces

The SOAP handler has two interfaces with user-written programs: the header processing program interface, which passes information between the SOAP handler and a header processing program; and the application interface, which passes information between the SOAP handler and the target application.

The application interface

The application interface is a channel that is passed between a SOAP handler and the target application program when it is invoked with a channel interface. When the target is invoked with a COMMAREA interface, the channel is not available to the target application program..

The channel (named DFHAHC-V1) used by the application interface passes the following containers:

DFHWS-XMLNS

Contains a list of name-value pairs that map namespace prefixes to namespaces.

- On input, the list contains the namespaces that are in scope from the SOAP envelope.
- On output, the list contains the namespace data that is assumed to be in the envelope tag.

DFHWS-BODY

Contains the body section of the SOAP envelope. Typically, the application will modify the contents. If the application does not modify the contents, the application handler program must update the contents of this container, even if it's putting the same content back into the container before returning to the terminal handler.

DFHNORESPONSE

In the request phase of a service requester pipeline, indicates that the service provider is not expected to return a response. The contents of container DFHNORESPONSE are undefined; message handlers that need to know if the service provider is expected to return a response need only determine if the container is present or not:

- If container DFHNORESPONSE is present, then no response is expected.
- If container DFHNORESPONSE is absent, then a response **is** expected.

The channel also passes all the context containers that were passed to the calling message handler. A header processing program may add containers to the channel; the added containers are passed as user containers to the next handler in the pipeline.

Dynamic routing of inbound requests in a terminal handler

When the terminal handler of a service provider pipeline is one of the CICS-supplied SOAP message handlers, the target application handler program specified in container DFHWS-APPHANDLER is, in some cases, eligible for dynamic routing. All pipeline processing prior to the application handler program is always performed locally in the CICS region that received the SOAP message.

The transaction that runs the target application handler program is eligible for routing when one of the following is true:

- The transaction under which the pipeline is processing the message is defined as DYNAMIC or REMOTE. This transaction is defined in the URIMAP that is used to map the URI from the inbound SOAP message.
- A program in the pipeline has changed the contents of container DFHWS-USERID from its initial value.
- A program in the pipeline has changed the contents of container DFHWS-TRANID from its initial value.
- A WS-AT SOAP header exists in the inbound SOAP message.

In all of the above scenarios, a task switch occurs during the pipeline processing. The second task runs under the transaction specified in the DFHWS-TRANID container. This task switch provides an opportunity for dynamic routing to take place, but only if MRO is used to connect the CICS regions together. In addition, the CICS region that you are routing to must support channels and containers.

The routing will only take place if the TRANSACTION definition for the transaction named in DFHWS-TRANID specifies one of the following sets of attributes:

DYNAMIC(YES)
The transaction is routed using the distributed routing model, in which the routing program is specified in the **DSRTPGM** system initialization parameter.

DYNAMIC(NO) REMOTESYSTEM(*sysid*)
The transaction is routed to the system identified by *sysid*.

For more information, see the *CICS Customization Guide*.

For applications deployed with the CICS Web services assistant, there is a second opportunity to dynamically route the request, at the point where CICS links to the user's program. At this point, the request is routed using the dynamic routing model, in which the routing program is specified in the **DTRPGM** system initialization parameter. Eligibility for routing is determined, in this case, by the characteristics of the program. If you are using a channel and containers when linking to the program, you can only dynamically route the request to CICS regions that are at V3.1 or higher. If you are using a COMMAREA, this restriction does not apply.

For more information, see the *CICS Customization Guide*.

Containers used in the pipeline

A pipeline typically consists of a number of message handler programs and, when the CICS-supplied SOAP message handlers are used, a number of header processing programs. CICS uses containers to pass information to and from these programs. The programs also use containers to communicate with other programs in the pipeline.

The CICS pipeline links to the message handlers and to the header processing programs using a channel with a number of containers. Some containers are optional, others are required by all message handlers, and others are used by some message handlers, and not by others.

Before a handler is invoked, some or all of the containers are populated with information which the handler can use to perform its work. The containers returned by the handler determine the subsequent processing, and are passed on to later handlers in the pipeline.

The containers can be categorized as:

Control containers
These are essential to the operation of the pipeline. Handlers can use the control containers to modify the sequence in which the handlers are processed. The names of the control containers are defined by CICS, and begin with the characters `DFH`.

Context containers
These contain information about the environment in which the handlers are called. CICS puts information in these containers before it invokes the first message handler, but, in some cases, the handlers are free to change the contents, or delete the containers. Changes to the context containers do not directly affect the sequence in which the handlers are invoked. The names of the context containers are defined by CICS, and begin with the characters `DFH`.

Header processing program containers
These contain information that is used by header processing programs that are invoked from the CICS-supplied SOAP message handlers.

Security containers
These contain information that are used by the Trust client interface and the security message handler to process security tokens using a Security Token Service (STS). The names of the security containers are defined by CICS, and begin with the characters `DFH`.

Generated containers
These contain the data from the SOAP message, such as variable arrays and long strings, that are passed to and from the application program for processing. CICS automatically creates these containers during pipeline processing, and the names begin with the characters `DFH`.

User containers
These contain information which one message handler needs to pass to another. The use of user containers is entirely a matter for the message

handlers. You can choose your own names for these containers, but you must not use names that start with DFH.

The control containers

The control containers are essential to the operation of the pipeline. Handlers can use the control containers to modify the sequence in which the handlers are processed.

Container DFHERROR

DFHERROR is a container of DATATYPE(BIT) that is used to convey information about pipeline errors to other message handlers.

Table 3. Structure of container DFHERROR. All fields in the structure contain character data.

Field name	Length (bytes)	Contents
PIISNEB-MAJOR-VERSION	1	“1”
PIISNEB-MINOR-VERSION	1	“1”
PIISNEB-ERROR-TYPE	1	A numeric value denoting the type of error. The values are described in Table 4.
PIISNEB-ERROR-MODE	1	**P** The error occurred in a provider pipeline **R** The error occurred in a requester pipeline **T** The error occurred in a Trust client
PIISNEB-ABCODE	4	The abend code when the error is associated with a transaction abend.
PIISNEB-ERROR-CONTAINER1	16	The name of the container when the error is associated with a container.
PIISNEB-ERROR-CONTAINER2	16	The name of the second container when the error is associated with more than one container.
PIISNEB-ERROR-NODE	8	The name of the handler program in which the error occurred.

Table 4. Values for field PIISNEB-ERROR-TYPE

Value of PIISNEB-ERROR-TYPE	Meaning
1	The handler program abended. The abend code is in field PIISNEB-ABCODE.
2	A container required by the handler was empty. The name of the container is in field PIISNEB-ERROR-CONTAINER1.

Table 4. Values for field PIISNEB-ERROR-TYPE (continued)

Value of PIISNEB-ERROR-TYPE	Meaning
3	A container required by the handler was missing. The name of the container is in field PIISNEB-ERROR-CONTAINER1.
4	Two containers were passed to the handler when only one was expected. The names of the containers are in fields PIISNEB-ERROR-CONTAINER1 and PIISNEB-ERROR-CONTAINER2.
5	An attempt to link to the target program failed. If target program abended, the abend code is in container PIISNEB-ABCODE.
6	The pipeline manager failed to communicate with a remote server due to an error in the underlying transport.
7	There is an error with the DFHWS-STSACTION container. It is missing, corrupt or contains an invalid value.
8	DFHPIRT failed to start the pipeline.
9	DFHPIRT failed to put a message in a container.
10	DFHPIRT failed to get a message from a container.
11	An unhandled error has occurred.

The COBOL declaration of the container's structure is this:

```
01 PIISNEB.
  02 PIISNEB-MAJOR-VERSION PIC X(1).
  02 PIISNEB-MINOR-VERSION PIC X(1).
  02 PIISNEB-ERROR-TYPE PIC X(1).
  02 PIISNEB-ERROR-MODE PIC X(1).
  02 PIISNEB-ABCODE PIC X(4).
  02 PIISNEB-ERROR-CONTAINER1 PIC X(16).
  02 PIISNEB-ERROR-CONTAINER2 PIC X(16).
  02 PIISNEB-ERROR-NODE PIC X(8).
```

The language copybooks that map the container are:

Table 5.

Language	Copybook
COBOL	DFHPIUCO
PL/I	DFHPIUCL
C and C++	dfhpiuch.h
Assembler	DFHPIUCD

Container DFHFUNCTION

DFHFUNCTION is a container of DATATYPE(CHAR) that contains a 16-character string that indicates where in a pipeline a program is being invoked.

The string has one of the following values. The rightmost character positions are padded with blank characters.

`RECEIVE-REQUEST`
: The handler is a non-terminal handler in a service provider pipeline, and is being invoked to process an inbound request message. On entry to the handler, the message is in control container DFHREQUEST.

`SEND-RESPONSE`
: The handler is a non-terminal handler in a service provider pipeline, and is being invoked to process an outbound response message. On entry to the handler, the message is in control container DFHRESPONSE.

`SEND-REQUEST`
: The handler is being invoked by a pipeline that is sending a request; that is, in a service requester that is processing an outbound message

`RECEIVE-RESPONSE`
: The handler is being invoked by a pipeline that is receiving a response; that is, in a service requester that is processing an inbound message

`PROCESS-REQUEST`
: The handler is being invoked as the terminal handler of a service provider pipeline

`NO-RESPONSE`
: The handler is being invoked after processing a request, when there is no response to be processed.

`HANDLER-ERROR`
: The handler is being invoked because an error has been detected.

In a service provider pipeline that processes a request and returns a response, the values of DFHFUNCTION that occur are `RECEIVE-REQUEST`, `PROCESS-REQUEST`, and `SEND-RESPONSE`. Figure 23 shows the sequence in which the handlers are invoked, and the values of DFHFUNCTION that are passed to each handler.

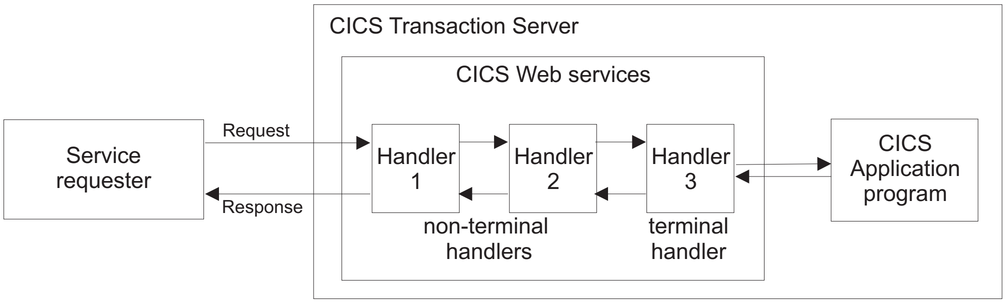


Figure 23. Sequence of handlers in a service provider pipeline

Sequence	Handler	DFHFUNCTION
1	Handler 1	`RECEIVE-REQUEST`
2	Handler 2	`RECEIVE-REQUEST`
3	Handler 3	`PROCESS-REQUEST`
4	Handler 2	`SEND-RESPONSE`
5	Handler 1	`SEND-RESPONSE`

In a service requester pipeline, that sends a request and receives a response, the values of DFHFUNCTION that occur are `SEND-REQUEST` and `RECEIVE-RESPONSE`. Figure 24 on page 109 shows the sequence in which the handlers are invoked, and the values of DFHFUNCTION that are passed to each handler.

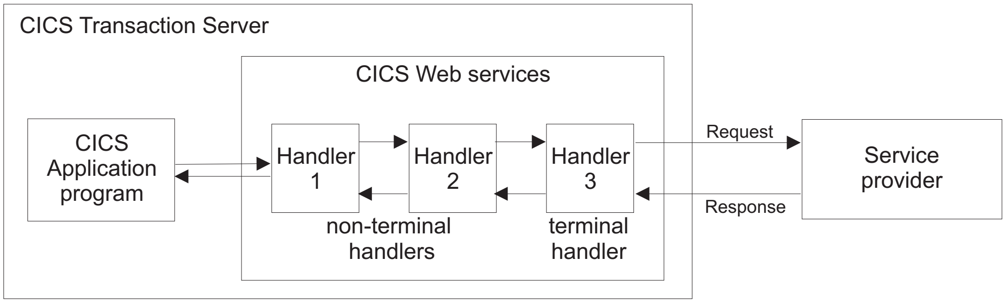


Figure 24. Sequence of handlers in a service requester pipeline

Sequence	Handler	DFHFUNCTION
1	Handler 1	`SEND-REQUEST`
2	Handler 2	`SEND-REQUEST`
3	Handler 3	`SEND-REQUEST`
4	Handler 3	`RECEIVE-RESPONSE`
5	Handler 2	`RECEIVE-RESPONSE`
6	Handler 1	`RECEIVE-RESPONSE`

The values of DFHFUNCTION that can be encountered in a given message handler depends upon whether the pipeline is a provider or requester, whether the pipeline is in the request or response phase, and whether the handler is a terminal handler or a non-terminal handler. The following table summarizes when each value can occur:

Value of DFHFUNCTION	Provider or requester pipeline	Pipeline phase	Terminal or non-terminal handler
`RECEIVE-REQUEST`	Provider	Request phase	Non-terminal
`SEND-RESPONSE`	Provider	Response phase	Non-terminal
`SEND-REQUEST`	Requester	Request phase	Non-terminal
`RECEIVE-RESPONSE`	Requester	Response phase	Non-terminal
`PROCESS-REQUEST`	Provider	Request phase	Terminal
`NO-RESPONSE`	Both	Response phase	Non-terminal
`HANDLER-ERROR`	Both	Both	Both

Container DFHHTTPSTATUS

DFHHTTPSTATUS is a container of `DATATYPE(CHAR)` that is used to specify the HTTP status code and status text for a message produced in the response phase of a service provider pipeline.

The content of the DFHHTTPSTATUS container must be the same as the initial status line of an HTTP response message, which has the following structure:

```
HTTP/1.1 nnn tttttttt
```

`HTTP/1.1`
The version and release of HTTP.

`nnn` The 3-digit decimal HTTP status code to return.

tttttttt
The human-readable status text associated with the status code `nnn`.

The following string is an example of the content:

```
HTTP/1.1 412 Precondition Failed
```

The DFHHTTPSTATUS container is ignored when the pipeline uses the WebSphere MQ transport.

Container DFHMEDIATYPE

DFHMEDIATYPE is a container of `DATATYPE(CHAR)` that is used to specify the media type for a message produced in the response phase of a service provider pipeline.

The content of the DFHMEDIATYPE container must consist of a type and a subtype separated by a slash character. The following strings show two examples of correct content for the DFHMEDIATYPE container:

```
text/plain
```

```
image/svg+xml
```

The DFHMEDIATYPE container is ignored when the pipeline uses the WebSphere MQ transport.

Container DFHNORESPONSE

DFHNORESPONSE is a container of DATATYPE(CHAR) that, in the request phase of a service requester pipeline, indicates that the service provider is not expected to return a response.

The contents of container DFHNORESPONSE are undefined; message handlers that need to know if the service provider is expected to return a response need only determine if the container is present or not:

- If container DFHNORESPONSE is present, then no response is expected.
- If container DFHNORESPONSE is absent, then a response **is** expected.

This information is provided, initially, by the service requester application, based upon the protocol used with the service provider. Therefore, it is inadvisable to delete this container in a message handler (or to create it, if it does not exist), as doing so may disturb the protocol between the end points.

Other than in the request phase of a service requester pipeline, the use of this container is not defined.

Container DFHREQUEST

DFHREQUEST is a container of DATATYPE(CHAR) that contains the request message that is processed in the request phase of a pipeline.

If one of the CICS-supplied SOAP message handlers is configured in the pipeline, the container DFHREQUEST is updated to include the SOAP message headers in the SOAP envelope. If the message is constructed by a CICS-supplied SOAP message handler, and has not been changed subsequently, DFHREQUEST contains a complete SOAP envelope and all of its contents is in the UTF-8 code page.

Container DFHREQUEST is present in the request when a message handler is invoked, and container DFHFUNCTION contains `RECEIVE-REQUEST` or `SEND-REQUEST`.

In this situation, the normal protocol is to return DFHREQUEST to the pipeline with the same or modified contents. Processing of the pipeline's request phase continues normally, with the next message handler program in the pipeline (if there is one).

As an alternative, your message handler can delete container DFHREQUEST, and put a response in container DFHRESPONSE . If you do this, the normal sequence of processing is reversed, and the processing continues with the response phase of the pipeline.

Container DFHRESPONSE

DFHRESPONSE is a container of DATATYPE(CHAR) that contains the response message that is processed in the response phase of a pipeline. If the message was constructed by a CICS-supplied SOAP message handler, and has not been changed subsequently, DFHRESPONSE contains a complete SOAP envelope and all its contents in UTF-8 code page.

Container DFHRESPONSE is present when a message handler is invoked, and container DFHFUNCTION contains `SEND-RESPONSE` or `RECEIVE-RESPONSE`.

In this situation, the normal protocol is to return DFHRESPONSE to the pipeline with the same or modified contents. Pipeline processing continues normally, with the next message handler program in the pipeline (if there is one).

Container DFHRESPONSE is also present (with a length of zero) when DFHFUNCTION contains `RECEIVE-REQUEST`, `SEND-REQUEST`, `PROCESS-REQUEST`, or `HANDLER-ERROR`.

How containers control the pipeline protocols

The contents of the DFHFUNCTION, DFHREQUEST, and DFHRESPONSE containers together control the pipeline protocols.

During the two phases of a pipeline's execution (the request phase and the response phase) the value of DFHFUNCTION determines which control containers are passed to each message handler:

DFHFUNCTION	Context	DFHREQUEST	DFHRESPONSE
RECEIVE-REQUEST	Service provider; request phase	Present (length > 0)	Present (length = 0)
SEND-RESPONSE	Service provider; response phase	Absent	Present (length > 0)
SEND-REQUEST	Service requester; request phase	Present (length > 0)	Present (length = 0)
RECEIVE-RESPONSE	Service requester; response phase	Absent	Present (length > 0)
PROCESS-REQUEST	Service provider; terminal handler	Present (length > 0)	Present (length = 0)
HANDLER-ERROR	Service requester or provider; either phase	Absent	Present (length = 0)
NO-RESPONSE	Service requester or provider; response phase	Absent	Absent

Subsequent processing is determined by which containers your message handler passes back to the pipeline:

During the request phase

- Your message handler can return container DFHREQUEST. Processing continues in the request phase with the next handler. The length of the data in the container must not be zero.
- Your message handler can return container DFHRESPONSE. Processing switches to the response phase, and the same handler is invoked with DFHFUNCTION set to SEND-RESPONSE in a service provider, and RECEIVE-RESPONSE in a service requester. The length of the data in the container must not be zero.
- Your message handler can return no containers. Processing switches to the response phase, and the same handler is invoked with DFHFUNCTION set to NO-RESPONSE.

In the terminal handler (service provider only)

- Your message handler can return container DFHRESPONSE. Processing switches to the response phase, and the previous handler is invoked with a new value of DFHFUNCTION (SEND-RESPONSE). The length of the data in the container must not be zero.
- Your message handler can return no containers. Processing switches to the response phase, and the previous handler is invoked with a new value of DFHFUNCTION (NO-RESPONSE).

During the response phase

- Your message handler can return container DFHRESPONSE. Processing continues in the response phase, and next handler is invoked. The length of the data in the container must not be zero.
- Your message handler can return no containers. Processing continues in the response phase, and the next handler in sequence is invoked with a new value of DFHFUNCTION (NO-RESPONSE).

Important: During the request phase, your message handler can return DFHREQUEST or DFHRESPONSE, but not both. Since both containers are present when your message handler is invoked, you must delete one of them.

This table shows the action taken by the pipeline for all values of DFHFUNCTION and all combinations of DFHREQUEST and DFHRESPONSE returned by each message handler.

DFHFUNCTION	Context	DFHREQUEST	DFHRESPONSE	Action
RECEIVE-REQUEST	Service provider; request phase	Present (length > 0)	Present	(error)
			Absent	Invoke the next handler with function RECEIVE-REQUEST
		Present (length = 0)	Not applicable	(error)
		Absent	Present (length > 0)	Switch to response phase, and invoke the same handler with function SEND-RESPONSE
			Present (length = 0)	(error)
			Absent	Invoke the same handler with function NO-RESPONSE
SEND-RESPONSE	Service provider; response phase	Not applicable	Present (length > 0)	Invoke the previous handler with function SEND-RESPONSE
			Present (length = 0)	(error)
			Absent	Invoke the same handler with function NO-RESPONSE
SEND-REQUEST	Service requester; request phase	Present (length > 0)	Present (length ≥ 0)	(error)
			Absent	Invoke the next handler with function SEND-REQUEST
		Present (length = 0)	Not applicable	(error)
		Absent	Present (length > 0)	Switch to response phase, and invoke the previous handler with function RECEIVE-RESPONSE
			Present (length = 0)	(error)
			Absent	Invoke the same handler with function NO-RESPONSE
RECEIVE-RESPONSE	Service requester; response phase	Not applicable	Present (length > 0)	Invoke the previous handler with function RECEIVE-RESPONSE
			Present (length = 0)	(error)
			Absent	Invoke the same handler with function NO-RESPONSE
PROCESS-REQUEST	Service provider; terminal handler	Not applicable	Present (length > 0)	Invoke the previous handler with function RECEIVE-RESPONSE
			Present (length = 0)	(error)
			Absent	Invoke the same handler with function NO-RESPONSE

DFHFUNCTION	Context	DFHREQUEST	DFHRESPONSE	Action
HANDLER-ERROR	Service requester or provider; either phase	Not applicable	Present (length > 0)	Invoke the previous handler with function SEND-RESPONSE or RECEIVE-RESPONSE
			Present (length = 0)	(error)
			Absent	Invoke the same handler with function NO-RESPONSE

The context containers

In some situations, user-written message handler programs, and header processing programs, need information about the context in which they are invoked. CICS provides this information in a set of *context containers* which are passed to the programs.

CICS initializes the contents of each context container, but, in some cases, you can change the contents in your message handler programs, and header processing program. For example, in a service provider pipeline in which the terminal handler is one of the CICS-provided SOAP handlers, you can change the userid and transaction ID of the target application program by modifying the contents of the appropriate context containers.

Some of the information provided in the containers applies only to a service provider, or only to a service requester, and therefore some of the context containers are not available in both.

Container DFH-HANDLERPLIST

DFH-HANDLERPLIST is a container of DATATYPE(CHAR) that is initialized with the contents of the appropriate `<handler_parameter_list>` element of the pipeline configuration file.

If you have not specified a handler parameter list in the pipeline configuration file, then the container is empty (that is, it has a length of zero).

You cannot change the contents of this container.

Container DFH-SERVICEPLIST

DFH-SERVICEPLIST is a container of DATATYPE(CHAR) that contains the contents of the `<service_parameter_list>` element of the pipeline configuration file.

If you have not specified a service parameter list in the pipeline configuration file, then the container is empty (that is, it has a length of zero).

You cannot change the contents of this container.

Container DFHWS-APPHANDLER

DFHWS-APPHANDLER is a container of DATATYPE(CHAR) that, in a service provider pipeline, is initialized with the contents of the `<apphandler>` element of the pipeline configuration file.

In the terminal handler of the pipeline, the CICS-supplied SOAP handlers get the name of the target application program from this container.

You can change the contents of this container in your message handlers or header processing programs.

CICS does not provide this container in a service requester pipeline.

Container DFHWS-DATA

DFHWS-DATA is a container of DATATYPE(BIT) that is used in service requester applications and optionally in service provider applications that are deployed with the CICS Web services assistant. It holds the top level data structure that is mapped to and from a SOAP request.

In service requester applications, container DFHWS-DATA must be present when the service requester program issues an `EXEC CICS INVOKE WEBSERVICE` command. When the command is issued, CICS converts the data structure that is in the container into a SOAP request. When the SOAP response is received, CICS converts it into another data structure that is returned to the application in the same container.

In service provider applications, container DFHWS-DATA is used by default when you do not specify the `CONTID` parameter on the DFHLS2WS or DFHWS2LS batch jobs. CICS converts the SOAP request message into the data structure that is passed to the application in the DFHWS-DATA container. The response is then saved in the same container, and CICS converts the data structure into a SOAP response message.

Container DFHWS-MEP

DFHWS-MEP is a container of DATATYPE(BIT) that holds a representative value for the message exchange pattern (MEP) of an inbound or outbound SOAP message. This value is one byte in length.

CICS supports four message exchange patterns for both service requesters and service providers. The message exchange pattern is defined in the WSDL 2.0 document for the Web service and determines whether CICS should respond as the provider, and if CICS should expect a response from an external provider. In requester mode, the time that CICS waits for a response is configured using the PIPELINE resource.

If you used the CICS Web services assistant to deploy your application, this container is populated by CICS:

- In a service provider pipeline, this container is populated by the application handler DFHPITP when it receives the inbound message from the terminal handler.
- In a service requester pipeline, this container is populated when the application uses the `INVOKE WEBSERVICE` command.

If the application uses the DFHPIRT channel to start the pipeline, the application is responsible for populating this container. If the container is not present or has no value, CICS assumes that the request is using either the In-Out or In-Only MEP, depending on whether the DFHNORESPONSE container is present in the channel.

Table 6. Values that can appear in container DFHWS-MEP

Value	MEP	URI
1	In-Only	http://www.w3.org/ns/wsdl/in-only
2	In-Out	http://www.w3.org/ns/wsdl/in-out

Table 6. Values that can appear in container DFHWS-MEP (continued)

Value	MEP	URI
4	Robust-In-Only	http://www.w3.org/ns/wsdl/robust-in-only
8	In-Optional-Out	http://www.w3.org/ns/wsdl/in-opt-out

Container DFHWS-OPERATION

DFHWS-OPERATION is a container of DATATYPE(CHAR) that is normally used in a service provider application deployed with the CICS Web services assistant. It holds the name of the operation that is specified in a SOAP request.

In a service provider, the container supplies the name of the operation for which the application is being invoked. It is populated when a CICS-supplied SOAP message handler passes control to the target application program, and is visible only when the target program is invoked with a channel interface.

In a service requester pipeline, the container holds the name specified in the OPERATION option of the EXEC CICS INVOKE WEBSERVICE command. The container is not available to the application that issues the command.

Container DFHWS-PIPELINE

DFHWS-PIPELINE is a container of DATATYPE(CHAR) that contains the name of the PIPELINE in which the program is being run.

You cannot change the contents of this container.

Container DFHWS-RESPWAIT

DFHWS-RESPWAIT is a container of DATATYPE(BIT) that contains an unsigned fullword binary number to represent the timeout in seconds that applies to outbound Web service request messages.

The initial value of this container is based upon the RESPWAIT attribute of the PIPELINE resource, but you can change this value during pipeline processing if appropriate.

This container is used only in requester mode pipelines.

Container DFHWS-SOAPLEVEL

DFHWS-SOAPLEVEL is a container of DATATYPE(BIT) that holds information about the level of SOAP used in the message that you are processing.

The container hold a binary fullword that indicates which level of SOAP is used for a Web service request or response:

1 The request or response is a SOAP 1.1 message.

2 The request or response is a SOAP 1.2 message.

10 The request or response is not a SOAP message.

You cannot change the contents of this container.

Container DFHWS-TRANID

DFHWS-TRANID is a container of DATATYPE(CHAR) that is initialized with the transaction ID of the task in which the pipeline is running.

If you change the contents of this container in a service provider pipeline in which the terminal handler is one of the CICS-supplied SOAP handlers (and you do so before control is passed to the target application program), the target application will execute in a new task with the new transaction ID.

Container DFHWS-URI

DFHWS-URI is a container of DATATYPE(CHAR) that contains the URI of the Web service.

In a service provider pipeline, CICS extracts the relative URI from the incoming message and places it in the DFHWS-URI container. For example, if the URI of the Web services is `http://example.com/location/address` or `jms://queue?destination=INPUT.QUEUE&targetService=/location/address`, then the relative URI is `/location/address`.

In a service requester pipeline, CICS puts the URI that is specified on the **INVOKE WEBSERVICE** command, or if missing the WEBSERVICE resource definition, in the DFHWS-URI container.

Container DFHWS-USERID

DFHWS-USERID is a container of DATATYPE(CHAR) that is initialized with the user ID of the task in which the pipeline is running.

If you change the contents of this container in a service provider pipeline in which the terminal handler is one of the CICS-supplied SOAP handlers (and you do so before control is passed to the target application program), the target application will execute in a new task that is associated with the new userid. Unless you change the contents of container DFHWS-TRANID, the new task has the same transaction ID as the pipeline's task.

Container DFHWS-WEBSERVICE

DFHWS-WEBSERVICE is a container of DATATYPE(CHAR) that is used in a service provider pipeline only. It holds the name of the WEBSERVICE that specifies the execution environment when the target application has been deployed using the Web services assistant.

CICS does not provide this container in a service requester pipeline.

Container DFHWS-CID-DOMAIN

DFHWS-CID-DOMAIN is a container of DATATYPE(CHAR). It contains the domain name that is used to generate content-ID values for referencing binary attachments.

The value of the domain name is `cicsts` by default. You can override the value by specifying the `<mime_options>` element in the pipeline configuration file.

You cannot change the contents of this container.

Container DFHWS-MTOM-IN

DFHWS-MTOM-IN is a container of DATATYPE(BIT) that holds information about the specified options for the `<cics_mtom_handler>` element of the pipeline configuration file, and information about the message format that has been received in the pipeline.

It contains the information to process an inbound MTOM message in the pipeline. The inbound message could be a request message from a Web service requester or a response message from a Web service provider.

If you do not specify a <cics_mtom_handler> element in the pipeline configuration file, or if a SOAP message is received instead of an MTOM message, this container is not created.

If Web services security is configured in the pipeline, or if validation is switched on for a Web service, the contents of field XOP_MODE in DFHWS-MTOM-IN can be overridden by CICS when the container is created. For example, if you configure the pipeline to process the content of MTOM messages in direct mode, and you then switch validation on for the Web service, CICS overrides the defined value in the pipeline configuration file and sets the XOP processing to run in compatibility mode. This is due to the restrictions in support for processing XOP documents and binary attachments in the pipeline.

You cannot change the contents of this container.

Table 7. Structure of container DFHWS-MTOM-IN

Field name	**Length (bytes)**	**Contents**
MTOM_STATUS	4	Contains the value "1", indicating that the message received by CICS is in MTOM format.
MTOMNOXOP_STATUS	4	Contains one of the following values: **0** The MTOM message contains binary attachments. **1** The MTOM message does not contain binary attachments.
XOP_MODE	4	Contains one of the following values: **0** No XOP processing takes place. **1** XOP processing takes place in compatibility mode. **2** XOP processing takes place in direct mode.

Container DFHWS-MTOM-OUT

DFHWS-MTOM-OUT is a container of DATATYPE(BIT) that holds information about the specified options for the <cics_mtom_handler> element of the pipeline configuration file.

It contains the information to process an outbound MTOM message in the pipeline, whether it is a response message for a Web service requester or a request message for a Web service provider.

If you do not specify a <cics_mtom_handler> element in the pipeline configuration file, or if the <mtom_options> element in the pipeline configuration file has the attribute send_mtom="no", this container is not created.

In provider mode, this container is created at the same time as the DFHWS-MTOM-IN container. If the <mtom_options> element in the pipeline configuration file has the attribute send_mtom="same", the MTOM_STATUS field is set to indicate whether the Web service requester wants an MTOM or SOAP response message.

If Web services security is configured in the pipeline, or if validation is switched on for a Web service, the XOP_MODE field of DFHWS-MTOM-OUT can be changed by CICS when the container is created. For example, if you configure the pipeline to process the XOP document and any binary attachments using direct mode, and you then switch validation on for a Web service, CICS overrides the defined value in the pipeline configuration file and sets the XOP processing to run in compatibility mode when it creates the container. This is due to the restrictions in support for processing XOP documents and binary attachments in the pipeline.

You cannot change the contents of this container.

Table 8. Structure of container DFHWS-MTOM-OUT

Field name	**Length (bytes)**	**Contents**
MTOM_STATUS	4	Indicates whether MTOM is enabled: **0** MTOM is not enabled. The outbound message should be sent in SOAP format. **1** MTOM is enabled. The outbound message should be sent in MTOM format
MTOMNOXOP_STATUS	4	Indicates whether to use MTOM when there are no binary attachments: **0** Do not send an MTOM message when there are no binary attachments. **1** Send an MTOM message when there are no binary attachments.
XOP_MODE	4	Indicates what XOP processing should take place: **0** No XOP processing takes place. **1** XOP processing takes place in compatibility mode. **2** XOP processing takes place in direct mode.

Container DFHWS-WSDL-CTX

DFHWS-WSDL-CTX is a container of DATATYPE(CHAR), that is used in either a service provider or a service requester application deployed with the CICS Web services assistant. It holds WSDL context information that can be used for monitoring purposes.

DFHWS-WSDL-CTX holds the following context information for the WSDL document:

- The name and namespace of the operation for which the application is being invoked.
- If known, the name and namespace for the WSDL 1.1 port or WSDL 2.0 endpoint that is being used.

These values are separated by space characters. DFHWS-WSDL-CTX is populated by CICS only at runtime level 2.1 and above.

If you used the CICS Web services assistant to deploy your application, this container is populated by CICS:

- In a service provider pipeline, this container is populated by the application handler DFHPITP when it receives the inbound message from the terminal handler.
- In a service requester pipeline, this container is populated when the application uses the **INVOKE WEBSERVICE** command.

If the application uses the DFHPIRT program to start the pipeline, the application populates the DFHWS-WSDL-CTX container if required.

Container DFHWS-XOP-IN

DFHWS-XOP-IN is a container of DATATYPE(BIT). It contains a list of references to the binary attachments that have been unpackaged from an inbound MIME message and placed in containers using XOP processing.

Each attachment record in the DFHWS-XOP-IN container consists of:

- The 16-byte name of the container that holds the MIME headers.
- The 16-byte name of the container that holds the binary attachment.
- The 2-byte length of the content-ID, in signed halfword binary format.
- The content-ID, including the < and > delimiters, stored as an ASCII character string.

You cannot change the contents of this container.

Container DFHWS-XOP-OUT

DFHWS-XOP-OUT is a container of DATATYPE(BIT). It contains a list of references to the containers that hold binary attachments. The binary attachments are packaged into an outbound MIME message by the MTOM handler program.

Each attachment record in the DFHWS-XOP-OUT container consists of:

- The 16-byte name of the container that holds the MIME headers for the binary attachment.
- The 16-byte name of the container that holds the binary attachment.
- The 2-byte length of the content-ID, in signed halfword binary format.
- The content-ID, including the < and > delimiters, stored as an ASCII character string.

You cannot change the contents of this container.

The security containers

Security containers are used on the DFHWSTC-V1 channel to send and receive identity tokens from a Security Token Service (STS) such as Tivoli Federated Identity Manager. This interface is called the *Trust client interface* and can be used in Web service requester and provider pipelines.

Container DFHWS-IDTOKEN

DFHWS-IDTOKEN is a container of DATATYPE(CHAR). It contains the token that the Security Token Service (STS) should validate or use to issue an identity token for the message.

The token should be in XML format.

This container should only be used with channel DFHWSTC-V1 for the Trust client interface.

Container DFHWS-RESTOKEN

DFHWS-RESTOKEN is a container of DATATYPE(CHAR). It contains the response from the Security Token Service (STS).

The response depends on the action that was requested from the STS in the DFHWS-STSACTION container.

- If the action is issue, this container holds the token that the STS has exchanged for the one that was sent in the DFHWS-IDTOKEN container.
- If the action is validate, this container holds a URI to indicate whether the security token that was sent in the DFHWS-IDTOKEN container is valid or invalid. The URIs that can be returned are:

URI	Description
`http://schemas.xmlsoap.org/ws/2005/02/trust/status/valid`	The security token is valid.
`http://schemas.xmlsoap.org/ws/2005/02/trust/status/invalid`	The security token is invalid.

This container is returned on the channel DFHWSTC-V1 when using the Trust client interface.

Container DFHWS-SERVICEURI

DFHWS-SERVICEURI is a container of DATATYPE(CHAR). It contains the URI that the Security Token Service (STS) should use as the AppliesTo scope.

The AppliesTo scope is used to determine which Web service the security token is associated with.

This container should only be used with channel DFHWSTC-V1 for the Trust client interface.

Container DFHWS-STSACTION

DFHWS-STSACTION is a container of DATATYPE(CHAR). It contains the URI of the action that the Security Token Service (STS) should take to either validate or issue a security token.

The URI values that you can specify in this container are:

URI	Description
`http://schemas.xmlsoap.org/ws/2005/02/trust/Issue`	The STS should issue a token in exchange for the one that is sent in the DFHWS-IDTOKEN container.
`http://schemas.xmlsoap.org/ws/2005/02/trust/Validate`	The STS should validate the token that is sent in the DFHWS-IDTOKEN container.

This container should only be used with channel DFHWSTC-V1 for the Trust client interface.

Container DFHWS-STSFAULT

DFHWS-STSFAULT is a container of DATATYPE(CHAR). It contains the error that was returned by the Security Token Service (STS).

If an error occurs, the STS issues a SOAP fault. The contents of the SOAP fault are returned in this container.

This container is returned on the channel DFHWSTC-V1 when using the Trust client interface.

Container DFHWS-STSREASON

DFHWS-STSREASON is a container of DATATYPE(CHAR). It contains the contents of the `<wst:Reason>` element, if this element is present in the response message from the Security Token Service (STS).

The `<wst:Reason>` element contains an optional string that provides information relating to the status of the validation request that was sent to the STS by CICS. If the security token is invalid, the information provided by the STS in this element could help you determine why this has occurred.

For more information, see the *Web Services Trust Language* specification that is published at http://www.ibm.com/developerworks/library/specification/ws-trust/.

Container DFHWS-STSURI

DFHWS-STSURI is a container of DATATYPE(CHAR). It contains the absolute URI of the Security Token Service (STS) that should be used to validate or issue an identity token for the SOAP message.

The format of the URI is `http://www.example.com:8080/TrustServer/SecurityTokenService`. You can use HTTP or HTTPS, depending on your security requirements.

This container should only be used with channel DFHWSTC-V1 for the Trust client interface.

Container DFHWS-TOKENTYPE

DFHWS-TOKENTYPE is a container of DATATYPE(CHAR). It contains the URI of the requested token type that the Security Token Service (STS) should issue as an identity token for the SOAP message.

You can specify any valid token type, but it must be supported by the STS.

This container should only be used with channel DFHWSTC-V1 for the Trust client interface.

Containers generated by CICS

CICS generates containers to store data such as variable arrays and long strings. These containers are created during pipeline processing and are used as input to, or output from, the application program. These containers are prefixed with DFH.

The naming convention for these containers is to use the CICS module that created them, combined with a numeric suffix to make the container name unique within the request. The container names that occur during pipeline processing are:

DFHPICC-*nnnnnnnn*
: Containers that are used to store strings and variable arrays, that are passed to the application. This can also include binary data.

DFHPIII-*nnnnnnnn*
: Outbound attachment containers created when the pipeline is enabled with the MTOM message handler and is running in direct mode. These containers are created when binary data is provided in a field rather than in a container by the application program.

DFHPIMM-*nnnnnnnn*
: Inbound attachment containers created during the processing of MIME messages. These containers are generated by CICS when the MTOM

message handler is enabled in the pipeline. When direct mode processing is enabled, these containers may be passed through to the application directly.

DFHPIXO-*nnnnnnnn*
: Outbound attachment containers created when the pipeline is enabled with the MTOM message handler and is running in compatibility mode.

The numbered container names start from 1 for each Web service request, for example DFHPICC-00000001. However, if an application program uses **INVOKE WEBSERVICE** to initiate more than one Web service request in the same channel, it is possible that the containers returned to the application for one response could still exist when a further request is made. In this situation, CICS checks to see if the container already exists and increments the number of the generated container to avoid a naming conflict.

User containers

These contain information which one message handler needs to pass to another. The use of user containers is entirely a matter for the message handlers. You can choose your own names for these containers, but you must not use names that start with DFH.

Customizing pipeline processing

In addition to providing your own message handlers, you can also use a global user exit point to customize the processing of provider mode pipelines.

You must understand the best practices for writing global user exit programs before customizing the pipeline. You must be using the DFHPITP application handler in your pipeline to use the global user exit point.

The XWSPRROO exit point enables you to access containers on the current channel after the Web services provider application has issued the Web service response message and before CICS creates the body of the response message.

1. Use the DFH$PIEX sample exit program to write your own global user exit program. DFH$PIEX is in the SDFHSAMP library. You are recommended to make the program threadsafe.
2. Enable the global user exit program.
3. Test your global user exit program to ensure it works correctly.

Chapter 8. Creating a Web service

You can expose existing CICS applications as Web services and create new CICS applications to act as Web service providers or requesters.

Before you begin, ensure that you have correctly configured your CICS system to support Web services and that you have created the necessary infrastructure to support the deployment of your Web service. As part of your planning activities, you should have also decided whether you want to use the Web services assistant, which enables you to use the CICS Web services support at run time.

The CICS Web services assistant is a supplied utility that simplifies the process of creating the necessary artifacts for a new Web service provider or service requester application, or enabling an existing application as a Web service provider.

It can create a WSDL document from a simple language structure, or a language structure from an existing WSDL document, and supports COBOL, C/C++ and PL/I. It also generates information used to enable automatic runtime conversion of the SOAP messages to containers and COMMAREAs, and *vice versa*, which is used by the CICS Web services support during pipeline processing.

1. Create a Web service by either:
   - Using the Web services assistant to create the Web service description or language structures and deploy them into CICS. You can perform a **PIPELINE SCAN** to automatically create the required CICS resources.
   - Using WebSphere Developer for System z or the Java API to create the Web service description or language structures and deploy them into CICS. Using this method, you can also perform a **PIPELINE SCAN** to automatically create the required CICS resources.
   - Creating or changing an application program to handle the XML in the inbound and outbound messages, including the data conversion, and populate the correct containers in the pipeline. You must create the required CICS resources manually.
2. Invoke the Web service to test that it works as you intended. If you are using the Web services assistant to deploy your Web service, you can use the **SET WEBSERVICE** command to turn validation on. This checks that the data is converted correctly.

These steps are explained in more detail in the following section.

The CICS Web services assistant

The CICS Web services assistant is a set of batch utilities which can help you to transform existing CICS applications into Web services and to enable CICS applications to use Web services provided by external providers. The assistant supports rapid deployment of CICS applications for use in service providers and service requesters, with the minimum of programming effort.

When you use the Web services assistant for CICS, you do not have to write your own code for parsing inbound messages and for constructing outbound messages; CICS maps data between the body of a SOAP message and the application program's data structure.

The assistant can create a WSDL document from a simple language structure, or a language structure from an existing WSDL document, and supports COBOL, C/C++, and PL/I. It also generates information used to enable automatic runtime conversion of the SOAP messages to containers and COMMAREAs, and *vice versa*.

The CICS Web services assistant comprises two utility programs:

DFHLS2WS
Generates a Web service binding file from a language structure. This utility also generates a Web service description.

DFHWS2LS
Generates a Web service binding file from a Web service description. This utility also generates a language structure that you can use in your application programs.

The JCL procedures to run both programs are in the `hlq.XDFHINST` library.

DFHLS2WS: high-level language to WSDL conversion

The DFHLS2WS procedure generates a Web service description and a Web service binding file from a high-level language data structure. You can use DFHLS2WS when you expose a CICS application program as a service provider.

As per the W3C recommendation for WSDL documents, DFHLS2WS uses a top level wrapper element to contain the body of the SOAP message. The wrapper element takes the name of the WSDL operation and is represented as a `complexType` in the WSDL document.

The job control statements for DFHLS2WS, its symbolic parameters, its input parameters and their descriptions, and an example job help you to use this procedure.

Job control statements for DFHLS2WS

JOB Starts the job.

EXEC Specifies the procedure name (DFHLS2WS).

DFHLS2WS requires sufficient storage to run a Java virtual machine (JVM). You are advised to specify `REGION=200M` on the EXEC statement.

INPUT.SYSUT1 DD
Specifies the input. The input parameters are usually specified in the input stream. However, they can be defined in a data set or in a member of a partitioned data set.

Symbolic parameters

The following symbolic parameters are defined in cataloged procedure DFHLS2WS:

JAVADIR=*path*
Specifies the name of the Java directory that is used by DFHLS2WS. The value of this parameter is appended to `/usr/lpp/` to produce a complete path name of `/usr/lpp/`*path*.

Usually, you do not specify this parameter. The default value is the value that was supplied to the CICS installation job (DFHISTAR) in the **JAVADIR** parameter.

PATHPREF=*prefix*
: Specifies an optional prefix that extends the z/OS UNIX directory path used on other parameters. The default is the empty string.

  Usually, you do not specify this parameter. The default value is the value that was supplied to the CICS installation job (DFHISTAR) in the **JAVADIR** parameter.

SERVICE=*value*
: Use this parameter only when directed to do so by IBM support.

TMPDIR=*tmpdir*
: Specifies the location of a directory in z/OS UNIX that DFHLS2WS uses as a temporary work space. The user ID under which the job runs must have read and write permission to this directory.

  The default value is `/tmp`.

TMPFILE=*tmpprefix*
: Specifies a prefix that DFHLS2WS uses to construct the names of the temporary workspace files.

  The default value is `LS2WS`

USSDIR=*path*
: Specifies the name of the CICS TS directory in the UNIX system services file system. The value of this parameter is appended to `/usr/lpp/cicsts/` to produce a complete path name of `/usr/lpp/cicsts/`*path*

  Usually, you do not specify this parameter. The default value is the value that was supplied to the CICS installation job (DFHISTAR) in the **USSDIR** parameter.

The temporary work space

DFHLS2WS creates the following three temporary files when it runs:

tmpdir/*tmpprefix*.in

tmpdir/*tmpprefix*.out

tmpdir/*tmpprefix*.err

where

tmpdir is the value specified in the **TMPDIR** parameter

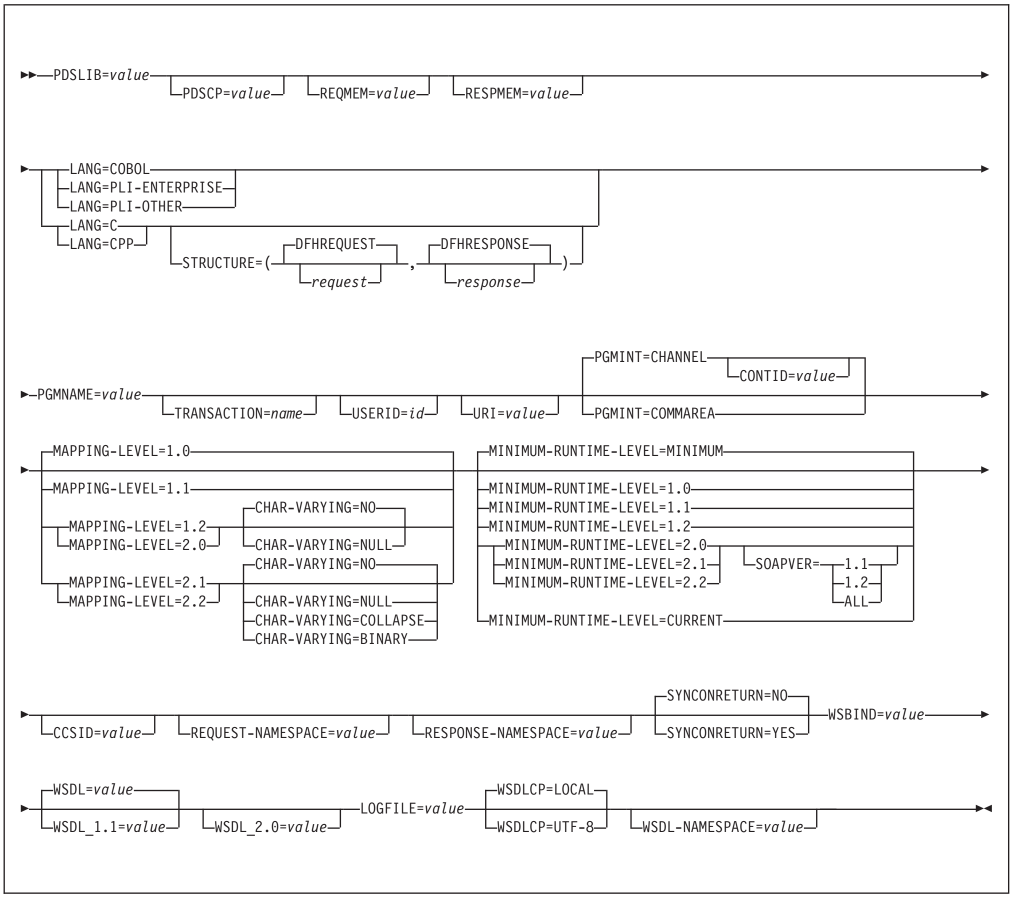
tmpprefix is the value specified in the **TMPFILE** parameter.

The default names for the files, when **TMPDIR** and **TMPFILE** are not specified, are:

```
/tmp/LS2WS.in
/tmp/LS2WS.out
/tmp/LS2WS.err
```

DFHLS2WS does not lock access to the generated z/OS UNIX file names. Therefore, if two or more instances of DFHLS2WS run concurrently, and use the same temporary workspace files, nothing prevents one job from overwriting the workspace files while another job is using them. Overwriting can lead to unpredictable failures. Therefore, you are advised to devise a naming convention, and operating procedures, that avoids this situation. For example, you can use the system symbolic parameter SYSUID to generate workspace file names that are unique to an individual user. These temporary files are deleted before the end of the job.

Input parameters for DFHLS2WS



Parameter use

- You can specify the input parameters in any order.
- Each parameter must start on a new line.
- A parameter, and its continuation character, if you use one, must not extend beyond column 72; columns 73 to 80 must contain blanks.
- If a parameter is too long to fit on a single line, use an asterisk (*) character at the end of the line to indicate that the parameter continues on the next line. Everything, including spaces, before the asterisk is considered part of the parameter. For example:

  ```
  WSBIND=wsbinddir*
  /app1
  ```

  is equivalent to

  ```
  WSBIND=wsbinddir/app1
  ```
- A # character in the first character position of the line is a comment character. The line is ignored.

Parameter descriptions

CCSID=*value*

Specifies the CCSID that is used at run time to encode character data in the application data structure. The value of this parameter overrides the value of the **LOCALCCSID** system initialization parameter. The value must be an EBCDIC

CCSID that is supported by Java and z/OS conversion services. If you do not specify this parameter, the application data structure is encoded using the CCSID specified in the system initialization parameter.

You can use this parameter with any mapping level. However, if you want to deploy the generated files into a CICS TS 3.1 region, you must apply APAR PK23547 to achieve the minimum runtime level of code to install the Web service binding file.

CHAR-VARYING=**NO**|**NULL**|**COLLAPSE**|**BINARY**

Specifies how character fields in the language structure are mapped when the mapping level is 1.2 or higher. A character field in COBOL is a Picture clause of type X, for example `PIC(X) 10`; a character field in C/C++ is a character array. This parameter does not apply to Enterprise and Other PL/I language structures. You can select these options:

NO Character fields are mapped to an `xsd:string` and are processed as fixed-length fields. The maximum length of the data is equal to the length of the field. NO is the default value for the **CHAR-VARYING** parameter for COBOL and PL/I at mapping levels 2.0 and earlier.

NULL Character fields are mapped to an `xsd:string` and are processed as null-terminated strings. CICS adds a terminating null character when transforming from a SOAP message. The maximum length of the character string is calculated as one character less than the length indicated in the language structure. NULL is the default value for the **CHAR-VARYING** parameter for C/C++.

COLLAPSE

Character fields are mapped to an `xsd:string`. Trailing white space in the field is not included in the SOAP message. COLLAPSE is the default value for the **CHAR-VARYING** parameter for COBOL and PL/I at mapping level 2.1 onwards.

BINARY

Character fields are mapped to an `xsd:base64binary` and are processed as fixed-length fields. The BINARY value on the **CHAR-VARYING** parameter is available only at mapping levels 2.1 and onwards.

CONTID=*value*

In a service provider, specifies the name of the container that holds the top-level data structure used to represent a SOAP message.

LANG=**COBOL**

Specifies that the programming language of the high-level language structure is COBOL.

LANG=**PLI-ENTERPRISE**

Specifies that the programming language of the high-level language structure is Enterprise PL/I.

LANG=**PLI-OTHER**

Specifies that the programming language of the high-level language structure is a level of PL/I other than Enterprise PL/I.

LANG=**C**

Specifies that the programming language of the high-level language structure is C.

LANG=CPP
Specifies that the programming language of the high-level language structure is C++.

LOGFILE=*value*
The fully qualified z/OS UNIX name of the file into which DFHLS2WS writes its activity log and trace information. DFHLS2WS creates the file, but not the directory structure, if it does not already exist.

Usually, you do not use this file, but it might be requested by the IBM service organization if you encounter problems with DFHLS2WS.

| **MAPPING-LEVEL={1.0|1.1|1.2|2.0|2.1|2.2}**
Specifies the level of mapping that DFHLS2WS uses when generating the Web service binding file and Web service description. You can select these options:

1.0 This mapping level is the default. It indicates that the Web service binding file is generated using CICS TS 3.1 mapping levels.

1.1 Use this mapping to regenerate a binding file at this specific level.

1.2 At this mapping level, you can use the parameter **CHAR-VARYING** to control how character arrays are processed at runtime. VARYING and VARYINGZ arrays are also supported in PL/I.

2.0 Use this mapping level in a CICS TS 3.2 region to take advantage of the enhancements to the mapping between the language structure and Web services binding file.

2.1 Use this mapping level with a CICS TS 3.2 region that has APAR PK59794 applied. At this mapping level you can take advantage of the new values for the **CHAR-VARYING** parameter, COLLAPSE and BINARY. FILLER fields in COBOL and * fields in PL/I are systematically ignored at this mapping level, the fields do not appear in the generated WSDL document and an appropriate gap is left in the data-structures at run time.

2.2 Use this mapping level with a CICS TS 3.2 region that has APAR PK69738 applied to take advantage of mapping enhancements when using DFHWS2LS.

For details of what is supported at each level of mapping, see “Mapping levels
| for the CICS Web services assistant” on page 146.

| **MINIMUM-RUNTIME-LEVEL={MINIMUM|1.0|1.1|1.2|2.0|2.1|2.2|CURRENT}**
Specifies the minimum CICS runtime environment into which the Web service binding file can be deployed. If you select a level that does not match the other parameters that you have specified, you receive an error message. You can select these options:

MINIMUM
The lowest possible runtime level of CICS is allocated automatically given the parameters that you have specified.

1.0 The generated Web service binding file deploys successfully into a CICS TS 3.1 region that does not have APARs PK15904 and PK23547 applied. Some parameters are not available at this runtime level.

1.1 The generated Web service binding file deploys successfully into a CICS TS 3.1 region that has at least APAR PK15904 applied. You can use a mapping level of 1.1 or below for the MAPPING-LEVEL parameter. Some parameters are not available at this runtime level.

1.2 The generated Web service binding file deploys successfully into a CICS TS 3.1 region that has both APAR PK15904 and PK23547 applied. You can use a mapping level of 1.2 or below for the MAPPING-LEVEL parameter. Some parameters are not available at this runtime level.

2.0 The generated Web service binding file deploys successfully into a CICS TS 3.2 region. You can use a mapping level of 2.0 or below for the MAPPING-LEVEL parameter. Some parameters are not available at this runtime level.

2.1 The generated Web service binding file deploys successfully into a CICS TS 3.2 region that has APAR PK59794 applied. You can use a mapping level of 2.1 or below for the **MAPPING-LEVEL** parameter. You can use any optional parameter at this level.

2.2 The generated Web service binding file deploys successfully into a CICS TS 3.2 region that has APAR PK69738 applied. With this runtime level, you can use a mapping level of 2.2 or below for the **MAPPING-LEVEL** parameter. You can use any optional parameter at this level.

CURRENT
The generated Web service binding file deploys successfully into a CICS region at the same runtime level as the one used to generate the Web service binding file.

PDSLIB=*value*
Specifies the name of the partitioned data set that contains the high-level language data structures to be processed. The data set members used for the request and response are specified in the **REQMEM** and **RESPMEM** parameters respectively.

Restriction: The records in the partitioned data set must have a fixed-length of 80 bytes.

PDSCP=*value*
Specifies the code page used in the partitioned data set members specified in the **REQMEM** and **RESPMEM** parameters, where *value* is a CCSID number or a Java code page number. If this parameter is not specified, the z/OS UNIX System Services code page is used. For example, you might specify `PDSCP=037`.

PGMINT=**CHANNEL|COMMAREA**
For a service provider, specifies how CICS passes data to the target application program:

CHANNEL
CICS uses a channel interface to pass data to the target application program.

A single container is identified for the application data for both the input and the output. Use the **CONTID** parameter to specify the name of this container. The default name is DFHWS-DATA.

COMMAREA
CICS uses a communication area to pass data to the target application program.

PGMNAME=*value*
Specifies the name of the CICS PROGRAM resource for the target application program that will be exposed as a Web service. The CICS Web service support will link to this program.

REQMEM=*value*
Specifies the name of the partitioned data set member that contains the high-level language structure for the Web service request. For a service provider, the Web service request is the input to the application program.

REQUEST-NAMESPACE=*value*
Specifies the namespace of the XML schema for the request message in the generated Web service description. If you do not specify this parameter, CICS generates a namespace automatically.

RESPMEM=*value*
Specifies the name of the partitioned data set member which contains the high-level language structure for the Web service response. For a service provider, the Web service response is the output from the application program.

Omit this parameter if there is no response, that is, for one way messages.

RESPONSE-NAMESPACE=*value*
Specifies the namespace of the XML schema for the response message in the generated Web service description. If you do not specify this parameter, CICS generates a namespace automatically.

SOAPVER=**1.1**|**1.2**|**ALL**
Specifies the SOAP level to use in the generated Web service description. This parameter is only available when the **MINIMUM-RUNTIME-LEVEL** is set to 2.0 or above.

1.1 The SOAP 1.1 protocol should be used as the binding for the Web service description.

1.2 The SOAP 1.2 protocol should be used as the binding for the Web service description.

ALL Both the SOAP 1.1 or 1.2 protocol can be used as the binding for the Web service description.

If you do not specify a value for this parameter, the default value depends on the version of WSDL that you want to create:

- If you require only WSDL 1.1, the SOAP 1.1 binding is used.
- If you require only WSDL 2.0, the SOAP 1.2 binding is used.
- If you require both WSDL 1.1 and WSDL 2.0, both SOAP 1.1 and 1.2 bindings are used for each Web service description.

STRUCTURE=(*request*,*response*)
For C and C++ only, specifies the names of the high-level structures contained in the partitioned data set members that are specified in the **REQMEM** and **RESPMEM** parameters:

request
Specifies the name of the high-level structure that contains the request when the **REQMEM** parameter is specified. The default value is DFHREQUEST.

The partitioned data set member must contain a high-level structure with the name that you specify, or a structure named DFHREQUEST if you do not specify a name.

response

Specifies the name of the high-level structure that contains the response when the **RESPMEM** parameter is specified. The default value is DFHRESPONSE.

If you specify a value, the partitioned data set member must contain a high-level structure with the name that you specify, or a structure named DFHRESPONSE if you do not specify a name.

SYNCONRETURN=**NO**|**YES**

Specifies whether the remote Web service can issue a sync point.

NO The remote Web service cannot issue a sync point. This value is the default. If the remote Web service issues a sync point, it fails with an ADPL abend.

YES The remote Web service can issue a sync point. If you select `YES`, the remote task is committed as a separate unit of work when control returns from the remote Web service. If the remote Web service updates a recoverable resource and a failure occurs after it returns, the update to that resource cannot be backed out.

TRANSACTION=*name*

In a service provider, this parameter specifies the 1 to 4 character name of an alias transaction that can start the pipeline. The value of this parameter is used to define the TRANSACTION attribute of the URIMAP resource when it is created automatically using the PIPELINE scan command.

Acceptable characters:
`A-Z a-z 0-9 $ @ # _ < >`

URI=*value*

This parameter specifies the relative or absolute URI that a client will use to access the Web service. CICS uses the value specified when it generates a URIMAP resource from the Web service binding file created by DFHLS2WS. The parameter specifies the path component of the URI to which the URIMAP definition applies.

USERID=*id*

In a service provider, this parameter specifies a 1 to 8 character user ID, which can be used by any Web client. For an application-generated response or a Web service, the alias transaction is attached under this user ID. The value of this parameter is used to define the USERID attribute of the URIMAP resource when it is created automatically using the PIPELINE scan command.

Acceptable characters:
`A-Z a-z 0-9 $ @ #`

WSBIND=*value*

The fully qualified z/OS UNIX name of the Web service binding file. DFHLS2WS creates the file, but not the directory structure, if it does not already exist. The file extension is `.wsbind`.

WSDL=*value*

The fully qualified z/OS UNIX name of the file into which the Web service description is written. The Web service description conforms to the WSDL 1.1 specification. DFHLS2WS creates the file, but not the directory structure, if it does not already exist.

WSDL_1.1=*value*

The fully qualified z/OS UNIX name of the file into which the Web service description is written. The Web service description conforms to the WSDL 1.1 specification. DFHLS2WS creates the file, but not the directory structure, if it does not already exist. The file extension is `.wsdl`. This parameter produces the same result as the **WSDL** parameter, so you can specify only one or the other.

WSDL_2.0=*value*

The fully qualified z/OS UNIX name of the file into which the Web service description is written. The Web service description conforms to the WSDL 2.0 specification. DFHLS2WS creates the file, but not the directory structure, if it does not already exist. The file extension is `.wsdl`. This parameter can be used in conjunction with the **WSDL** or **WSDL_1.1** parameters. It is available only when the **MINIMUM-RUNTIME-LEVEL** is set to `2.0` or higher.

WSDLCP=**LOCAL**|**UTF-8**

Specifies the code page that is used to generate the WSDL document.

LOCAL

Specifies that the WSDL document is generated using the local code page and no encoding tag is generated in the WSDL document.

UTF-8 Specifies that the WSDL document is generated using the UTF-8 code page. An encoding tag is generated in the WSDL document. If you specify this option, you must ensure that the encoding remains correct when copying the WSDL document between different platforms.

WSDL-NAMESPACE=*value*

Specifies the namespace for CICS to use in the generated WSDL document.

If you do not specify this parameter, CICS generates a namespace automatically.

Other information

- The user ID under which DFHLS2WS runs must be defined to OMVS. The user ID must have read permission to the CICS z/OS UNIX file structure and PDS libraries and write permission to the directories specified on the **LOGFILE**, **WSBIND**, and **WSDL** parameters.
- The user ID must have a sufficiently large storage allocation to run Java.

Example

```
//LS2WS JOB  'accounting information',name,MSGCLASS=A
//  SET QT=''''
//JAVAPROG EXEC DFHLS2WS,
// TMPFILE=&QT.&SYSUID.&QT
//INPUT.SYSUT1 DD *
PDSLIB=//CICSHLQ.SDFHSAMP
REQMEM=DFH0XCP4
RESPMEM=DFH0XCP4
LANG=COBOL
LOGFILE=/u/exampleapp/wsbind/example.log
MINIMUM-RUNTIME-LEVEL=2.2
MAPPING-LEVEL=2.2
CHAR-VARYING=COLLAPSEPGMNAME=DFH0XCMN
URI=http://myserver.example.org:8080/exampleApp/example
PGMINT=COMMAREA
SOAPVER=ALL
SYNCONRETURN=YES
WSBIND=/u/exampleapp/wsbind/example.wsbind
```

```
WSDL=/u/exampleapp/wsdl/example.wsdl
WSDL_2.0=/u/exampleapp/wsdl/example_20.wsdl
WSDLCP=LOCAL
WSDL-NAMESPACE=http://mywsdlnamespace/*
```

DFHWS2LS: WSDL to high-level language conversion

Cataloged procedure DFHWS2LS generates a high-level language data structure and a Web service binding file from a Web service description. You can use DFHWS2LS when you expose a CICS application program as a service provider or when you construct a service requester.

The job control statements for DFHWS2LS, its symbolic parameters, its input parameters and their descriptions, and an example job help you to use this procedure.

Job control statements for DFHWS2LS

JOB Starts the job.

EXEC Specifies the procedure name (DFHWS2LS).

DFHWS2LS requires sufficient storage to run a Java virtual machine (JVM). You are advised to specify `REGION=200M` on the EXEC statement.

INPUT.SYSUT1 DD
Specifies the input. The input parameters are usually specified in the input stream. However, they can be defined in a data set or in a member of a partitioned data set.

Symbolic parameters

The following symbolic parameters are defined in cataloged procedure DFHWS2LS:

JAVADIR=*path*
Specifies the name of the Java directory that is used by DFHWS2LS. The value of this parameter is appended to `/usr/lpp/` to produce a complete path name of `/usr/lpp/`*path*.

Usually, you do not specify this parameter. The default value is the value that was supplied to the CICS installation job (DFHISTAR) in the **JAVADIR** parameter.

PATHPREF=*prefix*
Specifies an optional prefix that extends the z/OS UNIX directory path used on other parameters. The default is the empty string.

Usually, you do not specify this parameter. The default value is the value that was supplied to the CICS installation job (DFHISTAR) in the **JAVADIR** parameter.

TMPDIR=*tmpdir*
Specifies the location of a directory in z/OS UNIX that DFHWS2LS uses as a temporary work space. The user ID under which the job runs must have read and write permission to this directory.

The default value is `/tmp`.

TMPFILE=*tmpprefix*
Specifies a prefix that DFHWS2LS uses to construct the names of the temporary workspace files.

The default value is `WS2LS`.

USSDIR=*path*
Specifies the name of the CICS TS directory in the UNIX system services file

system. The value of this parameter is appended to `/usr/lpp/cicsts/` to produce a complete path name of `/usr/lpp/cicsts/`*`path`*.

Usually, you do not specify this parameter. The default value is the value that was supplied to the CICS installation job (DFHISTAR) in the **USSDIR** parameter.

SERVICE=*value*
Use this parameter only when directed to do so by IBM support.

The temporary work space

DFHWS2LS creates the following three temporary files when it runs:

tmpdir/*tmpprefix*.in

tmpdir/*tmpprefix*.out

tmpdir/*tmpprefix*.err

where

tmpdir is the value specified in the **TMPDIR** parameter

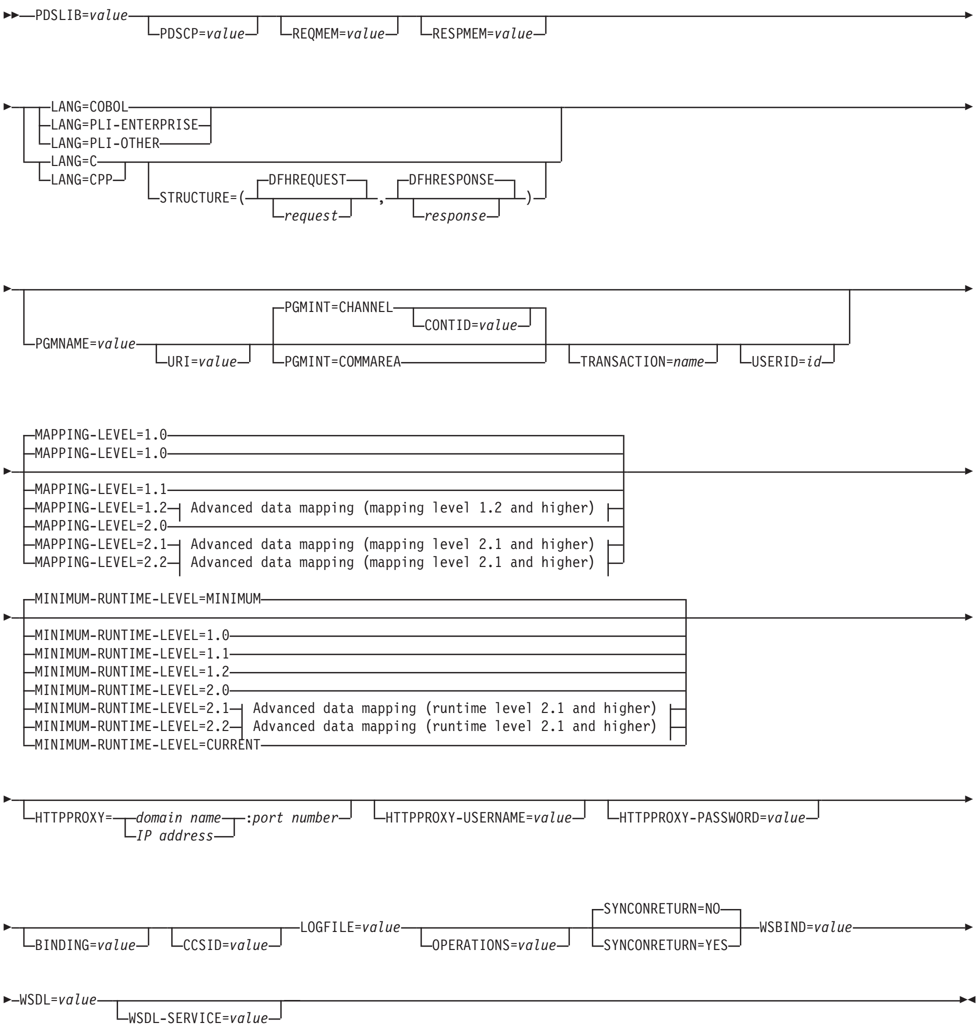
tmpprefix is the value specified in the **TMPFILE** parameter.

The default names for the files, when **TMPDIR** and **TMPFILE** are not specified, are:

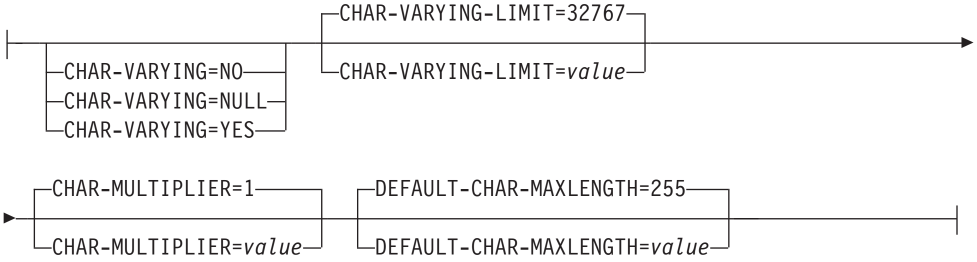
```
/tmp/WS2LS.in
/tmp/WS2LS.out
/tmp/WS2LS.err
```

DFHWS2LS does not lock access to the generated z/OS UNIX file names. Therefore, if two or more instances of DFHWS2LS run concurrently, and use the same temporary workspace files, nothing prevents one job from overwriting the workspace files while another job is using them. Overwritting can lead to unpredictable failures. Therefore, you are advised to devise a naming convention, and operating procedures, that will avoid this situation. For example, you can use the system symbolic parameter SYSUID to generate workspace file names that are unique to an individual user. These temporary files are deleted before the end of the job.

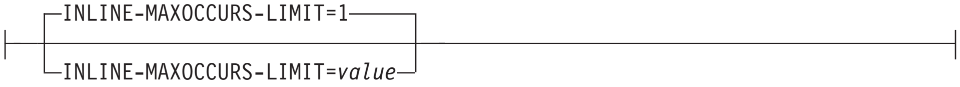
Input parameters for DFHWS2LS



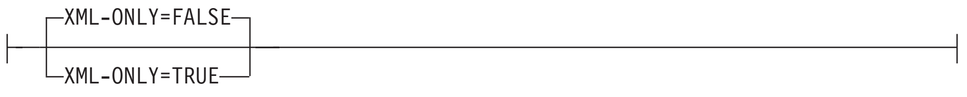
Advanced data mapping (mapping level 1.2 and higher):



Advanced data mapping (mapping level 2.1 and higher):



Advanced data mapping (runtime level 2.1 and higher):



Parameter use

- You can specify the input parameters in any order.
- Each parameter must start on a new line.
- A parameter, and its continuation character, if you use one, must not extend beyond column 72; columns 73 to 80 must contain blanks.
- If a parameter is too long to fit on a single line, use an asterisk (*) character at the end of the line to indicate that the parameter continues on the next line. Everything, including spaces, before the asterisk is considered part of the parameter. For example:

  ```
  WSBIND=wsbinddir*
  /app1
  ```

  is equivalent to

  ```
  WSBIND=wsbinddir/app1
  ```
- A # character in the first character position of the line is a comment character. The line is ignored.

Parameter descriptions

BINDING=*value*
: If the Web service description contains more than one `wsdl:Binding` element, use this parameter to specify which one is to be used to generate the language structure and Web service binding file. Specify the value of the `name` attribute that is used on the `wsdl:Binding` element in the Web service description.

CCSID=*value*
: Specifies the CCSID that is used at run time to encode character data in the application data structure. The value of this parameter overrides the value of the **LOCALCCSID** system initialization parameter. The value must be an EBCDIC CCSID that is supported by Java and z/OS conversion services. If you do not specify this parameter, the application data structure is encoded using the CCSID specified in the system initialization parameter.

  You can use this parameter with any mapping level. However, if you want to deploy the generated files into a CICS TS 3.1 region, you must apply APAR PK23547 to achieve the minimum runtime level of code to install the Web service binding file.

CHAR-MULTIPLIER=**1**|*value*
: Specifies the number of bytes to allow for each character when the mapping level is 1.2 or higher. The *value* of this parameter can be a positive integer in the range of 1 to 2 147 483 647. All nonnumeric character-based mappings are subject to this multiplier. Binary, numeric, zoned, and packed decimal fields are not subject to this multiplier.

This parameter can be useful if, for example, you are planning to use DBCS characters where you could opt for a multiplier of 3 to allow space for potential shift-out and shift-in characters around every double-byte character at run time.

CHAR-VARYING=**NO**|**NULL**|**YES**

Specifies how variable-length character data is mapped when the mapping level is 1.2 or higher. Variable-length binary data types are always mapped to either a container or a varying structure. If you do not specify this parameter, the default mapping depends on the language specified. The options that you can select are:

NO Variable-length character data is mapped as fixed-length strings.

NULL Variable-length character data is mapped to null-terminated strings.

YES Variable-length character data is mapped to a CHAR VARYING data type in PL/I. In the COBOL, C, and C++ languages, variable-length character data is mapped to an equivalent representation that comprises two related elements: data length and the data.

CHAR-VARYING-LIMIT=**32767**|*value*

Specifies the maximum size of binary data and variable-length character data that is mapped to the language structure when the mapping level is 1.2 or higher. If the character or binary data is larger than the value specified in this parameter, it is mapped to a container and the container name is used in the generated language structure. The *value* can range from 0 to the default 32 767 bytes.

CONTID=*value*

In a service provider, specifies the name of the container that holds the top-level data structure used to represent a SOAP message.

DEFAULT-CHAR-MAXLENGTH=**255**|*value*

Specifies the default array length of character data in characters for mappings where no length is implied in the Web service description document, when the mapping level is 1.2 or higher. The *value* of this parameter can be a positive integer in the range of 1 to 2 147 483 647.

HTTPPROXY={*domain name*|*IP address*}:*port number*

If your WSDL contains references to other WSDL files that are located on the internet, and the system on which you are running DFHWS2LS uses a proxy server to access the internet, specify the domain name or IP address and the port number of the proxy server. For example:

```
HTTPPROXY=proxy.example.com:8080
```

In other cases, this parameter is not required.

HTTPPROXY-USERNAME=*value*

Specifies the HTTP proxy username that must be used with **HTTPPROXY-PASSWORD** if the system on which you are running DFHWS2LS uses a HTTP proxy server to access the Internet, and the HTTP proxy server uses basic authentication. You can use this parameter only when you also specify **HTTPPROXY**.

HTTPPROXY-PASSWORD=*value*

Specifies the HTTP proxy password that must be used with **HTTPPROXY-USERNAME** if the system on which you are running DFHWS2LS uses a HTTP proxy server to access the Internet, and the HTTP proxy server uses basic authentication. You can use this parameter only when you also specify **HTTPPROXY**.

INLINE-MAXOCCURS-LIMIT=<u>1</u>|*value*

Specifies whether or not inline variable repeating content is used based on the `maxOccurs` attribute. Variably repeating content that is mapped inline is placed in the current container with the rest of the generated language structure. The variably repeating content is stored in two parts, as a counter which stores the number of occurrences of the data and as an array which stores each occurrence of the data. The alternative mapping for variably repeating content is container-based mapping which stores the number of occurrences of the data and the name of the container where the data is placed. Storing the data in a separate container has performance implications which might make inline mapping preferable.

The **INLINE-MAXOCCURS-LIMIT** parameter is available only at mapping level 2.1 onwards. The value of **INLINE-MAXOCCURS-LIMIT** can be a positive integer in the range of 0 to 32 767. A value of `0` indicates that inline mapping is not used. A value of `1` ensures that optional elements are mapped inline. If the *value* of the `maxOccurs` attribute is greater than the *value* of **INLINE-MAXOCCURS-LIMIT** container based mapping is used, otherwise inline mapping is used.

When deciding if you want variably repeating lists to be mapped inline, consider the length of a single item of recurring data. If few instances of long length occur, container-based mapping is preferable; if many instances of short length occur, inline mapping is preferable. For more information on variably repeating content, see “Variable arrays of elements in DFHWS2LS” on page 177.

LANG=**COBOL**

Specifies that the programming language of the high-level language structure is COBOL.

LANG=**PLI-ENTERPRISE**

Specifies that the programming language of the high-level language structure is Enterprise PL/I.

LANG=**PLI-OTHER**

Specifies that the programming language of the high-level language structure is a level of PL/I other than Enterprise PL/I.

LANG=**C**

Specifies that the programming language of the high-level language structure is C.

LANG=**CPP**

Specifies that the programming language of the high-level language structure is C++.

LOGFILE=*value*

The fully qualified z/OS UNIX name of the file into which DFHWS2LS writes its activity log and trace information. DFHWS2LS creates the file, but not the directory structure, if it does not already exist.

Usually, you do not use this file, but it may be requested by the IBM service organization if you encounter problems with DFHWS2LS.

MAPPING-LEVEL=**{<u>1.0</u>|1.1|1.2|2.0|2.1|2.2}**

Specifies the level of mapping that DFHWS2LS uses when generating the Web service binding file and language structure. You can select these options:

1.0 The Web service binding file and language structure are generated using CICS TS 3.1 mapping levels.

1.1 XML attributes and `<list>` and `<union>` data types are mapped to the language structure. Character and binary data that have a maximum length of more than 32 767 bytes is mapped to a container. The container name is created in the language structure.

1.2
Use the parameters **CHAR-VARYING** and **CHAR-VARYING-LIMIT** to control how character data is mapped and processed at run time. If you do not specify either of these parameters, binary and character data that has a maximum length of less than 32 768 bytes is mapped to a VARYING structure for all languages except C++, where character data is mapped to a null-terminated string.

2.0
Use this mapping level in a CICS TS 3.2 region or above to take advantage of the enhancements to the mapping between the language structure and Web services binding file.

2.1
Use this mapping level with a CICS TS 3.2 region that has APAR PK59794 applied. Mapping level 2.1 provides `<xsd:any>` and `xsd:anyType` support, the option to map variably repeating content inline with the **INLINE-MAXOCCURS-LIMIT** parameter, and support for `minOccurs="0"` on `<xsd:sequence>`, `<xsd:choice>` and `<xsd:all>`.

2.2
Use this mapping level with a CICS TS 3.2 region that has APAR PK69738 applied. Mapping level 2.2 provides the following support:

- Elements with fixed values
- Enhanced support for `<xsd:choice>` elements
- Abstract data types
- Abstract elements
- Substitution groups

For details of what is supported at each level of mapping, see "Mapping levels for the CICS Web services assistant" on page 146.

MINIMUM-RUNTIME-LEVEL={MINIMUM|1.0|1.1|1.2|2.0|2.1|2.2|CURRENT}
Specifies the minimum CICS runtime environment into which the Web service binding file can be deployed. If you select a level that does not match the other parameters that you have specified, you receive an error message. You can select these options:

MINIMUM
The lowest possible runtime level of CICS is allocated automatically given the parameters that you have specified.

1.0
The generated Web service binding file deploys successfully into a CICS TS 3.1 region that does not have APARs PK15904 and PK23547 applied. Some parameters are not available at this runtime level.

1.1
The generated Web service binding file deploys successfully into a CICS TS 3.1 region that has at least APAR PK15904 applied. You can use a mapping level of 1.1 or below for the MAPPING-LEVEL parameter. Some parameters are not available at this runtime level.

1.2
The generated Web service binding file deploys successfully into a CICS TS 3.1 region that has both APAR PK15904 and PK23547 applied. You can use a mapping level of 1.2 or below for the MAPPING-LEVEL parameter. Some parameters are not available at this runtime level.

2.0
The generated Web service binding file deploys successfully into a CICS TS 3.2 region. You can use a mapping level of 2.0 or below for the MAPPING-LEVEL parameter. Some parameters are not available at this runtime level.

2.1 The generated Web service binding file deploys successfully into a CICS TS 3.2 region that has APAR PK59794 applied. You can use a mapping level of 2.1 or below for the **MAPPING-LEVEL** parameter. You can use any optional parameter at this level.

2.2 The generated Web service binding file deploys successfully into a CICS TS 3.2 region that has APAR PK69738 applied. With this runtime level, you can use a mapping level of 2.2 or below for the **MAPPING-LEVEL** parameter. You can use any optional parameter at this level.

CURRENT
The generated Web service binding file deploys successfully into a CICS region at the same runtime level as the one used to generate the Web service binding file.

OPERATIONS=*value*
For Web service requester applications, specifies a subset of valid `wsdl:Operation` elements from the Web service description that is used to generate the Web service binding file. Each Operation element is separated by a space; the list can span more than one line if necessary. You can use this parameter for both WSDL 1.1 and WSDL 2.0 documents.

PDSLIB=*value*
Specifies the name of the partitioned data set that contains the generated high-level language. The data set members used for the request and response are specified in the **REQMEM** and **RESPMEM** parameters respectively.

PDSCP=*value*
Specifies the code page used in the partitioned data set members specified in the **REQMEM** and **RESPMEM** parameters, where *value* is a CCSID number or a Java code page number. If this parameter is not specified, the z/OS UNIX System Services code page is used. For example, you might specify `PDSCP=037`.

PGMINT=**CHANNEL|COMMAREA**
For a service provider, specifies how CICS passes data to the target application program:

CHANNEL
CICS uses a channel interface to pass data to the target application program. There might be several containers involved in the program interface, however a single container is identified for the top-level of the application data for both the input and the output. Use the **CONTID** parameter to specify the name of this container. The default name is DFHWS-DATA.

COMMAREA
CICS uses a communication area to pass data to the target application program.

This parameter is ignored when the output from DFHWS2LS is used in a service requester.

PGMNAME=*value*
Specifies the name of a CICS PROGRAM resource.

When DFHWS2LS is used to generate a Web service binding file that will be used in a service provider, you must supply this parameter. It specifies the resource name of the application program that is exposed as a Web service.

When DFHWS2LS is used to generate a Web service binding file that will be used in a service requester, omit this parameter.

REQMEM=*value*
Specifies a 1 to 6 character prefix that DFHWS2LS uses to generate the names of the partitioned data set members that will contain the high-level language structures for the Web service request:

- For a service provider, the Web service request is the input to the application program
- For a service requester, the Web service request is the output from the application program

DFHWS2LS generates a partitioned data set member for each operation. It generates the member name by appending a 2 digit number to the prefix.

Although this parameter is optional, you must specify it if the Web service description contains a definition of a request.

RESPMEM=*value*
Specifies a 1 to 6 character prefix that DFHWS2LS uses to generate the names of the partitioned data set members that will contain the high-level language structures for the Web service response:

- For a service provider, the Web service response is the output from the application program
- For a service requester, the Web service response is the input to the application program

DFHWS2LS generates a partitioned data set member for each operation. It generates the member name by appending a two digit number to the prefix.

Omit this parameter if no response is invoked; that is, for one way messages.

STRUCTURE=(*request*,*response*)
For C and C++ only, specifies how the names of the request and response structures are generated.

The generated request and response structures are given names of *requestnn* and *responsenn* where *nn* is a numeric suffix that is generated to distinguish the structures for each operation.
If one or both names is omitted, the structures have the same name as the partitioned data set member names generated from the **REQMEM** and **RESPMEM** parameters that you specify.

SYNCONRETURN=**NO**|**YES**
Specifies whether the remote Web service can issue a sync point.

NO The remote Web service cannot issue a sync point. This value is the default. If the remote Web service issues a sync point, it fails with an ADPL abend.

YES The remote Web service can issue a sync point. If you select YES, the remote task is committed as a separate unit of work when control returns from the remote Web service. If the remote Web service updates a recoverable resource and a failure occurs after it returns, the update to that resource cannot be backed out.

TRANSACTION=*name*
In a service provider, this parameter specifies the 1 to 4 character name of an alias transaction that can start the pipeline. The value of this parameter is used to define the TRANSACTION attribute of the URIMAP resource when it is created automatically using the PIPELINE scan command.

Acceptable characters:
`A-Z a-z 0-9 $ @ # _ < >`

URI=*value*
In a service provider, this parameter specifies the relative URI that a client uses to access the Web service. CICS uses the value specified when it generates a URIMAP resource from the Web service binding file created by DFHWS2LS. The parameter specifies the path component of the URI to which the URIMAP definition applies.

In a service requester, the URI of the target Web service is *not* specified with this parameter. The `soap:address` location from the `wsdl:port` specified in the Web service description is used if present, although you can override that with the `URI` option on the **EXEC CICS INVOKE WEBSERVICE** command.

USERID=*id*
In a service provider, this parameter specifies a 1 to 8 character user ID, which can be used by any Web client. For an application-generated response or a Web service, the alias transaction is attached under this user ID. The value of this parameter is used to define the USERID attribute of the URIMAP resource when it is created automatically using the PIPELINE scan command.

Acceptable characters:
`A-Z a-z 0-9 $ @ #`

WSBIND=*value*
The fully qualified z/OS UNIX name of the Web service binding file. DFHWS2LS creates the file, but not the directory structure, if it does not already exist. The file extension defaults to `.wsbind`.

WSDL=*value*
The fully qualified z/OS UNIX name of the file that contains the Web service description.

WSDL-SERVICE=*value*
Specifies the `wsdl:Service` element that is used when the Web service description contains more than one Service element for a Binding element. If you specify a value for the **BINDING** parameter, the Service element that you specify for this parameter must be consistent with the specified Binding element. You can use this parameter with either WSDL 1.1 or WSDL 2.0 documents.

XML-ONLY=**TRUE**|**FALSE**
Specifies whether or not CICS transforms the XML in the SOAP message to application data. Use the XML-ONLY parameter to write Web service applications that process the XML themselves.

TRUE CICS does not perform any transformations to the XML. The service requester or provider application must work with the contents of the DFHWS-BODY container directly to map data between XML and the high-level language.

FALSE
CICS does transform the XML to a high-level language.

This parameter is available only at runtime level 2.1 onwards.

Other information

- The user ID under which DFHWS2LS runs must be defined to OMVS. The user ID must have read permission to the CICS z/OS UNIX file structure and PDS libraries and write permission to the directories specified on the **LOGFILE** , **WSBIND**, and **WSDL** parameters.
- The user ID must have a sufficiently large storage allocation to run Java.

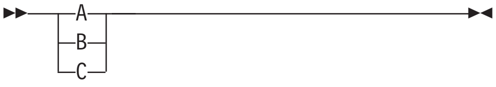
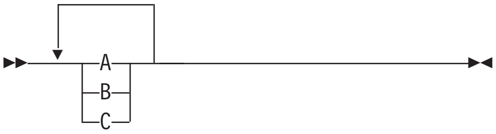
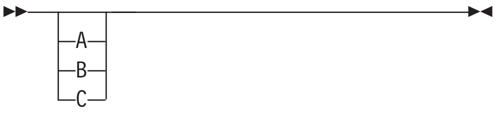
Example

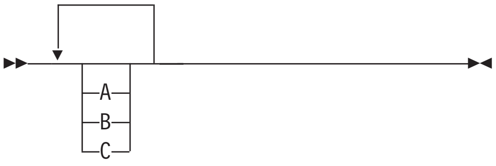
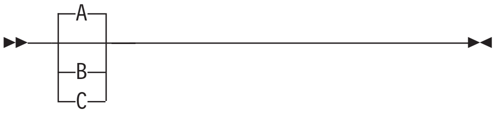
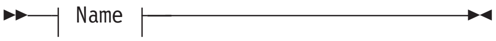
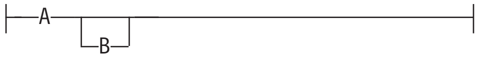
```
//WS2LS JOB  'accounting information',name,MSGCLASS=A
//  SET QT=''''
//JAVAPROG EXEC DFHWS2LS,
// TMPFILE=&QT.&SYSUID.&QT
//INPUT.SYSUT1 DD *
PDSLIB=//CICSHLQ.SDFHSAMP
REQMEM=CPYBK1
RESPMEM=CPYBK2
LANG=COBOL
LOGFILE=/u/exampleapp/wsbind/example.log
MAPPING-LEVEL=2.2
CHAR-VARYING=NULL
INLINE-MAXOCCURS-LIMIT=2
PGMNAME=DFH0XCMN
URI=exampleApp/example
PGMINT=COMMAREA
SYNCONRETURN=YES
WSBIND=/u/exampleapp/wsbind/example.wsbind
WSDL=/u/exampleapp/wsdl/example.wsdl
/*
```

Syntax notation

Syntax notation specifies the permissible combinations of options or attributes that you can specify on CICS commands, resource definitions, and many other things.

The conventions used in the syntax notation are:

Notation	Explanation
	Denotes a set of required alternatives. You must specify one (and only one) of the values shown.
	Denotes a set of required alternatives. You must specify at least one of the values shown. You can specify more than one of them, in any sequence.
	Denotes a set of optional alternatives. You can specify none, or one, of the values shown.

Notation	Explanation
	Denotes a set of optional alternatives. You can specify none, one, or more than one of the values shown, in any sequence.
	Denotes a set of optional alternatives. You can specify none, or one, of the values shown. **A** is the default value that is used if you do not specify anything.
 **Name:** 	A reference to a named section of syntax notation.
	A= denote characters that should be entered exactly as shown. *value* denotes a variable, for which you should specify an appropriate value.

Mapping levels for the CICS Web services assistant

A mapping is the set of rules that specifies how information is converted between language structures and XML schemas. To benefit from the most sophisticated mappings available, you are recommended to set the **MAPPING-LEVEL** parameter to the latest level.

Each level of mapping inherits the function of the previous mapping, with the highest level of mapping offering the best capabilities available. The highest mapping level provides more control over data conversion at run time and removes restrictions on support for certain data types and XML elements. For details of these restrictions for each supported high-level language, see “Data mapping limitations when using the CICS Web services assistant” on page 151.

You can set the **MAPPING-LEVEL** parameter to an earlier level if you want to redeploy applications that were previously enabled at that level.

Mapping level 2.2 and higher

Mapping level 2.2 is compatible with a CICS TS 3.2 region, with APAR PK69738 applied.

At mapping level 2.2 and higher, DFHWS2LS supports the following XML mappings:

- Fixed values for elements
- Substitution groups
- Abstract data types

- <xsd:sequence> elements inside <xsd:choice> elements

DFHWS2LS provides enhanced support for the following XML mappings:

- Abstract elements
- <xsd:choice> elements

Mapping level 2.1 and higher

Mapping level 2.1 is compatible with a CICS TS 3.2 region, with APAR PK59794 applied, and higher.

This mapping level includes greater control over the way variable content is handled with the new **INLINE-MAXOCCURS-LIMIT** parameter and new values on the **CHAR-VARYING** parameter.

At mapping level 2.1 and higher, DFHWS2LS offers the following new and improved support for XML mappings:

- The <xsd:any> element
- The xsd:anyType type
- Abstract elements
- The **INLINE-MAXOCCURS-LIMIT** parameter
- The minOccurs attribute

The **INLINE-MAXOCCURS-LIMIT** parameter specifies whether variably repeating lists are mapped inline. For more information on mapping variably repeating content inline, see “Variable arrays of elements in DFHWS2LS” on page 177.

Support for the minOccurs attribute has been enhanced on the <xsd:sequence>, <xsd:choice> and <xsd:all> elements. If minOccurs="0", the CICS Web services assistant treats these element as though the minOccurs="0" attribute is also an attribute of all its child elements.

At mapping level 2.1 and higher, DFHLS2WS offers the following new and improved support for XML mappings:

- FILLER fields in COBOL and PL/I are ignored
- A value of COLLAPSE for the **CHAR-VARYING** parameter
- A value of BINARY for the **CHAR-VARYING** parameter

FILLER fields in COBOL and PL/I are ignored, they do not appear in the generated XML schema and an appropriate gap is left in the data structures at run time.

COLLAPSE causes CICS to ignore trailing spaces in text fields.

BINARY provides support for binary fields. This value is useful when converting COBOL into an XML schema. This option is available only on SBCS character arrays and allows the array to be mapped to fixed-length xsd:base64Binary fields rather than to xsd:string fields.

Mapping level 1.2 and higher

Mapping level 1.2 is compatible with a CICS TS 3.1 region and higher.

Greater control is available over the way character and binary data are transformed at run time with these additional parameters on the batch tools:

- **CHAR-VARYING**
- **CHAR-VARYING-LIMIT**
- **CHAR-MULTIPLIER**
- **DEFAULT-CHAR-MAXLENGTH**

If you decide to use the **CHAR-MULTIPLIER** parameter in DFHWS2LS, note that the following rules apply after the value of this parameter is used to calculate the amount of space required for character data.

- DFHWS2LS provides these mappings:
  - Variable-length character data types that have a maximum length of more than 32 767 bytes map to a container. You can use the **CHAR-VARYING-LIMIT** parameter to set a lower limit. A 16-byte field is created in the language structure to store the name of the container. At run time, the character data is stored in a container and the container name is put in the language structure.
  - Variable-length character data types that have a maximum length of less than 32 768 bytes map to a VARYING structure for all languages except C/C++ and Enterprise PL/I. In C/C++, these data types are mapped to null-terminated strings, and in Enterprise PL/I these data types are mapped to VARYINGZ structures. You can use the **CHAR-VARYING** parameter to select the way that variable-length character data is mapped.
  - Variable-length binary data that has a maximum length of less than 32 768 bytes maps to a VARYING structure for all languages. If the maximum length is equal to or greater than 32 768 bytes, the data is mapped to a container. A 16-byte field is created in the language structure to store the name of the container. At run time, the binary data is stored in a container and the container name is put in the language structure.

If you have character data types in the XML schema that do not have a length associated with them, you can assign a default length using the **DEFAULT-CHAR-MAXLENGTH** parameter in DFHWS2LS.

DFHLS2WS provides these mappings:

- Character fields map to an `xsd:string` data type and can be processed as fixed-length fields or null-terminated strings at run time. You can use the **CHAR-VARYING** parameter to select the way that variable-length character data is handled at run time for all languages except PL/I.
- Base64Binary data types map to a container if the maximum length of the data is greater than 32 767 bytes or when the length is not defined. If the length of the data is 32 767 or less, the base64Binary data type is mapped to a VARYING structure for all languages.

Mapping level 1.1 and higher

Mapping level 1.1 is compatible with a CICS TS 3.1 region and higher.

This mapping level provides improved mapping of XML character and binary data types, in particular when mapping data of variable length that has `maxLength` and `minLength` attributes defined with different values in the XML schema. Data is handled in the following ways:

- Character and binary data types that have a fixed-length that is greater than 16 MB map to a container for all languages except PL/I. In PL/I, fixed-length character and binary data types that are greater than 32 767 bytes are mapped to a container. A 16-byte field is created in the language structure to store the name of the container. At run time, the fixed-length data is stored in a container and the container name is put in the language structure.

Because containers are variable in length, fixed-length data that is mapped to a container is not padded with spaces or nulls, or truncated, to match the fixed length specified in the XML schema or Web service description. If the length of the data is significant, you can either write your application to check it or, if you are using DFHWS2LS, turn SOAP validation on in the CICS region. Note that SOAP validation has a significant performance impact.

- XML schema `<list>` and `<union>` data types map to character fields.
- Schema-defined XML attributes are mapped rather than ignored. A maximum of 255 attributes is allowed for each XML element. See "Support for XML attributes" on page 181 for further information.
- The `xsi:nil` attribute is supported. See "Support for XML attributes" on page 181 for further information.

Mapping level 1.1 only

Mapping level 1.1 is compatible with a CICS TS 3.1 region and higher.

This mapping level provides improved mapping of XML character and binary data types, in particular when mapping data of variable length that has `maxLength` and `minLength` attributes defined with different values in the XML schema. Data is handled in the following ways:

- Variable-length binary data types map to a container. A 16-byte field is created in the language structure to store the name of the container. At run time, the binary data is stored in a container and the container name is put in the language structure.
- Variable-length character data types that have a maximum length greater than 32 767 bytes map to a container. A 16-byte field is created in the language structure to store the name of the container. At run time, the character data is stored in a container and the container name is put in the language structure.
- Character and binary data types that have a fixed length of less than 16 MB map to fixed-length fields for all languages except PL/I. In PL/I, fixed-length character and binary data types that are 32 767 bytes or less map to fixed-length fields.
- CICS encodes and decodes data in the hexBinary format but not in base64Binary format. Base64Binary data types in the XML schema map to a field in the language structure. The size of the field is calculated using the formula: 4×(ceil(*z*/3)) where:
  - *z* is the length of the data type in the XML schema
  - ceil(*x*) is the smallest integer greater than or equal to *x*

  If the length of *z* is greater than 24 566 bytes, the resulting language structure fails to compile. If you have base64Binary data that is greater than 24 566 bytes, you are recommended to use a mapping level of 1.2. Mapping level 1.2 allows you to map the base64Binary data to a container instead of using a field in the language structure.

Mapping level 1.0 only

Mapping level 1.0 is compatible with a CICS TS 3.1 region and higher.

Note the following limitations, which have been modified in later mapping levels:

- DFHWS2LS maps character and binary data types in the XML schema to fixed-length fields in the language structure. Look at this partial XML schema:

```
<xsd:element name="example">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:maxLength value="33000"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

That partial XML schema appears in a COBOL language structure like this:

```
15 example     PIC X(33000)
```

- CICS encodes and decodes data in the hexBinary format but not in base64Binary format. DFHWS2LS maps Base64Binary data to a fixed-length character field, the contents of which must be encoded or decoded by the application program.
- DFHWS2LS ignores XML attributes during processing.
- DFHLS2WS interprets character and binary fields in the language structure as fixed-length fields and maps those fields to XML elements that have a `maxLength` attribute. At run time, the fields in the language structure are filled with spaces or nulls if insufficient data is available.

High-level language and XML schema mapping

Use the CICS Web services assistant to help you map high-level language structures to WSDL documents, and to map WSDL documents to high-level language structures. When the Web services assistant generates WSDL documents from high-level language data structures, or vice-versa, it generates a mapping between the language structures and the XML data types.

Utility programs DFHWS2LS and DFHLS2WS are collectively known as the CICS Web services assistant:

- DFHLS2WS maps high-level language structures to WSDL documents.
- DFHWS2LS maps WSDL documents to high-level language structures.

The two mappings are not symmetrical:

- If you process a language data structure with DFHLS2WS and then process the resulting WSDL document with the complementary utility program, DFHWS2LS, do not expect the final data structure to be the same as the one you started with. However, the final data structure is logically equivalent to the one that you started with.
- If you process a WSDL document with DFHWS2LS and then process the resulting language structure with the complementary utility program, DFHLS2WS, do not expect the XML schema in the final WSDL document to be the same as the one you started with.
- In some cases, DFHWS2LS generates language structures that are not supported by DFHLS2WS.

You must code language structures processed by DFHLS2WS according to the rules of the language, as implemented in the language compilers that CICS supports.

Related reference

"Data mapping limitations when using the CICS Web services assistant"
CICS supports bidirectional data mappings between high-level language structures and XML schemas, or WSDL documents that conform to WSDL version 1.1 or 2.0, with certain limitations. These limitations apply only to the DFHWS2LS tool and vary according to the mapping level.

Data mapping limitations when using the CICS Web services assistant

CICS supports bidirectional data mappings between high-level language structures and XML schemas, or WSDL documents that conform to WSDL version 1.1 or 2.0, with certain limitations. These limitations apply only to the DFHWS2LS tool and vary according to the mapping level.

Limitations at all mapping levels

- Only SOAP bindings that use literal encoding are supported. Therefore, you must set the `use` attribute to a value of `literal`; `use="encoded"` is not supported.
- Data type definitions must be encoded using the XML Schema Definition language (XSD). In the schema, data types used in the SOAP message must be explicitly declared.
- The length of some keywords in the Web services description is limited. For example, operation, binding, and part names are limited to 255 characters. In some cases the maximum operation name length might be slightly shorter.
- Any SOAP faults defined in the Web service description are ignored. If you want a service provider application to send a SOAP fault message, use the **EXEC CICS SOAPFAULT** command.
- DFHWS2LS supports only a single `<xsd:any>` in a particular scope. For example, the following schema fragment is not supported:

  ```
  <xsd:sequence>
   <xsd:any/>
   <xsd:any/>
  </xsd:sequence>
  ```

  This `<xsd:any>` can specify `minOccurs` and `maxOccurs` if required. For example, the following schema fragment is supported:

  ```
  <xsd:sequence>
   <xsd:any minOccurs="2" maxOccurs="2"/>
  </xsd:sequence>
  ```
- Cyclic references are not supported. For example, where type A contains type B which, in turn, contains type A.
- Recurrence is not generally supported in group elements, such as `<xsd:choice>`, `<xsd:sequence>`, `<xsd:group>`, or `<xsd:all>` elements. For example, the following schema fragment is not supported:

  ```
  <xsd:choice maxOccurs="2">
     <xsd:element name="name1" type="string"/>
  </xsd:choice>
  ```

  The exception to this is at mapping level 2.1 and higher, when `maxOccurs="1"` and `minOccurs="0"` are supported on these elements.
- DFHWS2LS does not support data types and elements in the SOAP message that are derived from the declared data types and elements in the XML schema either from the `xsi:type` attribute or from a substitution group, except at mapping level 2.2 and higher if the parent element or type is defined as abstract.

- Embedded <xsd:sequence> and <xsd:group> elements inside an <xsd:choice> element are not supported prior to mapping level 2.2. Embedded <xsd:choice> and <xsd:all> elements inside an <xsd:choice> element are never supported.

Improved support at mapping level 1.1 and higher

When the mapping level is 1.1 or higher, DFHWS2LS provides support for the following XML elements and element type:

- The <xsd:list> element
- The <xsd:union> element
- The xsd:anySimpleType type
- The <xsd:attribute> element, at mapping level 1.0 this is ignored

Improved support at mapping level 2.1 and higher

When the mapping level is 2.1 or higher, DFHWS2LS supports the following XML elements and element attributes:

- The <xsd:any> element
- The xsd:anyType type
- Abstract elements. In earlier mapping levels abstract elements are only supported as nonterminal types in an inheritance hierarchy.
- The maxOccurs and minOccurs attributes on the <xsd:all>, <xsd:choice>, and <xsd:sequence> elements, only when maxOccurs="1" and minOccurs="0"
- "FILLER" fields in COBOL and "*" fields in PL/I are suppressed. The fields do not appear in the generated WSDL and an appropriate gap is left in the data structures at run time.

Improved support at mapping level 2.2 and higher

When the mapping level is 2.2 or higher, DFHWS2LS provides improved support for the <xsd:choice> element, supporting a maximum of 255 options in the <xsd:choice> element. For more information on <xsd:choice> support, see “Support for <xsd:choice>” on page 185.

At mapping level 2.2 and higher, the CICS Web services assistant support the following XML mappings:

- Substitution groups
- Fixed values for elements
- Abstract data types

Embedded <xsd:sequence> and <xsd:group> elements inside an <xsd:choice> element are supported at mapping level 2.2 and higher. For example, the following schema fragment is supported:

```
<xsd:choice>
   <xsd:element name="name1" type="string"/>
   <xsd:sequence/>
</xsd:choice>
```

If the parent element or type in the SOAP message is defined as abstract, DFHWS2LS supports data types and elements that are derived from the declared data types and elements in the XML schema.

Related reference

"High-level language and XML schema mapping" on page 150
Use the CICS Web services assistant to help you map high-level language structures to WSDL documents, and to map WSDL documents to high-level language structures. When the Web services assistant generates WSDL documents from high-level language data structures, or vice-versa, it generates a mapping between the language structures and the XML data types.

"Mapping levels for the CICS Web services assistant" on page 146
A mapping is the set of rules that specifies how information is converted between language structures and XML schemas. To benefit from the most sophisticated mappings available, you are recommended to set the **MAPPING-LEVEL** parameter to the latest level.

"Support for <xsd:any> and xsd:anyType" on page 183
DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

"Support for abstract elements and abstract data types" on page 188
The CICS Web service assistant provides support for abstract elements and abstract data types at mapping level 2.2 and higher. The Web services assistant maps abstract elements and abstract data types in a similar way to substitution groups.

"Support for substitution groups" on page 187
You can use a substitution group to define a group of XML elements that are interchangeable. The CICS Web services assistant provides support for substitution groups at mapping level 2.2 and higher.

COBOL to XML schema mapping

The DFHLS2WS utility program supports mappings between COBOL data structures and the XML schema definitions that are included in each Web service description.

COBOL names are converted to XML names according to the following rules:

1. Duplicate names are made unique by the addition of one or more numeric digits.

   For example, two instances of `year` become `year` and `year1`.
2. Hyphens are replaced by underscore characters. Strings of contiguous hyphens are replaced by contiguous underscores.

   For example, `current-user--id` becomes `current_user__id`.
3. Segments of names that are delimited by hyphens and that contain only upper case characters are converted to lower case.

   For example, `CA-REQUEST-ID` becomes `ca_request_id`.
4. A leading underscore character is added to names that start with a numeric character.

   For example, `9A-REQUEST-ID` becomes `_9a_request_id`.

DFHLS2WS maps COBOL data description elements to schema elements according to the following table. COBOL data description elements that are not shown in the table are not supported by DFHLS2WS. The following restrictions also apply:

- Data description items with level-numbers of 66 and 77 are not supported. Data description items with a level-number of 88 are ignored.

- The following clauses on data description entries are not supported:

  OCCURS DEPENDING ON
  OCCURS INDEXED BY
  REDEFINES
  RENAMES (that is level 66)
  DATE FORMAT

- The following clauses on data description items are ignored:

  BLANK WHEN ZERO
  JUSTIFIED
  VALUE

- The SIGN clause SIGN TRAILING is supported. The SIGN clause SIGN LEADING is only supported when the mapping level specified in DFHLS2WS is 1.2 or higher.
- SEPARATE CHARACTER is supported at a mapping level of 1.2 or higher for both SIGN TRAILING and SIGN LEADING clauses.
- The following phrases on the USAGE clause are not supported:

  OBJECT REFERENCE
  POINTER
  FUNCTION-POINTER
  PROCEDURE-POINTER

- The following phrases on the USAGE clause are supported at a mapping level of 1.2 or higher.

  COMPUTATIONAL-1
  COMPUTATIONAL-2

- The only PICTURE characters supported for DISPLAY and COMPUTATIONAL-5 data description items are 9, S, and Z.
- The PICTURE characters supported for PACKED-DECIMAL data description items are 9, S, V, and Z.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to NULL, character arrays are mapped to an `xsd:string` and are processed as null-terminated strings.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to BINARY, character arrays are mapped to `xsd:base64Binary` and are processed as binary data.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to COLLAPSE, trailing white space is ignored for strings.

COBOL data description	Schema simpleType

`PIC X(`*n*`)`
`PIC A(`*n*`)`
`PIC G(`*n*`) DISPLAY-1`
`PIC N(`*n*`)`
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:string">`
	`    <xsd:maxlength value="`*n*`"/>`
	`    <xsd:whiteSpace value="preserve"/>`
	`  </xsd:restriction>`
	`</xsd:simpleType>`
	
	where *m*=*n*

COBOL data description	Schema simpleType

PIC S9 DISPLAY
PIC S99 DISPLAY
PIC S999 DISPLAY
PIC S9999 DISPLAY
	<xsd:simpleType>
	  <xsd:restriction base="xsd:short">
	    <xsd:minInclusive value="-*n*"/>
	    <xsd:maxInclusive value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *n* is the maximum value that can be represented by the pattern of '9' characters.

PIC S9(*z*) DISPLAY
 	
where 5 ≤ *z* ≤ 9
	<xsd:simpleType>
	  <xsd:restriction base="xsd:int">
	    <xsd:minInclusive value="-*n*"/>
	    <xsd:maxInclusive value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *n* is the maximum value that can be represented by the pattern of '9' characters.

PIC S9(*z*) DISPLAY
 	
where 9 < *z*
	<xsd:simpleType>
	  <xsd:restriction base="xsd:long">
	    <xsd:minInclusive value="-*n*"/>
	    <xsd:maxInclusive value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *n* is the maximum value that can be represented by the pattern of '9' characters.

PIC 9 DISPLAY
PIC 99 DISPLAY
PIC 999 DISPLAY
PIC 9999 DISPLAY
	<xsd:simpleType>
	  <xsd:restriction base="xsd:unsignedShort">
	    <xsd:minInclusive value="0"/>
	    <xsd:maxInclusive value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *n* is the maximum value that can be represented by the pattern of '9' characters.

PIC 9(*z*) DISPLAY
 	
where 5 ≤ *z* ≤ 9
	<xsd:simpleType>
	  <xsd:restriction base="xsd:unsignedInt">
	    <xsd:minInclusive value="0"/>
	    <xsd:maxInclusive value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *n* is the maximum value that can be represented by the pattern of '9' characters.

PIC 9(*z*) DISPLAY
 	
where 9 < *z*
	<xsd:simpleType>
	  <xsd:restriction base="xsd:unsignedLong">
	    <xsd:minInclusive value="0"/>
	    <xsd:maxInclusive value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *n* is the maximum value that can be represented by the pattern of '9' characters.

COBOL data description	Schema simpleType

PIC S9(*n*) COMP
PIC S9(*n*) COMP-4
PIC S9(*n*) COMP-5
PIC S9(*n*) BINARY
 	
where *n* ≤ 4.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:short">
	  </xsd:restriction>
	</xsd:simpleType>

PIC S9(*n*) COMP
PIC S9(*n*) COMP-4
PIC S9(*n*) COMP-5
PIC S9(*n*) BINARY
 	
where 5 ≤ *n* ≤ 9.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:int">
	  </xsd:restriction>
	</xsd:simpleType>

PIC S9(*n*) COMP
PIC S9(*n*) COMP-4
PIC S9(*n*) COMP-5
PIC S9(*n*) BINARY
 	
where 9 <*n*.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:long">
	  </xsd:restriction>
	</xsd:simpleType>

PIC 9(*n*) COMP
PIC 9(*n*) COMP-4
PIC 9(*n*) COMP-5
PIC 9(*n*) BINARY
 	
where *n* ≤ 4.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:unsignedShort">
	  </xsd:restriction>
	</xsd:simpleType>

PIC 9(*n*) COMP
PIC 9(*n*) COMP-4
PIC 9(*n*) COMP-5
PIC 9(*n*) BINARY
 	
where 5 ≤ *n* ≤ 9.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:unsignedInt">
	  </xsd:restriction>
	</xsd:simpleType>

PIC 9(*n*) COMP
PIC 9(*n*) COMP-4
PIC 9(*n*) COMP-5
PIC 9(*n*) BINARY
 	
where 9 <*n*.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:unsignedLong">
	  </xsd:restriction>
	</xsd:simpleType>

PIC S9(*m*)V9(*n*) COMP-3	<xsd:simpleType>
	  <xsd:restriction base="xsd:decimal">
	    <xsd:totalDigits value="*p*"/>
	    <xsd:fractionDigits value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *p* = *m* + *n*.

PIC 9(*m*)V9(*n*) COMP-3	<xsd:simpleType>
	  <xsd:restriction base="xsd:decimal">
	    <xsd:totalDigits value="*p*"/>
	    <xsd:fractionDigits value="*n*"/>
	    <xsd:minInclusive value="0"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	where *p* = *m* + *n*.

COBOL data description	Schema simpleType

`PIC S9(m)V9(n) DISPLAY`
Supported at mapping level 1.2 only
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:decimal">`
	`    <xsd:totalDigits value="p"/>`
	`    <xsd:fractionDigits value="n"/>`
	`  </xsd:restriction>`
	`</xsd:simpleType>`
	where *p* = *m* + *n*.

`COMP-1`
Supported at mapping level 1.2 only
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:float">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`COMP-2`
Supported at mapping level 1.2 only
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:double">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

Related reference

"XML schema to COBOL mapping"
The DFHWS2LS utility program supports mappings between the XML schema definitions that are included in each Web service description and COBOL data structures.

"Example of how to handle variably repeating content in COBOL" on page 190
In COBOL, you cannot process variably repeating content by using pointer arithmetic to address each instance of the data. Other programming languages do not have this limitation. This example shows you how to handle variably repeating content in COBOL.

XML schema to COBOL mapping

The DFHWS2LS utility program supports mappings between the XML schema definitions that are included in each Web service description and COBOL data structures.

The CICS Web services assistant generates unique and valid names for COBOL variables from the schema element names using the following rules:

1. COBOL reserved words are prefixed with 'X'.

   For example, DISPLAY becomes XDISPLAY.
2. Characters other than A-Z, a-z, 0-9 or hyphen are replaced with 'X'.

   For example, monthly_total becomes monthlyXtotal.
3. If the last character is a hyphen, it is replaced with 'X'.

   For example, ca-request- becomes ca-requestX.
4. If the schema specifies that the variable has varying cardinality (that is, minOccurs and maxOccurs are specified on an xsd:element with different values), and the schema element name is longer than 23 characters, it is truncated to that length.

   If the schema specifies that the variable has fixed cardinality, and the schema element name is longer than 28 characters, it is truncated to that length.
5. Duplicate names in the same scope are made unique by the addition of one or two numeric digits to the second and subsequent instances of the name.

   For example, three instances of year become year, year1 and year2.

6. Five characters are reserved for the strings `-cont` or `-num` which are used when the schema specifies that the variable has varying cardinality; that is, when `minOccurs` and `maxOccurs` are specified with different values.

   For more information, see “Variable arrays of elements in DFHWS2LS” on page 177.
7. For attributes, the previous rules are applied to the element name. The prefix `attr-` is added to the element name, and this is followed by `-value` or `-exist`. If the total length is longer than 28 characters, the element name is truncated. For more information, see “Support for XML attributes” on page 181.

   The nillable attribute has special rules. The prefix `attr-` is added, but `nil-` is also added to the beginning of the element name. The element name is followed by `-value`. If the total length is longer than 28 characters, the element name is truncated.

The total length of the resulting name is 30 characters or less.

DFHWS2LS maps schema types to COBOL data description elements using the specified mapping level according to the following table. You should also note the following points:

- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to NULL, variable-length character data is mapped to null-terminated strings and an extra character is allocated for the null-terminator.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to YES, variable-length character data is mapped to two related elements: a length field and a data field. For example:

  ```
  <xsd:simpleType name="VariableStringType">
     <xsd:restriction base="xsd:string">
         <xsd:minLength value="1"/>
         <xsd:maxLength value="10000"/>
     </xsd:restriction>
  </xsd:simpleType>
  <xsd:element name="textString" type="tns:VariableStringType"/>
  ```

  maps to

  ```
  15 textString-length PIC S9999 COMP-5 SYNC
  15 textString        PIC X(10000)
  ```

Schema simple type	COBOL data description

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:anyType">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 2.0 and below
	Not supported
	Mapping level 2.1
	Supported

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:anySimpletype">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.0
	Not supported
	Mapping level 1.1 and higher
	`PIC X(255)`

Schema simple type	COBOL data description

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:`*type*`"`
`     <xsd:length value="`*z*`"/>`
`  </xsd:restriction>`
`</xsd:simpleType>`
 	
where *type* is one of:
`string`
`normalizedString`
`token`
`Name`
`NMTOKEN`
`language`
`NCName`
`ID`
`IDREF`
`ENTITY`
`hexBinary`
	All mapping levels
	`PIC X(`*z*`)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:`*type*`"`
`  </xsd:restriction>`
`</xsd:simpleType>`
 	
where *type* is one of:
`duration`
`date`
`time`
`gDay`
`gMonth`
`gYear`
`gMonthDay`
`gYearMonth`
	All mapping levels
	`PIC X(32)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:dateTime"`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.2 and below
	`PIC X(32)`
	
	Mapping level 2.0 and higher
	
	`PIC X(40)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:`*type*`">`
`  </xsd:restriction>`
`</xsd:simpleType>`
 	
where *type* is one of:
`byte`
`unsignedByte`
	All mapping levels
	`PIC X DISPLAY`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:short">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	`PIC S9999 COMP-5 SYNC`
	or
	`PIC S9999 DISPLAY`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedShort">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	`PIC 9999 COMP-5 SYNC`
	or
	`PIC 9999 DISPLAY`

Schema simple type	COBOL data description

<xsd:simpleType>
  <xsd:restriction base="xsd:integer">
  </xsd:restriction>
</xsd:simpleType>
	All mapping levels
	PIC S9(18) COMP-3

<xsd:simpleType>
  <xsd:restriction base="xsd:int">
  </xsd:restriction>
</xsd:simpleType>
	All mapping levels
	PIC S9(9) COMP-5 SYNC
	or
	PIC S9(9) DISPLAY

<xsd:simpleType>
  <xsd:restriction base="xsd:unsignedInt">
  </xsd:restriction>
</xsd:simpleType>
	All mapping levels
	PIC 9(9) COMP-5 SYNC
	or
	PIC 9(9) DISPLAY

<xsd:simpleType>
  <xsd:restriction base="xsd:long">
  </xsd:restriction>
</xsd:simpleType>
	All mapping levels
	PIC S9(18) COMP-5 SYNC
	or
	PIC S9(18) DISPLAY

<xsd:simpleType>
  <xsd:restriction base="xsd:unsignedLong">
  </xsd:restriction>
</xsd:simpleType>
	All mapping levels
	PIC 9(18) COMP-5 SYNC
	or
	PIC 9(18) DISPLAY

<xsd:simpleType>
  <xsd:restriction base="xsd:decimal">
    <xsd:totalDigits value="*m*"
    <xsd:fractionDigits value="*n*"
  </xsd:restriction>
</xsd:simpleType>
	All mapping levels
	PIC 9(*p*)V9(*n*) COMP-3
	where *p* = *m* - *n*.

<xsd:simpleType>
  <xsd:restriction base="xsd:boolean">
   </xsd:restriction>
</xsd:simpleType>
	All mapping levels
	PIC X DISPLAY
	The value x'00' implies false, x'01' implies true.

<xsd:simpleType>
  <xsd:list>
     <xsd:simpleType>
         <xsd:restriction base="xsd:int"/>
     </xsd:simpleType>
  </xsd:list>
</xsd:simpleType>
	Mapping level 1.0
	Not supported
	Mapping level 1.1 and higher
	PIC X(255)

<xsd:simpleType> <xsd:union memberTypes="xsd:int xsd:string"/> </xsd:simpleType>	Mapping level 1.0 Not supported Mapping level 1.1 and higher PIC X(255)

Schema simple type	COBOL data description
<xsd:simpleType> <xsd:restriction base="xsd:base64Binary"> <xsd:length value="*z*"/> </xsd:restriction> </xsd:simpleType> <xsd:simpleType> <xsd:restriction base="xsd:base64Binary"> </xsd:restriction> </xsd:simpleType> where the length is not defined.	Mapping level 1.0 Not supported Mapping level 1.1 PIC X(*y*) where *y* =4×(ceil(*z*/3)). ceil(*x*) is the smallest integer greater than or equal to *x*. Mapping level 1.2 and higher PIC X(*z*) where the length is fixed. PIC X(16) where the length is not defined. The field holds the 16-byte name of the container that stores the binary data.

<xsd:simpleType>
  <xsd:restriction base="xsd:float">
  </xsd:restriction>
</xsd:simpletype>
	Mapping level 1.1 and below
	PIC X(32)
	Mapping level 1.2 and higher
	COMP-1

<xsd:simpleType>
  <xsd:restriction base="xsd:double">
  </xsd:restriction>
</xsd:simpletype>
	Mapping level 1.1 and below
	PIC X(32)
	Mapping level 1.2 and higher
	COMP-2

Some of the Schema types shown in the table map to a COBOL format of COMP-5 SYNC or of DISPLAY, depending upon what values (if any) are specified in the `minInclusive` and `maxInclusive` facets:

- For signed types (`short`, `int`, and `long`), DISPLAY is used when the following are specified:

  ```
  <xsd:minInclusive value="-a"/>
  <xsd:maxInclusive value="a"/>
  ```

  where *a* is a string of 9s.
- For unsigned types (`unsignedShort`, `unsignedInt`, and `unsignedLong`), DISPLAY is used when the following are specified:

  ```
  <xsd:minInclusive value="0"/>
  <xsd:maxInclusive value="a"/>
  ```

  where *a* is a string of 9s.

When any other value is specified, or no value is specified, COMP-5 SYNC is used.

Related reference

"COBOL to XML schema mapping" on page 153
The DFHLS2WS utility program supports mappings between COBOL data structures and the XML schema definitions that are included in each Web service description.

"Support for <xsd:any> and xsd:anyType" on page 183
DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

"Example of how to handle variably repeating content in COBOL" on page 190
In COBOL, you cannot process variably repeating content by using pointer arithmetic to address each instance of the data. Other programming languages do not have this limitation. This example shows you how to handle variably repeating content in COBOL.

C and C++ to XML schema mapping

The DFHLS2WS utility program supports mappings between C and C++ data types and the XML schema definitions that are included in each Web service description.

C and C++ names are converted to XML names according to the following rules:

1. Characters that are not valid in XML element names are replaced with 'X'.

   For example, `monthly-total` becomes `monthlyXtotal`.
2. Duplicate names are made unique by the addition of one or more numeric digits.

   For example, two instances of `year` become `year` and `year1`.

DFHLS2WS maps C and C++ data types to schema elements according to the following table. C and C++ types that are not shown in the table are not supported by DFHLS2WS. The following restrictions also apply:

- Header files must contain a top level `struct` instance.
- You cannot declare a structure type that contains itself as a member
- The following C and C++ data types are not supported:
  `decimal`
  `long double`
  `wchar_t` (C++ only)
- The following are ignored if they are present in the header file.

  Storage class specifiers:
  `auto`
  `register`
  `static`
  `extern`
  `mutable`

  Qualifiers
  `const`
  `volatile`
  `_Export` (C++ only)
  `_Packed` (C only)

  Function specifiers
  `inline` (C++ only)
  `virtual` (C++ only)

  Initial values

- The header file must not contain the following:

  Unions

  Class declarations

  Enumeration data types

  Pointer type variables

  Template declarations

  Predefined macros - that is, macros with names which start and end with two underscore characters (__)

  The line continuation sequence (a \ symbol that is immediately followed by a newline character)

  Prototype function declarators

  Preprocessor directives

  Bit fields

  The `__cdecl` (or `_cdecl`) keyword (C++ only)
- The application programmer must use a 32 bit compiler to ensure that an int masp to 4 bytes.
- The following C++ reserved keywords are not supported:

  `explicit`

  `using`

  `namespace`

  `typename`

  `typeid`
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to NULL, character arrays are mapped to an `xsd:string` and are processed as null-terminated strings.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to BINARY, character arrays are mapped to `xsd:base64Binary` and are processed as binary data.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to COLLAPSE, `<xsd:whiteSpace value="collapse"/>` is generated for strings.

C and C++ data type	Schema simpleType
char[*z*]	<xsd:simpleType> <xsd:restriction base="xsd:string"> <xsd:length value="*z*"/> </xsd:restriction> </xsd:simpletype>
char	<xsd:simpleType> <xsd:restriction base="xsd:byte"> </xsd:restriction> </xsd:simpletype>
unsigned char	<xsd:simpleType> <xsd:restriction base="xsd:unsignedByte"> </xsd:restriction> </xsd:simpletype>
short	<xsd:simpleType> <xsd:restriction base="xsd:short"> </xsd:restriction> </xsd:simpletype>

C and C++ data type	Schema simpleType

`unsigned short`	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:unsignedShort">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`int`
`long`
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:int">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`unsigned int`
`unsigned long`
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:unsignedInt">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`long long`	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:long">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`unsigned long long`	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:unsignedLong">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`bool`
(C++ only)
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:boolean">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`float`
Supported at mapping level 1.2 and higher
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:float">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

`double`
Supported at mapping level 1.2 and higher
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:double">`
	`  </xsd:restriction>`
	`</xsd:simpletype>`

Related reference

"XML schema to C and C++ mapping"
The DFHWS2LS utility program supports mappings between the XML schema definitions that are included in each Web service description and C and C++ data types.

XML schema to C and C++ mapping

The DFHWS2LS utility program supports mappings between the XML schema definitions that are included in each Web service description and C and C++ data types.

The CICS Web services assistant generates unique and valid names for C and C++ variables from the schema element names using the following rules:

1. Characters other than A-Z, a-z, 0-9, or _ are replaced with '`X`'.

   For example, `monthly-total` becomes `monthlyXtotal`.
2. If the first character is not an alphabetic character it is replaced by a leading '`X`'.

   For example, `_monthlysummary` becomes `Xmonthlysummary`.
3. If the schema element name is longer than 50 characters, it is truncated to that length.
4. Duplicate names in the same scope are made unique by the addition of one or more numeric digits.

For example, two instances of `year` become `year` and `year1`.

5. Five characters are reserved for the strings `_cont` or `_num` which are used when the schema specifies that the variable has varying cardinality; that is, when `minOccurs` and `maxOccurs` are specified on an `xsd:element`.

   For more information, see "Variable arrays of elements in DFHWS2LS" on page 177.
6. For attributes, the previous rules are applied to the element name. The prefix `attr_` is added to the element name, and this is followed by `_value` or `_exist`. If the total length is longer than 28 characters, the element name is truncated.

   The nillable attribute has special rules. The prefix `attr_` is added, but `nil_` is also added to the beginning of the element name. The element name is followed by `_value`. If the total length is longer than 28 characters, the element name is truncated.

The total length of the resulting name is 57 characters or less.

DFHWS2LS maps schema types to C and C++ data types according to the following table. The following rules also apply:

- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to NULL, variable-length character data is mapped to null-terminated strings.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to YES, variable-length character data is mapped to two related elements: a length field and a data field.

Schema simpleType	C and C++ data type

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:anyType">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 2.0 and below
	Not supported
	Mapping level 2.1 and higher
	Supported (see Note 1)

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:anySimpletype">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.0
	Not supported
	Mapping level 1.1 and higher
	`char[255]`

Schema simpleType	C and C++ data type
<xsd:simpleType> <xsd:restriction base="xsd:*type*"> <xsd:length value="*z*"/> </xsd:restriction> </xsd:simpleType> where *type* is one of: string normalizedString token Name NMTOKEN language NCName ID IDREF ENTITY hexBinary	All mapping levels char[*z*]
<xsd:simpleType> <xsd:restriction base="xsd:*type*"> </xsd:restriction> </xsd:simpleType> where *type* is one of: duration date decimal time gDay gMonth gYear gMonthDay gYearMonth	All mapping levels char[32]
<xsd:simpleType> <xsd:restriction base="xsd:dateTime"> </xsd:restriction> </xsd:simpleType>	Mapping level 1.2 and below char[32] Mapping level 2.0 and higher char[40]

<xsd:simpleType>
  <xsd:restriction base="xsd:byte">
  </xsd:restriction>
</xsd:simpletype>
	All mapping levels
	signed char

<xsd:simpleType>
  <xsd:restriction base="xsd:unsignedByte">
  </xsd:restriction>
</xsd:simpletype>
	All mapping levels
	char

<xsd:simpleType>
  <xsd:restriction base="xsd:short">
  </xsd:restriction>
</xsd:simpletype>
	All mapping levels
	short

Schema simpleType	C and C++ data type

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedShort">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	All mapping levels
	`unsigned short`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:integer">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	All mapping levels
	`char[33]`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:int">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	All mapping levels
	`int`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedInt">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	All mapping levels
	`unsigned int`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:long">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	All mapping levels
	`long long`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedLong">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	All mapping levels
	`unsigned long long`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:boolean">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	All mapping levels
	`bool` (C++ only)
	`short` (C only)

`<xsd:simpleType>`
` <xsd:list>`
`     <xsd:simpleType>`
`         <xsd:restriction base="xsd:int"/>`
`     </xsd:simpleType>`
`  </xsd:list>`
`</xsd:simpleType>`
	Mapping level 1.0
	Not supported
	Mapping level 1.1 and higher
	`char[255]`

`<xsd:simpleType>`
` <xsd:union memberTypes="xsd:int xsd:string"/>`
`</xsd:simpleType>`
	Mapping level 1.0
	Not supported
	Mapping level 1.1 and higher
	`char[255]`

`<xsd:simpleType>`
` <xsd:restriction base="xsd:base64Binary">`
`    <xsd:length value="`*z*`"/>`
` </xsd:restriction>`
`</xsd:simpleType>`
`<xsd:simpleType>`
`  <xsd:restriction base="xsd:base64binary">`
`  </xsd:restriction>`
`</xsd:simpletype>`
where the length is not defined
	Mapping level 1.1 and below
	`char[`*y*`]`
	where *y* =4×(ceil(*z*/3)). ceil(*x*) is the smallest integer greater than or equal to *x*.
	Mapping level 1.2 and higher
	`char[`*z*`]`
	where the length is fixed.
	`char[16]`
	is the name of the container that stores the binary data when the length is not defined.

Schema simpleType	C and C++ data type

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:float">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	Mapping level 1.1 and below
	`char[32]`
	Mapping level 1.2 and higher
	`float(*)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:double">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	Mapping level 1.0 and below
	`char[32]`
	Mapping level 1.2 and higher
	`double(*)`

Related reference

"C and C++ to XML schema mapping" on page 162
The DFHLS2WS utility program supports mappings between C and C++ data types and the XML schema definitions that are included in each Web service description.

"Support for <xsd:any> and xsd:anyType" on page 183
DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

PL/I to XML schema mapping

The DFHLS2WS utility program supports mappings between PL/I data structures and the XML schema definitions that are included in each Web service description. Because there are differences between the Enterprise PL/I compiler and older PL/I compilers two language options are supported, `PLI-ENTERPRISE` and `PLI-OTHER`.

PL/I names are converted to XML names according to the following rules:

1. Characters that are not valid in XML element names are replaced with '`x`'.

   For example, `monthly$total` becomes `monthlyxtotal`.
2. Duplicate names are made unique by the addition of one or more numeric digits.

   For example, two instances of `year` become `year` and `year1`.

DFHLS2WS maps PL/I data types to schema elements according to the following table. PL/I types that are not shown in the table are not supported by DFHLS2WS. The following restrictions also apply:

- Data items with the COMPLEX attribute are not supported.
- Data items with the FLOAT attribute are supported at a mapping level of 1.2 or higher. Enterprise PL/I FLOAT IEEE is not supported.
- VARYING and VARYINGZ pure DBCS strings are supported at a mapping level of 1.2 or higher.
- Data items specified as DECIMAL(*p*,*q*) are supported only when $p \geq q$
- Data items specified as BINARY(*p*,*q*) are supported only when $q = 0$.
- If the PRECISION attribute is specified for a data item, it is ignored.
- PICTURE strings are not supported.
- ORDINAL data items are treated as FIXED BINARY(7) data types.

- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to NULL, character arrays are mapped to an `xsd:string` and are processed as null-terminated strings; this does not apply for Enterprise PL/I.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to BINARY, character arrays are mapped to `xsd:base64Binary` and are processed as binary data.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to COLLAPSE, `<xsd:whiteSpace value="collapse"/>` is generated for strings.

DFHLS2WS does not fully implement the padding algorithms of PL/I, and therefore you must declare padding bytes explicitly in your data structure. DFHLS2WS issues a message if it detects that padding bytes are missing. Each top level structure must start on a double word boundary and each byte within the structure must be mapped to the correct boundary. Consider this code fragment:

```
3 FIELD1 FIXED BINARY(7),
3 FIELD2 FIXED BINARY(31),
3 FIELD3 FIXED BINARY(63);
```

In this example:

- FIELD1 is 1 byte long and can be aligned on any boundary.
- FIELD2 is 4 bytes long and must be aligned on a full word boundary.
- FIELD3 is 8 bytes long and must be aligned on a double word boundary.

The Enterprise PL/I compiler aligns FIELD3 first, because it has the strongest boundary requirements. It then aligns FIELD2 at the fullword boundary immediately before FIELD3, and FIELD1 at the byte boundary immediately before FIELD3. Finally, so that the entire structure will be aligned at a fullword boundary, the compiler inserts three padding bytes immediately before FIELD1.

Because DFHLS2WS does not insert equivalent padding bytes, you must declare them explicitly before the structure is processed by DFHLS2WS. For example:

```
3 PAD1   FIXED BINARY(7),
3 PAD2   FIXED BINARY(7),
3 PAD3   FIXED BINARY(7),
3 FIELD1 FIXED BINARY(7),
3 FIELD2 FIXED BINARY(31),
3 FIELD3 FIXED BINARY(63);
```

Alternatively, you can change the structure to declare all the fields as unaligned and recompile the application which uses the structure. For further information on PL/I structural memory alignment requirements refer to *Enterprise PL/I Language Reference*.

PL/I data description	Schema

`FIXED BINARY (n)`
where *n* ≤ 7
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:byte"/>`
	`</xsd:simpleType>`

`FIXED BINARY (n)`
where 8 ≤ *n* ≤ 15
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:short"/>`
	`</xsd:simpleType>`

`FIXED BINARY (n)`
where 16 ≤ *n* ≤ 31
	`<xsd:simpleType>`
	`  <xsd:restriction base="xsd:int"/>`
	`</xsd:simpleType>`

PL/I data description	Schema

`FIXED BINARY (n)`
where 32 ≤ *n* ≤ 63
Restriction: Enterprise PL/I only
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:long"/>`
	`</xsd:simpleType>`

`UNSIGNED FIXED BINARY(n)`
where *n* ≤ 8
Restriction: Enterprise PL/I only
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:unsignedByte"/>`
	`</xsd:simpleType>`

`UNSIGNED FIXED BINARY(n)`
where 9 ≤ *n* ≤ 16
Restriction: Enterprise PL/I only
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:unsignedShort"/>`
	`</xsd:simpleType>`

`UNSIGNED FIXED BINARY(n)`
where 17 ≤ *n* ≤ 32
Restriction: Enterprise PL/I only
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:unsignedInt"/>`
	`</xsd:simpleType>`

`UNSIGNED FIXED BINARY(n)`
where 33 ≤ *n* ≤ 64
Restriction: Enterprise PL/I only
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:unsignedLong"/>`
	`</xsd:simpleType>`

`FIXED DECIMAL(n,m)`	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:decimal">`
	`<xsd:totalDigits value="n"/>`
	`<xsd:fractionDigits value="m"/>`
	`</xsd:restriction>`
	`</xsd:simpleType>`

`BIT(n)`
where *n* is a multiple of 8. Other values are not supported.
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:hexBinary">`
	`<xsd:length value="m"/>`
	`</xsd:restriction>`
	`</xsd:simpleType>`
	where `m = n/8`

`CHARACTER(n)`
`VARYING` and `VARYINGZ` are also supported at mapping level 1.2 and higher.
Restriction: `VARYINGZ` is only supported by Enterprise PL/I
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:string">`
	`<xsd:maxLength value="n"/>`
	`<xsd:whiteSpace value="preserve"/>`
	`</xsd:restriction>`
	`</xsd:simpleType>`

`GRAPHIC(n)`
`VARYING` and `VARYINGZ` are also supported at mapping level 1.2 and higher.
Restriction: `VARYINGZ` is only supported by Enterprise PL/I
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:hexBinary">`
	`<xsd:length value="m"/>`
	`</xsd:restriction>`
	`</xsd:simpleType>`
	at a mapping level of 1.0 and 1.1, where `m = 2*n`
	`<xsd:simpleType>`
	`<xsd:restriction base="xsd:string">`
	`<xsd:length value="n"/>`
	`<xsd:whiteSpace value="preserve"/>`
	`</xsd:restriction>`
	`</xsd:simpleType>`
	at a mapping level of 1.2 or higher

PL/I data description	Schema

WIDECHAR(*n*)
Restriction: Enterprise PL/I only
	<xsd:simpleType>
	  <xsd:restriction base="xsd:hexBinary">
	    <xsd:length value="*m*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	at a mapping level of 1.0 and 1.1, where *m* = 2**n*
	<xsd:simpleType>
	  <xsd:restriction base="xsd:hexBinary">
	    <xsd:length value="*n*"/>
	  </xsd:restriction>
	</xsd:simpleType>
	
	at a mapping level of 1.2 or higher

ORDINAL **Restriction:** Enterprise PL/I only	<xsd:simpleType> <xsd:restriction base="xsd:byte"/> </xsd:simpleType>

BINARY FLOAT(*n*) where *n* <= 21
 	
Supported at mapping level 1.2 and higher.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:float">
	  </xsd:restriction>
	</xsd:simpletype>

BINARY FLOAT(*n*) where 21 < *n* <= 53
 	
Values greater than 53 are not supported.
 	
Supported at mapping level 1.2 and higher.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:double">
	  </xsd:restriction>
	</xsd:simpletype>

DECIMAL FLOAT(*n*)where *n* <= 6
 	
Supported at mapping level 1.2 and higher.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:float">
	  </xsd:restriction>
	</xsd:simpletype>

DECIMAL FLOAT(*n*)where 6 < *n* <= 16
 	
Values greater than 16 are not supported.
 	
Supported at mapping level 1.2 and higher.
	<xsd:simpleType>
	  <xsd:restriction base="xsd:double">
	  </xsd:restriction>
	</xsd:simpletype>

Related reference

"XML schema to PL/I mapping"
The DFHWS2LS utility program supports mappings between the XML schema definitions that are included in each Web service description and the PL/I data structures. Because there are differences between the Enterprise PL/I compiler and older PL/I compilers two language options are supported, PLI-ENTERPRISE and PLI-OTHER.

XML schema to PL/I mapping

The DFHWS2LS utility program supports mappings between the XML schema definitions that are included in each Web service description and the PL/I data structures. Because there are differences between the Enterprise PL/I compiler and older PL/I compilers two language options are supported, PLI-ENTERPRISE and PLI-OTHER.

The CICS Web services assistant generates unique and valid names for PL/I variables from the schema element names using the following rules:

1. Characters other than A-Z, a-z, 0-9, @ # or $ are replaced with 'X'.

   For example, monthly-total becomes monthlyXtotal.

2. If the schema specifies that the variable has varying cardinality (that is, minOccurs and maxOccurs attributes are specified with different values on the xsd:element), and the schema element name is longer than 24 characters, it is truncated to that length.

   If the schema specifies that the variable has fixed cardinality, and the schema element name is longer than 29 characters, it is truncated to that length.

3. Duplicate names in the same scope are made unique by the addition of one or more numeric digits to the second and subsequent instances of the name.

   For example, three instances of year become year, year1 and year2.

4. Five characters are reserved for the strings _cont or _num which are used when the schema specifies that the variable has varying cardinality; that is, when minOccurs and maxOccurs attributes are specified with different values.

   For more information, see "Variable arrays of elements in DFHWS2LS" on page 177.

5. For attributes, the previous rules are applied to the element name. The prefix attr- is added to the element name, and this is followed by -value or -exist. If the total length is longer than 28 characters, the element name is truncated. For more information, see "Support for XML attributes" on page 181.

   The nillable attribute has special rules. The prefix attr- is added, but nil- is also added to the beginning of the element name. The element name is followed by -value. If the total length is longer than 28 characters, the element name is truncated.

The total length of the resulting name is 31 characters or less.

DFHWS2LS maps schema types to PL/I data types according to the following table. You should also note the following points:

- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is set to NULL, variable-length character data is mapped to null-terminated strings and an extra character is allocated for the null-terminator.
- If the **MAPPING-LEVEL** parameter is set to 1.2 or higher and the **CHAR-VARYING** parameter is not specified, by default variable-length character data is mapped to a VARYINGZ data type for Enterprise PL/I and VARYING data type for Other PL/I.
- Variable-length binary data is mapped to a VARYING data type if it less than 32 768 bytes and a container if it is more than 32 768 bytes.

Schema	PL/I data description

<xsd:simpleType>
  <xsd:restriction base="xsd:anyType">
  </xsd:restriction>
</xsd:simpleType>
	Mapping level 2.0 and below
	Not supported
	Mapping level 2.1 and higher
	Supported

<xsd:simpleType>
  <xsd:restriction base="xsd:anySimpletype">
  </xsd:restriction>
</xsd:simpleType>
	Mapping level 1.1 and higherCHAR(255)

Schema	PL/I data description

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:type">`
`    <xsd:maxLength value="z"/>`
`    <xsd:whiteSpace value="preserve"/>`
`  </xsd:restriction>`
`</xsd:simpleType>`
where *type* is one of:
`string`
`normalizedString`
`token`
`Name`
`NMTOKEN`
`language`
`NCName`
`ID`
`IDREF`
`ENTITY`
	All mapping levels`CHARACTER(z)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:type">`
`  </xsd:restriction>`
`</xsd:simpleType>`
where *type* is one of:
`duration`
`date`
`time`
`gDay`
`gMonth`
`gYear`
`gMonthDay`
`gYearMonth`
	All mapping levels`CHAR(32)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:dateTime">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.2 and below
	`CHAR(32)`
	Mapping level 2.0 and higher
	`CHAR(40)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:hexBinary">`
`    <xsd:length value="y"/>`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.1 and below
	`BIT(z)`
	where $z = 8 \times y$ and $z < 4095$ bytes.
	`CHAR(z)`
	where $z = 8 \times y$ and $z > 4095$ bytes.
	Mapping levels 1.2 and higher
	`CHAR(y)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:byte">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	Enterprise PL/I
	`SIGNED FIXED BINARY (7)`
	Other PL/I
	`FIXED BINARY (7)`

Schema	PL/I data description

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedByte">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	Enterprise PL/I
	`UNSIGNED FIXED BINARY (8)`
	Other PL/I
	`FIXED BINARY (8)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:short">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	Enterprise PL/I
	`SIGNED FIXED BINARY (15)`
	Other PL/I
	`FIXED BINARY (15)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedShort">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	Enterprise PL/I
	`UNSIGNED FIXED BINARY (16)`
	Other PL/I
	`FIXED BINARY (16)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:integer">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	Enterprise PL/I
	`FIXED DECIMAL(31,0)`
	Other PL/I
	`FIXED DECIMAL(15,0)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:int">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levels
	Enterprise PL/I
	`SIGNED FIXED BINARY (31)`
	Other PL/I
	`FIXED BINARY (31)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedInt">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.1 and below
	Enterprise PL/I
	`UNSIGNED FIXED BINARY(32)`
	Mapping level 1.2 and higher
	Enterprise PL/I
	`CHAR(`*y*`)`
	where *y* is a fixed length that is less than 16MB.
	All mapping levels
	Other PL/I
	`BIT(64)`

Schema	PL/I data description

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:long">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.1 and below
	Enterprise PL/I
	SIGNED FIXED BINARY(63)
	Mapping level 1.2 and higher
	Enterprise PL/I
	CHAR(*y*)
	where *y* is a fixed length that is less than 16MB.
	All mapping levels
	Other PL/I
	BIT(64)

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:unsignedLong">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.1 and below
	Enterprise PL/I
	UNSIGNED FIXED BINARY(64)
	Mapping level 1.2 and higher
	Enterprise PL/I
	CHAR(*y*)
	where *y* is a fixed length that is less than 16MB.
	All mapping levels
	Other PL/I
	BIT(64)

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:boolean">`
`  </xsd:restriction>`
`</xsd:simpleType>`
	Mapping level 1.1 and below
	Enterprise PL/I
	SIGNED FIXED BINARY (7)
	Other PL/I
	FIXED BINARY (7)
	Mapping level 1.2 and higher
	Enterprise PL/I
	BIT(7)
	BIT(1)
	Other PL/I
	BIT(7)
	BIT(1)
	where BIT(7) is provided for alignment and BIT(1) contains the boolean mapped value.

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:decimal">`
`    <xsd:totalDigits value="`*n*`"/>`
`    <xsd:fractionDigits value="`*m*`"/>`
`  </xsd:restriction>`
`</xsd:simpleType>`
	All mapping levelsFIXED DECIMAL(*n*,*m*)

Schema	PL/I data description

`<xsd:simpleType>`
`  <xsd:list>`
`     <xsd:simpleType>`
`         <xsd:restriction base="xsd:int"/>`
`     </xsd:simpleType>`
`  </xsd:list>`
`</xsd:simpleType>`
	All mapping levels`CHAR(255)`

`<xsd:simpleType>`
`  <xsd:union memberTypes="xsd:int xsd:string"/>`
`</xsd:simpleType>`
	All mapping levels`CHAR(255)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:base64Binary">`
`    <xsd:length value="`*y*`"/>`
`  </xsd:restriction>`
`</xsd:simpleType>`
`<xsd:simpleType>`
`  <xsd:restriction base="xsd:base64Binary">`
`  </xsd:restriction>`
`</xsd:simpleType>`
where the length is not defined
	Mapping level 1.0
	Not supported
	Mapping level 1.1
	`CHAR(`*z*`)`
	where *z* =4×(ceil(*y*/3)). ceil(*x*) is the smallest integer greater than or equal to *x*.
	Mapping level 1.2 and higher
	`CHAR(`*y*`)`
	where the length is fixed.
	`CHAR(16)`
	where the length is not defined. The field holds the 16-byte name of the container that stores the binary data.

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:float">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	Mapping levels 1.0 and 1.1
	`CHAR(32)`
	Mapping level 1.2 and higher
	Enterprise PL/I
	`DECIMAL FLOAT(6) HEXADEC`
	Other PL/I
	`DECIMAL FLOAT(6)`

`<xsd:simpleType>`
`  <xsd:restriction base="xsd:double">`
`  </xsd:restriction>`
`</xsd:simpletype>`
	Mapping levels 1.0 and 1.1
	`CHAR(32)`
	Mapping level 1.2 and higher
	Enterprise PL/I
	`DECIMAL FLOAT(16) HEXADEC`
	Other PL/I
	`DECIMAL FLOAT(16)`

Related reference

"PL/I to XML schema mapping" on page 168
The DFHLS2WS utility program supports mappings between PL/I data structures and the XML schema definitions that are included in each Web service description. Because there are differences between the Enterprise PL/I compiler and older PL/I compilers two language options are supported, `PLI-ENTERPRISE` and `PLI-OTHER`.

"Support for <xsd:any> and xsd:anyType" on page 183
DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

Variable arrays of elements in DFHWS2LS

A SOAP message can contain an array with varying numbers of elements. In general, WSDL documents that contain varying numbers of elements do not map efficiently into a single high-level language data structure. CICS uses container-based mappings or inline mappings to handle varying numbers of elements in SOAP messages.

An array with a varying number of elements is represented in the XML schema by using the `minOccurs` and `maxOccurs` attributes on the element declaration:

> The `minOccurs` attribute specifies the minimum number of times the element can occur. It can have a value of 0 or any positive integer.
>
> The `maxOccurs` attribute specifies the maximum number of time the element can occur. It can have a value of any positive integer greater than or equal to the value of the `minOccurs` attribute. It can also take a value of `unbounded`, which indicates that there is no upper limit to the number of times the element can occur.

The default value for both attributes is 1.

This example denotes an 8-byte string that is optional, that is, it can occur zero or one times in the SOAP message:

```
<xsd:element name="component" minOccurs="0" maxOccurs="1">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:length value="8"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

The following example denotes a 8-byte string that must occur at least once:

```
<xsd:element name="component" minOccurs="1" maxOccurs="unbounded">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:length value="8"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

In general, WSDL documents that contain varying numbers of elements do not map efficiently into a single high-level language data structure. Therefore, to handle these cases, CICS uses a series of connected data structures that are passed to the application program in a series of containers. These structures are used as input and output from the application. When CICS receives a SOAP message, it is responsible for populating these structures and the application is responsible for reading them. Where CICS is sending a SOAP message, the application is responsible for populating these structures and CICS is responsible for reading them.

The format of these data structures is best explained with a series of examples. These examples use an array of simple 8-byte fields. However, the model supports arrays of complex data types and arrays of data types that contain other arrays.

Fixed number of elements

The first example illustrates an element that occurs exactly three times:

```
<xsd:element name="component" minOccurs="3" maxOccurs="3">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:length value="8"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

In this example, because the number of times that the element occurs is known in advance, it can be represented as a fixed length array in a simple COBOL declaration (or the equivalent in other languages):

```
05 component PIC X(8) OCCURS 3 TIMES
```

Varying number of elements at mapping level 2 and below

This example illustrates a mandatory element that can occur from one to five times.

```
<xsd:element name="component" minOccurs="1" maxOccurs="5">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:length value="8"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

The main data structure contains a declaration of two fields. At run time, the first field `component-num` contains the number of times that the element appears in the SOAP message, and the second field, `component-cont`, contains the name of a container.

```
05 component-num PIC S9(9) COMP-5
05 component-cont PIC X(16)
```

A second data structure contains the declaration of the element itself:

```
01 DFHWS-component
  02 component PIC X(8)
```

You must examine the value of `component-num` (which will contain a value in the range 1-5) to find out how many times the element occurs. The element contents are located in the container named in `component-cont`, the container holds an array of elements, where each element is mapped by the `DFHWS-component` data structure.

If `minOccurs="0"` and `maxOccurs="1"` the element is optional. To process the data structure in your application program, you must examine the value of `component-num`. If it is zero, there is no component element in the message, and the contents of `component-cont` is undefined. If it is one, the component element is in the container named in `component-cont`. The contents of the container are mapped by the `DFHWS-component` data structure.

Note: If the SOAP message consists of a single recurring element, DFHWS2LS generates two language structures. The main language structure contains the number of elements in the array and the name of a container which holds the array of elements. The second language structure maps a single instance of the recurring element.

Varying number of elements at mapping level 2.1 and above

At mapping level 2.1 and above, DFHWS2LS includes the **INLINE-MAXOCCURS-LIMIT** parameter. The **INLINE-MAXOCCURS-LIMIT** parameter specifies the way that varying numbers of elements are handled. The mapping options for varying numbers of elements are container-based mapping, described in the "Varying number of elements at mapping level 2 and below" on page 178 section, or inline mapping. The *value* of this parameter can be a positive integer in the range 0 - 32 767:

The default value of **INLINE-MAXOCCURS-LIMIT** is `1`, this ensures that optional elements are mapped inline.

A value of `0` for the **INLINE-MAXOCCURS-LIMIT** parameter means that inline mapping never occurs.

If `maxOccurs` is less than or equal to the value of **INLINE-MAXOCCURS-LIMIT**, inline mapping is used.

If `maxOccurs` is greater than the value of **INLINE-MAXOCCURS-LIMIT**, container-based mapping, is used.

Mapping varying numbers of elements inline results in the generation of both an array, as happens with the fixed occurrence example above, and a counter. The `component-num` field indicates how many instances of the element are present, and these are addressed via the array. For the example shown in the "Varying number of elements at mapping level 2 and below" on page 178 section, when **INLINE-MAXOCCURS-LIMIT** is less than or equal to 5, the generated data structure is:

```
05 component-num PIC S9(9) COMP-5 SYNC.
05 component OCCURS 5 PIC X(8).
```

The first field, `component-num`, is identical to the output for the container-based mapping example in the previous section. The second field contains an array of length 5 which is large enough to contain the maximum number of elements that could be generated.

Inline mapping differs from container-based mapping, which stores the number of occurrences of the element and the name of the container where the data is placed, because it stores all the data in the current container. Storing the data in the current container will generally improve performance and make inline mapping preferable.

Nested variable arrays

Complex WSDL documents may contain variably recurring elements which in turn contain variably recurring elements. When this is the case, the structure described is extended beyond the two levels described in the examples.

This example illustrates an optional element (`<component2>`) nested in a mandatory element (`<component1>`) that can occur from one to five times.

```
<xsd:element name="component1" minOccurs="1" maxOccurs="5">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="component2" minOccurs="0" maxOccurs="1">
        <xsd:simpleType>
          <xsd:restriction base="xsd:string">
```

```
            <xsd:length value="8"/>
          </xsd:restriction>
        </xsd:simpleType>
      </xsd:element>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
```

The top level data structure is exactly the same as in the previous examples:

```
05 component1-num PIC S9(9) COMP-5
05 component1-cont PIC X(16)
```

But the second data structure contains:

```
01 DFHWS-component1
  02 component2-num PIC S9(9) COMP-5
  02 component2-cont PIC X(16)
```

And a third level structure contains:

```
01 DFHWS-component2
  02 component2 PIC X(8)
```

The number of occurrences of the outermost element (`<component1>`) is in `component1-num`.

The container named in `component1-cont` contains an array with that number of instances of the second data structure (`DFHWS-component1`).

Each instance of `component2-cont` names a different container, each of which contains the data structure mapped by the third level structure (`DFHWS-component2`).

To illustrate this, consider the fragment of XML that matches the example:

```
<component1><component2>string1</component2></component1>
<component1><component2>string2</component2></component1>
<component1></component1>
```

There are three instances of `<component1>`. The first two each contain an instance of `<component2>`; the third instance does not.

In the top level data structure, `component1-num` contains a value of 3. In the container named in `component1-cont` are three instances of `DFHWS-component1`:

1. In the first, `component2-num` has a value of 1, and the container named in `component2-cont` holds *string1*.
2. In the second, `component2-num` has a value of 1, and the container named in `component2-cont` holds *string2*.
3. In the third, `component2-num` has a value of 0, and the contents of `component2-cont` is undefined.

In this instance, the complete data structure is represented by four containers in all:

- The root data structure in container DFHWS-DATA.
- The container named in `component1-cont`.
- Two containers named in the first two instances of `component2-cont`.

Optional structures and xsd:choice

DFHWS2LS supports the use of `maxOccurs` and `minOccurs` on `xsd:sequence`, `xsd:choice` and `xsd:all` elements only at mapping level 2.1, and above where the minOccurs and maxOccurs attributes are set to minOccurs="0" and maxOccurs="1". DFHWS2LS generates mappings that treat these elements as though each child element in them is optional. When you implement an application with these elements take care to ensure that invalid combinations of options are not generated by the application. Each of the elements has its own count field in the generated languages structure, these fields should either all be set to "0" or all be set to"1". Any other combination of values is invalid, except for with xsd:choice elements.

xsd:choice is used to indicate that only one of the options within the element can be used. It is supported at all mapping levels. DFHWS2LS handles each of the options in an xsd:choice as though it is in an xsd:sequence element with minOccurs="0" and maxOccurs="1". Take care when you implement an application using the xsd:choice element to ensure that invalid combinations of options are not generated by the application. Each of the elements has its own count field in the generated languages structure, exactly one of which must be set to '1' and the others must all be set to '0'. Any other combination of values is invalid, except when the xsd:choice is itself optional, in which case it is valid for all of the fields to be set to '0'.

Related reference

"Example of how to handle variably repeating content in COBOL" on page 190
In COBOL, you cannot process variably repeating content by using pointer arithmetic to address each instance of the data. Other programming languages do not have this limitation. This example shows you how to handle variably repeating content in COBOL.

Support for XML attributes

XML schemas can specify attributes that are allowed or required in a SOAP message. The Web services assistant utility DFHWS2LS ignores XML attributes by default. To process XML attributes that are defined in the XML Schema, the value of the **MAPPING-LEVEL** parameter in DFHWS2LS should be 1.1 or higher.

Optional attributes

Attributes can be optional or required and can be associated with any element in the SOAP message. For every optional attribute defined in the schema, two fields are generated in the appropriate language structure.

1. An existence flag - this field is treated as a boolean data type and is typically one byte in length.
2. A value - this field is mapped in the same way as an equivalently typed XML element. For example, an attribute of type NMTOKEN is mapped in the same way as an XML element of type NMTOKEN.

The attribute existence and value fields appear in the generated language structure before the field for the element they are associated with. Unexpected attributes that appear in the instance document are ignored.

For example, consider the following schema attribute definition:

```
<xsd:attribute name="age" type="xsd:short" use="optional" />
```

This optional attribute would be mapped to the following COBOL structure:

```
05 attr-age-exist  PIC X DISPLAY
05 attr-age-value  PIC S9999 COMP-5 SYNC
```

Runtime processing of optional attributes

When CICS receives and reads SOAP messages, the following runtime processing takes place for optional attributes:

- If the attribute is present, the existence flag is set and the value is mapped.
- If the attribute is not present, the existence flag is not set.
- If the attribute has a default value and is present, the value is mapped.
- If the attribute has a default value and is not present, the default value is mapped.

Optional attributes that have default values are treated as required attributes.

When CICS produces a SOAP message based on the contents of a COMMAREA or a container, the following runtime processing takes place:

- If the existence flag is set, the attribute is transformed and included in the message.
- If the existence flag is not set, the attribute is not included in the message.

Required attributes and runtime processing

For every attribute that is required, only the value field is generated in the appropriate language structure.

When CICS receives and reads SOAP messages at run time, if the attribute is present then the value is mapped. If the attribute is not present:

- As the provider, CICS generates a SOAP fault message indicating there is an error in the client's SOAP message.
- As the requester, CICS returns a conversion error resp2 code of 13 to the application.

When CICS produces a SOAP message based on the contents of a COMMAREA or container, the attribute is transformed and included in the message.

The nillable attribute

The nillable attribute is a special attribute that can appear on an `xsd:element` within an XML schema. It specifies that the `xsi:nil` attribute is valid for the element in a SOAP message. If an element has the `xsi:nil` attribute specified, it indicates that the element is present but has no value, and therefore no content is associated with it.

If an XML schema has defined the nillable attribute as true, then it is mapped as a required attribute that takes a boolean value.

In runtime processing, when CICS receives a SOAP message and reads an `xsi:nil` attribute:

- The value of the attribute is true or false.
- If the value is true, the values of the element or nested elements within the scope of the `xsi:nil` attribute must be ignored by the application.

When CICS produces a SOAP message based on the contents of a COMMAREA or container for which the value for the `xsi:nil` attribute is true:

- The `xsi:nil` attribute is generated into the SOAP message.
- The value of the associated element is ignored.

- Any nested elements within the element are ignored.

Consider the following example XML schema, which could be part of a WSDL document:

```
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
 <xsd:element name="root" nillable="true">
  <xsd:complexType>
   <xsd:sequence>
    <xsd:element nillable="true" name="num" type="xsd:int"  maxOccurs="3" minOccurs="3"/>
   </xsd:sequence>
  </xsd:complexType>
 </xsd:element>
</xsd:schema>
```

An example of a partial SOAP message that conforms to this schema is:

```
<root xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
 <num xsi:nil="true"/>
 <num>15</num>
 <num xsi:nil="true"/>
</root>
```

In COBOL, this SOAP message would map to:

```
05    root
10    attr-nil-root-value  PIC X DISPLAY
10    num                  OCCURS 3
15    num1                 PIC S9(9) COMP-5 SYNC
15    attr-nil-num-value   PIC X DISPLAY
10    filler               PIC X(3)
```

Support for <xsd:any> and xsd:anyType

DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

Before you can use `<xsd:any>` and `xsd:anyType` with DFHWS2LS you must set the following parameters:

- Set the **MAPPING-LEVEL** parameter to `2.1` or higher.
- In provider mode, set the **PGMINT** parameter to CHANNEL.

<xsd:any> example

This example uses `<xsd:any>` to describe some optional unstructured XML content following the `"Surname"` tag in the `"Customer"` tag:

```
<xsd:element name="Customer">
 <xsd:complexType>
  <xsd:sequence>
   <xsd:element name="Title" type="xsd:string"/>
   <xsd:element name="FirstName" type="xsd:string"/>
   <xsd:element name="Surname" type="xsd:string"/>
   <xsd:any minOccurs="0"/>
  </xsd:sequence>
 </xsd:complexType>
</xsd:element>
```

An example SOAP message that conforms to this XML schema is:

```
<xml version='1.0' encoding='UTF-8'?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
  <SOAP-ENV:Body>
    <Customer xmlns="http://www.example.org/anyExample">
      <Title xmlns="">Mr</Title>
      <FirstName xmlns="">John</FirstName>
      <Surname xmlns="">Smith</Surname>
      <ExtraInformation xmlns="http://www.example.org/ExtraInformation">
        <!-- This 'ExtraInformation' tag is associated with the optional xsd:any from the XML schema
             It can contain any well formed XML. -->
        <ExampleField1>one</ExampleField1>
        <ExampleField2>two</ExampleField2>
      </ExtraInformation>
    </Customer>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

If this SOAP message was sent to CICS, CICS populates the `Customer-xml-cont` container with the following XML data:

```
<ExtraInformation xmlns="http://www.example.org/ExtraInformation">
  <!-- This 'ExtraInformation' tag is associated with the optional xsd:any from the XML schema.
       It can contain any well formed XML. -->
  <ExampleField1>one</ExampleField1>
  <ExampleField2>two</ExampleField2>
</ExtraInformation>
```

CICS also populates the `Customer-xmlns-cont` container with the following in-scope XML namespace declarations:

```
xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"xmlns="http://www.example.org/anyExample"
```

xsd:anyType example

The `xsd:anyType` is the base data type from which all simple and complex data types are derived. It does not restrict the data content. If you do not specify a data type, it defaults to `xsd:anyType`; for example, these two XML fragments are equivalent:

```
<xsd:element name="Name" type="xsd:anyType"/>
```

```
<xsd:element name="Name"/>
```

Generated language structures

The language structures generated for `<xsd:any>` or `xsd:anyType` take the following form in COBOL and an equivalent form for the other languages:

elementName-xml-cont PIC X(16)

The name of a container that holds the raw XML. When CICS processes an incoming SOAP message, it places the subset of the SOAP message that the `<xsd:any>` or `xsd:anyType` defines into this container. The application can only process the XML data natively. The application must generate the XML, populate this container, and supply the container name.

This container must be populated in text mode. If CICS populates this container, it does so using the same variant of EBCDIC as the Web service is defined to use. Characters that do not exist in the target EBCDIC codepage are replaced with substitute characters, even if the container is read by the application in UTF-8.

elementName-xmlns-cont PIC X(16)

The name of a container that holds any in-scope namespace prefix declarations. The contents of this container are similar to those of the

DFHWS-XMLNS container, except that it includes all of the in-scope namespace declarations that are relevant rather than only the subset from the SOAP Envelope tag.

This container must be populated in text mode. If CICS populates this container, it does so using the same variant of EBCDIC as the Web service is defined to use. Characters that do not exist in the target EBCDIC codepage are replaced with substitute characters, even if the container is read by the application in UTF-8.

This container is used only when processing SOAP messages sent to CICS. If the application tries to supply a container with namespace declarations when an output SOAP message is generated, the container and its contents are ignored by CICS. CICS requires that the XML supplied by the application is entirely self-contained with respect to namespace declarations.

For `<xsd:any>`, the two variable names use the enclosing XML element name; in the `<xsd:any>` example, the variable names are `Customer-xml-cont PIC X(16)` and `Customer-xmlns-cont PIC X(16)`. For `xsd:anyType`, the direct XML element name is used; in the `xsd:anyType` example, the variable names are `Name-xml-cont PIC X(16)` and `Name-xmlns-cont PIC X(16)`.

Support for `<xsd:choice>`

An `<xsd:choice>` element indicates that only one of the options in the element can be used. The CICS Web services assistant provides varying degrees of support for `<xsd:choice>` elements at the various mapping levels.

Support for `<xsd:choice>` at mapping level 2.2 and higher

At mapping level 2.2 and higher, DFHWS2LS provides improved support for `<xsd:choice>` elements. The assistant generates a new container that stores the value associated with the `<xsd:choice>` element. The assistant generate language structures containing the name of a new container and an extra field:

fieldname-**enum**
: The discriminating field to indicate which of the options the `<xsd:choice>` element will use.

fieldname-**cont**
: The name of the container that stores the option to be used. A further language structure is generated to map the value of the option.

The following XML schema fragment includes an `<xsd:choice>` element:

```
<xsd:element name="choiceExample">
   <xsd:complexType>
      <xsd:choice>
         <xsd:element name="option1" type="xsd:string" />
         <xsd:element name="option2" type="xsd:int" />
         <xsd:element name="option3" type="xsd:short" maxOccurs="2" minOccurs="2" />
      </xsd:choice>
   </xsd:complexType>
</xsd:element>
```

If this XML schema fragment is processed at mapping level 2.2 or higher, the assistant generates the following COBOL language structures:

```
   03 choiceExample.
      06 choiceExample-enum         PIC X DISPLAY.
          88 empty                     VALUE X'00'.
          88 option1                   VALUE X'01'.
          88 option2                   VALUE X'02'.
          88 option3                   VALUE X'03'.
      06 choiceExample-cont         PIC X(16).


01 Example-option1.
   03 option1-length                PIC S9999 COMP-5 SYNC.
   03 option1                       PIC X(255).

01 Example-option2.
   03 option2                       PIC S9(9) COMP-5 SYNC.

01 Example-option3.
   03 option3 OCCURS 2             PIC S9999 COMP-5 SYNC.
```

Limitations for <xsd:choice> at mapping level 2.2 and higher

DFHWS2LS does not support nested `<xsd:choice>` elements; for example, the following XML is not supported:

```
<xsd:choice>
   <xsd:element name ="name1" type="string"/>
   <xsd:choice>
      <xsd:element name ="name2a" type="string"/>
      <xsd:element name ="name2b" type="string"/>
   </xsd:choice>
</xsd:choice>
```

DFHWS2LS does not support recurring `<xsd:choice>` elements; for example, the following XML is not supported:

```
<xsd:choice maxOccurs="2">
   <xsd:element name ="name1" type="string"/>
</xsd:choice>
```

DFHWS2LS supports a maximum of 255 options in an `<xsd:choice>` element.

Support for `<xsd:choice>` at mapping level 2.1 and below

At mapping level 2.1 and below, DFHWS2LS provides limited support for `<xsd:choice>` elements. DFHWS2LS treats each of the options in an `<xsd:choice>` element as though it is an `<xsd:sequence>` element that can occur at most once.

Only one of the options in an `<xsd:choice>` element can be used, so take care when you implement an application using the `<xsd:choice>` element that you generate only valid combinations of options. Each of the elements has its own `count` field in the generated languages structure, exactly one of which must be set to 1 and the others must all be set to 0. Any other combination of values is incorrect, except when the `<xsd:choice>` is itself optional, in which case it is valid for all of the fields to be set to 0.

Related reference

"Support for <xsd:any> and xsd:anyType" on page 183
DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

"Support for abstract elements and abstract data types" on page 188
The CICS Web service assistant provides support for abstract elements and abstract data types at mapping level 2.2 and higher. The Web services assistant maps abstract elements and abstract data types in a similar way to substitution groups.

"Support for substitution groups"
You can use a substitution group to define a group of XML elements that are interchangeable. The CICS Web services assistant provides support for substitution groups at mapping level 2.2 and higher.

Support for substitution groups

You can use a substitution group to define a group of XML elements that are interchangeable. The CICS Web services assistant provides support for substitution groups at mapping level 2.2 and higher.

At mapping level 2.2 and higher, DFHWS2LS supports substitution groups using similar mappings to those used for `<xsd:choice>` elements. The assistant generates an enumeration field and a new container name in the language structure.

The following XML schema fragment includes an array of two `subGroupParent` elements, each of which can be replaced with `replacementOption1` or `replacementOption2`:

```
<xsd:element name="subGroupExample" >
   <xsd:complexType>
      <xsd:sequence>
         <xsd:element ref="subGroupParent" maxOccurs="2" minOccurs="2" />
      </xsd:sequence>
   </xsd:complexType>
</xsd:element>

<xsd:element name="subGroupParent" type="xsd:anySimpleType" />
<xsd:element name="replacementOption1" type="xsd:int" substitutionGroup="subGroupParent" />
<xsd:element name="replacementOption2" type="xsd:short" substitutionGroup="subGroupParent" />
```

Processing this XML fragment with the assistant generates the following COBOL language structures:

```
   03 subGroupExample.
      06 subGroupParent OCCURS2.
         09 subGroupExample-enum PIC X DISPLAY.
            88 empty              VALUE X '00'.
            88 replacementOption1  VALUE X '01'.
            88 replacementOption2  VALUE X '02'.
            88 subGroupParent      VALUE X '03'.
         09 subGroupExample-cont PIC X (16).



01 Example-replacementOption1.
   03 replacementOption1      PIC S9(9) COMP-5 SYNC.

01 Example-replacementOption2.
   03 replacementOption2      PIC S9999 COMP-5 SYNC.
```

```
01 Example-subGroupParent.
   03 subGroupParent-length   PIC S9999 COMP-5 SYNC.
   03 subGroupParent          PIC X(255).
```

For more information about substitution groups, see the *W3C XML Schema Part 1: Structures Second Edition specification*: http://www.w3.org/TR/xmlschema-1/#Elements_Equivalence_Class

Related reference

"Support for <xsd:any> and xsd:anyType" on page 183
DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

"Support for `<xsd:choice>`" on page 185
An `<xsd:choice>` element indicates that only one of the options in the element can be used. The CICS Web services assistant provides varying degrees of support for `<xsd:choice>` elements at the various mapping levels.

"Support for abstract elements and abstract data types"
The CICS Web service assistant provides support for abstract elements and abstract data types at mapping level 2.2 and higher. The Web services assistant maps abstract elements and abstract data types in a similar way to substitution groups.

Support for abstract elements and abstract data types

The CICS Web service assistant provides support for abstract elements and abstract data types at mapping level 2.2 and higher. The Web services assistant maps abstract elements and abstract data types in a similar way to substitution groups.

Support for abstract elements at mapping level 2.2 and higher

At mapping level 2.2 and above, DFHWS2LS treats abstract elements in almost the same way as substitution groups except that the abstract element is not a valid member of the group. If there are no substitutable elements, the abstract element is treated as an `<xsd:any>` element and uses the same mappings as an `<xsd:any>` element at mapping level 2.1.

The following XML schema fragment specifies two options that can be used in place of the abstract element. The abstract element itself is not a valid option:

```
<xsd:element name="abstractElementExample" >
   <xsd:complexType>
      <xsd:sequence>
         <xsd:element ref="abstractElementParent" maxOccurs="2" minOccurs="2" />
      </xsd:sequence>
   </xsd:complexType>
</xsd:element>

<xsd:element name="abstractElementParent" type="xsd:anySimpleType" abstract="true" />
<xsd:element name="replacementOption1" type="xsd:int" substitutionGroup="abstractElementParent" />
<xsd:element name="replacementOption2" type="xsd:short" substitutionGroup="abstractElementParent" />
```

Processing this XML fragment with the assistant generates the following COBOL language structures:

```
   03 abstractElementExample.
      06 abstractElementParent OCCURS 2.
         09 abstractElementExample-enum  PIC X DISPLAY.
            88 empty                          VALUE X '00'.
            88 replacementOption1             VALUE X '01'.
            88 replacementOption2             VALUE X '02'.
         09 abstractElementExample-cont  PIC X (16).


01 Example-replacementOption1.
   03 replacementOption1                  PIC S9(9) COMP-5 SYNC.

01 Example-replacementOption2.
   03 replacementOption2                  PIC S9999 COMP-5 SYNC.
```

For more information about abstract elements, see the *W3C XML Schema Part 0: Primer Second Edition specification*: http://www.w3.org/TR/xmlschema-0/#SubsGroups

Support for abstract data types at mapping level 2.2 and higher

At mapping level 2.2 and higher, DFHWS2LS treats abstract data types as substitution groups. The assistant generates an enumeration field and a new container name in the language structure.

The following XML schema fragment specifies two alternatives that can be used in place of the abstract type:

```
<xsd:element name="AbstractDataTypeExample" type="abstractDataType" />

<xsd:complexType name="abstractDataType" abstract="true">
   <xsd:simpleContent>
      <xsd:extension base="xsd:string" />
   </xsd:simpleContent>
</xsd:complexType>
<xsd:complexType name="option1">
   <xsd:simpleContent>
      <xsd:restriction base="abstractDataType">
         <xsd:length value="5" />
      </xsd:restriction>
   </xsd:simpleContent>
</xsd:complexType>
<xsd:complexType name="option2">
   <xsd:simpleContent>
      <xsd:restriction base="abstractDataType">
         <xsd:length value="10" />
      </xsd:restriction>
   </xsd:simpleContent>
</xsd:complexType>
```

Processing this XML fragment with the assistant generates the following COBOL language structures:

```
   03 AbstractDataTypeExamp-enum   PIC X DISPLAY.
     88 empty                         VALUE X'00'.
     88 option1                       VALUE X'01'.
     88 option2                       VALUE X'02'.
   03 AbstractDataTypeExamp-cont   PIC X(16).
```

The language structures are generated into separate copybooks. The language structure generated for `option1` is generated into one copybook:

```
   03 option1          PIC X(5).
```

The language structure for `option2` is generated into a different copybook:

```
   03 option2          PIC X(10).
```

For more information about abstract data types, see the *W3C XML Schema Part 0: Primer Second Edition specification*: http://www.w3.org/TR/xmlschema-0/#SubsGroups

Related reference

"Support for <xsd:any> and xsd:anyType" on page 183
DFHWS2LS supports the use of `<xsd:any>` and `xsd:anyType` in the XML schema. You can use the `<xsd:any>` XML schema element to describe a section of an XML document with undefined content. `xsd:anyType` is the base data type from which all simple and complex data types are derived; it has no restrictions or constraints on the data content.

"Support for `<xsd:choice>`" on page 185
An `<xsd:choice>` element indicates that only one of the options in the element can be used. The CICS Web services assistant provides varying degrees of support for `<xsd:choice>` elements at the various mapping levels.

"Support for substitution groups" on page 187
You can use a substitution group to define a group of XML elements that are interchangeable. The CICS Web services assistant provides support for substitution groups at mapping level 2.2 and higher.

Example of how to handle variably repeating content in COBOL

In COBOL, you cannot process variably repeating content by using pointer arithmetic to address each instance of the data. Other programming languages do not have this limitation. This example shows you how to handle variably repeating content in COBOL.

The following example WSDL document represents a Web service with application data that consists of an 8-character string that recurs a variable number of times:

```
<?xml version="1.0"?>
<definitions name="ExampleWSDL"
             targetNamespace="http://www.example.org/variablyRepeatingData/"
             xmlns="http://schemas.xmlsoap.org/wsdl/"
             xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
             xmlns:tns="http://www.example.org/variablyRepeatingData/"
             xmlns:xsd="http://www.w3.org/2001/XMLSchema">

 <types>
   <xsd:schema targetNamespace="http://www.example.org/variablyRepeatingData/">
     <xsd:element name="applicationData">
       <xsd:complexType>
         <xsd:sequence>
           <xsd:element name="component" minOccurs="1" maxOccurs="unbounded">
             <xsd:simpleType>
               <xsd:restriction base="xsd:string">
                 <xsd:length value="8"/>
               </xsd:restriction>
             </xsd:simpleType>
           </xsd:element>
         </xsd:sequence>
       </xsd:complexType>
     </xsd:element>
   </xsd:schema>
 </types>

 <message name="exampleMessage">
   <part element="tns:applicationData" name="messagePart"/>
 </message>

 <portType name="examplePortType">
```

```
   <operation name="exampleOperation">
     <input message="tns:exampleMessage"/>
     <output message="tns:exampleMessage"/>
   </operation>
 </portType>

 <binding name="exampleBinding" type="tns:examplePortType">
   <soap:binding style="document" transport="http://schemas.xmlsoap.org/soap/http"/>
   <operation name="exampleOperation">
     <soap:operation soapAction=""/>
     <input><soap:body parts="messagePart" encodingStyle="" use="literal"/></input>
     <output><soap:body parts="messagePart" encodingStyle="" use="literal"/></output>
   </operation>
 </binding>
</definitions>
```

Processing this WSDL document through DFHWS2LS generates the following COBOL language structures:

```
           03 applicationData.

             06 component-num                 PIC S9(9) COMP-5 SYNC.
             06 component-cont                PIC X(16).


         01 DFHWS-component.
           03 component                     PIC X(8).
```

Note that the 8–character `component` field is defined in a separate structure called `DFHWS-component`. The main data structure is called `applicationData` and it contains two fields, `component-num` and `component-cont`. The `component-num` field indicates how many instances of the `component` data are present and the `component-cont` field indicates the name of a container that holds the concatenated list of `component` fields.

The following COBOL code demonstrates one way to process the list of variably recurring data. It makes use of a linkage section array to address subsequent instances of the data, each of which is displayed by using the `DISPLAY` statement:

```
IDENTIFICATION DIVISION.
       PROGRAM-ID.    EXVARY.

       ENVIRONMENT DIVISION.
       DATA DIVISION.
       WORKING-STORAGE SECTION.

      * working storage variables
       01 APP-DATA-PTR             USAGE IS POINTER.
       01 APP-DATA-LENGTH          PIC S9(8) COMP.
       01 COMPONENT-PTR            USAGE IS POINTER.
       01 COMPONENT-DATA-LENGTH    PIC S9(8) COMP.
       01 COMPONENT-COUNT          PIC S9(8) COMP-4 VALUE 0.
       01 COMPONENT-LENGTH         PIC S9(8) COMP.

       LINKAGE SECTION.

      * a large linkage section array
       01 BIG-ARRAY PIC X(659999).

      * application data structures produced by DFHWS2LS
      * this is normally referenced with a COPY statement
       01 DFHWS2LS-data.
          03 applicationData.
            06 component-num  PIC S9(9) COMP-5 SYNC.
            06 component-cont PIC X(16).
```

```
 01 DFHWS-component.
    03 component        PIC X(8).



 PROCEDURE DIVISION USING DFHEIBLK.
 A-CONTROL SECTION.
 A010-CONTROL.

* Get the DFHWS-DATA container
     EXEC CICS GET CONTAINER('DFHWS-DATA')
               SET(APP-DATA-PTR)
               FLENGTH(APP-DATA-LENGTH)
     END-EXEC
     SET ADDRESS OF DFHWS2LS-data TO APP-DATA-PTR

* Get the recurring component data
     EXEC CICS GET CONTAINER(component-cont)
               SET(COMPONENT-PTR)
               FLENGTH(COMPONENT-DATA-LENGTH)
     END-EXEC

* Point the component structure at the first instance of the data
     SET ADDRESS OF DFHWS-component TO COMPONENT-PTR

* Store the length of a single component
     MOVE LENGTH OF DFHWS-component TO COMPONENT-LENGTH

* process each instance of component data in turn
     PERFORM WITH TEST AFTER
           UNTIL COMPONENT-COUNT = component-num

* display the current instance of the data
        DISPLAY 'component value is: ' component

* address the next instance of the component data
        SET ADDRESS OF BIG-ARRAY TO ADDRESS OF DFHWS-component
        SET ADDRESS OF DFHWS-component
            TO ADDRESS OF BIG-ARRAY (COMPONENT-LENGTH + 1:1)
        ADD 1 TO COMPONENT-COUNT

* end the loop
     END-PERFORM.

* Point the component structure back at the first instance of
* of the data, for any further processing we may want to perform
     SET ADDRESS OF DFHWS-component TO COMPONENT-PTR

* return to CICS.

     EXEC CICS
          RETURN
     END-EXEC

     GOBACK.
```

The code above provides a generic solution to handling variably repeating content. The array, BIG-ARRAY, moves to the start of each component in turn and does not remain fixed at the start of the data. The component data structure is then moved to point at the first byte of the next component. COMPONENT-PTR can be used to recover the start position of the component data if required.

Here is an example SOAP message that conforms to the WSDL document:

```
<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
 <SOAP-ENV:Body>
   <applicationData xmlns="http://www.example.org/variablyRepeatingData/">
     <component xmlns="">VALUE1</component>
     <component xmlns="">VALUE2</component>
     <component xmlns="">VALUE3</component>
   </applicationData>
 </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Here is the output produced by the COBOL program when it processes the SOAP message:

```
CPIH 20080115103151 component value is: VALUE1
CPIH 20080115103151 component value is: VALUE2
CPIH 20080115103151 component value is: VALUE3
```

Creating a Web service provider using the Web services assistant

The CICS Web services assistant simplifies the task of deploying your CICS applications in a service provider setting.

When you use the assistant to deploy a CICS application as a service provider, you have two options:

- Start with a Web service description, and use the assistant to generate the language data structures.

  Use this option when you are implementing a service provider that conforms with an existing Web service description.
- Start with the language data structures, and use the assistant to generate the Web service description.

  Use this option when you are exposing an existing program as a Web service, and are willing to expose aspects of the program's interfaces in the Web service description and the SOAP messages.

Creating a service provider application from a Web service description

Using the CICS Web services assistant, you can create a service provider application from a Web service description that complies with WSDL 1.1 or WSDL 2.0.

Your Web services description must be in a file in z/OS UNIX and a suitable provider mode pipeline must be installed in the CICS region. The user ID under which DFHWS2LS runs must be defined to OMVS. The user ID must have read permission to z/OS UNIX and PDS libraries, and write permission to the directories specified on the **LOGFILE**, **WSBIND**, and **WSDL** parameters. The user ID must also have a sufficiently large storage allocation to run Java.

Follow these steps for the Web service description that you want to use as input.

1. Use batch program DFHWS2LS to generate a Web service binding file, and one or more language data structures. DFHWS2LS contains a large set of optional parameters that provide you with flexibility to create the binding file and language structures that your application requires. The options that you should consider when Web service enabling an existing application are:
   a. What mechanism should CICS use for passing data to the service provider application program? You can opt to use channels and pass the data in containers, or use a COMMAREA. It is recommended that you use channels and containers. Specify this using the **PGMINT** parameter.

b. What language do you want to generate? DFHWS2LS can generate COBOL, C/C++, or PL/I language data structures. Specify this using the **LANG** parameter.

c. What mapping level do you want to use? The higher the mapping level, the more control and support you have available for the handling of character and binary data at run time. Some optional parameters are also only available at the higher mapping levels. It is recommended that you use the highest level of mapping available.

d. What URI do you want the Web service requester to use? Specify a relative URI using the **URI** parameter, for example `URI=/my/test/webservice`. This indicates the URI that CICS associates with your Web service. The value is used by CICS when creating the URIMAP resource.

e. What transaction and user id do you want to use to run the Web service request and response under? You can use an alias transaction to run the application to compose a response to the service requester. The alias transaction is attached under the user ID. Specify this using the **TRANSACTION** and **USERID** parameters. These values are used when creating the URIMAP resource. If you don't want to use a specific transaction, do not use these parameters.

When you submit DFHWS2LS, CICS generates the Web service binding file and places it in the location that you specified using the **WSBIND** parameter. The language structures are placed in the partitioned data set that you specified using the **PDSLIB** parameter.

2. Copy the generated Web service binding file to the pickup directory of the provider mode PIPELINE resource that you want to use for your Web service application. You must copy the binding file in binary mode.
3. Optional: Copy the Web service description to the same directory as the Web service binding file. This allows you to perform validation to test that your Web service is working as expected at run time.
4. Write a service provider application program to interface with the generated language structures and implement the required business logic.
5. Although you can use RDO to create the necessary resources, it is recommended that you use the **PIPELINE SCAN** command to dynamically create the WEBSERVICE and URIMAP resources.
   - The WEBSERVICE resource encapsulates the Web service binding file in CICS and is used at run time.
   - The URIMAP resource tells CICS to associate the WEBSERVICE resource with a specific URI.

If you have any problems submitting DFHWS2LS, or the resources do not install correctly, see “Diagnosing deployment errors” on page 247.

Creating a service provider application from a data structure

Using the CICS Web services assistant, you can create a service provider application from a high-level language data structure.

Before you can process your high-level language data structures, you must ensure that:

- The data structures are defined separately from the source program (for example in a COBOL copy book).
- If your PL/I or COBOL application program uses different data structures for its input and its output, the data structures are defined in two different members in a

partitioned data set. If the same structure is used for input and output, the structure should be defined in a single member.

For C and C++, your data structures can be in the same member in a partitioned data set.

Which data structures you process depend upon whether you are using a wrapper program:

- If you are using a wrapper program, the copy book is the interface to the wrapper program.
- If you are not using a wrapper program, the copy book is the interface to the business logic.

The language structures must be available in a partitioned data set and a suitable pipeline must be installed in the CICS region. The user ID under which DFHLS2WS runs must be defined to OMVS. The user ID must have read permission to z/OS UNIX and PDS libraries, and write permission to the directories specified on the **LOGFILE**, **WSBIND**, and **WSDL** parameters. The user ID must also have a sufficiently large storage allocation to run Java.

1. Use batch program DFHLS2WS to generate a Web service binding file and Web service description from the language structure. DFHLS2WS contains a large set of optional parameters that provide you with flexibility to create the binding file and language structures that your application requires. The options you should consider when Web service enabling an existing application are:
   a. What mechanism should CICS use for passing data to the service provider application program? You can opt to use channels and pass the data in containers, or use a COMMAREA. Specify this using the **PGMINT** parameter.
   b. What level of Web service description (WSDL document) do you want to generate? CICS generates descriptions that comply with either WSDL 1.1 or WSDL 2.0 documents. If you want the service provider application to support requests that comply with both levels of WSDL, specify values for the **WSDL_1.1** and **WSDL_2.0** parameters. Ensure that the file names are different when using more than one WSDL parameter. This produces two Web service descriptions and a binding file.
   c. What version of the SOAP protocol do you want to use? You can specify this using the **SOAPVER** parameter. It is recommended that you use the ALL value. This gives the flexibility to use either SOAP 1.1 or SOAP 1.2 as the binding for the Web service description, although you must install the Web service into a pipeline that is configured with the SOAP 1.2 message handler. You can only use this parameter when the **MINIMUM-RUNTIME-LEVEL** is 2.0.
   d. What mapping level do you want to use? The higher the mapping level, the more control and support you have available for the handling of character and binary data at run time. Some optional parameters are also only available at the higher mapping levels. It is recommended that you use the highest level of mapping available.
   e. What URI do you want the Web service requester to use? Specify an absolute URI using the **URI** parameter, for example `URI=http://www.example.org:80/my/test/webservice`. The relative part of this address, i.e. `/my/test/webservice`, is used when creating the URIMAP resource. The full URI is used as the `soap:address` element in the Web service description. This is true for both HTTP and WMQ URIs.

   When you submit DFHLS2WS, CICS generates the Web service binding file and places it in the location that you specified using the **WSBIND** parameter. The generated Web service description is placed in the location that you specified using the **`WSDL`**, **`WSDL_1.1`**, or **`WSDL_2.0`** parameter.

2. Review the generated Web service description and perform any necessary customization. This is explained in “Customizing generated Web service description documents.”
3. Copy the Web service binding file to the pickup directory of the provider mode pipeline that you want to use for your Web service application. You must copy the Web service binding file in binary mode.
4. Optional: Copy the Web service description to the same directory as the Web service binding file. This allows you to perform validation to test that your Web service is working as expected at run time.
5. Although you can use RDO to create the necessary resources, it is recommended that you use the **`PIPELINE SCAN`** command to dynamically create the WEBSERVICE and URIMAP resources.
   - The WEBSERVICE resource encapsulates the Web service binding file in CICS and is used at run time.
   - The URIMAP resource tells CICS to associate the WEBSERVICE resource with a specific URI.

If you have any problems submitting DFHLS2WS, or the resources do not install correctly, see “Diagnosing deployment errors” on page 247.

You should make the Web services description available to anyone who needs to develop a Web service requester that will access your service.

Customizing generated Web service description documents

The Web service description (WSDL) documents that are generated by DFHLS2WS contain some automatically generated content that might be appropriate for you to change before publishing.

Customizing WSDL documents can result in regenerating the Web services binding file and in some cases, writing a wrapper program.

1. If you want to advertise support for HTTPS or communicate using WebSphere MQ, it is recommended that you use the **`URI`** parameter in DFHLS2WS to set an absolute URI. If you have not done this, then you need to change the `wsdl:service` and `wsdl:binding` elements at the end of the WSDL document. The generated WSDL includes comments to assist you in making these changes. Changing these elements does not require you to regenerate the Web services binding file.
2. If you want to supply the network location of your Web service, it is recommended that you use the **`URI`** parameter in DFHLS2WS to set an absolute URI. If you have not done this, add the details to the `soap:address` within the `wsdl:service` element.
   a. If you are using an HTTP-based protocol, replace *my-server* with the TCP/IP host name of your CICS region and *my-port* with the port number of the TCPIPSERVICE resource.
   b. If you are using WebSphere MQ as the transport protocol, replace *myQueue* with the name of the appropriate queue.

   These changes can be made without requiring any change to the Web services binding file.

Note: If you are changing the port name and namespace without regenerating the WSBind file then the monitoring information may be wrong at runtime level 2.1 onwards.

3. Consider if the automatically generated names in the WSDL document are appropriate for your purposes. The values that you can rename are:
   - The targetNamespace of the WSDL document
   - The targetNamespace of the XML schemas within the WSDL document
   - The wsdl:portType name
   - The wsdl:operation name
   - The wsdl:binding name
   - The wsdl:service name
   - The names of the fields in the XML schemas within the WSDL document.

   These values form part of the programmatic interface to which a client program must be coded. If the generated names are not sufficiently meaningful, it could make maintenance of your application code harder over a long period of time. It is recommended that you use the DFHLS2WS parameters **REQUEST-NAMESPACE** and **RESPONSE-NAMESPACE** to change the targetNamespace of the XML schemas, and the **WSDL-NAMESPACE** parameter to change the targetNamespace of the WSDL document.

   If you change any of these values, you need to regenerate the Web services binding file using DFHWS2LS. The language structures that are produced will not be the same as your existing language structures, but are compatible with your existing application, so no application changes are required. However, you can ignore the new language structures and use the new Web services binding file with the original structures.
4. Consider if the COMMAREA fields exposed in the XML schemas are appropriate. You might want to consider removing those fields that are not helpful to a Web service client developer. For example:
   - fields that are only used for output values could be removed from the schema that maps the input data structures
   - filler fields
   - automatically generated annotations

   If you make any of these changes, you need to regenerate the Web services binding file using DFHWS2LS. The new language structures that are generated are not compatible with the original language structures, so you need to write a wrapper program to map data from the new representation to the old one. This wrapper program needs to perform an **EXEC CICS LINK** command to the target application program and then map the returned data.

   This level of customization requires the most effort, but results in the most meaningful programmatic interfaces for your Web services client developers to work with.
5. If you want to put the generated WSDL document through DFHWS2LS to create new language structures, decide whether to keep the annotations in the WSDL document. The annotations override the normal mapping rules when DFHWS2LS generates the language structures. Overriding the mapping rules ensures that the generated language structures are compatible with the version that was used by DFHLS2WS. If you want to use the default mapping rules to produce the language structures, remove the annotations.

For an example of a WSDL document, see “An example of the generated WSDL document” on page 283.

Sending a SOAP fault

In a service provider, you can use the CICS API to send a SOAP fault to a Web service requester. This could either be issued by the service provider application, or by a header processing program in the pipeline.

To use the API, the service provider application must use channels and containers. If the application uses COMMAREAs, you need to write a wrapper program that does use channels and containers to create the SOAP fault message. You can only use the API in a header processing program if it is invoked directly from a CICS-supplied SOAP message handler.

You might want to issue a SOAP fault to the Web service requester if your application logic cannot satisfy the request for example, or if there is an underlying problem with the request message. Note that CICS does not consider issuing a SOAP fault as an error, so the normal message response pipeline processing takes place rather than any error processing. If you do want to roll back any transactions, this must be performed by the application program.

1. In your program, use the **EXEC CICS SOAPFAULT CREATE** command to send a SOAP fault.
2. Code the CLIENT or SERVER option on the command. This indicates where the problem has occurred, either on the client side or on the server.
   - CLIENT indicates that there is a problem with the request message that was received.
   - SERVER indicates that there was a problem when the request message was processed by CICS. This could be an application problem, for example it is unable to satisfy the request, or it could be an underlying problem that occurs during the pipeline processing.
3. Add the FAULTSTRING option and its length in the FAULTSTRLEN option to provide a summary of why the fault has been issued by the service provider. The contents of this option are in XML. Any data supplied by the application must be in a format that is suitable for direct inclusion in an XML document. The application might have to specify some characters as XML entities. For example, if the < character is used anywhere other than the start of an XML tag, the application must change it to &lt;. The following example shows an incorrect FAULTSTRING option:

   ```
   dcl msg_faultString char(*) constant('Error: Value A < Value B');
   ```

   The correct way to specify this FAULTSTRING option is as follows:

   ```
   dcl msg_faultString char(*) constant('Error: Value A &lt; Value B');
   ```

   Tip: To avoid using XML entities, you can wrapper the data in an XML CDATA construct. XML processors do not parse character data in this construct. Using this method, you could specify the following FAULTSTRING option:

   ```
   dcl msg_faultString char(*) constant('<![CDATA[Error: Value A < Value B]]>');
   ```
4. Code the DETAIL option and its length in the DETAILLENGTH option to provide the details of why the fault has been issued by the service provider. The contents of this option are in XML. The same guidance applies to the DETAIL option as to the FAULSTRING option.
5. Optional: If you are invoking the API from a header processing program, define the program in the pipeline configuration file. The header processing program should be defined in either the <cics_soap_1.1_handler> or <cics_soap_1.2_handler> element.

When your program issues this command, CICS creates the SOAP fault response message at the appropriate SOAP level. If your service provider application issues the command, it does not need to create a SOAP response and put it in the DFHRESPONSE container. The pipeline processes the SOAP fault through the message handlers and sends the response to the Web service provider.

Example

The **SOAPFAULT CREATE** command has a number of options to provide you with flexibility to respond appropriately to a Web service requester. Here is a simple example of a completed command that creates a SOAP fault that can be used for both SOAP 1.1 and SOAP 1.2.

```
EXEC CICS SOAPFAULT CREATE CLIENT
     DETAIL(msg_detail)
     DETAILLENGTH(length(msg_detail))
     FAULTSTRING(msg_faultString)
     FAULTSTRLEN(length(msg_faultString));
```

where *msg_detail* and *msg_faultString* could be coded with the following values:

```
dcl msg_detail char(*) constant('<ati:ExampleFault xmlns="http://www.example.org/faults"
xmlns:ati="http://www.example.org/faults">Detailed error message goes here.</ati:ExampleFault>');
dcl msg_faultString char(*) constant('Something went wrong');
```

Creating a Web service requester using the Web services assistant

The CICS Web services assistant simplifies the task of deploying your CICS applications in a service requester setting.

When you use the CICS Web services assistant to deploy a CICS application as a service requester, you must start with a Web service description, and generate the language data structures from it.

Creating a service requester application from a Web service description

Using the CICS Web services assistant, you can create a service requester application from a Web service description that complies with WSDL 1.1 or WSDL 2.0.

Your Web services description must be in a file in HFS and a suitable requester mode pipeline must be installed in the CICS region.

1. Use batch program DFHWS2LS to generate a Web service binding file and one or more language structures.
   a. What mapping level do you want to use? The higher the mapping level, the more control and support you have available for the handling of character and binary data at run time. Some optional parameters are also only available at the higher mapping levels. It is recommended that you use the highest level of mapping available.
   b. What code page do you want to use when transforming data at run time? If you want to use a specific code page for your application that is different from the code page for the CICS region, use the **CCSID** parameter. The code page must be EBCDIC, and supported by both Java and z/OS conversion services.
   c. Do you want to support a subset of the Operations that are declared in the Web service description? If you have a very large Web service description, and only want your service requester application to support a certain number

of Operations, use the **OPERATION** parameter to list which ones you want. Each operation should be separated with a space and is case sensitive.

Important: Do not specify parameters such as **PROGRAM**, **URI**, **TRANSACTION** and **USERID** when you use DFHWS2LS. These parameters apply only to a service provider application, and if specified, cause a provider mode Web service binding file to be produced.

As well as the Web service binding file, the program generates a language data structure.

2. Check the log file to see if there were any problems when DHWS2LS generated the binding file and language structures. There might be some elements or options in the Web service description that CICS does not support. If there are any warning or error messages, read through the advice that is provided and take any appropriate action. You might need to rerun the batch program.
3. Copy the Web service binding file to the pickup directory of the requester mode pipeline that you want to use for your Web service application. Use the **INQUIRE PIPELINE** command to:
   a. Ensure that the PIPELINE resource is configured for service requester applications. The value of the MODE attribute shows whether the installed pipeline supports requester or provider Web service applications.
   b. Ensure that the correct SOAP protocol is supported in the pipeline for your Web service. The SOAPlevel attribute indicates which version is supported. In service requester mode, the binding of the Web service must match the version of SOAP that is supported in the pipeline. You cannot install a Web service with a SOAP 1.1 binding into a service requester pipeline that supports SOAP 1.2.
   c. Ensure that the configured timeout for the pipeline is suitable for your service requester application. The timeout is displayed as the value of the RESPWAIT attribute on the PIPELINE resource. If no timeout is specified on the pipeline, the default for the transport is used.
      - The default timeout for HTTP is 10 seconds.
      - The default timeout for WMQ is 60 seconds.

      There is also a dispatcher timeout for each transaction in the CICS region. If this value is less than the default for either protocol, the timeout occurs with the dispatcher.
4. Optional: Copy the Web service description to the same pickup directory as the Web service binding file. This allows you to turn validation on for the Web service at run time.
5. Use the language data structure generated in step 1 on page 199 to write your wrapper program. Use an **EXEC CICS INVOKE WEBSERVICE** command in your wrapper program to communicate with the Web service. The options on the command include:
   - The name of the WEBSERVICE resource
   - The operation for which the Web service is being invoked
6. Although you can use RDO to create the necessary resources, it is recommended that you use the **PIPELINE SCAN** command to dynamically create the WEBSERVICE and URIMAP resources.
   - The WEBSERVICE resource encapsulates the Web service binding file in CICS and is used at run time.
   - The URIMAP resource tells CICS to associate the WEBSERVICE resource with a specific URI.
7. Write a wrapper program that you can substitute for your communications logic.

Creating a Web service using tooling

Instead of using the Web services assistant JCL, you can use WebSphere Developer for System z or write your own Java program to create the required files in CICS.

1. You can either:
   - Use the tool WebSphere Developer for System z to create a Web service binding file, and the Web service description or language structures. For more information about this tool see http://www-306.ibm.com/software/awdtools/devzseries/.
   - Write your own Java program, using the provided API, to invoke the Web services assistant. This API is described in the Web services assistant: Class Reference Javadoc. It includes comments that explain the classes and sample code is also provided to give an example of how you might invoke the Web services assistant. The Javadoc also contains a complete list of the JAR files that are required and where they can be found in z/OS UNIX.

     You can run your Java program on the z/OS or Windows platform. If you run the program on Windows, you should transfer the generated Web services binding file to a suitable pickup directory in binary mode using FTP or an equivalent process.
2. If you are generating a Web service description from a language structure, review the file and perform any necessary customization. This is explained in "Customizing generated Web service description documents" on page 196.
3. Deploy the generated Web service binding file into a suitable pipeline pickup directory.
4. Optional: Copy the Web service description into the pickup directory of the pipeline. This enables you to perform validation of the Web service to check that it is working as expected.
5. If you started with a Web service description, write a service provider or requester application program to interface with the generated language structures.
6. Perform a **PIPELINE SCAN** to automatically create the required CICS resources.

Creating XML-aware Web service applications

If you decide not to use the CICS-supplied data mappings and write your own XML-aware data applications instead, there are two ways to do this. You can either use the XML-ONLY option on DFHWS2LS, or you can write your own application without using any of the tooling. The most straightforward way to create an XML-aware application is with the XML-ONLY option.

Writing your own XML-aware applications involves writing code to both parse and generate XML documents. One way to write your own XML-aware application is to use the XML PARSE and XML GENERATE statements in COBOL. Another way to write your own XML-aware applications uses other IBM tools; for example, you can use the IBM Rational® Developer for System z® tool to generate COBOL XML converter programs that can be invoked from your applications.

Creating an XML-aware service provider application

Your XML-aware service provider application must work with the containers that are passed to it and handle the data conversion between the XML and the program language.

The following steps guide you through the creation of your XML-aware application, including whether to use any of the CICS tooling.

1. Decide if you want to generate a Web service binding file for your XML-aware application using DFHWS2LS. The advantage of generating a Web service binding file is that you can use CICS services, such as validation to test your Web service and CICS monitoring using global user exits.
   - If you want to generate a Web service binding file, run DFHWS2LS specifying the **`XML-ONLY`** parameter and a **`MINIMUM-RUNTIME-LEVEL`** of 2.1 or higher. The Web service binding file enables the application program to work directly with the contents of the DFHWS-BODY container. In all other respects the generated binding file shares the same deployment characteristics and the same runtime behavior as a file generated without the **`XML-ONLY`** parameter.
   - If you do not want to use a Web service binding file, configure your service provider pipeline so that the Web service request reaches your XML-aware application. You can either configure the terminal handler in the pipeline configuration file to use your XML-aware application program or create a message handler that dynamically switches to your application depending on the URI that is received in the pipeline.
2. Write your application to handle the Web service request that is held in the following containers:

   DFHWS-BODY
   For an inbound SOAP request when the pipeline includes a CICS-provided SOAP message handler, the contents of the SOAP body.

   DFHREQUEST
   The complete request (including the envelope for a SOAP request) received from the pipeline.

   DFHWS-XMLNS
   A list of name-value pairs that map namespace prefixes to namespaces for the XML content of the request.

   DFHWS-SOAPACTION
   The SOAPAction header associated with the SOAP message in container DFHWS-BODY.

   When you code API commands to work with the containers, you do not need to specify the `CHANNEL` option, because all the containers are associated with the current channel (the channel that was passed to the program). If you need to know the name of the channel, use the **`EXEC CICS ASSIGN CHANNEL`** command.
3. Optional: Your application can also use additional containers that are available to message handlers in the pipeline, as well as any other containers that the message handlers create as part of their processing. For a complete list of containers, see “Containers used in the pipeline” on page 105.
4. When your application has processed the request, construct a Web service response using the following containers:

   DFHRESPONSE
   The complete response message to be passed to the pipeline. Use this container if you do not use SOAP for your messages, or if you want to build the complete SOAP message (including the envelope) in your program.

   If you supply a SOAP body in container DFHWS-BODY, DFHRESPONSE should be empty. If you supply content in both DFHWS-BODY and DFHRESPONSE, CICS uses DFHRESPONSE.

DFHWS-BODY
For an outbound SOAP response, the contents of the SOAP body. Provide this container when the terminal handler of your pipeline is a CICS-provided SOAP message handler. The message handler will construct the full SOAP message containing the body.

Your program must create this container, even if the request and response are identical. If you do not, CICS issues an internal server error.

You can also use any of the other containers to pass information that your pipeline needs for processing the outbound response.

If your Web service does not return a response, you must return container DFHNORESPONSE to indicate that there is no response. The contents of the container are unimportant, as the message handler checks only whether the container is present or not.

5. Create a URIMAP resource. If you are using the `XML-ONLY` parameter and you have specified a value for the `URI` parameter of DFHWS2LS, the URIMAP is created automatically for you during the PIPELINE SCAN process.

Creating an XML-aware service requester application

Your XML-aware Web service requester application must handle the data conversion between the XML and the programming language, and populate the control containers in the pipeline.

You can write your own XML-aware service requester application using the `XML-ONLY` parameter on DFHWS2LS, or you can write it without using any of the tooling. The most straightforward way to write your own XML-aware service requester application is by using the `XML-ONLY` parameter on DFHWS2LS; the `XML-ONLY` parameter is available at runtime level 2.1 and above.

Using the `XML-ONLY` parameter will result in a WSBind file being generated that instructs CICS that the application will work directly with the contents of the DFHWS-BODY container. The generated WSBind file must be installed into a requester mode PIPELINE and this will result in a requester mode WEBSERVICE resource being created. The application must generate XML for the body of the Web service request and store it in the DFHWS-BODY container. It must then call the `EXEC CICS INVOKE WEBSERVICE` command. The outbound message will be sent to the Web services provider. The body of the response message will also be in the DFHWS-BODY container after the call completes.

XML aware requester applications may receive SOAP Fault messages back from the remote provider mode application. Where this happens the requester application is responsible for interpreting the SOAP Fault and distinguishing it from a regular response message. If the `INVOKE WEBSERVICE` command is used with an `XML-ONLY` WEBSERVICE, CICS will not set the response code which is normally used to indicate that a SOAP Fault was received.

If you are writing your own XML-aware service requester application without using the `XML-ONLY` option, complete the following steps:

1. Create a channel and populate it with containers. Provide the following information in each container:

DFHWS-PIPELINE
The name of the PIPELINE resource used for the outbound request.

DFHWS-URI
The URI of the target Web service

DFHWS-BODY
For an outbound SOAP request, the contents of the SOAP body. Provide this container when the pipeline includes a CICS-provided SOAP message handler. The message handler will construct the full SOAP message containing the body.

DFHREQUEST
The complete request message to be passed to the pipeline. Use this container if you do not use SOAP for your messages, or if you want to build the complete SOAP message (including the envelope) in your program. The pipeline should not include a CICS-provided SOAP message handler. This avoids duplicate SOAP headers being sent in the outbound message.

If you supply a SOAP body in container DFHWS-BODY, DFHREQUEST should be empty. If you supply content in both DFHWS-BODY and DFHREQUEST, CICS uses DFHREQUEST.

DFHWS-XMLNS
A list of name-value pairs that map namespace prefixes to namespaces for the XML content of the request.

DFHWS-SOAPACTION
The SOAPAction header to be added to the SOAP message specified in container DFHWS-BODY.

2. Link to program DFHPIRT. Use this command:

```
EXEC CICS LINK PROGRAM(DFHPIRT) CHANNEL(userchannel)
```

where *userchannel* is the channel which holds your containers. The outbound message is processed by the message handlers and header processing programs in the pipeline and sent to the Web service provider.

3. Retrieve the containers that contain the Web service response from the same channel. The response from the Web service provider could be a successful response or a SOAP fault. The Web service requester application must be able to handle both types of response from the service provider. The complete response is contained in the following containers:

DFHRESPONSE
The complete response (including the envelope for a SOAP response) received from the Web service provider.

DFHWS-BODY
When the pipeline includes a CICS-provided SOAP message handler, the contents of the SOAP body.

DFHERROR
Error information from the pipeline.

Validating SOAP messages

When you use the CICS Web services assistant to deploy your applications, you can specify that the SOAP messages should be validated at run time, to ensure that they conform to the Schema that is contained in the Web service description. You can perform validation in both provider and requester mode.

CICS uses a Java program to validate SOAP messages. Therefore, you must have Java support enabled in your CICS region to perform validation.

Validation of the SOAP message takes place before it is transformed into an application data structure, and when a SOAP message is generated from the application data structure. The SOAP message is validated using the XML schema in the WSDL, before then being validated against the transformation requirements of CICS.

When validation is turned off, CICS does not use the Java program. CICS validates SOAP messages only to the extent that is necessary to confirm that they contain well-formed XML, and to transform them. This means that it is possible for a SOAP message to be successfully validated using the WSDL, but then fail in the runtime environment and vice versa.

Important: During development and testing of your Web service deployment, using full validation will assist in detecting problems in the message exchange between a service requester and a service provider. However, there is a substantial overhead associated with performing complete validation of the SOAP messages, and it is inadvisable to validate messages in a fully tested production application.

To have your SOAP message validated, perform the following steps:

1. Ensure that you have a Web service description associated with your WEBSERVICE resource. This will be the case for WEBSERVICE resource definitions that were created automatically if the Web service description was present in the PIPELINE's pickup directory when the directory was scanned.

   For WEBSERVICE definitions that were created with RDO, the Web service description is specified with the WSDLFILE attribute.
2. Turn validation on for the WEBSERVICE. Use the following CEMT or SPI command: `SET WEBSERVICE(`*name*`) VALIDATION`. For WEBSERVICEs that are defined with RDO you can specify whether validation is required or not in the VALIDATION attribute, but you can change this setting after the WEBSERVICE is installed with the **SET WEBSERVICE** command.

Check the system log to find out if the SOAP message is valid. Message DFHPI1002 indicates that the SOAP message was successfully validated, and message DFHPI1001 indicates that the validation failed.

When you no longer need validation for the Web service, use the following command to turn it off: `SET WEBSERVICE(`*name*`) NOVALIDATION`.

Chapter 9. Interfacing with service provider and requester applications

You must code your service provider and service requester applications (or wrapper programs) to interact with the Web services support in CICS. How you code your program depends upon whether you are developing a service provider application or a service requester, and whether you are using the CICS Web services assistant to deploy your application.

How an application is invoked in a service provider

The way you invoke an application program (or a wrapper program) in a service provider depends upon whether or not you are using the Web services assistant to deploy your application.

How CICS invokes a service provider program deployed with the Web services assistant

When a service provider application that has been deployed using the CICS Web services assistant is invoked, CICS links to it with a COMMAREA or a channel.

You specify which sort of interface is used when you run JCL procedure DFHWS2LS or DFHLS2WS with the **PGMINT** parameter. If you specify a channel, you can name the container in the **CONTID** parameter.

- If the program is invoked with a COMMAREA interface, the COMMAREA contains the top level data structure that CICS created from the SOAP request.
- If the program is invoked with a channel interface, the top level data structure is passed to your program in the container that was specified in the **CONTID** parameter of DFHWS2LS or DFHLS2WS. If you did not specify the **CONTID** parameter, the data is passed in container DFHWS-DATA. The channel interface supports arrays with varying numbers of elements, which are represented as series of connected data structures in a series of containers. These containers will also be present.

  When you code API commands to work with the containers, you do not need to specify the `CHANNEL` option, because all the containers are associated with the current channel (the channel that was passed to the program). If you need to know the name of the channel, use the **EXEC CICS ASSIGN CHANNEL** command.

When your program has processed the request, it must use the same mechanism to return the response: if the request was received in a COMMAREA, then the response must be returned in the COMMAREA; if the request was received in a container, the response must be returned in the same container.

If an error is encountered when the application program is issuing a response message, CICS rolls back all of the changes unless the application has performed a syncpoint.

If the Web service provided by your program is not designed to return a response, CICS will ignore anything in the COMMAREA or container when the program returns.

Invoking a Web service from a CICS program

The way you invoke a Web service from an application program (or from a wrapper program) depends upon whether or not you are using the Web services assistant to deploy your application.

Invoking a Web service from an application deployed with the Web services assistant

A service requester application that is deployed with the Web services assistant uses the **EXEC CICS INVOKE WEBSERVICE** command to invoke a Web service. The request and response are mapped to a data structure in container DFHWS-DATA.

1. Create a channel and populate it with containers. At the minimum, container DFHWS-DATA must be present. It holds the top level data structure that CICS will convert into a SOAP request. If the SOAP request contains any arrays that have varying numbers of elements, they are represented as a series of connected data structures in a series of containers. These containers must also be present in the channel.
2. Invoke the target Web service. Use this command:

   ```
   EXEC CICS INVOKE WEBSERVICE(webservice)
                    CHANNEL(userchannel)
                    OPERATION(operation)
   ```

   where:

   webservice is the name of the WEBSERVICE resource that defines the Web service to be invoked. The WEBSERVICE resource specifies the location of the Web service description, and the Web service binding file that CICS uses when it communicates with the Web service.

   userchannel is the channel that holds container DFHWS-DATA and any other containers associated with the application's data structure.

   operation is the name of the operation that is to be invoked in the target Web service.

   You can also specify URI(*uri*) where *uri* is the URI of the Web service to be invoked. If this option is omitted, then the Web service binding file associated with the WEBSERVICE resource definition must include either a provider URI (obtained from the Web service description by DFHWS2LS) or a provider application name (specified as the **PGMNAME** input parameter to DFHWS2LS).

   The provider application name in the Web service binding file associated with the WEBSERVICE resource is used to enable local optimization of the Web service request. If you use this optimization, the **EXEC CICS INVOKE WEBSERVICE** command is optimized to an **EXEC CICS LINK** command. This optimization has an effect on the behavior of the **EXEC CICS INVOKE WEBSERVICE** command when the Web service is not expected to send a response:

   - When the optimization is not in effect, control returns from the **EXEC CICS INVOKE WEBSERVICE** command as soon as the request message is sent.
   - When the optimization is in effect, control returns from the **EXEC CICS INVOKE WEBSERVICE** command only when the target program returns.

   When the Web service is expected to send a response, control returns from the command when the response is available.
3. If the command was successful, retrieve the response containers from the channel. At the minimum, container DFHWS-DATA will be present. It holds the top level data structure that CICS created from the SOAP response. If the

response contains any arrays that have varying numbers of elements, they are a represented as series of connected data structures in a series of containers. These containers will be present in the channel.

4. If the service requester receives a SOAP fault message from the invoked Web service, you need to decide if the application program should roll back any changes. If this occurs, an INVREQ error with a RESP2 value of 6 is returned to the application program. However, if optimization is in effect, the same transaction is used in both the requester and provider. If an error occurs in a locally optimized Web service provider, all of the work done by the transaction rolls back in both the provider and the requester. An INVREQ error is returned to the requester with a RESP2 value of 16.

Runtime limitations for code generated by the Web services assistant

At runtime, CICS is capable of transforming almost any valid SOAP message that conforms to the Web service description (WSDL) into the equivalent data structures. However, there are some limitations that you should be aware of when developing a service requester or service provider application using the Web services assistant batch jobs.

Code pages

CICS can support SOAP messages sent to it in any code page if there is an appropriate HTTP or WMQ header identifying the code page. CICS converts the SOAP message to UTF-8 to process it in the pipeline, before transforming it to the code page required by the application program. To minimize the performance impact, it is recommended that you use the UTF-8 code page when sending SOAP messages to CICS. CICS always sends SOAP messages in UTF-8.

CICS can only transform SOAP messages if the code page used to convert data between the SOAP message and the application program is EBCDIC. Applications that expect data to be encoded in code pages such as UTF-8, ASCII and ISO8859-1 are unsupported. If you want to use DBCS characters within your data structures and SOAP messages, then you must specify a code page that supports DBCS. The EBCDIC code page that you select must also be supported by both Java and z/OS conversion services. z/OS conversion services must also be configured to support the conversion from the code page of the SOAP message to UTF-8.

To set an appropriate code page, you can either use the **LOCALCCSID** system initialization parameter or the optional **CCSID** parameter in the Web services assistant jobs. If you use the **CCSID** parameter, the value that you specify overrides the **LOCALCCSID** code page for that particular Web service. If you do not specify the **CCSID** parameter, the **LOCALCCSID** code page is used to convert the data and the Web service binding file is encoded in US EBCDIC (Cp037).

Containers

In service provider mode, if you specify that the **PGMINT** parameter has a value of `CHANNEL`, then the container that holds your application data must be written to and read from in binary mode. This container is DFHWS-DATA by default. The **PUT CONTAINER** command must either have the `DATATYPE` option set to BIT, or you must omit the `FROMCCSID` option so that BIT remains the default. For example, the following code explicitly states that the data in the container CUSTOMER-RECORD on the current channel should be written in binary mode.

```
EXEC CICS PUT CONTAINER (CUSTOMER-RECORD)
              FROM (CREC)
              DATATYPE(BIT)
```

Although the containers themselves are all in BIT mode, any text fields within the language structure that map this data must use an EBCDIC code page - the same code page as you have specified in the **LOCALCCSID** or **CCSID** parameter. If you are using DFHWS2LS to generate the Web service binding file, there could be many containers on the channel that hold parts of the complete data structure. If this is the case, then the text fields in each of these containers must be read from and written to using the same code page.

If the application program is populating containers that are going to be converted to SOAP messages, the application is responsible for ensuring that the containers have the correct amount of content. If a container holds less data than expected, CICS issues a conversion error.

If an application program uses the **INVOKE WEBSERVICE** command, then any containers it passes to CICS could potentially be reused and the data within them replaced. If you want to keep the data in these containers, create a new channel and copy the containers to it before you run the program. If you have a provider mode Web service that is also a requester mode Web service, it is recommended that you use a different channel when using the **INVOKE WEBSERVICE** command, rather than using the default channel that it was originally attached to. If your application program is using the **INVOKE WEBSERVICE** command many times, it is recommended that you either use different channels on each call to CICS, or ensure that all the important data from the first request is saved before making the second request.

Conforming with the Web services description

A Web service description could describe some of the possible content of a SOAP message as optional. If this is the case, DFHWS2LS allocates fields within the generated language structure to indicate whether the content is present or not. At runtime, CICS populates these fields accordingly. If a field, for example an existence flag or an occurrence field, indicates that the information is not present, the application program should not attempt to process the fields associated with that optional content.

If a SOAP message is missing some of its content when CICS transforms it, the equivalent fields within the data structures are not initialized when passed to the application program.

A Web service description can also specify the white space processing rules to use when reading a SOAP message, and CICS implements these rules at runtime.

- If the value of the `xsd:whiteSpace` facet is `replace`, the white space characters such as “tab” and “carriage return” are replaced with spaces.
- If the value of the `xsd:whiteSpace` facet is `collapse`, any leading and trailing white space characters are removed when generating SOAP messages.

SOAP messages

CICS does not support SOAP message content derivation. For example, a SOAP message could use the `xsi:type` attribute to specify that an element has a particular type, together with an `xsi:schemaLocation` attribute to specify the location of the schema that describes the element. CICS does not support the capability of dynamically retrieving the schema and transforming the value of the element based on the content of the schema. CICS does support the xsi:nil attribute when the mapping level set in the Web services assistant is 1.1 or higher, but this is the only XML schema instance attribute that is supported.

DFHWS2LS might have to make assumptions about the maximum length or size of some values in the SOAP message. For example, if the XML schema does not specify a maximum length for an xsd:string, then DFHWS2LS assumes that the maximum length is 255 characters and generates a language structure accordingly. You can change this value by using the **DEFAULT-CHAR-MAXLENGTH** parameter in DFHWS2LS. At runtime, if CICS encounters a SOAP message with a value that is larger than the space that has been allocated in the language structure, CICS issues a conversion error.

If CICS is the service provider, a SOAP fault message is returned to the requester. If CICS is the service requester, then an appropriate RESP2 code is returned from the **INVOKE WEBSERVICE** command.

Some characters have special meanings in XML, such as the < and > characters. If any of these special characters appear within a character array that is processed by CICS at runtime, then it is replaced with the equivalent entity. The XML entities that are supported are:

Character	XML entity
&	&amp;
<	&lt;
>	&gt;
"	&quot;
'	&apos;

CICS also supports the canonical forms of the numeric character references used for white space codes:

Character	XML entity
Tab	&#x9;
Carriage return	&#xA;
Line feed	&#xD;

Note that this support does not extend to any pipeline handler programs that are invoked.

The null character (x'00') is invalid in any XML document. If a character type field that is provided by the application program contains the null character, CICS truncates the data at that point. This allows you to treat character arrays as null terminated strings. Character type fields generated by DFHWS2LS from base64Binary or hexBinary XML schema data types represent binary data and could contain null characters without truncation.

SOAP fault messages

If CICS is the service provider, and you want the application program to issue a SOAP fault message, use the **SOAPFAULT CREATE** command. In order to use this API command, you must specify that the Web services assistant **PGMINT** parameter has a value of CHANNEL. If you do not specify this value, and the application program invokes the **SOAPFAULT CREATE** command, CICS does not attempt to generate a SOAP response message.

Chapter 10. Support for Web Services transactions

The Web Services Atomic Transaction (or WS-AtomicTransaction) specification and the Web Services Coordination (or WS-Coordination) specification define protocols for short-term transactions that enable transaction processing systems to interoperate in a Web services environment. Transactions that use WS-AtomicTransaction have the *ACID* properties of atomicity, consistency, isolation, and durability.

The specifications can be found at http://www.ibm.com/developerworks/library/specification/ws-tx/.

Note: CICS supports the November 2004 level of the specifications.

CICS applications that are deployed as Web service providers or requesters can participate in distributed transactions with other Web service implementations that support the specifications.

Registration services

Registration services is that part of the WS-Coordination model that enables an application to register for coordination protocols. In a distributed transaction, the registration services in the participating systems communicate with one another to enable the connected applications to participate in those protocols.

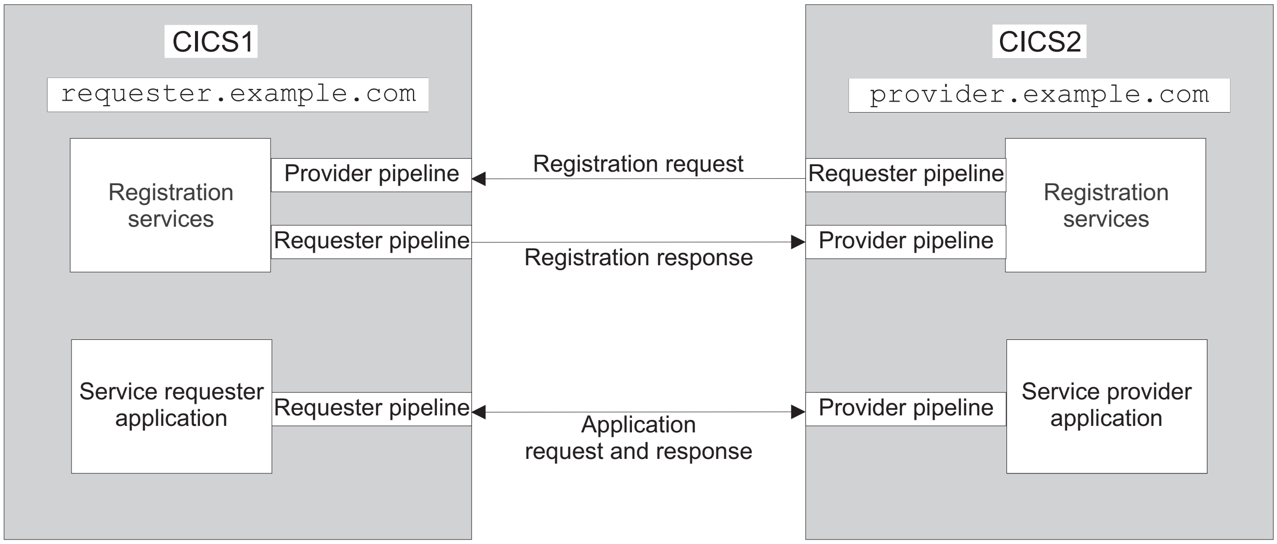


Figure 25. Registration services

Figure 25 shows two CICS systems, CICS1 and CICS2. A service requester application in CICS1 invokes a service provider application in CICS2. The two CICS regions and the applications are configured so that the two applications participate in a single distributed transaction, using the WS-Coordination protocols. The service requester application is the coordinator, and the service provider application is the participant.

In support of these protocols, the registration services in the two CICS regions interact at the start of the transaction, and again during transaction termination. During these interactions, registration services in both regions can operate at different times as a service provider and as a requester. Therefore, in each region, registration services use a service provider pipeline, and a service requester pipeline. The pipelines are defined to CICS with the PIPELINE and associated resources.

The registration services in each region are associated with an endpoint address. Thus, in the example, registration services in CICS1 has an endpoint address of `requester.example.com`; that in CICS2 has an endpoint address of `provider.example.com`.

In a CICSplex, you can distribute the registration services provider pipeline to a different region. This is shown in Figure 26.

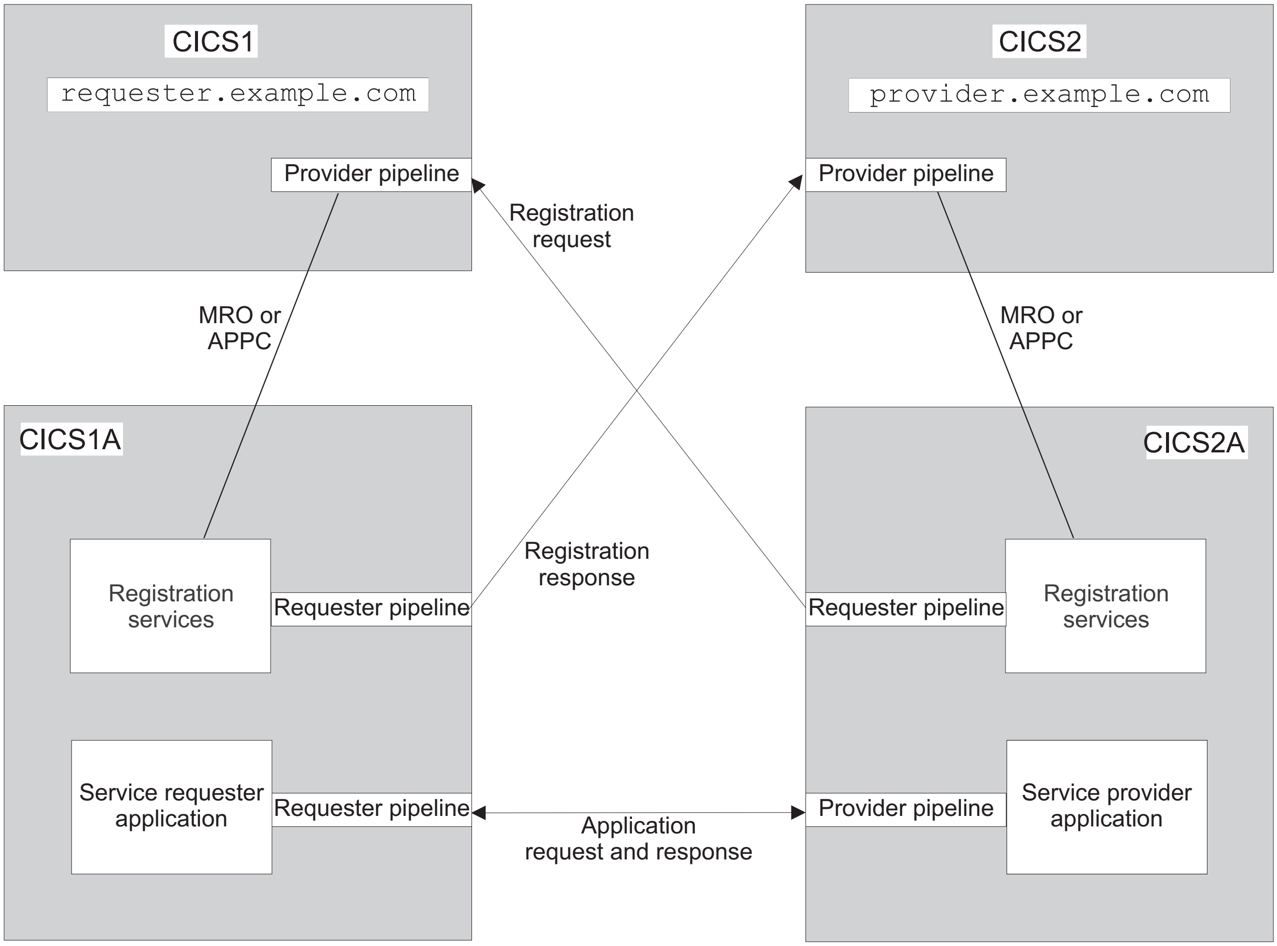


Figure 26. Registration services in a CICSPlex®

In this configuration, the provider pipeline communicates with registration services using MRO or APPC. The registration services requester pipeline must remain in the same region as the application's requester pipeline.

This configuration is useful when your service requester and provider applications are distributed across a large number of regions. When you configure the application's pipelines to participate in Web service transactions, you must provide information about the registration services endpoint by providing the IP address and port number of the registration services provider pipeline. By having a single endpoint, you can simplify configuration, because all your pipelines will contain the same information. For example, in Figure 26 on page 214 the IP address that you specify in the application's requester pipeline is `requester.example.com`.

The same arguments apply to the service provider application. In the example, the provider application's pipeline will specify an IP address of `requester.example.com`.

Configuring CICS for Web service transactions

For Web service requester and provider applications to participate in Web service transactions, you must configure CICS accordingly by installing a number of CICS resources.

Before you can install these resources you must know the location of the pipeline configuration files that CICS supplies in support of Web service transactions. By default, the configuration files are supplied in the `/usr/lpp/cicsts/cicsts32/pipeline/configs` directory, but the default file path might have been changed during CICS installation.

CICS support for Web service transactions uses a CICS-supplied registration services service provider and service requester, and you must install resources for both of these. Even if your applications are all service providers, or all service requesters, you must install both.

You must also install a program definition for the header handler program that is invoked when you run your service provider and requester applications.

The resources you require to configure CICS for Web service transactions are all supplied in the DFWSAT group, except for DFHPIDIR which is supplied in one of the following groups: DFHPIVS, DFHPIVR, or DFHPICF. The DFHWSAT group is not included in the DFHLIST list, and therefore is not installed automatically. You cannot change the resources supplied by CICS in the DFHWSAT group.

To configure CICS for Web service transactions:

1. Add the DFHPIDIR data set to your startup JCL. DFHPIDIR stores a mapping between contexts and tasks.
   a. Add a new DD statement for the DFHPIDIR data set to your CICS startup JCL
   b. Create the DFHPIDIR data set using information in DFHDEFDS.JCL. The default RECORDSIZE of DFHPIDIR is 1 KB, which is adequate for most uses. You can create DFHPIDIR with a larger RECORDSIZE if you need to.
   c. Install the appropriate group for the data set on your CICS system: DFHPIVS, DFHPIVR, or DFHPICF.

   If you want to share the DFHPIDIR file across CICS regions, the regions must be logically connected over MRO.
2. Copy the contents of the DFHWSAT group to another group. You cannot change the resources supplied by CICS in the DFHWSAT group. However, you must change the CONFIGFILE attribute in the PIPELINE resources.
3. Modify the CICS-supplied registration services provider PIPELINE resource. The PIPELINE is named DFHWSATP, and specifies pipeline configuration file `/usr/lpp/cicsts/cicsts32/pipeline/configs/registrationservicePROV.xml` in the CONFIGFILE attribute.

   a. Change the CONFIGFILE attribute to reflect the location of the file in your system.
   b. Leave the other attributes unchanged.

   Use the pipeline configuration file exactly as provided; do not change its contents.
4. Install the PIPELINE resource. The registration services provider PIPELINE resource need not be in the same CICS region as your service requester or provider applications, but must be connected to that region with a suitable MRO or APPC connection.
5. Without changing it, install the URIMAP that is used by the registration services provider in the same region as the PIPELINE. The URIMAP is named DFHRSURI.
6. Modify the CICS-supplied registration services requester PIPELINE resource. The PIPELINE is named DFHWSATR, and specifies pipeline configuration file `/usr/lpp/cicsts/cicsts32/pipeline/configs/registrationserviceREQ.xml` in the CONFIGFILE attribute.
   a. Change the CONFIGFILE attribute to reflect the location of the file in your system.
   b. Leave the other attributes unchanged.

   Use the pipeline configuration file exactly as provided; do not change its contents.
7. Install the PIPELINE resource. The registration services requester PIPELINE resource must be in the same CICS region as the service requester and provider applications.
8. Install the programs used by the registration service provider pipeline in the same region as your PIPELINE resources. The programs are DFHWSATX, DFHWSATR, and DFHPIRS. If both your PIPELINE resources are in different regions, you must install these programs in both regions.
9. Install the PROGRAM resource definition for the header handler program. The program is named DFHWSATH. Install the PROGRAM in the regions where your service provider and requester applications run.

CICS is now configured so that your service provider and requester applications can participate in distributed transactions using WS-AtomicTransaction and WS-Coordination protocols.

You must now configure each participating application individually.

Configuring a service provider for Web service transactions

If a service provider application is to participate in Web service transactions, the pipeline configuration file must specify a `<headerprogram>` and a `<service_parameter_list>`.

So that your service provider application can participate in Web service transactions, it must use SOAP protocols to communicate with the service requester, and you must configure your pipeline to use one of the CICS-provided SOAP message handlers. Even if you have configured your service provider application correctly, it will participate in Web service transactions with the service requester only if the requester application has been set up to participate.

In addition to the pipeline configuration information that is specific to your application, the configuration file must contain information that CICS uses to ensure that your application participates in Web service transactions.

CICS provides an example of a pipeline configuration file containing this information in file /usr/lpp/cicsts/cicsts32/samples/pipelines/wsatprovider.xml.

To configure a service provider for Web service transactions:

1. In the definition of your terminal handler, code a <headerprogram> element in the <cics_soap_1.1_handler> or <cics_soap_1.2_handler> element. Code the <program_name>, <namespace>, <localname>, and <mandatory> elements exactly as shown in this example:

   ```
   <terminal_handler>
     <cics_soap_1.1_handler>
       <headerprogram>
         <program_name>DFHWSATH</program_name>
         <namespace>http://schemas.xmlsoap.org/ws/2004/10/wscoor</namespace>
         <localname>CoordinationContext</localname>
         <mandatory>false</mandatory>
       </headerprogram>
     </cics_soap_1.1_handler>
   </terminal_handler>
   ```

   Include other <headerprogram> elements if your application needs them.
2. Code a <registration_service_endpoint> element in a <service_parameter_list>. Code the <registration_service_endpoint> as follows:

   ```
   <registration_service_endpoint>
   http://address:port/cicswsat/RegistrationService
   </registration_service_endpoint>
   ```

   where

   address is the IP address of the CICS region where the registration service provider pipeline is installed.

   port is the port number used by the registration service provider pipeline.

   Code everything else exactly as shown; the string cicswsat/RegistrationService matches the PATH attribute of URIMAP DFHRSURI:

   ```
   <registration_service_endpoint>
   http://provider.example.com:7160/cicswsat/RegistrationService
   </registration_service_endpoint>
   ```

Configuring a service requester for Web service transactions

If a service requester application is to participate in Web service transactions, the pipeline configuration file must specify a <headerprogram> and a <service_parameter_list>.

In order that your service requester application can participate in Web service transactions, it must use SOAP protocols to communicate with the service provider, and your pipeline must be configured to use one of the CICS-provided SOAP message handlers. Even if you have configured your service requester application correctly, it will only participate in Web service transactions with the service provider if the provider application has been set up to participate.

In addition to the pipeline configuration information that is specific to your application, the configuration file must contain information which CICS uses to ensure that your application participates in Web service transactions.

CICS provides an example of a pipeline configuration file containing this information in file /usr/lpp/cicsts/cicsts32/samples/pipelines/wsatrequester.xml.

1. Code a <headerprogram> element in the <cics_soap_1.1_handler> or <cics_soap_1.2_handler> element. Code the <program_name>, <namespace>, <localname>, and <mandatory> elements exactly as shown in the example below. For example:

   ```
   <cics_soap_1.1_handler>
     <headerprogram>
       <program_name>DFHWSATH</program_name>
       <namespace>http://schemas.xmlsoap.org/ws/2004/10/wscoor</namespace>
       <localname>CoordinationContext</localname>
       <mandatory>true</mandatory>
     </headerprogram>
   </cics_soap_1.1_handler>
   ```

   You can include other <headerprogram> elements if your application needs them.

2. Code a <registration_service_endpoint> element in a <service_parameter_list>. Code the <registration_service_endpoint> as follows:

   ```
   <registration_service_endpoint>
   http://address:port/cicswsat/RegistrationService
   </registration_service_endpoint>
   ```

   where

   address is the IP address of the CICS region where the registration service provider pipeline is installed.

   port is the port number used by the registration service provider pipeline.

   There must be no space between the start the <registration_service_endpoint> element, its contents, and the end of the <registration_service_endpoint> element. Spaces have been included in this example for clarity.

3. If you want CICS to create a new transactional context for each request, rather than using the same one for requests in the same unit of work, add the empty element, <new_tx_context_required/>, in a <service_parameter_list> to your pipeline configuration file:

   ```
   <service_parameter_list>
     <registration_service_endpoint>
     http://requester.example.com:7159/cicswsat/RegistrationService
     </registration_service_endpoint>
     <new_tx_context_required/>
   </service_parameter_list>
   ```

   There must be no space between the start the <registration_service_endpoint> element, its contents, and the end of the <registration_service_endpoint> element. Spaces have been included in this example for clarity.

   The <new_tx_context_required/> setting is not the default for CICS, and is not included in the example pipeline configuration file, wsatprovider.xml. If you add <new_tx_context_required/> in a <service_parameter_list> to your pipeline configuration file, loopback calls to CICS are allowed, so be aware that a deadlock might occur in this situation.

Determining if the SOAP message is part of an atomic transaction

When a CICS Web service is invoked in the atomic transaction pipeline, the SOAP message does not necessarily have to be part of an atomic transaction.

The `<soapenv:Header>` element contains specific information when the SOAP message is part of an atomic transaction. To find out if the SOAP message is part of an atomic transaction, you can either:

- Look inside the contents of the `<soapenv:Header>` element using a trace.
  1. Perform an auxiliary trace using component PI and set the tracing level to 2.
  2. Look for trace point PI 0A31, which contains the information for the request container. In particular, look for `PIIS EVENT - REQUEST_CNT` which appears just before the `<wsa:Action>` element.
- Use a user-written message handler program in the DFHWSATP pipeline to display the content of the DFHREQUEST container when it contains the data `RECEIVE-REQUEST`. If you opt for this approach, make sure that you define the message handler program in the pipeline configuration file.

The following example shows the information that you could see in the SOAP envelope header for an atomic transaction.

```
<soapenv:Header>
  <wscoor:CoordinationContext soapenv:mustUnderstand="1">  1
     <wscoor:Expires>500</wscoor:Expires>
     <wscoor:Identifier>com.ibm.ws.wstx:
        0000010a2b5008c80000000200000019a75aab901a1758a4e40e2731c61192a10ad6e921
     </wscoor:Identifier>
     <wscoor:CoordinationType>http://schemas.xmlsoap.org/ws/2004/10/wsat</wscoor:CoordinationType>  2
     <wscoor:RegistrationService  3
        xmlns:wscoor="http://schemas.xmlsoap.org/ws/2004/10/wscoor">
        <wsa:Address xmlns:wsa="http://schemas.xmlsoap.org/ws/2004/08/addressing">
           http://clientIPaddress:clientPort/_IBMSYSAPP/wscoor/services/RegistrationCoordinatorPort
        </wsa:Address>
        <wsa:ReferenceProperties
           xmlns:wsa="http://schemas.xmlsoap.org/ws/2004/08/addressing">
               <websphere-wsat:txID
                     xmlns:websphere-wsat="http://wstx.Transaction.ws.ibm.com/extension">com.ibm.ws.wstx:
                     0000010a2b5008c80000000200000019a75aab901a1758a4e40e2731c61192a10ad6e921
               </websphere-wsat:txID>
               <websphere-wsat:instanceID
                     xmlns:websphere-wsat="http://wstx.Transaction.ws.ibm.com/extension">com.ibm.ws.wstx:
                     0000010a2b5008c80000000200000019a75aab901a1758a4e40e2731c61192a10ad6e921
               </websphere-wsat:instanceID>
         </wsa:ReferenceProperties>
      </wscoor:RegistrationService>
  </wscoor:CoordinationContext>
</soapenv:Header>
```

1. The CoordinationContext indicates that the SOAP message is intended to participate in an atomic transaction. It contains the necessary information for the Web service provider to be part of the coordination service, assuming that the provider is configured to recognize and process the header.
2. The CoordinationType indicates the version of the WS-AT specification that the coordination context complies with.
3. The coordination RegistrationService describes where the coordinator's registration point is, and the information that the participating Web service must return to the coordinator when it attempts to register as a component of the atomic transaction.

Checking the progress of an atomic transaction

When a CICS Web service is invoked as part of an atomic transaction, the transaction passes through a number of states. These states indicate whether the transaction was successful or had to roll back.

If you need to access this information, you can either:

- Look inside the contents of the <wsa:Action> element using a trace.
  1. Perform an auxiliary trace using component PI and set the tracing level to 2.
  2. Look for trace point PI 0A31, which contains the information for the request container. In particular, look for PIIS EVENT - REQUEST_CNT which appears just before the <wsa:Action> element.
- Use a user-written message handler program in the DFHWSATR and DFHWSATP pipelines to display the content of DFHWS-SOAPACTION containers. If you opt for this approach, make sure that you define the message handler program in the pipeline configuration files.

The states for a transaction that completes successfully and is committed are:

```
"http://schemas.xmlsoap.org/ws/2004/10/wscoor/Register"
"http://schemas.xmlsoap.org/ws/2004/10/wscoor/RegisterResponse"
"http://schemas.xmlsoap.org/ws/2004/10/wsat/Prepare"
"http://schemas.xmlsoap.org/ws/2004/10/wsat/Prepared"
"http://schemas.xmlsoap.org/ws/2004/10/wsat/Commit"
"http://schemas.xmlsoap.org/ws/2004/10/wsat/Committed "
```

The states for a transaction that is rolled back are:

```
 "http://schemas.xmlsoap.org/ws/2004/10/wscoor/Register"
"http://schemas.xmlsoap.org/ws/2004/10/wscoor/RegisterResponse"
"http://schemas.xmlsoap.org/ws/2004/10/wsat/Rollback"
"http://schemas.xmlsoap.org/ws/2004/10/wsat/Aborted"
```

Chapter 11. Support for MTOM/XOP optimization of binary data

In standard SOAP messages, binary objects are base64-encoded and included in the message body. This increases their size by 33%, which for very large binary objects can significantly impact transmission time. Implementing MTOM/XOP provides a solution to this problem.

The SOAP Message Transmission Optimization Mechanism (MTOM) and XML-binary Optimized Packaging (XOP) specifications, often referred to as MTOM/XOP, define a method for optimizing the transmission of large base64Binary data objects within SOAP messages:

- The MTOM specification conceptually defines a method for optimizing SOAP messages by separating out binary data, which is otherwise base64-encoded, and sending it in separate binary attachments using a MIME Multipart/Related message. This type of MIME message is called an *MTOM message*. Sending the data in binary format significantly reduces its size, thus optimizing the transmission of the SOAP message.
- The XOP specification defines an implementation for optimizing XML messages using binary attachments in a packaging format that includes but is not limited to MIME messages.

CICS implements support for these specifications in both requester and provider pipelines when the transport protocol is WebSphere MQ, HTTP, or HTTPS. As an alternative to including the base64Binary data directly in the SOAP message, CICS applications that are deployed as Web service providers or requesters can use this support to send and receive MTOM messages with binary attachments.

You can configure this support by using additional options in the pipeline configuration file.

MTOM/XOP and SOAP

When you use MTOM/XOP to optimize a SOAP message, the XOP processing serializes it into a MIME Multipart/Related message. The XOP processing extracts the base64Binary data from the SOAP message and packages it as separate binary attachments within the MIME message, in a similar manner to e-mail attachments.

The size of the base64Binary data is significantly smaller because the attachments are encoded in binary format. The XOP processing converts the XML in the SOAP message to XOP format by replacing the base64Binary data with a special `<xop:Include>` element that references the relevant MIME attachment using a URI.

The modified SOAP message is called the *XOP document* and it forms the root document within the message. The XOP document and binary attachments together form the *XOP package*. When applied to the SOAP MTOM specification, the XOP package is a MIME message in MTOM format.

The overall content-type header of the MIME message identifies the root document by using a Content-ID. Here is an example of a content-type header:

```
Content-Type: Multipart/Related; boundary=MIME_boundary;
 type="application/soap+xml"; start="<claim@insurance.com>"
```

The **start** parameter contains the Content-ID of the XOP document. If the content-type header does not include this parameter, the first part in the MIME message is assumed to be the XOP document.

The order of the attachments in the MIME message is unimportant. In some messages for example, the binary attachments could appear before the XOP document. An application that handles MIME messages must not rely on the attachments appearing in a specific order. For detailed information, read the MTOM/XOP specifications.

The following example demonstrates how XOP processing can optimize a simple SOAP message that contains a JPEG image. The SOAP message is as follows:

```
<soap:Envelope
 xmlns:soap="http://www.w3.org/2003/05/soap-envelope"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns:xmime="http://www.w3.org/2003/12/xop/mime">
 <soap:Body>
 <submitClaim>
  <accountNumber>5XJ45-3B2</accountNumber>
  <eventType>accident</eventType>
  <image xmime:contentType="image/jpeg" xsi:type="base64binary">4f3e..(encoded image)</image>
 </submitClaim>
 </soap:Body>
</soap:Envelope>
```

An MTOM/XOP version of this SOAP message is below.

```
MIME-Version: 1.0
Content-Type: Multipart/Related; boundary=MIME_boundary;
 type="application/soap+xml"; start="<claim@insurance.com>" 1

--MIME_boundary
Content-Type: application/soap+xml; charset=UTF-8
Content-Transfer-Encoding: 8bit
Content-ID: <claim@insurance.com> 2

<soap:Envelope
 xmlns:soap="http://www.w3.org/2003/05/soap-envelope"
 xmlns:xop='http://www.w3.org/2004/08/xop/include'
 xmlns:xop-mime='http://www.w3.org/2005/05/xmlmime'>
 <soap:Body>
 <submitClaim>
  <accountNumber>5XJ45-3B2</accountNumber>
  <eventType>accident</eventType>
  <image xop-mime:content-type='image/jpeg'><xop:Include href="cid:image@insurance.com"/></image> 3
</submitClaim>
 </soap:Body>
</soap:Envelope>

--MIME_boundary
Content-Type: image/jpeg
Content-Transfer-Encoding: binary
Content-ID: <image@insurance.com> 4

...binary JPG image...

--MIME_boundary--
```

1. The **start** parameter indicates which part of the MIME message is the root XOP document.
2. The `Content-ID` value identifies a part of the MIME message. In this case, it is the root XOP document.
3. The `<xop:Include>` element references the JPEG binary attachment.

4. The `Content-ID` identifies the JPEG in the binary attachment.

MTOM messages and binary attachments in CICS

CICS supports and controls the handling of MTOM messages in both Web service provider and requester pipelines using an MTOM handler program and XOP processing.

You enable and configure the MTOM handler and XOP processing using options that are defined in the pipeline configuration file. When enabled, the MTOM handler accepts and unpackages inbound MTOM messages containing XOP documents and binary attachments, and outbound MTOM messages are packaged and sent. If the MTOM handler is not enabled in the pipeline and CICS receives an MTOM message, it is rejected with a SOAP fault.

You can configure a provider pipeline to perform the following processing:

- Accept MTOM messages, but never send MTOM response messages.
- Accept MTOM messages and send the same type of response message.
- Accept MTOM messages, but only send MTOM messages when there are binary attachments present.
- Accept MTOM messages and always send MTOM response messages.
- Process XOP documents and binary attachments in direct or compatibility mode.

You can configure a requester pipeline to perform the following processing:

- Never send an MTOM message, but accept MTOM response messages.
- Send MTOM messages only when there are binary attachments and accept MTOM response messages.
- Always send MTOM messages and accept MTOM response messages.
- Process XOP documents and binary attachments in direct or compatibility mode.

Modes of support

There are certain scenarios in which CICS cannot support the XOP document format in messages directly. For example, the Web Services Security support and Web service validation cannot parse the `<xop:Include>` elements in the XOP document. Therefore, the pipeline provides two modes of support to handle XOP documents and any associated binary attachments:

direct mode

In direct mode, the binary attachments associated with an inbound or outbound MTOM message are passed in containers through the pipeline and handled directly by the application, without the need to perform any data conversion.

compatibility mode

Compatibility mode is used when the pipeline processing requires the message to be in standard XML format, with any binary data stored as base64Binary fields in the message. For inbound messages, the XOP document and binary attachments are reconstituted into a standard XML message, either at the beginning of the pipeline when Web Services Security is enabled, or at the end of the pipeline when Web service validation is enabled. For outbound messages, a standard XML message is created and passed along the pipeline. The MTOM handler converts it to XOP format just before CICS sends it.

Compatibility mode is much less efficient than direct mode because binary data is converted to base64 format and back again. However, it does allow your Web services to interoperate with other MTOM/XOP Web service requesters and providers without needing to change your applications.

Inbound MTOM message processing

When the MTOM handler is enabled in the pipeline, it checks the headers of the inbound message in the DFHREQUEST or DFHRESPONSE container to determine the format of the message during the transport handling processing.

When a MIME Multipart/Related message is received, the MTOM handler unpackages the message as follows:

1. Puts the headers and binary data from each binary attachment into separate containers.
2. Puts the list of containers in the DFHWS-XOP-IN container.
3. Puts the XOP document, which formed the root of the message, back in the DFHREQUEST or DFHRESPONSE container, replacing the original message.

If the XOP document has no binary attachments, it is handled as a normal XML message and does not require XOP processing. If the XOP document does have binary attachments, XOP processing is enabled for the message.

If XOP processing is enabled, the MTOM handler checks the pipeline properties to determine if the current message is to be processed in direct or compatibility mode, and puts this information in the DFHWS-MTOM-IN container.

In provider mode, the MTOM handler also creates the DFHWS-MTOM-OUT container to determine how the outbound response message should be processed.

Direct mode

When you are using CICS Web services support, either when a service provider pipeline uses the DFHPITP application handler or a service requester application uses the `INVOKE WEBSERVICE` command, the pipeline can process the XOP document and binary attachments in direct mode.

In this mode, the MTOM handler passes the XOP document and associated containers to the next message handler in the pipeline for processing. The CICS Web services support interprets the `<xop:Include>` elements. If the base64Binary field is represented as a container in the application data structure, the attachment container name is stored in the structure. If the field is represented as a variable or fixed length string, the contents of the container are copied to the relevant application data structure field. The data structure is then passed to the application program.

Compatibility mode

If you have configured your pipeline to use a custom application handler, or you have enabled Web Services Security, the message is processed in compatibility mode. In this mode, the XOP processing immediately reconstitutes the XOP document and binary attachments into a SOAP message, so that the content can be successfully processed in the pipeline. The XOP processing is as follows:

1. Scans the XOP document for `<xop:Include>` elements, replacing each occurrence with the binary data from the referenced attachment in base64-encoded format.
2. Discards the DFHWS-XOP-IN container and all of the attachment containers.

The reconstituted SOAP message is then passed to the next handler in the pipeline to be processed as normal.

If you have enabled Web service validation, the pipeline switches to compatibility mode when the message reaches the application handler. The message is reconstituted into a SOAP message, validated, and passed to the application.

Outbound MTOM message processing

When the pipeline is configured to send outbound MTOM messages, the Web service and pipeline properties are checked to determine how the message is to be processed and sent.

Two containers, DFHWS-MTOM-OUT and DFHWS-XOP-OUT, store these properties. In a requester mode pipeline, CICS creates these containers when the application issues the **EXEC CICS INVOKE WEBSERVICE** command. In a provider mode pipeline, the DFHWS-MTOM-OUT container is already initialized with the options that are determined by the MTOM handler from the inbound message.

If the outbound message can be processed in direct mode, the optimization of the message takes place immediately. If the outbound message has to be processed in compatibility mode, the optimization takes place at the very end of the pipeline processing.

If you have not deployed your Web service provider or requester application using the CICS Web services assistant, or if you have Web service validation enabled or Web Services Security enabled in your pipeline, the outbound message is processed in compatibility mode.

Direct mode

In direct mode, the following processing takes place:

1. A XOP document is constructed from the application's data structure in container DFHWS-DATA. Any binary fields that are equal to or larger in size than 1,500 bytes are identified, and the binary data and MIME headers describing the binary attachment are put in separate containers. If the binary data is already in a container, that container is used directly as the attachment. A `<xop:Include>` element is then inserted in the XML in place of the usual base64-encoded binary data using a generated Content-ID. For example:
   ```
   <xop:Include href="cid:generated-content-ID-value"
    xmlns:xop="http://www.w3.org/2004/08/xop/include">
   ```
2. All of the containers are added to the attachment list in the DFHWS-XOP-OUT container.
3. When the SOAP handler has processed DFHWS-DATA, the XOP document and SOAP envelope are stored in the DFHREQUEST or DFHRESPONSE container and processed through the pipeline.
4. When the last message handler has finished, the MTOM handler packages the XOP document and binary attachments into a MIME Multipart/Related message and sends it to the Web service requester or provider. The DFHWS-XOP-OUT container and any associated containers are then discarded.

Compatibility mode

If the pipeline cannot handle the XOP document directly, the following processing takes place:

1. The SOAP body is constructed in DFHWS-DATA from the application data structure and processed in the pipeline as normal.
2. When the final handler has finished processing the message, the MTOM handler checks the options in the DFHWS-MTOM-OUT container to determine whether MTOM should be used, optionally taking into account whether any binary attachments are present. If the MTOM handler determines that MTOM is not required, no XOP processing takes place and CICS sends a SOAP message as normal.
3. If the MTOM handler determines that the outbound message is to be sent in MTOM format, the XOP processing scans the message for eligible fields to split the data out into binary attachments. For a field to be eligible, it must have the MIME `contentType` attribute specified on the element and the associated binary value must consist of valid base64Binary data in canonical form. The size of the data must be greater than 1,500 bytes. The XOP processing creates the binary attachments and attachment list and then replaces the fields with `<xop:Include>` elements.
4. The MTOM handler packages the XOP document and binary attachments as a MIME Multipart/Related message and CICS sends it to the Web service requester or provider.

Restrictions when using MTOM/XOP

By enabling the MTOM handler in the pipeline, you can support Web service implementations that use the MTOM/XOP optimization. With the compatibility mode option, you can interoperate with these Web services without having to change your Web service applications. However, in certain situations you cannot use MTOM/XOP or its use is restricted.

Using the CICS Web services assistant

The direct mode optimization for MTOM/XOP is only available if you are using DFHWS2LS at a mapping level of at least 1.2, and the WSDL document contains at least one field of type xsd:base64Binary. Web services that are enabled using DFHLS2WS are not eligible for XOP optimization.

Web services generated using DFHLS2WS with CHAR-VARYING=BINARY specified may be eligible for the MTOM/XOP optimizations. Other Web services generated using DFHLS2WS do not contain binary data and are not eligible for the MTOM/XOP optimizations, but will work normally in a PIPELINE that supports MTOM/XOP.

Provider pipelines

CICS provides a default application handler called DFHPITP that can be configured in a provider pipeline. This application handler is capable of handling XOP documents and creating the necessary containers to support the pipeline processing in both direct and compatibility mode. If you are using your own application handler in a provider pipeline, and you want to enable MTOM/XOP, you must configure the pipeline to run in compatibility mode.

Requester pipelines

If your applications use the **`INVOKE WEBSERVICE`** command, CICS handles the optimization of the SOAP message for you in direct and compatibility mode. If you are using the program DFHPIRT to start the pipeline, you can send and receive MIME Multipart/Related messages in compatibility mode only.

Web Services Security

If you enable the MTOM handler in the pipeline configuration file to run in direct mode, and you also enable the Web Services Security message handler, the pipeline supports the handling of MTOM messages in compatibility mode only.

Handling binary data

When you have large binary data to include in your Web service, for example a graphic file such as a JPEG, you can use MTOM/XOP to optimize the size of the message that is sent to the service provider or requester. The minimum size of binary data that can be optimized using MTOM/XOP is 1500 bytes. If the binary data in a field is less than 1500 bytes, CICS does not optimize the field.

As stated in the XOP specification, base64Binary data must not contain any white space. Any application programs that produce base64Binary data must use the canonical form. If the base64Binary data in an outbound message does contain white space, CICS does not convert the data to a binary attachment. When CICS generates base64Binary data, the fields are provided in canonical form and therefore contain no white space.

The `contentType` attribute must be present on base64Binary fields for XOP processing to occur in compatibility mode on outbound messages. The contentType attribute must not be present on hexBinary fields.

Web service validation

If you switch on Web service validation, the following pipeline processing takes place:

- If an inbound XOP document has been passed through the pipeline in direct mode, CICS automatically switches to compatibility mode and converts it back to standard XML when CICS Web service support is about to validate the document.
- An outbound SOAP message is generated as standard XML and processed in compatibility mode.

This processing occurs because validation cannot handle the contents of XOP documents.

Configuring CICS to support MTOM/XOP

To configure support for MTOM messages in CICS, you must add the MTOM handler to your pipeline configuration files.

Before performing this task, you must identify or create the pipeline configuration files to which you will add configuration information for MTOM/XOP.

1. Add a `<cics_mtom_handler>` element to your pipeline configuration file. This element must be first in the `<provider_pipeline>` element and the last element before the `<service_parameter_list>` in the `<requester_pipeline>` element. Code the following elements:

   ```
   <cics_mtom_handler>
     <dfhmtom_configuration version="1">
     </dfhmtom_configuration>
   </cics_mtom_handler>
   ```

The <dfhmtom_configuration> element is a container for the other elements in the configuration. If you want to accept the default settings for MTOM/XOP processing, you can specify an empty element as follows:

```
<cics_mtom_handler/>
```

2. Optional: Code an <mtom_options> element. In both a service provider and service requester pipeline, this element specifies whether the outbound message is packaged as an MTOM message.
   a. Code the send_mtom attribute to define if the outbound message should be sent as an MTOM message. For details of this attribute, see "The <mtom_options> element" on page 89.
   b. Code the send_when_no_xop attribute to define if the outbound message should be sent as an MTOM message when there are no binary attachments present. For details of this attribute, see "The <mtom_options> element" on page 89.
3. Optional: Code a <xop_options> element with an apphandler_supports_xop attribute. The value of this attribute specifies if the application handler can handle XOP documents directly. If you do not include this element, the default depends on whether the <apphandler> element specifies DFHPITP or another program. For details of this attribute, see "The <xop_options> element" on page 90.
4. Optional: Code a <mime_options> element with a content_id_domain attribute. The value of this attribute specifies the domain name that is used when generating MIME content-ID values, which are used to identify binary attachments. For details of this attribute, see "The <mime_options> element" on page 92.

Example

The following example shows a completed <cics_mtom_handler> in which all the optional elements are present:

```
<provider_pipeline>
  <cics_mtom_handler>
    <dfhmtom_configuration version="1">
      <mtom_options send_mtom="same" send_when_no_xop="no" />
      <xop_options apphandler_supports_xop="yes" />
      <mime_options content_id_domain="example.org" />
    </dfhmtom_configuration>
  </cics_mtom_handler>
....
</provider_pipeline>
```

Chapter 12. Support for securing Web services

CICS Transaction Server for z/OS provides support for a number of related specifications that enable you to secure SOAP messages.

The *Web Services Security (WSS): SOAP Message Security 1.0* specification describes the use of *security tokens* and *digital signatures* to protect and authenticate SOAP messages.

Web Services Security protects the *privacy* and *integrity* of SOAP messages by, respectively, protecting messages from unauthorized disclosure and preventing unauthorized and undetected modification. WSS provides this protection by digitally signing and encrypting XML elements in the message. The elements that can be protected are the body or any elements in the body or the header. You can give different levels of protection to different elements within the SOAP message.

The *Web Services Trust Language* specification enhances Web Services Security further by providing a framework for requesting and issuing security tokens and managing trust relationships between Web service requesters and providers. This extension to the authentication of SOAP messages enables Web services to validate and exchange security tokens of different types using a trusted third party. This third party is called a *Security Token Service* (STS).

CICS Transaction Server for z/OS provides support for these specifications through the use of a CICS-supplied security handler. When the security handler is enabled in the pipeline, CICS provides the following support:

- For outbound messages, CICS provides support for digital signing and encryption of the entire SOAP body. CICS can also exchange a username token for a security token of a different type with an STS.
- For inbound messages, CICS supports messages in which the body or elements of the body and header are encrypted or digitally signed. CICS can also exchange and validate security tokens with an STS.

CICS also provides a separate Trust client interface so that you can interact with an STS without using the CICS security handler.

Prerequisites

To implement Web Services Security, you must apply a number of updates to your CICS region.

1. Install the free IBM XML Toolkit for z/OS v1.9. You can download it from the following site: http://www.ibm.com/servers/eserver/zseries/software/xml/. You must install version 1.9. Later versions do not work with Web Services Security support in CICS.
2. Apply ICSF APAR OA14956 if it is not already installed in your CICS region.
3. Add the following libraries to the DFHRPL concatenation:
   - *hlq*.SIXMLOD1
   - *hlq*.SCEERUN
   - *hlq*.SDFHWSLD

   where *hlq* is the high-level qualifier of the CICS region.

   The first two libraries contain DLLs that the security handler requires at run time:

- The XML toolkit provides IXM4C56 in *hlq*.SIXMLOD1.
- The Language Environment runtime provides C128N in *hlq*.SCEERUN.

The *hlq*.SDFHWSLD library enables CICS to find the DFHWSSE1 and DFHWSXXX Web Services Security modules.

4. You might need to increase the value of the **EDSALIM** system initialization parameter. The three DLLs that must be loaded require approximately 15 MB of EDSA storage.

If you do not have the libraries specified, you get the following message:

```
CEE3501S The module module_name was not found.
```

The *module_name* varies depending on which library is missing.

Planning for securing Web services

You must decide the best way of securing your Web services. CICS supports a number of options, including a configurable security message handler and a separate Trust client interface.

CICS implements Web Services Security at a pipeline level rather than for each Web service. CICS does not support Web Services Security (WSS) or WS-Trust in pipelines that are used for atomic transactions, so you cannot specify the CICS-supplied security handler in these pipelines. Answer the following questions to decide how best to implement security:

1. Is the performance of your pipeline processing important? Using WSS to secure your Web services incurs a significant performance impact.

   The main advantage of implementing WSS is that, by encrypting part of a SOAP message, you can send the message through a chain of intermediate nodes, all of which might have legitimate reasons to look at the SOAP header to make routing or processing decisions, but are not allowed to view the content of the message. By encrypting those sections that must be confidential you obtain these advantages:

   - You do not incur the overhead of encrypting and decrypting at every node in a chain of intermediate processes.
   - You can route a confidential message over a public network of untrusted nodes, where only the ultimate recipient of the data can understand it.

   As an alternative to using Web Services Security, you can use SSL to encrypt the whole data stream.
2. If you want to use Web Services Security, what level of security do you want? The options range from basic authentication, where the message header includes a user name and a password, through to combining digital signatures and encryption in the message. The options that the CICS security handler supports are described in “The options for securing SOAP messages” on page 231.
3. Does the CICS-supplied security handler meet your requirements? If you want to perform more advanced security processing, you must write your own custom security handler. This handler must perform the necessary authentication of messages, either directly with RACF or using a Security Token Service, and handle the processing of digital certificates and encrypted elements. See “Writing a custom security handler” on page 243 for details.
4. Does your pipeline include an MTOM handler? If you are planning to enable both the MTOM handler and the security handler in your pipeline configuration file, any MIME Multipart/Related messages are processed in compatibility mode.

CICS uses compatibility mode because the security handler cannot parse the XOP elements in the body of the message. This mode can have a further effect on the performance of the pipeline processing.

The options for securing SOAP messages

CICS supports both signing and encrypting SOAP messages, so you can select the level of security that is most appropriate for the data that you are sending or receiving in the SOAP message.

You can choose from these options:

Trusted authentication

In service provider pipelines, CICS can accept a *username token* in the SOAP message header as trusted. This type of security token usually contains a user name and password, but, in this case, the password is not required. CICS trusts the provided user name and places it in container DFHWS-USERID and the message is processed in the pipeline.

In service requester pipelines, CICS can send a username token without the password in the SOAP message header to the service provider.

Basic authentication

In service provider mode, CICS can accept a username token in the SOAP message header for authentication on inbound SOAP messages. This type of security token contains a user name and password. CICS verifies the username token using an external security manager such as RACF. If successful, the user name is placed in container DFHWS-USERID and the SOAP message is processed in the pipeline. If CICS cannot verify the username token, a SOAP fault message is returned to the service requester.

Username tokens that contain passwords are not supported in service requester mode or on outbound SOAP messages.

Advanced authentication

In service provider and requester pipelines, you can verify or exchange security tokens with a Security Token Service (STS) for authentication purposes. The STS enables CICS to accept and send messages that have security tokens in the message header that are not normally supported; for example, Kerberos tokens or SAML assertions.

For an inbound message, you can select to verify or exchange a security token. If the request is to exchange the security token, CICS must receive a username token back from the STS. For an outbound message, you can only exchange a username token for a security token.

Signing with X.509 certificates

In service provider and service requester mode, you can provide an X.509 certificate in the SOAP message header to sign the body of the SOAP message for authentication. This type of security token is known as a *binary security token*. To accept binary security tokens from inbound SOAP messages, the public key associated with the certificate must be imported into an external security manager, such as RACF, and associated with the key ring that is specified in the **KEYRING** system initialization parameter. For outbound SOAP messages, you must generate and publish the public key to the intended recipients. The Integrated Cryptographic Service Facility (ICSF) is used to generate public keys.

When you specify the label associated with an X.509 digital certificate, do not use the following characters:

```
< > : ! =
```

You can also include a second X.509 certificate in the header and sign it using the first certificate. Signing the second certificate with the first certificate allows you to run the work in CICS under the user ID associated with the second X.509 certificate. The certificate that you are using to sign the SOAP message must be associated with a trusted user ID, and have surrogate authority in order to assert that work will run under a different identity, the *asserted identity*, without the trusted user ID having the password associated with that identity.

Encrypting

In service provider and service requester mode, you can encrypt the SOAP message body using a symmetric algorithm such as Triple DES or AES. A symmetric algorithm is where the same key is used to encrypt and decrypt the data. This key is known as a *symmetric key*. It is then included in the message and encrypted using a combination of the intended recipient's public key and the asymmetric key encryption algorithm RSA 1.5. This combination provides you with increased security, because the asymmetric algorithm is complex and it is difficult to decrypt the symmetric key. However, you obtain better performance because the majority of the SOAP message is encrypted with the symmetric algorithm, which is faster to decrypt.

For inbound SOAP messages, the service requester or provider can encrypt an element in the SOAP body and then encrypt the SOAP body as a whole. This encryption might be particularly appropriate for an element that contains sensitive data. If CICS receives a SOAP message with two levels of encryption, CICS decrypts both levels automatically. Outbound SOAP messages do not support two levelsof encryption.

CICS does not support inbound SOAP messages that have an encrypted element in the message header and no encrypted elements in the SOAP body.

Signing and encrypting

In service provider and service requester mode, you can choose to both sign and encrypt a SOAP message. CICS always signs the SOAP message body first and then encrypts it. The advantage of this method is that it gives you both message confidentiality and integrity.

Authentication using a Security Token Service

CICS can interoperate with a Security Token Service (STS), such as Tivoli Federated Identity Manager, to provide more advanced authentication of Web services.

An STS is a Web service that acts as a trusted third party to broker trust relationships between a Web service requester and a Web service provider. In a similar manner to a certificate authority in an SSL handshake, the STS guarantees that the requester and provider can "trust" the credentials that are provided in the message. This trust is represented through the exchange of security tokens. An STS can issue, exchange, and validate these security tokens, and establish trust relationships, allowing Web services from different trust domains to communicate successfully. For more details, see the WS-Trust specification.

CICS acts as a Trust client and can send two types of Web service request to an STS. The first type of request is to validate the security token in the WS-Security message header; the second type of request is to exchange the security token for a different type. This exchange of tokens enables CICS to send and receive messages that contain different security tokens from a wide variety of trust domains, such as SAML assertions and Kerberos tokens.

You can either configure the CICS security handler to define how CICS should interact with an STS or write your own message handler to use a separately provided Trust client interface. Whichever method you choose, you are recommended to use SSL to secure the connection between CICS and the STS.

How the security handler invokes the STS

The CICS security handler uses the information in the pipeline configuration file to send a Web service request to the Security Token Service (STS). The type of request that is sent depends on the action that you want the STS to perform.

In a service provider pipeline

In a service provider pipeline, the security handler supports two types of actions. You can configure the security handler to perform one of the following actions:

- Send a request to the STS to validate the first instance of a security token, or the first security token of a specific type, in the WS-Security header of the inbound message.
- Send a request to the STS to exchange the first instance of a security token, or the first security token of a specific type, in the WS-Security header of the inbound message, for a security token that CICS can understand.

The security handler dynamically creates a pipeline to send the Web service request to the STS. This pipeline exists until a response is received from the STS, after which it is deleted. If the request is successful, the STS returns an identity token or the status of the token's validity. The security handler places the token in the DFHWS-USERID container.

If the STS encounters an error, it returns a SOAP fault to the security handler. The security handler then passes a fault back to the Web service requester.

In a service requester pipeline

In a service requester pipeline, the security handler can request to exchange a token with the STS only. The pipeline configuration file defines what type of token the STS should issue to the security handler.

If the request is successful, the token is placed in DFHWS-USERID and then included in the outbound message header. If the STS encounters an error, it returns a SOAP fault to the security handler. The security handler then passes the fault back through the pipeline to the Web service requester application.

The security handler can request only one type of action from the STS for the pipeline. It can also exchange only one type of token for an outbound request message, and is limited to handling the first token in the WS-Security message header, either the first instance or of a specific type. These options cover the most common scenarios for using an STS, but might not offer you the processing that you require for handling inbound and outbound messages.

If you want to provide more specific processing to handle many tokens in the inbound message headers or exchange multiple types of tokens for outbound messages, you are recommended to use the Trust client interface. Using this interface, you can create a custom message handler to send your own Web service request to the STS.

The Trust client interface

The Trust client interface enables you to interact with a Security Token Service (STS) directly, rather than using the security handler, giving you the flexibility to provide more advanced processing of tokens than the security handler.

The Trust client interface is an enhancement to the CICS-supplied program DFHPIRT. This program is normally used to start a pipeline when a Web service requester application has not been deployed using the CICS Web services assistant. However, the program DFHPIRT can also act as the Trust client interface to the STS.

You can invoke the Trust client interface by linking to DFHPIRT from a message handler or header processing program, passing a channel called DFHWSTC-V1 and a set of security containers. Using these containers, you have the flexibility to request either a validate or issue action from the STS, select what token type to exchange, and pass the appropriate token from the message header. DFHPIRT dynamically creates a pipeline, composes a Web service request from the security containers, and sends it to the STS.

DFHPIRT waits for the response from the STS and passes this back in the DFHWS-RESTOKEN container to the message handler. If the STS encounters an error, it returns a SOAP fault. DFHPIRT puts the fault in the DFHWS-STSFAULT container and returns to the linking program in the pipeline.

You can use the Trust client interface without enabling the security handler in your service provider and service requester pipelines or you can use the Trust client interface in addition to the security handler.

Signing of SOAP messages

For inbound messages, CICS supports digital signatures on elements in the SOAP body and on SOAP header blocks. For outbound messages, CICS signs all elements in the SOAP body.

A SOAP message is an XML document, consisting of an `<Envelope>` element, which contains an optional `<Header>` element, and a mandatory `<Body>` element.

The *WSS: SOAP Message Security* specification permits the contents of the `<Header>` and the `<Body>` to be signed at the element level. That is, in a given message, individual elements can be signed or not, or can be signed with different signatures or using different algorithms. For example, in a SOAP message used in an online purchasing application, it is appropriate to sign elements that confirm receipt of an order, because these elements might have legal status. However, to avoid the overhead of signing the entire message, other information might safely be left unsigned.

For inbound messages, the security message handler can verify the digital signature on individual elements in the SOAP `<Header>` and the `<Body>`. The security handler verifies the following elements:

- Verify signed elements it encounters in the <Header>.
- Verify signed elements in the SOAP <Body>. If the handler is configured to expect a signed body, CICS will reject with a fault any SOAP message in which the body is not signed.

For outbound messages, the security message handler can sign the SOAP <Body> only; it does not sign the <Header>. The security handler's configuration information specifies the algorithm and key used to sign the body.

Signature algorithms

CICS supports the signature algorithms required by the XML Signature specification. A universal resource identifier (URI) identifies each algorithm.

Algorithm	URI
Digital Signature Algorithm with Secure Hash Algorithm 1 (DSA with SHA1)	`http://www.w3.org/2000/09/xmldsig#dsa-sha1`
Rivest-Shamir-Adleman algorithm with Secure Hash Algorithm 1 (RSA with SHA1)	`http://www.w3.org/2000/09/xmldsig#rsa-sha1`

Inbound SOAP messages support only the DSA with SHA1 signature algorithm.

Example of a signed SOAP message

This example of a SOAP message has been signed by CICS.

```
<?xml version="1.0" encoding="UTF8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
<SOAP-ENV:Header>
 <wsse:Security xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
                xmlns:wsse="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd"
                xmlns:wsu="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-utility-1.0.xsd"
                xmlns:xenc="http://www.w3.org/2001/04/xmlenc#" SOAP-ENV:mustUnderstand="1">
 <wsse:BinarySecurityToken 1
              EncodingType="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-soap-message-security-1.0#Base64Binary"
              ValueType="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-x509-token-profile-1.0#X509"
              wsu:Id="x509cert00">MIIChDCCAe2gAwIBAgIBADANBgkqhkiG9w0BAQUFADAwMQswCQYDVQQGEwJHQjEMMAoGA1UEChMD
                                  SUJNMRMwEQYDVQQDEwpXaWxsIFlhdGVzMB4XDTA2MDEzMTAwMDAwMFoXDTA3MDEzMTIzNTk1OVow
                                  MDELMAkGA1UEBhMCR0IxDDAKBgNVBAoTA0lCTTETMBEGA1UEAxMKV2lsbCBZYXRlczCBnzANBgkq
                                  hkiG9w0BAQEFAAOBjQAwgYkCgYEArsRj/n+3RN75+jaxuOMBWSHvZCB0egv8qu2UwLWEeiogePsR
                                  6Ku4SuHbBwJtWNr0xBTAAS9lEa70yhVdppxOnJBOCiERg7S0HUdP7a8JXPFzA+BqV63JqRgJyxN6
                                  msfTAvEMR07LIXmZAte62nwcFrvCKNPCFIJ5mkaJ9v1p7jkCAwEAAaOBrTCBqjA/BglghkgBhvhC
                                  AQ0EMhMwR2VuZXJhdGVkIGJ5IHRoZSBTZWN1cml0eSBTZXJ2ZXIgZm9yIHovT1MgKFJBQ0YpMDgG
                                  ZQVRFU0BVSy5JQk0uQ09ggdJQk0uQ09NhgtXV1cuSUJNLkNPTYcECRRlBjAO
 </wsse:BinarySecurityToken>
 <ds:Signature xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
  <ds:SignedInfo xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
                 xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
                 xmlns:wsu="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-utility-1.0.xsd"
                 xmlns:xenc="http://www.w3.org/2001/04/xmlenc#">
   <ds:CanonicalizationMethod Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#">
    <c14n:InclusiveNamespaces xmlns:c14n="http://www.w3.org/2001/10/xml-exc-c14n#" PrefixList="ds wsu xenc SOAP-ENV "/>
   </ds:CanonicalizationMethod>
   <ds:SignatureMethod Algorithm="http://www.w3.org/2000/09/xmldsig#rsa-sha1"/>
   <ds:Reference URI="#TheBody">
    <ds:Transforms>
     <ds:Transform Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#">
       <c14n:InclusiveNamespaces xmlns:c14n="http://www.w3.org/2001/10/xml-exc-c14n#" PrefixList="wsu SOAP-ENV "/>
     </ds:Transform>
    </ds:Transforms>
    <ds:DigestMethod Algorithm="http://www.w3.org/2000/09/xmldsig#sha1"/> 2
    <ds:DigestValue>QORZEA+gpafluShspHxhrjaFlXE=</ds:DigestValue> 3
   </ds:Reference>
  </ds:SignedInfo>
  <ds:SignatureValue>drDH0XESiyN6YJm27mfK1ZMG4Q4IsZqQ9N9V6kEnw2lk7aM3if77XNFnyKS4deglbC3ga11kkaFJ 4
                     p4jLOmYRqqycDPpqPm+UEu7mzfHRQGe7H0EnFqZpikNqZK5FF6fvYlv2JgTDPwrOSYXmhzwegUDT
                     lTVjOvuUgXYrFyaO3pw=</ds:SignatureValue>
   <ds:KeyInfo>
    <wsse:SecurityTokenReference>
      <wsse:Reference URI="#x509cert00"
                      ValueType="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-x509-token-profile-1.0#X509"/> 5
    </wsse:SecurityTokenReference>
   </ds:KeyInfo>
  </ds:Signature>
 </wsse:Security>
</SOAP-ENV:Header>
<SOAP-ENV:Body xmlns:wsu="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-utility-1.0.xsd" wsu:Id="TheBody">
 <getVersion xmlns="http://msgsec.wssecfvt.ws.ibm.com"/>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

1. The binary security token contains the base64Binary encoding of the X.509 certificate. This encoding includes the public key that the intended recipient of the SOAP message uses to verify the signature.
2. The algorithm that is used during the hashing process to produce the message digest.
3. The value of the message digest.
4. The digest value is then encrypted with the user's private key and included here as the signature value.
5. References the binary security token that contains the public key that is used to verify the signature.

CICS support for encrypted SOAP messages

For inbound messages, CICS can decrypt any encrypted elements in the SOAP body and encrypted SOAP header blocks where the body is also encrypted. For outbound messages, CICS encrypts the entire SOAP body.

A SOAP message is an XML document, consisting of an `<Envelope>` element, which contains an optional `<Header>` element, and a mandatory `<Body>` element.

The *WSS: SOAP Message Security* specification allows some of the contents of the `<Header>` and all of the contents of the `<Body>` to be encrypted at the element level. That is, in a given message, individual elements can have different levels of encryption or can be encrypted using different algorithms. For example, in a SOAP message used in an online purchasing application, it would be appropriate to encrypt an individual's credit card details to ensure that they remain confidential. However, to avoid the overhead of encrypting the entire message, some information might safely be encrypted using a less secure (but faster) algorithm and other information might safely be left unencrypted.

For inbound messages, the CICS-supplied security message handler can decrypt individual elements in the SOAP `<Body>`, and can decrypt elements in the SOAP `<Header>` if the SOAP body is also encrypted. The security message handler always decrypts the following:

- Elements it encounters in the `<Header>` in the order that the elements are found.
- Elements in the SOAP `<Body>`. If you want to reject a SOAP message that does not have an encrypted `<Body>`, configure the handler to expect an encrypted body using the `<expect_encrypted_body>` element.

For outbound messages, the security message handler supports encryption of the contents of the SOAP `<Body>` only; it does not encrypt any elements in the `<Header>`. When the security message handler encrypts the `<Body>`, all elements in the body are encrypted with the same algorithm and using the same key. The algorithm and information about the key are specified in the handler's configuration information.

Encryption algorithms

CICS supports the encryption algorithms required by the XML Encryption specification. A universal resource identifier (URI) identifies each algorithm.

Algorithm	URI
Triple Data Encryption Standard algorithm (Triple DES)	`http://www.w3.org/2001/04/xmlenc#tripledes-cbc`
Advanced Encryption Standard (AES) algorithm with a key length of 128 bits	`http://www.w3.org/2001/04/xmlenc#aes128-cbc`
Advanced Encryption Standard (AES) algorithm with a key length of 192 bits	`http://www.w3.org/2001/04/xmlenc#aes192-cbc`
Advanced Encryption Standard (AES) algorithm with a key length of 256 bits	`http://www.w3.org/2001/04/xmlenc#aes256-cbc`

Example of an encrypted SOAP message

This example of a SOAP message has been encrypted by CICS.

```
<?xml version="1.0" encoding="UTF8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
<SOAP-ENV:Header>
 <wsse:Security xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
                xmlns:wsse="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd"
                xmlns:wsu="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-utility-1.0.xsd"
                xmlns:xenc="http://www.w3.org/2001/04/xmlenc#" SOAP-ENV:mustUnderstand="1">

  <wsse:BinarySecurityToken
                EncodingType="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-soap-message-security-1.0#Base64Binary" 1
                ValueType="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-x509-token-profile-1.0#X509"
                wsu:Id="x509cert00">MIIChDCCAe2gAwIBAgIBADANBgkqhkiG9w0BAQUFADAwMQswCQYDVQQGEwJHQjEMMAoGA1UEChMD
                                    SUJNMRMwEQYDVQQDEwpXaWxsIFlhdGVzMB4XDTA2MDEzMTAwMDAwMFoXDTA3MDEzMTIzNTk1OVow
                                    MDELMAkGA1UEBhMCR0IxDDAKBgNVBAoTA0lCTTETMBEGA1UEAxMKV2lsbCBZYXRlczCBnzANBgkq
                                    hkiG9w0BAQEFAAOBjQAwgYkCgYEArsRj/n+3RN75+jaxuOMBWSHvZCB0egv8qu2UwLWEeiogePsR
                                    6Ku4SuHbBwJtWNr0xBTAAS9lEa70yhVdppxOnJBOCiERg7S0HUdP7a8JXPFzA+BqV63JqRgJyxN6
                                    msfTAvEMR07LIXmZAte62nwcFrvCKNPCFIJ5mkaJ9v1p7jkCAwEAAaOBrTCBqjA/BglghkgBhvhC
                                    AQ0EMhMwR2VuZXJhdGVkIGJ5IHRoZSBTZWN1cml0eSBTZXJ2ZXIgZm9yIHovT1MgKFJBQ0YpMDgG
                                    A1UdEQQxMC+BEVdZQVRFU0BVSy5JQk0uQ09NggdJQk0uQ09NhgtXV1cuSUJNLkNPTYcECRRlBjAO
                                    BgNVHQ8BAf8EBAMCAfYwHQYDVR0OBBYEFMiPX6VZKP5+mSOY1TLNQGVvJzu+MA0GCSqGSIb3DQEB
                                    BQUAA4GBAHdrS409Jhoe67pHL2gs7x4SpV/NOuJnn/w25sjjop3RLgJ2bKtK6RiEevhCDim6tnYW
                                    NyjBL1VdN7u5M6kTfd+HutR/HnIrQ3qPkXZK4ipgC0RWDJ+8APLySCxtFL+J0LN9Eo6yjiHL68mq
                                    uZbTH2LvzFMy4PqEbmVKbmA87alF
  </wsse:BinarySecurityToken>
  <xenc:EncryptedKey xmlns:xenc="http://www.w3.org/2001/04/xmlenc#">
   <xenc:EncryptionMethod Algorithm="http://www.w3.org/2001/04/xmlenc#rsa-1_5"/> 2
   <ds:KeyInfo xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
    <wsse:SecurityTokenReference>
     <wsse:Reference URI="#x509cert00"
                     ValueType="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-x509-token-profile-1.0#X509"/>  3
    </wsse:SecurityTokenReference>
   </ds:KeyInfo>
   <xenc:CipherData>
    <xenc:CipherValue>M6bDQtJrvX0pEjAEIcf6bq6MP3ySmB4TQOa/B5UlQj1vWjD56V+GRJbF7ZCES5ojwCJHRVKW1ZB5 4
                      Mb+aUzSWlsoHzHQixc1JchgwCiyIn+E2TbG3R9m0zHD3XQsKTyVaOTlR7VPoMBd1ZLNDIomxjZn2
                      p7JfxywXkObcSLhdZnc=</xenc:CipherValue>
   </xenc:CipherData>
   <xenc:ReferenceList>
    <xenc:DataReference URI="#Enc1"/>
   </xenc:ReferenceList>
  </xenc:EncryptedKey>
 </wsse:Security>
</SOAP-ENV:Header>
<SOAP-ENV:Body>
 <xenc:EncryptedData xmlns:xenc="http://www.w3.org/2001/04/xmlenc#" Id="Enc1" Type="http://www.w3.org/2001/04/xmlenc#Content">
  <xenc:EncryptionMethod Algorithm="http://www.w3.org/2001/04/xmlenc#tripledes-cbc"/> 5
  <xenc:CipherData>
   <xenc:CipherValue>kgvqKnMcgIUn7rl1vkFXF0g4SodEd3dxAJo/mVN6ef211B1MZelg7OyjEHf4ZXwlCdtOFebIdlnK 6
                     rrksql1Mpw6So7ID8zav+KPQUKGm4+E=</xenc:CipherValue>
  </xenc:CipherData>
 </xenc:EncryptedData>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

1. The binary security token contains the base64Binary encoding of the X.509 certificate. This encoding includes the public key that was used to encrypt the symmetric key.
2. States the algorithm that was used to encrypt the symmetric key.
3. References the binary security token that contains the public key used to encrypt the symmetric key.
4. The encrypted symmetric key that was used to encrypt the message.
5. The encryption algorithm that was used to encrypt the message.
6. The encrypted message.

Configuring RACF for Web Services Security

You must configure an external security manager, such as RACF, to create public-private key pairs and X.509 certificates for signing and encrypting outbound SOAP messages, and to authenticate and decrypt signed and encrypted inbound SOAP messages.

Before you perform this task, you must have RACF set up to work with CICS. Specify the **DFLTUSER**, **KEYRING**, and **SEC=YES** system initialization parameters in the CICS region that contains your Web services pipelines.

1. To authenticate inbound SOAP messages that are signed:
   a. Import the X.509 certificate into RACF as an ICSF key.
   b. Attach the certificate to the key ring specified in the **KEYRING** system initialization parameter, using the **RACDCERT** command.

      ```
      RACDCERT ID(userid1)
      CONNECT(ID(userid2) LABEL('label-name') RING(ring-name)
      ```

      where:
      - *userid1* is the default user ID of the key ring or has authority to attach certificates to the key ring for other user IDs.
      - *userid2* is the user ID that you want to associate with the certificate
      - *label-name* is the name of the certificate
      - *ring-name* is the name of the key ring that is specified in the **KEYRING** system initialization parameter.

   c. Optional: If you want to use asserted identities, ensure that the user ID associated with the certificate has surrogate authority to allow work to run under other user IDs. You should also make sure that any additional certificates included in the SOAP message header are also imported into RACF.

The SOAP message can contain a binary security token in the header that either includes the certificate or contains a reference to the certificate. This reference can be the KEYNAME (the certificate label in RACF), a combination of the ISSUER and SERIAL number, or the SubjectKeyIdentifier. CICS can only recognize the SubjectKeyIdentifier if it has been specified as an attribute in the definition of the certificate in RACF.

2. To sign outbound SOAP messages:
   a. Create an X.509 certificate and a public-private key pair using the following **RACDCERT** command.

      ```
      RACDCERT ID(userid2) GENCERT
      SUBJECTSDN(CN('common-name')
                 T('title')
                 OU('organizational-unit')
                 O('organization')
                 L('locality')
                 SP('state-or-province')
                 C('country'))
      WITHLABEL('label-name')
      ```

      where *userid2* is the user ID that you want to associate with the certificate. When you specify the certificate *label-name* value, do not use the following characters:

      ```
      < > : ! =
      ```

   b. Attach the certificate to the key ring specified in the **KEYRING** system initialization parameter. Use the **RACDCERT** command.
   c. Export the certificate and publish it to the intended recipient of the SOAP message.

   You can edit the pipeline configuration file so that CICS automatically includes the X.509 certificate in the binary security token of the SOAP message header for the intended recipient to validate the signature.

3. To decrypt inbound SOAP messages that are encrypted, the SOAP message must include the public key that is part of a key pair, where the private key is defined in CICS.
   a. Generate a public-private key pair and certificate in RACF for encryption. Use ICSF to generate the key pair and certificate.
   b. Attach the certificate to the key ring specified in the **KEYRING** system initialization parameter. Use the **RACDCERT** command.
   c. Export the certificate and publish it to the generator of the SOAP messages that you want to decrypt.

   The generator of the SOAP message can then import the certificate that contains the public key and use it to encrypt the SOAP message. The SOAP message can contain a binary security token in the header that either includes the public key or contains a reference to it. This reference can be the KEYNAME, a combination of the ISSUER and SERIAL number, or the SubjectKeyIdentifier. CICS can only recognize the SubjectKeyIdentifier if it has been specified as an attribute in the definition of the public key in RACF.

4. To encrypt outbound SOAP messages:
   a. Import the certificate that contains the public key that you want to use for encryption into RACF as an ICSF key. The intended recipient must have the private key associated with the public key to decrypt the SOAP message.
   b. Attach the certificate that contains the public key to the key ring specified in the **KEYRING** system initialization parameter. Use the **RACDCERT** command.

CICS uses the public key in the certificate to encrypt the SOAP body and sends the certificate containing the public key as a binary security token in the SOAP message header, as defined in the pipeline configuration file.

The above configuration for signing and encrypting outbound messages requires that the certificate used is owned by the CICS region userid. The certificate must be owned by the CICS region userid because RACF allows only the certificate owner to extract the private key, which is used for the signing or encryption process.

If CICS needs to sign or encrypt a message using a certificate that it does not own, for example a single certificate shared by multiple CICS systems where each system has a different region userid, the following conditions must be true:

1. You must be using one of the following z/OS releases:
   - z/OS 1.9 or above
   - z/OS 1.8 with PTF UA37039
   - z/OS 1.7 with PTF UA37038
2. The certificate must be connected to its key ring with the PERSONAL usage option.
3. If the certificate is a USER certificate, the CICS region userid that wishes to use the certificate must have READ or UPDATE authority for the <ringOwner>.<ringName>.LST resource in the RDATALIB class.
4. The RDATALIB class must have been activated using the RACLIST option.

CICS uses the RACF R_datalib callable service to extract the private key from the certificate. For more information, see the *z/OS Security Server RACF Callable Services* guide.

Configuring the pipeline for Web Services Security

To configure a pipeline to support Web Services Security (WSS), you must add a security handler to your pipeline configuration files. You can use the CICS-supplied security handler or create your own. This information describes how to define the CICS security handler.

Before performing this task, you must identify or create the pipeline configuration files to which you will add configuration information for WSS.

1. Add a `<wsse_handler>` element to your pipeline. The handler must be included in the `<service_handler_list>` element in a service provider or requester pipeline. Code the following elements:

   ```
   <wsse_handler>
     <dfhwsse_configuration version="1">

     </dfhwsse_configuration>
   </wsse_handler>
   ```

   The `<dfhwsse_configuration>` element is a container for the other elements in the configuration.
2. Optional: Code an `<authentication>` element.
   - In a service requester pipeline, the `<authentication>` element specifies the type of authentication that the security header of outbound SOAP messages will use.
   - In a service provider pipeline, the element specifies whether CICS will use the security tokens in an inbound SOAP message to determine the user ID under which work will be processed.

a. Code the **trust** attribute to specify whether asserted identity is used and the nature of the trust relationship between service provider and requester. For details of the **trust** attribute, see "The <authentication> element" on page 81.

b. Optional: If you specified **trust=none**, code the **mode** attribute to specify how credentials found in the message are processed. For details of the **mode** attribute, see "The <authentication> element" on page 81.

c. Within the <authentication> element, code the following:

1) An optional, empty <suppress/> element.

If this element is specified in a service provider pipeline, the handler will not attempt to use any security tokens in the message to determine under which user ID the work will run.

If this element is specified in a service requester pipeline, the handler will not attempt to add to the outbound SOAP message any of the security tokens that are required for authentication.

2) An optional <algorithm> element that specifies the URI of the algorithm used to sign the body of the SOAP message. You must specify this element if the combination of trust and mode attribute values indicate that the messages are signed.

You can specify the following algorithms:

Algorithm	URI
Digital Signature Algorithm with Secure Hash Algorithm 1 (DSA with SHA1)	`http://www.w3.org/2000/09/xmldsig#dsa-sha1`
Rivest-Shamir-Adleman algorithm with Secure Hash Algorithm 1 (RSA with SHA1)	`http://www.w3.org/2000/09/xmldsig#rsa-sha1`

3) An optional <certificate_label> element that specifies the label associated with an X.509 digital certificate installed in RACF. If this element is specified in a service requester pipeline, and the <suppress> element is not specified, the certificate is added to the security header in the SOAP message. If you do not specify a <certificate_label> element, CICS uses the default certificate in the RACF key ring.

This element is ignored in a service provider pipeline.

3. Optional: Code an <sts_authentication> element. This element is an alternative to the <authentication> element and you must not code both in your pipeline configuration file. This element specifies that a Security Token Service (STS) is used for authentication and determines what type of request is sent.

a. Optional: In service provider mode only, code the **action** attribute to specify whether the STS will verify or exchange a security token. For details of the **action** attribute, see "The <sts_authentication> element" on page 84.

b. Within the <sts_authentication> element, code the following:

1) An <auth_token_type> element. This element is required when you specify a <sts_authentication> element in a service requester pipeline and optional in a service provider pipeline.

- In a service requester pipeline, the <auth_token_type> element indicates the type of token the STS will issue when CICS sends it the user ID contained in the DFHWS-USERID container. The token that CICS receives from the STS is placed in the header of the outbound message.

- In a service provider pipeline, the <auth_token_type> element is used to determine which identity token CICS takes from the message header and send to the STS to exchange or validate. CICS uses the first identity token of the specified type in the message header. If you do not specify this element, CICS uses the first identity token that it finds in the message header. CICS does not consider the following as identity tokens:
  - wsu:Timestamp
  - xenc:ReferenceList
  - xenc:EncryptedKey
  - ds:Signature

2) In a service provider pipeline only, an optional, empty <suppress/> element. If this element is specified, the handler does not attempt to use any security tokens in the message to determine under which user ID the work will run, including the identity token that is returned by the STS.

4. Optional: Code an <sts_endpoint> element. Use this element only if you have also specified an <sts_authentication> element. In the <sts_endpoint> element, code the following:
   - An <endpoint> element. This element contains a URI that points to the location of the Security Token Service (STS) on the network. You are recommended to use SSL or TLS to keep the connection to the STS secure, rather than using HTTP.

     You can also specify a WebSphere MQ endpoint using the JMS format of URI.
5. Optional: If you require inbound SOAP messages to be digitally signed, code an empty <expect_signed_body/> element.

   The <expect_signed_body/> element indicates that the <body> of the inbound message must be signed. If the body of an inbound message is not correctly signed, CICS rejects the message with a security fault.
6. Optional: If you want to reject inbound SOAP messages that are digitally signed, code an empty <reject_signature/> element.
7. Optional: If you require inbound SOAP messages to be encrypted, code an empty <expect_encrypted_body/> element.

   The <expect_encrypted_body/> element indicates that the <body> of the inbound message must be encrypted. If the body of an inbound message is not correctly encrypted, CICS rejects the message with a security fault.
8. If you want to reject inbound SOAP messages that are partially or fully encrypted, code an empty <reject_encryption/> element.
9. Optional: If you require outbound SOAP messages to be signed, code a <sign_body> element.
   a. In the <sign_body> element, code an <algorithm> element.
   b. Following the <algorithm> element, code a <certificate_label> element.

   This example is of a completed <sign_body> element:

```
<sign_body>
  <algorithm>http://www.w3.org/2000/09/xmldsig#rsa-sha1</algorithm>
  <certificate_label>SIGCERT01</certificate_label>
</sign_body>
```

10. Optional: If you require outbound SOAP messages to be encrypted, code an <encrypt_body> element.
    a. In the <encrypt_body> element, code an <algorithm> element.
    b. Following the <algorithm> element, code a <certificate_label> element.

    This example is of a completed <encrypt_body> element:

```
<encrypt_body>
  <algorithm>http://www.w3.org/2001/04/xmlenc#tripledes-cbc</algorithm>
  <certificate_label>ENCCERT02</certificate_label>
</encrypt_body>
```

Example

The following example shows a completed security handler in which most of the optional elements are present:

```
<wsse_handler>
    <dfhwsse_configuration version="1">
      <authentication trust="signature" mode="basic">
        <suppress/>
        <certificate_label>AUTHCERT03</certificate_label>
      </authentication>
      <expect_signed_body/>
      <expect_encrypted_body/>
      <sign_body>
        <algorithm>http://www.w3.org/2000/09/xmldsig#rsa-sha1</algorithm>
        <certificate_label>SIGCERT01</certificate_label>
      </sign_body>
      <encrypt_body>
        <algorithm>http://www.w3.org/2001/04/xmlenc#tripledes-cbc</algorithm>
        <certificate_label>ENCCERT02</certificate_label>
      </encrypt_body>
    </dfhwsse_configuration>
</wsse_handler>
```

Writing a custom security handler

If you want to use your own security procedures and processing, you can write a custom message handler to process secure SOAP messages in the pipeline.

You must decide the level of security that your security handler will support and ensure that an appropriate SOAP fault is returned when a message includes security that is not supported.

The message handler must also be able to cope with security on inbound and outbound messages.

1. Retrieve the DFHREQUEST or DFHRESPONSE container using an **EXEC CICS GET CONTAINER** command.
2. Parse the XML to find the security token that is in the WS-Security message header. The header starts with the <wsse:Security> element. The security token might be a user name and password, a digital certificate, or an encryption key. A message can have many tokens in the security header, so your handler must identify the correct one to process.
3. Perform the appropriate processing, depending on what security is implemented in the message.
    a. If you want to perform basic authentication, issue an **EXEC CICS VERIFY PASSWORD** command. This command checks the user name and password in the security header of the message. If this command is successful, update

the DFHWS-USERID container with an **EXEC CICS PUT CONTAINER**. Otherwise, issue an **EXEC CICS SOAPFAULT CREATE** command.

b. If you want to perform advanced authentication, either by exchanging or validating a range of tokens with a Security Token Service, use the Trust client interface. See “Invoking the Trust client from a message handler” for details.

c. Validate the credentials of the digital certificate if the message is signed.

d. If parts of the message are encrypted, decrypt the message using the information in the security header. The “Web Services Security: SOAP Message Security” on page 29 specification tells you how to do this.

Define your security handler program in CICS and update the pipeline configuration file, ensuring that it is correctly placed in the XML. In a service requester pipeline configuration file, the security handler should be configured to run at the end of the pipeline. In a service provider pipeline configuration file, configure the security handler to run at the beginning of the pipeline.

For general information on how to write a custom message handler, see *Application Development for CICS Web Services*, an IBM Redbooks® publication, which is available from http://www.redbooks.ibm.com/abstracts/sg247126.html.

Invoking the Trust client from a message handler

CICS provides an interface so that you can write your own message handler to invoke a Security Token Service (STS). Providing your own message handler enables you to perform more advanced processing than the CICS-supplied security handler.

You can use the Trust client instead of the security handler or in addition to it. To use the Trust client interface:

1. Extract the correct token from the security message header of the inbound or outbound message.
2. Link to program DFHPIRT, passing the channel DFHWSTC-V1 and the following required containers:
   - DFHWS-STSURI, containing the location of the STS on the network.
   - DFHWS-STSACTION, containing the URI of the type of request that the STS will perform. The two supported actions are issue and validate.
   - DFHWS-IDTOKEN, containing the token that will either be verified or exchanged by the STS.
   - DFHWS-TOKENTYPE, containing the type of token that the STS will send back in the response.
   - DFHWS-SERVICEURI, containing the URI of the Web service operation that is being invoked.

   You can optionally include the DFHWS-XMLNS container to provide the namespaces of the SOAP message that contains the security token. This container is described in more detail in “The header processing program interface” on page 101.
3. DFHPIRT returns with the response from the STS. A successful response is stored in the DFHWS-RESTOKEN container.

If the STS encounters a problem with the request, it returns a SOAP fault. DFHPIRT puts the SOAP fault in the DFHWS-STSFAULT container. If the STS provides a reason for issuing the SOAP fault, this reason is put in the DFHWS-STSREASON container.

If an abend occurs, a DFHERROR container is returned that contains details of the processing error.

Your message handler must handle these responses and perform suitable processing in the event of an error. For example, the message handler might pass back a suitable SOAP fault to the Web service requester.

4. Process the response as appropriate. In provider mode, your pipeline processing must ensure that a user name and password that CICS can understand are placed in the DFHWS-USERID container by the time the message reaches the application handler. In requester mode, your message handler must add the correct token to the outbound message security header.

When you have written your message handler, define and install the program in CICS and update the appropriate pipeline configuration files. In service requester pipelines, define your message handler to occur at the end of the pipeline processing but before the CICS-supplied security handler. In service provider pipelines, define your message handler at the beginning of the pipeline but after the CICS-supplied security handler.

Chapter 13. Diagnosing problems

The problems that you might encounter when implementing Web services in CICS can occur during the deployment process or at run time, when CICS is transforming SOAP messages.

Diagnosing deployment errors

Deployment errors can occur when you try to run the Web services assistant batch jobs or install a PIPELINE or WEBSERVICE resource in CICS. If a deployment error occurs, PIPELINE resources usually install in a DISABLED state and WEBSERVICE resources install in an UNUSABLE state. The most common deployment errors are described here, including the symptom of the problem, the cause, and the solution.

Information and error messages associated with the Web services assistant batch jobs are in the job log. Error messages associated with installing resources are in the system log.

- You receive a return code of 4, 8, or 12 when running the Web services assistant batch jobs DFHWS2LS or DFHLS2WS. The return codes mean the following:
  - 4 - Warning. The job completed successfully, but one or more warning messages have been issued.
  - 8 - Input error. The job did not complete successfully. One or more error messages were issued while validating the input parameters.
  - 12 - Error. The job did not complete successfully. One or more error messages were issued during execution.
  1. Check the job log for any warning or error messages. Look up the detailed explanations for the messages. The explanations normally describe actions that you can take to fix the problem.
  2. Ensure that you have entered the correct values for each of the parameters in the job. Treat parameter values such as file names and elements in the Web service description as case-sensitive.
  3. Ensure that you have specified the correct combination of parameters. For example, if you include the **PGMNAME** parameter in DFHWS2LS when generating a Web service binding file for a service requester, you receive an error and the job does not complete successfully.
- You receive a return code of 1, 136, or 139 when running the Web services assistant batch jobs DFHWS2LS or DFHLS2WS. These return codes indicate that the JVM has failed, usually because insufficient storage is available. The Web services assistants require a JCL region size of at least 200 MB.
  1. Increase the region size or consider setting the region size to 0 MB.
  2. Check for any active IEFUSI exits, which can limit the region size.
- You receive a DFHPI0914 error message when attempting to install a WEBSERVICE resource. The message includes some information about the cause of the install failure.
  1. Check that you have authorized CICS to read the Web service binding file in z/OS UNIX.
  2. Check that the Web service binding file is not corrupt. This corruption can occur, for example, if you use FTP to transfer the file to z/OS UNIX in text mode rather than binary mode.

3. Check that two Web service binding files with the same name are not in different pick-up directories.
4. If you are attempting to install a resource for a Web service requester application, check that the version of the SOAP binding matches the level supported in the pipeline. You cannot install a SOAP 1.1 WEBSERVICE resource into a service requester pipeline that supports SOAP 1.2.
5. Check that you are not installing a provider mode WEBSERVICE resource into a requester mode pipeline. Provider mode Web service binding files specify a **PROGRAM** value, but requester mode binding files do not.
6. If you are using DFHWS2LS or DFHLS2WS, check that you have specified the correct parameters when generating the Web service binding file. Some parameters, such as **PGMNAME**, are allowed for Web service providers only and must be excluded if you are creating a Web service requester.
7. If you are using DFHWS2LS or DFHLS2WS, check the messages issued by the job to see if you need to resolve any problems before creating the WEBSERVICE resource.

- The PIPELINE resource fails to install and you receive a DFHPI0700, DFHPI0712, DFHPI0714, or similar error message.
  1. If you received a DFHPI0700 error message, you must enable PL/I language support in your CICS region. This support is required before you can install any PIPELINE resources. See the *CICS Transaction Server for z/OS Installation Guide* for more information.
  2. Check that you have authorized CICS to access the z/OS UNIX directories to read the pipeline configuration files.
  3. Check that the directory you are specifying in the **WSDIR** parameter is valid. In particular, check the case because directory and file names in z/OS UNIX are case-sensitive.
  4. Ensure that you do not have a PIPELINE resource of the same name in an ENABLED state in the CICS region.
- The PIPELINE resource installs in a DISABLED state. You get an error message in the range of DFHPI0702 to DFHPI0711.
  1. Check that no errors occur in the pipeline configuration file. The elements in the pipeline configuration file can appear only in certain places. If you specify these elements incorrectly you receive a DFHPI0702 error message. This message includes the name of the element that is causing the problem. Check the element description to make sure you have coded it in the correct place.
  2. Check that you do not have any unprintable characters, such as tabs, in the pipeline configuration file.
  3. Check that the XML is valid. If the XML is not valid, it can cause parsing errors when you attempt to install the PIPELINE resource.
  4. Ensure that the pipeline configuration file is encoded in US EBCDIC. If you try to use a different EBCDIC encoding, CICS cannot process the file.

Diagnosing service provider runtime errors

If you are having problems receiving or processing inbound messages in a provider mode pipeline, the problem might be with the transport or a specific SOAP message.

- You receive a DFHPI0401, DFHPI0502, or similar message, indicating that an HTTP or WMQ transport error has occurred. If the transport is HTTP, the client receives a 500 Server Internal Error message. If the transport is WMQ, the message is written to the dead letter queue (DLQ). A SOAP fault is not returned to the Web service requester, because CICS cannot determine what type of message was received.

- You receive a DFHPI*xxxx* message and a 404 Not Found error message.
  1. If you are not using the Web services assistant, you must create a URIMAP resource. If you are using the Web services assistant, the URIMAP is created automatically for you when you run the **PIPELINE SCAN** command. The system log provides information on any errors that occurred as a result of running this command.
  2. Check that the WEBSERVICE resource is enabled and that the URIMAP with which it is associated with is as expected. If your WEBSERVICE resource has installed in an UNUSABLE state, see "Diagnosing deployment errors" on page 247.
  3. Check that you have correctly specified the URI and port number. In particular, check the case because the attribute PATH on the URIMAP resource is case-sensitive.
- If unexpected errors are being reported, consider using CEDX to debug the Web service application.
  1. Check the system log to see what error messages are being reported by CICS. The system log might give you an indication of what type of error is occurring. If CICS is not reporting any errors, ensure that the request is reaching CICS through the network.
  2. Run CEDX against CPIH for the HTTP transport, CPIQ for the WMQ transport, or the transaction that you specified in the URIMAP if it is different.

     If a task switch occurs during the pipeline processing before the application handler, then, unless the DFHWS-TRANID container is populated, the new task runs under the same transaction id as the first one. Running under the same transaction id can interfere with running CEDX, because the first task has a lock on the CEDX session. You can avoid this problem by using DFHWS-TRANID to change the transaction id when the task switches, allowing you to use CEDX on both the pipeline and application tasks separately.For more information on CEDX, see Using the CEDX transaction in *CICS Supplied Transactions*.
  3. If CEDX does not activate or allow you to solve the problem, consider running auxiliary trace with the PI, SO, AP, EI, and XS domains active. Auxiliary trace might indicate whether there is a security problem, TCP/IP problem, application program problem, or pipeline problem in your CICS region. Look for any exception trace points or abends.
- If you are receiving conversion errors, see "Diagnosing data conversion errors" on page 253.
- If you think your problem is related to MTOM messages, see "Diagnosing MTOM/XOP errors" on page 251.

Diagnosing service requester runtime errors

Problems can occur when sending Web service requests from your service requester application or when receiving SOAP fault messages from the Web service provider.

Problems that occur can be caused by errors in individual Web services or problems at the transport level.

- If you are using the **INVOKE WEBSERVICE** command in your application program, RESP and RESP2 codes are returned when a problem occurs.

1. Look up the meaning of the RESP and RESP2 codes for the INVOKE WEBSERVICE command to give you an indication of what the problem might be.
2. Check the CICS system log for any messages that can help you determine the cause of the problem.

- If you cannot send a SOAP request message and the pipeline is returning a DFHERROR container, a problem occurred when the pipeline tried to process the SOAP message.
  1. Look at the contents of the DFHERROR container. It usually contains an error message and some data describing the problem that occurred.
  2. Have you introduced any new message handlers or header processing programs in the pipeline? If you have, try removing the new program and rerunning the Web service to see if the problem still occurs. If your message handler is trying to perform some processing using a container that is not present in the pipeline, or is trying to update a container that is read-only, the pipeline stops processing and returns an error in the DFHERROR container. Header processing programs can update only a limited set of containers in the pipeline. See "The header processing program interface" on page 101 for details.
  3. If the Web service requester application is not using the **INVOKE WEBSERVICE** command to send a Web service request, check that it has created all of the necessary control containers and that they are the right datatype. In particular, check that the DFHREQUEST container has a datatype of CHAR rather than BIT.
  4. If the Web service requester application is using the **INVOKE WEBSERVICE** command, an INVREQ and a RESP2 code of 14 are returned, indicating that a data conversion error has occurred. See "Diagnosing data conversion errors" on page 253.
  5. Check that a custom message handler has not invalidated the XML in your SOAP message during pipeline processing. CICS does not perform any validation on outbound messages in the pipeline. If your application uses the **INVOKE WEBSERVICE** command, the XML is generated by CICS and is well-formed when the body of the SOAP message is placed in the DFHREQUEST container. However, if you have any additional message handlers that change the contents of the SOAP message, these changes are not validated in the pipeline.
- If you can send a SOAP message, but are getting a timeout or transport error, a SOAP fault is normally returned. If your program is using the **INVOKE WEBSERVICE** command, CICS returns a RESP value of TIMEDOUT and RESP2 code of 2 for a timeout error, and a RESP value of INVREQ and RESP2 code of 17 for a transport error.
  1. Check that the network endpoint is present.
  2. Ensure that you have correctly configured the RESPWAIT attribute on the PIPELINE resource to meet your application's requirements. The RESPWAIT attribute defines how long CICS waits for a reply from the Web service provider before returning to the application. If you do not specify a value, CICS uses the defaults of 10 seconds for HTTP and 60 seconds for WMQ. However, CICS also has a timeout in the dispatcher for each transaction, and, if this is less than the default of the protocol that is being used, CICS uses the dispatcher timeout instead.
- If you can send a SOAP message, but are getting a SOAP fault response back from the Web service provider that you did not expect, look at the contents of the DFHWS-BODY container for details of the SOAP fault.

1. If you sent a complete SOAP envelope in DFHREQUEST using the DFHPIRT interface, ensure that the outbound message does not contain duplicate SOAP headers. Duplication can occur when the requester pipeline uses a SOAP 1.1 or SOAP 1.2 message handler. The SOAP message handlers add SOAP headers, even if they are already specified in the SOAP envelope by the service requester application. In this scenario, you can do one of the following:
   - Remove the SOAP 1.1 or SOAP 1.2 message handler from the pipeline. The removal will affect any other service requester applications that use this pipeline.
   - Remove the SOAP headers from the SOAP envelope that the application puts in DFHREQUEST. CICS adds the necessary SOAP headers for you. If you want to perform additional processing on the headers, you can use the header processing program interface.
   - Use a **WEB SEND** command instead in your application and opt out of the Web services support.

- If you think the problem is related to sending or receiving MTOM messages, see "Diagnosing MTOM/XOP errors."

Diagnosing MTOM/XOP errors

MTOM/XOP errors can occur at run time, in both requester and provider mode pipelines.

If you are having problems configuring a pipeline to support MTOM/XOP, read "Diagnosing deployment errors" on page 247. If you are having problems with MTOM/XOP at runtime, read the following points:

- If you are able to send a Web service request message in MTOM format, but are receiving a SOAP fault message from the Web service provider, look at the contents of the DFHWS-BODY container for details of the SOAP fault.
  1. Is the Web service provider able to receive MIME Multipart/Related messages? If the Web service provider does not support the MTOM format, the fault that you receive can vary depending on the implementation. If the Web service provider is another CICS application, the SOAP fault indicates that the MIME message is not a valid content type. Use the **CEMT INQUIRE WEBSERVICE** command to find out if the Web service supports MTOM/XOP.
  2. If the Web service provider can receive MIME messages, check if the pipeline is sending the message in direct or compatibility mode. Use the **INQUIRE PIPELINE** command to retrieve the status of the pipeline. If you are sending an MTOM message in direct mode, there might be a problem with the XML.
  3. To find out if the problem is with the XML, turn validation on for the Web service. Validation causes the MTOM message to be processed in compatibility mode through the pipeline. As part of this processing, the MTOM handler parses the message contents to optimize the base64Binary data. If the error is in the XML, CICS puts the error in the DFHERROR container and issues an MTOM transport failure in the pipeline. Look for message DFHPI0602.
  4. Examine the contents of the DFHERROR container to see if it indicates which problem occurred. If you do not have enough information to diagnose the cause of the problem, run a level 2 trace of the PI domain.

5. Look for trace point PI 0C16. This trace point describes the problem that was encountered in more detail, and will help you to fix the problem with the XML that is provided by the requester application.

- If expected binary attachments are missing from the outbound MTOM message, the binary data might be considered too small to optimize as a binary attachment. CICS creates binary attachments only for data that is large enough to justify the processing overhead of optimizing it in the pipeline. Any binary data below 1,500 bytes in size is not optimized.
- If you cannot send an outbound MTOM message in compatibility mode and the pipeline is returning a DFHERROR container, a problem is occurring when the pipeline tries to process the MTOM message.
  1. Look at the contents of the DFHERROR container. This will contain an error message and some data describing the problem that occurred.
  2. Check that the XML in your outbound MTOM message is valid. CICS does not perform any validation on outbound messages in the pipeline.
- If you receive a DFHPI1100E message, a problem has occurred with the MIME headers of an MTOM message that was received by CICS. The CICS message contains the general class of MIME error that occurred. To find the exact problem that occurred:
  1. If you have auxiliary trace active in your CICS region, check for any exception trace entries.
  2. Look for trace point PI 1305. This trace point describes the nature of the MIME header error, the location of the error in the header, and up to 80 bytes of text before and after the error so that you can understand the context of where the error occurred.

  For example, the following excerpt of trace indicates that the MIME content-type start parameter was invalid because it was not enclosed in quotes, but included characters that are not valid outside a quoted string.

```
PI 1305 PIMM *EXC* - MIME_PARSE_ERROR -

             TASK-01151 KE_NUM-0214 TCB-QR   /009C7B68 RET-9C42790A TIME-10:33:41.3667303015 INTERVAL-00.0000053281        =000599=
               1-0000  C5A79785 83A38584 40978199 819485A3  859940A5 8193A485 40A39692 85954096  *Expected parameter value token o*
                 0020  994098A4 96A38584 40A2A399 899587                                         *r quoted string                 *
               2-0000  D4C9D4C5 40A2A895 A381A740 85999996  994081A3 404EF0F0 F0F0F1F1 F2408995  *MIME syntax error at +0000112 in*
                 0020  40C39695 A38595A3 60A3A897 85408885  81848599                             * Content-type header            *
               3-0000  5F626F75 6E646172 793B2074 7970653D  22617070 6C696361 74696F6E 2F786F70  *_boundary; type="application/xop*
                 0020  2B786D6C 223B2073 74617274 2D696E66  6F3D2261 70706C69 63617469 6F6E2F73  *+xml"; start-info="application/s*
                 0040  6F61702B 786D6C22 3B207374 6172743D                                       *oap+xml"; start=                *
               4-0000  3C736F61 70736C75 6E674074 6573742E  68757273 6C65792E 69626D2E 636F6D3E  *<soapslung@test.hursley.ibm.com>*
                 0020  3B206368 61727365 743D7574 662D38                                         *; charset=utf-8                 *
```

- The pipeline processing fails to parse an inbound MTOM message and the Web service requester receives a SOAP fault message. This combination indicates that a problem has occurred with the XOP document in the MTOM message. In direct mode, the application handler generates the SOAP fault. If the pipeline is running in compatibility mode, the MTOM handler parses the message when constructing the SOAP message. In this case, CICS issues a DFHPI prefixed error message and a SOAP fault.
  1. The DFHPI prefixed error message indicates what was wrong with the XOP document. For example, it might be an invalid MIME header or a missing binary attachment.
  2. To find the exact cause of the problem, check for any exception trace points. In particular, look for trace points beginning with PI 13*xx*. They describes the exception that occurred in more detail.

  You can also run a PI level 2 trace to establish the sequence of events leading up to the error, but running level 2 trace can have a significant performance impact and is not recommended on production regions.

Diagnosing data conversion errors

Data conversion errors can occur at run time when converting a SOAP message into a CICS COMMAREA or container and from a COMMAREA or container into a SOAP message.

Symptoms include the generation of SOAP fault messages and CICS messages indicating that a failure has occurred.

If you have a data conversion problem, you perform the following steps:

1. Ensure that the WEBSERVICE resource is up-to-date. Regenerate the Web service binding file for the Web service and redeploy it to CICS.
2. Ensure that the remote Web service has been generated using the same version of the Web service document (WSDL) as used or generated by CICS.
3. If you are sure that the WEBSERVICE resource is using a current Web service binding file, perform the following steps:
   a. Enable runtime validation for the WEBSERVICE resource using the command `CEMT SET WEBSERVICE(`*name*`) VALIDATION` where *name* is the WEBSERVICE resource name.
   b. Check for the CICS messages DFHPI1001 or DFHPI1002 in the message log. DFHPI1001 describes the precise nature of the data conversion problem, and will help you to identify the source of the conversion error. DFHPI1002 indicates that no problems were found.
   c. When you no longer need validation for the Web service, use the following command to turn validation off: `CEMT SET WEBSERVICE(`*name*`) NOVALIDATION`.
4. If you still have not determined the reason for the conversion error, take a CICS trace of the failing Web service. Look for the following PI domain exception trace entries:

   ```
   PI 0F39 - PICC   *EXC* - CONVERSION_ERROR
   PI 0F08 - PIII   *EXC* - CONVERSION_ERROR
   ```

   A PICC conversion error indicates that a problem occurred when transforming a SOAP message received by CICS into a COMMAREA or container. A PIII conversion error indicates that a problem occurred when generating a SOAP message from a COMMAREA or container supplied by the application program. In both cases, the trace point identifies the name of the field associated with the conversion error and might also identify the value that is causing the problem. If either of these trace points appear, it will be followed by a conversion error. For a possible interpretation of these conversion errors, see “Conversion errors in trace points” on page 254.

Why data conversion errors occur

CICS validates SOAP messages only to the extent that it is necessary to confirm that they contain well-formed XML and to transform them. So a SOAP message might be successfully validated using the WSDL, but then fail in the runtime environment and vice versa.

The WEBSERVICE resource encapsulates the mapping instructions to enable CICS to perform data conversion at run time. A conversion error occurs when the input does not match the expected data, as described in the WEBSERVICE resource.

This mismatch can occur for any of the following reasons:

- A SOAP message that is received by CICS is not well-formed and valid when checked against the Web service description (WSDL) associated with the WEBSERVICE resource.
- A SOAP message that is received by CICS is well-formed and valid but contains values that are out of range for the WEBSERVICE resource.
- The contents of a COMMAREA or container are not consistent with the WEBSERVICE resource and the language structure from which the Web service was generated.

For example, the WSDL document might specify range restrictions on a field, such as an unsignedInt that can have a value only between 10 and 20. If a SOAP message contains a value of 25, validating the SOAP message will cause it to be rejected as invalid. The value 25 is accepted as a valid value for an integer and is passed to the application.

As a second example, the WSDL document might specify a string without specifying a maximum length. DFHWS2LS assumes a maximum length of 255 characters by default when generating the Web service binding file. If the SOAP message contains 300 characters, then, although the check against the WSDL will validate the message because no maximum length is set, an error is reported when attempting to transform the message because the value does not fit the 255 character buffer allocated by CICS.

Code page issues

CICS uses the value of the **LOCALCCSID** system initialization parameter to encode the application program data. However, the Web service binding file is encoded in US EBCDIC (Cp037). This encoding can lead to problems converting data when the code page used by the application program encodes characters differently from the US EBCDIC code page. To avoid this problem, you can use the **CCSID** parameter in the Web services assistant batch jobs to specify a different code page to encode data between the application program and the Web services binding file. The value of this parameter overrides the **LOCALCCSID** system initialization parameter for that particular WEBSERVICE resource. The value of **CCSID** must be an EBCDIC CCSID.

Conversion errors in trace points

When you run tracing for a failing Web service and find the PI domain exception trace points PI 0F39 or PI 0F08, CICS provides a conversion error. Possible interpretations for these conversion errors are provided to help you diagnose the cause of the conversion error and, where appropriate, next steps are also given.

The following conversion errors refer to COMMAREAs, but these errors can equally apply to containers.

INPUT_TOO_LONG
This conversion error occurs in these cases:

- A SOAP element that is declared as numeric contains more than 31 digits
- A numeric field in the COMMAREA contains a value that is more than 31 digits in length.

OUTPUT_OVERFLOW
This conversion error occurs in these cases:

- A SOAP element contains a value that is too long to fit in the associated field of the COMMAREA

- A SOAP element contains a numeric value that is outside the permitted range for the associated field in the COMMAREA.

Consider changing the Web service description (WSDL) to explicitly supply a `maxLength` facet for this field. If a `maxLength` is specified in the WSDL, CICS ensures that this much space is set aside in the COMMAREA for the field. If a `maxLength` facet is not specified, CICS uses a default of 255 characters. The default might be an inappropriate value for the field.

You can also add a `whitespace` facet for character-based fields and set it to "collapse". This setting ensures that white space is removed from the field. By default, white space is preserved.

NEGATIVE_UNSIGNED
This conversion error occurs in these cases:

- A negative number has been found in a SOAP element that is declared as unsigned.
- A negative number has been found in a COMMAREA field that is declared as unsigned.

NO_FRACTION_DIGITS
This conversion error occurs when a SOAP element contains a number that has a decimal point but is not followed by any valid fractional digits.

FRACTION_TOO_LONG
This conversion error occurs when a SOAP element contains a number with more nonzero fraction digits than the WSDL allows.

INVALID_CHARACTER
This conversion error occurs in these cases:

- A SOAP element that is declared as a Boolean contains a value other than 0, 1, true, or false.
- A SOAP element that is declared as hexBinary contains a value that is not in the range 0-9, a-f, A-F.
- A SOAP element that is declared as numeric contains a nonnumeric character
- A SOAP message is not well-formed.

ODD_HEX_DIGITS
This conversion error occurs when a SOAP element that is declared as hexBinary contains an odd number of hexadecimal characters.

INVALID_PACKED_DEC
This conversion error occurs when a packed decimal field in the COMMAREA contains an illegal value that cannot be converted to XML.

INVALID_ZONED_DEC
This conversion error occurs when a zoned decimal field in the COMMAREA contains an illegal value that cannot be converted to XML.

INCOMPLETE_DBCS
This conversion error occurs when a DBCS sequence in the COMMAREA is missing a shift in (SI) character.

SOAP fault messages for conversion errors

If a conversion error occurs at run time and CICS is acting as a Web service provider, a SOAP fault message is issued to the service requester. This SOAP fault message includes the message that CICS issues.

The service requester can receive one of the following SOAP fault messages:

- `Cannot convert SOAP message`

  This fault message implies that either the SOAP message is not well-formed and valid, or its values are out of range.
- `Outbound data cannot be converted`

  This fault message implies that the contents of a COMMAREA or container are not consistent.
- `Operation not part of web service`

  This fault message is a special variation of when CICS receives an invalid SOAP message.

If CICS is the Web service requester, the **INVOKE WEBSERVICE** command returns a RESP code of INVREQ and a RESP2 value of 14.

Chapter 14. The CICS catalog manager example application

The CICS catalog example application is a working COBOL application that is designed to illustrate best practice when connecting CICS applications to external clients and servers.

The example is constructed around a simple sales catalog and order processing application, in which the end user can perform these functions:

- List the items in a catalog.
- Inquire on individual items in the catalog.
- Order items from the catalog.

The catalog is implemented as a VSAM file.

The base application has a 3270 user interface, but the modular structure, with well-defined interfaces between the components, makes it possible to add further components. In particular, the application comes with Web service support, which is designed to illustrate how you can extend an existing application into the Web services environment.

The base application

The base application, with its 3270 user interface, provides functions with which you can list the contents of a stored catalog, select an item from the list, and enter a quantity to order. The application has a modular design which makes it simple to extend the application to support newer technology, such as Web services.

Figure 27 on page 258 shows the structure of the base application.

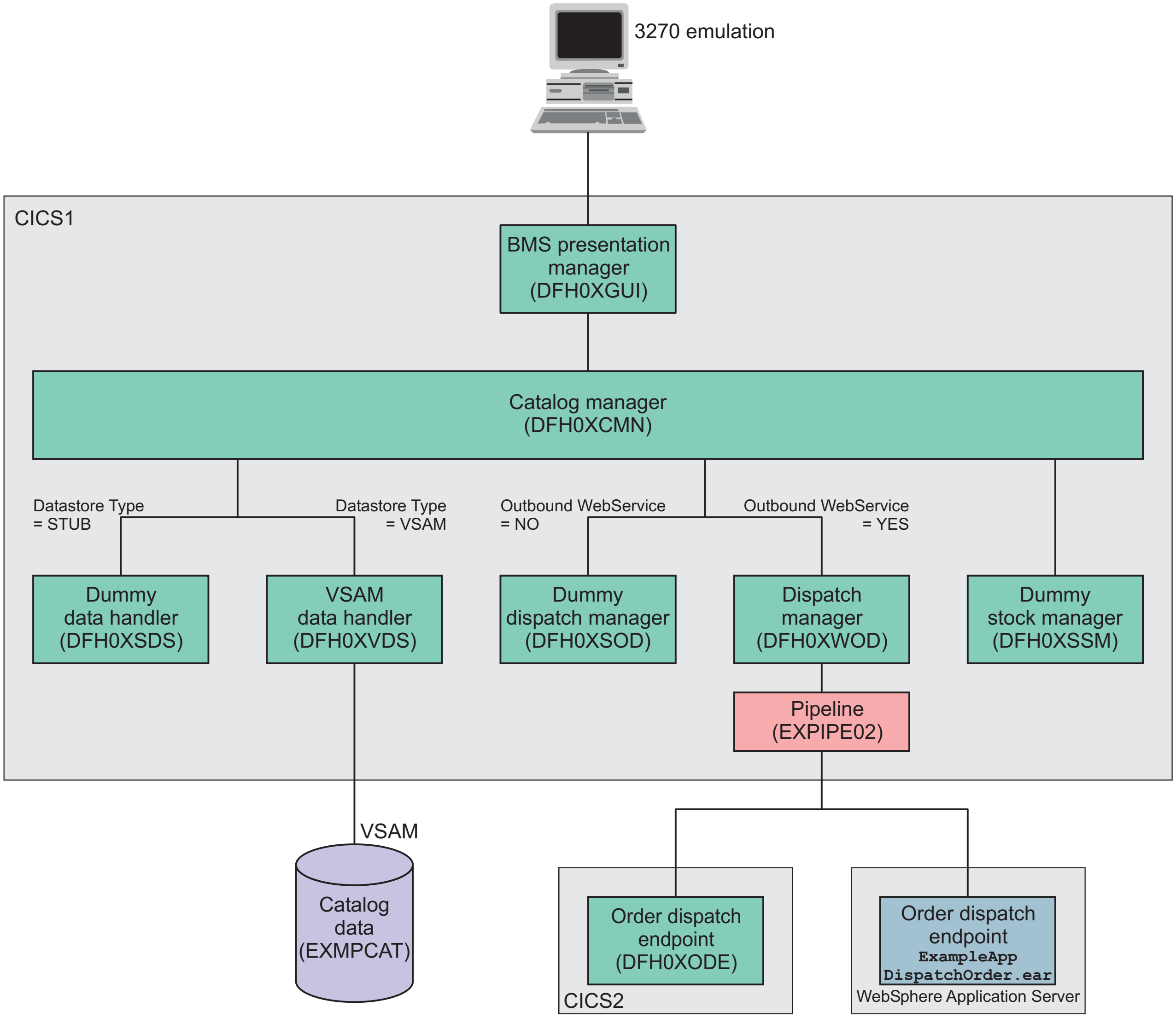

3270 emulation
CICS1
BMS presentation manager (DFH0XGUI)
Catalog manager (DFH0XCMN)
Datastore Type = STUB
Datastore Type = VSAM
Outbound WebService = NO
Outbound WebService = YES
Dummy data handler (DFH0XSDS)
VSAM data handler (DFH0XVDS)
Dummy dispatch manager (DFH0XSOD)
Dispatch manager (DFH0XWOD)
Dummy stock manager (DFH0XSSM)
Pipeline (EXPIPE02)
VSAM
Catalog data (EXMPCAT)
Order dispatch endpoint (DFH0XODE)
CICS2
Order dispatch endpoint ExampleApp DispatchOrder.ear
WebSphere Application Server

Figure 27. Structure of the base application

The components of the base application are:

1. A BMS presentation manager (DFH0XGUI) that supports a 3270 terminal or emulator, and that interacts with the main catalog manager program.
2. A catalog manager program (DFH0XCMN) that is the core of the example application, and that interacts with several back-end components.
3. The back-end components are:
   - A data handler program that provides the interface between the catalog manager program and the data store. The base application provides two versions of this program. They are the VSAM data handler program (DFH0XVDS), which stores data in a VSAM data set; and a dummy data handler (DFH0XSDS), which does not store data, but simply returns valid responses to its caller. Configuration options let you choose between the two programs.
   - A dispatch manager program that provides an interface for dispatching an order to a customer. Again, configuration options let you choose between the two versions of this program: DFHX0WOD is a Web service requester that

invokes a remote order dispatch end point, and DFHX0SOD is a dummy program that simply returns valid responses to its caller.

There are two equivalent order dispatch endpoints: DFH0XODE is a CICS service provider program; `ExampleAppDispatchOrder.ear` is an enterprise archive that can be deployed in WebSphere Application Server or similar environments.

- A dummy stock manager program (DFH0XSSM) that returns valid responses to its caller, but takes no other action.

BMS presentation manager

The presentation manager is responsible for all interactions with the end user via 3270 BMS panels. No business decisions are made in this program.

The BMS presentation manager can be used in two ways:

- As part of the base application.
- As a CICS Web service client that communicates with the base application using SOAP messages.

Data handler

The data handler provides the interface between the catalog manager and the data store.

The example application provides two versions of the data handler:

- The first version uses a VSAM file as the data store.
- The second version is a dummy program that always returns the same data on an inquire and does not store the results of any update requests.

Dispatch manager

The dispatch manager is responsible for dispatching the order to the customer once the order has been confirmed.

The example application provides two versions of the dispatch manager program:

- The first version is a dummy program that returns a correct response to the caller, but takes no other action.
- The second version is a Web service requester program that makes a request to the endpoint address defined in the configuration file.

Order dispatch endpoint

The order dispatch program is a Web service provider program that is responsible for dispatching the item to the customer.

In the example application, the order dispatcher is a dummy program that returns a correct response to the caller, but takes no other action. It makes it possible for all configurations of the example Web services to be operable.

Stock manager

The stock manager is responsible for managing the replenishment of the stock.

In the example program, the stock manager is a dummy program that returns a correct response to the caller, but takes no other action.

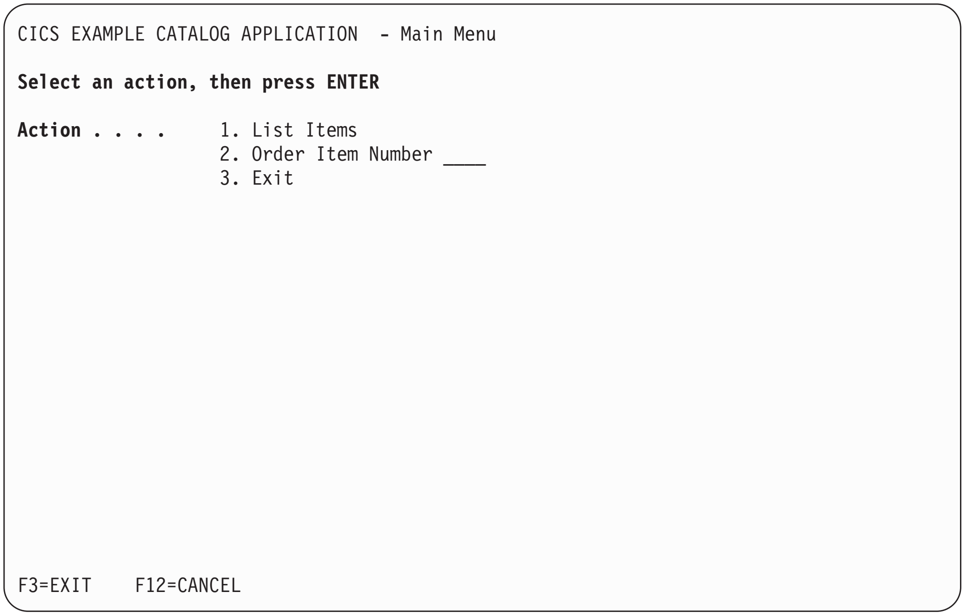
Application configuration

The example application includes a program that lets you configure the base application.

Running the example application with the BMS interface

The base application can be invoked using its BMS interface.

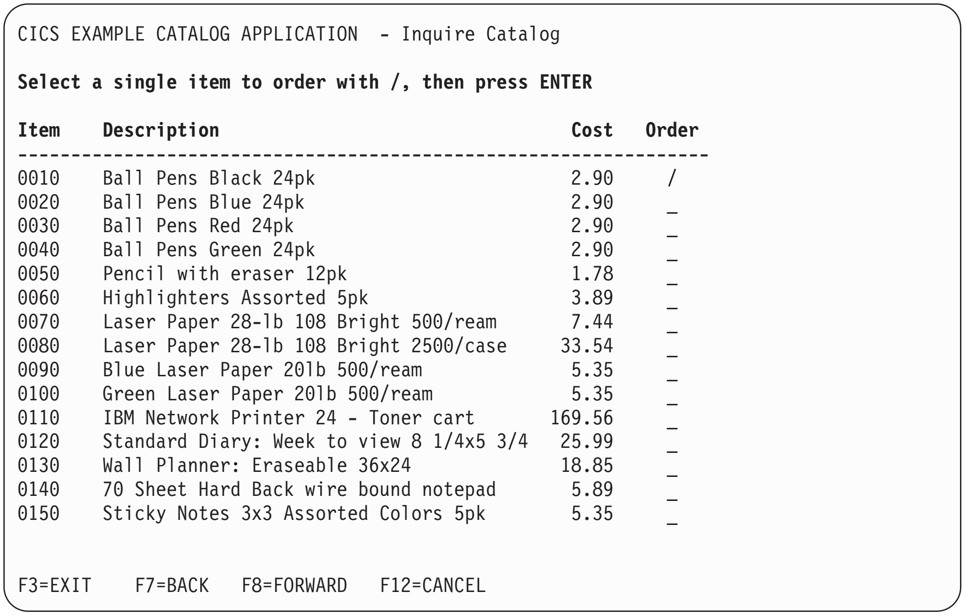
1. Enter transaction EGUI from a CICS terminal. The example application displays the following menu:



```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .     1. List Items
                   2. Order Item Number ____
                   3. Exit

















F3=EXIT    F12=CANCEL
```

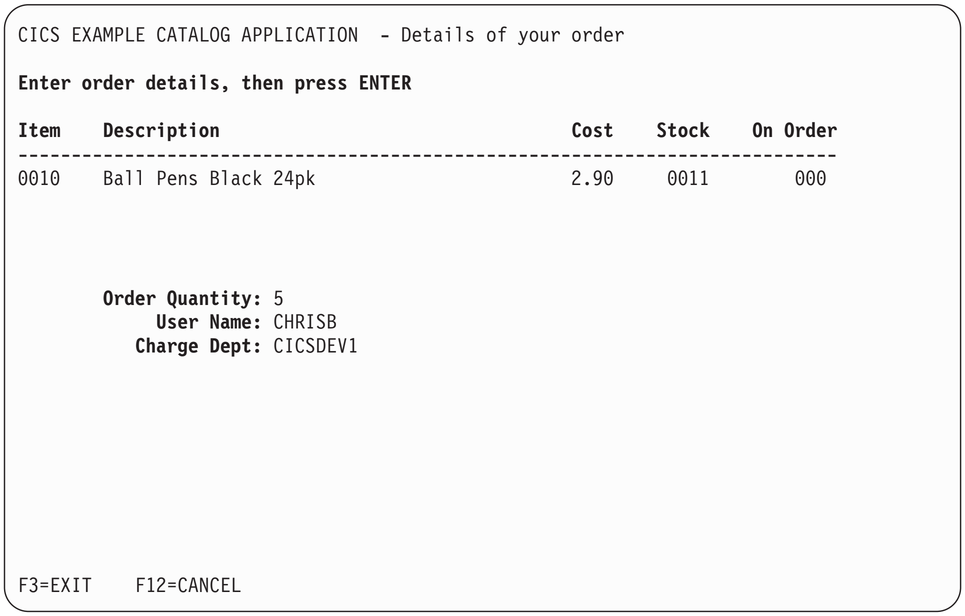
   The options on the menu enable you to list the items in the catalog, order an item, or exit the application.

2. Type 1 and press ENTER to select the LIST ITEMS option. The application displays a list of items in the catalog.



```
CICS EXAMPLE CATALOG APPLICATION  - Inquire Catalog

Select a single item to order with /, then press ENTER

Item    Description                                 Cost   Order
-----------------------------------------------------------------
0010    Ball Pens Black 24pk                        2.90     /
0020    Ball Pens Blue 24pk                         2.90     _
0030    Ball Pens Red 24pk                          2.90     _
0040    Ball Pens Green 24pk                        2.90     _
0050    Pencil with eraser 12pk                     1.78     _
0060    Highlighters Assorted 5pk                   3.89     _
0070    Laser Paper 28-lb 108 Bright 500/ream       7.44     _
0080    Laser Paper 28-lb 108 Bright 2500/case     33.54     _
0090    Blue Laser Paper 20lb 500/ream              5.35     _
0100    Green Laser Paper 20lb 500/ream             5.35     _
0110    IBM Network Printer 24 - Toner cart       169.56     _
0120    Standard Diary: Week to view 8 1/4x5 3/4   25.99     _
0130    Wall Planner: Eraseable 36x24              18.85     _
0140    70 Sheet Hard Back wire bound notepad       5.89     _
0150    Sticky Notes 3x3 Assorted Colors 5pk        5.35     _


F3=EXIT    F7=BACK   F8=FORWARD   F12=CANCEL
```

3. Type / in the **ORDER** column, and press ENTER to order an item. The application displays details of the item to be ordered.



```
CICS EXAMPLE CATALOG APPLICATION  - Details of your order

Enter order details, then press ENTER

Item    Description                                 Cost    Stock    On Order
-----------------------------------------------------------------------------
0010    Ball Pens Black 24pk                        2.90     0011        000




        Order Quantity: 5
             User Name: CHRISB
           Charge Dept: CICSDEV1









F3=EXIT    F12=CANCEL
```

4. If there is sufficient stock to fulfil the order, enter the following information.
   a. Complete the `ORDER QUANTITY` field. Specify the number of items you want to order.
   b. Complete the `USERID` field. Enter a 1 to 8-character string. The base application does not check the value that is entered here.
   c. Complete the `CHARGE DEPT` field. Enter a 1 to 8-character string. The base application does not check the value that is entered here.
5. Press `ENTER` to submit the order and return to the main menu.
6. Select the `EXIT` option to end the application.

Installing and setting up the base application

Before you can run the base application you must define and populate two VSAM data sets, and install two transaction definitions.

Creating and defining the VSAM data sets

The example application uses two KSDS VSAM data sets to be defined and populated. One data set contains configuration information for the example application. The other contains the sales catalog.

1. Locate the JCL to create the VSAM data sets. During CICS installation, the JCL is placed in the *hlq*.SDFHINST library:
   - Member `DFH$ECNF` contains the JCL to generate the configuration data set.
   - Member `DFH$ECAT` contains the JCL to generate the catalog data set.
2. Modify the JCL and access method services commands.
   a. Supply a valid JOB card.
   b. Supply a suitable high-level qualifier for the data set names in the access method services commands. As supplied, the JCL uses a high-level qualifier of `HLQ`.

      The following command defines the catalog file:

```
DEFINE CLUSTER (NAME(hlq.EXMPLAPP.catname)-
       TRK(1 1) -
       KEYS(4 0) -
       RECORDSIZE(80,80) -
       SHAREOPTIONS(2 3) -
       INDEXED -
       ) -
       DATA (NAME(hlq.EXMPLAPP.catname.DATA) -
       ) -
       INDEX (NAME(hlq.EXMPLAPP.catname.INDEX) -
       )
```

where

- *hlq* is a high-level qualifier of your choice
- *catname* is a name of your choice. The name used in the example application as supplied is EXMPCAT.

.

The following command defines the configuration file:

```
DEFINE CLUSTER (NAME(hlq.EXMPLAPP.EXMPCONF)-
          TRK(1 1) -
          KEYS(9 0) -
          RECORDSIZE(350,350) -
          SHAREOPTIONS(2 3) -
          INDEXED -
          ) -
          DATA (NAME(hlq.EXMPLAPP.EXMPCONF.DATA) -
          ) -
          INDEX (NAME(hlq.EXMPLAPP.EXMPCONF.INDEX) -
          )
```

where *hlq* is a high-level qualifier of your choice.

3. Run both jobs to create and populate the data sets.
4. Use the CEDA transaction to create a FILE definition for the catalog file.
   a. Enter the following: `CEDA DEF FILE(EXMPCAT)G(EXAMPLE)`. Alternatively, you can copy the FILE definition from CICS supplied group DFH$EXBS.
   b. Enter the following additional attributes:

      DSNAME(*hlq*.EXMPLAPP.EXMPCAT)

      ADD(YES)

      BROWSE(YES)

      DELETE(YES)

      READ(YES)

      UPDATE(YES)
   c. Use the default values for all other attributes.
5. Use the CEDA transaction to create a FILE definition for the configuration file.
   a. Enter the following: `CEDA DEF FILE(EXMPCONF) G(EXAMPLE)`. Alternatively, you can copy the FILE definition from CICS supplied group DFH$EXBS.
   b. Enter the following additional attributes:

      DSNAME(*hlq*.EXMPLAPP.EXMPCONF)

      ADD(YES)

      BROWSE(YES)

      DELETE(YES)

      READ(YES)

      UPDATE(YES)
   c. Use the default values for all other attributes.

Defining the 3270 interface

The example application is supplied with a 3270 user interface to run the application and to customize it. The user interface consists of two transactions, EGUI and ECFG. A third transaction, ECLI, is used for the CICS Web service client.

1. Use the CEDA transaction to create TRANSACTION definitions for the transactions.
   a. To define transaction EGUI, enter the following: `CEDA DEF TRANS(EGUI) G(EXAMPLE) PROG(DFH0XGUI)`.
   b. To define transaction ECFG, enter the following: `CEDA DEF TRANS(ECFG) G(EXAMPLE) PROG(DFH0XCFG)`
   c. Optional: To define transaction ECLI, enter the following: `CEDA DEF TRANS(ECLI) G(EXAMPLE) PROG(DFH0XCUI)`

   Use the default values for all other attributes.

   Note: The correct operation of the example application does not depend on the names of the transactions, so you can use different names if you wish.

   Alternatively, you can copy the TRANSACTION definitions for EGUI and ECFG from CICS supplied group DFH$EXBS, and the definition for ECLI from group DFH$EXWS.
2. Optional: If you do not wish to use program autoinstall, use the CEDA transaction to create PROGRAM definitions for the base application programs and MAPSET definitions for the BMS maps.
   a. Define MAPSET resource definitions for the BMS maps in members DFH0XS1, DFH0XS2, and DFH0XS3. For details of what is in each member, see “Components of the base application” on page 285.
   b. Define PROGRAM resource definitions, using the command `CEDA DEF PROG(`*`program`*`) G(EXAMPLE)`. You should create definitions for the following COBOL programs:

Table 9. SDFHSAMP members containing COBOL source for the base application.

Member name	Description
DFH0XCFG	Program invoked by transaction ECFG to read and update the VSAM configuration file
DFH0XCMN	Controller program for the catalog application. All requests pass through it.
DFH0XGUI	Program invoked by transaction EGUI to manage the sending of the BMS maps to the terminal user and the receiving of the maps from the terminal user. It links to program DFH0XCMN.
DFH0XODE	One of two versions of the endpoint for the order dispatch Web service. This is the version that runs in CICS. It simply sets the text `"Order in dispatch"` in the return COMMAREA.
DFH0XSDS	A *stubbed* or dummy version of the data store program that allows the application to work when the VSAM catalog file has not been set up. It uses data defined in the program rather than data stored in a VSAM file.
DFH0XSOD	A stubbed version of the order dispatch program. It sets the return code in the COMMAREA to 0 and returns to its caller. It is used when outbound Web services are not required.
DFH0XSSM	A stubbed version of the stock manager (replenishment) program. It sets the return code in the COMMAREA to 0 and returns to its caller.

Table 9. SDFHSAMP members containing COBOL source for the base application. (continued)

Member name	Description
DFH0XVDS	The VSAM version of the data store program. It accesses the VSAM file to perform reads and updates of the catalog.
DFH0XWOD	The Web service version of the order dispatch program. It issues an EXEC CICS INVOKE WEBSERVICE to make an outbound Web service call to an order dispatcher

Use the default values for all other attributes.

c. Optional: To define COBOL program DFH0XCUI, enter the following: `CEDA DEF PROG(DFH0XCUI) G(EXAMPLE)`. Use the default values for all other attributes. This program is required if you want to use transaction ECLI that starts the Web service client.

Completing the installation

To complete the installation, install the RDO group that contains your resource definitions.

Enter the following command at a CICS terminal: `CEDA I G(EXAMPLE)`.

The application is now ready for use.

Configuring the example application

The base application includes a transaction (ECFG) that you can use to configure the example application.

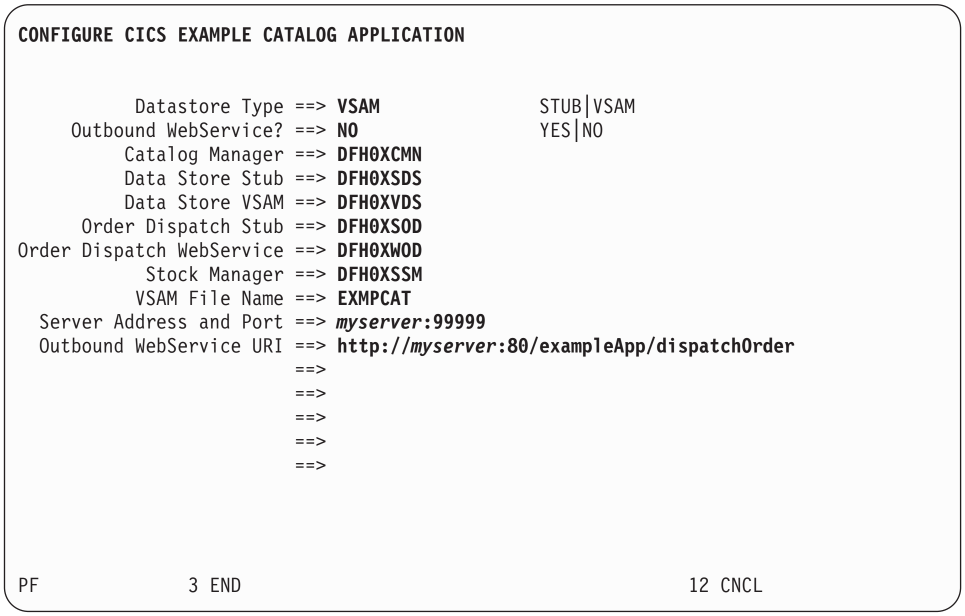
The configuration transaction uses mixed case information. You must use a terminal that can handle mixed case information correctly.

The transaction lets you specify a number of aspects of the example application. These include:

- The overall configuration of the application, such as the use of Web services
- The network addresses used by the Web services components of the application
- The names of resources, such as the file used for the data store
- The names of programs used for each component of the application

The configuration transaction lets you replace CICS-supplied components of the example application with your own, without restarting the application.

1. Enter the transaction ECFG to start the configuration application. CICS displays the following screen:



```
CONFIGURE CICS EXAMPLE CATALOG APPLICATION


           Datastore Type ==> VSAM               STUB|VSAM
     Outbound WebService? ==> NO                 YES|NO
          Catalog Manager ==> DFH0XCMN
          Data Store Stub ==> DFH0XSDS
          Data Store VSAM ==> DFH0XVDS
      Order Dispatch Stub ==> DFH0XSOD
Order Dispatch WebService ==> DFH0XWOD
            Stock Manager ==> DFH0XSSM
           VSAM File Name ==> EXMPCAT
  Server Address and Port ==> myserver:99999
  Outbound WebService URI ==> http://myserver:80/exampleApp/dispatchOrder
                          ==>
                          ==>
                          ==>
                          ==>
                          ==>




PF              3 END                                         12 CNCL
```

2. Complete the fields.

Datastore Type
Specify STUB if you want to use the Data Store Stub program.

Specify VSAM if you want to use the VSAM data store program.

Outbound WebService
Specify YES if you want to use a remote Web service for your Order Dispatch function, that is, if you want the catalog manager program to link to the Order Dispatch Web service program.

Specify NO if you want to use a stub program for your Order Dispatch function, that is, if you want the catalog manager program to link to the Order Dispatch Stub program.

Catalog Manager
Specify the name of the Catalog Manager program. The program supplied with the example application is DFH0XCMN.

Data Store Stub
If you specified STUB in the **Datastore Type** field, specify the name of the Data Store Stub program. The program supplied with the example application is DFH0XSDS.

Data Store VSAM
If you specified VSAM in the **Datastore Type** field, specify the name of the VSAM data store program. The program supplied with the example application is DFH0XVDS.

Order Dispatch Stub
If you specified NO in the **Outbound WebService** field, specify the name of the Order Dispatch Stub program. The program supplied with the example application is DFH0XSOD.

Order Dispatch WebService
If you specified YES in the **Outbound WebService** field, specify the name of the program that functions as a service requester. The program supplied with the example application is DFH0XWOD.

Stock Manager
Specify the name of the Stock Manager program. The program supplied with the example application is DFH0XSSM.

VSAM File Name
If you specified VSAM in the **Datastore Type** field, specify the name of the CICS FILE definition. The name used in the example application as supplied is EXMPCAT.

Server Address and Port
If you are using the CICS Web service client, specify the IP address and port of the system on which the example application is deployed as a Web service.

Outbound WebService URI
If you specified YES in the **Outbound WebService** field, specify the location of the Web service that implements the dispatch order function. If you are using the supplied CICS endpoint set this to: `http://`*`myserver`*`:`*`myport`*`/exampleApp/dispatchOrder` where *`myserver`* and *`myport`* are your CICS server address and port respectively.

Web service support for the example application

The Web service support extends the example application, providing a Web client front end and two versions of a Web service endpoint for the order dispatcher component.

The Web client front end and one version of the Web service endpoint are supplied as enterprise archives (EARs) that will run in the following environments:

Environment	EAR files

WebSphere Application Server Version 5.1	`ExampleAppClient.ear`
	`ExampleAppWrapperClient.ear`
	`ExampleAppDispatchOrder.ear`

WebSphere Application Server Version 6.1	`ExampleAppClientV6.ear`
	`ExampleAppWrapperClient.ear`
	`DispatchOrderV6.ear`

WebSphere Developer for System z Version 7 uses the Web service endpoint for WebSphere Application Server Version 6.1.

The second version of the Web service endpoint is supplied as a CICS service provider application program (DFH0XODE).

Figure 28 on page 267 shows one configuration of the example application.

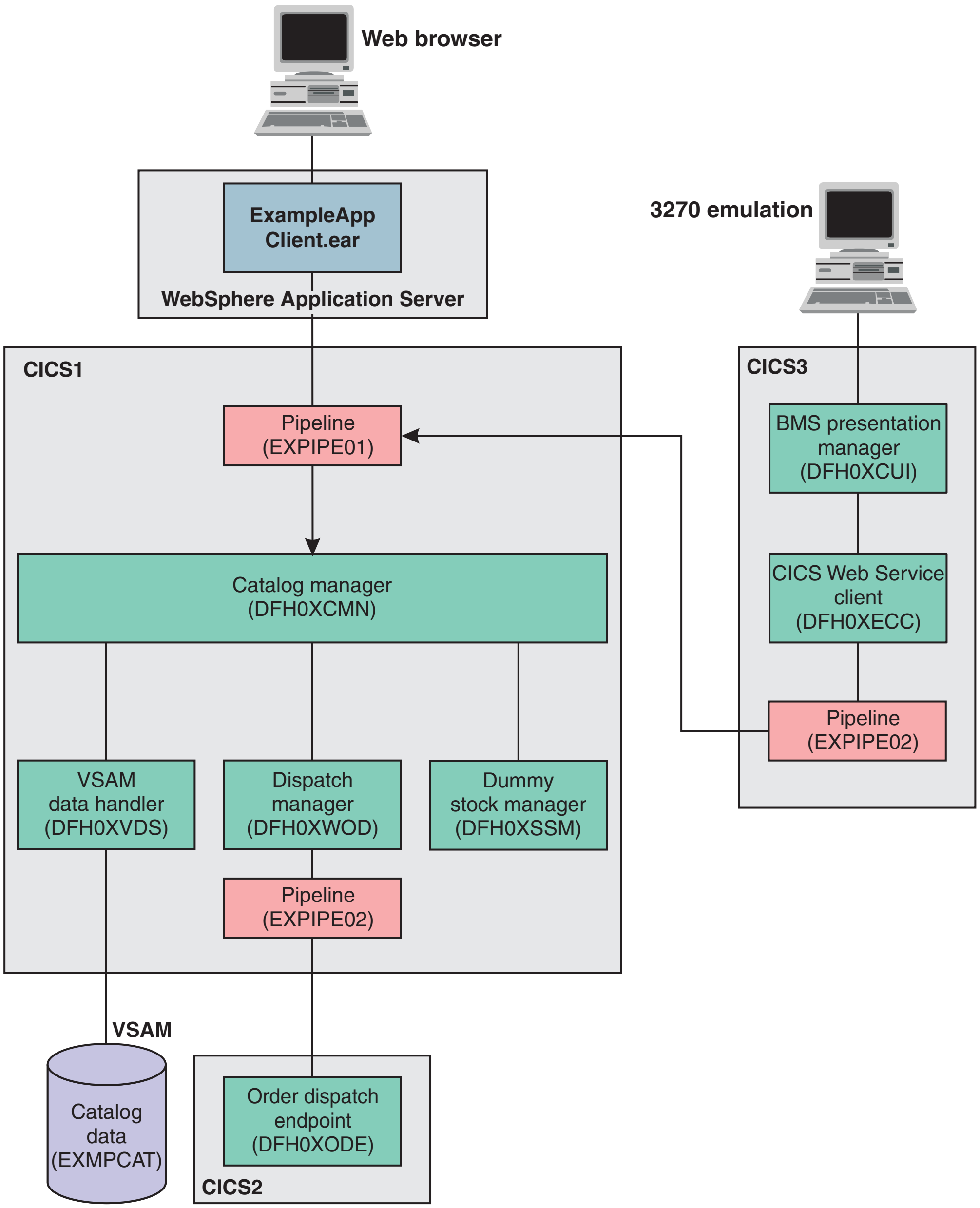

Web browser
ExampleApp Client.ear
WebSphere Application Server
3270 emulation
CICS1
Pipeline (EXPIPE01)
Catalog manager (DFH0XCMN)
VSAM data handler (DFH0XVDS)
Dispatch manager (DFH0XWOD)
Dummy stock manager (DFH0XSSM)
Pipeline (EXPIPE02)
CICS3
BMS presentation manager (DFH0XCUI)
CICS Web Service client (DFH0XECC)
Pipeline (EXPIPE02)
VSAM
Catalog data (EXMPCAT)
Order dispatch endpoint (DFH0XODE)
CICS2

Figure 28. The example application configured as a Web service provider

In this configuration, the application is accessed through two different clients:

- A Web browser client connected to WebSphere Application Server, in which `ExampleAppClient.ear` is deployed.
- CICS Web service client DFH0XECC. This client uses the same BMS presentation logic as the base application but uses module DFH0XCUI instead of DFH0XGUI.

Figure 29 on page 268 shows another way to configure the example application as a Web service.

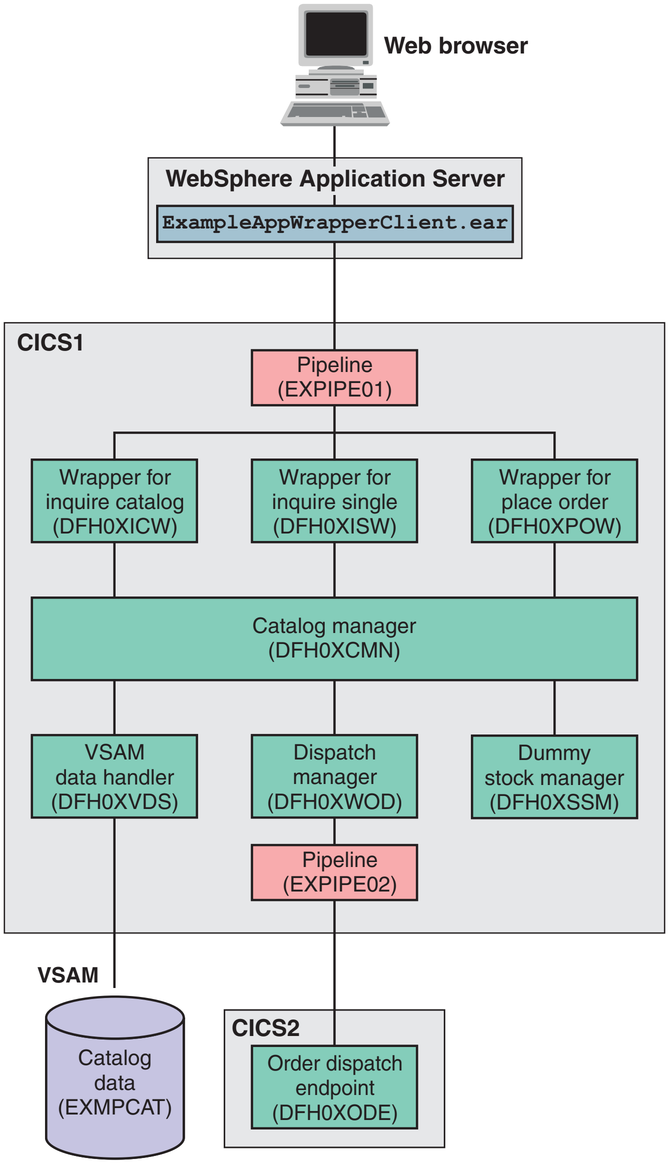

Web browser
WebSphere Application Server
ExampleAppWrapperClient.ear
CICS1
Pipeline (EXPIPE01)
Wrapper for inquire catalog (DFH0XICW)
Wrapper for inquire single (DFH0XISW)
Wrapper for place order (DFH0XPOW)
Catalog manager (DFH0XCMN)
VSAM data handler (DFH0XVDS)
Dispatch manager (DFH0XWOD)
Dummy stock manager (DFH0XSSM)
Pipeline (EXPIPE02)
VSAM
Catalog data (EXMPCAT)
CICS2
Order dispatch endpoint (DFH0XODE)

Figure 29. Alternate Web service provider configuration

In this configuration, the Web browser client is connected to WebSphere Application Server, in which `ExampleAppWrapperClient.ear` is deployed. In CICS, three wrapper applications (for the inquire catalog, inquire single, and place order functions) are deployed as service provider applications. They in turn link to the base application.

Configuring code page support

As supplied, the example application uses two coded character sets. You must configure your system to enable data conversion between the two character sets.

The coded character sets used in the example application are:

CCSID	Description
037	EBCDIC Group 1: USA, Canada (z/OS), Netherlands, Portugal, Brazil, Australia, New Zealand)

1208 UTF-8 Level 3

Add the following statements to the conversion image for your z/OS system:

```
CONVERSION 037,1208;
CONVERSION 1208,037;
```

For more information, see the *CICS Transaction Server for z/OS Installation Guide*.

Defining the Web service client and wrapper programs

If you are not using program autoinstall, you need to define resource definitions for the Web service client and wrapper programs.

1. Define PROGRAM resource definitions for the wrapper programs, using the command `CEDA DEF PROG(`*`program`*`) G(EXAMPLE)` You should create definitions for the following COBOL programs:

Table 10. SDFHSAMP members containing COBOL source code for the wrapper modules

Member name	Description
DFH0XICW	Wrapper program for the `inquireCatalog` service.
DFH0XISW	Wrapper program for the `inquireSingle` service.
DFH0XPOW	Wrapper program for the `purchaseOrder` service.

2. Define a PROGRAM resource definition for the Web services client program DFH0XECC, using the command `CEDA DEF PROG(DFH0XECC) G(EXAMPLE)`. This is a COBOL program. You can use default values for all of the other attributes.

Installing Web service support

Before you can run the Web service support for the example application, you must create two z/OS UNIX directories, and create and install a number of CICS resource definitions.

Creating z/OS UNIX directories

Web service support for the example application requires a *shelf directory* and a *pickup directory* in z/OS UNIX.

The shelf directory is used to store the Web service binding files that are associated with WEBSERVICE resources. Each WEBSERVICE resource is, in turn, associated with a PIPELINE. The shelf directory is managed by the PIPELINE resource and you should not modify its contents directly. Several PIPELINES can use the same shelf directory, as CICS ensures a unique directory structure beneath the shelf directory for each PIPELINE.

The pickup directory is the directory that contains the Web service binding files associated with a PIPELINE. When a PIPELINE is installed, or in response to a **`PERFORM PIPELINE SCAN`** command, information in the binding files is used to dynamically create the WEBSERVICE and URIMAP definitions associated with the PIPELINE.

The example application uses `/var/cicsts` for the shelf directory.

A pipeline will read in an XML pipeline configuration file at install time. It is therefore also useful to define a directory in which to store these.

Creating the PIPELINE definition

The complete definition of a pipeline consists of a PIPELINE resource and a pipeline configuration file. The file contains the details of the message handlers that will act on Web service requests and responses as they pass through the pipeline.

The example application uses the CICS-supplied SOAP 1.1 handler to deal with the SOAP envelopes of inbound and outbound requests. CICS provides sample pipeline configuration files which you can use in your service provider and service requester.

More than one WEBSERVICE can share a single PIPELINE, therefore you need define only one pipeline for the inbound requests of the example application. You must, however, define a second PIPELINE for the outbound requests as a single PIPELINE cannot be configured to be both a provider and requester pipeline at the same time.

1. Use the CEDA transaction to create a PIPELINE definition for the service provider.
   a. Enter the following: `CEDA DEF PIPE(EXPIPE01) G(EXAMPLE)`. Alternatively, you can copy the PIPELINE definition from CICS supplied group DFH$EXWS.
   b. Enter the following additional attributes:

      ```
      STATUS(Enabled)
      CONFIGFILE(/usr/lpp/cicsts
                /samples/pipelines/basicsoap11provider.xml)
      SHELF(var/cicsts)
      WSDIR(/usr/lpp/cicsts/samples/webservices/wsbind/provider/)
      ```

      Note that the z/OS UNIX entries are case sensitive and assume a default CICS z/OS UNIX install root of `/usr/lpp/cicsts`.
2. Use the CEDA transaction to create a PIPELINE definition for the service requester.
   a. Enter the following: `CEDA DEF PIPE(EXPIPE02) G(EXAMPLE)`. Alternatively, you can copy the PIPELINE definition from CICS supplied group DFH$EXWS.
   b. Enter the following additional attributes:

      ```
      STATUS(Enabled)
      CONFIGFILE(/usr/lpp/cicsts
                /samples/pipelines/basicsoap11requester.xml)
      SHELF(var/cicsts)
      WSDIR(/usr/lpp/cicsts/samples/webservices/wsbind/requester/)
      ```

      Note that the z/OS UNIX entries are case sensitive and assume a default CICS z/OS UNIX install root of `/usr/lpp/cicsts`.

Creating a TCPIPSERVICE

As the client connects to your Web services over an HTTP transport you must define a TCPIPSERVICE to receive the inbound HTTP traffic.

Use the CEDA transaction to create a TCPIPSERVICE definition to handle inbound HTTP requests.

1. Enter the following: `CEDA DEF TCPIPSERVICE(EXMPPORT) G(EXAMPLE)`. Alternatively, you can copy the TCPIPSERVICE definition from CICS supplied group DFH$EXWS.
2. Enter the following additional attributes:

   ```
   URM(DFHWBAAX)
   ```

PORTNUMBER(*port*) where *port* is an unused port number in your CICS system.

PROTOCOL(HTTP)

TRANSACTION(CWXN)

3. Use the default values for all other attributes.

Dynamically installing the WEBSERVICE and URIMAP resources

Each function exposed as a Web service requires a WEBSERVICE resource to map between the incoming XML of the SOAP BODY and the COMMAREA interface of the program, and a URIMAP resource that routes incoming requests to the correct PIPELINE and WEBSERVICE. Although you can use RDO to define and install your WEBSERVICE and URIMAP resources, you can also have CICS create them dynamically when you install a PIPELINE resource.

Install the PIPELINE resources. Use the following commands:

```
CEDA INSTALL PIPELINE(EXPIPE01) G(EXAMPLE)
CEDA INSTALL PIPELINE(EXPIPE02) G(EXAMPLE)
```

When you install each PIPELINE resource, CICS scans the directory specified in the PIPELINE's WSDIR attribute (the pickup directory). For each Web service binding file in the directory, that is for each file with the `.wsbind` suffix, CICS installs a WEBSERVICE and a URIMAP if one does not already exist. Existing resources are replaced if the information in the binding file is newer than the existing resources.
When the PIPELINE is later disabled and discarded all associated WEBSERVICE and URIMAP resources will also be discarded.
If you have already installed the PIPELINE, use the **PERFORM PIPELINE SCAN** command to initiate the scan of the PIPELINE's pickup directory.
When you have installed the PIPELINEs, the following WEBSERVICEs and their associated URIMAPs will be installed in your system:

```
dispatchOrder
dispatchOrderEndpoint
inquireCatalog
inquireSingle
placeOrder
```

The names of the WEBSERVICEs are derived from the names of the Web service binding files; the names of the URIMAPs are generated dynamically. You can view the resources with a **CEMT INQUIRE WEBSERVICE** command:

```
I WEBS
STATUS:  RESULTS - OVERTYPE TO MODIFY
 Webs(dispatchOrder                  ) Pip(EXPIPE02)
    Ins                                                       Dat(20041203)
 Webs(dispatchOrderEndpoint          ) Pip(EXPIPE01)
    Ins Uri(£539140 ) Pro(DFH0XODE) Com                       Dat(20041203)
 Webs(inquireCatalog                 ) Pip(EXPIPE01)
    Ins Uri(£539141 ) Pro(DFH0XCMN) Com                       Dat(20041203)
 Webs(inquireSingle                  ) Pip(EXPIPE01)
    Ins Uri(£539142 ) Pro(DFH0XCMN) Com                       Dat(20041203)
 Webs(placeOrder                     ) Pip(EXPIPE01)
    Ins Uri(£539150 ) Pro(DFH0XCMN) Com                       Dat(20041203)
```

The display shows the names of the PIPELINE, the URIMAP, and the target program that is associated with each WEBSERVICE. Note that in this example, there is no URIMAP or target program displayed for WEBSERVICE(dispatchOrder) because the WEBSERVICE is for an outbound request. WEBSERVICE(dispatchOrderEndpoint) represents the local CICS implementation of the dispatch order service.

Creating the WEBSERVICE resources with RDO

As an alternative to using the PIPELINE scanning mechanism to install WEBSERVICE resources, you can create and install them using Resource Definition Online (RDO).

Important: If you use RDO to define the WEBSERVICE and URIMAP resources, you must ensure that their Web service binding files are **not** in the pickup directory of the PIPELINE. This ensures that the WEBSERVICE and URIMAP resources are not dynamically installed during a pipeline scan of the pickup directory. Alternatively, you can ensure that no value is specified for WSDIR in the PIPELINE. However, if you do not specify a value for WSDIR, no pipeline scans of the pickup directory occur. Therefore, all WEBSERVICE and URIMAP resources have to be created and installed using RDO.

1. Use the CEDA transaction to create a WEBSERVICE definition for the inquire catalog function of the example application.
   a. Enter the following: `CEDA DEF WEBSERVICE(EXINQCWS) G(EXAMPLE)`.
   b. Enter the following additional attributes:
```
PIPELINE(EXPIPE01)
WSBIND(/usr/lpp/cicsts/samples
      /webservices/wsbind/provider/inquireCatalog.wsbind)
```
2. Repeat the preceding step for each of the following functions of the example application.

Function	WEBSERVICE name	PIPELINE attribute	WSBIND attribute
INQUIRE SINGLE ITEM	EXINQSWS	EXPIPE01	/usr/lpp/cicsts/samples /webservices/wsbind /provider/inquireSingle.wsbind
PLACE ORDER	EXORDRWS	EXPIPE01	/usr/lpp/cicsts/samples /webservices/wsbind /provider/placeOrder.wsbind
DISPATCH STOCK	EXODRQWS	EXPIPE02	/usr/lpp/cicsts/samples /webservices/wsbind /requester/dispatchOrder.wsbind
DISPATCH STOCK endpoint (optional)	EXODEPWS	EXPIPE01	/usr/lpp/cicsts/samples /webservices/wsbind /provider/dispatchOrderEndpoint.wsbind

Creating the URIMAP resources with RDO

As an alternative to using the PIPELINE scanning mechanism to install URIMAP resources, you can create and install them using Resource Definition Online (RDO).

Important: If you use RDO to define the WEBSERVICE and URIMAP resources, you must ensure that their Web service binding files are **not** in the pickup directory of the PIPELINE. This ensures that the WEBSERVICE and URIMAP resources are not dynamically installed during a pipeline scan of the pickup directory. Alternatively, you can ensure that no value is specified for WSDIR in the PIPELINE. However, if you do not specify a value for WSDIR, no pipeline scans of the pickup directory occur. Therefore, all WEBSERVICE and URIMAP resources have to be created and installed using RDO.

1. Use the CEDA transaction to create a URIMAP definition for the inquire catalog function of the example application.
   a. Enter the following: `CEDA DEF URIMAP(INQCURI) G(EXAMPLE)`.
   b. Enter the following additional attributes:

```
USAGE(PIPELINE)
HOST(*)
PATH(/exampleApp/inquireCatalog)
TCPIPSERVICE(SOAPPORT)
PIPELINE(EXPIPE01)
WEBSERVICE(EXINQCWS)
```

2. Repeat the preceding step for each of the remaining functions of the example application. Use the following names for your URIMAPs:

Function	URIMAP name
INQUIRE SINGLE ITEM	INQSURI
PLACE ORDER	ORDRURI
DISPATCH STOCK	Not required
DISPATCH STOCK endpoint (optional)	ODEPURI

   a. Specify the following distinct attributes for each URIMAP:

Function	URIMAP name	PATH	WEBSERVICE
INQUIRE SINGLE ITEM	INQSURI	/exampleApp/inquireSingle	EXINQSWS
PLACE ORDER	ORDRURI	/exampleApp/placeOrder	EXORDRWS
DISPATCH STOCK endpoint (optional)	ODEPURI	/exampleApp/dispatchOrder	EXODEPWS

   b. Enter the following additional attributes, which are the same for all the URIMAPs:

```
USAGE(PIPELINE)
HOST(*)
TCPIPSERVICE(SOAPPORT)
PIPELINE(EXPIPE01)
```

Completing the installation

To complete the installation, install the RDO group that contains your resource definitions.

Enter the following command at a CICS terminal: `CEDA I G(EXAMPLE)`.

The application is now ready for use.

Configuring the Web client

Before you can use the Web client, you must deploy the enterprise archive (EAR) for the client into one of the supported environments and configure it to call the appropriate end points in your CICS system.

The supported environments are:

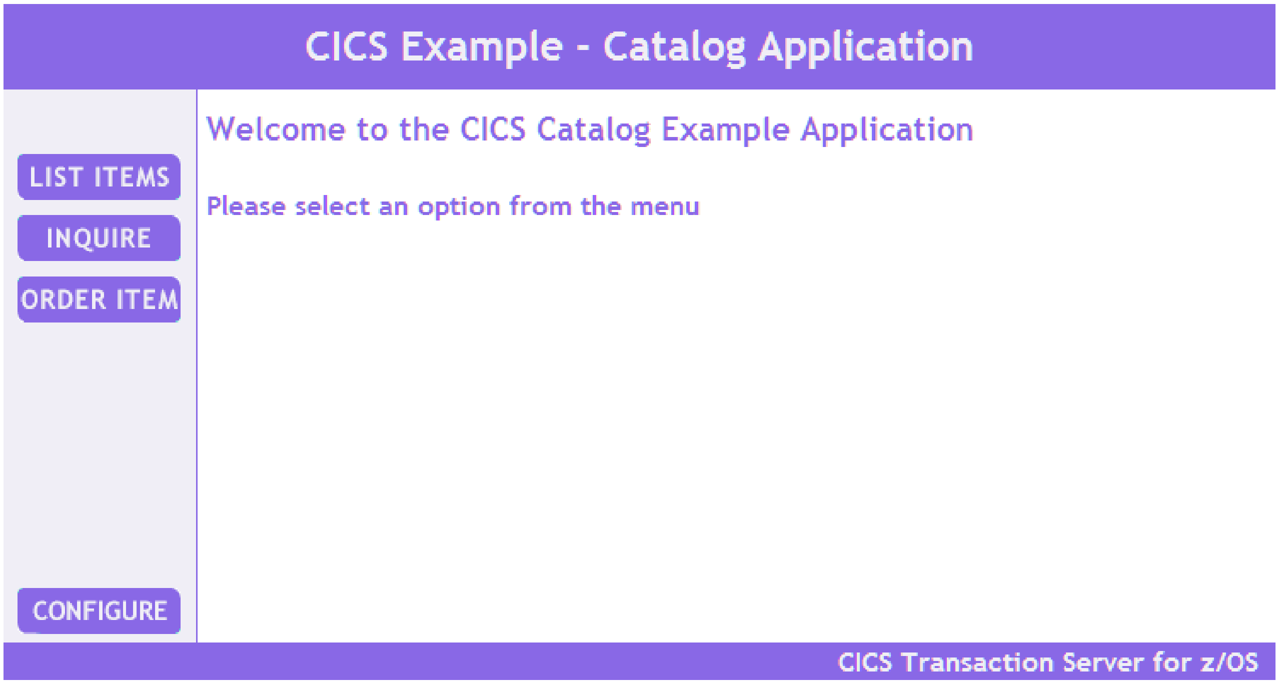
- WebSphere Application Server Version 5 Release 1 or later
- WebSphere Studio Application Developer Version 5 Release 1 or later with a WebSphere unit test environment
- WebSphere Studio Enterprise Developer Version 5 Release 1 later with a WebSphere unit test environment.

The supported environments for the ExampleAppClientV6.ear client application are:

- WebSphere Application Server Version 6
- Rational Application Developer Version 6 or later with a WebSphere unit test environment
- WebSphere Developer for zSeries® Version 6 or later with a WebSphere unit test environment

The EAR files are located in the `*hlq*/samples/webservices/client` directory in z/OS UNIX.

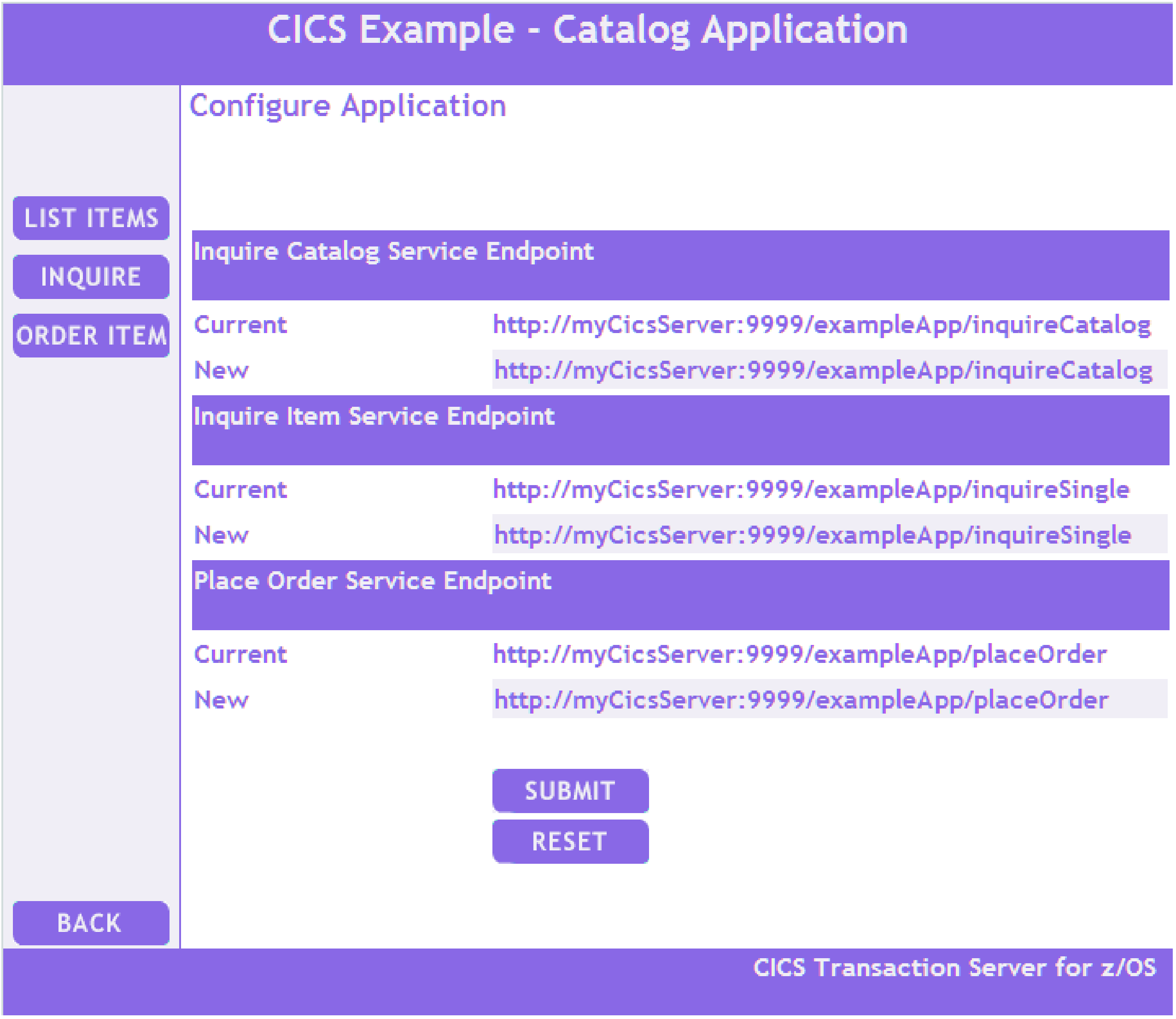
1. If you are using a Version 5 WebSphere product, to start the Web client enter the following in your Web browser: `http://*myserver*:9080/ExampleAppClientWeb/`, where *myserver* is the hostname of the server on which the Web service client is installed. If you are using a Version 6 WebSphere product, to start the Web client enter the following in your Web browser: `http://*myserver*:9080/ExampleAppClientV6Web/` The example application displays the following page:


CICS Example - Catalog Application
LIST ITEMS
INQUIRE
ORDER ITEM
CONFIGURE
CICS Transaction Server for z/OS

Welcome to the CICS Catalog Example Application

Please select an option from the menu

2. Click the **CONFIGURE** button to bring up the configuration page. The configuration page is displayed.



CICS Example - Catalog Application

Configure Application

Inquire Catalog Service Endpoint

Current	http://myCicsServer:9999/exampleApp/inquireCatalog
New	http://myCicsServer:9999/exampleApp/inquireCatalog

Inquire Item Service Endpoint

Current	http://myCicsServer:9999/exampleApp/inquireSingle
New	http://myCicsServer:9999/exampleApp/inquireSingle

Place Order Service Endpoint

Current	http://myCicsServer:9999/exampleApp/placeOrder
New	http://myCicsServer:9999/exampleApp/placeOrder

CICS Transaction Server for z/OS

3. Enter the new endpoints for the Web service. There are three endpoints to configure:

   Inquire catalog

   Inquire item

   Place order

   a. In the URLs replace the string 'myCicsServer' with the name of the system on which your CICS is running.
   b. Replace the port number '9999' with the port number configured in the TCPIPSERVICE resource, in the example this to 30000.
4. Click the **SUBMIT** button.

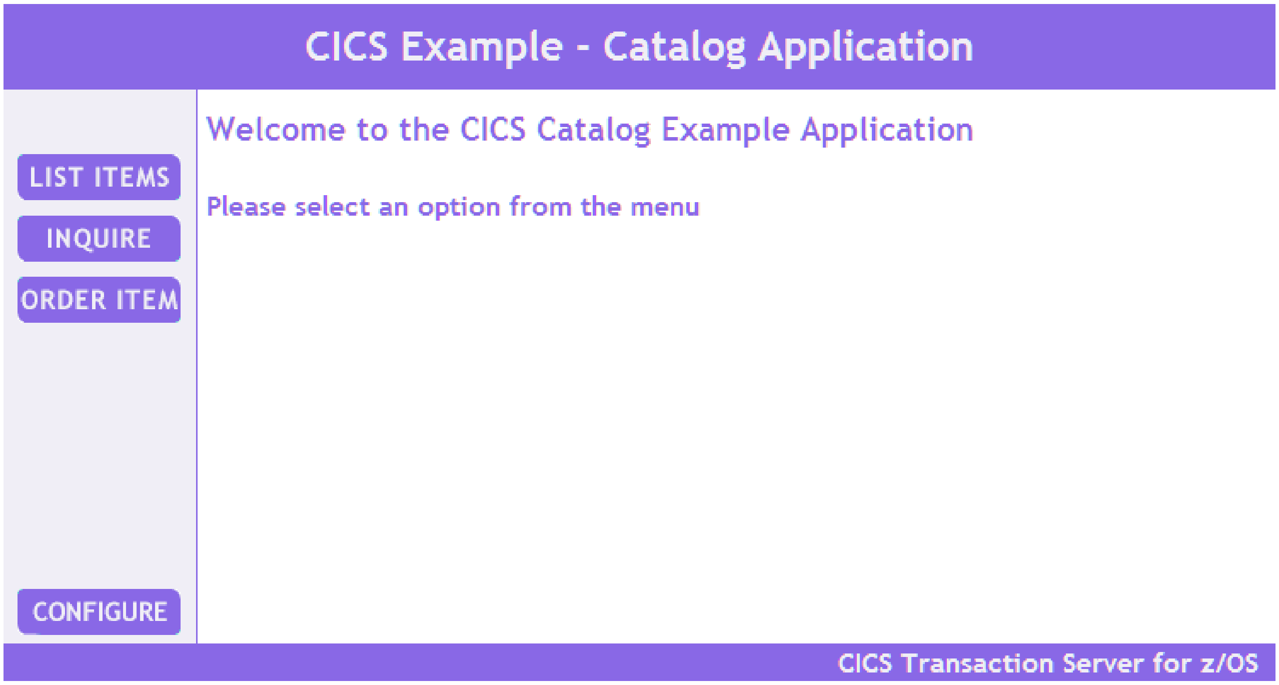
The Web application is now ready to run.

Note: The URL the Web services invoke is stored in an HTTP session. It is therefore necessary to repeat this configuration step each time a browser is first connected to the client.

Running the Web service enabled application

You can invoke the example application from a Web browser.

1. Enter the following in your Web browser: `http://`*`myserver`*`:9080/ExampleAppClientWeb/`, where *`myserver`* is the host name of the server on which the Web service client is installed. The example application displays the following page:

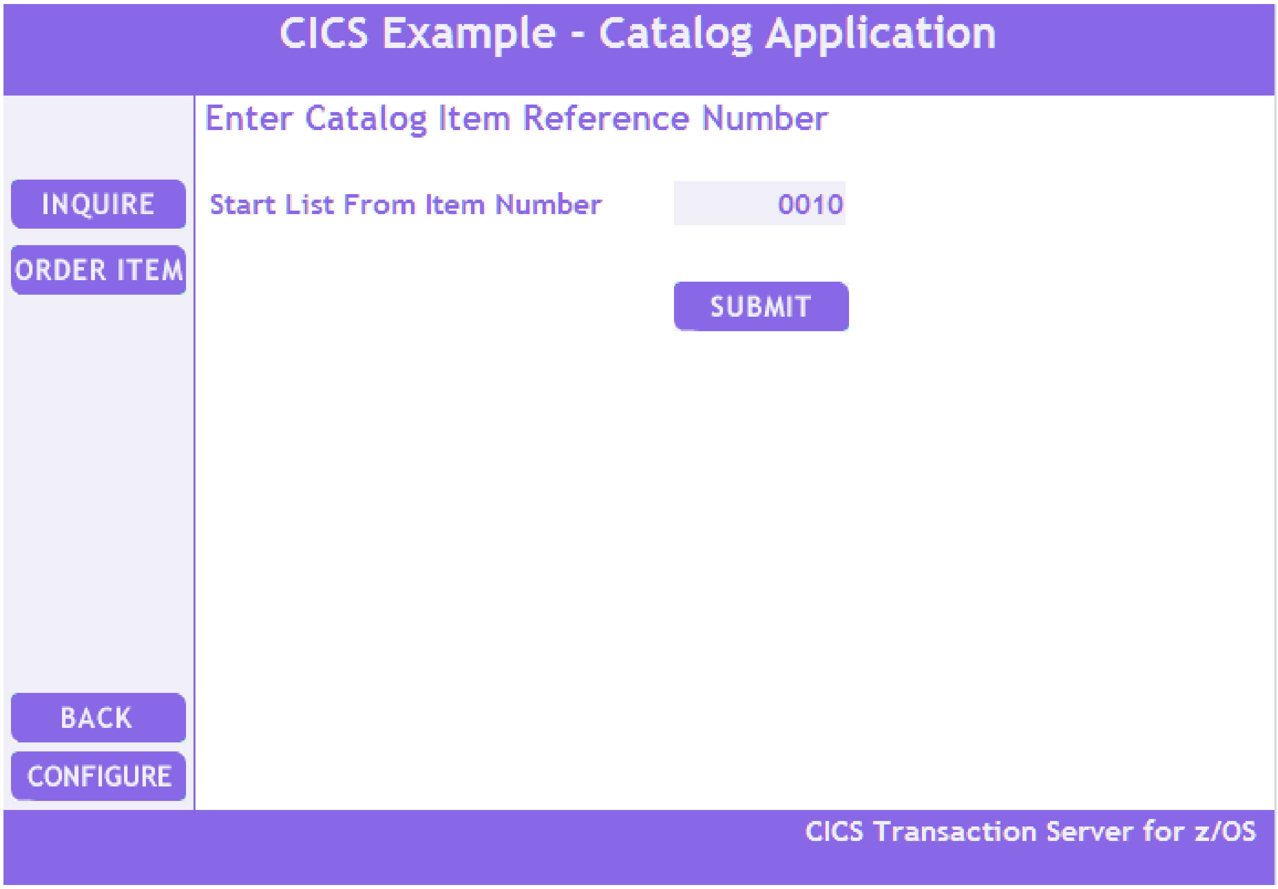


CICS Example - Catalog Application

Welcome to the CICS Catalog Example Application

Please select an option from the menu

2. Click the **INQUIRE** button. The example application displays the following page:



CICS Example - Catalog Application

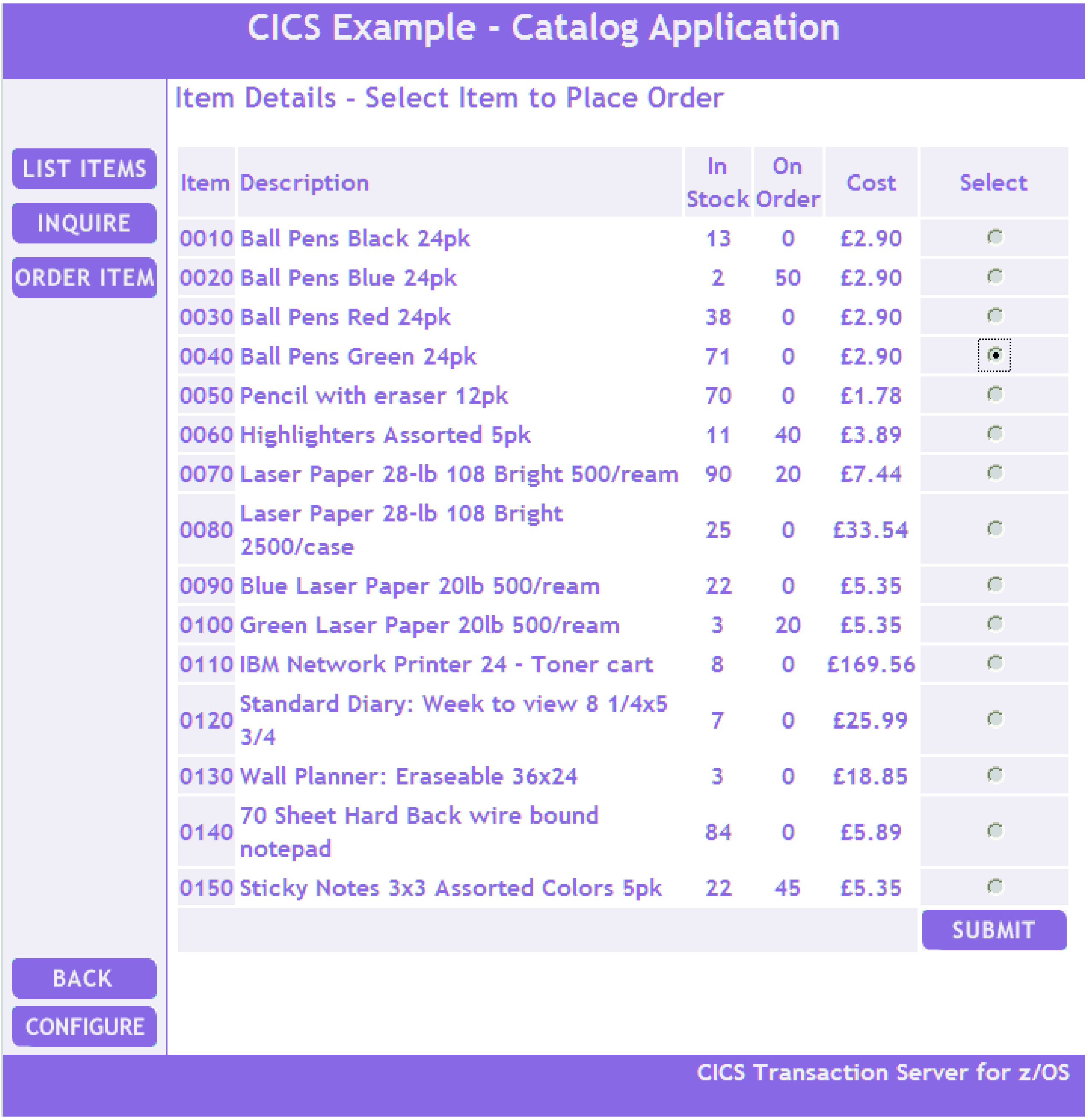
Enter Catalog Item Reference Number

Start List From Item Number 0010

3. Enter an item number, and click the **SUBMIT** button.

   Tip: The base application is primed with item numbers in the sequence 0010, 0020, ... through 0210.

   The application displays the following page, which contains a list of items in the catalog, starting with the item number that you entered.



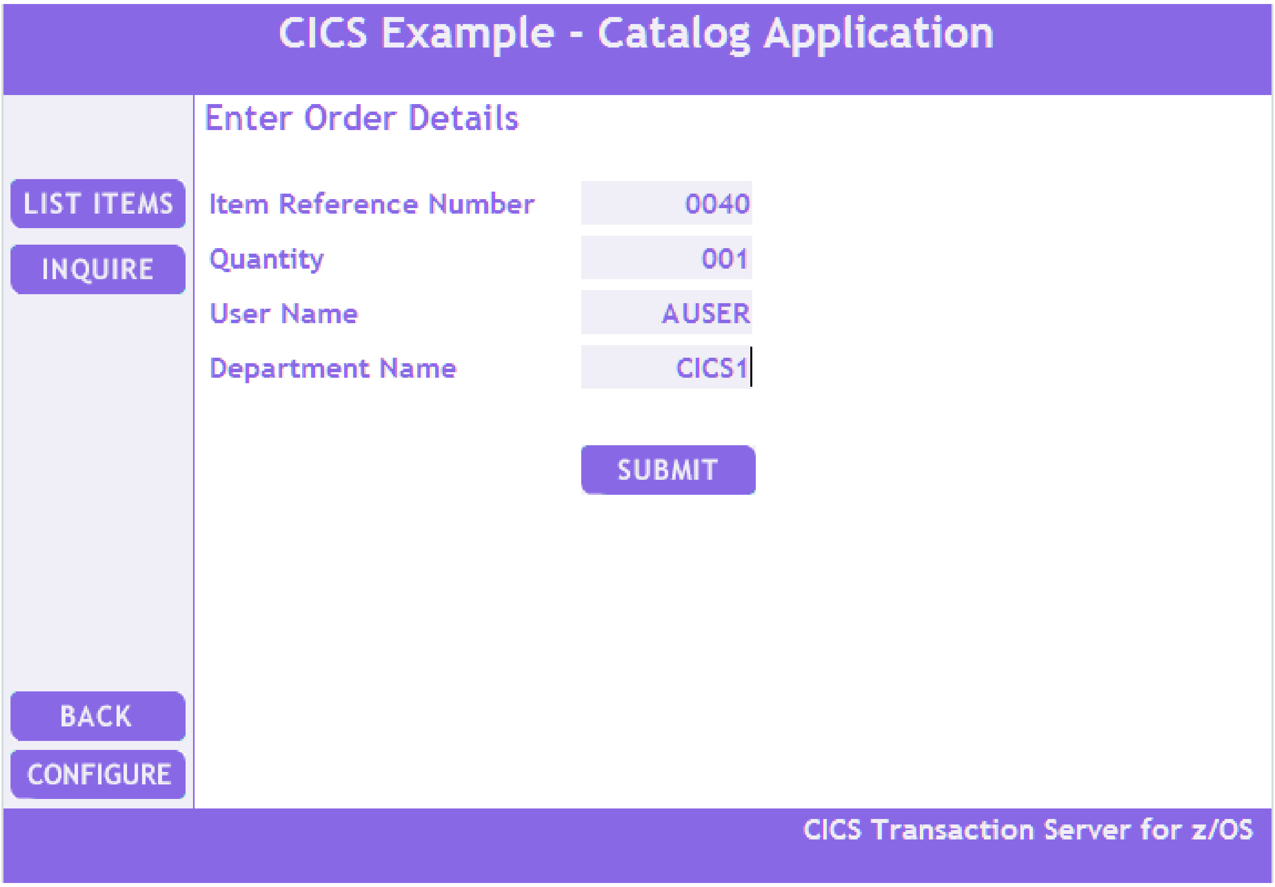
CICS Example - Catalog Application

Item Details - Select Item to Place Order

Item	Description	In Stock	On Order	Cost	Select
0010	Ball Pens Black 24pk	13	0	£2.90	○
0020	Ball Pens Blue 24pk	2	50	£2.90	○
0030	Ball Pens Red 24pk	38	0	£2.90	○
0040	Ball Pens Green 24pk	71	0	£2.90	●
0050	Pencil with eraser 12pk	70	0	£1.78	○
0060	Highlighters Assorted 5pk	11	40	£3.89	○
0070	Laser Paper 28-lb 108 Bright 500/ream	90	20	£7.44	○
0080	Laser Paper 28-lb 108 Bright 2500/case	25	0	£33.54	○
0090	Blue Laser Paper 20lb 500/ream	22	0	£5.35	○
0100	Green Laser Paper 20lb 500/ream	3	20	£5.35	○
0110	IBM Network Printer 24 - Toner cart	8	0	£169.56	○
0120	Standard Diary: Week to view 8 1/4x5 3/4	7	0	£25.99	○
0130	Wall Planner: Eraseable 36x24	3	0	£18.85	○
0140	70 Sheet Hard Back wire bound notepad	84	0	£5.89	○
0150	Sticky Notes 3x3 Assorted Colors 5pk	22	45	£5.35	○

4. Select the item that you want to order.
   a. Click the radio button in the **Select** column for the item you want to order.
   b. Click the **SUBMIT** button.

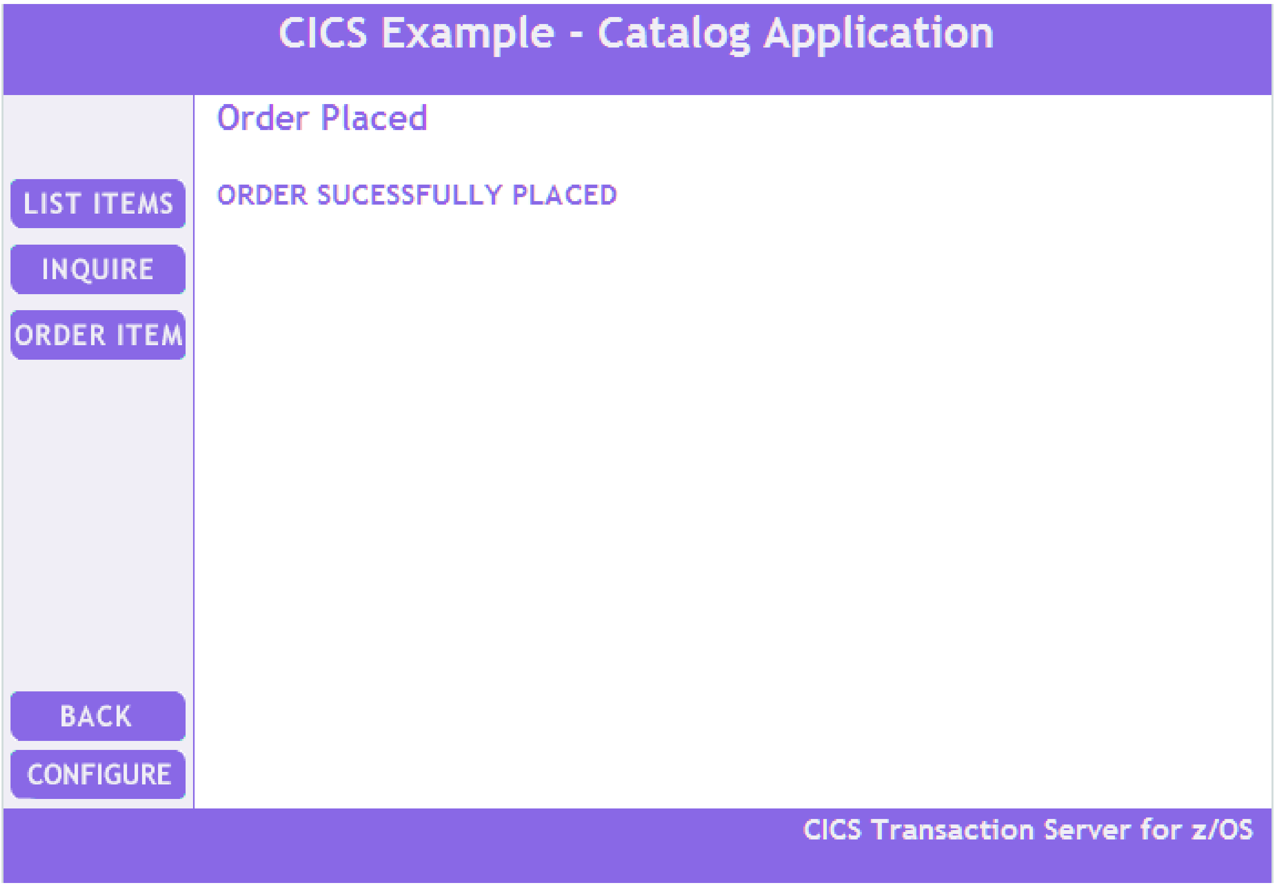
   The application displays the following page:


CICS Example - Catalog Application
Enter Order Details
LIST ITEMS
INQUIRE
BACK
CONFIGURE
SUBMIT
CICS Transaction Server for z/OS

Item Reference Number 0040
Quantity 001
User Name AUSER
Department Name CICS1

5. To place an order, enter the following information.
   a. Complete the `Quantity` field. Specify the number of items you want to order.
   b. Complete the `User Name` field. Enter a 1 to 8-character string. The base application does not check the value that is entered here.
   c. Complete the `Department Name` field. Enter a 1 to 8-character string. The base application does not check the value that is entered here.
   d. Click the **SUBMIT** button.

   The application displays the following page to confirm that the order has been placed:


CICS Example - Catalog Application

Order Placed

ORDER SUCESSFULLY PLACED

Deploying the example application

You can use the Web services assistant to deploy parts of the example application as a Web service. Although the application as supplied will work without performing this task, you will need to perform a similar task if you want to deploy your own applications to extend the example application.

Extracting the program interface

In order to deploy a program with the CICS Web services assistant, you must create a copybook that matches the program's COMMAREA or container interface.

In this example, the INQUIRE SINGLE ITEM function of the central Catalog Manager program (DFH0XCMN) will be deployed as a Web service. The interface to this program is a COMMAREA; the structure of the COMMAREA is defined in the copy book DFH0XCP1:

```
*    Catalogue COMMAREA structure
           03 CA-REQUEST-ID            PIC X(6).
           03 CA-RETURN-CODE           PIC 9(2).
           03 CA-RESPONSE-MESSAGE      PIC X(79).
           03 CA-REQUEST-SPECIFIC      PIC X(911).
      *    Fields used in Inquire Catalog
           03 CA-INQUIRE-REQUEST REDEFINES CA-REQUEST-SPECIFIC.
               05 CA-LIST-START-REF        PIC 9(4).
               05 CA-LAST-ITEM-REF         PIC 9(4).
               05 CA-ITEM-COUNT            PIC 9(3).
               05 CA-INQUIRY-RESPONSE-DATA PIC X(900).
```

```
         05 CA-CAT-ITEM  REDEFINES CA-INQUIRY-RESPONSE-DATA
                         OCCURS 15 TIMES.
             07 CA-ITEM-REF         PIC 9(4).
             07 CA-DESCRIPTION      PIC X(40).
             07 CA-DEPARTMENT       PIC 9(3).
             07 CA-COST             PIC X(6).
             07 IN-STOCK            PIC 9(4).
             07 ON-ORDER            PIC 9(3).
*    Fields used in Inquire Single
     03 CA-INQUIRE-SINGLE REDEFINES CA-REQUEST-SPECIFIC.
         05 CA-ITEM-REF-REQ         PIC 9(4).
         05 FILLER                  PIC 9(4).
         05 FILLER                  PIC 9(3).
         05 CA-SINGLE-ITEM.
             07 CA-SNGL-ITEM-REF    PIC 9(4).
             07 CA-SNGL-DESCRIPTION PIC X(40).
             07 CA-SNGL-DEPARTMENT  PIC 9(3).
             07 CA-SNGL-COST        PIC X(6).
             07 IN-SNGL-STOCK       PIC 9(4).
             07 ON-SNGL-ORDER       PIC 9(3).
         05 FILLER                  PIC X(840).
*    Fields used in Place Order
     03 CA-ORDER-REQUEST REDEFINES CA-REQUEST-SPECIFIC.
         05 CA-USERID               PIC X(8).
         05 CA-CHARGE-DEPT          PIC X(8).
         05 CA-ITEM-REF-NUMBER      PIC 9(4).
         05 CA-QUANTITY-REQ         PIC 9(3).
         05 FILLER                  PIC X(888).
```

The copybook defines 3 separate interfaces for the INQUIRE CATALOG, INQUIRE SINGLE ITEM and the PLACE ORDER functions, which are overlaid on one another in the copybook. However, the DFHLS2WS utility does not support the REDEFINES statement. Therefore you must extract from the combined copybook just those sections that relate to the inquire single function:

```
*    Catalogue COMMAREA structure
           03 CA-REQUEST-ID           PIC X(6).
           03 CA-RETURN-CODE          PIC 9(2) DISPLAY.
           03 CA-RESPONSE-MESSAGE     PIC X(79).
      *    Fields used in Inquire Single
           03 CA-INQUIRE-SINGLE.
               05 CA-ITEM-REF-REQ         PIC 9(4) DISPLAY.
               05 FILLER                  PIC X(4) DISPLAY.
               05 FILLER                  PIC X(3) DISPLAY.
               05 CA-SINGLE-ITEM.
                   07 CA-SNGL-ITEM-REF    PIC 9(4) DISPLAY.
                   07 CA-SNGL-DESCRIPTION PIC X(40).
                   07 CA-SNGL-DEPARTMENT  PIC 9(3) DISPLAY.
                   07 CA-SNGL-COST        PIC X(6).
                   07 IN-SNGL-STOCK       PIC 9(4) DISPLAY.
                   07 ON-SNGL-ORDER       PIC 9(3) DISPLAY.
     05 FILLER                  PIC X(840).
```

The redefined element CA-REQUEST-SPECIFIC has been removed and replaced by the section of the copybook that redefined it for the inquire single function. This copybook is now suitable for use with the Web service assistant.

This copybook is supplied with the example application as copybook DFH0XCP4.

Running the Web services assistant program DFHLS2WS

The CICS Web services assistant consists of two batch programs which can help you to transform existing CICS applications into Web services, and to enable CICS applications to use Web services provided by external providers. Program DFHLS2WS transforms a language structure to generate a Web service binding file and a Web service description.

1. Copy the supplied sample JCL to a suitable working file. The JCL is supplied in `samples/webservices/JCL/LS2WS`.
2. Add a valid JOB card to the JCL.
3. Code the parameters for DFHLS2WS. The required parameters for the INQUIRE SINGLE ITEM function of the example application are:

   ```
   //INPUT.SYSUT1 DD *
   LOGFILE=/u/exampleapp/wsbind/inquireSingle.log
   PDSLIB=CICSHLQ.SDFHSAMP
   REQMEM=DFH0XCP4
   RESPMEM=DFH0XCP4
   LANG=COBOL
   PGMNAME=DFH0XCMN
   PGMINT=COMMAREA
   URI=exampleApp/inquireSingle
   WSBIND=/u/exampleapp/wsbind/inquireSingle.wsbind
   WSDL=/u/exampleapp/wsdl/inquireSingle.wsdl
   */
   ```

   The parameters are as follows:

   LOGFILE=/u/exampleapp/wsbind/inquireSingle.log
   The file that is used to record diagnostic information from DFHLS2WS. The file is normally used only by IBM's software support organization.

   PDSLIB=CICSHLQ.SDFHSAMP
   The name of the partitioned data set (PDS) where the Web service assistant will look for copybooks that define the request and response structures. In the example this is SDFHSAMP of the CICS installed datasets.

   REQMEM=DFH0XCP4
   RESPMEM=DFH0XCP4
   These parameters define the language structure for the request and the response to the program. In the example the request and the response have the same structure and are defined by the same copybook.

   LANG=COBOL
   The target program and the data structures are written in COBOL

   PGMNAME=DFH0XCMN
   The name of the target program that will be invoked when a Web service request is received.

   PGMINT=COMMAREA
   The target program is invoked with a COMMAREA interface.

   URI=exampleApp/inquireSingle

   The unique part of the URI that will be used in the generated Web service definition, and used to create the URIMAP resource that will map incoming requests to the correct Web service. The value specified will result in the service being available to external clients at:

   `http://`*`mycicsserver`*`:`*`myport`*`/exampleApp/inquireSingle`

   where *mycicsserver* and *myport* are the CICS server address and the port onto which this WEBSERVICE has been installed.

   Note: The parameter does **not** have a leading '/'.

WSBIND=/u/exampleapp/wsbind/inquireSingle.wsbind

The location on z/OS UNIX to which the Web service binding file will be written.

Note: If the file is to be used with the PIPELINE scanning mechanism it **must** have the extension `.wsbind`.

WSDL=/u/exampleapp/wsdl/inquireSingle.wsdl

The location on z/OS UNIX to which the file containing the generated Web service description will be written. It is good practice to use matching names for the Web service binding file and its corresponding Web service description.

Tip: Conventionally, files containing Web service descriptions have the extension `.wsdl`.

The Web services description provides the information that a client needs to access the Web service. It contains an XML schema definition of the request and response, and location information for the service.

4. Run the job. A Web service description and Web service binding file will be created in the locations specified.
5. Customize the service location in the Web service description. As generated, the `<service>` element contains the following:

```
<service name="DFHCMNService">
<port binding="tns:DFH0XCMNHTTPSoapBinding" name="DFH0XCMNPort">
<soap:address location="http://my-server:my-port/exampleApp/inquireSingle"/>
</port>
</service>
```

Before the Web service description can be published to clients, you must make the following changes:

a. Replace *my-server* with the CICS server location.

b. Replace *my-port* with the port number.

An example of the generated WSDL document

```
<?xml version="1.0" ?>
<definitions targetNamespace="http://www.DFH0XCMN.DFH0XCP4.com" xmlns="http://schemas.xmlsoap.org/wsdl/"
xmlns:reqns="http://www.DFH0XCMN.DFH0XCP4.Request.com" xmlns:resns="http://www.DFH0XCMN.DFH0XCP4.Response.com"
xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/" xmlns:tns="http://www.DFH0XCMN.DFH0XCP4.com">
    <types>
        <xsd:schema attributeFormDefault="qualified" elementFormDefault="qualified"
        targetNamespace="http://www.DFH0XCMN.DFH0XCP4.Request.com" xmlns:tns="http://www.DFH0XCMN.DFH0XCP4.Request.com"
        xmlns:xsd="http://www.w3.org/2001/XMLSchema">
            <xsd:complextype abstract="false" block="#all" final="#all" mixed="false" name="ProgramInterface">
                <xsd:annotation>
                    <xsd:documentation source="http://www.ibm.com/software/htp/cics/annotations">
                    This schema was generated by the CICS Web services assistant.
                    </xsd:documentation>
                </xsd:annotation>
                <xsd:sequence>
                    <xsd:element name="ca_request_id" nillable="false">
                        <xsd:simpletype>
                            <xsd:annotation>
                                <xsd:appinfo source="http://www.ibm.com/software/htp/cics/annotations">
                                #Thu Nov 03 11:55:26 GMT 2005 com.ibm.cics.wsdl.properties.synchronized=false
                                </xsd:appinfo>
                            </xsd:annotation>
                            <xsd:restriction base="xsd:string">
                                <xsd:maxlength value="6"/>
                                <xsd:whitespace value="preserve"/>
                            </xsd:restriction>
                        </xsd:simpletype>
                    </xsd:element>

.... most of the schema for the request is removed

                </xsd:sequence>
            </xsd:complextype>
            <xsd:element name="DFH0XCMNOperation" nillable="false" type="tns:ProgramInterface"/>
        </xsd:schema>
        <xsd:schema attributeFormDefault="qualified" elementFormDefault="qualified"
        targetNamespace="http://www.DFH0XCMN.DFH0XCP4.Response.com" xmlns:tns="http://www.DFH0XCMN.DFH0XCP4.Response.com"
        xmlns:xsd="http://www.w3.org/2001/XMLSchema">

... schema content for the reply is removed

        </xsd:schema>
    </types>
    <message name="DFH0XCMNOperationResponse">
        <part element="resns:DFH0XCMNOperationResponse" name="ResponsePart"/>
    </message>
    <message name="DFH0XCMNOperationRequest">
        <part element="reqns:DFH0XCMNOperation" name="RequestPart"/>
    </message>
    <porttype name="DFH0XCMNPort">
        <operation name="DFH0XCMNOperation">
            <input message="tns:DFH0XCMNOperationRequest" name="DFH0XCMNOperationRequest"/>
            <output message="tns:DFH0XCMNOperationResponse" name="DFH0XCMNOperationResponse"/>
        </operation>
    </porttype>
    <binding name="DFH0XCMNHTTPSoapBinding" type="tns:DFH0XCMNPort">
        <!-- This soap:binding indicates the use of SOAP 1.1 -->
        <soap:binding style="document" transport="http://schemas.xmlsoap.org/soap/http"/>
        <!-- This soap:binding indicates the use of SOAP 1.2 -->
        <!-- <soap:binding style="document" transport="http://www.w3.org/2003/05/soap-http"/> -->
        <operation name="DFH0XCMNOperation">
             <soap:operation soapAction="" style="document"/>
             <input name="DFH0XCMNOperationRequest">
             <soap:body parts="RequestPart" use="literal"/>
             </input>
            <output name="DFH0XCMNOperationResponse">
                <soap:body parts="ResponsePart" use="literal"/>
            </output>
        </operation>
    </binding>
    <service name="DFH0XCMNService">
        <port binding="tns:DFH0XCMNHTTPSoapBinding" name="DFH0XCMNPort">
            <!-- This soap:address indicates the location of the Web service over HTTP.
                 Please replace "my-server" with the TCPIP host name of your CICS region.
                 Please replace "my-port" with the port number of your CICS TCPIPSERVICE. -->
            <soap:address location="http://my-server:my-port/exampleApp/inquireSingles.log"/>
            <!-- This soap:address indicates the location of the Web service over HTTPS. -->
            <!-- <soap:address location="https://my-server:my-port/exampleApp/inquireSingles.log"/> -->
            <!-- This soap:address indicates the location of the Web service over MQSeries.
                 Please replace "my-queue" with the appropriate queue name. -->
            <!-- <soap:address location="jms:/queue?destination=my-queue&amp;connectionFactory=()&amp;
            targetService=/exampleApp/inquireSingles.log&amp;initialContextFactory=com.ibm.mq.jms.Nojndi" /> -->
        </port>
    </service>
</definitions>
```

Deploying the Web services binding file

The Web services binding file created by DFHLS2WS is deployed into your CICS region dynamically when you install a PIPELINE resource.

When a PIPELINE scan command is issued, either explicitly via a CEMT P PIPELINE() SCAN or automatically during a PIPELINE installation, CICS scans the pickup directory to search for Web service binding files - that is, for file names with the `.wsbind` extension. For each binding file found, CICS determines whether to install a WEBSERVICE resource.

A URIMAP resource is also created to map the URI, as provided in the JCL, to the installed WEBSERVICE and the PIPELINE onto which the WEBSERVICE is installed. When a scanned WEBSERVICE is discarded the URIMAP associated with it is also discarded.

1. Modify PIPELINE(EXPIPE01), which is the PIPELINE definition for your provider pipeline. Change the WSDIR parameter to `/u/exampleapp/wsbind`. This pickup directory contains the Web service binding file that you generated with DFHLS2WS.
2. Copy any other Web service binding files used by the application to the same directory. In this example, the files to copy are:

   ```
   inquireCatalog
   placeOrder
   ```

   They are provided in directory `/usr/lpp/cicsts/samples/webservices/wsbind/provider`.
3. Install the PIPELINE. CICS will create a WEBSERVICE resource and a URIMAP resource from your Web service binding file.

Components of the base application

Table 11. SDFHSAMP members containing BMS maps

Member name	Description
DFH0XS1	BMS macros for the mapset consisting of the map (EXMENU) for the **Main Menu** screen and the map (EXORDR) for the **Details of your order** screen.
DFH0XS2	BMS macros for the mapset consisting of the map (EXINQC) for the **Inquire Catalog** screen.
DFH0XS3	BMS macros for the mapset consisting of the map (EXCONF) for the **Configure CICS example catalog application** screen.
DFH0XM1	Cobol copy book generated by assembling DFH0XS1. DFH0XGUI and DFH0XCUI include this copy book
DFH0XM2U	Cobol copy book generated by assembling DFH0XS2 and editing the result to include an indexed array structure for ease of copy book programming. DFH0XGUI and DFH0XCUI include this copy book.
DFH0XM3	Cobol copy book generated by assembling DFH0XS3. DFH0XCFG includes this copy book

Table 12. SDFHSAMP members containing COBOL source for the base application.

Member name	Description
DFH0XCFG	Program invoked by transaction ECFG to read and update the VSAM configuration file
DFH0XCMN	Controller program for the catalog application. All requests pass through it.

Table 12. SDFHSAMP members containing COBOL source for the base application. (continued)

Member name	Description
DFH0XGUI	Program invoked by transaction EGUI to manage the sending of the BMS maps to the terminal user and the receiving of the maps from the terminal user. It links to program DFH0XCMN.
DFH0XODE	One of two versions of the endpoint for the order dispatch Web service. This is the version that runs in CICS. It simply sets the text `"Order in dispatch"` in the return COMMAREA.
DFH0XSDS	A *stubbed* or dummy version of the data store program that allows the application to work when the VSAM catalog file has not been set up. It uses data defined in the program rather than data stored in a VSAM file.
DFH0XSOD	A stubbed version of the order dispatch program. It sets the return code in the COMMAREA to 0 and returns to its caller. It is used when outbound Web services are not required.
DFH0XSSM	A stubbed version of the stock manager (replenishment) program. It sets the return code in the COMMAREA to 0 and returns to its caller.
DFH0XVDS	The VSAM version of the data store program. It accesses the VSAM file to perform reads and updates of the catalog.
DFH0XWOD	The Web service version of the order dispatch program. It issues an EXEC CICS INVOKE WEBSERVICE to make an outbound Web service call to an order dispatcher

Table 13. SDFHSAMP members containing COBOL copy books for the basic application

Member name	Description
DFH0XCP1	Defines a COMMAREA structure which includes the request and response for the inquire catalog, inquire single, and place order functions. Programs DFH0XCMN, DFH0XCUI, DFH0XECC, DFH0XGUI, DFH0XICW, DFH0XISW, DFH0XPOW, DFH0XSDS, and DFH0XVDS include this copy book.
DFH0XCP2	Defines a COMMAREA structure for the order dispatcher and stock manager modules. Programs DFH0XCMN, DFH0XSOD, DFH0XSSM, and DFH0XWOD include this copy book
DFH0XCP3	Defines a data structure for an inquire catalog request and response. Used as input to DFHLS2WS in order to produce `inquireCatalog.wsdl` and `inquireCatalog.wsbind` .
DFH0XCP4	Defines a data structure for an inquire single request and response. Used as input to DFHLS2WS in order to produce `inquireSingle.wsdl` and `inquireSingle.wsbind`.
DFH0XCP5	Defines a data structure for a place order request and response. Used as input to DFHLS2WS in order to produce `placeOrder.wsdl` and `placeOrder.wsbind`
DFH0XCP6	Defines a data structure for a dispatch order request and response. Used as input to DFHLS2WS in order to produce `dispatchOrder.wsdl` and `dispatchOrder.wsbind`
DFH0XCP7	Defines the data structure for a dispatch order request. Programs DFH0XODE and DFH0XWOD include this copy book
DFH0XCP8	Defines the data structure for a dispatch order response. Programs DFH0XODE and DFH0XWOD include this copy book.

Table 14. SDFHSAMP members containing COBOL source code for the Web service client application which runs in CICS

Member name	Description
DFH0XCUI	Program invoked by transaction ECLI to manage the sending of the BMS maps to the terminal user and the receiving of the maps from the terminal user. It links to program DFH0XECC.

DFH0XECC	Makes outbound Web service requests to the base application, using the EXEC CICS INVOKE WEBSERVICE command. The WEBSERVICE specified is one of the following:
	`inquireCatalogClient`
	`inquireSingleClient`
	`placeOrderClient`

Table 15. SDFHSAMP members containing COBOL copy books for the Web service client application which runs in CICS.. They are all generated by DFHWS2LS, and are included by program DFH0XECC.

Member name	Description
DFH0XCPA	Defines the data structure for the inquire catalog request.
DFH0XCPB	Defines the data structure for the inquire catalog response.
DFH0XCPC	Defines the data structure for the inquire single request.
DFH0XCPD	Defines the data structure for the inquire single response.
DFH0XCPE	Defines the data structure for the place order request.
DFH0XCPF	Defines the data structure for the place order response.

Table 16. SDFHSAMP members containing COBOL source code for the wrapper modules

Member name	Description
DFH0XICW	Wrapper program for the `inquireCatalog` service.
DFH0XISW	Wrapper program for the `inquireSingle` service.
DFH0XPOW	Wrapper program for the `purchaseOrder` service.

Table 17. SDFHSAMP members containing COBOL copy books for the wrapper modules

Member name	Description
DFH0XWC1	Defines the data structure for the inquire catalog request. Program DFH0XICW includes this copy book.
DFH0XWC2	Defines the data structure for the inquire catalog response. Program DFH0XICW includes this copy book.
DFH0XWC3	Defines the data structure for the inquire single request. Program DFH0XISW includes this copy book.
DFH0XWC4	Defines the data structure for the inquire single response. Program DFH0XISW includes this copy book.
DFH0XWC5	Defines the data structure for the place order request. Program DFH0XPOW includes this copy book.
DFH0XWC6	Defines the data structure for the place order response. Program DFH0XPOW includes this copy book

Table 18. CICS Resource Definitions

Resource name	Resource type	Comment
EXAMPLE	CICS Resource definition group	CICS resource definitions required for the example application
EGUI	TRANSACTION	Transaction to invoke program DFH0XGUI to start the BMS interface to the application (Customizable)
ECFG	TRANSACTION	Transaction to invoke the program DFH0XCFG to start the example configuration BMS interface (Customizable)
EXMPCAT	FILE	File definition of the EXMPCAT VSAM file for the application catalog (Customizable)
EXMPCONF	FILE	File definition of the EXMPCONF application configuration file.

The catalog manager program

The catalog manager is the controlling program for the business logic of the example application, and all interactions with the example application pass through it.

To ensure that the program logic is simple, the catalog manager performs only limited type checking and error recovery.

The catalog manager supports a number of operations. Input and output parameters for each operation are defined in a single data structure, which is passed to and from the program in a COMMAREA.

COMMAREA structures

```
*    Catalogue COMMAREA structure
           03 CA-REQUEST-ID            PIC X(6).
           03 CA-RETURN-CODE           PIC 9(2).
           03 CA-RESPONSE-MESSAGE      PIC X(79).
           03 CA-REQUEST-SPECIFIC      PIC X(911).
      *    Fields used in Inquire Catalog
           03 CA-INQUIRE-REQUEST REDEFINES CA-REQUEST-SPECIFIC.
               05 CA-LIST-START-REF        PIC 9(4).
               05 CA-LAST-ITEM-REF         PIC 9(4).
               05 CA-ITEM-COUNT            PIC 9(3).
               05 CA-INQUIRY-RESPONSE-DATA PIC X(900).
               05 CA-CAT-ITEM  REDEFINES CA-INQUIRY-RESPONSE-DATA
                               OCCURS 15 TIMES.
                   07 CA-ITEM-REF          PIC 9(4).
                   07 CA-DESCRIPTION       PIC X(40).
                   07 CA-DEPARTMENT        PIC 9(3).
                   07 CA-COST              PIC X(6).
                   07 IN-STOCK             PIC 9(4).
                   07 ON-ORDER             PIC 9(3).
      *    Fields used in Inquire Single
           03 CA-INQUIRE-SINGLE REDEFINES CA-REQUEST-SPECIFIC.
               05 CA-ITEM-REF-REQ          PIC 9(4).
               05 FILLER                   PIC 9(4).
               05 FILLER                   PIC 9(3).
               05 CA-SINGLE-ITEM.
                   07 CA-SNGL-ITEM-REF     PIC 9(4).
                   07 CA-SNGL-DESCRIPTION  PIC X(40).
                   07 CA-SNGL-DEPARTMENT   PIC 9(3).
                   07 CA-SNGL-COST         PIC X(6).
                   07 IN-SNGL-STOCK        PIC 9(4).
                   07 ON-SNGL-ORDER        PIC 9(3).
               05 FILLER                   PIC X(840).
      *    Fields used in Place Order
           03 CA-ORDER-REQUEST REDEFINES CA-REQUEST-SPECIFIC.
               05 CA-USERID                PIC X(8).
               05 CA-CHARGE-DEPT           PIC X(8).
               05 CA-ITEM-REF-NUMBER       PIC 9(4).
               05 CA-QUANTITY-REQ          PIC 9(3).
               05 FILLER                   PIC X(888).
```

```
 *    Dispatcher/Stock Manager COMMAREA structure
           03 CA-ORD-REQUEST-ID                PIC X(6).
           03 CA-ORD-RETURN-CODE               PIC 9(2).
           03 CA-ORD-RESPONSE-MESSAGE          PIC X(79).
           03 CA-ORD-REQUEST-SPECIFIC          PIC X(23).
      *    Fields used in Dispatcher
           03 CA-DISPATCH-ORDER REDEFINES CA-ORD-REQUEST-SPECIFIC.
               05 CA-ORD-ITEM-REF-NUMBER       PIC 9(4).
               05 CA-ORD-QUANTITY-REQ          PIC 9(3).
               05 CA-ORD-USERID                PIC X(8).
               05 CA-ORD-CHARGE-DEPT           PIC X(8).
      *    Fields used in Stock Manager
           03 CA-STOCK-MANAGER-UPDATE REDEFINES CA-ORD-REQUEST-SPECIFIC.
               05 CA-STK-ITEM-REF-NUMBER       PIC 9(4).
               05 CA-STK-QUANTITY-REQ          PIC 9(3).
               05 FILLER                       PIC X(16).
```

Return codes

Each operation of the catalog manager can return a number of return codes.

Type	Code	Explanation
General	00	Function completed without error
Catalog file	20	Item reference not found
	21	Error opening, reading, or ending browse of catalog file
	22	Error updating file
Configuration file	50	Error opening configuration file
	51	Data store type was neither STUB nor VSAM
	52	Outbound Web service switch was neither Y nor N

Type	Code	Explanation
Remote Web service	30	The **EXEC CICS INVOKE WEBSERVICE** command returned an INVREQ condition
	31	The **EXEC CICS INVOKE WEBSERVICE** command returned an NOTFND condition
	32	The **EXEC CICS INVOKE WEBSERVICE** command returned a condition other than INVREQ or NOTFND
Application	97	Insufficient stock to complete order
	98	Order quantity was not a positive number
	99	DFH0XCMN received a COMMAREA in which the CA-REQUEST-ID field was not set to one of the following: 01INQC, 01INQS, or 01ORDR

INQUIRE CATALOG operation

This operation returns a list of up to 15 catalog items, starting with the item specified by the caller.

Input parameters

CA-REQUEST-ID
A string that identifies the operation. For the INQUIRE CATALOG command, the string contains "01INQC"

CA-LIST-START-REF
The reference number of the first item to be returned.

Output parameters

CA-RETURN-CODE

CA-RESPONSE-MESSAGE
A human readable string, containing "*num* ITEMS RETURNED" where *num* is the number of items returned.

CA-LAST-ITEM-REF
The reference number of the last item returned.

CA-ITEM-COUNT
The number of items returned.

CA-CAT-ITEM
An array containing the list of catalog items returned. The array has 15 elements; if fewer than 15 items are returned, the remaining array elements contain blanks.

INQUIRE SINGLE ITEM operation

This operation returns a single catalog item specified by the caller.

Input parameters

CA-REQUEST-ID
A string that identifies the operation. For the INQUIRE SINGLE ITEM command, the string contains “01INQS”

CA-ITEM-REF-REQ
The reference number of the item to be returned.

Output parameters

CA-RETURN-CODE

CA-RESPONSE-MESSAGE
A human readable string, containing RETURNED ITEM: REF=*item-reference*' where *item-reference* is the reference number of the returned item.

CA-SINGLE-ITEM
An array containing in its first element the returned catalog item.

PLACE ORDER operation

This operation places an order for a single item. If the required quantity is not available a message is returned to the user. If the order is successful, a call is made to the Stock Manager informing it what item has been ordered and the quantity ordered.

Input parameters

CA-REQUEST-ID
A string that identifies the operation. For the PLACE ORDER operation, the string contains '01ORDR'

CA-USERID
An 8-character user ID which the application uses for dispatch and billing.

CA-CHARGE-DEPT
An 8-character department ID which the application uses for dispatch and billing.

CA-ITEM-REF-NUMBER
The reference number of the item to be ordered.

CA-QUANTITY-REQ
The number of items required.

Output parameters

CA-RETURN-CODE

CA-RESPONSE-MESSAGE
A human readable string, containing 'ORDER SUCCESSFULLY PLACED'.

DISPATCH STOCK operation

This operation places a call to the stock dispatcher program, which in turn dispatches the order to the customer.

Input parameters

CA-ORD-REQUEST-ID
A string that identifies the operation. For the DISPATCH ORDER operation, the string contains '01DSPO'

CA-ORD-USERID
An 8-character user ID which the application uses for dispatch and billing.

CA-ORD-CHARGE-DEPT
An 8-character department ID which the application uses for dispatch and billing.

CA-ORD-ITEM-REF-NUMBER
The reference number of the item to be ordered.

CA-ORD-QUANTITY-REQ
The number of items required.

Output parameters

CA-ORD-RETURN-CODE

NOTIFY STOCK MANAGER operation

This operation takes details of the order that has been placed to decide if stock replenishment is necessary.

Input parameters

CA-ORD-REQUEST-ID
A string that identifies the operation. For the NOTIFY STOCK MANAGER operation, the string contains '01STKO'

CA-STK-ITEM-REF-NUMBER
The reference number of the item to be ordered.

CA-STK-QUANTITY-REQ
The number of items required.

Output parameters

CA-ORD-RETURN-CODE

File Structures and Definitions

The example application uses two VSAM files: the catalog file which contains the details of all items stocked and their stock levels, and the configuration file which holds user-selected options for the application.

Catalog file

The catalog file is a KSDS VSAM file which contains all information relating to the product inventory.

Records in the file have the following structure:

Name	COBOL data type	Description
WS-ITEM-REF-NUM	PIC 9(4)	Item reference number
WS-DESCRIPTION	PIC X(40)	Item description
WS-DEPARTMENT	PIC 9(3)	Department identification number
WS-COST	PIC ZZZ.99	Item price
WS-IN-STOCK	PIC 9(4)	Number of items in stock
WS-ON-ORDER	PIC 9(3)	Number of items on order

Configuration file

The configuration file is a KSDS VSAM file which contains information used to configure the example application.

The configuration file is a KSDS VSAM file with four distinct records.

Table 19. General information record

Name	COBOL data type	Description
PROGS-KEY	PIC X(9)	Key field for the general information record, containing 'EXMP-CONF'
filler	PIC X	
DATASTORE	PIC X(4)	A character string that specifies the type of data store program to be used. Values are: 'STUB' 'VSAM'
filler	PIC X	
DO-OUTBOUND-WS	PIC X	A character that specifies whether the dispatch manager is make an outbound Web service request. Values are: 'Y' 'N'
filler	PIC X	
CATMAN-PROG	PIC X(8)	The name of the catalog manager program
filler	PIC X	
DSSTUB-PROG	PIC X(8)	The name of the dummy data handler program
filler	PIC X	
DSVSAM-PROG	PIC X(8)	The name of the VSAM data handler program
filler	PIC X	
ODSTUB-PROG	PIC X(8)	The name of the dummy order dispatcher module
filler	PIC X	
ODWEBS-PROG	PIC X(8)	The name of the outbound Web service order dispatcher program
filler	PIC X	
STKMAN-PROG	PIC X(8)	The name of the stock manager program
filler	PIC X(10)	

Table 20. Outbound URL record

Name	COBOL data type	Description
URL-KEY	PIC X(9)	Key field for the general information record, containing 'OUTBNDURL'
filler	PIC X	
OUTBOUND-URL	PIC X(255)	Outbound URL for the order dispatcher Web service request

Table 21. Catalog file information record

Name	COBOL data type	Description
URL-FILE-KEY	PIC X(9)	Key field for the general information record, containing 'VSAM-NAME'
filler	PIC X	
CATALOG-FILE-NAME	PIC X(8)	Name of the CICS FILE resource used for the catalog file

Table 22. Server information record

Name	COBOL data type	Description
WS-SERVER-KEY	PIC X(9)	Key field for the server information record, containing 'WS-SERVER'
filler	PIC X	
CATALOG-FILE-NAME	PIC X(8)	For the CICS Web service client only, the IP address and port of the system on which the example application is deployed as a Web service

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Web Services Guide
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