9.4

IBM MQ Technical overview

Note

Before using this information and the product it supports, read the information in “Notices” on page 299.

This edition applies to version 9 release 4 of IBM® MQ and to all subsequent releases and modifications until otherwise indicated in new editions.

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IBM MQ Technical overview

Use IBM MQ to connect your applications and manage the distribution of information across your organization.

IBM MQ enables programs to communicate with one another across a network of unlike components (processors, operating systems, subsystems, and communication protocols) using a consistent application programming interface. Applications designed and written using this interface are known as message queuing applications.

Use the following subtopics to find out about message queuing and other features provided by IBM MQ.

Related concepts

Introduction to IBM MQ

Where to find product requirements and support information

Related tasks

Planning an IBM MQ architecture

Related reference

"Main features and benefits of message queuing" on page 7

This information highlights some features and benefits of message queuing. It describes features such as security and data integrity of message queuing.

Introduction to message queuing

The IBM MQ products enable programs to communicate with one another across a network of unlike components (processors, operating systems, subsystems, and communication protocols) using a consistent application programming interface.

Applications designed and written using this interface are known as *message queuing* applications, because they use the *messaging* and *queuing* style:

- Messaging means that programs communicate by sending each other data in messages rather than calling each other directly.
- Queuing means that messages are placed on queues in storage, allowing programs to run independently of each other, at different speeds and times, in different locations, and without having a logical connection between them.

Message queuing has been used in data processing for many years. It is most commonly used today in electronic mail. Without queuing, sending an electronic message over long distances requires every node on the route to be available for forwarding messages, and the addressees to be logged on and conscious of the fact that you are trying to send them a message. In a queuing system, messages are stored at intermediate nodes until the system is ready to forward them. At their final destination they are stored in an electronic mailbox until the addressee is ready to read them.

Even so, many complex business transactions are processed today without queuing. In a large network, the system might be maintaining many thousands of connections in a ready-to-use state. If one part of the system suffers a problem, many parts of the system become unusable.

You can think of message queuing as being electronic mail for programs. In a message queuing environment, each program that makes up part of an application suite performs a well-defined, self-contained function in response to a specific request. To communicate with another program, a program must put a message on a predefined queue. The other program retrieves the message from the queue, and processes the requests and information contained in the message. So message queuing is a style of program-to-program communication.

Queuing is the mechanism by which messages are held until an application is ready to process them. Queuing allows you to:

- Communicate between programs (which might each be running in different environments) without having to write the communication code.
- Select the order in which a program processes messages.
- Balance loads on a system by arranging for more than one program to service a queue when the number of messages exceeds a threshold.
- Increase the availability of your applications by arranging for an alternative system to service the queues if your primary system is unavailable.

What is a message queue?

A message queue, known simply as a queue, is a named destination to which messages can be sent. Messages accumulate on queues until they are retrieved by programs that service those queues.

Queues reside in, and are managed by, a queue manager, (see "Message queuing terminology" on page 9). The physical nature of a queue depends on the operating system on which the queue manager is running. A queue can either be a volatile buffer area in the memory of a computer, or a data set on a permanent storage device (such as a disk). The physical management of queues is the responsibility of the queue manager and is not made apparent to the participating application programs.

Programs access queues only through the external services of the queue manager. They can open a queue, put messages on it, get messages from it, and close the queue. They can also set, and inquire about, the attributes of queues.

Different styles of message queuing

Point-to-point

One message is placed on the queue and one application receives that message.

In point-to-point messaging, a sending application must know information about the receiving application before it can send a message to that application. For example, the sending application might need to know the name of the queue to which to send the information, and might also specify a queue manager name.

Publish/Subscribe

A copy of each message published by a publishing application is delivered to every interested application. There might be many, one, or no interested applications. In publish/subscribe an interested application is known as a subscriber and the messages are queued on a queue identified by a subscription.

Publish/subscribe messaging allows you to decouple the provider of information from the consumers of that information. The sending application and receiving application do not need to know as much about each other for the information to be sent and received. For more information, see "Publish/subscribe messaging" on page 60.

Benefits of message queuing to the application designer and developer

IBM MQ allows application programs to use *message queuing* to participate in message-driven processing. Application programs can communicate across different platforms by using the appropriate message queuing software products. For example, z/OS® applications can communicate through IBM MQ for z/OS. The applications are shielded from the mechanics of the underlying communications. Some of the other benefits of message queuing are:

- You can design applications using small programs that you can share between many applications.
- You can quickly build new applications by reusing these building blocks.
- Applications written to use message queuing techniques are not affected by changes in the way that queue managers work.
- You do not need to use any communication protocols. The queue manager deals with all aspects of communication for you.

- Programs that receive messages need not be running at the time that messages are sent to them. The messages are retained on queues.

Designers can reduce the cost of their applications because development is faster, fewer developers are needed, and demands on programming skill are lower than those for applications that do not use message queuing.

IBM MQ implements a common application programming interface known as the *message queue interface* (or MQI) wherever the applications run. This makes it easier for you to port application programs from one platform to another.

For details about the MQI, see The Message Queue Interface overview.

Main features and benefits of message queuing

This information highlights some features and benefits of message queuing. It describes features such as security and data integrity of message queuing.

The main features of applications that use message queuing techniques are:

Note: When considering IBM MQ clients and servers, you do not have to change a server application to support additional IBM MQ MQI clients on new platforms. Similarly, the IBM MQ MQI client can, without change, function with additional types of servers.

No direct connections between programs

Message queuing is a technique for indirect program-to-program communication. It can be used within any application where programs communicate with each other. Communication occurs by one program putting messages on a queue (owned by a queue manager) and another program getting the messages from the queue.

Programs can get messages that were put on a queue by other programs. The other programs can be connected to the same queue manager as the receiving program, or to another queue manager. This other queue manager might be on another system, a different computer system, or even within a different business or enterprise.

There are no physical connections between programs that communicate using message queues. A program sends messages to a queue owned by a queue manager, and another program retrieves messages from the queue (see Figure 1 on page 8).

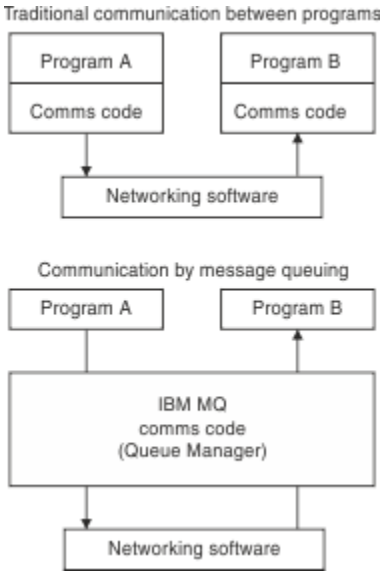


Figure 1. Message queuing compared with traditional communication

As with electronic mail, the individual messages that are part of a transaction travel through a network on a store-and-forward basis. If a link between nodes fails, the message is kept until the link is restored, or the operator or program redirects the message.

The mechanism by which a message moves from queue to queue is hidden from the programs. Therefore the programs are simpler.

Time-independent communication

Programs requesting others to do work do not have to wait for the reply to a request. They can do other work, and process the reply either when it arrives or at a later time. When writing a messaging application, you need not know (or be concerned) when a program sends a message, or when the target is able to receive the message. The message is not lost; it is retained by the queue manager until the target is ready to process it. The message stays on the queue until it is removed by a program. This means that the sending and receiving application programs are decoupled; the sender can continue processing without waiting for the receiver to acknowledge receipt of the message. The target application does not even have to be running when the message is sent. It can retrieve the message after it is has been started.

Small programs

Message queuing allows you to use the advantages of using small, self-contained programs. Instead of a single, large program performing all the parts of a job sequentially, you can spread the job over several smaller, independent programs. The requesting program sends messages to each of the separate programs, asking them to perform their function; when each program is complete, the results are sent back as one or more messages.

Message-driven processing

When messages arrive on a queue, they can automatically start an application using *triggering*. If necessary, the applications can be stopped when the message (or messages) have been processed.

Event-driven processing

Programs can be controlled according to the state of queues. For example, you can arrange for a program to start as soon as a message arrives on a queue, or you can specify that the program does not start until there are, for example, 10 messages above a certain priority on the queue, or 10 messages of any priority on the queue.

Message priority

A program can assign a priority to a message when it puts the message on a queue. This determines the position in the queue at which the new message is added.

Programs can get messages from a queue either in the order in which the messages are in the queue, or by getting a specific message. (A program might want to get a specific message if it is looking for the reply to a request that it sent earlier.)

Security

Security facilities are provided, including authentication of applications when they use a queue manager, authorization checks when they use resources such as a queue on the queue manager, and encryption of message data as it travels over the network, and as it resides on queues. For more information about security, see Security Overview.

Data integrity

Data integrity is provided by units of work. The synchronization of the start and end of units of work is fully supported as an option on each MQGET or MQPUT, allowing the results of the unit of work to be committed or rolled back. Sync point support operates either internally or externally to IBM MQ depending on the form of sync point coordination selected for the application.

Recovery support

For recovery to be possible, all persistent IBM MQ updates are logged. If recovery is necessary, all persistent messages are restored, all in-flight transactions are rolled back, and any sync point commit and backouts are handled in the normal way of the sync point manager in control. For more information about persistent messages, see Message persistence.

Message queuing terminology

This information gives an insight into some terms used in message queuing.

They include:

- Channels
- Cluster
- IBM MQ MQI client
- z/OS Intra-group queuing
- Message
- Message channel agent
- Message descriptor
- Point-to-point
- Publish/subscribe
- Queue
- Queue manager
- z/OS Queue sharing group
- z/OS Shared queue
- Subscription
- Topic

Channels

Channels are used to move messages from one queue manager to another and they shield applications from the underlying communications protocols. The queue managers might exist on the same system, or a different systems on the same platform, or on different platforms. The messages that are sent can originate from many places:

- User-written application programs that transfer data from one node to another.
- User-written administration applications that use PCF commands or the MQAI.
- The IBM MQ Explorer.
- Queue managers that send instrumentation event messages to another queue manager.
- Queue managers that send remote administration commands to another queue manager. For example, using MQSC commands or the administrative REST API.

For more information about channels, see “Channel definitions” on page 31.

Cluster

A *cluster* is a network of queue managers that are logically associated in some way.

In an IBM MQ network using distributed queuing without clustering, every queue manager is independent. If one queue manager needs to send messages to another, it must have defined a transmission queue and a channel to the remote queue manager.

There are two different reasons for using clusters: to reduce system administration and to improve availability and workload balancing.

As soon as you establish even the smallest cluster, you benefit from simplified system administration. Queue managers that are part of a cluster need fewer definitions and so the risk of making an error in your definitions is reduced.

For more information about clustering, see Clusters.

IBM MQ MQI client

IBM MQ MQI *clients* are independently installable components of IBM MQ. An MQI client allows you to run IBM MQ applications with a communications protocol, to interact with one or more Message Queue Interface (MQI) servers on other platforms and to connect to their queue managers.

For full details on how to install and use IBM MQ MQI client components, see the following topics:

- AIX Installing an IBM MQ client on AIX®
- Linux Installing an IBM MQ client on Linux®
- Windows Installing an IBM MQ client on Windows
- IBM i Installing an IBM MQ client on IBM i

and Configuring connections between the server and client.

Intra-group queuing

z/OS

Queue managers in a queue sharing group can communicate using normal channels or you can use a technique called *intra-group queuing* (IGQ), which lets you perform fast message transfer without defining channels. This applies only to IBM MQ for z/OS.

For more information about intra-group queuing, see “Intra-group queuing” on page 208.

Message

In message queuing, a message is a collection of data sent by one program and intended for another program. See IBM MQ messages.

For information about message types, see Types of message.

Message channel agent

A message channel agent is one end of a channel. A pair of message channel agents, one sending and one receiving, make up a channel and move messages from one queue manager to another.

For information about how message channel agents are used, see Introduction to distributed queue management.

Message descriptor

An IBM MQ message consists of control information and application data.

The control information is defined in a message descriptor structure (MQMD) and contains such things as:

- The type of the message
- An identifier for the message
- The priority for delivery of the message

The structure and content of the application data is determined by the participating programs, not by IBM MQ.

For more information, see MQMD.

Point-to-point messaging

In point-to-point messaging, each message travels from one producing application to one consuming application. Messages are transferred through the producing application putting messages onto a queue and the consuming application gets them from that queue.

Publish/subscribe messaging

In publish/subscribe messaging, a copy of each message published by a publishing application is delivered to every interested application. There might be many, one or no interested applications. In publish/subscribe an interested application is known as a subscriber and the messages are queued on a queue identified by a subscription.

For more information, see “Publish/subscribe messaging” on page 60.

Queue

A named destination to which messages can be sent. Messages accumulate on queues until they are retrieved by programs that service those queues.

For more information, see “Queues” on page 19.

Queue manager

A *queue manager* is a system program that provides queuing services to applications.

It provides an application programming interface so that programs can put messages on, and get messages from, queues. A queue manager provides additional functions so that administrators can create new queues, alter the properties of existing queues, and control the operation of the queue manager.

For IBM MQ message queuing services to be available on a system, there must be a queue manager running. You can have more than one queue manager running on a single system (for example, to

separate a test system from a *live* system). To an application, each queue manager is identified by a *connection handle* (*Hconn*).

Many different applications can use the services of the queue manager at the same time and these applications can be entirely unrelated. For a program to use the services of a queue manager, it must establish a connection to that queue manager.

For applications to send messages to applications that are connected to other queue managers, the queue managers must be able to communicate among themselves. IBM MQ implements a *store-and-forward* protocol to ensure the safe delivery of messages between such applications.

For more information, see "Queue managers" on page 27.

Queue sharing group

The queue managers that can access the same set of shared queues form a group called a *queue sharing group* (QSG). They communicate with each other with a coupling facility (CF) that stores the shared queues. This applies only to IBM MQ for z/OS.

For more information, see "Shared queues and queue sharing groups" on page 164.

Shared queue

A *shared queue* is a type of local queue with messages that can be accessed by one or more queue managers that are in a sysplex. This is not the same as a queue being shared by more than one application, using the same queue manager. This applies only to IBM MQ for z/OS.

Subscription

A publish/subscribe application can register an interest in messages about specific topics. When an application does this it is known as a subscriber and the term subscription defines how matching messages are queued for processing.

A subscription contains information about the identity of the subscriber and the identity of the destination queue on to which publications are to be placed. It also contains information about how a publication is to be placed on the destination queue.

For more information, see "Subscribers and subscriptions" on page 64.

Topic

A topic is a character string that describes the subject of the information that is published in a publish/subscribe message.

Topics are key to the successful delivery of messages in a publish/subscribe system. Instead of including a specific destination address in each message, a publisher assigns a topic to each message. The queue manager matches the topic with a list of subscribers who have subscribed to that topic, and delivers the message to each of those subscribers.

For more information, see "Topics" on page 66.

Messages and queues

Messages and queues are the basic components of a message queuing system.

What is a message?

A *message* is a string of bytes that is meaningful to the applications that use it. Messages are used to transfer information from one application program to another (or between different parts of the same application). The applications can be running on the same platform, or on different platforms.

An IBM MQ message is made up of:

- *The application data.* The content and structure of the application data is defined by the application programs that use it.
- *A message descriptor.* The message descriptor identifies the message and contains additional control information, such as the type of message and the priority assigned to the message by the sending application.

  The format of the message descriptor is defined by IBM MQ. For a complete description of the message descriptor, see MQMD - Message descriptor.
- *Message properties.* Meta-data about the message. The content of the message properties are defined by the application programs that use them. For more information, see Message properties.

Message lengths

The default maximum message length is 4 MB, although you can increase this to a maximum length of 100 MB (where 1 MB equals 1 048 576 bytes). In practice, the message length might be limited by:

- The maximum message length defined for the receiving queue
- The maximum message length defined for the queue manager
- The maximum message length defined by the queue
- The maximum message length defined by either the sending or receiving application
- The amount of storage available for the message

It might take several messages to send all the information that an application requires.

How do applications send and receive messages?

Application programs send and receive messages using **MQI calls**.

For example, to put a message onto a queue, an application:

1. Opens the required queue by issuing an MQI `MQOPEN` call
2. Issues an MQI `MQPUT` call to put the message onto the queue

Another application can retrieve the message from the same queue by issuing an MQI `MQGET` call

For more information about MQI calls, see MQI calls.

What is a queue?

A *queue* is a data structure used to store messages.

Each queue is owned by a *queue manager*. The queue manager is responsible for maintaining the queues it owns, and for storing all the messages it receives onto the appropriate queues. The messages might be put on the queue by application programs, or by a queue manager as part of its normal operation.

Predefined queues and dynamic queues

Queues can be characterized by the way they are created:

- **Predefined queues** are created by an administrator using the appropriate MQSC or PCF commands. Predefined queues are permanent; they exist independently of the applications that use them and survive IBM MQ restarts.
- **Dynamic queues** are created when an application issues an MQOPEN request specifying the name of a *model queue*. The queue created is based on a *template queue definition*, which is called a model queue. You can create a model queue using the MQSC command DEFINE QMODEL. The attributes of a model queue (for example, the maximum number of messages that can be stored on it) are inherited by any dynamic queue that is created from it.

  Model queues have an attribute that specifies whether the dynamic queue is to be permanent or temporary. Permanent queues survive application and queue manager restarts; temporary queues are lost on restart.

Retrieving messages from queues

Suitably authorized applications can retrieve messages from a queue according to the following retrieval algorithms:

- First-in-first-out (FIFO).
- Message priority, as defined in the message descriptor. Messages that have the same priority are retrieved on a FIFO basis.
- A program request for a specific message.

The MQGET request from the application determines the method used.

IBM MQ objects

Queue managers define the properties of IBM MQ objects. The values of these properties affect the way in which IBM MQ processes these objects. You create and manage objects using IBM MQ commands and interfaces. From your applications, you use the Message Queue Interface (MQI) to control objects. Objects are identified by an IBM MQ *object descriptor* (MQOD) when addressed from a program.

Object administration

The administration of objects includes the following tasks:

- Starting and stopping queue managers.
- Creating objects, particularly queues, for applications.
- Displaying or altering the attributes of objects.
- Deleting objects.
- Working with channels to create communication paths to queue managers on other (remote) systems.
- Creating *clusters* of queue managers to simplify the overall administration process, and to balance workload.

With the exception of dynamic queues, objects must be defined to the queue manager before you can work with them.

When you use an IBM MQ command to carry out an object administration operation, the queue manager checks that you have the required level of authority to perform the operation. Similarly, when an application uses the MQOPEN call to open an object, the queue manager checks that the application has the required level of authority before it allows access to that object. The checks are made on the name of the object being opened.

You can define and manage objects by using the following methods:

- The PCF commands described in Programmable command formats reference and Automating administration tasks
- The MQSC commands described in The MQSC commands

- z/OS The IBM MQ for z/OS operations and control panels, described in Administering IBM MQ for z/OS
- Windows Linux The IBM MQ Explorer (Windows and Linux for Intel systems only). For more information, see Introduction to MQ Explorer.

You can also manage objects by using the following methods:

- Control commands, which are typed in from a keyboard. See Administering IBM MQ for Multiplatforms using control commands.
- IBM MQ Administration Interface (MQAI) calls in a program. See IBM MQ Administration Interface (MQAI).

ALW For sequences of IBM MQ commands on AIX, Linux, and Windows, you can use the MQSC facility to run a series of commands held in a file. For more information, see Administering IBM MQ using MQSC commands.

IBM i For sequences of IBM MQ for IBM i commands that you use regularly you can write CL programs. For more information, see Managing IBM MQ for IBM i using CL commands.

z/OS For sequences of IBM MQ for z/OS commands that you use regularly, you can write administration programs that create messages containing commands and that put these messages on the system-command input queue. The queue manager processes the messages on this queue in the same way that it processes commands entered from the command line or from the operations and control panels. This technique is described in the Writing programs to administer IBM MQ, and demonstrated in the Mail Manager sample application delivered with IBM MQ for z/OS. For a description of this sample, see Sample programs for IBM MQ for z/OS .

Object attributes

The properties of an object are defined by its attributes. Some you can specify, others you can only view.

For example, the maximum message length that a queue can accommodate is defined by its **MaxMsgLength** attribute; you can specify this attribute when you create a queue. The **DefinitionType** attribute specifies how the queue was created; you can only display this attribute.

In IBM MQ, there are two ways of referring to an attribute:

- Using its PCF name, for example, **MaxMsgLength**.
- Using its MQSC command name, for example, MAXMSGL.

Queue sharing groups

z/OS

Queue managers that can access the same set of shared queues form a group called a *queue sharing group* (QSG), and they communicate with each other using a coupling facility (CF) that stores the shared queues. Note that a QSG is not strictly an object.

A shared queue is a type of local queue with messages that can be accessed by one or more queue managers that are in a queue sharing group. This is not the same as a queue being shared by more than one application, using the same queue manager.

Queue sharing groups have a name of up to four characters. The name must be unique in your network, and must be different from any queue manager names.

Important: Shared queues and queue sharing groups are supported only on IBM MQ for z/OS.

See “Shared queues and queue sharing groups” on page 164 for more information.

System default objects

System default objects are a set of object definitions that are created automatically whenever a queue manager is created. You can copy and modify any of these object definitions for use in applications at your installation.

Default object names have the stem SYSTEM; for example, the default local queue is SYSTEM.DEFAULT.LOCAL.QUEUE, and the default receiver channel is SYSTEM.DEF.RECEIVER. You cannot rename these objects; default objects of these names are required.

When you define an object, any attributes that you do not specify explicitly are copied from the appropriate default object. For example, if you define a local queue, those attributes that you do not specify are taken from the default queue SYSTEM.DEFAULT.LOCAL.QUEUE.

See System and default objects for more information.

Object types

Many of the administration tasks involve manipulating various types of IBM MQ *objects*.

For information about naming IBM MQ objects, see "Naming IBM MQ objects" on page 35.

For information about the default objects created on a queue manager, see "System default objects" on page 16.

For information about the different types of IBM MQ objects, see the following:

Authentication information objects

An authentication information object provides the definitions required to perform certificate revocation checking.

The queue manager authentication information object forms part of IBM MQ support for Transport Layer Security (TLS). It provides the definitions needed to check for revoked certificates. Certification Authorities revoke certificates that can no longer be trusted.

You can use the MQSC command **DEFINE AUTHINFO** to define an authentication information object. For more information about the attributes of authentication information objects, see **DEFINE AUTHINFO**.

You can use the following IBM MQ control commands with an authentication information object:

- **setmqaut** (grant or revoke authority)
- **dspmqaut** (display object authorization)
- **dmpmqaut** (dump authorizations)
- **rcrmqobj** (re-create object)
- **rcdmqimg** (record media image)
- **dspmqfls** (display file names)

For an overview of TLS, and the use of the authentication information objects, see Transport Layer Security (TLS) concepts and TLS security protocols in IBM MQ.

Channels

Channels are objects that provide a communication path from one queue manager to another.

See "Channels" on page 29 for more information.

Communication information objects

IBM MQ Multicast offers low latency, high fanout, reliable multicast messaging. A communication information (COMMINFO) object is needed to use Multicast transmission.

See "IBM MQ Multicast" on page 104 for more information.

A COMMINFO object is an IBM MQ object that contains the attributes associated with multicast transmission. For more information about these attributes, see DEFINE COMMINFO. For more information about creating a COMMINFO object, see Getting started with multicast.

Listeners

Listeners are processes that accept network requests from other queue managers, or client applications, and start associated channels.

Listener processes can be started using the **runmqlsr** control command.

Listener objects are IBM MQ objects that allow you to manage the starting and stopping of listener processes from within the scope of a queue manager. By defining attributes of a listener object you do the following:

- Configure the listener process.
- Specify whether the listener process automatically starts and stops when the queue manager starts and stops.

Important: z/OS Listener objects are not supported on IBM MQ for z/OS. For more information about how IBM MQ for z/OS implements listening, by using the channel initiator, see "The channel initiator on z/OS" on page 160.

Namelists

A *namelist* is an IBM MQ object that contains a list of cluster names, queue names or authentication information object names. In a cluster, it can be used to identify a list of clusters for which the queue manager holds the repositories.

A namelist is an IBM MQ object that contains a list of other IBM MQ objects. Typically, namelists are used by applications such as trigger monitors, where they are used to identify a group of queues. The advantage of using a namelist is that it is maintained independently of applications; it can be updated without stopping any of the applications that use it. Also, if one application fails, the namelist is not affected and other applications can continue using it.

Name lists are also used with queue manager clusters to maintain a list of clusters referred to by more than one IBM MQ object.

You can define and modify namelists by using the MQSC commands DEFINE NAMELIST and ALTER NAMELIST .

Note: z/OS Alternatively, on z/OS, you can use the IBM MQ for z/OS operations and control panels

Programs can use the MQI to find out which queues are included in these namelists. The organization of the namelists is the responsibility of the application designer and system administrator.

For a list of namelist attributes available to use, see Attributes for namelists,

Process definitions

Process definition objects allow applications to be started without the need for operator intervention by defining the attributes of the application for use by the queue manager.

The process definition object defines an application that starts in response to a trigger event on an IBM MQ queue manager. The process definition attributes include the application ID, the application type, and data specific to the application. For more information, see *Initiation queues* in "Queues used for specific purposes by IBM MQ" on page 26.

To allow an application to be started without the need for operator intervention, as described in Starting IBM MQ applications using triggers, the attributes of the application must be known to the queue manager. These attributes are defined in a *process definition object*.

The **ProcessName** attribute is fixed when the object is created. However, you can change other attributes by using the IBM MQ commands.

Note: z/OS Alternatively, on z/OS, you can use the IBM MQ for z/OS operations and control panels.

You can inquire about the values of all the attributes by using MQINQ - Inquire object attributes.

For a list of process definition attributes available to use, see Attributes for process definitions.

Queues

An IBM MQ *queue* is a named object on which applications can put messages, and from which applications can get messages.

See "Queues" on page 19 for more information.

Queue managers

IBM MQ queue managers provide queuing services to applications, and manages the queues that belong to them.

See "Queue managers" on page 27 for more information.

Services

Service objects are a way of defining programs to be run when a queue manager starts or stops.

Programs can be one of the following types:

Servers
A *server* is a service object that has the parameter SERVTYPE specified as SERVER. A server service object is the definition of a program that will be executed when a specified queue manager is started. Only one instance of a server process can be executed concurrently. While running, the status of a server process can be monitored using the MQSC command, DISPLAY SVSTATUS. Typically server service objects are definitions of programs such as dead letter handlers or trigger monitors, however the programs that can be run are not limited to those supplied with IBM MQ. Additionally, a server service object can be defined to include a command that will be run when the specified queue manager is shut down to end the program.

Commands
A *command* is a service object that has the parameter SERVTYPE specified as COMMAND. A command service object is the definition of a program that will be executed when a specified queue manager is started or stopped. Multiple instances of a command process can be executed concurrently. Command service objects differ from server service objects in that once the program is executed the queue manager will not monitor the program. Typically command service objects are definitions of programs that are short lived and will perform a specific task such as starting one, or more, other tasks.

Important: z/OS Service objects are not supported on IBM MQ for z/OS.

For more information see Working with services.

Storage classes

z/OS

A storage class maps one or more queues to a page set.

This means that messages for that queue are stored (subject to buffering) on that page set.

Storage classes are supported only on IBM MQ for z/OS.

For further information about storage classes, see Planning your IBM MQ environment on z/OS.

Topic objects

A *topic object* is an IBM MQ object that allows you to assign specific, non-default attributes to topics.

A *topic* is defined by an application publishing or subscribing to a particular *topic string*. A topic string can specify a hierarchy of topics by separating them with a forward slash character (/). This can be visualized by a *topic tree*. For example, if an application publishes to the topic strings `/Sport/American Football` and `/Sport/Soccer`, a topic tree is created that has a parent node `Sport` with two children, `American Football`, and `Soccer`.

Topics inherit their attributes from the first parent administrative node found in their topic tree. If there are no administrative topic nodes in a particular topic tree, then all topics inherit their attributes from the base topic object, SYSTEM.BASE.TOPIC.

You can create a topic object at any node in a topic tree by specifying that node's topic string in the TOPICSTR attribute of the topic object. You can also define other attributes for the administrative topic node. For more information about these attributes, see The MQSC commands, or Automating administration using PCF commands. Each topic object, by default, inherits its attributes from its closest parent administrative topic node.

Topic objects can also be used to hide the full topic tree from application developers. If a topic object named `FOOTBALL.US` is created for the topic `/Sport/American Football`, an application can publish or subscribe to the object named `FOOTBALL.US` instead of the string `/Sport/American Football` with the same result.

If you enter a #, +, /, or * character within a topic string on a topic object, the character is treated as a normal character within the string, and is considered to be part of the topic string associated with a topic object.

For more information about topic objects, see “Publish/subscribe messaging” on page 60.

Related concepts

“Introduction to message queuing” on page 5
The IBM MQ products enable programs to communicate with one another across a network of unlike components (processors, operating systems, subsystems, and communication protocols) using a consistent application programming interface.

Related reference

The MQSC commands

Queues

Introduction to IBM MQ queues and queue attributes.

Messages are stored on a queue, so that if the putting application is expecting a reply to its message, it is free to do other work while waiting for that reply. Applications access a queue by using the Message Queue Interface (MQI), described in The Message Queue Interface overview.

Before a message can be put on a queue, the queue must have already been created. A queue is owned by a queue manager, and that queue manager can own many queues. However, each queue must have a name that is unique within that queue manager.

A queue is maintained through a queue manager. In most cases, each queue is physically managed by its queue manager but this is not apparent to an application program. IBM MQ for z/OS shared queues can be managed by any queue manager in the queue sharing group.

To create a queue you can use IBM MQ commands (MQSC), PCF commands, or platform-specific interfaces. For example, the IBM MQ for z/OS operations and control panels are platform-specific.

You can create local queues for temporary jobs *dynamically* from your application. For example, you can create *reply-to* queues (which are not needed after an application ends). For more information, see “Dynamic and Model queues” on page 24.

Before using a queue, you must open the queue, specifying what you want to do with it. For example, you can open a queue for:

- Browsing messages only (not retrieving them)
- Retrieving messages (and either sharing the access with other programs, or with exclusive access)
- Putting messages on the queue
- Inquiring about the attributes of the queue
- Setting the attributes of the queue

For a complete list of the options that you can specify when you open a queue, see MQOPEN - Open object.

Attributes of queues

Some of the attributes of a queue are specified when the queue is defined, and cannot be changed afterward (for example, the type of the queue). Other attributes of queues can be grouped into those that can be changed:

- By the queue manager during the processing of the queue (for example, the current depth of a queue)
- Only by commands (for example, the text description of the queue)
- By applications, using the MQSET call (for example, whether put operations are allowed on the queue)

You can find the values of all the attributes using the MQINQ call.

The attributes that are common to more than one type of queue are:

QName
Name of the queue.

QType
Type of the queue.

QDesc
Text description of the queue.

InhibitGet
Whether programs are allowed to get messages from the queue. However, you can never get messages from remote queues.

InhibitPut
Whether programs are allowed to put messages on the queue.

DefPriority
Default priority for messages put on the queue.

DefPersistence
Default persistence for messages put on the queue

Scope
Controls whether an entry for this queue also exists in a name service.

z/OS The **Scope** attribute is not supported on z/OS

For a full description of these attributes, see Attributes for queues.

Ways of defining queues

You can define queues to IBM MQ by using the MQSC DEFINE command or the PCF Create Queue command. The commands specify the type of queue and its attributes. For example, a local queue object has attributes that specify what happens when applications reference that queue in MQI calls. Examples of attributes are:

- Whether applications can retrieve messages from the queue (GET enabled)
- Whether applications can put messages on the queue (PUT enabled)
- Whether access to the queue is exclusive to one application or shared between applications

- The maximum number of messages that can be stored on the queue at the same time (maximum queue depth)
- The maximum length of messages that can be put on the queue

There are also various platform-specific interfaces that you can use to define queues.

Related concepts

"Cluster queues" on page 57
A cluster queue is a queue that is hosted by a cluster queue manager and made available to other queue managers in the cluster.

"Dead-letter queues" on page 48
The dead-letter queue (or undelivered-message queue) is the queue to which messages are sent if they cannot be routed to their correct destination. Each queue manager typically has a dead-letter queue.

Automating administration using PCF commands

IBM MQ Console: Working with queues

Related tasks

Administering IBM MQ using MQSC commands

Creating and configuring queue managers and objects with MQ Explorer

IBM i Managing IBM MQ for IBM i using CL commands

z/OS Sources from which you can issue MQSC and PCF commands on IBM MQ for z/OS

Related reference

"Comparison between shared queues and cluster queues" on page 57
This information is designed to help you compare shared queues and cluster queues, and decide which might be more suitable for your system.

Related information

"What is a shared queue?" on page 164

Local queues

Transmission, initiation, dead-letter, command, default, channel, and event queues are types of local queue.

A queue is known to a program as *local* if it is owned by the queue manager to which the program is connected. You can get messages from, and put messages on, local queues.

The queue definition object holds the definition information of the queue as well as the physical messages put on the queue.

Each queue manager can have some local queues that it uses for special purposes:

Transmission queues

When an application sends a message to a remote queue, the local queue manager stores the message in a special local queue, called a *transmission queue*. Applications can put messages directly on a transmission queue, or indirectly through a remote queue definition.

When a queue manager sends messages to a remote queue manager, it identifies the transmission queue using the following sequence:

1. The transmission queue named on the XMITQ attribute of the local definition of a remote queue.
2. A transmission queue with the same name as the remote queue manager. This value is the default value on XMITQ of the local definition of a remote queue.
3. The transmission queue named on the DEFXMITQ attribute of the local queue manager.

A *message channel agent* is a channel program is associated with the transmission queue and it delivers the message to its next destination. The next destination is the queue manager to which the message channel is connected. It is not necessarily the same queue manager as the final destination of the message. When the message is delivered to its next destination, it is deleted from the

transmission queue. The message might have to pass through many queue managers on its journey to its final destination. You must define a transmission queue at each queue manager along the route, each holding messages waiting to be transmitted to the next destination. A normal transmission queue holds messages for the next destination, although the messages might have different eventual destinations. A cluster transmission queue holds messages for multiple destinations. The `correlID` of each message identifies the channel that the message is placed on to transfer it to its next destination.

You can define several transmission queues at a queue manager. You might define several transmission queues for the same destination, with each one being used for a different class of service. For example, you might want to create different transmission queues for small messages and large messages going to the same destination. You can then transfer the messages using different messages channels, so that the large messages do not hold up the smaller messages. All messages to cluster queues or cluster topics are placed on the single cluster transmission queue `SYSTEM.CLUSTER.TRANSMIT.QUEUE`, by default. As an option, you can change the default, and separate the message traffic going to different cluster queue managers onto different cluster transmission queues. If you set the queue manager attribute `DEFCLXQ` to `CHANNEL`, each cluster-sender channel creates a separate cluster transmission queue. As an alternative, you can manually define cluster transmission queues for cluster-sender channels to use.

Transmission queues can trigger a message channel agent to send messages onward; see Starting IBM MQ applications using triggers.

z/OS On IBM MQ for z/OS, if you are using intra-group queuing, the transmission queue is serviced by an *intra-group queuing agent*. A shared transmission queue is used when using intra-group queuing on IBM MQ for z/OS.

Initiation queues

An *initiation queue* is a local queue on which the queue manager puts a trigger message when a trigger event occurs on an application queue.

A trigger event is an event that is intended to cause a program to start processing a queue. For example, an event might be more than 10 messages arriving. For more information about how triggering works, see Starting IBM MQ applications using triggers.

Dead-letter (undelivered message) queue

A *dead-letter (undelivered message) queue* is a local queue on which the queue manager puts messages that it cannot deliver.

When the queue manager puts a message on the dead-letter queue, it adds a header to the message. The header information includes the reason that the queue manager put the message on the dead-letter queue. It also contains the destination of the original message, the date, and the time that the queue manager put the message on the dead-letter queue.

Applications can also use the queue for messages that they cannot deliver. For more information, see Using the dead-letter (undelivered message) queue.

System command queue

The *system command queue* is a queue to which suitably authorized applications can send IBM MQ commands. These queues receive the PCF, MQSC, and CL commands, as supported on your platform, in readiness for the queue manager to action them.

z/OS On IBM MQ for z/OS the queue is called `SYSTEM.COMMAND.INPUT` ; on other platforms it is called `SYSTEM.ADMIN.COMMAND.QUEUE`. The commands accepted vary by platform. See Programmable command formats reference for details.

System default queues

The *system default queues* contain the initial definitions of the queues for your system. When you create a queue definition, the queue manager copies the definition from the appropriate system default queue. Creating a queue definition is different from creating a dynamic queue. The definition of the dynamic queue is based upon the model queue you choose as the template for the dynamic queue.

Event queues
Event queues hold event messages. These messages are reported by the queue manager or a channel.

Remote queues

To a program, a queue is *remote* if it is owned by a different queue manager to the one to which the program is connected.

Where a communication link has been established, a program can send a message to a remote queue. A program can never get a message from a remote queue.

The queue definition object, created when you define a remote queue, only holds the information necessary for the local queue manager to locate the queue to which you want your message to go. This object is known as the *local definition of a remote queue*. All the attributes of the remote queue are held by the queue manager that owns it, because it is a local queue to that queue manager.

When opening a remote queue, to identify the queue you must specify either of the following:

- The name of the local definition that defines the remote queue. From the viewpoint of an application, this is the same as opening a local queue. An application does not need to know if a queue is local or remote.

  To create a local definition of a remote queue on all platforms except IBM i, use the DEFINE QREMOTE command.

  IBM i On IBM i, use the CRTMQMQ command.
- The name of the remote queue manager and the name of the queue as it is known to that remote queue manager.

Local definitions of remote queues have three attributes in addition to the common attributes described in “Attributes of queues” on page 20. These three attributes are:

RemoteQName
The name that the queue's owning queue manager knows it by.

RemoteQMgrName
The name of the owning queue manager.

XmitQName
The name of the local transmission queue that is used when forwarding messages to other queue managers.

For more information about these attributes, see Attributes for queues.

If you use the MQINQ call against the local definition of a remote queue, the queue manager returns the attributes of the local definition only, that is the remote queue name, the remote queue manager name, and the transmission queue name, not the attributes of the matching local queue in the remote system.

See also Transmission queues.

Alias queues

An *alias queue* is an IBM MQ object that you can use to access another queue or a topic. This means that more than one program can work with the same queue, accessing it using different names.

The queue resulting from the resolution of an alias name, known as the base queue, can be any of the following types of queues, as supported by the platform:

- A local queue
- The local definition of a remote queue.

- z/OS A shared queue, which is a type of local queue only available on IBM MQ for z/OS.
- A predefined queue
- A dynamic queue

An alias name can also resolve to a topic. If an application currently puts messages onto a queue, it can be made to publish to a topic by making the queue name an alias for the topic. No change to the application code is necessary.

Note: An alias cannot directly resolve to another alias on the same queue manager.

An example of the use of alias queues is for a system administrator to give different access authorities to the base queue name (that is, the queue to which the alias resolves) and to the alias queue name. This means that a program or user can be authorized to use the alias queue, but not the base queue.

Alternatively, authorization can be set to inhibit put operations for the alias name, but allow them for the base queue.

In some applications, the use of alias queues means that system administrators can easily change the definition of an alias queue object without having to get the application changed.

IBM MQ makes authorization checks against the alias name when programs try to use that name. It does not check that the program is authorized to access the name to which the alias resolves. A program can therefore be authorized to access an alias queue name, but not the resolved queue name.

In addition to the general queue attributes described in “Queues” on page 19, alias queues have a **BaseQName** attribute. This is the name of the base queue to which the alias name resolves. For a fuller description of this attribute, see BaseQName (MQCHAR48).

The *InhibitGet* and **InhibitPut** attributes (see “Queues” on page 19) of alias queues belong to the alias name. For example, if the alias-queue name ALIAS1 resolves to the base-queue name BASE, inhibitions on ALIAS1 affect ALIAS1 only and BASE is not inhibited. However, inhibitions on BASE also affect ALIAS1.

The *DefPriority* and **DefPersistence** attributes also belong to the alias name. So, for example, you can assign different default priorities to different aliases of the same base queue. Also, you can change these priorities without having to change the applications that use the aliases.

Dynamic and Model queues

This information provides an insight into dynamic queues, properties of temporary and permanent dynamic queues, uses of dynamic queues, some considerations when using dynamic queues, and model queues.

When an application program issues an MQOPEN call to open a model queue, the queue manager dynamically creates an instance of a local queue with the same attributes as the model queue. Depending on the value of the *DefinitionType* field of the model queue, the queue manager creates either a temporary or permanent dynamic queue (See Creating dynamic queues).

Properties of temporary dynamic queues

Temporary dynamic queues have the following properties:

- z/OS They cannot be shared queues, accessible from queue managers in a queue sharing group.

  Note that queue sharing groups are only available on IBM MQ for z/OS.
- They hold nonpersistent messages only.
- They are unrecoverable.
- They are deleted when the queue manager is started.
- They are deleted when the application that issued the MQOPEN call that created the queue closes the queue or terminates.
  - If there are any committed messages on the queue, they are deleted.

- If there are any uncommitted MQGET, MQPUT, or MQPUT1 calls outstanding against the queue at this time, the queue is marked as being logically deleted, and is only physically deleted (after these calls have been committed) as part of close processing, or when the application terminates.
- If the queue is in use at this time (by the creating, or another application), the queue is marked as being logically deleted, and is only physically deleted when closed by the last application using the queue.
- Attempts to access a logically deleted queue (other than to close it) fail with reason code MQRC_Q_DELETED.
- MQCO_NONE, MQCO_DELETE and MQCO_DELETE_PURGE are all treated as MQCO_NONE when specified on an MQCLOSE call for the corresponding MQOPEN call that created the queue.

Properties of permanent dynamic queues

Permanent dynamic queues have the following properties:

- They hold persistent or nonpersistent messages.
- They are recoverable in the event of system failures.
- They are deleted when an application (not necessarily the one that issued the MQOPEN call that created the queue) successfully closes the queue using the MQCO_DELETE or MQCO_DELETE_PURGE option.
  - A close request with the MQCO_DELETE option fails if there are any messages (committed or uncommitted) still on the queue. A close request with the MQCO_DELETE_PURGE option succeeds even if there are committed messages on the queue (the messages being deleted as part of the close), but fails if there are any uncommitted MQGET, MQPUT, or MQPUT1 calls outstanding against the queue.
  - If the delete request is successful, but the queue happens to be in use (by the creating, or another application), the queue is marked as being logically deleted and is only physically deleted when closed by the last application using the queue.
- They are not deleted if closed by an application that is not authorized to delete the queue, unless the closing application issued the MQOPEN call that created the queue. Authorization checks are performed against the user identifier (or alternate user identifier if MQOO_ALTERNATE_USER_AUTHORITY was specified) that was used to validate the corresponding MQOPEN call.
- They can be deleted in the same way as a normal queue.

Uses of dynamic queues

You can use dynamic queues for:

- Applications that do not require queues to be retained after the application has terminated.
- Applications that require replies to messages to be processed by another application. Such applications can dynamically create a reply-to queue by opening a model queue. For example, a client application can:
  1. Create a dynamic queue.
  2. Supply its name in the **ReplyToQ** field of the message descriptor structure of the request message.
  3. Place the request on a queue being processed by a server.

The server can then place the reply message on the reply-to queue. Finally, the client could process the reply, and close the reply-to queue with the delete option.

Considerations when using dynamic queues

Consider the following points when using dynamic queues:

- In a client-server model, each client must create and use its own dynamic reply-to queue. If a dynamic reply-to queue is shared between more than one client, deleting the reply-to queue might be delayed because there is uncommitted activity outstanding against the queue, or because

the queue is in use by another client. Additionally, the queue might be marked as being logically deleted, and inaccessible for subsequent API requests (other than MQCLOSE).

- If your application environment requires that dynamic queues must be shared between applications, ensure that the queue is only closed (with the delete option) when all activity against the queue has been committed. This should be by the last user. This ensures that deletion of the queue is not delayed, and minimizes the period that the queue is inaccessible because it has been marked as being logically deleted.

Model queues

A *model queue* is a template of a queue definition that you use when creating a dynamic queue.

You can create a local queue dynamically from an IBM MQ program, naming the model queue that you want to use as the template for the queue attributes. At that point you can change some attributes of the new queue. However, you cannot change the **DefinitionType**. If, for example, you require a permanent queue, select a model queue with the definition type set to permanent. Some conversational applications can use dynamic queues to hold replies to their queries because they probably do not need to maintain these queues after they have processed the replies.

You specify the name of a model queue in the *object descriptor* (MQOD) of your MQOPEN call. Using the attributes of the model queue, the queue manager dynamically creates a local queue for you.

You can specify a name (in full) for the dynamic queue, or the stem of a name (for example, ABC) and let the queue manager add a unique part to this, or you can let the queue manager assign a complete unique name for you. If the queue manager assigns the name, it puts it in the MQOD structure.

You cannot issue an MQPUT1 call directly to a model queue , but you can issue an MQPUT1 to the dynamic queue that has been created by opening a model queue.

MQSET and MQINQ cannot be issued against a model queue. Opening a model queue with MQOO_INQUIRE or MQOO_SET results in subsequent MQINQ and MQSET calls being made against the dynamically created queue.

The attributes of a model queue are a subset of those of a local queue. For a fuller description, see Attributes for queues.

Queues used for specific purposes by IBM MQ

IBM MQ uses some local queues for specific purposes related to its operation.

You must define these queues before IBM MQ can use them.

Initiation queues

Initiation queues are queues that are used in triggering. A queue manager puts a trigger message on an initiation queue when a trigger event occurs. A trigger event is a logical combination of conditions that is detected by a queue manager. For example, a trigger event might be generated when the number of messages on a queue reaches a predefined depth. This event causes the queue manager to put a trigger message on a specified initiation queue. This trigger message is retrieved by a *trigger monitor*, a special application that monitors an initiation queue. The trigger monitor then starts the application program that was specified in the trigger message.

If a queue manager is to use triggering, at least one initiation queue must be defined for that queue manager. See Managing objects for triggering, runmqtrm, and Starting IBM MQ applications using triggers

Transmission queues

Transmission queues are queues that temporarily store messages that are destined for a remote queue manager. You must define at least one transmission queue for each remote queue manager to which the local queue manager is to send messages directly. These queues are also used in remote administration; see Remote administration from a local queue manager. For information about the use of transmission queues in distributed queuing, see IBM MQ distributed queuing techniques.

Each queue manager can have a default transmission queue. If a queue manager that is not part of a cluster puts a message onto a remote queue, the default action is to use the default transmission

queue. If there is a transmission queue with the same name as the destination queue manager, the message is placed on that transmission queue. If there is a queue manager alias definition, in which the **RQMNAME** parameter matches the destination queue manager, and the **XMITQ** parameter is specified, the message is placed on the transmission queue named by **XMITQ**. If there is no **XMITQ** parameter, the message is placed on the local queue named in the message.

Cluster transmission queues
Each queue manager within a cluster has a cluster transmission queue called SYSTEM.CLUSTER.TRANSMIT.QUEUE, and a model cluster transmission queue, SYSTEM.CLUSTER.TRANSMIT.MODEL.QUEUE. Definitions of these queues are created by default when you define a queue manager. If the queue manager attribute, **DEFCLXQ**, is set to CHANNEL, a permanent dynamic cluster transmission queue is automatically created for each cluster-sender channel that is created. The queues are called SYSTEM.CLUSTER.TRANSMIT. *ChannelName*. You can also define cluster transmission queues manually.

A queue manager that is part of the cluster sends messages on one of these queues to other queue managers that are in the same cluster.

During name resolution, a cluster transmission queue takes precedence over the default transmission queue, and a specific cluster transmission queue takes precedence over SYSTEM.CLUSTER.TRANSMIT.QUEUE.

Dead-letter queues
A dead-letter (undelivered-message) queue is a queue that stores messages that cannot be routed to their correct destinations. A message cannot be routed when, for example, the destination queue is full. The supplied dead-letter queue is called SYSTEM.DEAD.LETTER.QUEUE.

For distributed queuing, define a dead-letter queue on each queue manager involved.

Command queues
The command queue, SYSTEM.ADMIN.COMMAND.QUEUE, is a local queue to which suitably authorized applications can send MQSC commands for processing. These commands are then retrieved by an IBM MQ component called the command server. The command server validates the commands, passes the valid ones on for processing by the queue manager, and returns any responses to the appropriate reply-to queue.

A command queue is created automatically for each queue manager when that queue manager is created.

Reply-to queues
When an application sends a request message, the application that receives the message can send back a reply message to the sending application. This message is put on a queue, called a reply-to queue, which is normally a local queue to the sending application. The name of the reply-to queue is specified by the sending application as part of the message descriptor.

Event queues
Instrumentation events can be used to monitor queue managers independently of MQI applications.

When an instrumentation event occurs, the queue manager puts an event message on an event queue. This message can then be read by a monitoring application, which might inform an administrator or initiate some remedial action if the event indicates a problem.

Note: Trigger events are different from instrumentation events. Trigger events are not caused by the same conditions, and do not generate event messages.

For more information about instrumentation events, see Instrumentation events.

Queue managers

An introduction to *queue managers* and the queuing services that they provide to applications.

A program must have a connection to a queue manager before it can use the services of that queue manager. A program can make this connection explicitly (using the MQCONN or MQCONNX call), or the

connection might be made implicitly (this depends on the platform and the environment in which the program is running).

An IBM MQ queue manager ensures the following actions:

- Object attributes are changed according to the commands received.
- Special events such as trigger events or instrumentation events are generated when the appropriate conditions are met.
- Messages are put on the correct queue, as requested by the application making the MQPUT call. The application is informed if this cannot be done, and an appropriate reason code is given.

Each queue belongs to a single queue manager and is said to be a *local queue* to that queue manager. The queue manager to which an application is connected is said to be the *local queue manager* for that application. For the application, the queues that belong to its local queue manager are local queues.

A *remote queue* is a queue that belongs to another queue manager. A *remote queue manager* is any queue manager other than the local queue manager. A remote queue manager can exist on a remote machine across the network, or might exist on the same machine as the local queue manager. IBM MQ supports multiple queue managers on the same machine.

A queue manager object can be used in some MQI calls. For example, you can inquire about the attributes of the queue manager object using the MQI call MQINQ.

Attributes of queue managers

Associated with each queue manager is a set of attributes (or properties) that define its characteristics. Some of the attributes of a queue manager are fixed when it is created; you can change others using the IBM MQ commands. You can inquire about the values of all the attributes, except those used for Transport Layer Security (TLS) encryption, using the MQINQ call.

The fixed attributes include:

- The name of the queue manager
- The platform on which the queue manager runs (for example, Windows)
- The level of system control commands that the queue manager supports
- The maximum priority that you can assign to messages processed by the queue manager
- The name of the queue to which programs can send IBM MQ commands
- The maximum length of messages the queue manager can process z/OS (fixed only in IBM MQ for z/OS)
- Whether the queue manager supports syncpointing when programs put and get messages

The *changeable* attributes include:

- A text description of the queue manager
- The identifier of the character set the queue manager uses for character strings when it processes MQI calls
- The time interval that the queue manager uses to restrict the number of trigger messages
- z/OS The time interval that the queue manager uses to determine how often queues are to be scanned for expired messages (IBM MQ for z/OS only)
- The name of the queue manager's dead-letter (undelivered message) queue
- The name of the queue manager's default transmission queue
- The maximum number of open handles for any one connection
- The enabling and disabling of various categories of event reporting
- The maximum number of uncommitted messages within a unit of work

Queue managers and workload management

You can set up a cluster of queue managers that has more than one definition for the same queue (for example, the queue managers in the cluster could be clones of each other). Messages for a particular queue can be handled by any queue manager that hosts an instance of the queue. A workload-management algorithm decides which queue manager handles the message and so spreads the workload between your queue managers; see The cluster workload management algorithm for further information.

Channels

A *channel* is a logical communication link, used by distributed queue managers, between an IBM MQ MQI client and an IBM MQ server, or between two IBM MQ servers.

Channels are used to move messages from one queue manager to another and they shield applications from the underlying communications protocols. The queue managers might exist on the same system, or a different systems on the same platform, or on different platforms. The messages that are sent can originate from many places:

- User-written application programs that transfer data from one node to another.
- User-written administration applications that use PCF commands or the MQAI.
- The IBM MQ Explorer.
- Queue managers that send instrumentation event messages to another queue manager.
- Queue managers that send remote administration commands to another queue manager. For example, using MQSC commands or the administrative REST API.

A channel has two definitions: one at each end of the connection. For queue managers to communicate with one another, you must define one channel object at the queue manager that is to send messages, and another, complementary one, at the queue manager that is to receive them. The same *channel name* must be used at each end of the connection, and the *channel type* used must be compatible.

There are three categories of channel in IBM MQ, with different channel types within these categories:

- Message channels, which are unidirectional, and transfer messages from one queue manager to another.
- MQI channels, which are bidirectional, and transfer MQI calls from an IBM MQ MQI client to a queue manager, and responses from a queue manager to an IBM MQ client.
- AMQP channels, which are bidirectional and connect an AMQP client to a queue manager on a server machine. IBM MQ uses AMQP channels to transfer AMQP calls and responses between AMQP applications and queue managers

Message channels

The purpose of a message channel is to transfer messages from one queue manager to another. Message channels are not required by the client server environment.

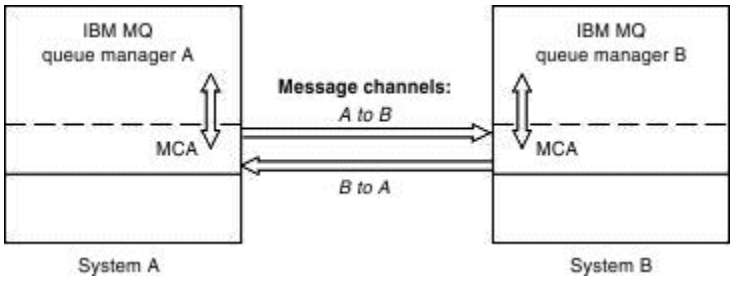


Figure 2. Message channels between two queue managers

A message channel is a one-way link. If you want a remote queue manager to respond to messages sent by a local queue manager, you must set up a second channel to send responses back to the local queue manager.

A message channel connects two queue managers by using *message channel agents* (MCAs). There is a message channel agent at each end of a channel. You can allow an MCA to transfer messages using multiple threads. This process is known as *pipelining*. Pipelining enables the MCA to transfer messages more efficiently, improving channel performance. For more information about pipelining, see Attributes of channels.

For more information about channels, see Channel-exit calls and data structures, and "Distributed queuing components" on page 45.

MQI channels

A Message Queue Interface (MQI) channel connects an IBM MQ MQI client to a queue manager on a server machine, and is established when you issue an MQCONN or MQCONNX call from an IBM MQ MQI client application.

It is a two-way link and is used for the transfer of MQI calls and responses only, including MQPUT calls that contain message data and MQGET calls that result in the return of message data. There are different ways of creating and using the channel definitions (see Defining MQI channels).

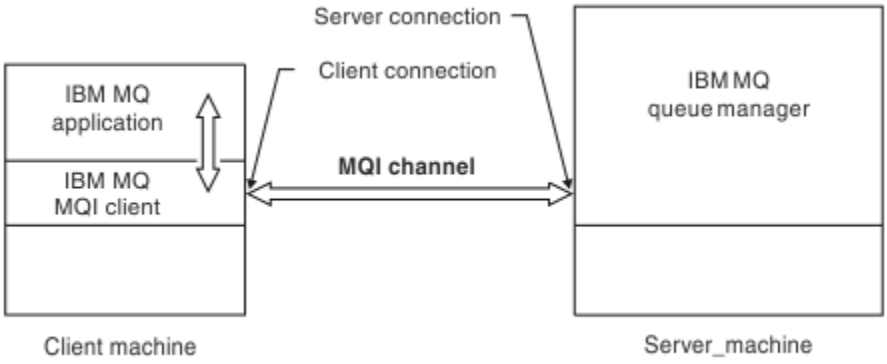


Figure 3. Client-connection and server-connection on an MQI channel

z/OS An MQI channel can be used to connect a client to a single queue manager, or to a queue manager that is part of a queue sharing group (see Connecting a client to a queue sharing group).

There are two channel types for MQI channel definitions. They define the bi-directional MQI channel.

Client-connection channel
This type is for the IBM MQ MQI client.

Server-connection channel
This type is for the server running the queue manager, with which the IBM MQ application, running in an IBM MQ MQI client environment, is to communicate.

AMQP channels

Multi

There is only one type of AMQP channel.

You use the channel to connect an AMQP messaging application with a queue manager, enabling the application to exchange messages with IBM MQ applications. An AMQP channel allows you to develop an application using MQ Light, and then deploy it as an enterprise application, taking advantage of the enterprise-level facilities provided by IBM MQ.

Client connection channels

Client connection channels are objects that provide a communication path from an IBM MQ MQI client to a queue manager.

Client connection channels are used in distributed queuing to move messages between a queue manager and a client. They shield applications from the underlying communications protocols. The client might exist on the same, or different, platform from the queue manager.

Channel definitions

See “Channel definitions” on page 31 for descriptions of each type of channel.

Related concepts

“Distributed queuing and clusters” on page 41
Distributed queuing means sending messages from one queue manager to another. The receiving queue manager can be on the same machine or another; nearby or on the other side of the world. It can be running on the same platform as the local queue manager, or can be on any of the platforms supported by IBM MQ. You can manually define all the connections in a distributed queuing environment, or you can create a cluster and let IBM MQ define much of the connection detail for you.

Message Queue Interface overview

Related tasks

Administering remote IBM MQ objects

Stopping MQI channels

Configuring connections between the server and client

Related reference

Channel-exit calls and data structures

“Communications” on page 34
IBM MQ MQI clients use MQI channels to communicate with the server.

Channel definitions

Tables describing the different types of message channels and MQI channels that IBM MQ uses.

When referring to message channels, the word channel is often used as a synonym for a channel definition. It is usually clear from the context whether we are talking about a complete channel, which has two ends, or a channel definition, which has only one end.

Message channels

Message channel definitions can be one of the following types:

Message channel definition type	Description
Sender	A sender channel is a message channel that the queue manager uses to send messages to other queue managers. To send messages using a sender channel, you must also create, on the other queue manager, a receiver channel with the same name as the sender channel. You can also use sender channels with requester channels if you are implementing a "callback" mechanism.

Message channel definition type	Description
Server	A server channel is a message channel that the queue manager uses to send messages to other queue managers. To send messages using a server channel, you must also create, on the other queue manager, a receiver channel with the same name as the server channel. You can also use server channels with requester channels. In that case, the requester channel definition at the other end of the channel requests the server channel definition to start. The server sends messages to the requester. The server can also initiate the communication as long as the server knows the connection name of the partner channel.
Receiver	A receiver channel is a message channel that the queue manager uses to receive messages from other queue managers. To receive messages using a receiver channel, you must also create, on the other queue manager, a sender or a server channel with the same name as this receiver channel.
Requester	A Requester channel is a message channel that the queue manager uses to receive messages from other queue managers. A Requester channel can request the partner channel defined at the remote end to start. If the partner channel is a Server channel, the Server channel accepts the start request and starts to send messages, from the transmission queue identified in the Server channel definition, to the Requester channel. If the partner channel is a Sender channel, the Sender channel accepts the start request but then closes the connection with the Requester. The Sender channel then starts, negotiates a session with the partner Requester channel and starts to send messages from the transmission queue identified in the Sender channel definition. This latter case essentially provides for a call back mechanism in that the Requester channel requests the Sender channel to call back.
Cluster-sender	A cluster-sender (CLUSSDR) channel definition defines the sending end of a channel on which a cluster queue manager can send cluster information to one of the full repositories. The cluster-sender channel is used to notify the repository of any changes to the queue manager's status, for example the addition or removal of a queue. It is also used to transmit messages. The full repository queue managers themselves have cluster-sender channels that point to each other. They use them to communicate cluster status changes to each other. It is of little importance which full repository a queue manager's CLUSSDR channel definition points to. After the initial contact has been made, further cluster queue manager objects are defined automatically as required so that the queue manager can send cluster information to every full repository, and messages to every queue manager.

Message channel definition type	Description
Cluster-receiver	A cluster-receiver (CLUSRCVR) channel definition defines the receiving end of a channel on which a cluster queue manager can receive messages from other queue managers in the cluster. A cluster-receiver channel can also carry information about the cluster-information destined for the repository. By defining the cluster-receiver channel, the queue manager indicates to the other cluster queue managers that it is available to receive messages. You need at least one cluster-receiver channel for each cluster queue manager.

For each channel you must define both ends so that you have a channel definition for each end of the channel. The two ends of the channel must be compatible types.

You can have the following combinations of channel definitions:

- Sender-Receiver
- Server-Receiver
- Requester-Server
- Requester-Sender (callback)
- Cluster-sender-Cluster-receiver

Message channel agents

Each channel definition that you create belongs to a particular queue manager. A queue manager can have several channels of the same or different types. At each end of the channel is a program, the message channel agent (MCA). At one end of the channel, the caller MCA takes messages from the transmission queue and sends them through the channel. At the other end of the channel, the responder MCA receives the messages and delivers them to the remote queue manager.

A caller MCA can be associated with a sender, server, or requester channel. A responder MCA can be associated with any type of message channel.

IBM MQ supports the following combinations of channel types at the two ends of a connection:

Caller		Direction of message flow	Responder	
Channel type	**Listener required?**		**Listener required?**	**Channel type**
Sender	No	Caller to Responder	Yes	Receiver
Server	No	Caller to Responder	Yes	Receiver
Server	No	Caller to Responder	Yes	Requester
Requester	No	Responder to Caller	Yes	Server
Requester	Yes	Responder to Caller	Yes	Sender

MQI channels

MQI channels can be one of the following types:

MQI channel type	Description
Server connection	A server connection channel is a bidirectional MQI channel that is used to connect an IBM MQ client to an IBM MQ server. The server connection channel is the server end of the channel.
Client connection	A client connection channel is a bidirectional MQI channel that is used to connect an IBM MQ client to an IBM MQ server. IBM MQ Explorer also uses client connections to connect to remote queue managers. The client connection channel is the client end of the channel. When you create a client-connection channel, a file is created on the computer that hosts the queue manager. You must then copy the client-connection file to the IBM MQ client computer.

Multi *Multiple thread support - pipelining*

You can optionally allow a message channel agent (MCA) to transfer messages using multiple threads. This process, called *pipelining*, enables the MCA to transfer messages more efficiently, with fewer wait states, which improves channel performance. Each MCA is limited to a maximum of two threads.

You control pipelining with the *PipeLineLength* parameter in the qm.ini file. This parameter is added to the Channels stanza.

Note: Pipelining is effective only for TCP/IP channels.

When you use pipelining, the queue managers at both ends of the channel must be configured to have a *PipeLineLength* greater than 1.

Channel exit considerations

Pipelining can cause some exit programs to fail, because:

- Exits might not be called serially.
- Exits might be called alternately from different threads.

Check the design of your exit programs before you use pipelining:

- Exits must be reentrant at all stages of their execution.
- When you use MQI calls, remember that you cannot use the same MQI handle when the exit is invoked from different threads.

Consider a message exit that opens a queue and uses its handle for MQPUT calls on all subsequent invocations of the exit. This fails in pipelining mode because the exit is called from different threads. To avoid this failure, keep a queue handle for each thread and check the thread identifier each time the exit is invoked.

Communications

IBM MQ MQI clients use MQI channels to communicate with the server.

A channel definition must be created at both the IBM MQ MQI client and server ends of the connection. How to create channel definitions is explained in Defining MQI channels.

The transmission protocols possible are shown in the following table:

Table 1. Transmission protocols for MQI channels

Client platform	LU 6.2	TCP/IP	NetBIOS	SPX
IBM i IBM i		Yes		

Table 1. Transmission protocols for MQI channels (continued)				
Client platform	**LU 6.2**	**TCP/IP**	**NetBIOS**	**SPX**
Linux AIX AIX and Linux systems	Yes [1]	Yes		
Windows Windows	Yes	Yes	Yes	Yes

Note:

1. Linux LU6.2 is not supported on the following platforms:
   - Linux (POWER platform)
   - Linux (x86-64 platform)
   - Linux (zSeries s390x platform)

Transmission protocols - combination of IBM MQ MQI client and server platforms shows the possible combinations of IBM MQ MQI client and server platforms, using these transmission protocols.

An IBM MQ application on an IBM MQ MQI client can use all the MQI calls in the same way as when the queue manager is local. **MQCONN** or **MQCONNX** associates the IBM MQ application with the selected queue manager, creating a *connection handle*. Other calls using that connection handle are then processed by the connected queue manager. IBM MQ MQI client communication requires an active connection between the client and server, in contrast to communication between queue managers, which is connection-independent and time-independent.

The transmission protocol is specified by using the channel definition and does not affect the application. For example, a Windows application can connect to one queue manager over TCP/IP and to another queue manager over NetBIOS.

Performance considerations

The transmission protocol you use might affect the performance of the IBM MQ client and server system. In certain situations where transmission is slow, you can use IBM MQ channel compression.

Naming IBM MQ objects

The naming convention adopted for IBM MQ objects depends on the object. The name of the machines and the user IDs that you use with IBM MQ are also subject to some naming restrictions.

Each instance of a queue manager is known by its name. This name must be unique within the network of interconnected queue managers, so that one queue manager can unambiguously identify the target queue manager to which any given message is sent.

For the other types of object, each object has a name associated with it and can be referred to by that name. These names must be unique within one queue manager and object type. For example, you can have a queue and a process with the same name, but you cannot have two queues with the same name.

In IBM MQ, names can have a maximum of 48 characters, with the exception of *channels* which have a maximum of 20 characters. For more information about naming IBM MQ objects, see “Rules for naming IBM MQ objects” on page 36.

The name of the machines and the user IDs that you use with IBM MQ are also subject to some naming restrictions:

- Ensure that the machine name does not contain any spaces. IBM MQ does not support machine names that include spaces. If you install IBM MQ on such a machine, you cannot create any queue managers.
- For IBM MQ authorizations, names of user IDs and groups must be no longer than 20 characters (spaces are not allowed).

- Windows An IBM MQ for Windows server does not support the connection of an IBM MQI client if the client is running under a user ID that contains the @ character, for example, abc@d.

Related concepts

"IBM MQ file names" on page 39
Each IBM MQ queue manager, queue, process definition, namelist, channel, client connection channel, listener, service, and authentication information object is represented by a file. Because object names are not necessarily valid file names, the queue manager converts the object name into a valid file name where necessary.

Related reference

"Rules for naming IBM MQ objects" on page 36
IBM MQ object names have maximum lengths and are case-sensitive. Not all characters are supported for every object type, and many objects have rules concerning the uniqueness of names.

Rules for naming IBM MQ objects

IBM MQ object names have maximum lengths and are case-sensitive. Not all characters are supported for every object type, and many objects have rules concerning the uniqueness of names.

There are many different types of IBM MQ object, and objects from each type can all have the same name because they exist in separate object namespaces: For example, a local queue and a sender channel can both have the same name. However, an object cannot have the same name as another object in the same namespace: For example, a local queue cannot have the same name as a model queue, and a sender channel cannot have the same name as a receiver channel.

The following IBM MQ objects exist in separate object namespaces:

- Authentication information
- Channel
- Client channel
- Listener
- Namelist
- Process
- Queue
- Service
- Storage class
- Subscription
- Topic

Character length of object names

In general, IBM MQ object names can be up to 48 characters long. This rule applies to the following objects:

- Authentication information
- Cluster
- Listener
- Namelist
- Process definition
- Queue
- Queue manager
- Service
- Subscription

- Topic

There are restrictions:

1. z/OS On z/OS systems, queue managers must be a maximum of 4 characters, and must be in uppercase characters and numeric characters only.
2. The maximum length of channel object names and client connection channel names is 20 characters. See Defining the channels for more information about channels.
3. Topic strings can be a maximum of 10240 bytes. All IBM MQ object names are case-sensitive.
4. Subscription names can be a maximum of 10240 bytes, and can contain spaces.
5. The maximum length of storage class names is 8 characters.
6. The maximum length of CF structure names is 12 characters.

Characters in object names

The valid characters for IBM MQ object names are:

Characters	Restrictions
Uppercase A - Z	• None
Lowercase a - z	• In MQSC scripts, names with lowercase characters must be enclosed in single quotation marks. This prevents the lowercase characters being folded into uppercase. • Systems using EBCDIC Katakana cannot use lowercase a- z characters in object names. • z/OS There might be restrictions when using lowercase characters on z/OS systems, for example, queue manager names cannot contain lowercase characters. • IBM i On IBM i systems when using CL commands, names with lowercase characters must be enclosed in single quotation marks. This prevents the lowercase characters being folded into uppercase.
Numerics 0 - 9	• None
Period (.)	• None
Underscore (_)	• Multi None • z/OS Avoid using names with leading or trailing underscores because they cannot be handled by the IBM MQ for z/OS operations and control panels.

Characters	Restrictions
Forward slash (/)	• Windows On Windows systems, the first character of a queue manager name cannot be a forward slash. • IBM i On IBM i systems when using CL commands, names containing a forward slash must be enclosed in single quotation marks. • z/OS None
Percent sign (%)	• ALW None • z/OS If you are using RACF® as the external security manager for IBM MQ for z/OS, do not use % in object names because the names are not included in security checks when RACF generic profiles are used. • IBM i On IBM i systems when using CL commands, names containing a percent sign must be enclosed in single quotation marks.

There are also some general rules concerning characters on object names:

1. Leading or embedded blanks are not allowed.
2. National language characters are not allowed.
3. Any name that is less than the full field length can be padded to the right with blanks. All short names that are returned by the queue manager are always padded to the right with blanks.

Queue names

The name of a queue has two parts:

- The name of a queue manager
- The local name of the queue as it is known to that queue manager

Each part of the queue name is 48 characters long.

To refer to a local queue, you can omit the name of the queue manager (by replacing it with blank characters or using a leading null character). However, all queue names returned to a program by IBM MQ contain the name of the queue manager.

z/OS A shared queue, accessible to any queue manager in its queue sharing group, cannot have the same name as any non-shared local queue in the same queue sharing group. This restriction avoids the possibility of an application mistakenly opening a shared queue when it intended to open a local queue, or vice versa. Shared queues and queue sharing groups are only available on IBM MQ for z/OS.

To refer to a remote queue, a program must include the name of the queue manager in the full queue name, or there must be a local definition of the remote queue.

When an application uses a queue name, that name can be either the name of a local queue (or an alias to one) or the name of a local definition of a remote queue, but the application does not need to know which, unless it needs to get a message from the queue (when the queue must be local). When the application opens the queue object, the MQOPEN call performs a name resolution function to determine on which queue to perform subsequent operations. The significance of this is that the application has no built-in dependency on particular queues being defined at particular locations in

a network of queue managers. Therefore, if a system administrator relocates queues in the network, and changes their definitions, the applications that use those queues do not need to be changed.

Reserved object names

Object names that start with SYSTEM. are reserved for objects defined by the queue manager. You can use the **Alter**, **Define**, and **Replace** commands to change these object definitions to suit your installation. The names that are defined for IBM MQ are listed in full in Queue names.

z/OS On IBM MQ for z/OS, the coupling facility application structure name CSQSYSAPPL is reserved.

Related concepts

Installation name on AIX, Linux, and Windows

IBM MQ file names

Each IBM MQ queue manager, queue, process definition, namelist, channel, client connection channel, listener, service, and authentication information object is represented by a file. Because object names are not necessarily valid file names, the queue manager converts the object name into a valid file name where necessary.

The default path to a queue manager directory is as follows:

- A prefix, which is defined in the IBM MQ configuration information:
  - Linux AIX On AIX and Linux, the default prefix is `/var/mqm`. This is configured in the `DefaultPrefix` stanza of the mqs.ini configuration file.
  - Windows On Windows 32-bit systems, the default prefix is `C:\Program Files (x86)\IBM\WebSphere MQ`. On Windows 64-bit systems, the default prefix is `C:\Program Files\IBM\MQ`. For both 32-bit and 64-bit installations, the data directories are installed into `C:\ProgramData\IBM\MQ`. This is configured in the `DefaultPrefix` stanza of the mqs.ini configuration file.

  Where available, the prefix can be changed using the IBM MQ properties page in the IBM MQ Explorer, otherwise edit the `mqs.ini` configuration file manually.
- The queue manager name is transformed into a valid directory name. For example, the queue manager:

  ```
  queue.manager
  ```

  would be represented as:

  ```
  queue!manager
  ```

  This process is referred to as *name transformation*.

In IBM MQ, you can give a queue manager a name containing up to 48 characters.

For example, you could name a queue manager:

```
QUEUE.MANAGER.ACCOUNTING.SERVICES
```

However, each queue manager is represented by a file and there are limitations on the maximum length of a file name, and on the characters that can be used in the name. As a result, the names of files representing objects are automatically transformed to meet the requirements of the file system.

The rules governing the transformation of a queue manager name are as follows:

1. Transform individual characters:

- From . to !
- From / to &

2. If the name is still not valid:
   a. Truncate it to eight characters
   b. Append a three-character numeric suffix

For example, assuming the default prefix and a queue manager with the name `queue.manager`:

- Windows On Windows with NTFS or FAT32, the queue manager name becomes:

```
C:\Program Files\IBM\MQ\qmgrs\queue!manager
```

- Windows On Windows with FAT, the queue manager name becomes:

```
C:\Program Files\IBM\MQ\qmgrs\queue!ma
```

- Linux AIX On AIX and Linux, the queue manager name becomes:

```
/var/mqm/qmgrs/queue!manager
```

The transformation algorithm also distinguishes between names that differ only in case on file systems that are not case sensitive.

Object name transformation

Object names are not necessarily valid file system names. You might need to transform your object names. The method used is different from that for queue manager names because, although there are only a few queue manager names on each machine, there can be a large number of other objects for each queue manager. Queues, process definitions, namelists, channels, client connection channels, listeners, services, and authentication information objects are represented in the file system.

When a new name is generated by the transformation process, there is no simple relationship with the original object name. You can use the **dspmqfls** command to convert between real and transformed object names.

Related reference
dspmqfls (display file names)
Related information
AllQueueManagers stanza of the mqs.ini file

IBM i Object names on IBM i

A queue manager has an associated queue manager library that has a unique name. Queue manager names and object names might need to be transformed to meet the requirements of the IBM i Integrated File System (IFS).

When a queue manager is created, IBM MQ associates a queue manager library with it. This queue manager library is given a unique name, no more than 10 characters long, largely based on the user defined queue manager name. Both the queue manager, and the queue manager library are placed in to a directory that is also based on the queue manager name with the prefix `/QIBM/UserData/mqm`. An example of a queue manager, queue manager library, and directory follows:

Queue manager name	ORANGE
Queue manager library name	QMORANGE

Directory	/QIBM/UserData/mqm/ORANGE

All queue manager names and queue manager library names are written to stanzas in the file /QIBM/UserData/mqm/mqs.ini.

IBM MQ IFS directories and files

The IBM i Integrated File System (IFS) is used extensively by IBM MQ to store data. For more information about the IFS see the *Integrated File System Introduction*.

Each IBM MQ object, for example, a channel or a queue manager, is represented by a file. Because object names are not necessarily valid file names, the queue manager converts the object name into a valid file name where necessary.

The path to a queue manager directory is formed from the following:

- A prefix, which is defined in the queue manager configuration file, qm.ini. The default prefix is /QIBM/UserData/mqm.
- A literal, qmgrs.
- A coded queue manager name, which is the queue manager name transformed into a valid directory name. For example, the queue manager queue/manager is represented by queue&manager.

This process is referred to as name transformation.

IFS queue manager name transformation

In IBM MQ, you can give a queue manager a name containing up to 48 characters.

For example, you can name a queue manager QUEUE/MANAGER/ACCOUNTING/SERVICES. In the same way that a library is created for each queue manager, each queue manager is also represented by a file. Because of variant codepoints in EBCDIC, there are limitations to the characters that can be used in the name. As a result, the names of IFS files representing objects are automatically transformed to meet the requirements of the file system.

Using the example of a queue manager with the name queue/manager, transforming the character / to &, and assuming the default prefix, the queue manager name in IBM MQ for IBM i becomes /QIBM/UserData/mqm/qmgrs/queue&manager.

Object name transformation

Object names are not necessarily valid file system names, so the object names might need to be transformed. The method used is different from that for queue manager names because, although there only a few queue manager names for each machine, there can be a large number of other objects for each queue manager. Only process definitions, queues, and namelists are represented in the file system; channels are not affected by these considerations.

When a new name is generated by the transformation process, there is no simple relationship with the original object name. You can use the DSPMQMOBJN command to view the transformed names for IBM MQ objects.

Distributed queuing and clusters

Distributed queuing means sending messages from one queue manager to another. The receiving queue manager can be on the same machine or another; nearby or on the other side of the world. It can be running on the same platform as the local queue manager, or can be on any of the platforms supported by IBM MQ. You can manually define all the connections in a distributed queuing environment, or you can create a cluster and let IBM MQ define much of the connection detail for you.

Distributed queuing

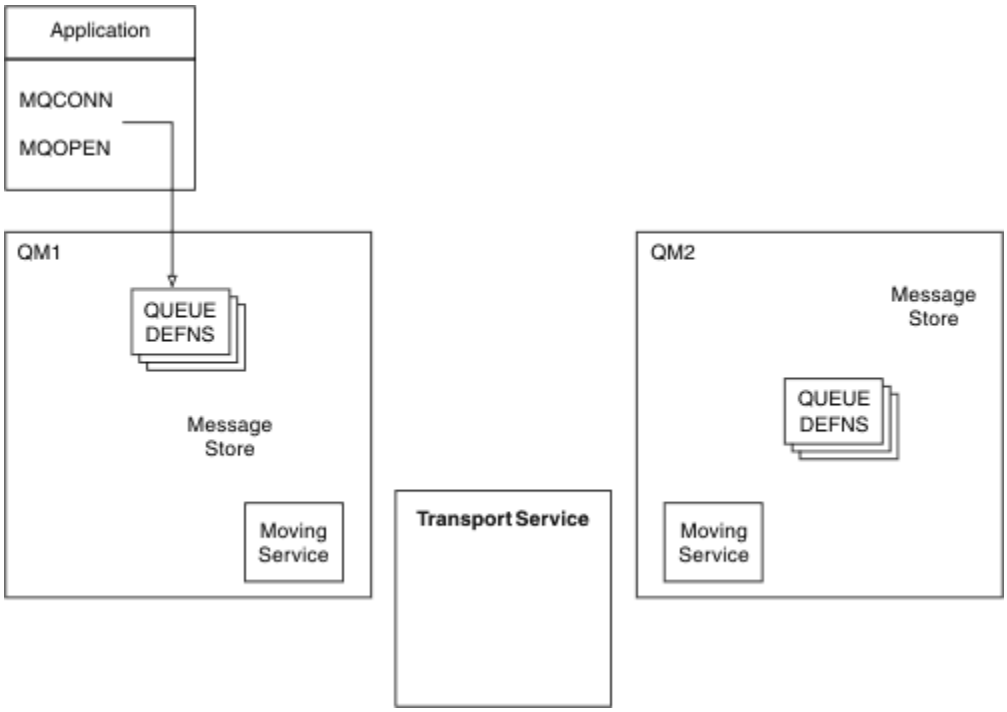


Figure 4. Overview of the components of distributed queuing

In the previous figure:

- An application uses the MQCONN call to connect to a queue manager. The application then uses the MQOPEN call to open a queue so that it can put messages on the queue.
- Each queue manager has a definition for each of its queues. It can have definitions of *local queues* (that is, hosted by this queue manager) , and definitions of *remote queues* (that is, hosted by other queue managers).
- If the messages are destined for a remote queue, the local queue manager holds them on a *transmission queue*, which persists them in a message store, until they can be forwarded to the remote queue manager.
- Each queue manager contains communications software, known as the *moving service*, that the queue manager uses to communicate with other queue managers.
- The *transport service* is independent of the queue manager and can be any one of the following (depending on the platform):
  - Systems Network Architecture Advanced Program-to Program Communication (SNA APPC)
  - Transmission Control Protocol/Internet Protocol (TCP/IP)
  - Network Basic Input/Output System (NetBIOS)
  - Sequenced Packet Exchange (SPX)

Components needed to send a message

If a message is to be sent to a remote queue manager, the local queue manager needs definitions for a *transmission queue* and a *channel*. A channel is a one-way communication link between two queue managers. It can carry messages destined for any number of queues at the remote queue manager.

Each end of a channel has a separate definition, defining it, for example, as the sending end or the receiving end. A simple channel consists of a *sender* channel definition at the local queue manager and a *receiver* channel definition at the remote queue manager. These two definitions must have the same name, and together they constitute one channel.

The software that handles the sending and receiving of messages is called the *Message Channel Agent* (MCA). There is a *message channel agent* (MCA) at each end of a channel.

Each queue manager should have a *dead-letter queue* (also known as the *undelivered message queue*). Messages are put on this queue if they cannot be delivered to their destination.

The following figure shows the relationship between queue managers, transmission queues, channels, and MCAs:

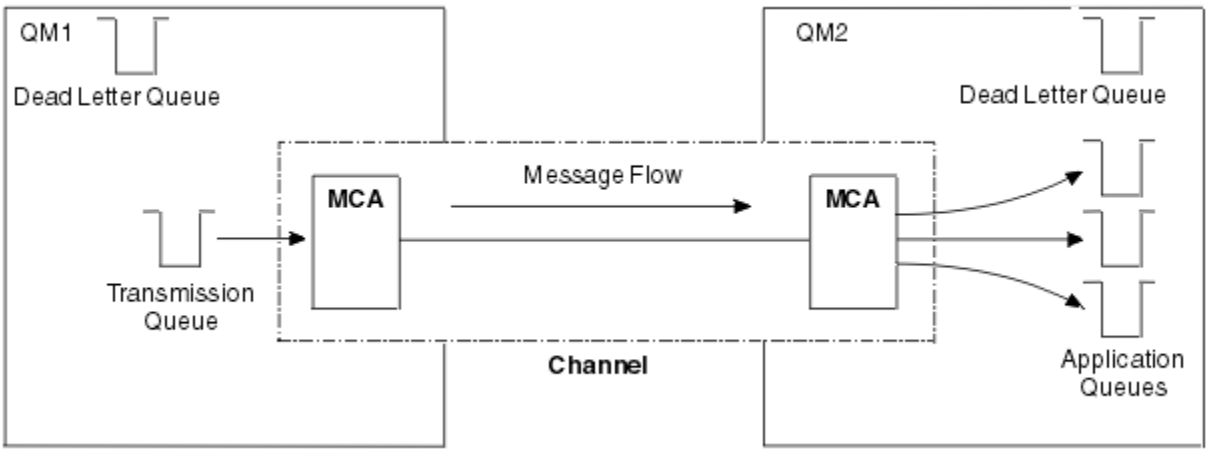


Figure 5. Sending messages

Components needed to return a message

If your application requires messages to be returned from the remote queue manager, you need to define another channel, to run in the opposite direction between the queue managers, as shown in the following figure:

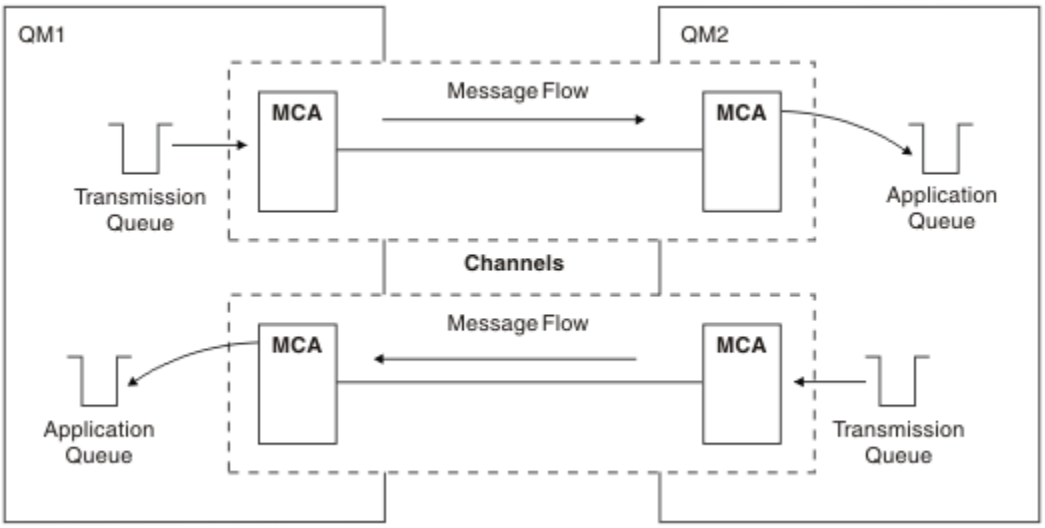


Figure 6. Sending messages in both directions

Clusters

Rather than manually defining all the connections in a distributed queuing environment, you can group a set of queue managers in a cluster. When you do this, the queue managers can make the queues that they host available to other queue managers in the cluster without the need for explicit channel definitions, remote-queue definitions, or transmission queues for each destination. Every queue manager in a cluster has a single transmission queue that transmits messages to any other queue manager in the cluster.

For each queue manager, you only need to define one cluster-receiver channel and one cluster-sender channel; any additional channels are automatically managed by the cluster.

An IBM MQ client can connect to a queue manager that is part of a cluster, just as it can connect to any other queue manager. As with manually-configured distributed queuing, you use the MQPUT call to put a message to a queue at any queue manager. You use the MQGET call to retrieve messages from a local queue.

Queue managers on platforms that support clusters do not have to be part of a cluster. You can continue to manually configure distributed queuing as well as, or instead of, using clusters.

Benefits of using clusters

Clustering provides two key benefits:

- Clusters simplify the administration of IBM MQ networks, which usually require many object definitions for channels, transmit queues, and remote queues to be configured. This situation is especially true in large, potentially changing, networks where many queue managers need to be interconnected. This architecture is particularly hard to configure and actively maintain.
- Clusters can be used to distribute the workload of message traffic across queues and queue managers in the cluster. Such distribution allows the message workload of a single queue to be distributed across equivalent instances of that queue located on multiple queue managers. This distribution of the workload can be used to achieve greater resilience to system failures, and to improve the scaling performance of particularly active message flows in a system. In such an environment, each of the instances of the distributed queues have consuming applications processing the messages. For more information, see Using clusters for workload management.

How messages are routed in a cluster

You can think of a cluster as a network of queue managers maintained by a conscientious systems administrator. Whenever you define a cluster queue, the systems administrator automatically creates corresponding remote-queue definitions as needed on the other queue managers.

You do not need to make transmission queue definitions because IBM MQ provides a transmission queue on each queue manager in the cluster. This single transmission queue can be used to carry messages to any other queue manager in the cluster. You are not limited to using a single transmission queue. A queue manager can use multiple transmission queues to separate the messages going to each queue manager in a cluster. Typically, a queue manager uses a single cluster transmission queue. You can change the queue manager attribute DEFCLXQ, so that a queue manager uses a different cluster transmission queue for each queue manager in a cluster. You can also define cluster transmission queues manually.

All the queue managers that join a cluster agree to work in this way. They send out information about themselves and about the queues they host, and they receive information about the other members of the cluster.

To ensure that no information is lost when a queue manager becomes unavailable, you specify two queue managers in the cluster to act as *full repositories*. These queue managers store a full set of information about all the queue managers and queues in the cluster. All other queue managers in the cluster only store information about those queue managers and queues with which they exchange messages. These queue managers are known as *partial repositories*. For more information, see “Cluster repository” on page 55.

In order to become part of a cluster, a queue manager must have two channels; a cluster-sender channel and a cluster-receiver channel:

- A cluster-sender channel is a communication channel like a sender channel. You must manually create one cluster-sender channel on a queue manager to connect it to a full repository that is already a member of the cluster.
- A cluster-receiver channel is a communication channel like a receiver channel. You must manually create one cluster-receiver channel. The channel acts as the mechanism for the queue manager to receive cluster communications.

All other channels that are needed for communication between this queue manager and other members of the cluster are then created automatically.

The following figure shows the components of a cluster called CLUSTER:

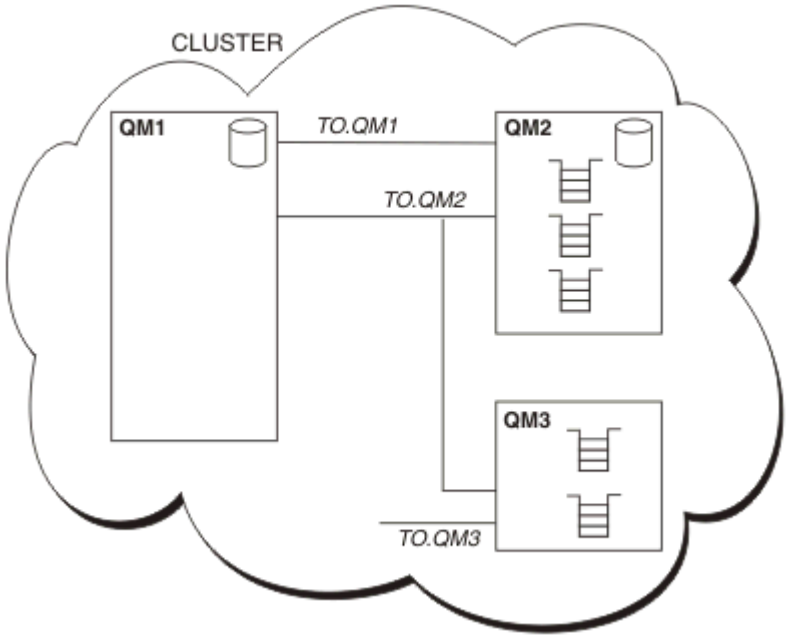


Figure 7. A cluster of queue managers

- CLUSTER contains three queue managers, QM1, QM2, and QM3.
- QM1 and QM2 host full repositories of information about the queue managers and queues in the cluster.
- QM2 and QM3 host some cluster queues, that is, queues that are accessible to any other queue manager in the cluster.
- Each queue manager has a cluster-receiver channel called TO.qmgr on which it can receive messages.
- Each queue manager also has a cluster-sender channel on which it can send information to one of the repository queue managers.
- QM1 and QM3 send to the repository at QM2 and QM2 sends to the repository at QM1.

Distributed queuing components

The components of distributed queuing are message channels, message channel agents, transmission queues, channel initiators and listeners, and channel-exit programs. The definition of each end of a message channel can be one of several types.

Message channels are the channels that carry messages from one queue manager to another. Do not confuse message channels with MQI channels. There are two types of MQI channel, server-connection (SVRCONN) and client-connection (CLNTCONN) . For more information, see Channels.

The definition of each end of a message channel can be one of the following types:

- Sender (SDR)
- Receiver (RCVR)
- Server (SVR)
- Requester (RQSTR)
- Cluster sender (CLUSSDR)
- Cluster receiver (CLUSRCVR)

A message channel is defined using one of these types defined at one end, and a compatible type at the other end. Possible combinations are:

- Sender-receiver
- Requester-server
- Requester-sender (callback)
- Server-receiver
- Cluster sender-cluster receiver

Detailed instructions for creating a sender-receiver channel are included in Defining the channels. For examples of the parameters needed to set up sender-receiver channels, see Example configuration information applicable to your platform. For the parameters needed to define a channel of any type, see DEFINE CHANNEL.

Sender-receiver channels

A sender in one system starts the channel so that it can send messages to the other system. The sender requests the receiver at the other end of the channel to start. The sender sends messages from its transmission queue to the receiver. The receiver puts the messages on the destination queue. Figure 8 on page 46 illustrates this.

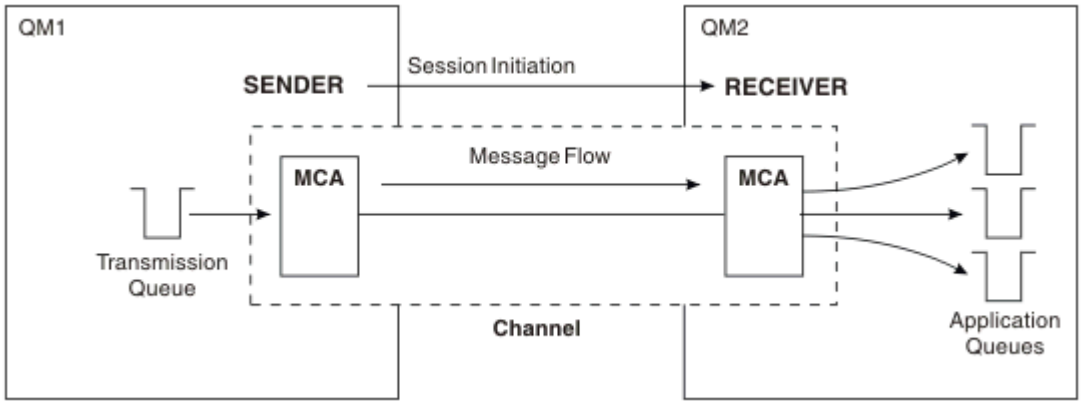


Figure 8. A sender-receiver channel

Requester-server channels

A requester in one system starts the channel so that it can receive messages from the other system. The requester requests the server at the other end of the channel to start. The server sends messages to the requester from the transmission queue defined in its channel definition.

A server channel can also initiate the communication and send messages to a requester. This applies only to *fully qualified* servers, that is server channels that have the connection name of the partner specified in the channel definition. A fully qualified server can either be started by a requester, or can initiate a communication with a requester.

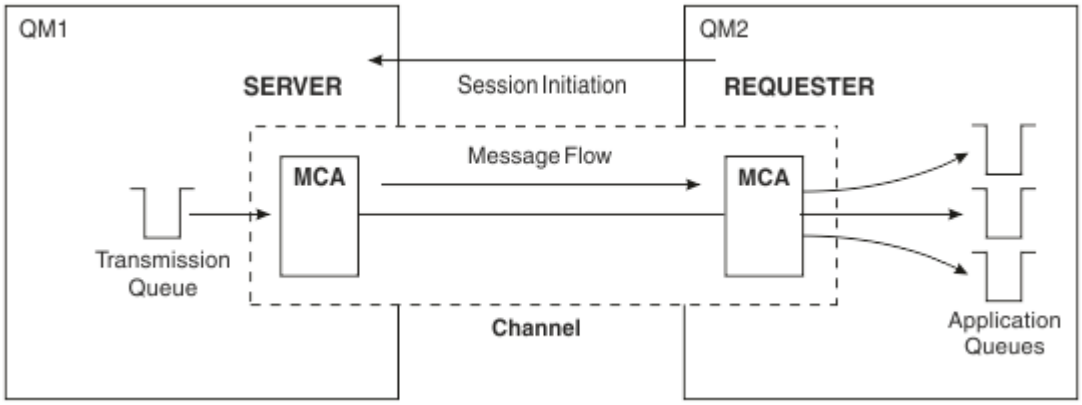


Figure 9. A requester-server channel

Requester-sender channels

The requester starts the channel and the sender terminates the call. The sender then restarts the communication according to information in its channel definition (known as *callback*). It sends messages from the transmission queue to the requester.

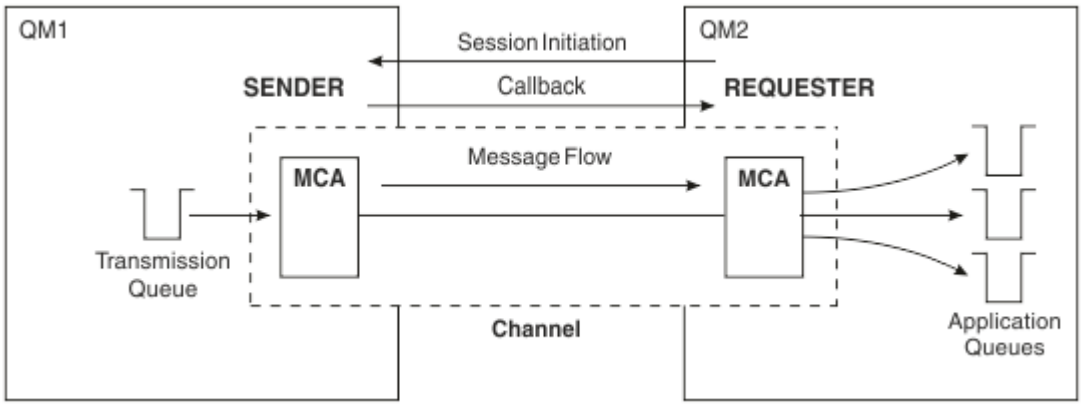


Figure 10. A requester-sender channel

Server-receiver channels

This is like sender-receiver but applies only to *fully qualified* servers, that is server channels that have the connection name of the partner specified in the channel definition. Channel startup must be initiated at the server end of the link. The illustration of this is like the illustration in Figure 8 on page 46.

Cluster-sender channels

In a cluster, each queue manager has a cluster-sender channel on which it can send cluster information to one of the full repository queue managers. Queue managers can also send messages to other queue managers on cluster-sender channels.

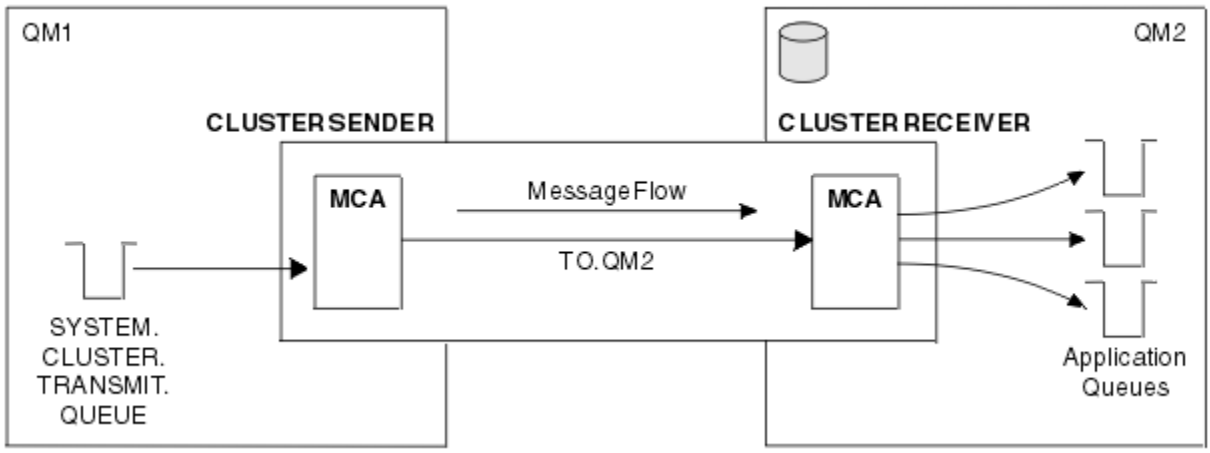


Figure 11. A cluster-sender channel

Cluster-receiver channels

In a cluster, each queue manager has a cluster-receiver channel on which it can receive messages and information about the cluster. The illustration of this is like the illustration in Figure 11 on page 48.

Dead-letter queues

The dead-letter queue (or undelivered-message queue) is the queue to which messages are sent if they cannot be routed to their correct destination. Each queue manager typically has a dead-letter queue.

A *dead-letter queue* (DLQ), sometimes referred to as an *undelivered-message queue*, is a holding queue for messages that cannot be delivered to their destination queues, for example because the queue does not exist, or because it is full. Dead-letter queues are also used at the sending end of a channel, for data-conversion errors.. Every queue manager in a network typically has a local queue to be used as a dead-letter queue so that messages that cannot be delivered to their correct destination can be stored for later retrieval.

Messages can be put on the DLQ by queue managers, message channel agents (MCAs), and applications. All messages on the DLQ must be prefixed with a *dead-letter header* structure, MQDLH. The *Reason* field of the MQDLH structure contains a reason code that identifies why the message is on the DLQ.

You should typically define a dead-letter queue for each queue manager. If you do not, and the MCA is unable to put a message, it is left on the transmission queue and the channel is stopped. Also, if fast, non-persistent messages (see Fast, nonpersistent messages) cannot be delivered, and no dead-letter queue exists on the target system, these messages are discarded.

However, using dead-letter queues can affect the sequence in which messages are delivered, and so you might choose not to use them.

Related tasks

Working with dead-letter queues

Undelivered messages troubleshooting

Related reference

runmqdlq (run dead-letter queue handler)

Remote queue definitions

Remote queue definitions are definitions for queues that are owned by another queue manager.

Whereas applications can retrieve messages only from local queues, they can put messages on local queues or remote queues. Therefore, as well as a definition for each of its local queues, a queue manager can have *remote queue definitions*. The advantage of remote queue definitions is that they enable an

application to put a message to a remote queue without having to specify the name of the remote queue or the remote queue manager, or the name of the transmission queue. Remote queue definitions give you location independence.

There are other uses for remote queue definitions, which are described later.

How to get to the remote queue manager

You might not always have one channel between each source and target queue manager. There are a number of other ways of linking between the two, including multi-hopping, sharing channels, using different channels and clustering.

Multi-hopping

If there is no direct communication link between the source queue manager and the target queue manager, it is possible to pass through one or more *intermediate queue managers* on the way to the target queue manager. This is known as a *multi-hop*.

You need to define channels between all the queue managers, and transmission queues on the intermediate queue managers. This is shown in Figure 12 on page 49.

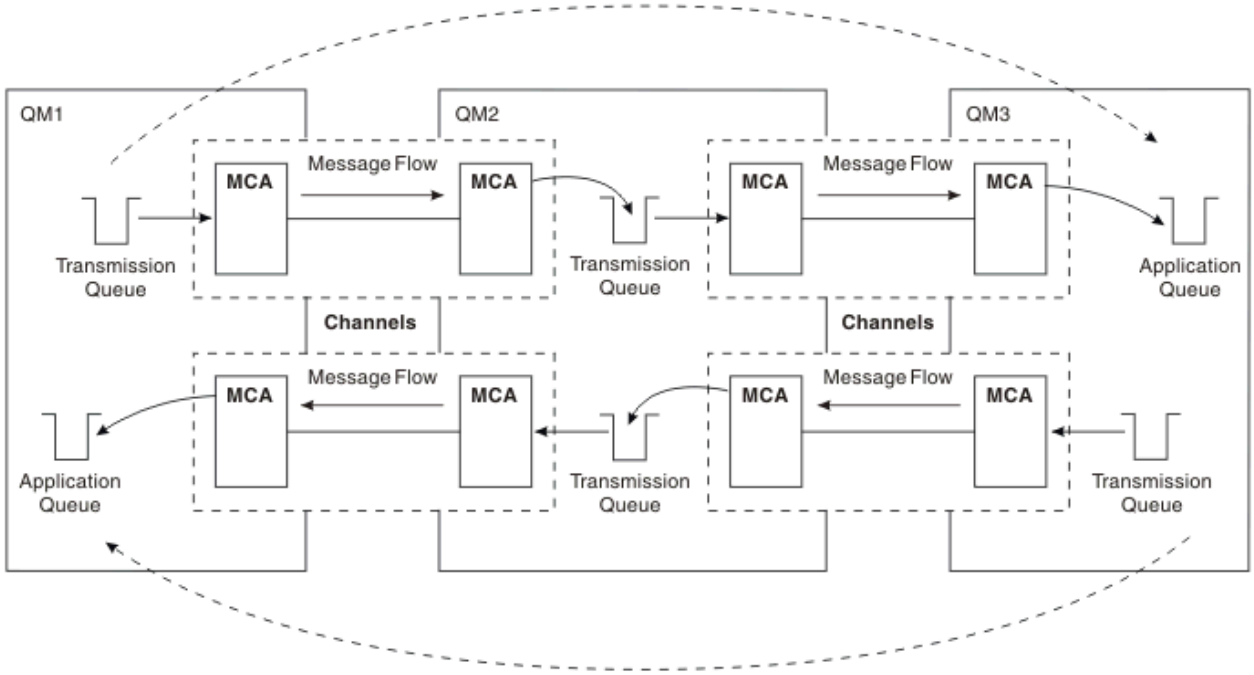


Figure 12. Passing through intermediate queue managers

Sharing channels

As an application designer, you have the choice of forcing your applications to specify the remote queue manager name along with the queue name, or creating a *remote queue definition* for each remote queue. This definition holds the remote queue manager name, the queue name, and the name of the transmission queue. Either way, all messages from all applications addressing queues at the same remote location have their messages sent through the same transmission queue. This is shown in Figure 13 on page 50.

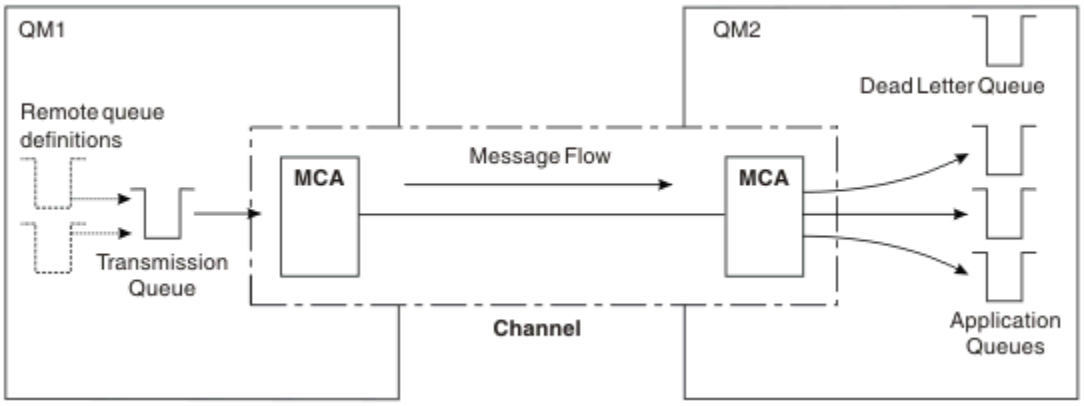


Figure 13. Sharing a transmission queue

Figure 13 on page 50 illustrates that messages from multiple applications to multiple remote queues can use the same channel.

Using different channels

If you have messages of different types to send between two queue managers, you can define more than one channel between the two. There are times when you need alternative channels, perhaps for security purposes, or to trade off delivery speed against sheer bulk of message traffic.

To set up a second channel you need to define another channel and another transmission queue, and create a remote queue definition specifying the location and the transmission queue name. Your applications can then use either channel but the messages are still delivered to the same target queues. This is shown in Figure 14 on page 50.

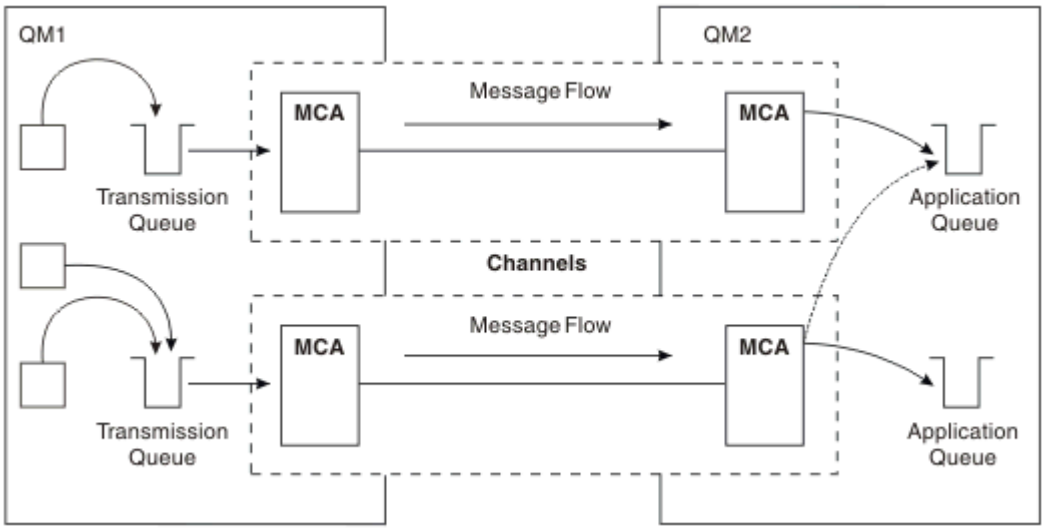


Figure 14. Using multiple channels

When you use remote queue definitions to specify a transmission queue, your applications must **not** specify the location (that is, the destination queue manager) themselves. If they do, the queue manager does not use the remote queue definitions. Remote queue definitions give you location independence. Applications can put messages to a *logical* queue without knowing where the queue is located and you can alter the *physical* queue without having to change your applications.

Using clustering

Every queue manager within a cluster defines a cluster-receiver channel. When another queue manager wants to send a message to that queue manager, it defines the corresponding cluster-sender channel

automatically. For example, if there is more than one instance of a queue in a cluster, the cluster-sender channel could be defined to any of the queue managers that host the queue. IBM MQ uses a workload management algorithm that uses a round-robin routine to select an available queue manager to route a message to. For more information see Clusters.

Addressing information

When an application puts messages that are destined for a remote queue manager, the local queue manager adds a transmission header to them before placing them on the transmission queue. This header contains the name of the destination queue and queue manager, that is, the *addressing information*.

In a single queue manager environment, the address of a destination queue is established when an application opens a queue for putting messages to. Because the destination queue is on the same queue manager, there is no need for any addressing information.

In a distributed queuing environment, the queue manager needs to know not only the destination queue name, but also the location of that queue (that is, the queue manager name), and the route to that remote location (that is, the transmission queue). This addressing information is contained in the transmission header. The receiving channel removes the transmission header and uses the information in it to locate the destination queue.

You can avoid the need for your applications to specify the name of the destination queue manager if you use a remote queue definition. This definition specifies the name of the remote queue, the name of the remote queue manager to which messages are destined, and the name of the transmission queue used to transport the messages.

What are aliases?

Aliases are used to provide a quality of service for messages. The queue manager alias enables a system administrator to alter the name of a target queue manager without causing you to have to change your applications. It also enables the system administrator to alter the route to a destination queue manager, or to set up a route that involves passing through a number of other queue managers (multi-hopping). The reply-to queue alias provides a quality of service for replies.

Queue manager aliases and reply-to queue aliases are created using a remote-queue definition that has a blank RNAME. These definitions do not define real queues; they are used by the queue manager to resolve physical queue names, queue manager names, and transmission queues.

Alias definitions are characterized by having a blank RNAME.

Queue name resolution

Queue name resolution occurs at every queue manager each time a queue is opened. Its purpose is to identify the target queue, the target queue manager (which might be local), and the route to that queue manager (which might be null). The resolved name has three parts: the queue manager name, the queue name, and, if the queue manager is remote, the transmission queue.

When a remote queue definition exists, no alias definitions are referenced. The queue name supplied by the application is resolved to the name of the destination queue, the remote queue manager, and the transmission queue specified in the remote queue definition. For more detailed information about queue name resolution, see Queue name resolution.

If there is no remote queue definition and a queue manager name is specified, or resolved by the name service, the queue manager looks to see if there is a queue manager alias definition that matches the supplied queue manager name. If there is, the information in it is used to resolve the queue manager name to the name of the destination queue manager. The queue manager alias definition can also be used to determine the transmission queue to the destination queue manager.

If the resolved queue name is not a local queue, both the queue manager name and the queue name are included in the transmission header of each message put by the application to the transmission queue.

The transmission queue used typically has the same name as the resolved queue manager, unless changed by a remote queue definition or a queue manager alias definition. If you have not defined such a transmission queue but you have defined a default transmission queue, then this is used.

z/OS Names of queue managers running on z/OS are limited to four characters.

Queue manager alias definitions

Queue manager alias definitions apply when an application that opens a queue to put a message, specifies the queue name **and** the queue manager name.

Queue manager alias definitions have three uses:

- When sending messages, remapping the queue manager name
- When sending messages, altering or specifying the transmission queue
- When receiving messages, determining whether the local queue manager is the intended destination for those messages

Outbound messages - remapping the queue manager name

Queue manager alias definitions can be used to remap the queue manager name specified in an MQOPEN call. For example, an MQOPEN call specifies a queue name of THISQ and a queue manager name of YOURQM. At the local queue manager, there is a queue manager alias definition like the following example:

```
DEFINE QREMOTE (YOURQM) RQMNAME(REALQM)
```

This shows that the real queue manager to be used, when an application puts messages to queue manager YOURQM, is REALQM. If the local queue manager is REALQM, it puts the messages to the queue THISQ, which is a local queue. If the local queue manager is not called REALQM, it routes the message to a transmission queue called REALQM. The queue manager changes the transmission header to say REALQM instead of YOURQM.

Outbound messages - altering or specifying the transmission queue

Figure 15 on page 52 shows a scenario where messages arrive at queue manager QM1 with transmission headers showing queue names at queue manager QM3. In this scenario, QM3 is reachable by multi-hopping through QM2.

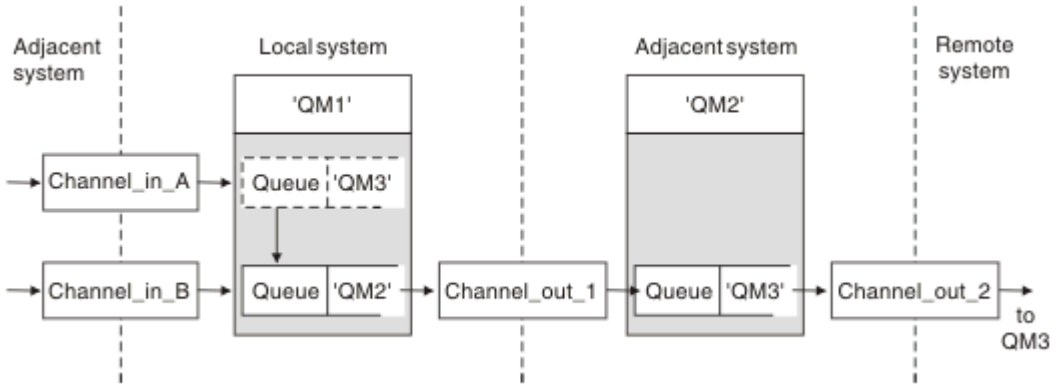


Figure 15. Queue manager alias

All messages for QM3 are captured at QM1 with a queue manager alias. The queue manager alias is named QM3 and contains the definition QM3 through transmission queue QM2. The definition looks like the following example:

```
DEFINE QREMOTE (QM3) RNAME(' ') RQMNAME(QM3) XMITQ(QM2)
```

The queue manager puts the messages on transmission queue QM2 but does not alter the transmission queue header because the name of the destination queue manager, QM3, does not alter.

All messages arriving at QM1 and showing a transmission header containing a queue name at QM2 are also put on the QM2 transmission queue. In this way, messages with different destinations are collected onto a common transmission queue to an appropriate adjacent system, for onward transmission to their destinations.

Inbound messages - determining the destination

A receiving MCA opens the queue referenced in the transmission header. If a queue manager alias definition exists with the same name as the queue manager referenced, then the queue manager name received in the transmission header is replaced with the RQMNAME from that definition.

This process has two uses:

- Directing messages to another queue manager
- Altering the queue manager name to be the same as the local queue manager

Reply-to queue alias definitions

A reply-to queue alias definition specifies alternative names for the reply information in the message descriptor. The advantage of this is that you can alter the name of a queue or queue manager without having to alter your applications.

Queue name resolution

When an application replies to a message, it uses the data in the *message descriptor* of the message it received to find out the name of the queue to reply to. The sending application indicates where replies are sent to and attaches this information to its messages. This concept must be coordinated as part of your application design.

Queue name resolution takes place at the sending end of your application, before the message is put to a queue. Queue name resolution therefore occurs before interaction with the remote application that the message is being sent to. This is the only situation in which name resolution takes place at a time when a queue is not being opened.

Queue name resolution using a queue manager alias

Normally an application specifies a reply-to queue and leaves the reply-to queue manager name blank. The queue manager completes its own name at put time. This method works well except when you want an alternative channel to be used for replies, for example, a channel that uses transmission queue QM1_relief instead of the default return channel which uses transmission queue QM1. In this situation, the queue manager names specified in transmission-queue headers do not match "real" queue manager names, but are respecified using queue manager alias definitions. In order to return replies along alternative routes, it is necessary to map reply-to queue data as well, using reply-to queue alias definitions.

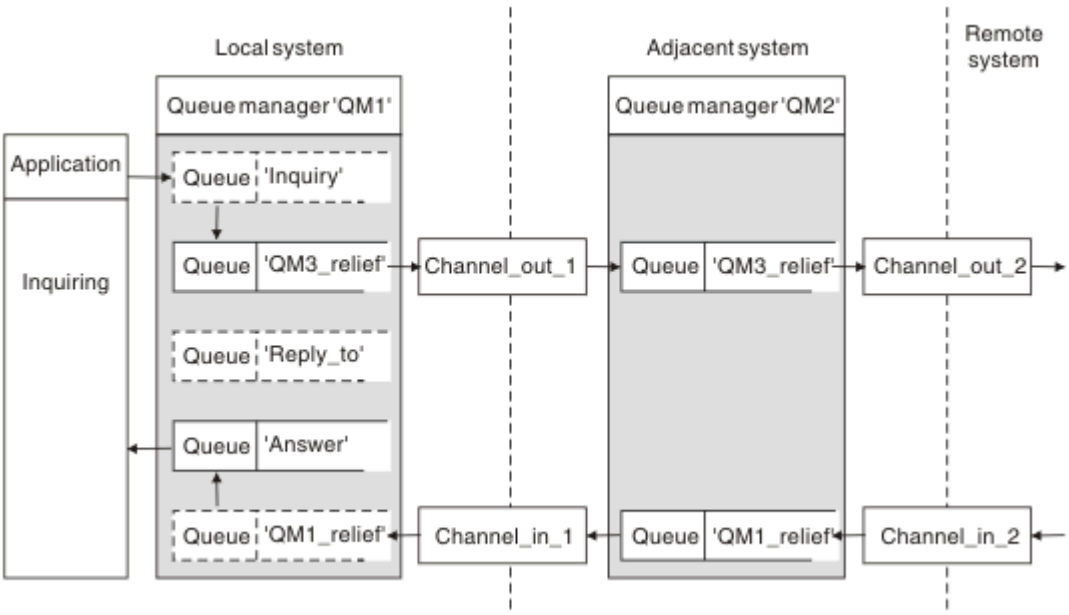


Figure 16. Reply-to queue alias used for changing reply location

In the example in Figure 16 on page 54:

1. The application puts a message using the MQPUT call and specifying the following information in the message descriptor:

   ```
   ReplyToQ='Reply_to'
   ReplyToQMgr=' '
   ```

   ReplyToQMgr must be blank in order for the reply-to queue alias to be used.
2. You create a reply-to queue alias definition called `Reply_to`, which contains the name `Answer`, and the queue manager name `QM1_relief`.

   ```
   DEFINE QREMOTE ('Reply_to') RNAME ('Answer')
   RQMNAME ('QM1_relief')
   ```
3. The messages are sent with a message descriptor showing `ReplyToQ='Answer'` and `ReplyToQMgr='QM1_relief'`.
4. The application specification must include the information that replies are to be found in queue `Answer` rather than `Reply_to`.

To prepare for the replies you have to create the parallel return channel, defining:

- At QM2, the transmission queue named `QM1_relief`

  ```
  DEFINE QLOCAL ('QM1_relief') USAGE(XMITQ)
  ```
- At QM1, the queue manager alias `QM1_relief`

  ```
  DEFINE QREMOTE ('QM1_relief') RNAME() RQMNAME(QM1)
  ```

  This queue manager alias terminates the chain of parallel return channels and captures the messages for QM1.

If you think you might want to do this at sometime in the future, ensure applications use the alias name from the start. For now this is a normal queue alias to the reply-to queue, but later it can be changed to a queue manager alias.

Reply-to queue name

Care is needed with naming reply-to queues. The reason that an application puts a reply-to queue name in the message is that it can specify the queue to which its replies are sent. When you create a reply-to queue alias definition with this name, you cannot have the actual reply-to queue (that is, a local queue definition) with the same name. Therefore, the reply-to queue alias definition must contain a new queue name as well as the queue manager name, and the application specification must include the information that its replies are found in this other queue.

The applications now have to retrieve the messages from a different queue from the one they named as the reply-to queue when they put the original message.

Cluster components

Clusters are composed of queue managers, cluster repositories, cluster channels, and cluster queues.

See the following subtopics for information about each of the cluster components:

Related concepts

Comparison of clustering and distributed queuing

Related tasks

Configuring a queue manager cluster

Setting up a new cluster

Cluster repository

A repository is a collection of information about the queue managers that are members of a cluster.

The repository information includes queue manager names, their locations, their channels, which queues they host, and other information. The information is stored in the form of messages on a queue called `SYSTEM.CLUSTER.REPOSITORY.QUEUE`. This queue is one of the default objects. Multi On Multiplatforms, it is defined when you create an IBM MQ queue manager. z/OS On IBM MQ for z/OS, it is defined as part of queue manager customization.

Full repository and partial repository

Typically, two queue managers in a cluster hold a full repository. The remaining queue managers all hold a partial repository.

A queue manager that hosts a complete set of information about every queue manager in the cluster has a full repository. Other queue managers in the cluster have partial repositories containing a subset of the information in the full repositories.

A partial repository contains information about only those queue managers with which the queue manager needs to exchange messages. The queue managers request updates to the information they need, so that if it changes, the full repository queue manager sends them the new information. For much of the time, a partial repository contains all the information a queue manager needs to perform within the cluster. When a queue manager needs some additional information, it makes inquiries of the full repository and updates its partial repository. The queue managers use the `SYSTEM.CLUSTER.COMMAND.QUEUE` queue to request and receive updates to the repositories.

When migrating queue managers that are members of a cluster, migrate full repositories before partial repositories. This is because an older repository cannot store newer attributes introduced in a newer release. It tolerates them, but does not store them.

Cluster queue manager

A cluster queue manager is a queue manager that is a member of a cluster.

A queue manager can be a member of more than one cluster. Each cluster queue manager must have a name that is unique throughout all the clusters of which it is a member.

A cluster queue manager can host queues, which it advertises to the other queue managers in the cluster. However, it does not have to do this. It can instead feed messages into queues hosted elsewhere in the cluster, and receive only responses that are directed explicitly to it.

z/OS In IBM MQ for z/OS, a cluster queue manager can be a member of a queue sharing group. In this case, it shares its queue definitions with other queue managers in the same queue sharing group.

Cluster queue managers are autonomous. They have full control over queues and channels that they define. Their definitions cannot be modified by other queue managers (other than queue managers in the same queue sharing group). Repository queue managers do not control the definitions in other queue managers in the cluster. They hold a complete set of all the definitions, for use when required. A cluster is a federation of queue managers.

After you create or alter a definition on a cluster queue manager, the information is sent to the full repository queue manager. Other repositories in the cluster are updated later.

Full Repository queue manager

A full repository queue manager is a cluster queue manager that holds a full representation of the cluster's resources. To ensure availability, set up two or more full repository queue managers in each cluster. Full repository queue managers receive information sent by the other queue managers in the cluster and update their repositories. They send messages to each other to be sure that they are both kept up to date with new information about the cluster.

Queue managers and repositories

Every cluster has at least one (preferably two) queue managers holding full repositories of information about the queue managers, queues, and channels in a cluster. These repositories also contain requests from the other queue managers in the cluster for updates to the information.

The other queue managers each hold a partial repository, containing information about the subset of queues and queue managers with which they need to communicate. The queue managers build up their partial repositories by making inquiries when they first need to access another queue or queue manager. They request that they are notified of any new information concerning that queue or queue manager.

Each queue manager stores its repository information in messages on a queue called `SYSTEM.CLUSTER.REPOSITORY.QUEUE`. The queue managers exchange repository information in messages on a queue called `SYSTEM.CLUSTER.COMMAND.QUEUE`.

Each queue manager that joins a cluster defines a cluster-sender, `CLUSSDR`, channel to one of the repositories. It immediately learns which other queue managers in the cluster hold full repositories. From then on, the queue manager can request information from any of the repositories. When the queue manager sends information to the chosen repository, it also sends information to one other repository (if there is one).

A full repository is updated when the queue manager hosting it receives new information from one of the queue managers that is linked to it. The new information is also sent to another repository, to reduce the risk of it being delayed if a repository queue manager is out of service. Because all the information is sent twice, the repositories have to discard duplicates. Each item of information carries a sequence number, which the repositories use to identify duplicates. All repositories are kept in step with each other by exchanging messages.

Cluster queues

A cluster queue is a queue that is hosted by a cluster queue manager and made available to other queue managers in the cluster.

A cluster queue definition is advertised to other queue managers in the cluster. The other queue managers in the cluster can put messages to a cluster queue without needing a corresponding remote-queue definition. A cluster queue can be advertised in more than one cluster by using a cluster namelist.

When a queue is advertised, any queue manager in the cluster can put messages to it. To put a message, the queue manager must find out, from the full repositories, where the queue is hosted. Then it adds some routing information to the message and puts the message on a cluster transmission queue.

A cluster queue can be a queue that is shared by members of a queue sharing group in IBM MQ for z/OS.

Related tasks

Defining cluster queues

Comparison between shared queues and cluster queues

This information is designed to help you compare shared queues and cluster queues, and decide which might be more suitable for your system.

Channel Initiator costs

In cluster queues, messages are sent by channels, so allow for channel initiator costs in addition to application costs. There are costs in the network because channels get and put messages. These costs are not present with shared queues, which therefore use less processing power than cluster queues when moving messages between queue managers in a queue sharing group.

Availability of messages

When putting to a queue, cluster queues send the message to one of the queue managers with active channels connected to your queue manager. On the remote queue manager, if applications used to process the messages are not working, the messages are not processed and wait until the applications start. Similarly, if a queue manager is shut down, any messages on the queue manager are not made available until the queue manager restarts. These instances show lower message availability than when using shared queues.

When using shared queues, any application in the queue sharing group can get messages that are sent. If you shut down one queue manager in the queue sharing group, messages are available to the other queue managers, providing higher message availability than when using cluster queues.

Capacity

A coupling facility is more expensive than a disk; therefore the cost of storing 1,000,000 messages in a local queue is lower than having a coupling facility with enough capacity to store the same number of messages.

Sending to other queue managers

Shared-queue messages are only available within a queue sharing group. If you want to use a queue manager outside of the queue sharing group, you must use channels. You can use clustering to workload balance between multiple remote distributed queue managers.

Workload balancing

You can use clustering to give weight to which channels and queue managers get a proportion of the messages sent. For example, you can send 60% of messages to one queue manager, and 40% of messages to another queue manager. This instance does not depend on the ability of the remote queue manager to process work. The system with the first queue manager might be overloaded, and the system

with the second queue manager might be idle, but most of the messages still go to the first queue manager.

With shared queues, two CICS® systems can get messages. If one system is overloaded, the other system takes over most the workload.

Cluster channels

On every full repository, you manually define a cluster-receiver channel, and a set of cluster-sender channels to connect to every other full repository in the cluster. When you add a partial repository, you manually define a cluster-receiver channel, and a single cluster-sender channel that connects to one of the full repositories. Further cluster-sender channels are defined automatically by the cluster when needed. Auto-defined cluster-sender channels take their attributes from the corresponding cluster-receiver channel definition on the receiving queue manager.

Cluster-receiver channel: CLUSRCVR

A CLUSRCVR channel definition defines the end of a channel on which a cluster queue manager can receive messages from other queue managers in the cluster.

You must define at least one CLUSRCVR channel for each cluster queue manager. By defining the CLUSRCVR channel, the queue manager shows the other cluster queue managers that it is available to receive messages.

A CLUSRCVR channel definition also enables other queue managers to auto-define corresponding cluster-sender channel definitions. See the “Auto-defined cluster-sender channels” on page 58 section of this article.

Cluster-sender channel: CLUSSDR

You manually define a CLUSSDR channel from every full repository queue manager to every other full repository queue manager in the cluster. All the updates exchanged by the full repositories flow exclusively on these channels. By manually defining these channels, you control the network of full repositories explicitly.

When you add a partial repository queue manager to a cluster, you manually define a single CLUSSDR channel to connect to one of the full repositories. It makes little difference which full repository you choose, because after the initial contact has been made, further cluster queue manager objects for your queue manager, including CLUSSDR channels, are defined automatically as necessary. This enables your queue manager to send cluster information to any full repository, and send messages to any queue manager in the cluster.

As is explained in the section of this article, auto-defined sender channels are based on the configuration of the cluster-receiver channel. Therefore any channel properties you set on cluster channels should be set identically on matching CLUSSDR and cluster-receiver channels, or only set on cluster-receiver channels.

You should only manually define CLUSSDR channels for the reasons previously described. That is, to initially connect a partial repository to a full repository, or to connect two full repositories together. Manually configuring a CLUSSDR channel that connects to a partial repository, or to a queue manager not in the cluster, causes error messages such as AMQ9427 and AMQ9428 to be issued. Although this might sometimes be unavoidable as a temporary situation, for example when modifying the location of a full repository, the manual definition should be deleted as soon as possible.

Auto-defined cluster-sender channels

Typically when you add a partial repository queue manager to a cluster you manually define only two cluster channels on the queue manager:

- A cluster-sender (CLUSSDR) channel to a full repository queue manager for the cluster.
- A cluster receiver (CLUSRCVR) channel.

The CLUSSDR channel you define lets the queue manager make initial contact with the cluster. After the initial contact has been made, further CLUSSDR channels are defined automatically by the cluster when needed.

An auto-defined CLUSSDR channel takes its attributes from the corresponding CLUSRCVR channel definition on the receiving queue manager. Even if there is a manually defined CLUSSDR channel, the attributes from the auto-defined CLUSSDR channel are used. Suppose, for example that you define a CLUSRCVR channel without specifying a port number in the **CONNAME** parameter, and manually define a CLUSSDR channel that does specify a port number. When the auto-defined CLUSSDR channel replaces the manually defined one, the port number (taken from the CLUSRCVR channel) becomes blank. The default port number is used and the channel fails.

Where there are configuration differences between a manually defined CLUSSDR channel and the corresponding CLUSRCVR channel definition, some differences take effect immediately (for example, the workload balancing parameters), and some take effect only on channel restart (for example, TLS configuration).

To avoid confusion, as far as possible observe the following guidelines:

- Only manually define CLUSSDR channels to point to full repositories.
- Where you do have manually defined CLUSSDR channels, configure them to identically match the corresponding CLUSRCVR channel definition on the receiving queue manager.

See also Working with auto-defined channels.

Related concepts

Working with auto-defined channels

Working with cluster transmission queues and cluster-sender channels

Related tasks

Setting up a new cluster

Adding a queue manager to a cluster

Cluster topics

Cluster topics are administrative topics with the **cluster** attribute defined. Information about cluster topics is pushed to all members of a cluster, and combined with local topics to create portions of a topic space that spans multiple queue managers. This enables messages published on a topic on one queue manager to be delivered to subscriptions of other queue managers in the cluster.

When you define a cluster topic on a queue manager, the cluster topic definition is sent to the full repository queue managers. The full repositories then propagate the cluster topic definition to all queue managers within the cluster, making the same cluster topic available to publishers and subscribers at any queue manager in the cluster. The queue manager on which you create a cluster topic is known as a cluster topic host. The cluster topic can be used by any queue manager in the cluster, but any modifications to a cluster topic must be made on the queue manager where that topic is defined (the host) at which point the modification is propagated to all members of the cluster through the full repositories.

For information about configuring cluster topics to use *direct routing* or *topic host routing*, and about clustered topic inheritance and wildcard subscriptions, see Defining cluster topics.

For information about the commands to use to display cluster topics, see the related information.

Related concepts

Working with administrative topics

Working with subscriptions

Related reference

DISPLAYTOPIC

DISPLAYTPSTATUS

DISPLAYSUB

Default cluster objects

Multi On Multiplatforms, the default cluster objects are included in the set of default objects automatically created when you define a queue manager. z/OS On z/OS, the default cluster object definitions can be found in the customization samples.

Note: You can alter the default channel definitions in the same way as any other channel definition, by running MQSC or PCF commands. Do not alter the default queue definitions, except for SYSTEM.CLUSTER.HISTORY.QUEUE.

SYSTEM.CLUSTER.COMMAND.QUEUE
Each queue manager in a cluster has a local queue called SYSTEM.CLUSTER.COMMAND.QUEUE which is used to transfer messages to the full repository. The message contains any new or changed information about the queue manager, or any requests for information about other queue managers. SYSTEM.CLUSTER.COMMAND.QUEUE is normally empty.

SYSTEM.CLUSTER.HISTORY.QUEUE
Each queue manager in a cluster has a local queue called SYSTEM.CLUSTER.HISTORY.QUEUE. SYSTEM.CLUSTER.HISTORY.QUEUE is used to store the history of cluster state information for service purposes.

In the default object settings, SYSTEM.CLUSTER.HISTORY.QUEUE is set to PUT (ENABLED). To suppress history collection change the setting to PUT (DISABLED).

SYSTEM.CLUSTER.REPOSITORY.QUEUE
Each queue manager in a cluster has a local queue called SYSTEM.CLUSTER.REPOSITORY.QUEUE. This queue is used to store all the full repository information. This queue is not normally empty.

SYSTEM.CLUSTER.TRANSMIT.QUEUE
Each queue manager has a definition for a local queue called SYSTEM.CLUSTER.TRANSMIT.QUEUE. SYSTEM.CLUSTER.TRANSMIT.QUEUE is the default transmission queue for all messages to all queues and queue managers that are within clusters. You can change the default transmission queue for each cluster-sender channel to SYSTEM.CLUSTER.TRANSMIT. *ChannelName*, by changing the queue manager attribute DEFCLXQ . You cannot delete SYSTEM.CLUSTER.TRANSMIT.QUEUE. It is also used to define authorization checks whether the default transmission queue that is used is SYSTEM.CLUSTER.TRANSMIT.QUEUE or SYSTEM.CLUSTER.TRANSMIT. *ChannelName*.

SYSTEM.DEF.CLUSRCVR
Each cluster has a default CLUSRCVR channel definition called SYSTEM.DEF.CLUSRCVR. SYSTEM.DEF.CLUSRCVR is used to supply default values for any attributes that you do not specify when you create a cluster-receiver channel on a queue manager in the cluster.

SYSTEM.DEF.CLUSSDR
Each cluster has a default CLUSSDR channel definition called SYSTEM.DEF.CLUSSDR. SYSTEM.DEF.CLUSSDR is used to supply default values for any attributes that you do not specify when you create a cluster-sender channel on a queue manager in the cluster.

Related concepts
Working with default cluster objects

Publish/subscribe messaging

Publish/subscribe messaging allows you to decouple the provider of information, from the consumers of that information. The sending application and receiving application do not need to know anything about each other for the information to be sent and received.

Before a point-to-point IBM MQ application can send a message to another application, it needs to know something about that application. For example, it needs to know the name of the queue to which to send the information, and might also specify a queue manager name.

IBM MQ publish/subscribe removes the need for your application to know anything about the target application. All the sending application has to do is this:

- *Put* an IBM MQ message that contains the information that the application wants.
- Assign the message to a topic that denotes the subject of the information.
- Let IBM MQ handle the distribution of that information.

Similarly, the target application does not have to know anything about the source of the information it receives.

The following figure shows the simplest publish/subscribe system. There is one publisher, one queue manager, and one subscriber. A subscription is made by the subscriber on a queue manager, a publication is sent from the publisher to the queue manager, and the publication is then forwarded by the queue manager to the subscriber.

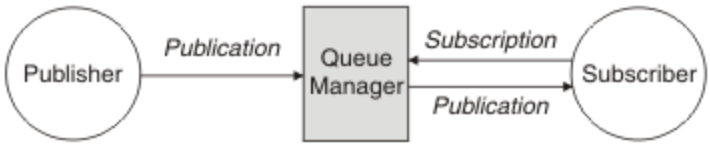


Figure 17. Simple publish/subscribe configuration

A typical publish/subscribe system has more than one publisher and more than one subscriber on many different topics, and often has more than one queue manager. An application can be both a publisher and a subscriber.

Another significant difference between publish/subscribe messaging and point-to-point is that a message sent to a point-to-point queue is only processed by a single consuming application. A message published to a publish/subscribe topic, where more than one subscriber has registered an interest, is processed by every interested subscriber.

Publish/subscribe components

Publish/subscribe is the mechanism by which subscribers can receive information, in the form of messages, from publishers. The interactions between publishers and subscribers are controlled by queue managers, using standard IBM MQ facilities.

A typical publish/subscribe system has more than one publisher and more than one subscriber on many different topics, and often has more than one queue manager. An application can be both a publisher and a subscriber.

The provider of information is called a *publisher*. Publishers supply information about a subject, without needing to know anything about the applications that are interested in that information. Publishers generate this information in the form of messages, called *publications* that they want to publish and define the topic of these messages.

The consumer of the information is called a *subscriber*. Subscribers create *subscriptions* that describe the topic that the subscriber is interested in. Thus, the subscription determines which publications are forwarded to the subscriber. Subscribers can make multiple subscriptions and can receive information from many different publishers.

Published information is sent in an IBM MQ message, and the subject of the information is identified by its *topic*. The publisher specifies the topic when it publishes the information, and the subscriber specifies the topics about which it wants to receive publications. The subscriber is sent information about only those topics it subscribes to.

It is the existence of topics that allows the providers and consumers of information to be decoupled in publish/subscribe messaging by removing the need to include a specific destination in each message as is required in point-to-point messaging.

Interactions between publishers and subscribers are all controlled by a queue manager. The queue manager receives messages from publishers, and subscriptions from subscribers (to a range of topics). The queue manager's job is to route the published messages to the subscribers that have registered an interest in the topic of the messages.

Standard IBM MQ facilities are used to distribute messages, so your applications can use all the features that are available to existing IBM MQ applications. This means that you can use persistent messages to get once-only assured delivery, and that your messages can be part of a transactional unit-of-work to ensure that messages are delivered to the subscriber only if they are committed by the publisher.

Publishers and publications

In IBM MQ publish/subscribe a publisher is an application that makes information about a specified topic available to a queue manager in the form of a standard IBM MQ message called a publication. A publisher can publish information about more than one topic.

Publishers use the MQPUT verb to put a message to a previously opened topic, this message is a publication. The local queue manager then routes the publication to any subscribers who have subscriptions to the topic of the publication. A published message can be consumed by more than one subscriber.

In addition to distributing publications to all local subscribers that have appropriate subscriptions, a queue manager can also distribute the publication to any other queue managers connected to it, either directly or through a network of queue managers that have subscribers to the topic.

In an IBM MQ publish/subscribe network, a publishing application can also be a subscriber.

Publications under syncpoint

Publishers can issue MQPUT or MQPUT1 calls in syncpoint to include all messages delivered to subscribers in a unit of work. If the MQPMO_RETAIN option, or topic delivery options NPMSGDLV or PMSGDLV with values ALL or ALLDUR are specified, the queue manager uses internal MQPUT or MQPUT1 calls in syncpoint, within the scope of the publisher MQPUT or MQPUT1 call.

State and event information

Publications can be categorized as either state publications, such as the current price of a stock, or event publications, such as a trade in that stock.

State publications

State publications contain information about the current state of something, such as the price of stock or the current score in a soccer match. When something happens (for example, the stock price changes or the soccer score changes), the previous state information is no longer required because it is superseded by the new information.

A subscriber will want to receive the current version of the state information when it starts, and be sent new information whenever the state changes.

If a publication contains state information, it is often published as a retained publication. A new subscriber typically wants the current state information immediately; the subscriber does not want to wait for an event that causes the information to be republished. Subscribers will automatically receive a topic's retained publication when it subscribes unless the subscriber uses the MQSO_PUBLICATIONS_ON_REQUEST or MQSO_NEW_PUBLICATIONS_ONLY options.

Event publications

Event publications contain information about individual events that occur, such as a trade in some stock or the scoring of a particular goal. Each event is independent of other events.

A subscriber will want to receive information about events as they happen.

Retained publications

By default, after a publication is sent to all interested subscribers it is discarded. However, a publisher can specify that a copy of a publication is retained so that it can be sent to future subscribers who register an interest in the topic.

Deleting publications after they have been sent to all interested subscribers is suitable for event information, but is not always suitable for state information. By retaining a message, new subscribers do not have to wait for information to be published again before they receive initial state information. For example, a subscriber with a subscription to a stock price would receive the current price straight away, without waiting for the stock price to change (and hence be republished).

The queue manager can retain only one publication for each topic, so the existing retained publication of a topic is deleted when a new retained publication arrives at the queue manager. However, the deletion of the existing publication might not occur synchronously with the arrival of the new retained publication. Therefore, wherever possible, have no more than one publisher sending retained publications on any topic.

Subscribers can specify that they do not want to receive retained publications by using the MQSO_NEW_PUBLICATIONS_ONLY subscription option. Existing subscribers can ask for duplicate copies of retained publications to be sent to them.

There are times when you might not want to retain publications, even for state information:

- If all subscriptions to a topic are made before any publications are made on that topic, and you do not expect, or do not allow, new subscriptions, there is no need to retain publications because they are delivered to the complete set of subscribers the first time they are published.
- If publications occur frequently, such as every second, a new subscriber (or a subscriber recovering from a failure) receives the current state almost immediately after their initial subscription, so there is no need to retain these publications.
- If the publications are large, you might end up needing a considerable amount of storage space to store the retained publication for each topic. In a multiple queue manager environment, retained publications are stored by all queue managers in the network that have a matching subscription.

When deciding whether to use retained publications, consider how subscribing applications recover from a failure. If the publisher does not use retained publications, the subscriber application might need to store its current state locally.

To ensure that a publication is retained, use the MQPMO_RETAIN put-message option. If this option is used and the publication cannot be retained, the message is not published and the call fails with MQRC_PUT_NOT_RETAINED.

If a message is a retained publication, this is indicated by the MQIsRetained message property. The persistence of a message is as it was when it was originally published.

Related concepts

Design considerations for retained publications in publish/subscribe clusters

Publications under syncpoint

In IBM MQ publish/subscribe, syncpoint can be used by publishers or internally by the queue manager.

Publishers use syncpoint when they issue MQPUT/MQPUT1 calls with the MQPMO_SYNCPOINT option. All messages delivered to subscribers count towards the maximum number of uncommitted messages in a unit of work.The MAXUMSGS queue manager attribute specifies this limit. If the limit is reached then the publisher receives the 2024 (07E8) (RC2024): MQRC_SYNCPOINT_LIMIT_REACHED reason code.

When a publisher issues MQPUT/MQPUT1 calls using MQPMO_NO_SYNCPOINT with the MQPMO_RETAIN option, or topic delivery options NPMSGDLV/PMSGDLV with values ALL or ALLDUR, the queue manager uses internal syncpoints to guarantee that messages are delivered as requested. The publisher can receive the 2024 (07E8) (RC2024): MQRC_SYNCPOINT_LIMIT_REACHED reason code if the limit is reached within the scope of the publisher MQPUT/MQPUT1 call.

Subscribers and subscriptions

In IBM MQ publish/subscribe, a subscriber is an application that requests information about a specific topic from a queue manager in a publish/subscribe network. A subscriber can receive messages, about the same or different topics, from more than one publisher.

Subscriptions can be created manually using an MQSC command or by applications. These subscriptions are issued to the local queue manager and contain information about the publications the subscriber wants to receive:

- The topic the subscriber is interested in; this can resolve to multiple topics if wildcards are used.
- An optional selection string to be applied to published messages.
- A handle to a queue (known as the *subscriber queue*), on which selected publications should be placed, and the optional CorrelId.

The local queue manager stores subscription information and when it receives a publication, scans the information to determine whether there is a subscription that matches the publication's topic and selection string. For each matching subscription, the queue manager directs the publication to the subscriber's subscriber queue. The information that a queue manager stores about subscriptions can be viewed by using the DIS SUB and DIS SBSTATUS commands.

A subscription is deleted only when one of the following events occurs:

- The subscriber unsubscribes using the MQCLOSE call (if the subscription was made non-durably).
- The subscription expires.
- The subscription is deleted by the system administrator using the DELETE SUB command.
- The subscriber application ends (if the subscription was made non-durably).
- The queue manager is stopped or restarted (if the subscription was made non-durably).

When getting messages, use appropriate options on the MQGET call. If your application processes only messages for one subscription then, as a minimum, you should use `get-by-correlid`, as demonstrated in the C sample program `amqssbxa.c` and at unmanaged MQ subscriber. The **`CorrelId`** to use is returned from MQSUB in the MQSD.**`SubCorrelId`** field.

Related concepts

Cloned and shared subscriptions

Related reference

Examples of how to define the sharedSubscription property

Managed queues and publish/subscribe

When you create a subscription you can choose to use managed queuing. If you use managed queuing a subscription queue is automatically created when you create a subscription. Managed queues are tidied up automatically in accordance with the durability of the subscription. Using managed queues means that you do not have to worry about creating queues to receive publications and any unconsumed publications are removed from subscriber queues automatically if a non-durable subscription connection is closed.

If an application has no need to use a particular queue as its subscriber queue, the destination for the publications it receives, it can make use of *managed subscriptions* using the MQSO_MANAGED subscription option. If you create a managed subscription, the queue manager returns an object handle to the subscriber for a subscriber queue that the queue manager creates where publications will be received. This is because a *managed subscriptions* is one where IBM MQ handles the subscription. The queue's object handle will be returned allowing you to browse, get or inquire on the queue (it is not possible to put to or set attributes of a managed queue unless you have been explicitly given access to temporary dynamic queues).

The durability of the subscription determines whether the managed queue remains when the subscribing application's connection to the queue manager is broken.

Managed subscriptions are particularly useful when used with non-durable subscriptions because when the application's connection is ended, unconsumed messages would otherwise remain on the subscriber

queue taking up space in your queue manager indefinitely. If you are using a managed subscription, the managed queue will be a temporary dynamic queue and as such will be deleted along with any unconsumed messages when the connection is broken for any of the following reasons:

- MQCLOSE with MQCO_REMOVE_SUB is used and the managed Hobj is closed.
- a connection is lost to an application using a non-durable subscription (MQSO_NON_DURABLE).
- a subscription is removed because it has expired and the managed Hobj is closed.

Managed subscriptions can also be used with durable subscriptions but it is possible that you would want to leave unconsumed messages on the subscriber queue so that they can be retrieved when the connection is reopened. For this reason, managed queues for durable subscriptions take the form of a permanent dynamic queue and will remain when the subscribing application's connection to the queue manager is broken.

You can set an expiry on your subscription if you want to use a permanent dynamic managed queue so that although the queue will still exist after the connection is broken, it will not continue to exist indefinitely.

If you delete the managed queue you will receive an error message.

The managed queues that are created are named with numbers at the end (timestamps) so that each is unique.

Subscription durability

Subscriptions can be configured to be durable or non-durable. Subscription durability determines what happens to subscriptions when subscribing applications disconnect from a queue manager.

Durable subscriptions

Durable subscriptions continue to exist when a subscribing application's connection to the queue manager is closed. If a subscription is durable, when the subscribing application disconnects, the subscription remains in place and can be used by the subscribing application when it reconnects requesting the subscription again using the **SubName** that was returned when the subscription was created.

When subscribing durably, a subscription name (**SubName**) is required. Subscription names must be unique within a queue manager so that it can be used to identify a subscription. This means of identification is necessary when specifying a subscription you want to resume, if you have either deliberately closed the connection to the subscription (using the MQCO_KEEP_SUB option) or have been disconnected from the queue manager. You can resume an existing subscription by using the MQSUB call with the MQSO_RESUME option. Subscription names are also displayed if you use the DISPLAY SBSTATUS command with SUBTYPE ALL or ADMIN.

When an application no longer requires a durable subscription it can be removed using the MQCLOSE function call with the MQCO_REMOVE_SUB option or it can be deleted manually use the MQSC command DELETE SUB.

You can use the **DURSUB** topic attribute to specify whether or not durable subscriptions can be made to a topic.

On return from an MQSUB call using the MQSO_RESUME option, subscription expiry is set to the original expiry of the subscription and not the remaining expiry time.

A queue manager continues to send publications to satisfy a durable subscription even if that subscriber application is not connected. This leads to a build up of messages on the subscriber queue. The easiest way to avoid this problem is to use a non-durable subscription wherever appropriate. However, where it is necessary to use durable subscriptions, a build up of messages can be avoided if the subscriber subscribes using the Retained publications option. A subscriber can then control when it receives publications by using the MQSUBRQ call.

Non-durable subscriptions

Non-durable subscriptions exist only as long as the subscribing application's connection to the queue manager remains open. The subscription is removed when the subscribing application disconnects from the queue manager either deliberately or by loss of connection. When the connection is closed, the information about the subscription is removed from the queue manager, and is no longer shown if you display subscriptions using the DISPLAY SBSTATUS command. No more messages are put to the subscriber queue.

What happens to any unconsumed publications on the subscriber queue for non-durable subscriptions is determined as follows.

- If a subscribing application is using a managed destination, any publications that have not been consumed are automatically removed.
- If the subscribing application provides a handle to its own subscriber queue when it subscribes, unconsumed messages are not removed automatically. It is the responsibility of the application to clear the queue if that is appropriate. If the queue is shared by more than one subscriber, or other point-to-point applications, it might not be appropriate to clear the queue completely.

Although not required for non-durable subscriptions, a subscription name if provided, is used by the queue manager. Subscription names must be unique within the queue manager so that it can be used to identify a subscription.

Related concepts

Cloned and shared subscriptions

Related tasks

Using JMS 2.0 shared subscriptions

Related reference

Examples of how to define the sharedSubscription property

Selection strings

A *selection string* is an expression that is applied to a publication to determine whether it matches a subscription. Selection strings can include wildcard characters.

When you subscribe, in addition to specifying a topic, you can specify a selection string to select publications according to their message properties.

The selection string is evaluated against the message as put by the publisher before it is modified for delivery to each subscriber. Take care when using fields in the selection string that might be modified as part of the publish operation. For example, the MQMD fields `UserIdentifier`, `MsgId`, and `CorrelId`.

Selection strings should not reference any of the message property fields added by the queue manager as part of the publish operation (see Publish/subscribe message properties), except for the message property `MQTopicString`, which contains the topic string for the publication.

Related concepts

Selection string rules and restrictions

Topics

A topic is the subject of the information that is published in a publish/subscribe message.

Messages in point-to-point systems are sent to a specific destination address. Messages in subject-based publish/subscribe systems are sent to subscribers based on the subject that describes the contents of the message. In content-based systems, messages are sent to subscribers based on the contents of the message itself.

The IBM MQ publish/subscribe system is a subject-based publish/subscribe system. A publisher creates a message, and publishes it with a topic string that best fits the subject of the publication. To receive publications, a subscriber creates a subscription with a pattern matching topic string to select publication topics. The queue manager delivers publications to subscribers that have subscriptions that match the publication topic, and are authorized to receive the publications. The article, “Topic strings” on page 67,

describes the syntax of topic strings that identify the subject of a publication. Subscribers also create topic strings to select which topics to receive. The topic strings that subscribers create can contain either of two alternative wildcard schemes to pattern match against the topic strings in publications. Pattern matching is described in “Wildcard schemes” on page 68.

In subject-based publish/subscribe, publishers, or administrators, are responsible for classifying subjects into topics. Typically subjects are organized hierarchically, into topic trees, using the `'/'` character to create subtopics in the topic string. See “Topic trees” on page 74 for examples of topic trees. Topics are nodes in the topic tree. Topics can be leaf-nodes with no further subtopics, or intermediate nodes with subtopics.

In parallel with organizing subjects into a hierarchical topic tree, you can associate topics with administrative topic objects. You assign attributes to a topic, such as whether the topic is distributed in a cluster, by associating it with an administrative topic object. The association is made by naming the topic using the `TOPICSTR` attribute of the administrative topic object. If you do not explicitly associate an administrative topic object to a topic, the topic inherits the attributes of its closest ancestor in the topic tree that you *have* associated with an administrative topic object. If you have not defined any parent topics at all, it inherits from `SYSTEM.BASE.TOPIC`. Administrative topic objects are described in “Administrative topic objects” on page 75.

Note: Even if you inherit all the attributes of a topic from `SYSTEM.BASE.TOPIC`, define a root topic for your topics that directly inherits from `SYSTEM.BASE.TOPIC`. For example, in the topic space of US states, `USA/Alabama` `USA/Alaska`, and so on, `USA` is the root topic. The main purpose of the root topic is to create discrete, non-overlapping topic spaces to avoid publications matching the wrong subscriptions. It also means you can change the attributes of your root topic to affect your whole topic space. For example, you might set the name for the **CLUSTER** attribute.

When you refer to a topic as a publisher or subscriber, you have a choice of supplying a topic string, or referring to a topic object. Or you can do both, in which case the topic string you supply defines a subtopic of the topic object. The queue manager identifies the topic by appending the topic string to the topic string prefix named in the topic object, inserting an additional `'/'` in between the two topic strings, for example, *topic string/object string*. “Combining topic strings” on page 72 describes this further. The resulting topic string is used to identify the topic and associate it with an administrative topic object. The administrative topic object is not necessarily the same topic object as the topic object corresponding to the master topic.

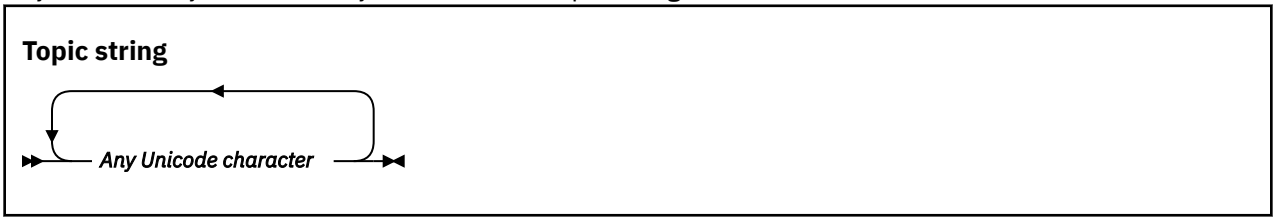
In content based publish/subscribe, you define what messages you want to receive by providing selection strings that search the contents of every message. IBM MQ provides an intermediate form of content based publish/subscribe using message selectors that scan message properties rather than the full content of the message, see Selectors. The archetypal use of message selectors is to subscribe to a topic and then qualify the selection with a numeric property. The selector enables you to specify you are interested in values only in a certain range; something you cannot do using either character or topic-based wildcards. If you do need to filter based on the full content of the message, you need to use IBM Integration Bus.

Topic strings

Label information you publish as a topic using a topic string. Subscribe to groups of topics using either character or topic based wildcard topic strings.

Topics

A *topic string* is a character string that identifies the topic of a publish/subscribe message. You can use any characters you like when you construct a topic string.



Three characters have special meaning in IBM WebSphere® MQ 7 publish/subscribe. They are allowed anywhere in a topic string, but use them with caution. The use of the special characters is explained in “Topic-based wildcard scheme” on page 69.

A forward slash (/)

The topic level separator. Use the '/' character to structure the topic into a topic tree.

Avoid empty topic levels, '//', if you can. These correspond to nodes in the topic hierarchy with no topic string. A leading or trailing '/' in a topic string corresponds to a leading or trailing empty node and should be avoided too.

The hash sign (#)

Used in combination with '/' to construct a multilevel wildcard in subscriptions. Take care using '#' adjacent to '/' in topic strings used to name published topics. “Examples of topic strings” on page 68 shows a sensible use of '#'.

The strings '.../#/...', '#/...' and '.../#' have a special meaning in subscription topic strings. The strings match all topics at one or more levels in the topic hierarchy. Thus if you created a topic with one of those sequences, you could not subscribe to it, without also subscribing to all topics at multiple levels in the topic hierarchy.

The plus sign (+)

Used in combination with '/' to construct a single-level wildcard in subscriptions. Take care using '+' adjacent to '/' in topic strings used to name published topics.

The strings '.../+/...', '+/...' and '.../+' have a special meaning in subscription topic strings. The strings match all topics at one level in the topic hierarchy. Thus if you created a topic with one of those sequences, you could not subscribe to it, without also subscribing to all topics at one level in the topic hierarchy.

Examples of topic strings

```
IBM/Business Area#/Results
IBM/Diversity/%African American
```

Related reference

TOPIC

Wildcard schemes

There are two wildcard schemes used to subscribe to multiple topics. The choice of scheme is a subscription option.

MQSO_WILDCARD_TOPIC
Select topics to subscribe to using the topic-based wildcard scheme.

This is the default if no wildcard schema is explicitly selected.

MQSO_WILDCARD_CHAR
Select topics to subscribe to using the character-based wildcard scheme.

Set either scheme by specifying the **wschema** parameter on the DEFINE SUB command. For more information, see DEFINE SUB.

Note: Subscriptions that were created before IBM WebSphere MQ 7.0 always use the character-based wildcard scheme.

Examples

```
IBM/+/Results
#/Results
```

```
IBM/Software/Results
IBM/*ware/Results
```

Topic-based wildcard scheme
Topic-based wildcards allow subscribers to subscribe to more than one topic at a time.

Topic-based wildcards are a powerful feature of the topic system in IBM MQ publish/subscribe. The multilevel wildcard and single level wildcard can be used for subscriptions, but they cannot be used within a topic by the publisher of a message.

The topic-based wildcard scheme allows you to select publications grouped by topic level. You can choose, for each level in the topic hierarchy, whether the string in the subscription for that topic level must exactly match the string in the publication or not. For example, the subscription `IBM/+/Results` selects all the topics,

```
IBM/Software/Results
IBM/Services/Results
IBM/Hardware/Results
```

There are two types of wildcard.

Multilevel wildcard

- The multilevel wildcard is used in subscriptions. When used in a publication it is treated as a literal.
- The multilevel wildcard character `'#'` is used to match any number of levels within a topic. For example, using the example topic tree, if you subscribe to `'USA/Alaska/#'`, you receive messages on topics `'USA/Alaska'` and `'USA/Alaska/Juneau'`.
- The multilevel wildcard can represent zero or more levels. Therefore, `'USA/#'` can also match the singular `'USA'`, where `'#'` represents zero levels. The topic level separator is meaningless in this context, because there are no levels to separate.
- The multilevel wildcard is only effective when specified on its own or next to the topic level separator character. Therefore, `'#'` and `'USA/#'` are valid topics where the `'#'` character is treated as a wildcard. However, although `'USA#'` is also a valid topic string, the `'#'` character is not regarded as a wildcard and does not have any special meaning. See “When topic-based wildcards are not wild” on page 71 for more information.

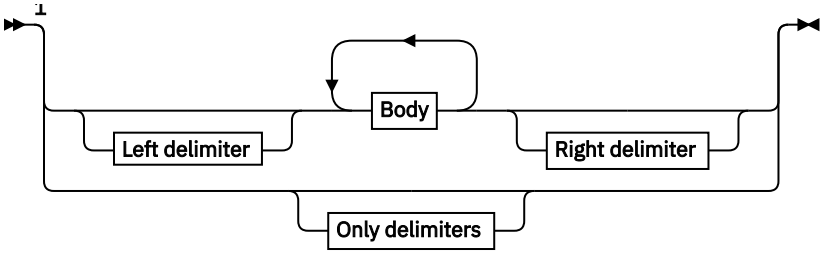
Single level wildcard

- The single wildcard is used in subscriptions. When used in a publication it is treated as a literal.
- The single-level wildcard character `'+'` matches one, and only one, topic level. For example, `'USA/+'` matches `'USA/Alabama'`, but not `'USA/Alabama/Auburn'`. Because the single-level wildcard matches only a single level, `'USA/+'` does not match `'USA'`.
- The single-level wildcard can be used at any level in the topic tree, and in conjunction with the multilevel wildcard. The single-level wildcard must be specified next to the topic level separator, except when it is specified on its own. Therefore, `'+'` and `'USA/+'` are valid topics where the `'+'` character is treated as a wildcard. However, although `'USA+'` is also a valid topic string, the `'+'` character is not regarded as a wildcard and does not have any special meaning. See “When topic-based wildcards are not wild” on page 71 for more information.

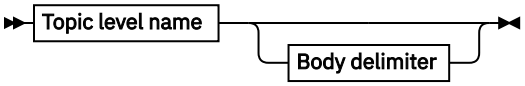
The syntax for the topic-based wildcard scheme has no escape characters. Whether `'#'` and `'+'` are treated as wildcards or not depends on their context. See “When topic-based wildcards are not wild” on page 71 for more information.

Note: The beginning and end of a topic string is treated in a special way. Using `'$'` to denote the end of the string, then `'$#/...'` is a multilevel wildcard, and `'$/#/..'`. is an empty node at the root, followed by a multilevel wildcard.

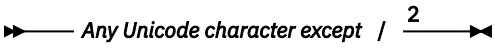
Topic-based wildcard string



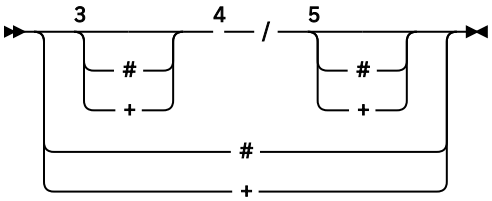
Body



Topic level name



Only delimiters



Notes:

[1] A null or zero length topic string is invalid

[2] You are advised not to use any of `*`, `?`, `%` in level name strings for compatibility between char based and topic-based wildcard schemes.

[3] These cases are equivalent to the *left delimiter* pattern.

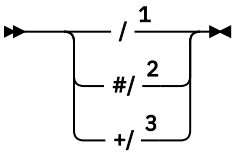
[4] / with no wildcards matches a single empty topic.

[5] These cases are equivalent to the *right delimiter* pattern.

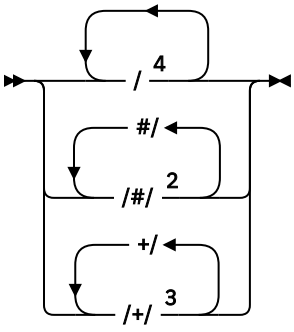
[6] Match every topic.

[7] Match every topic where there is only one level.

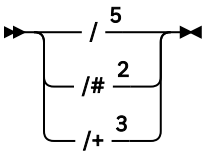
Left delimiter



Body delimiter



Right delimiter



Notes:

[1] The topic string starts with an empty topic
[2] Matches zero or more levels. Multiple multi-level match strings have the same effect as one multi-level match string.
[3] Matches exactly one level.
[4] // is an empty topic - a topic object with no topic string.
[5] The topic string ends with an empty topic

When topic-based wildcards are not wild

The wildcard characters '+' and '#' have no special meaning when they are mixed with other characters (including themselves) in a topic level.

This means that topics that contain '+' or '#' together with other characters in a topic level can be published.

For example, consider the following two topics:

1. level0/level1/+/level4/#
2. level0/level1/#+/level4/level#

In the first example, the characters '+' and '#' are treated as wildcards and are therefore not valid in a topic string that is to be published to but are valid in a subscription.

In the second example, the characters '+' and '#' are not treated as wildcards and therefore the topic string can be both published and subscribed to.

Examples

```
IBM/+/Results
#/Results
IBM/Software/Results
```

Character-based wildcard scheme
The character-based wildcard scheme allows you to select topics based on traditional character matching.

You can select all topics at multiple levels in a topic hierarchy using the string '*'. Using '*' in the character-based wildcard scheme is equivalent to using the topic-based wildcard string '#'

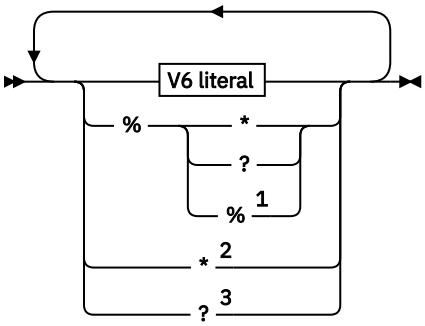
' *x*/*y* ' is equivalent to ' *x*/#/*y* ' in the topic-based scheme, and selects all topics in the topic hierarchy between levels ' *x* and *y* ', where ' *x* ' and ' *y* ' are topic names that are not in the set of levels returned by the wildcard.

'/+/' in the topic-based scheme has no exact equivalent in the character-based scheme. 'IBM/*/Results' would also select 'IBM/Patents/Software/Results'. Only if the set of topic names at each level of the hierarchy are unique, can you always construct queries with the two schemes that yield identical matches.

Used in a general way, '*' and '?' in the character-based scheme have no equivalents in the topic-based scheme. The topic-based scheme does not perform partial matching using wildcards. The character based wildcard subscription 'IBM/*ware/Results' has no topic-based equivalent.

Note: Matches using character wildcard subscriptions are slower than matches using topic-based subscriptions.

Character-based wildcard string



V6 literal

Notes:

[1] Means escape the following character, so that it is treated as a literal. `'%'` must be followed by either `'*'`, `'?'` or `'%'`. See “Examples of topic strings” on page 68.

[2] Means match zero or more characters in a subscription.

[3] Means match exactly one character in a subscription.

Examples

```
IBM/*/Results
IBM/*ware/Results
```

Combining topic strings

When creating subscriptions, or opening topics so you can publish messages to them, the topic string can be formed by combining two separate sub-topic strings, or "subtopics". One subtopic is provided by the application or administrative command as a topic string, and the other is the topic string associated with a topic object. You can use either subtopic as the topic string on its own, or combine them to form a new topic name.

For example, when you define a subscription using the MQSC command **DEFINE SUB**, the command can take either **TOPICSTR** (topic string) or **TOPICOBJ** (topic object) as an attribute, or both together. If only **TOPICOBJ** is provided, the topic string associated with that topic object is used as the topic string. If only **TOPICSTR** is provided, that is used as the topic string. If both are provided, they are concatenated to form a single topic string in the form **TOPICOBJ** / **TOPICSTR**, where the **TOPICOBJ** configured topic string is always first and the two parts of the string are always separated by a "/" character.

Similarly, in an MQI program the full topic name is created by MQOPEN. It is composed of two fields used in publish/subscribe MQI calls, in the order listed:

1. The **TOPICSTR** attribute of the topic object, named in the **ObjectName** field.
2. The **ObjectString** parameter defining the subtopic provided by the application.

The resulting topic string is returned in the **ResObjectString** parameter.

These fields are considered to be present if the first character of each field is not a blank or null character, and the field length is greater than zero. If only one of the fields is present, it is used unchanged as the topic name. If neither field has a value, the call fails with reason code MQRC_UNKNOWN_OBJECT_NAME, or MQRC_TOPIC_STRING_ERROR if the full topic name is not valid.

If both fields are present, a "/" character is inserted between the two elements of the resultant combined topic name.

The following table shows examples of topic string concatenation:

Table 2. Topic string concatenation examples

TOPICSTR of the topic object	**Topic string provided by application or DEFINE SUB command**	**Full topic name**	**Comment**
Football/Scores	' '	Football/Scores	The TOPICSTR of the topic object is used alone.
' '	Football/Scores	Football/Scores	The ObjectString/ TOPICSTR is used alone.
Football	Scores	Football/Scores	A "/" character is added at the concatenation point.
Football	/Scores	Football//Scores	An 'empty node' is produced between the two strings. This is different from "Football/ Scores".
/Football	Scores	/Football/Scores	The topic starts with an 'empty node'. This is different from "Football/ Scores".

The "/" character is considered as a special character, providing structure to the full topic name in"Topic trees" on page 74. The "/" character must not be used for any other reason, because the structure of the topic tree is affected. The topic "/Football" is not the same as the topic "Football".

Note: If you use a topic object when creating a subscription, the value of the topic object topic string is fixed in the subscription at define time. Any subsequent change to the topic object does not affect the topic string that the subscription is defined to.

Wildcard characters in topic strings

The following wildcard characters are special characters:

- plus sign (+)
- number sign (#)
- asterisk (*)
- question mark (?)

Wildcard characters only have special meaning when used by a subscription. These characters are not considered as invalid when used elsewhere, however you must ensure you understand how they are used and you might prefer not to use these characters in your topic strings when publishing or defining topic objects.

If you publish on a topic string with # or + mixed in with other characters (including themselves) within a topic level, the topic string can be subscribed to with either wildcard scheme.

If you publish on a topic string with # or + as the only character between two / characters, the topic string cannot be subscribed to explicitly by an application using the wildcard scheme MQSO_WILDCARD_TOPIC. This situation results in the application getting more publications than expected.

You should not use a wildcard character in the topic string of a defined topic object. If you do this, the character is treated as a literal character when the object is used by a publisher, and as a wildcard character when used by a subscription. This can lead to confusion.

Example code snippet

This code snippet, extracted from the example program Example 2: Publisher to a variable topic, combines a topic object with a variable topic string:

```
MQOD   td = {MQOD_DEFAULT}; /* Object Descriptor      */
td.ObjectType = MQOT_TOPIC;  /* Object is a topic      */
td.Version = MQOD_VERSION_4;  /* Descriptor needs to be V4  */
strncpy(td.ObjectName, topicName, MQ_TOPIC_NAME_LENGTH);
td.ObjectString.VSPtr = topicString;
td.ObjectString.VSLength = (MQLONG)strlen(topicString);
td.ResObjectString.VSPtr = resTopicStr;
td.ResObjectString.VSBufSize = sizeof(resTopicStr)-1;
MQOPEN(Hconn, &td, MQOO_OUTPUT | MQOO_FAIL_IF_QUIESCING, &Hobj, &CompCode, &Reason);
```

Topic trees

Each topic that you define is an element, or node, in the topic tree. The topic tree can either be empty to start with or contain topics that have been defined previously using MQSC or PCF commands. You can define a new topic either by using the create topic commands or by specifying the topic for the first time in a publication or subscription.

Although you can use any character string to define a topic's topic string, it is advisable to choose a topic string that fits into a hierarchical tree structure. Thoughtful design of topic stings and topic trees can help you with the following operations:

- Subscribing to multiple topics.
- Establishing security policies.

Although you can construct a topic tree as a flat, linear structure, it is better to build a topic tree in a hierarchical structure with one or more root topics. For more information about security planning and topics, see Publish/subscribe security.

Figure 18 on page 74 shows an example of a topic tree with one root topic.

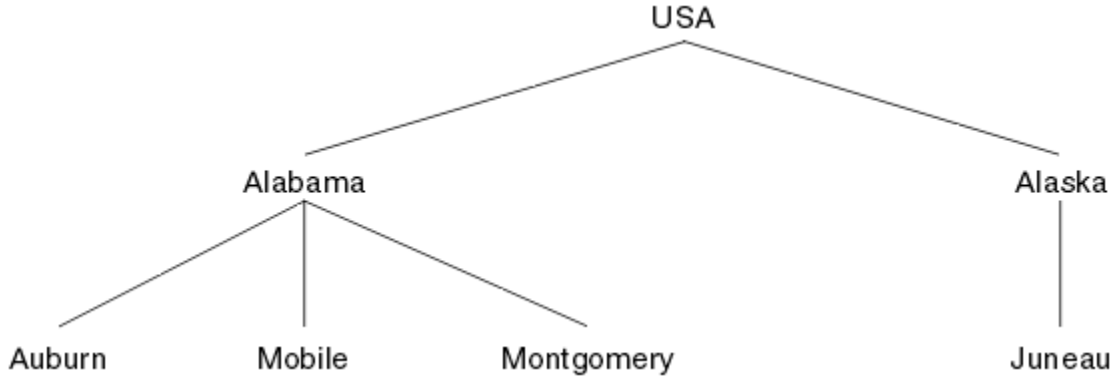


Figure 18. Example of a topic tree

Each character string in the figure represents a node in the topic tree. A complete topic string is created by aggregating nodes from one or more levels in the topic tree. Levels are separated by the "/" character. The format of a fully specified topic string is: "root/level2/level3".

The valid topics in the topic tree shown in Figure 18 on page 74 are:

"USA"
"USA/Alabama"
"USA/Alaska"
"USA/Alabama/Auburn"

"USA/Alabama/Mobile"
"USA/Alabama/Montgomery"
"USA/Alaska/Juneau"

When you design topic strings and topic trees, remember that the queue manager does not interpret, or attempt to derive meaning from, the topic string itself. It simply uses the topic string to send selected messages to subscribers of that topic.

The following principles apply to the construction and content of a topic tree:

- There is no limit to the number of levels in a topic tree.
- There is no limit to the length of the name of a level in a topic tree.
- There can be any number of "root" nodes; that is, there can be any number of topic trees.

Related tasks

Reducing the number of unwanted topics in the topic tree

Administrative topic objects

Using an administrative topic object, you can assign specific, non-default attributes to topics.

Figure 19 on page 75 shows how a high-level topic of `Sport` divided into separate topics covering different sports can be visualized as a topic tree:

Figure 19. Visualization of a topic tree

Figure 20 on page 75 shows how the topic tree can be divided further, to separate different types of information about each sport:

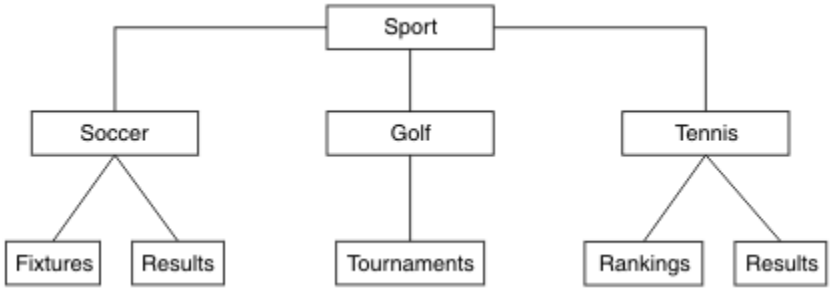


Figure 20. Extended topic tree

To create the topic tree illustrated, no administrative topic objects need be defined. Each of the nodes in this tree are defined by a topic string created in a publish or subscribe operation. Each topic in the tree inherits its attributes from its parent. Attributes are inherited from the parent topic object, because by default all attributes are set to ASPARENT. In this example, every topic has the same attributes as the `Sport` topic. The `Sport` topic has no administrative topic object, and inherits its attributes from SYSTEM.BASE.TOPIC.

Note, that it is not good practice to give authorities for non-mqm users at the root node of the topic tree, which is SYSTEM.BASE.TOPIC, because the authorities are inherited but cannot be restricted. Therefore, by giving authorities at this level, you are giving authorities to the whole tree. You should give the authority at a lower topic level in the hierarchy.

Administrative topic objects can be used to define specific attributes for particular nodes in the topic tree. In the following example, the administrative topic object is defined to set the durable subscriptions property DURSUB of the soccer topic to the value NO:

```
DEFINE TOPIC(FOOTBALL.EUROPEAN)
TOPICSTR('Sport/Soccer')
DURSUB(NO)
DESCR('Administrative topic object to disallow durable subscriptions')
```

The topic tree can now be visualized as:

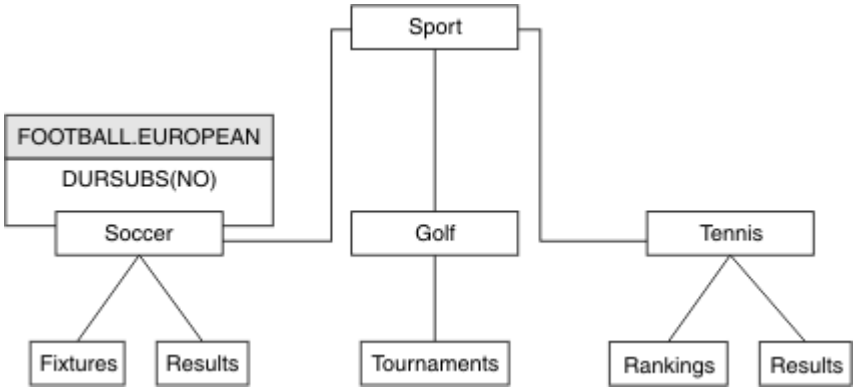


Figure 21. Visualization of an administrative topic object associated with the Sport/Soccer topic

Any applications subscribing to topics beneath Soccer in the tree can still use the topic strings they used before the administrative topic object was added. However, an application can now be written to subscribe using the object name FOOTBALL.EUROPEAN, instead of the string /Sport/Soccer. For example, to subscribe to /Sport/Soccer/Results, an application can specify MQSD.ObjectName as FOOTBALL.EUROPEAN and MQSD.ObjectString as Results.

With this feature, you can hide part of the topic tree from application developers. Define an administrative topic object at a particular node in the topic tree, then application developers can define their own topics as children of the node. Developers must know about the parent topic, but not about any other nodes in the parent tree.

Inheriting attributes

If a topic tree has many administrative topic objects, each administrative topic object, by default, inherits its attributes from its closest parent administrative topic. The previous example has been extended in Figure 22 on page 77:

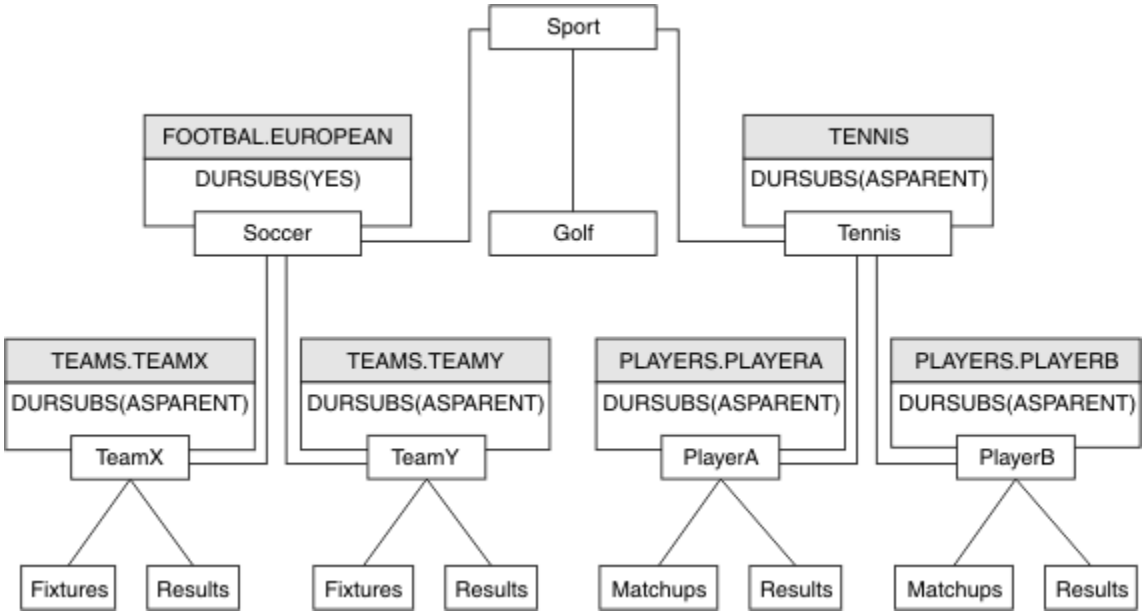


Figure 22. Topic tree with several administrative topic objects

For example use inheritance to give all the child topics of `/Sport/Soccer` the property that subscriptions are non-durable. Change the DURSUB attribute of `FOOTBALL.EUROPEAN` to `NO`.

This attribute can be set using the following command:

```
ALTER TOPIC(FOOTBALL.EUROPEAN) DURSUB(NO)
```

All the administrative topic objects of child topics of `Sport/Soccer` have the property DURSUB set to the default value ASPARENT. After changing the DURSUB property value of `FOOTBALL.EUROPEAN` to `NO`, the child topics of `Sport/Soccer` inherit the DURSUB property value `NO`. All child topics of `Sport/Tennis` inherit the value of DURSUB from `SYSTEM.BASE.TOPIC` object. `SYSTEM.BASE.TOPIC` has the value of YES.

Trying to make a durable subscription to the topic `Sport/Soccer/TeamX/Results` would now fail; however, trying to make a durable subscription to `Sport/Tennis/PlayerB/Results` would succeed.

Controlling wildcard usage with the WILDCARD property

Use the MQSC **Topic** WILDCARD property or the equivalent PCF Topic `WildcardOperation` property to control the delivery of publications to subscriber applications that use wildcard topic string names. The WILDCARD property can have one of two possible values:

WILDCARD
The behavior of wildcard subscriptions with respect to this topic.

PASSTHRU
Subscriptions made to a wildcarded topic less specific than the topic string at this topic object receive publications made to this topic and to topic strings more specific than this topic.

BLOCK
Subscriptions made to a wildcarded topic less specific than the topic string at this topic object do not receive publications made to this topic or to topic strings more specific than this topic.

The value of this attribute is used when subscriptions are defined. If you alter this attribute, the set of topics covered by existing subscriptions is not affected by the modification. This scenario applies also if the topology is changed when topic objects are created or deleted; the set of topics matching subscriptions created following the modification of the WILDCARD attribute is created using the modified topology. If you want to force the matching set of topics to be re-evaluated for existing subscriptions, you must restart the queue manager.

In the example, “Example: Create the Sport publish/subscribe cluster” on page 81, you can follow the steps to create the topic tree structure shown in Figure 23 on page 78.

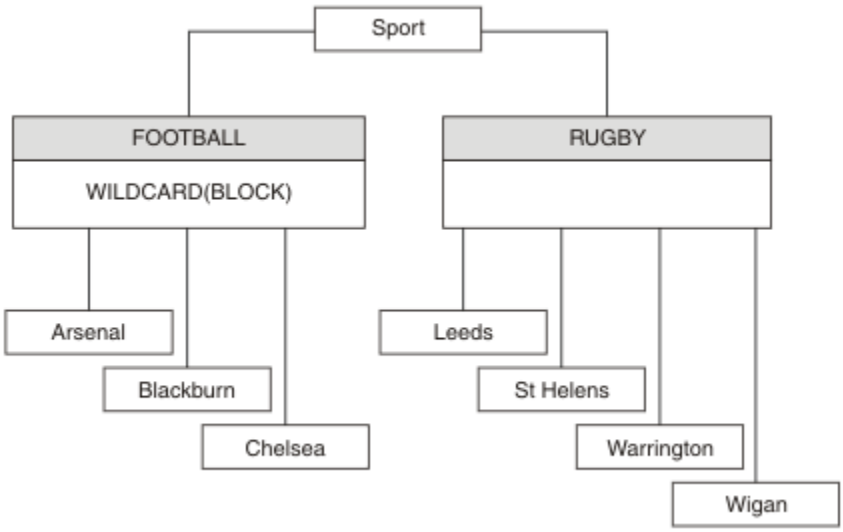


Figure 23. A topic tree that uses the WILDCARD property, BLOCK

A subscriber using the wildcard topic string `#` receives all publications to the `Sport` topic and the `Sport/Rugby` subtree. The subscriber receives no publications to the `Sport/Football` subtree, because the `WILDCARD` property value of the `Sport/Football` topic is `BLOCK`.

`PASSTHRU` is the default setting. You can set the `WILDCARD` property value `PASSTHRU` to nodes in the `Sport` tree. If the nodes do not have the `WILDCARD` property value `BLOCK`, setting `PASSTHRU` does not alter the behavior observed by subscribers to nodes in the `Sports` tree.

In the example, create subscriptions to see how the wildcard setting affects the publications that are delivered; see Figure 27 on page 83. Run the publish command in Figure 30 on page 84 to create some publications.

```
pub QMA
```

Figure 24. Publish to QMA

The results are shown in Table 3 on page 78. Notice how setting the `WILDCARD` property value `BLOCK`, prevents subscriptions with wildcards from receiving publications to topics within the scope of the wildcard.

Table 3. Publications received on QMA

Subscription	**Topic string**	**Publications received**	**Notes**

SPORTS	`Sports/#`	`Sports`
		`Sports/Rugby`
		`Sports/Rugby/Leeds`
			All publications to Football subtree blocked by `WILDCARD(BLOCK)` on `Sports/Football`

SARSENAL	`Sports/#/Arsenal`	-	`WILDCARD(BLOCK)` on `Sports/Football` prevents wildcard subscription on `Arsenal`

Table 3. Publications received on QMA (continued)			
Subscription	**Topic string**	**Publications received**	**Notes**
SLEEDS	Sports/#/Leeds	Sports/Rugby/Leeds	Default WILDCARD on Sports/Rugby does not prevent wildcard subscription on Leeds.

Note:

Suppose a subscription has a wildcard that matches a topic object with the WILDCARD property value BLOCK. If the subscription also has a topic string to the right of the matching wildcard, the subscription never receives a publication. The set of publications that are not blocked are publications to topics that are parents of the blocked wildcard. Publications to topics that are children of the topic with the BLOCK property value are blocked by the wildcard. Therefore subscription topic strings that include a topic to the right of the wildcard never receive any publications to match.

Setting the WILDCARD property value to BLOCK does not mean you cannot subscribe using a topic string that includes wildcards. Such a subscription is normal. The subscription has an explicit topic that matches the topic with a topic object having a WILDCARD property value BLOCK. It uses wildcards for topics that are parents or children of the topic with the WILDCARD property value BLOCK. In the example in Figure 23 on page 78, a subscription such as Sports/Football/# can receive publications.

Wildcards and cluster topics

Cluster topic definitions are propagated to every queue manager in a cluster. A subscription to a cluster topic at one queue manager in a cluster results in the queue manager creating proxy subscriptions. A proxy subscription is created at every other queue manager in the cluster. Subscriptions using topics strings containing wildcards, combined with cluster topics, can give hard to predict behavior. The behavior is explained in the following example.

In the cluster set up for the example, “Example: Create the Sport publish/subscribe cluster” on page 81, QMB has the same set of subscriptions as QMA, yet QMB received no publications after the publisher published to QMA, see Figure 24 on page 78. Although the Sports/Football and Sports/Rugby topics are cluster topics, the subscriptions defined in fullsubs.tst do not reference a cluster topic. No proxy subscriptions are propagated from QMB to QMA. Without proxy subscriptions, no publications to QMA are forwarded to QMB.

Some of the subscriptions, such as Sports/#/Leeds, might seem to reference a cluster topic, in this case Sports/Rugby. The Sports/#/Leeds subscription actually resolves to the topic object SYSTEM.BASE.TOPIC.

The rule for resolving the topic object referenced by a subscription such as, Sports/#/Leeds is as follows. Truncate the topic string to the first wildcard. Scan left through the topic string looking for the first topic that has an associated administrative topic object. The topic object might specify a cluster name, or define a local topic object. In the example, Sports/#/Leeds, the topic string after truncation is Sports, which has no topic object, and so Sports/#/Leeds inherits from SYSTEM.BASE.TOPIC, which is a local topic object.

To see how subscribing to clustered topics can change the way wildcard propagation works, run the batch script, upsubs.bat. The script clears the subscription queues, and adds the cluster topic subscriptions in fullsubs.tst. Run puba.bat again to create a batch of publications; see Figure 24 on page 78.

Table 4 on page 80 shows the result of adding two new subscriptions to the same queue manager that the publications were published on. The result is as expected, the new subscriptions receive one publication each, and the numbers of publications received by the other subscriptions are unchanged. The unexpected results occur on the other cluster queue manager; see Table 5 on page 80.

Table 4. Publications received on QMA			
Subscription	**Topic string**	**Publications received**	**Notes**
SPORTS	Sports/#	Sports Sports/Rugby Sports/Rugby/Leeds	All publications to Football subtree blocked by WILDCARD(BLOCK) on Sports/Football
SARSENAL	Sports/#/Arsenal	-	WILDCARD(BLOCK) on Sports/Football prevents wildcard subscription on Arsenal
SLEEDS	Sports/#/Leeds	Sports/Rugby/Leeds	Default WILDCARD on Sports/Rugby does not prevent wildcard subscription on Leeds.
FARSENAL	Sports/Football/Arsenal	Sports/Football/Arsenal	Arsenal receives a publication because the subscription does not have a wildcard.
FLEEDS	Sports/Rugby/Leeds	Sports/Rugby/Leeds	Leeds would receive a publication in any event.

Table 5 on page 80 shows the results of adding the two new subscriptions on QMB and publishing on QMA. Recall that QMB received no publications without these two new subscriptions. As expected, the two new subscriptions receive publications, because Sports/FootBall and Sports/Rugby are both cluster topics. QMB forwarded proxy subscriptions for Sports/Football/Arsenal and Sports/Rugby/Leeds to QMA, which then sent the publications to QMB.

The unexpected result is that the two subscriptions Sports/# and Sports/#/Leeds that previously received no publications, now receive publications. The reason is that the Sports/Football/Arsenal and Sports/Rugby/Leeds publications forwarded to QMB for the other subscriptions are now available for any subscriber attached to QMB. Consequently the subscriptions to the local topics Sports/# and Sports/#/Leeds receive the Sports/Rugby/Leeds publication. Sports/#/Arsenal continues not to receive a publication, because Sports/Football has its WILDCARD property value set to BLOCK.

Table 5. Publications received on QMB			
Subscription	**Topic string**	**Publications received**	**Notes**
SPORTS	*Sports/#*	*Sports/Rugby/Leeds*	*All publications to Football subtree blocked by WILDCARD(BLOCK) on Sports/Football*
SARSENAL	Sports/#/Arsenal	-	WILDCARD(BLOCK) on Sports/Football prevents wildcard subscription on Arsenal
SLEEDS	*Sports/#/Leeds*	*Sports/Rugby/Leeds*	*Default WILDCARD on Sports/Rugby does not prevent wildcard subscription on Leeds.*
FARSENAL	Sports/Football/Arsenal	Sports/Football/Arsenal	Arsenal receives a publication because the subscription does not have a wildcard.

Table 5. Publications received on QMB (continued)			
Subscription	**Topic string**	**Publications received**	**Notes**
FLEEDS	Sports/Rugby/Leeds	Sports/Rugby/Leeds	Leeds would receive a publication in any event.

In most applications, it is undesirable for one subscription to influence the behavior of another subscription. One important use of the WILDCARD property with the value BLOCK is to make the subscriptions to the same topic string containing wildcards behave uniformly. Whether the subscription is on the same queue manager as the publisher, or a different one, the results of the subscription are the same.

Wildcards and streams

For a new application written to the publish/subscribe API, the effect is that a subscription to * receives no publications. To receive all the Sports publications you must subscribe to Sports/*, or Sports/#, and similarly for Business publications.

The behavior of an existing queued publish/subscribe application does not change when the publish/subscribe broker is migrated to a later version of IBM MQ. The **StreamName** property in the **Publish**, **Register Publisher**, or **Subscriber** commands is mapped to the name of the topic the stream has been migrated to.

Wildcards and subscription points

For a new application written to the publish/subscribe API, the effect of the migration is that a subscription to * receives no publications. To receive all the Sports publications you must subscribe to Sports/*, or Sports/#, and similarly for Business publications.

The behavior of an existing queued publish/subscribe application does not change when the publish/subscribe broker is migrated to a later version of IBM MQ. The **SubPoint** property in the **Publish**, **Register Publisher**, or **Subscriber** commands is mapped to the name of the topic the subscription has been migrated to.

Example: Create the Sport publish/subscribe cluster

The steps that follow create a cluster, CL1, with four queue managers: two full repositories, CL1A and CL1B, and two partial repositories, QMA and QMB. The full repositories are used to hold only cluster definitions. QMA is designated the cluster topic host. Durable subscriptions are defined on both QMA and QMB.

Note: The example is coded for Windows. You must recode Create qmgrs.bat and create pub.bat to configure and test the example on other platforms.

1. Create the script files.
   a. Create topics.tst
   b. Create wildsubs.tst
   c. Create fullsubs.tst
   d. Create qmgrs.bat
   e. create pub.bat
2. Run Create qmgrs.bat to create the configuration.

```
qmgrs
```

Create the topics in Figure 23 on page 78. The script in figure 5 creates the cluster topics Sports/Football and Sports/Rugby.

Note: The REPLACE option does not replace the TOPICSTR properties of a topic. TOPICSTR is a property that is usefully varied in the example to test different topic trees. To change topics, delete the topic first.

```
DELETE TOPIC ('Sports')
DELETE TOPIC ('Football')
DELETE TOPIC ('Arsenal')
DELETE TOPIC ('Blackburn')
DELETE TOPIC ('Chelsea')
DELETE TOPIC ('Rugby')
DELETE TOPIC ('Leeds')
DELETE TOPIC ('Wigan')
DELETE TOPIC ('Warrington')
DELETE TOPIC ('St. Helens')

DEFINE TOPIC ('Sports')   TOPICSTR('Sports')
DEFINE TOPIC ('Football')  TOPICSTR('Sports/Football') CLUSTER(CL1) WILDCARD(BLOCK)
DEFINE TOPIC ('Arsenal')  TOPICSTR('Sports/Football/Arsenal')
DEFINE TOPIC ('Blackburn') TOPICSTR('Sports/Football/Blackburn')
DEFINE TOPIC ('Chelsea')  TOPICSTR('Sports/Football/Chelsea')
DEFINE TOPIC ('Rugby')   TOPICSTR('Sports/Rugby')  CLUSTER(CL1)
DEFINE TOPIC ('Leeds')   TOPICSTR('Sports/Rugby/Leeds')
DEFINE TOPIC ('Wigan')   TOPICSTR('Sports/Rugby/Wigan')
DEFINE TOPIC ('Warrington') TOPICSTR('Sports/Rugby/Warrington')
DEFINE TOPIC ('St. Helens') TOPICSTR('Sports/Rugby/St. Helens')
```

Figure 25. Delete and create topics: topics.tst

Note: Delete the topics, as REPLACE does not replace topic strings.

Create subscriptions with wildcards. The wildcards corresponding the topics with topic objects in Figure 23 on page 78. Create a queue for each subscription. The queues are cleared and the subscriptions deleted when the script is run or rerun.

Note: The REPLACE option does not replace TOPICOBJ or TOPICSTR properties of a subscription. TOPICOBJ or TOPICSTR are the properties that are usefully varied in the example to test different subscriptions. To change them, delete the subscription first.

```
DEFINE QLOCAL(QSPORTS)  REPLACE
DEFINE QLOCAL(QSARSENAL) REPLACE
DEFINE QLOCAL(QSLEEDS)  REPLACE
CLEAR QLOCAL(QSPORTS)
CLEAR QLOCAL(QSARSENAL)
CLEAR QLOCAL(QSLEEDS)

DELETE SUB  (SPORTS)
DELETE SUB  (SARSENAL)
DELETE SUB  (SLEEDS)
DEFINE SUB  (SPORTS)  TOPICSTR('Sports/#')     DEST(QSPORTS)
DEFINE SUB  (SARSENAL) TOPICSTR('Sports/+/Arsenal') DEST(QSARSENAL)
DEFINE SUB  (SLEEDS)  TOPICSTR('Sports/+/Leeds')  DEST(QSLEEDS)
```

Figure 26. Create wildcard subscriptions: wildsubs.tst

Create subscriptions that reference the cluster topic objects.

Note:

The delimiter, /, is automatically inserted between the topic string referenced by TOPICOBJ, and the topic string defined by TOPICSTR.

The definition, `DEFINE SUB(FARSENAL) TOPICSTR('Sports/Football/Arsenal') DEST(QFARSENAL)` creates the same subscription. TOPICOBJ is used as a quick way to reference topic string you have already defined. The subscription, when created, no longer refers to the topic object.

```
DEFINE QLOCAL(QFARSENAL) REPLACE
DEFINE QLOCAL(QRLEEDS)  REPLACE
CLEAR QLOCAL(QFARSENAL)
CLEAR QLOCAL(QRLEEDS)

DELETE SUB  (FARSENAL)
DELETE SUB  (RLEEDS)
DEFINE SUB  (FARSENAL) TOPICOBJ('Football') TOPICSTR('Arsenal') DEST(QFARSENAL)
DEFINE SUB  (RLEEDS)  TOPICOBJ('Rugby')  TOPICSTR('Leeds')  DEST(QRLEEDS)
```

Figure 27. Delete and create subscriptions: fullsubs.tst

Create a cluster with two repositories. Create two partial repositories for publishing and subscribing. Rerun the script to delete everything and start again. The script also creates the topic hierarchy, and the initial wildcard subscriptions.

Note:

On other platforms, write a similar script, or type all the commands. Using a script makes it quick to delete everything and start again with an identical configuration.

```
@echo off
set port.CL1B=1421
set port.CLIA=1420
for %%A in (CL1A CL1B QMA QMB) do call :createQM %%A
call :configureQM CL1A CL1B %port.CL1B% full
call :configureQM CL1B CL1A %port.CL1A% full
for %%A in (QMA QMB) do call :configureQM %%A CL1A %port.CL1A% partial
for %%A in (topics.tst wildsubs.tst) do runmqsc QMA < %%A
for %%A in (wildsubs.tst) do runmqsc QMB < %%A
goto:eof

:createQM
echo Configure Queue manager %1
endmqm -p %1
for %%B in (dlt crt str) do %%Bmqm %1
goto:eof

:configureQM
if %1==CL1A set p=1420
if %1==CL1B set p=1421
if %1==QMA set p=1422
if %1==QMB set p=1423
echo configure %1 on port %p% connected to repository %2 on port %3 as %4 repository
echo DEFINE LISTENER(LST%1) TRPTYPE(TCP) PORT(%p%) CONTROL(QMGR) REPLACE | runmqsc %1
echo START LISTENER(LST%1) | runmqsc %1
if full==%4 echo ALTER QMGR REPOS(CL1) DEADQ(SYSTEM.DEAD.LETTER.QUEUE) | runmqsc %1
echo DEFINE CHANNEL(TO.%2) CHLTYPE(CLUSSDR) TRPTYPE(TCP) CONNAME('LOCALHOST(%3)') CLUSTER(CL1)
REPLACE | runmqsc %1
echo DEFINE CHANNEL(TO.%1) CHLTYPE(CLUSRCVR) TRPTYPE(TCP) CONNAME('LOCALHOST(%p%)')
CLUSTER(CL1) REPLACE | runmqsc %1
goto:eof
```

Figure 28. Create queue managers: qmgrs.bat

Update the configuration by adding the subscriptions to the cluster topics.

```
@echo off
for %%A in (QMA QMB) do runmqsc %%A < wildsubs.tst
for %%A in (QMA QMB) do runmqsc %%A < upsubs.tst
```

Figure 29. Update subscriptions: upsubs.bat

Run `pub.bat`, with a queue manager as a parameter, to publish messages containing the publication topic string. `Pub.bat` uses the sample program **amqspub**.

```
@echo off
@rem Provide queue manager name as a parameter
set S=Sports
set S=6 Sports/Football Sports/Football/Arsenal
set S=6 Sports/Rugby Sports/Rugby/Leeds
for %%B in (6) do echo %%B | amqspub %%B %1
```

Figure 30. Publish: pub.bat

Streams and topics

Queued publish/subscribe has the concept of a publication stream that does not exist in the integrated publish/subscribe model. In queued publish/subscribe, streams provide a way of separating the flow of information for different topics. A stream is implemented as a top-level topic that can be mapped to a different topic identifier administratively.

The default stream SYSTEM.BROKER.DEFAULT.STREAM is set up automatically for all brokers and queue managers on a network, and no additional configuration is required to use the default stream. Think of the default stream as an unnamed default topic space. Topics published to the default stream are immediately available to all connected queue managers, with queued publish/subscribe enabled. Named streams are like separate, named, topic spaces. The named stream must be defined on each broker where it is used.

If the publishers and subscribers are on different queue managers, then after the brokers are connected in the same broker hierarchy, no further configuration is required for the publications, and subscriptions to flow between them. The same interoperability works in reverse, too.

Named streams

A solution designer, working with the queued publish/subscribe programming model, might decide to place all sports publications into a named stream called `Sport`. For the stream to be available to a queue manager that runs on IBM MQ with queued publish/subscribe enabled, the stream must be added manually.

Queued publish/subscribe applications that subscribe to `Soccer/Results` on stream `Sport` work without change. Integrated publish/subscribe applications that subscribe to the topic `Sport` using MQSUB, and supplying the topic string `Soccer/Results` receive the same publications too.

The task of adding a stream is described in the topic Adding a stream. You might need to add streams manually for two reasons.

1. You continue to develop your queued publish/subscribe applications that are running on later version queue managers, rather than migrate the applications to the integrated publish/subscribe MQI interface.
2. The default mapping of streams to topics leads to a "collision" in topic space, and publications on a stream have the same topic string as publications from elsewhere.

Authorities

By default, at the root of the topic tree there are multiple topic objects: SYSTEM.BASE.TOPIC, SYSTEM.BROKER.DEFAULT.STREAM, and SYSTEM.BROKER.DEFAULT.SUBPOINT. Authorities (for example, for publishing or subscribing) are determined by the authorities on the SYSTEM.BASE.TOPIC ; any authorities on SYSTEM.BROKER.DEFAULT.STREAM or SYSTEM.BROKER.DEFAULT.SUBPOINT are ignored. If either of SYSTEM.BROKER.DEFAULT.STREAM or SYSTEM.BROKER.DEFAULT.SUBPOINT are deleted and re-created with a non-empty topic string, authorities defined on those objects are used in the same way as a normal topic object.

Mapping between streams and topics

A queued publish/subscribe stream is mimicked in IBM MQ by creating a queue, and giving it the same name as the stream. Sometimes the queue is called the stream queue, because that is how it appears to

queued publish/subscribe applications. The queue is identified to the publish/subscribe engine by adding it to the special namelist called SYSTEM.QPUBSUB.QUEUE.NAMELIST. You can add as many streams as you need, by adding additional special queues to the namelist. Finally you need to add topics, with the same names as the streams, and the same topic strings as the stream name, so you can publish and subscribe to the topics.

However, in exceptional circumstances, you can give the topics corresponding to the streams any topic strings you choose when you define the topics. The purpose of the topic string is to give the topic a unique name in the topic space. Typically the stream name serves that purpose perfectly. Sometimes, a stream name and an existing topic name collide. To resolve the problem, choose another topic string for the topic associated with the stream. Choose any topic string, ensuring it is unique.

The topic string defined in the topic definition is prefixed in the normal way to the topic string provided by publishers and subscribers using the MQOPEN or MQSUB MQI calls. Applications referring to topics using topic objects are not affected by the choice of prefix topic string - which is why you can choose any topic string that keeps the publications unique in the topic space.

The remapping of different streams onto different topics relies on the prefixes used for the topic strings being unique, to separate one set of topics completely from another. You must define a universal topic naming convention that is rigidly adhered to for the mapping to work.

In IBM MQ, you use the prefixing mechanism to remap a topic string to another place in topic space.

Note: When you delete a stream, delete all the subscriptions on the stream first. This action is most important if any of the subscriptions originate from other brokers in the broker hierarchy.

Subscription points and topics

Named subscription points are emulated by topics and topic objects.

To add subscription points manually, see Adding a subscription point.

Subscription points in IBM MQ

IBM MQ maps subscription points to different topic spaces within the IBM MQ topic tree. Topics in command messages without a subscription point are mapped unchanged to the root of the IBM MQ topic tree and inherit properties from SYSTEM.BASE.TOPIC.

Command messages with a subscription point are processing using the list of topic objects in SYSTEM.QPUBSUB.SUBPOINT.NAMELIST. The subscription point name in the command message is matched against the topic string for each of the topic objects in the list. If a match is found, then the subscription point name is prepended, as a topic node, to the topic string. The topic inherits its properties from the associated topic object found in SYSTEM.QPUBSUB.SUBPOINT.NAMELIST.

The effect of using subscription points is to create a separate topic space for each subscription point. The topic space is rooted in a topic that has the same name as the subscription point. Topics in each topic space inherit their properties from the topic object with the same name as the subscription point.

Any properties not set in the matching topic object are inherited, in the normal fashion, from SYSTEM.BASE.TOPIC.

Existing queued publish/subscribe applications, using MQRFH2 message headers, continue to work by setting the **SubPoint** property in the Publish or Register subscriber command messages. The subscription point is combined with the topic string in the command message and the resulting topic processed like any other.

IBM MQ applications are unaffected by subscription points. If an application uses a topic that inherits information from one of the matching topic objects, that application interoperates with a queued application using the matching subscription point.

Example

An existing WebSphere Message Broker (now known as IBM Integration Bus) publish/subscribe application that was migrated to IBM MQ created two topic objects, GBP and USD, with the corresponding topic strings `'GBP'` and `'USD'`.

Existing publishers to the topic `NYSE/IBM/SPOT`, migrated to run on IBM MQ, that use the subscription point USD create publications on the topic `USD/NYSE/IBM/SPOT`. Similarly existing subscribers to `NYSE/IBM/SPOT`, using the subscription point USD create subscriptions to `USD/NYSE/IBM/SPOT`.

Subscribe to the dollar spot price in an IBM MQ publish/subscribe program by calling MQSUB. Create a subscription using the USD topic object and the topic string `'NYSE/IBM/SPOT'`, as illustrated in the 'C' code fragment.

```
strncpy(sd.ObjectName, "USD", MQ_TOPIC_NAME_LENGTH);
sd.ObjectString.VSPtr = "NYSE/IBM/SPOT";
sd.ObjectString.VSLength = MQVS_NULL_TERMINATED;
MQSUB(Hconn, &sd, &Hobj, &Hsub, &CompCode, &Reason);
```

1. Set the CLUSTER attribute of the USD and GBP topic objects on the cluster topic host.
2. Delete all the copies of the USD and GBP topic objects on other queue managers in the cluster.
3. Make sure that USD and GBP are defined in `SYSTEM.QPUBSUB.SUBPOINT.NAMELIST` on every queue manager in the cluster.

Example of a single queue manager publish/subscribe configuration

Figure 31 on page 87 illustrates a basic single queue manager publish/subscribe configuration. The example shows the configuration for a news service, where information is available from publishers about several topics:

- Publisher 1 is publishing information about sports results using a topic of Sport
- Publisher 2 is publishing information about stock prices using a topic of Stock
- Publisher 3 is publishing information about film reviews using a topic of Films, and about television listings using a topic of TV

Three subscribers have registered an interest in different topics, so the queue manager sends them the information that they are interested in:

- Subscriber 1 receives the sports results and stock prices
- Subscriber 2 receives the film reviews
- Subscriber 3 receives the sports results

None of the subscribers have registered an interest in the television listings, so these are not distributed.

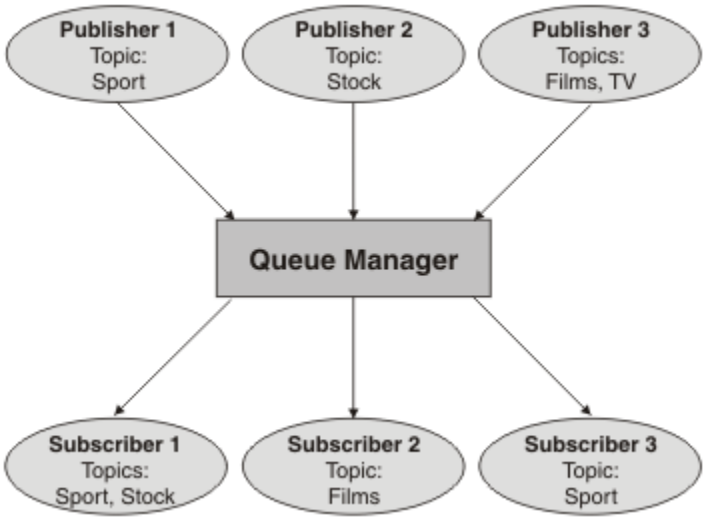


Figure 31. Single queue manager publish/subscribe example

Distributed publish/subscribe networks

Each queue manager matches messages published to a topic with the locally created subscriptions that have subscribed to that topic. You can configure a network of queue managers so that messages published by an application connected to one queue manager are delivered to matching subscriptions created on other queue managers in the network. This requires additional configuration over simple channels between queue managers.

A distributed publish/subscribe configuration is a set of queue managers connected together. The queue managers can all be on the same physical system, or they can be distributed over several physical systems. When you connect queue managers together, subscribers can subscribe to one queue manager and receive messages that were initially published to another queue manager. To illustrate this, the following figure adds a second queue manager to the configuration described in “Example of a single queue manager publish/subscribe configuration” on page 86.

- Queue manager 2 is used by Publisher 4 to publish weather forecast information, using a topic of Weather, and information about traffic conditions on major roads, using a topic of Traffic.
- Subscriber 4 also uses this queue manager, and subscribes to information about traffic conditions using topic Traffic.
- Subscriber 3 also subscribes to information about weather conditions, even though it uses a different queue manager from the publisher. This is possible because the queue managers are linked to each other.

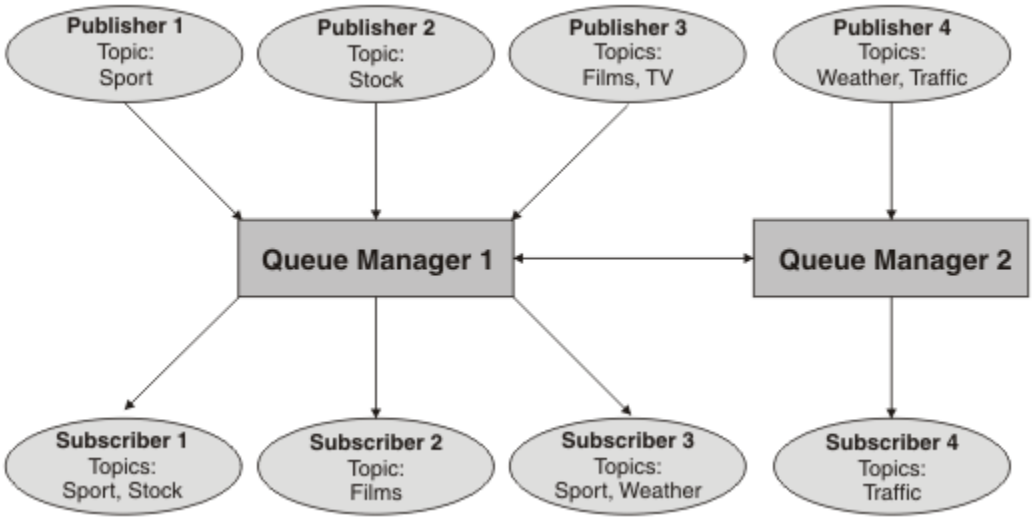


Figure 32. Publish/subscribe example with two queue managers

You can manually connect queue managers in a parent and child hierarchy, or you can create a publish/subscribe cluster and let IBM MQ define much of the connection detail for you. You can also use both topologies in combination, for example by joining several clusters together in a hierarchy.

Overview of publish/subscribe clusters

A publish/subscribe cluster is a standard cluster with one or more topic objects added to the cluster. When you define an administrative topic object on any queue manager in a cluster, and make that topic object clustered by specifying a cluster name, then publishers and subscribers to the topic can connect to any of the queue managers in the cluster, and messages published are routed to the subscribers over cluster channels between queue managers.

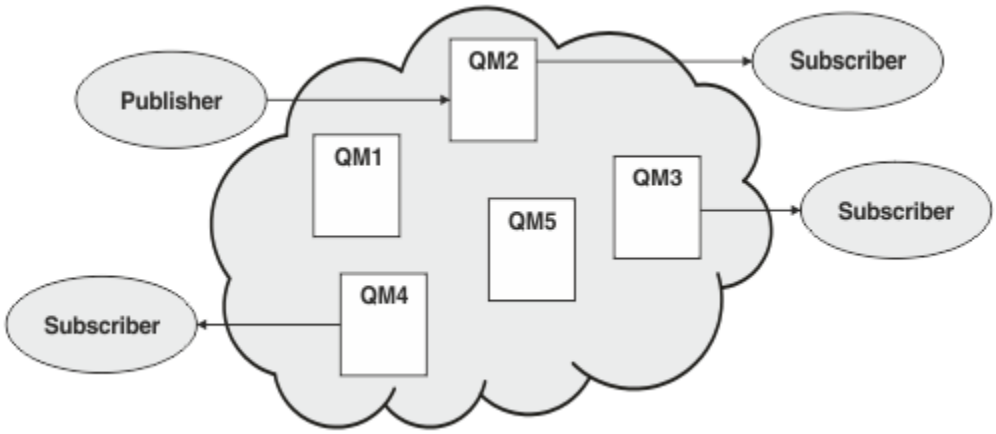


Figure 33. Publish/subscribe cluster

There are two ways to configure how publish/subscribe messages are routed in a cluster:

- direct routing
- topic host routing

When you configure a direct routed clustered topic, messages published on one queue manager are sent directly from that queue manager to every subscription on any other queue manager in the cluster. This can provide the most direct path for publications but does result in all queue managers in a cluster becoming aware of all other queue managers, each potentially having cluster channels established between them.

When you use topic host routing, messages published on one queue manager are sent from there to a queue manager that hosts a definition of the administered topic object. That *topic host queue manager* routes the message on to every subscription on any other queue manager in the cluster. If the publishers or subscribers are not located on the topic host queue managers, this results in a longer route for publications. However, the benefit is that only the topic host queue managers become aware of all other queue managers in the cluster, and potentially have cluster channels established with them.

For more information, see "Publish/subscribe clusters" on page 90.

Overview of publish/subscribe hierarchies

A publish/subscribe hierarchy is a set of queue managers connected by channels into a hierarchical structure. Each queue manager identifies its *parent* queue manager, as described in Connecting a queue manager to a publish/subscribe hierarchy.

Publishers and subscribers to a topic can connect to any queue manager in the hierarchy, and messages flow between them using the hierarchical queue manager connectivity.

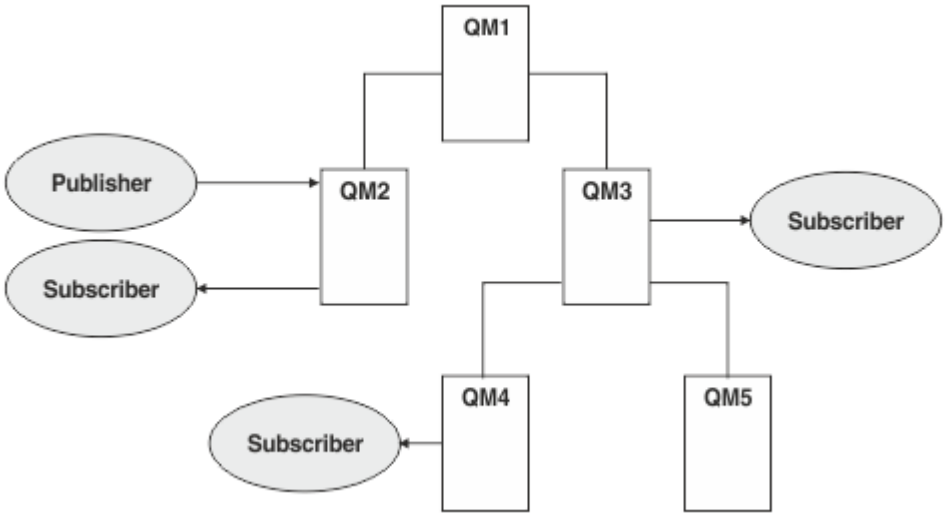


Figure 34. Publish/subscribe hierarchy

In the previous figure, publications delivered to the subscribers on QM3 and QM4 have been routed from QM2 to QM1 and then onto QM3 and finally QM4.

Hierarchies give you direct control over the relationships between every queue manager in the hierarchy. This allows fine-grained control over the routing of messages from publishers to subscribers, and is especially useful when routing between queue manager networks with restricted connectivity. You should give careful consideration to the availability and capability of every queue manager through which a message is routed on its way from publisher to subscribers.

For more information, see "Publish/subscribe hierarchies" on page 92.

Publication distribution between queue managers

In addition to the routing choices, there are two approaches to distributing publications across a network of queue managers:

- Only send publications from one queue manager to the queue managers that currently host a subscription for that publication.
- Send each publication to all queue managers, and let them match it against their subscriptions.

The former results in publication messages only being sent where necessary, but does require a level of subscription knowledge to be shared between queue managers. The latter does not require subscription

knowledge being shared, but can result in unnecessary publication messages being sent between queue managers.

By default, IBM MQ uses the former method, in which publications are only sent to queue managers that have subscriptions for them. The subscription knowledge is propagated between queue managers in the form of *proxy subscriptions*. It depends on the distribution and lifetime of subscriptions, and the frequency of publications, as to which is the most efficient to use in a distributed publish/subscribe topology. See Subscription performance in publish/subscribe networks.

Related concepts

"Topic trees" on page 74
Each topic that you define is an element, or node, in the topic tree. The topic tree can either be empty to start with or contain topics that have been defined previously using MQSC or PCF commands. You can define a new topic either by using the create topic commands or by specifying the topic for the first time in a publication or subscription.

Publish/subscribe hierarchy scenarios

Related tasks

Designing publish/subscribe clusters

Publish/subscribe clusters

A publish/subscribe cluster is a standard cluster of interconnected queue managers, on which publications are automatically moved from publishing applications to subscriptions that exist on any of the queue managers in the cluster. There are two options for routing publications across a publish/subscribe cluster: *direct routing* and *topic host routing*. The routing you choose depends upon the size and expected activity patterns for your cluster.

A cluster that is used for publish/subscribe messaging is no different from a standard IBM MQ cluster. As such, the queue managers within the publish/subscribe cluster can exist on physically separate computers and each pair of queue managers is automatically connected together by cluster channels when necessary. For more information, see Clusters.

To configure a standard cluster of queue managers for publish/subscribe messaging, you define one or more administered topic objects on a queue manager in the cluster. To make the topic a cluster topic, you configure the **CLUSTER** property with the name of the cluster. When you do this, any topic used by a publisher or subscriber at that point or below in the topic tree is shared across all queue managers in the cluster, and messages published to a clustered branch of the topic tree are automatically routed to subscriptions on other queue managers in the cluster.

Only one copy of each message is sent between the publisher queue manager and each of the other queue managers, irrespective of the number of subscribers for the message on the target queue manager. On arrival at a queue manager with one or more subscriptions, the message is duplicated across all subscriptions.

Any queue manager joining the cluster automatically becomes aware of the clustered topics, and publishers and subscribers on that queue manager automatically participate in the cluster.

Non-clustered publish/subscribe activity can also take place in a publish/subscribe cluster, by working with topic strings that do not fall under a clustered topic object.

There are two options for routing publications across a publish/subscribe cluster: *direct routing* and *topic host routing*. To choose the message routing to use within the cluster, you set the **CLROUTE** property on the administered topic object to one of the following values:

- **DIRECT**
- **TOPICHOST**

By default, topic routing is **DIRECT**. When you configure a direct routed clustered topic on a queue manager, all queue managers in the cluster become aware of all other queue managers in the cluster. When performing publish and subscribe operations, each queue manager can connect direct to any other queue manager in the cluster.

From IBM MQ 8.0, you can instead configure topic routing as **TOPICHOST**. When you use topic host routing, all queue managers in the cluster become aware of the cluster queue managers that host the routed topic definition (that is, the queue managers on which you have defined the topic object). When performing publish and subscribe operations, queue managers in the cluster connect only to these topic host queue managers, and not directly to each other. The topic host queue managers are responsible for routing publications from queue managers on which publications are published to queue managers with matching subscriptions.

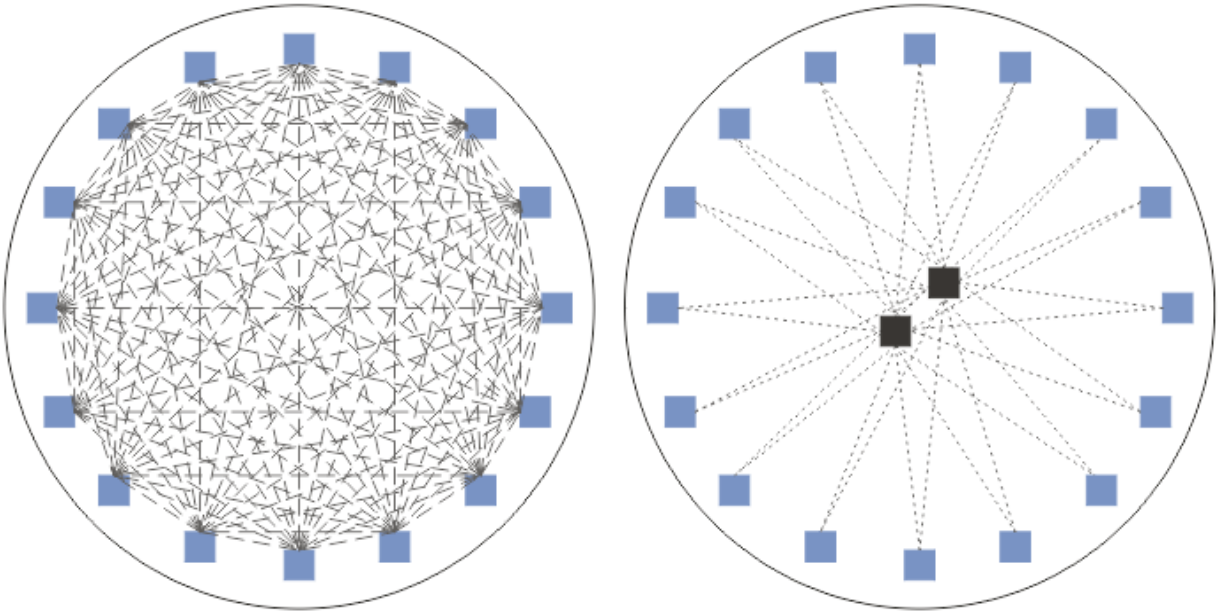


Figure 35. Direct routing and topic host routing

An overview of direct routing

When an administered topic object is configured for direct routing, the topic object only needs to be defined on one of the queue managers in the cluster for all queue managers to learn of it. The choice of queue manager on which the topic is defined does not affect the behavior of publish/subscribe messaging for the topic.

Each message flows directly from the publisher queue manager to each subscription on the other queue managers in the cluster, not passing through any intermediate queue managers.

By default, messages are sent only to other queue managers in the cluster that host one or more subscriptions.

- This relies on each queue manager directly informing all other queue managers in the cluster of all topics that currently have one or more subscriptions to it. This results in all queue managers in the cluster being aware of all topics being subscribed to, and any queue manager that hosts a subscription establishing a channel to every other queue manager. This is independent of whether each queue manager has a publisher.
- The knowledge of each individual subscribed topic on all queue managers can be removed by changing to a model of sending all publications to all queue managers in the cluster, irrespective of whether they have subscriptions. This reduces the subscription knowledge traffic, but is likely to increase the publication traffic and the number of channels each queue manager establishes. See Subscription performance in publish/subscribe networks.

Publish/subscribe message flows using direct routed clustered topics can span multiple publish/subscribe clusters by adding one queue manager from each cluster into a publish/subscribe hierarchy. See Combining the topic spaces of multiple clusters.

For a more detailed exploration of direct routing, see Direct routing in publish/subscribe clusters.

An overview of topic host routing

When an administered topic object is configured for topic host routing, publications from a queue manager in the cluster are routed through a queue manager where the topic object is configured (a "topic host"), and from there on to the queue managers where subscriptions exist.

- This relies on each queue manager informing all topic hosts of every topic that currently has one or more subscriptions to it. Any queue manager hosting a subscription establishes a channel to every topic host for the topic that the subscription relates to.
- Non-topic hosting queue managers are not made aware of other non-topic hosting queue managers in the cluster for the purposes of publish/subscribe, and channels are not established between them for that purpose.
- If the publishing application is connected to a queue manager hosting the topic, the published messages are routed directly to the queue managers where matching subscriptions have been created, without requiring an additional 'hop'. Similarly, if the matching subscriptions are created on the only queue manager hosting the topic, messages published to that topic are routed directly to that queue manager, without requiring an additional hop.
- Subscriptions on the same queue manager as the publisher are satisfied without first routing publications to the hosts of the topic object.

As for clustered queues, multiple queue managers can configure the same administrative topic object. This provides higher availability of message routing, and horizontal scaling through workload balancing. For topic host routed topic objects, when multiple queue managers configure the same named topic for the same branch of the topic tree, each topic host is made aware of the subscribed topics by every queue manager hosting a subscription.

- When a message is published, it is sent to one of the topic host queue managers to forward on to the subscription hosting queue managers. The choice of the topic host queue manager follows the same default workload balancing rules as for clustered point-to-point queues.
- If one or more topic host queue managers cannot be contacted by a publishing queue manager, messages are routed to the remaining available topic hosting queue managers.

Every publication to a topic in a routed branch of the topic tree is forwarded to one of the topic hosts, even if there are no subscriptions to that topic anywhere in the cluster. By default, messages are sent from here only to other queue managers in the cluster that host one or more subscriptions.

- This relies on each topic host queue manager being informed of all subscribed topic strings on each queue manager in the cluster.
- The knowledge of each individual subscribed topic can be removed by changing to a model of sending all publications routed to a topic host on to all queue managers in the cluster, irrespective of whether they have subscriptions. This reduces the subscription knowledge traffic but is likely to increase the publication traffic and potentially the number of channels established with each topic hosting queue manager. See Subscription performance in publish/subscribe networks.

Publish/subscribe message flows using topic host routed clustered topics **cannot** span multiple publish/subscribe clusters through the use of a publish/subscribe hierarchy.

For a more detailed exploration of topic host routing, see Topic host routing in publish/subscribe clusters.

Publish/subscribe hierarchies

You build a publish/subscribe hierarchy by linking the queue managers together using channels, then defining a child-parent relationship between pairs of queue managers. A message flows from a publisher to the subscriptions through the direct relations in a hierarchy. Note that this might mean multiple "hops" to get there.

Only one copy of the message is sent between any one pair of queue managers, irrespective of the number of subscribers for the message on the target queue manager. On arrival at a queue manager with one or more subscriptions, the message is duplicated across all subscriptions.

By default, messages are only sent to other queue managers in the hierarchy that are on the route to a subscription on another queue manager:

- This relies on each queue manager informing each direct relation of all topics that currently have one or more subscriptions to it, either on this queue manager or on one of its other relations. This results in all queue managers in the hierarchy being aware of all topics being subscribed to.
- This behavior can be changed to always send publications to all queue managers in the hierarchy, irrespective of any subscriptions existing. This removes the need for propagating the subscription information across the hierarchy, but can increase the publication traffic.

When you create a cluster, you need to take care not to create a loop causing messages to cycle forever within the network. No such loops can be created in a hierarchy.

Every queue manager must have a unique queue manager name.

Publish/subscribe message flows can span multiple publish/subscribe clusters. To do this, add one queue manager from each cluster into a publish/subscribe hierarchy.

For a more detailed exploration, see Routing in publish/subscribe hierarchies.

Proxy subscriptions in a publish/subscribe network

A proxy subscription is a subscription made by one queue manager for topics published on another queue manager. A proxy subscription flows between queue managers for each individual topic string that is subscribed to by a subscription. You do not create proxy subscriptions explicitly, the queue manager does so on your behalf.

You can connect queue managers together into a publish/subscribe cluster, or into a publish/subscribe hierarchy. Proxy subscriptions flow between the connected queue managers. Proxy subscriptions cause publications to a topic created by a publisher connected to one queue manager to be received by subscribers to that topic connected to other queue managers. See “Distributed publish/subscribe networks” on page 87.

In publish/subscribe topologies with many thousands of subscriptions to individual topic strings, or where the existence of those subscriptions might be rapidly changing, the overhead of proxy subscription propagation must be considered. In addition to the automatic aggregation described in the rest of this topic, you can make manual configuration changes that further restrict the flow of proxy subscriptions and publications between connected queue managers, and that reduce the latency of waiting for a proxy subscription to be propagated to all the connected queue managers. See Subscription performance in publish/subscribe networks.

Proxy subscriptions do not contain any selectors used by local subscriptions, and subscription topic strings that contain wildcards might be simplified. This can result in publications matching proxy subscriptions where the actual subscriptions do not, resulting in additional publication flow between queue managers. The queue manager hosting the subscriptions filters out such discrepancies so that additional publications are not returned to the subscriptions.

Proxy subscription aggregation

Proxy subscriptions are aggregated using a duplicate elimination system. For a particular resolved topic string, a proxy subscription is sent on the first local subscription or received proxy subscription. Subsequent subscriptions to the same topic string make use of this existing proxy subscription.

The proxy subscription is canceled after the last local subscription or received proxy subscription is canceled.

Publication aggregation

When there is more than one subscription to the same topic string on a queue manager, only a single copy of each publication matching that topic string is sent from other queue managers in the publish/subscribe topology. On arrival of the message, the local queue manager delivers a copy of the message to each matching subscription.

It is possible for more than one proxy subscription to match the topic string of a single publication when the proxy subscriptions contain wildcards. If a message is published on a queue manager that matches two or more proxy subscriptions created by a single connected queue manager, only one copy of the publication is forwarded to the remote queue manager to satisfy the multiple proxy subscriptions.

Related concepts

Loop detection in a distributed publish/subscribe network

Wildcards in proxy subscriptions

Subscriptions can use wildcards in topic strings to match against multiple topic strings in publications.

There are two wildcard schemas that a subscription can use: *topic-based* and *character-based*. See"Wildcard schemes" on page 68.

In IBM MQ all proxy subscriptions for wildcard subscriptions are converted to use topic-based wildcards. If a character-based wildcard is found, it is replaced with a # character, back to the nearest /. For example, `/aaa/bbb/c*d` is converted to `/aaa/bbb/#`. The conversion results in remote queue managers sending slightly more publications than were explicitly subscribed to. The additional publications are filtered out by the local queue manager, when it delivers the publications to its local subscribers.

Controlling wildcard usage with the WILDCARD property

Use the MQSC **Topic** WILDCARD property or the equivalent PCF Topic `WildcardOperation` property to control the delivery of publications to subscriber applications that use wildcard topic string names. The WILDCARD property can have one of two possible values:

WILDCARD
The behavior of wildcard subscriptions with respect to this topic.

PASSTHRU
Subscriptions made to a wildcarded topic less specific than the topic string at this topic object receive publications made to this topic and to topic strings more specific than this topic.

BLOCK
Subscriptions made to a wildcarded topic less specific than the topic string at this topic object do not receive publications made to this topic or to topic strings more specific than this topic.

The value of this attribute is used when subscriptions are defined. If you alter this attribute, the set of topics covered by existing subscriptions is not affected by the modification. This scenario applies also if the topology is changed when topic objects are created or deleted; the set of topics matching subscriptions created following the modification of the WILDCARD attribute is created using the modified topology. If you want to force the matching set of topics to be re-evaluated for existing subscriptions, you must restart the queue manager.

In the example, "Example: Create the Sport publish/subscribe cluster" on page 81, you can follow the steps to create the topic tree structure shown in Figure 23 on page 78.

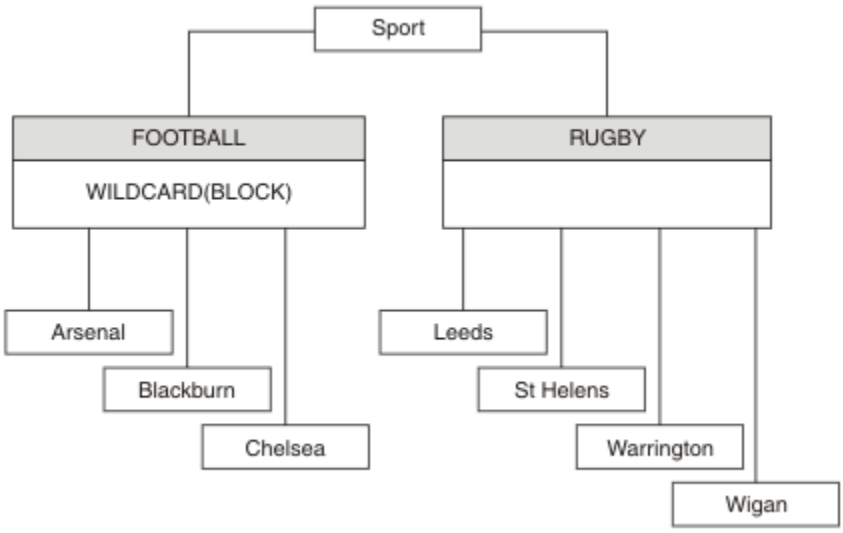


Figure 36. A topic tree that uses the WILDCARD property, BLOCK

A subscriber using the wildcard topic string `#` receives all publications to the `Sport` topic and the `Sport/Rugby` subtree. The subscriber receives no publications to the `Sport/Football` subtree, because the `WILDCARD` property value of the `Sport/Football` topic is `BLOCK`.

PASSTHRU is the default setting. You can set the `WILDCARD` property value PASSTHRU to nodes in the `Sport` tree. If the nodes do not have the `WILDCARD` property value `BLOCK`, setting PASSTHRU does not alter the behavior observed by subscribers to nodes in the `Sports` tree.

In the example, create subscriptions to see how the wildcard setting affects the publications that are delivered; see Figure 27 on page 83. Run the publish command in Figure 30 on page 84 to create some publications.

```
pub QMA
```

Figure 37. Publish to QMA

The results are shown in Table 3 on page 78. Notice how setting the `WILDCARD` property value `BLOCK`, prevents subscriptions with wildcards from receiving publications to topics within the scope of the wildcard.

Table 6. Publications received on QMA

Subscription	**Topic string**	**Publications received**	**Notes**

SPORTS	`Sports/#`	`Sports`
		`Sports/Rugby`
		`Sports/Rugby/Leeds`
			All publications to Football subtree blocked by `WILDCARD(BLOCK)` on `Sports/Football`

SARSENAL	`Sports/#/Arsenal`	-	`WILDCARD(BLOCK)` on `Sports/Football` prevents wildcard subscription on `Arsenal`
SLEEDS	`Sports/#/Leeds`	`Sports/Rugby/Leeds`	Default `WILDCARD` on `Sports/Rugby` does not prevent wildcard subscription on `Leeds`.

Note:

Suppose a subscription has a wildcard that matches a topic object with the WILDCARD property value BLOCK. If the subscription also has a topic string to the right of the matching wildcard, the subscription never receives a publication. The set of publications that are not blocked are publications to topics that are parents of the blocked wildcard. Publications to topics that are children of the topic with the BLOCK property value are blocked by the wildcard. Therefore subscription topic strings that include a topic to the right of the wildcard never receive any publications to match.

Setting the WILDCARD property value to BLOCK does not mean you cannot subscribe using a topic string that includes wildcards. Such a subscription is normal. The subscription has an explicit topic that matches the topic with a topic object having a WILDCARD property value BLOCK. It uses wildcards for topics that are parents or children of the topic with the WILDCARD property value BLOCK. In the example in Figure 23 on page 78, a subscription such as Sports/Football/# can receive publications.

Wildcards and cluster topics

Cluster topic definitions are propagated to every queue manager in a cluster. A subscription to a cluster topic at one queue manager in a cluster results in the queue manager creating proxy subscriptions. A proxy subscription is created at every other queue manager in the cluster. Subscriptions using topics strings containing wildcards, combined with cluster topics, can give hard to predict behavior. The behavior is explained in the following example.

In the cluster set up for the example, “Example: Create the Sport publish/subscribe cluster” on page 81, QMB has the same set of subscriptions as QMA, yet QMB received no publications after the publisher published to QMA, see Figure 24 on page 78. Although the Sports/Football and Sports/Rugby topics are cluster topics, the subscriptions defined in fullsubs.tst do not reference a cluster topic. No proxy subscriptions are propagated from QMB to QMA. Without proxy subscriptions, no publications to QMA are forwarded to QMB.

Some of the subscriptions, such as Sports/#/Leeds, might seem to reference a cluster topic, in this case Sports/Rugby. The Sports/#/Leeds subscription actually resolves to the topic object SYSTEM.BASE.TOPIC.

The rule for resolving the topic object referenced by a subscription such as, Sports/#/Leeds is as follows. Truncate the topic string to the first wildcard. Scan left through the topic string looking for the first topic that has an associated administrative topic object. The topic object might specify a cluster name, or define a local topic object. In the example, Sports/#/Leeds, the topic string after truncation is Sports, which has no topic object, and so Sports/#/Leeds inherits from SYSTEM.BASE.TOPIC, which is a local topic object.

To see how subscribing to clustered topics can change the way wildcard propagation works, run the batch script, upsubs.bat. The script clears the subscription queues, and adds the cluster topic subscriptions in fullsubs.tst. Run puba.bat again to create a batch of publications; see Figure 24 on page 78.

Table 4 on page 80 shows the result of adding two new subscriptions to the same queue manager that the publications were published on. The result is as expected, the new subscriptions receive one publication each, and the numbers of publications received by the other subscriptions are unchanged. The unexpected results occur on the other cluster queue manager; see Table 5 on page 80.

Table 7. Publications received on QMA

Subscription	Topic string	Publications received	Notes
SPORTS	Sports/#	Sports Sports/Rugby Sports/Rugby/Leeds	All publications to Football subtree blocked by WILDCARD(BLOCK) on Sports/Football
SARSENAL	Sports/#/Arsenal	-	WILDCARD(BLOCK) on Sports/Football prevents wildcard subscription on Arsenal

Table 7. Publications received on QMA (continued)			
Subscription	**Topic string**	**Publications received**	**Notes**
SLEEDS	Sports/#/Leeds	Sports/Rugby/Leeds	Default WILDCARD on Sports/Rugby does not prevent wildcard subscription on Leeds.
FARSENAL	Sports/Football/Arsenal	Sports/Football/Arsenal	Arsenal receives a publication because the subscription does not have a wildcard.
FLEEDS	Sports/Rugby/Leeds	Sports/Rugby/Leeds	Leeds would receive a publication in any event.

Table 5 on page 80 shows the results of adding the two new subscriptions on QMB and publishing on QMA. Recall that QMB received no publications without these two new subscriptions. As expected, the two new subscriptions receive publications, because Sports/FootBall and Sports/Rugby are both cluster topics. QMB forwarded proxy subscriptions for Sports/Football/Arsenal and Sports/Rugby/Leeds to QMA, which then sent the publications to QMB.

The unexpected result is that the two subscriptions Sports/# and Sports/#/Leeds that previously received no publications, now receive publications. The reason is that the Sports/Football/Arsenal and Sports/Rugby/Leeds publications forwarded to QMB for the other subscriptions are now available for any subscriber attached to QMB. Consequently the subscriptions to the local topics Sports/# and Sports/#/Leeds receive the Sports/Rugby/Leeds publication. Sports/#/Arsenal continues not to receive a publication, because Sports/Football has its WILDCARD property value set to BLOCK.

Table 8. Publications received on QMB			
Subscription	**Topic string**	**Publications received**	**Notes**
SPORTS	*Sports/#*	*Sports/Rugby/Leeds*	*All publications to Football subtree blocked by WILDCARD(BLOCK) on Sports/Football*
SARSENAL	Sports/#/Arsenal	-	WILDCARD(BLOCK) on Sports/Football prevents wildcard subscription on Arsenal
SLEEDS	*Sports/#/Leeds*	*Sports/Rugby/Leeds*	*Default WILDCARD on Sports/Rugby does not prevent wildcard subscription on Leeds.*
FARSENAL	Sports/Football/Arsenal	Sports/Football/Arsenal	Arsenal receives a publication because the subscription does not have a wildcard.
FLEEDS	Sports/Rugby/Leeds	Sports/Rugby/Leeds	Leeds would receive a publication in any event.

In most applications, it is undesirable for one subscription to influence the behavior of another subscription. One important use of the WILDCARD property with the value BLOCK is to make the subscriptions to the same topic string containing wildcards behave uniformly. Whether the subscription is on the same queue manager as the publisher, or a different one, the results of the subscription are the same.

Wildcards and streams

For a new application written to the publish/subscribe API, the effect is that a subscription to * receives no publications. To receive all the Sports publications you must subscribe to Sports/*, or Sports/#, and similarly for Business publications.

The behavior of an existing queued publish/subscribe application does not change when the publish/subscribe broker is migrated to a later version of IBM MQ. The **StreamName** property in the **Publish**, **Register Publisher**, or **Subscriber** commands is mapped to the name of the topic the stream has been migrated to.

Wildcards and subscription points

For a new application written to the publish/subscribe API, the effect of the migration is that a subscription to * receives no publications. To receive all the Sports publications you must subscribe to Sports/*, or Sports/#, and similarly for Business publications.

The behavior of an existing queued publish/subscribe application does not change when the publish/subscribe broker is migrated to a later version of IBM MQ. The **SubPoint** property in the **Publish**, **Register Publisher**, or **Subscriber** commands is mapped to the name of the topic the subscription has been migrated to.

Example: Create the Sport publish/subscribe cluster

The steps that follow create a cluster, CL1, with four queue managers: two full repositories, CL1A and CL1B, and two partial repositories, QMA and QMB. The full repositories are used to hold only cluster definitions. QMA is designated the cluster topic host. Durable subscriptions are defined on both QMA and QMB.

Note: The example is coded for Windows. You must recode Create qmgrs.bat and create pub.bat to configure and test the example on other platforms.

1. Create the script files.
    a. Create topics.tst
    b. Create wildsubs.tst
    c. Create fullsubs.tst
    d. Create qmgrs.bat
    e. create pub.bat
2. Run Create qmgrs.bat to create the configuration.

```
qmgrs
```

Create the topics in Figure 23 on page 78. The script in figure 5 creates the cluster topics Sports/Football and Sports/Rugby.

Note: The REPLACE option does not replace the TOPICSTR properties of a topic. TOPICSTR is a property that is usefully varied in the example to test different topic trees. To change topics, delete the topic first.

```
DELETE TOPIC ('Sports')
DELETE TOPIC ('Football')
DELETE TOPIC ('Arsenal')
DELETE TOPIC ('Blackburn')
DELETE TOPIC ('Chelsea')
DELETE TOPIC ('Rugby')
DELETE TOPIC ('Leeds')
DELETE TOPIC ('Wigan')
DELETE TOPIC ('Warrington')
DELETE TOPIC ('St. Helens')

DEFINE TOPIC ('Sports')   TOPICSTR('Sports')
DEFINE TOPIC ('Football')  TOPICSTR('Sports/Football') CLUSTER(CL1) WILDCARD(BLOCK)
DEFINE TOPIC ('Arsenal')  TOPICSTR('Sports/Football/Arsenal')
DEFINE TOPIC ('Blackburn') TOPICSTR('Sports/Football/Blackburn')
DEFINE TOPIC ('Chelsea')  TOPICSTR('Sports/Football/Chelsea')
DEFINE TOPIC ('Rugby')   TOPICSTR('Sports/Rugby')  CLUSTER(CL1)
DEFINE TOPIC ('Leeds')   TOPICSTR('Sports/Rugby/Leeds')
DEFINE TOPIC ('Wigan')   TOPICSTR('Sports/Rugby/Wigan')
DEFINE TOPIC ('Warrington') TOPICSTR('Sports/Rugby/Warrington')
DEFINE TOPIC ('St. Helens') TOPICSTR('Sports/Rugby/St. Helens')
```

Figure 38. Delete and create topics: topics.tst

Note: Delete the topics, as REPLACE does not replace topic strings.

Create subscriptions with wildcards. The wildcards corresponding the topics with topic objects in Figure 23 on page 78. Create a queue for each subscription. The queues are cleared and the subscriptions deleted when the script is run or rerun.

Note: The REPLACE option does not replace TOPICOBJ or TOPICSTR properties of a subscription. TOPICOBJ or TOPICSTR are the properties that are usefully varied in the example to test different subscriptions. To change them, delete the subscription first.

```
DEFINE QLOCAL(QSPORTS)  REPLACE
DEFINE QLOCAL(QSARSENAL) REPLACE
DEFINE QLOCAL(QSLEEDS)  REPLACE
CLEAR QLOCAL(QSPORTS)
CLEAR QLOCAL(QSARSENAL)
CLEAR QLOCAL(QSLEEDS)

DELETE SUB  (SPORTS)
DELETE SUB  (SARSENAL)
DELETE SUB  (SLEEDS)
DEFINE SUB  (SPORTS)  TOPICSTR('Sports/#')     DEST(QSPORTS)
DEFINE SUB  (SARSENAL) TOPICSTR('Sports/+/Arsenal') DEST(QSARSENAL)
DEFINE SUB  (SLEEDS)  TOPICSTR('Sports/+/Leeds')  DEST(QSLEEDS)
```

Figure 39. Create wildcard subscriptions: wildsubs.tst

Create subscriptions that reference the cluster topic objects.

Note:

The delimiter, /, is automatically inserted between the topic string referenced by TOPICOBJ, and the topic string defined by TOPICSTR.

The definition, `DEFINE SUB(FARSENAL) TOPICSTR('Sports/Football/Arsenal') DEST(QFARSENAL)` creates the same subscription. TOPICOBJ is used as a quick way to reference topic string you have already defined. The subscription, when created, no longer refers to the topic object.

```
DEFINE QLOCAL(QFARSENAL) REPLACE
DEFINE QLOCAL(QRLEEDS)  REPLACE
CLEAR QLOCAL(QFARSENAL)
CLEAR QLOCAL(QRLEEDS)

DELETE SUB  (FARSENAL)
DELETE SUB  (RLEEDS)
DEFINE SUB  (FARSENAL) TOPICOBJ('Football') TOPICSTR('Arsenal') DEST(QFARSENAL)
DEFINE SUB  (RLEEDS)  TOPICOBJ('Rugby')  TOPICSTR('Leeds')  DEST(QRLEEDS)
```

Figure 40. Delete and create subscriptions: fullsubs.tst

Create a cluster with two repositories. Create two partial repositories for publishing and subscribing. Rerun the script to delete everything and start again. The script also creates the topic hierarchy, and the initial wildcard subscriptions.

Note:

On other platforms, write a similar script, or type all the commands. Using a script makes it quick to delete everything and start again with an identical configuration.

```
@echo off
set port.CL1B=1421
set port.CLIA=1420
for %%A in (CL1A CL1B QMA QMB) do call :createQM %%A
call :configureQM CL1A CL1B %port.CL1B% full
call :configureQM CL1B CL1A %port.CL1A% full
for %%A in (QMA QMB) do call :configureQM %%A CL1A %port.CL1A% partial
for %%A in (topics.tst wildsubs.tst) do runmqsc QMA < %%A
for %%A in (wildsubs.tst) do runmqsc QMB < %%A
goto:eof

:createQM
echo Configure Queue manager %1
endmqm -p %1
for %%B in (dlt crt str) do %%Bmqm %1
goto:eof

:configureQM
if %1==CL1A set p=1420
if %1==CL1B set p=1421
if %1==QMA set p=1422
if %1==QMB set p=1423
echo configure %1 on port %p% connected to repository %2 on port %3 as %4 repository
echo DEFINE LISTENER(LST%1) TRPTYPE(TCP) PORT(%p%) CONTROL(QMGR) REPLACE | runmqsc %1
echo START LISTENER(LST%1) | runmqsc %1
if full==%4 echo ALTER QMGR REPOS(CL1) DEADQ(SYSTEM.DEAD.LETTER.QUEUE) | runmqsc %1
echo DEFINE CHANNEL(TO.%2) CHLTYPE(CLUSSDR) TRPTYPE(TCP) CONNAME('LOCALHOST(%3)') CLUSTER(CL1)
REPLACE | runmqsc %1
echo DEFINE CHANNEL(TO.%1) CHLTYPE(CLUSRCVR) TRPTYPE(TCP) CONNAME('LOCALHOST(%p%)')
CLUSTER(CL1) REPLACE | runmqsc %1
goto:eof
```

Figure 41. Create queue managers: qmgrs.bat

Update the configuration by adding the subscriptions to the cluster topics.

```
@echo off
for %%A in (QMA QMB) do runmqsc %%A < wildsubs.tst
for %%A in (QMA QMB) do runmqsc %%A < upsubs.tst
```

Figure 42. Update subscriptions: upsubs.bat

Run `pub.bat`, with a queue manager as a parameter, to publish messages containing the publication topic string. `Pub.bat` uses the sample program **amqspub**.

```
@echo off
@rem Provide queue manager name as a parameter
set S=Sports
set S=6 Sports/Football Sports/Football/Arsenal
set S=6 Sports/Rugby Sports/Rugby/Leeds
for %%B in (6) do echo %%B | amqspub %%B %1
```

Figure 43. Publish: pub.bat

Related concepts

Wildcard subscriptions and retained publications

Publication scope

When you configure a publish/subscribe cluster or hierarchy, the scope of a publication further controls whether queue managers forward a publication to remote queue managers. Use the **PUBSCOPE** topic attribute to administer the scope of publications.

If a publication is not forwarded to remote queue managers, only local subscribers receive the publication.

When you use a publish/subscribe cluster, the scope of publications is primarily controlled by the definition of clustered topic objects at certain points in the topic tree. Publication scope must be set to allow the flow of publications to other queue managers in the cluster. You should only restrict publication scope for a clustered topic when you need fine-grain control of specific topics on certain queue managers.

When you use a publish/subscribe hierarchy, the scope of publications is primarily controlled by this attribute in combination with the subscription scope attribute.

The **PUBSCOPE** attribute is used to determine the scope of publications made to a specific topic. You can set the attribute to one of the following values:

QMGR
: The publication is delivered only to local subscribers. These publications are called *local publications*. Local publications are not forwarded to remote queue managers and therefore are not received by subscribers connected to remote queue managers.

ALL
: The publication is delivered to local subscribers and subscribers connected to remote queue managers in a publish/subscribe cluster or hierarchy. These publications are called *global publications*.

ASPARENT
: Use the **PUBSCOPE** setting of the parent topic in the topic tree.

Publishers can also specify whether a publication is local or global using the MQPMO_SCOPE_QMGR put message option. If this option is used, it overrides any behavior that has been set using the **PUBSCOPE** topic attribute.

Related concepts

“Administrative topic objects” on page 75
Using an administrative topic object, you can assign specific, non-default attributes to topics.

Related tasks

Configuring distributed publish/subscribe networks

Subscription scope

The scope of a subscription controls whether a subscription on one queue manager receives publications that are published on another queue manager in a publish/subscribe cluster or hierarchy, or only publications from local publishers.

Limiting the subscription scope to a queue manager stops proxy subscriptions from being forwarded to other queue managers in the publish/subscribe topology. This reduces inter-queue manager publish/subscribe messaging traffic.

When you use a publish/subscribe cluster, the scope of subscriptions is primarily controlled by the definition of clustered topic objects at certain points in the topic tree. Subscription scope must be set to allow the flow of proxy subscriptions to other queue managers in the cluster. You should only restrict subscription scope for a clustered topic when you need fine-grain control of specific topics on certain queue managers.

When you use a publish/subscribe hierarchy, the scope of subscriptions is primarily controlled by this attribute in combination with the publication scope attribute.

The **SUBSCOPE** topic attribute is used to determine the scope of subscriptions made to a specific topic. You can set the attribute to one of the following values:

QMGR
: A subscription receives only local publications, and proxy subscriptions are not propagated to remote queue managers.

ALL
: A proxy subscription is propagated to remote queue managers in a publish/subscribe cluster or hierarchy, and the subscriber receives local and remote publications.

ASPARENT
: Use the **SUBSCOPE** setting of the parent topic in the topic tree.

When subscription scope for a topic is set to `ALL`, either directly or resolved through `ASPARENT`, individual subscriptions to that topic can restrict their scope to `QMGR` by specifying `MQSO_SCOPE_QMGR` when creating the subscription. A subscription to a topic that has a scope of `QMGR` cannot widen the scope to `ALL`.

Related concepts

“Administrative topic objects” on page 75
Using an administrative topic object, you can assign specific, non-default attributes to topics.

Related tasks

Configuring distributed publish/subscribe networks

Topic spaces

A topic space is the set of topics on which you can subscribe and publish. A queue manager in a distributed publish/subscribe topology has a topic space that potentially includes topics that have been subscribed and published to on connected queue managers in that topology.

Note: For an overview of topics within a queue manager, such as administrative topic objects, topic strings and topic trees, see“Topics” on page 66. Further references to *topics* in the current article refer to *topic strings* unless otherwise specified.

Topics are initially created in either of the following ways:

- administratively, when you define a topic object or durable subscription.
- dynamically, when an application creates a publication or subscription dynamically to a new topic.

Topics are propagated to other queue managers both through proxy subscriptions, and by creating administrative cluster topic objects. Proxy subscriptions result in publications being forwarded from the queue manager to which a publisher is connected, to the queue managers of subscribers.

Proxy subscriptions are propagated between all queue managers that are connected together by parent-child relationships in a queue manager hierarchy. The result is, you can subscribe on one queue manager to a topic defined on any other queue manager in the hierarchy. As long as there is a connected path between the queue managers, it does not matter how the queue managers are connected.

Proxy subscriptions are also propagated for subscriptions to cluster topics in a publish/subscribe cluster. A cluster topic is a topic that is attached to a topic object that has the **CLUSTER** attribute, or inherits the attribute from its parent. Topics that are not cluster topics are known as local topics and are not replicated to the cluster. No proxy subscriptions are propagated to the cluster from subscriptions to local topics.

To summarize, proxy subscriptions are created for subscribers in two circumstances.

1. A queue manager is a member of a hierarchy, and a proxy subscription is forwarded to the parent and children of the queue manager.
2. A queue manager is a member of a cluster, and the subscription topic string resolves to a topic that is associated with a cluster topic object. When the topic is a *direct routed* cluster topic, proxy subscriptions are forwarded to all members of the cluster. When the topic is a *topic host routed* cluster topic, proxy subscriptions are forwarded only to the queue managers in the cluster that have defined the clustered topic object. For more information see“Publish/subscribe clusters” on page 90.

If a queue manager is a member of a cluster and a hierarchy, proxy subscriptions are propagated by both mechanisms without delivering duplicate publications to the subscriber.

The topics spaces of three publish/subscribe topologies are described in the following list:

- “Case 1. Publish/subscribe clusters” on page 103.
- “Case 2. Publish/subscribe hierarchies” on page 104.

In separate topics, the following configuration tasks describe how to combine topic spaces.

- Creating a single topic space in a publish/subscribe cluster.
- Combining the topic spaces of multiple clusters.
- Combining and isolating topic spaces in multiple clusters.
- Publishing and subscribing to topic spaces in multiple clusters.

Case 1. Publish/subscribe clusters

In the example, assume that the queue manager is not connected to a publish/subscribe hierarchy.

If a queue manager is a member of a publish/subscribe cluster, its topic space is made up from local topics and cluster topics. Local topics are associated with topic objects without the **CLUSTER** attribute. If a queue manager has local topic object definitions, its topic space is different from another queue manager in the cluster that also has its own locally defined topic objects.

In a publish/subscribe cluster, you cannot subscribe to a topic defined on another queue manager, unless the topic you subscribe to resolves to a cluster topic object.

When the same named definitions of a cluster topic object are required on multiple queue managers, for example when using *topic host routing*, it is important that all definitions match where necessary. For more information, see Creating a single topic space in a publish/subscribe cluster.

A local definition of a topic object, whether the definition is for a cluster topic or a local topic, takes precedence over the same topic object defined elsewhere in the cluster. The locally defined topic is used, even if the object defined elsewhere is more recent.

It is important that a cluster topic object is associated with the same topic string everywhere in the cluster. You cannot modify the topic string with which a topic object is associated. To associate the same topic object with a different topic string, you must delete the topic object and re-create it with the new topic string. If the topic is clustered, the effect is to delete the copies of the topic object stored on the other members of the cluster and then to create copies of the new topic object everywhere in the cluster. The copies of the topic object all refer to the same topic string.

It is possible to accidentally create two definitions of the same named topic object on different queue managers in the cluster, with different topic strings. This can result in confusing behavior, because multiple definitions of the same topic object with different topic strings can produce different results depending how and where the topic is referenced. See Multiple cluster topic definitions of the same name for more information on this important point.

Case 2. Publish/subscribe hierarchies

In the example, assume that the queue manager is not a member of a publish/subscribe cluster.

In IBM MQ, if a queue manager is a member of a publish/subscribe hierarchy, its topic space consists of all the topics defined locally and on connected queue managers. The topic space of all the queue managers in a hierarchy is the same. There is no division of topics into local topics and global topics.

Set either of the **PUBSCOPE** and **SUBSCOPE** options to `QMGR`, to prevent a publication on a topic flowing from a publisher to a subscriber connected to different queue managers in the hierarchy.

Suppose you define a topic object `Alabama` with the topic string `USA/Alabama` on queue manager `QMA`. The result is as follows:

1. The topic space at `QMA` now includes the topic object `Alabama` and the topic string `USA/Alabama`.
2. An application or administrator can create a subscription at `QMA` using the topic object name `Alabama`.
3. An application can create a subscription to any topic, including `USA/Alabama`, at any queue manager in the hierarchy. If `QMA` has not been defined locally, the topic `USA/Alabama` resolves to the topic object `SYSTEM.BASE.TOPIC`.

Related concepts

"Publication scope" on page 101
When you configure a publish/subscribe cluster or hierarchy, the scope of a publication further controls whether queue managers forward a publication to remote queue managers. Use the **PUBSCOPE** topic attribute to administer the scope of publications.

"Subscription scope" on page 102
The scope of a subscription controls whether a subscription on one queue manager receives publications that are published on another queue manager in a publish/subscribe cluster or hierarchy, or only publications from local publishers.

Related tasks

Configuring distributed publish/subscribe networks

IBM MQ Multicast

IBM MQ Multicast offers low latency, high fan out, reliable multicast messaging.

Multicast is an efficient form of publish/subscribe messaging as it can be scaled to a high number of subscribers without detrimental effects in performance. IBM MQ enables reliable Multicast messaging by using acknowledgments, negative acknowledgments, and sequence numbers to achieve low latency messaging with high fan out.

IBM MQ Multicast's fair delivery enables near simultaneous delivery, ensuring that no recipient gains an advantage. As IBM MQ Multicast uses the network to deliver messages, a publish/subscribe engine is not needed to fan-out data. After a topic is mapped to a group address, there is no need for a queue manager because publishers and subscribers can operate in a peer-to-peer mode. This allows the load to be reduced on queue manager servers, and the queue manager server is no longer a potential point of failure.

Initial multicast concepts

IBM MQ Multicast can be easily integrated into existing systems and applications by using the Communication Information (COMMINFO) object. Two TOPIC object fields enable the quick configuration of existing TOPIC objects to support or ignore multicast traffic.

Objects needed for multicast

The following information is a brief overview of the two objects needed for IBM MQ Multicast:

COMMINFO object
The COMMINFO object contains the attributes associated with multicast transmission. For more information about the COMMINFO object parameters, see DEFINE COMMINFO.

The only COMMINFO field that MUST be set is the name of the COMMINFO object. This name is then used to identify the COMMINFO object to a topic. The **GRPADDR** field of the COMMINFO object must be checked to ensure that the value is a valid multicast group address.

TOPIC object
A topic is the subject of the information that is published in a publish/subscribe message, and a topic is defined by creating a TOPIC object. For more information about the TOPIC object parameters, see DEFINE TOPIC.

Existing topics can be used with multicast by changing the values of the following TOPIC object parameters: **COMMINFO** and **MCAST**.

- **COMMINFO** This parameter specifies the name of the multicast communication information object.
- **MCAST** This parameter specifies whether multicast is allowable at this position in the topic tree. By default, **MCAST** is set to ASPARENT meaning that the multicast attribute of the topic is inherited from the parent. Setting **MCAST** to ENABLED allows multicast traffic at this node.

Multicast networks and topics

The following information is an overview of what happens to subscriptions with different types of subscription and topic definition. These examples all assume that the TOPIC object **COMMINFO** parameter is set to the name of a valid COMMINFO object:

Topic set to multicast enabled
If the topic string **MCAST** parameter is set to ENABLED, subscriptions from multicast capable clients are allowed and a multicast subscription is made unless:

- It is a durable subscription from a multicast capable client.
- It is a non-managed subscription from a multicast capable client.
- It is a subscription from a non-multicast capable client.

In these cases a non-multicast subscription is made and subscriptions are downgraded to normal publish/subscribe.

Topic set to multicast disabled
If the topic string **MCAST** parameter is set to DISABLED, a non-multicast subscription is always made and subscriptions are downgraded to normal publish/subscribe.

Topic set to multicast only
If the topic string **MCAST** parameter is set to ONLY, subscriptions from multicast capable clients are allowed and a multicast subscription is made unless:

- It is a durable subscription: Durable subscriptions are rejected with reason code 2436 (0984) (RC2436): MQRC_DURABILITY_NOT_ALLOWED
- It is a non-managed subscription: Non-managed subscriptions are rejected with reason code 2046 (07FE) (RC2046): MQRC_OPTIONS_ERROR
- It is a subscription from a non-multicast capable client: These subscriptions are rejected with reason code 2560 (0A00) (RC2560): MQRC_MULTICAST_ONLY

- It is a subscription from a locally bound application: These subscriptions are rejected with reason code 2560 (0A00) (RC2560): MQRC_MULTICAST_ONLY

Windows Linux AIX MQ Telemetry overview

MQ Telemetry comprises a telemetry (MQXR) service that is part of a queue manager, telemetry clients that you can write yourself or download for free, and command line and explorer administrative interfaces. Telemetry refers to collecting data from and administering a wide range of remote devices. With MQ Telemetry you can integrate the collection of data and control of devices with web applications.

MQ Telemetry is a component of IBM MQ. Upgrading for these versions is essentially installing a later version of IBM MQ.

Sample applications continue to be freely available from Eclipse Paho and MQTT.org. See IBM MQ Telemetry Transport sample programs.

Because MQ Telemetry is a component of IBM MQ, MQ Telemetry can be installed with the main product, or after the main product has been installed. For migration information, see Migrating MQ Telemetry on Windows and Migrating MQ Telemetry on Linux.

Included in MQ Telemetry are the following components:

Telemetry channels
Use telemetry channels to manage the connection of MQTT clients to IBM MQ . Telemetry channels use new IBM MQ objects, such as the `SYSTEM.MQTT.TRANSMIT.QUEUE`, to interact with IBM MQ.

Telemetry (MQXR) service
MQTT clients use the `SYSTEM.MQXR.SERVICE` telemetry service to connect to telemetry channels.

IBM MQ Explorer support for MQ Telemetry
MQ Telemetry can be administered using IBM MQ Explorer.

Documentation
MQ Telemetry documentation is included in the standard IBM MQ product documentation. SDK documentation for Java and C clients is provided in the product documentation, and as Javadoc and HTML.

Telemetry concepts

You collect information from the environment all around you to decide what to do. As a consumer, you check what you have in store, before deciding about what food to buy. You want to know how long a journey is going to take if you leave now, before booking a connection. You check your symptoms, before deciding whether to visit the doctor. You check when a bus is going to arrive, before deciding whether to wait. The information for those decisions comes directly from meters and devices, from the written word on paper or from a screen, and from you. Where ever you are, and when ever you need to, you collect information, bring it together, analyze it, and act upon it.

If the sources of information are widely dispersed or inaccessible, it becomes difficult and costly to collect the most accurate information. If there are many changes you want to make, or it is difficult to make the changes, then the changes do not get made, or are made when they are less effective.

What if the costs of collecting information from, and controlling, widely dispersed devices is greatly reduced by connecting the devices with digital technology to the internet? The information can be analyzed using the resources of the internet and the enterprise. You have more opportunities to make informed decisions and act upon them.

Technological trends, and environmental and economic pressures, are driving these changes to happen:

1. The cost of connecting and controlling sensors and actuators is reducing, due to standardization and connection to low cost digital processors.
2. The internet, and internet technologies, are increasingly used to connect devices. In some countries, mobile phones exceed personal computers in the number of connections to internet applications. Other devices are surely following.

3. The internet, and internet technologies, make it much easier for an application to get data. Easy access to data is driving the use of data analytics to turn data from sensors into information that is useful in many more solutions.
4. Intelligent use of resources is often a quicker and cheaper way of reducing carbon emissions and costs. The alternatives: finding new resources, or developing new technologies to use existing resources, might be the long-term solution. In the short term developing new technologies, or finding new resources, is often riskier, slower, and more costly, than improving existing solutions.

Example

An example shows how these trends create new opportunities to interact with the environment intelligently.

The International Convention for the Safety of Life at Sea (SOLAS) requires Automatic Identification System (AIS) to be deployed on many ships. It is required on merchant ships over 300 tons and passenger ships. AIS is primarily a collision avoidance system for coastal shipping. It is used by marine authorities to monitor and control coastal waters.

Enthusiasts around the world are deploying low-cost AIS tracking stations and placing coastal shipping information onto the internet. Other enthusiasts are writing applications that combine information from AIS with other information from the internet. The results are put on websites, and published using Twitter and SMS.

In one application, information from AIS stations near Southampton is combined with ship ownership and geographical information. The application feeds live information about ferry arrivals and departures to Twitter. Regular commuters using the ferries between Southampton and the Isle of Wight subscribe to the news feed using Twitter or SMS. If the feed shows their ferry is running late, commuters can delay their departure and catch the ferry when it docks later than its scheduled arrival time.

For more examples, see “Telemetry use cases” on page 108.

Related tasks

Installing MQ Telemetry
Administering MQ Telemetry
Migrating MQ Telemetry on Windows
Migrating MQ Telemetry on Linux
Developing applications for MQ Telemetry
Troubleshooting MQ Telemetry problems

Related reference

MQ Telemetry Reference

Windows Linux AIX

Introduction to MQ Telemetry

People, businesses, and governments increasingly want to use MQ Telemetry to interact more smartly with the environment we live and work in. MQ Telemetry connects all kinds of devices to the internet and to the enterprise, and reduces the costs of building applications for smart devices.

What is MQ Telemetry?

- It is a feature of IBM MQ that extends the universal messaging backbone provided by IBM MQ to a wide range of remote sensors, actuators and telemetry devices. MQ Telemetry extends IBM MQ so that it can interconnect intelligent enterprise applications, services, and decision makers with networks of instrumented devices.
- The core parts of MQ Telemetry are:

  The MQ Telemetry (MQXR) service.
  This service runs inside the IBM MQ server, and uses the IBM MQ Telemetry Transport (MQTT) protocol to communicate with telemetry devices.

MQTT applications that you write.
These applications control the information that is carried between the telemetry devices and the IBM MQ queue manager, and any actions that are taken in response to that information. To help create these applications, you use MQTT client libraries.

What can it do for me?

- MQTT is an open messaging transport that allows MQTT implementations to be created for a wide variety of devices.
- MQTT clients can run on small footprint devices that have limited resources.
- MQTT works efficiently on networks where the bandwidth is low, where cost of sending data is expensive or which might be fragile.
- Message delivery is assured and decoupled from the application.
- Application programmers do not need to have communications programming knowledge.
- Messages can be exchanged with other messaging applications. These can be another telemetry application, or an MQI, JMS or enterprise messaging application.

How do I use it?

- Sample scripts are provided that work with a sample IBM MQ Telemetry Transport v3 client application (`mqttv3app.jar`). See IBM MQ Telemetry Transport sample programs.
- Use the IBM MQ Explorer and its associated tools to administer the telemetry feature of IBM MQ.
- Use the client libraries to help you create MQTT applications that connect to a queue manager, and that use publish/subscribe messaging.
- Distribute your application and client library to the device where your application is to run.

How does it work?

- MQTT is a publish subscribe protocol. An MQTT client application can publish messages to an MQTT server, or subscribe for messages that are sent by applications that connect to an MQTT server.
- MQTT client applications use client libraries that implement the MQTT message transport.
- A basic MQTT client application works like a standard MQ client but can run on a much wider variety of platforms and networks.
- The MQ Telemetry (MQXR) service turns an IBM MQ queue manager into an MQTT server.
- When an IBM MQ queue manager acts as the MQTT server, other applications that connect to the queue manager can subscribe for and receive the messages from the MQTT client.
- The queue manager acts as router distributing messages from publishing applications to subscribing applications.
- Messages can be distributed between different types of client applications. For instance, between Telemetry clients and JMS clients.

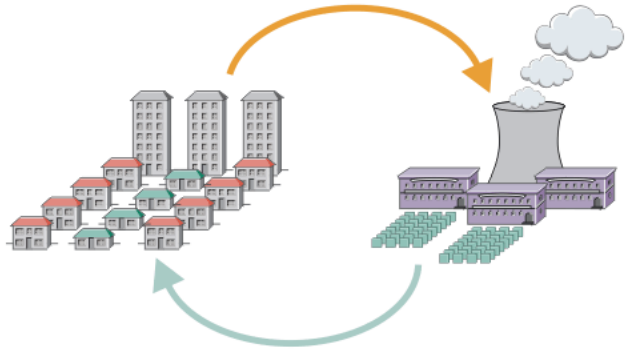
Note: MQ Telemetry replaces the SCADA nodes that were withdrawn in version 7 of WebSphere Message Broker (now known as IBM Integration Bus) and runs on Windows, Linux, and AIX.

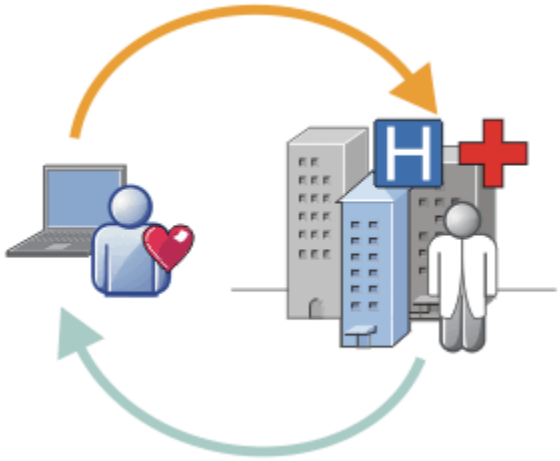
Windows Linux AIX Telemetry use cases

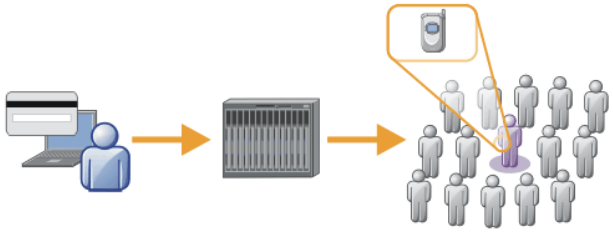
Telemetry is the automated sensing, measurement of data, and control of remote devices. The emphasis is on the transmission of data from devices to a central control point. Telemetry also includes sending configuration and control information to devices.

MQ Telemetry connects small devices by using the MQTT protocol, and connects the devices to other applications by using IBM MQ. MQ Telemetry bridges a gap between devices and the internet making it easier to build "smart solutions". Smart solutions unlock the wealth of information available on the internet, and in enterprise applications, for applications that monitor and control devices.

The following diagrams demonstrate some typical uses of MQ Telemetry:

Telemetry: Smart Electricity	
	• MQTT message containing energy usage data sent to service provider. • MQ Telemetry sends CONTROL COMMANDS based on analysis of energy usage data. • For more information, see the following use case: “Telemetry use case: Home energy monitoring and control” on page 111

Telemetry: Smart Health Services	
• MQ Telemetry sends Health Data to your Hospital & Doctor. • MQTT message alerts or feedback can be sent based on analysis of Health Data. • For more information, see the following use case: “Telemetry use case: Home patient monitoring” on page 109	

Telemetry: One in a Crowd	
	• A simple card transaction is sent to the bank's server. • MQ Telemetry identifies the one person from the thousands, alerting the customer that their card has been used. • MQ Telemetry can use the simplest input of information, and locate that individual.

The use cases described in the subtopics are drawn from actual examples. They illustrate some ways of using telemetry, and some of the common problems that telemetry technology must resolve.

Windows Linux AIX

Telemetry use case: Home patient monitoring

In the collaboration between IBM and a healthcare provider on a cardiac patient care system, an implanted cardioverter defibrillator communicates with a hospital. Data about the patient and the implanted device are transferred using RF telemetry to the MQTT device in the home of a patient.

Typically the transfer takes place nightly to a transmitter located at the bedside. The transmitter transfers the data securely over the phone system to the hospital, where the data is analyzed.

The system reduces the number of visits a patient must make to a physician. It detects when the patient or device needs attention, and in the event of an emergency, it alerts the on-call physician.

The collaboration between IBM and the healthcare provider has characteristics that are common to a number of telemetry use cases:

Invisibility

The device requires no user intervention other than supplying power, a telephone line, and being in proximity to the device for part of the day. Its operation is reliable and simple to use.

To remove the need for the patient to set up the device, the device supplier preconfigures the device. The patient only must plug it in. Elimination of configuration by the patient simplifies the operation of the device and reduces the chance the device is configured wrongly.

The MQTT client is embedded as part of the device. The device developer embeds the MQTT client implementation in the device and the developer, or supplier, configures the MQTT client as part of the preconfiguration.

The MQTT client is shipped as a Java SE JAR file, which the developer includes in their Java application. For non-Java environments, such as this one, the device developer can implement a client in a different language using the published MQTT formats and protocol. Alternatively, the developer can use one of the C clients shipped as shared libraries for Windows, Linux and ARM platforms.

Uneven connectivity

Communication between the defibrillator and the hospital has uneven network characteristics. Two different networks are used to solve the different problems of collecting data from the patient, and sending the data to the hospital. Between the patent and the MQTT device, a short-range low-power RF network is used. The transmitter connects to the hospital using a VPN TCP/IP connection over a low-bandwidth phone-line.

It is often impractical to find a way to connect every device directly to an Internet Protocol network. Using two networks, connected by a hub, is a common solution. The MQTT device is a simple hub, storing information from the patient, and forwarding it to the hospital.

Security

The physician must be able to trust the authenticity of the patient data, and the patient wants the privacy of their data to be respected.

In some situations it is sufficient to encrypt the connection, using VPN or TLS. In other situations, it is desirable to keep the data secure even after it has been stored.

Sometimes the telemetry device is not secure. It might be in a shared dwelling, for example. The user of the device must be authenticated to make sure that the data is from the correct patient. The device itself can be authenticated to the server using TLS, and the server authenticated to the device.

The telemetry channel between the device and the queue manager supports JAAS for user authentication and TLS for communication encryption, and device authentication. Access to a publication is controlled by the object authority manager in IBM MQ.

The identifier used to authenticate the user can be mapped to a different identifier, such as a common patient identity. A common identifier simplifies configuring authorization to publication topics in IBM MQ.

Connectivity

The connection between the MQTT device and the hospital uses dial-up, and works with a bandwidth as low as 300 baud.

To operate effectively at 300 baud, the MQTT protocol adds only a few extra bytes to a message in addition to TCP/IP headers.

The MQTT protocol provides single transmission *fire and forget* messaging, which keeps latencies low. It can also use multiple transmissions to guarantee *at least once* and *exactly once* delivery if guaranteed delivery is more important than response time. To guarantee delivery, messages are

stored at the device until they have been delivered successfully. If a device is connected wirelessly, guaranteed delivery is especially useful.

Scalability

Telemetry devices are typically deployed in large numbers, from tens of thousands to millions.

Connecting many devices to a system places large demands on a solution. There are business demands such as the cost of the devices and their software, and the administration demands of managing licenses, devices, and users. Technical demands include the load on the network, and on servers.

Opening connections uses more server resource than maintaining the open connections. But in a use case such as this that uses phone lines, the expense of connections means that connections are left open no longer than required. The data transfers are largely of a batched nature. The connections can be scheduled throughout the night to avoid a sudden peak of connections at bedtime.

On the client, the scalability of clients is helped by the minimal client configuration required. The MQTT client is embedded in the device. There is no requirement for a configuration or MQTT client license acceptance step to be built into the deployment of devices to patients.

On the server, MQ Telemetry has an initial target of 50,000 open connections per queue manager.

The connections are managed using the IBM MQ Explorer. The IBM MQ Explorer filters the connections to be displayed to a manageable number. With an appropriately chosen scheme of allocating identifiers to clients, you might filter connections based on geography, or alphabetically by patient name.

Telemetry use case: Home energy monitoring and control

Smart meters collect more detail about energy consumption than traditional meters.

Smart meters are often coupled with a local telemetry network to monitor and control individual appliances in a home. Some are also connected remotely for monitoring and control at a distance.

The remote connection could be set up by an individual, by a power utility, or by a central control point. The remote control point can read power usage and provide usage data. It can provide data to influence usage such as continuous pricing and weather information. It can limit load to improve overall power generation efficiency.

Smart meters are beginning to deployed widely. The UK government, for instance, is in consultation about deployment of smart meters to every UK home by 2020.

Home metering use cases have a number of common characteristics:

Invisibility

Unless the user wants to be involved in saving energy by using the meter, the meter must not require user intervention. It must not reduce the reliability of the energy supply to individual appliances.

An MQTT client can be embedded in the software deployed with the meter, and does not require separate installation or configuration.

Uneven connectivity

The communication between appliances and the smart meter demands different standards of connectivity than between the meter and the remote connection point.

The connection from the smart meter to appliances must be highly available and conform to network standards for a home area network.

The remote network is likely to use various physical connections. Some of them, such as cellular, have a high transmission cost, and can be intermittent. The MQTT v3 specification is aimed at remote connections, and connections between local adapters and the smart meter.

Connection between power outlets and applicances, and the meter, use a home area network, such as Zigbee. MQTT for sensor networks (MQTT-S), is designed to work with Zigbee and other low bandwidth network protocols. MQ Telemetry does not support MQTT-S directly. It requires a gateway to connect MQTT-S to MQTT v3.

Like home patient monitoring, solutions for home energy monitoring and control require multiple networks, connected using the smart meter as a hub.

Security

There are a number of security issues associated with smart meters. These issues include non-repudiation of transactions, authorization of any control actions that are initiated, and privacy of power consumption data.

To ensure privacy, data transferred between the meter and the remote control point by MQTT can be encrypted using TLS. To ensure authorization of control actions, the MQTT connection between the meter and the remote control point can be mutually authenticated using TLS.

Connectivity

The physical nature of the remote network can vary considerably. It might use an existing broadband connection, or use a mobile network with high call costs, and intermittent availability. For high cost, intermittent, connections MQTT is an efficient and reliable protocol; see “Telemetry use case: Home patient monitoring” on page 109.

Scalability

Eventually power companies, or central control points, plan to deploy tens of millions of smart meters. Initially, the numbers of meters per deployment are in the tens to hundreds of thousands. This number is comparable to the initial MQTT target of 50,000 open client connections per queue manager.

A critical aspect of the architecture for home energy monitoring and control is to use the smart meter as a network concentrator. Each appliance adapter is a separate sensor. By connecting them to a local hub using MQTT, the hub can concentrate the data flows onto a single TCP/IP session with the central control point, and also store messages for a short period to overcome session outages.

Remote connections must be left open in home energy use cases for two reasons. First, because opening connections takes a long time relative to sending requests. The time to open many connections to send "load-limitation" requests in a short interval is too long. Second, to receive load-limitation requests from the power company, the connection must first be opened by the client. With MQTT, connections are always initiated by the client, and to receive load-limitation requests from the power company, the connection must be left open.

If the rate of opening connections is critical, or the server initiates time-critical requests, the solution is typically to maintain many open connections.

Windows Linux AIX Telemetry use cases: Radio Frequency Identification (RFID)

RFID is the use of an embedded RFID tag to identify and track an object wirelessly. RFID tags can be read up to a range of several meters, and out of the line of sight of the RFID reader. Passive tags are activated by an RFID reader. Active tags transmit without external activation. Active tags must have a power source. Passive tags can include a power source to increase their range.

RFID is used in many applications, and the types of use cases vary enormously. RFID use cases, and home patient monitoring and home energy monitoring and control use cases, have some similarities and differences.

Invisibility

In many use cases, the RFID reader is deployed in large numbers and must work without user intervention. The reader includes an embedded MQTT client to communicate with a central control point.

For example, in a distribution warehouse, a reader uses a motion sensor to detect a pallet. It activates the RFID tags of items on the pallet and sends data and requests to central applications. The data is used to update the location of stock. The requests control what happens to the pallet next, such as moving it to a particular bay. Airlines, and airport baggage systems, are using RFID in this way.

In some RFID use cases, the reader has a standard computing environment, such as Java Platform, Micro Edition (Java ME). In these cases, the MQTT client might be deployed in a distinct configuration step, after manufacture.

Uneven connectivity

The RFID readers might be separated from the local control device that contains an MQTT client, or each reader might embed an MQTT client. Typically, geographical or communications factors indicate the choice of topology.

Security

Privacy and authenticity are security concerns in the attachment of RFID tags. RFID tags are unobtrusive and can be covertly monitored, spoofed, or tampered with.

Solution of RFID security issues increases the opportunity for deployment of new RFID solutions. Although the security exposure is in the RFID tag, and the local reader, using central information processing suggests approaches for countering different threats. For example, tag tampering might be detected by dynamically correlating stock levels against deliveries and dispatches.

Connectivity

RFID applications typically involved both batched store and forward of information gathered from RFID readers and immediate queries. In the distribution warehouse use case, the RFID reader is connected all the time. When a tag is read, it is published along with information about the reader. The warehousing application publishes the response back to the reader.

In the warehousing application the network is typically reliable, and the immediate requests might use *fire and forget* messages for low latency performance. The batched store and forward data might use *exactly once* messaging to minimize administration costs associated with loosing data.

Scalability

If the RFID application requires immediate responses, in the order of a second or two, then the RFID readers must stay connected.

Windows Linux AIX Telemetry use cases: Environment sensing

Environment sensing uses telemetry to collect information about river water levels and quality, atmospheric pollutants, and other environmental data.

Sensors are frequently located in remote places, without access to wired communication. Wireless bandwidth is expensive and reliability can be low. Typically, a number of environment sensors in a small geographical area are connected to a local monitoring device in a safe location. The local connections might be wired or wireless.

Invisibility

The sensor devices are likely to be less accessible, lower powered, and deployed in greater numbers, than the central monitoring device. The sensors are sometimes "dumb", and the local monitoring device includes adapters to transform and store sensor data. The monitoring device is likely to incorporate a general-purpose computer that supports Java Platform, Standard Edition (Java SE) or Java Platform, Micro Edition (Java ME). Invisibility is unlikely to be a major requirement when configuring the MQTT client.

Uneven connectivity

The capabilities of sensors, and cost and bandwidth of remote connection, typically results in a local monitoring hub connected to a central server.

Security

Unless the solution is being used in a military or defensive use case, security is not a major requirement.

Connectivity

Many uses do not require continuous monitoring or immediate availability of data. Exception data, such as a flood level alert, does need to be forwarded immediately. Sensor data is aggregated at the local monitor to reduce connection and communication costs, and then transferred using scheduled connections. Exception data is forwarded as soon as it is detected at the monitor.

Scalability

Sensors are concentrated around local hubs, and sensor data is aggregated into packets that are transmitted according to a schedule. Both these factors reduce the load on the central server that would be imposed by using directly connected sensors.

Windows Linux AIX Telemetry use cases: Mobile applications

Mobile applications are applications that run on wireless devices. The devices are either generic application platforms or custom devices.

General platforms include handheld devices such as phones and personal data assistants, and portable devices such as notebook computers. Custom devices use special purpose hardware tailored to specific applications. A device to record "signed-for" parcel delivery is an example of a custom mobile device. Applications on custom mobile devices are often built on a generic software platform.

Invisibility

The deployment of custom mobile applications is managed, and can include configuration of the MQTT client application. Invisibility is unlikely to be a major requirement when configuring the MQTT client.

Uneven connectivity

Unlike the local hub topology of the preceding use cases, mobile clients connect remotely. The client application layer connects directly to an application at the central hub.

Security

With little physical security, the mobile device, and the mobile user must be authenticated. TLS is used to confirm the identity of the device, and JAAS to authenticate the user.

Connectivity

If the mobile application depends on wireless coverage, it must be able to operate offline, and to deal efficiently with an interrupted connection. In this environment, the goal is to stay connected, but the application must be able to store and forward messages. Often the messages are orders, or delivery confirmations, and have important business value. They need to be stored and forwarded reliably.

Scalability

Scalability is not a major issue. The numbers of application clients are likely to not to exceed the thousands, or tens of thousands, in custom mobile application use cases.

Windows Linux AIX Connecting telemetry devices to a queue manager

Telemetry devices connect to a queue manager using an MQTT v3 client. The MQTT v3 client uses TCP/IP to connect to a TCP/IP listener called the telemetry (MQXR) service.

When you connect a telemetry device to a queue manager, the MQTT client initiates a TCP/IP connection using the `MqttClient.connect` method. Like IBM MQ clients, an MQTT client must be connected to the queue manager to send and receive messages. The connection is made at the server using a TCP/IP

listener, installed with MQ Telemetry, called the telemetry (MQXR) service. Each queue manager runs a maximum of one telemetry (MQXR) service.

The telemetry (MQXR) service uses the remote socket address set by each client in the `MqttClient.connect` method to allocate the connection to a telemetry channel. A socket address is the combination of TCP/IP host name and port number. Multiple clients that use the same remote socket address are connected to the same telemetry channel by the telemetry (MQXR) service.

If there are multiple queue managers on a server, split the telemetry channels between the queue managers. Allocate the remote socket addresses between the queue managers. Define each telemetry channel with a unique remote socket address. Two telemetry channels must not use the same socket address.

If the same remote socket address is configured for telemetry channels on multiple queue managers, the first telemetry channel to connect, wins. Subsequent channels connecting on the same address fail.

If there are multiple network adapters on the server, split the remote socket addresses between telemetry channels. The allocation of socket addresses is entirely arbitrary, as long as any specific socket address is configured on only one telemetry channel.

Configure IBM MQ to connect MQTT clients using the wizards provided in the MQ Telemetry supplement for IBM MQ Explorer. Alternatively, follow the instructions in Configuring a queue manager for telemetry on Linux and AIX and Configuring a queue manager for telemetry on Windows to configure telemetry manually.

Related reference

MQXR properties

Windows Linux AIX Telemetry connection protocols

MQ Telemetry supports TCP/IP IPv4 and IPv6, and TLS.

Windows Linux AIX Telemetry (MQXR) service

The telemetry (MQXR) service is a TCP/IP listener, that is managed as an IBM MQ service. Create the service using an IBM MQ Explorer wizard, or with a **runmqsc** command.

The MQ Telemetry (MQXR) service is called SYSTEM.MQXR.SERVICE .

The Telemetry sample configuration wizard, provided in the MQ Telemetry function for IBM MQ Explorer, creates the telemetry service and a sample telemetry channel; see Verifying the installation of MQ Telemetry by using IBM MQ Explorer .

Create the sample configuration from the command line; see Verifying the installation of MQ Telemetry using the command line.

The telemetry (MQXR) service starts and stops automatically with the queue manager. Control the service using the services folder in IBM MQ Explorer. To see the service, you must click the icon to stop IBM MQ Explorer filtering out SYSTEM objects from the display.

For an example of how to create the service manually, see

- Linux AIX Creating the `SYSTEM.MQXR.SERVICE` on Linux.
- Windows Creating the `SYSTEM.MQXR.SERVICE` on Windows.

These topics also specify the default key to require passphrases for MQTT TLS channels to be encrypted. For more information, see Encryption of passphrases for MQTT TLS channels.

Windows Linux AIX Telemetry channels

Create telemetry channels to create connections with different properties, such as Java Authentication and Authorization Service (JAAS) or TLS authentication, or to manage groups of clients.

Create Telemetry channels using the **New Telemetry Channel** wizard, supplied in the MQ Telemetry function for IBM MQ Explorer. Configure a channel, using the wizard, to accept connections from MQTT clients on a particular TCP/IP port. Since IBM WebSphere MQ 7.1, you can configure MQ Telemetry using the command line program, **runmqsc**.

Create multiple telemetry channels, on different ports, to make large numbers of client connections easier to manage, by splitting the clients into groups. Each telemetry channel has a different name.

You can configure telemetry channels with different security attributes to create different types of connection. Create multiple channels to accept client connections on different TCP/IP addresses. Use TLS to encrypt messages and authenticate the telemetry channel and client; see TLS configuration of MQTT clients and telemetry channels. Specify the user ID to simplify authorizing access to IBM MQ objects. Specify a JAAS configuration to authenticate the MQTT user with JAAS; see MQTT client identification, authorization, and authentication.

Windows Linux AIX IBM MQ Telemetry Transport protocol

The IBM MQ Telemetry Transport (MQTT) v3 protocol is designed for exchanging messages between small devices on low bandwidth, or expensive connections, and to send messages reliably. It uses TCP/IP.

The MQTT protocol is published; see IBM MQ Telemetry Transport format and protocol. Version 3 of the protocol uses publish/subscribe, and supports three qualities of service: *fire and forget*, *at least once*, and *exactly once*.

The small size of the protocol headers, and the byte array message payload, keeps messages small. The headers comprise a 2 byte fixed header, and up to 12 bytes of additional variable headers. The protocol uses 12 byte variable headers to subscribe and connect, and only 2 byte variable headers for most publications.

With three qualities of service, you can trade off between low-latency and reliability; see Qualities of service provided by an MQTT client. *Fire and forget* uses no persistent device storage, and only one transmission to send or receive a publication. *At least once*, and *exactly once* require persistent storage on the device to maintain the protocol state and save a message until it is acknowledged.

Windows Linux AIX MQTT clients

An MQTT client app is responsible for collecting information from the telemetry device, connecting to the server, and publishing the information to the server. It can also subscribe to topics, receive publications, and control the telemetry device.

Unlike IBM MQ client applications, MQTT client apps are not IBM MQ applications. They do not specify a queue manager to connect to. They are not limited to using specific IBM MQ programming interfaces. Instead, MQTT clients implement the MQTT 3 protocol. You can write your own client library to interface to the MQTT protocol in the programming language, and on the platform, of your choice. See IBM MQ Telemetry Transport format and protocol.

To simplify writing MQTT client apps, use the C, Java, and JavaScript client libraries that encapsulate the MQTT protocol for a number of platforms. If you incorporate these libraries in your MQTT apps, a fully functional MQTT client can be as short as 15 lines of code. MQTT client libraries are freely available from Eclipse Paho and MQTT.org. See IBM MQ Telemetry Transport sample programs.

The MQTT client app is always responsible for initiating a connection with a telemetry channel. After it is connected, either the MQTT client app or an IBM MQ application can start an exchange of messages.

MQTT client apps and IBM MQ applications publish and subscribe to the same set of topics. An IBM MQ application can also send a message directly to an MQTT client app without the client app first creating a subscription. See Configure distributed queuing to send messages to MQTT clients.

MQTT client apps are connected to IBM MQ using a telemetry channel. The telemetry channel acts as a bridge between the different types of message used by MQTT and IBM MQ. It creates publications and subscriptions in the queue manager on behalf of the MQTT client app. The telemetry channel sends publications that match the subscriptions of an MQTT client app from the queue manager to the MQTT client app.

Windows Linux AIX

Sending a message to an MQTT client

IBM MQ applications can send MQTT v3 clients messages by publishing to subscriptions created by clients, or by sending messages directly. MQTT clients can send messages to one another by publishing to topics subscribed to by other clients.

An MQTT client subscribes to a publication, which it receives from IBM MQ

Do the task, “Publishing a message to the MQTT client utility from IBM MQ Explorer” on page 119 to send a publication from IBM MQ to an MQTT client.

The standard way for an MQTT v3 client to receive messages is for it to create a subscription to a topic, or set of topics. In the example code snippet, Figure 44 on page 118, the MQTT client subscribes using the topic string `"MQTT Examples"`. An IBM MQ C application, Figure 45 on page 118, publishes to the topic using the topic string `"MQTT Examples"`. In the code snippet Figure 46 on page 118, the MQTT client receives the publication in the callback method, `messageArrived`.

For further information about how to configure IBM MQ to send publications in response to subscriptions from MQTT clients, see Publishing a message in response to an MQTT client subscription.

An IBM MQ application sends a message directly to an MQTT client

Do the task, “Sending a message to an MQTT client using IBM MQ Explorer” on page 123 to send a message directly from IBM MQ to an MQTT client.

A message sent in this way to an MQTT client is called an unsolicited message. MQTT v3 clients receive unsolicited messages as publications with a topic name set. The telemetry (MQXR) service sets the topic name to the remote queue name.

For further information about how to configure IBM MQ to send messages directly to MQTT clients, see Sending a message to a client directly.

An MQTT client publishes a message

An MQTT v3 client can publish a message that is received by another MQTT v3 client, but it cannot send an unsolicited message. The code snippet Figure 47 on page 119 shows how an MQTT v3 client, written in Java, publishes a message.

The typical pattern for sending a message to one specific MQTT v3 client, is for each client to create a subscription to its own `ClientIdentifier`. Do the task “Publishing a message to a specific MQTT v3 client” on page 124 to publish a message from one MQTT client to another MQTT client using `ClientIdentifier` as a topic string.

Example code snippets

The code snippet in Figure 44 on page 118 shows how an MQTT client written in Java creates a subscription. It also needs a callback method, `messageArrived` to receive publications for the subscription.

```
String    clientId = String.format("%-23.23s",
                     System.getProperty("user.name") + "_" +
                     (UUID.randomUUID().toString())).trim()).replace('-', '_');
MqttClient  client = new MqttClient("localhost", clientId);
String topicString = "MQTT Examples";
int          QoS = 1;
client.subscribe(topicString, QoS);
```

Figure 44. MQTT v3 client subscriber

The code snippet in Figure 45 on page 118 shows how an IBM MQ application written in C sends a publication. The code snippet is extracted from the task, Create a publisher to a variable topic

```
/* Define and set variables to.defaults */
/* Omitted lines declaring variables    */
char * topicName   = ""
char * topicString = "MQTT Examples"
char * publication = "Hello world!";
do {
  MQCONN(qMgrName, &Hconn, &CompCode, &Reason);
  if (CompCode != MQCC_OK) break;
  td.ObjectType = MQOT_TOPIC;    /* Object is a topic             */
  td.Version = MQOD_VERSION_4;   /* Descriptor needs to be V4     */
  strncpy(td.ObjectName, topicName,  MQ_TOPIC_NAME_LENGTH);
  td.ObjectString.VSPtr = topicString;
  td.ObjectString.VSLength = (MQLONG)strlen(topicString);
  MQOPEN(Hconn, &td, MQOO_OUTPUT | MQOO_FAIL_IF_QUIESCING, &Hobj, &CompCode, &Reason);
  if (CompCode != MQCC_OK) break;
  pmo.Options = MQPMO_FAIL_IF_QUIESCING | MQPMO_RETAIN;
  MQPUT(Hconn, Hobj, &md, &pmo, (MQLONG)strlen(publication)+1, publication, &CompCode, &Reason);
  if (CompCode != MQCC_OK) break;
  MQCLOSE(Hconn, &Hobj, MQCO_NONE, &CompCode, &Reason);
  if (CompCode != MQCC_OK) break;
  MQDISC(&Hconn, &CompCode, &Reason);
} while (0);
```

Figure 45. IBM MQ publisher

When the publication arrives, the MQTT client calls the `messageArrived` method of the MQTT application client `MqttCallback` class.

```
public class CallBack implements MqttCallback {
  public void messageArrived(MqttTopic topic, MqttMessage message) {
    try {
      System.out.println("Message arrived: \"" + message.toString()
          + "\" on topic \"" + topic.toString() + "\"");
    } catch (Exception e) {
      e.printStackTrace();
    }
  }
// ... Other callback methods
}
```

Figure 46. `messageArrived` method

Figure 47 on page 119 shows an MQTT v3 publishing a message to the subscription created in Figure 44 on page 118.

```
String          address = "localhost";
String         clientId = String.format("%-23.23s",
                          System.getProperty("user.name") + "_" +
                          (UUID.randomUUID().toString())).trim()).replace('-', '_');
MqttClient       client = new MqttClient(address, clientId);
String      topicString = "MQTT Examples";
MqttTopic         topic = client.getTopic(Example.topicString);
String     publication  = "Hello world";
MqttMessage     message = new MqttMessage(publication.getBytes());
MqttDeliveryToken token = topic.publish(message);
```

Figure 47. MQTT v3 client publisher

Windows Linux AIX Publishing a message to the MQTT client utility from IBM MQ Explorer

Follow the steps in this task to publish a message using IBM MQ Explorer, and subscribe to it with the MQTT client utility. An additional task shows you how to configure a queue manager alias rather than setting the default transmission queue to SYSTEM.MQTT.TRANSMIT.QUEUE.

Before you begin

The task assumes that you are familiar with IBM MQ and the IBM MQ Explorer, and that IBM MQ and MQ Telemetry feature are installed.

The user creating the queue manager resources for this task must have sufficient authority to do so. For demonstration purposes, the IBM MQ Explorer user ID is assumed to be member of the mqm group.

About this task

In the task, you create a topic in IBM MQ and subscribe to the topic using the MQTT client utility. When you publish to the topic using IBM MQ Explorer, the MQTT client receives the publication.

Procedure

Do one of the following tasks:

- You have installed MQ Telemetry, but you have not started it yet. Do the task: “Start task with no telemetry (MQXR) service yet defined” on page 120.
- You have run IBM MQ telemetry before, but want to use a new queue manager to do the demonstration. Do the task: “Start task with no telemetry (MQXR) service yet defined” on page 120.
- You want to do the task using an existing queue manager that has no telemetry resources defined. You do not want to run the **Define sample configuration** wizard.
  a. Do one of the following tasks to set up telemetry:
     – Configuring a queue manager for telemetry on Linux and AIX
     – Configuring a queue manager for telemetry on Windows
  b. Do the task: “Start task with a running telemetry (MQXR) service” on page 121
- If you want to do the task using an existing queue manager that already has telemetry resources defined, do the task: “Start task with a running telemetry (MQXR) service” on page 121.

What to do next

Do “Sending a message to an MQTT client using IBM MQ Explorer” on page 123 to send a message directly to the client utility.

Start task with no telemetry (MQXR) service yet defined

Create a queue manager and run the **Define sample configuration** to define sample telemetry resources for the queue manager. Publish a message using IBM MQ Explorer, and subscribe to it with the MQTT client utility.

About this task

When you set up sample telemetry resources using the **Define sample configuration**, the wizard sets the guest user ID permissions. Carefully consider if you want the guest user ID to be authorized in this way. `guest` on Windows, and `nobody` on Linux, are given permission to publish and subscribe to the root of the topic tree, and to put messages onto `SYSTEM.MQTT.TRANSMIT.QUEUE`.

The wizard also sets the default transmission queue to `SYSTEM.MQTT.TRANSMIT.QUEUE`, which might interfere with applications running on an existing queue manager. It is possible, but laborious, to configure telemetry and not use the default transmission queue; do the follow on task: "Using a queue manager alias" on page 122. In this task, you create a queue manager to avoid the possibility of interfering with any existing default transmission queue.

Procedure

1. Using IBM MQ Explorer, create and start a new queue manager.
   a) Right-click `Queue Managers` folder> **New** > **Queue manager ...**. Type a queue manager name > **Finish**.

      Make up a queue manager name; for example, `MQTTQMGR`.
2. Create and start the telemetry (MQXR) service and create a sample telemetry channel.
   a) Open the `Queue Managers\`*`QmgrName`*`\Telemetry` folder.
   b) Click **Define sample configuration...** > **Finish**

      Leave the **Launch MQTT Client Utility** check box checked.
3. Create a subscription for `MQTT Example` using the MQTT client utility.
   a) Click **Connect**.

      The **Client history** records a `Connected` event.
   b) Type `MQTT Example` into the **Subscription\Topic** field> **Subscribe**.

   The **Client history** records a `Subscribed` event.
4. Create `MQTTExampleTopic` in IBM MQ.
   a) Right-click the `Queue Managers\`*`QmgrName`*`\Topics` folder in the **MQ Explorer**> **New** > **Topic**.
   b) Type `MQTTExampleTopic` as the **Name** > **Next**.
   c) Type `MQTT Example` as the **Topic string** > **Finish**.
   d) Click **OK** to close the acknowledgment window.
5. Publish `Hello World!` to the topic `MQTT Example` using IBM MQ Explorer.
   a) Click the `Queue Managers\`*`QmgrName`*`\Topics` folder in the IBM MQ Explorer.
   b) Right-click `MQTTExampleTopic` > **Test publication...**
   c) Type `Hello World!` into the **Message data** field > **Publish message** > Switch to the MQTT Client Utility window.

   The **Client history** records a `Received` event.

Start task with a running telemetry (MQXR) service

Create a telemetry channel and a topic. Authorize the user to use the topic and the telemetry transmit queue. Publish a message using IBM MQ Explorer, and subscribe to it with the MQTT client utility.

Before you begin

In this version of the task, a queue manager, *QmgrName*, is defined and running. A telemetry (MQXR) service is defined and running. The telemetry (MQXR) service might have been created manually, or by running the **Define sample configuration** wizard.

About this task

In this task you configure an existing queue manager to send a publication to the MQTT client utility.

Step "1" on page 121 of the task sets the default transmission queue to SYSTEM.MQTT.TRANSMIT.QUEUE, which might interfere with applications running on an existing queue manager. It is possible, but laborious, to configure telemetry and not use the default transmission queue; do the follow on task: "Using a queue manager alias" on page 122.

Procedure

1. Set SYSTEM.MQTT.TRANSMIT.QUEUE as the default transmit queue.
   a) Right-click the Queue Managers*QmgrName* folder > **Properties...**
   b) Click **Communication** in the navigator.
   c) Click **Select...** > Select SYSTEM.MQTT.TRANSMIT.QUEUE > **OK** > **OK**.
2. Create a telemetry channel MQTTExampleChannel to connect the MQTT client utility to IBM MQ, and start the MQTT client utility.
   a) Right-click the Queue Managers*QmgrName* \Telemetry\Channels folder in the **MQ Explorer**> **New** > **Telemetry channel...**.
   b) Type MQTTExampleChannel in the **Channel name** field> **Next** > **Next**.
   c) Change the **Fixed user ID** on the client authorization panel to the user ID that is going to publish and subscribe to MQTTExample > **Next**.
   d) Leave **Launch Client Utility** checked> **Finish**.
3. Create a subscription for MQTT Example using the MQTT client utility.
   a) Click **Connect**.

      The **Client history** records a Connected event.
   b) Type MQTT Example into the **Subscription\Topic** field> **Subscribe**.

   The **Client history** records a Subscribed event.
4. Create MQTTExampleTopic in IBM MQ.
   a) Right-click the Queue Managers*QmgrName*\Topics folder in the **MQ Explorer**> **New** > **Topic**.
   b) Type MQTTExampleTopic as the **Name** > **Next**.
   c) Type MQTT Example as the **Topic string** > **Finish**.
   d) Click **OK** to close the acknowledgment window.
5. If you want a user, not in the mqm group, to publish and subscribe to the MQTTExample topic, do the following:
   a) Authorize the user to publish and subscribe to the topic MQTTExampleTopic:

```
setmqaut -m qMgrName -t topic -n MQTTExampleTopic -p User ID -all +pub +sub
```

   b) Authorize the user to put a message onto the SYSTEM.MQTT.TRANSMIT.QUEUE:

```
setmqaut -m qMgrName -t q -n SYSTEM.MQTT.TRANSMIT.QUEUE -p User ID -all +put
```

6. Publish `Hello World!` to the topic `MQTT Example` using IBM MQ Explorer.
   a) Click the `Queue Managers\`*`QmgrName`*`\Topics` folder in the IBM MQ Explorer.
   b) Right-click `MQTTExampleTopic` > **Test publication...**
   c) Type `Hello World!` into the **Message data** field > **Publish message** > Switch to the MQTT Client Utility window.

   The **Client history** records a `Received` event.

Using a queue manager alias

Publish a message to the MQTT client utility using IBM MQ Explorer without setting the default transmission queue to `SYSTEM.MQTT.TRANSMIT.QUEUE`.

The task is a continuation of the previous task, and uses a queue manager alias to avoid setting the default transmission queue to `SYSTEM.MQTT.TRANSMIT.QUEUE`.

Before you begin

Complete either the task, "Start task with no telemetry (MQXR) service yet defined" on page 120 or the task, "Start task with a running telemetry (MQXR) service" on page 121.

About this task

When an MQTT client creates a subscription, IBM MQ sends its response using `ClientIdentifier`, as the remote queue manager name. In this task, it uses the `ClientIdentifier`, `MyClient`.

If there is no transmission queue or queue manager alias called `MyClient`, the response is placed on the default transmission queue. By setting default transmission queue to `SYSTEM.MQTT.TRANSMIT.QUEUE`, the MQTT client gets the response.

You can avoid setting the default transmission queue to `SYSTEM.MQTT.TRANSMIT.QUEUE` by using queue manager aliases. You must set up a queue manager alias for every `ClientIdentifier`. Typically, there are too many clients to make it practical to use queue manager aliases. Often `ClientIdentifier` is unpredictable, making it impossible to configure telemetry this way.

Nonetheless, in some circumstances you might have to configure the default transmission queue to something other than `SYSTEM.MQTT.TRANSMIT.QUEUE`. The steps in Procedure configure a queue manager alias instead of setting the default transmission queue to `SYSTEM.MQTT.TRANSMIT.QUEUE`.

Procedure

1. Remove `SYSTEM.MQTT.TRANSMIT.QUEUE` as the default transmit queue.
   a) Right-click the `Queue Managers\`*`QmgrName`* `folder` > **Properties...**
   b) Click **Communication** in the navigator.
   c) Remove `SYSTEM.MQTT.TRANSMIT.QUEUE` from the **Default transmission queue** field > **OK**.
2. Check that you can no longer create a subscription with the MQTT client utility:
   a) Click **Connect**.

      The **Client history** records a `Connected` event.
   b) Type `MQTT Example` into the **Subscription\Topic** field> **Subscribe**.

   The **Client history** records a `Subscribe failed` and a `Connection lost` event.
3. Create a queue manager alias for the `ClientIdentifier`, `MyClient`.
   a) Right-click the `Queue Managers\`*`QmgrName`*`\Queues` folder> **New** > **Remote queue definition**.
   b) Name the definition, `MyClient` > **Next**.

c) Type `MyClient` in the **Remote queue manager** field.

d) Type `SYSTEM.MQTT.TRANSMIT.QUEUE` in the **Transmission queue** field > **Finish**.

4. Connect the MQTT client utility again.

a) Check the **Client identifier** is set to `MyClient`.

b) **Connect**

The **Client history** records a `Connected` event.

5. Create a subscription for `MQTT Example` using the MQTT client utility.

a) Click **Connect**.

The **Client history** records a `Connected` event.

b) Type `MQTT Example` into the **Subscription\Topic** field> **Subscribe**.

The **Client history** records a `Subscribed` event.

6. Publish `Hello World!` to the topic `MQTT Example` using IBM MQ Explorer.

a) Click the `Queue Managers\`*`QmgrName`*`\Topics` folder in the IBM MQ Explorer.

b) Right-click `MQTTExampleTopic` > **Test publication...**

c) Type `Hello World!` into the **Message data** field > **Publish message** > Switch to the MQTT Client Utility window.

The **Client history** records a `Received` event.

Windows Linux AIX Sending a message to an MQTT client using IBM MQ Explorer

Send a message to the MQTT client utility by putting a message onto an IBM MQ queue using IBM MQ Explorer. The task shows you how to configure a remote queue definition to send a message directly to an MQTT client.

Before you begin

Do the task, “Publishing a message to the MQTT client utility from IBM MQ Explorer” on page 119. Leave the MQTT client utility connected.

About this task

The task demonstrates sending a message to an MQTT client using queue rather than publishing to a topic. You do not create a subscription in the client. Step “2” on page 123 of the task demonstrates that the previous subscription has been deleted.

Procedure

1. Discard any existing subscriptions by disconnecting and reconnecting the MQTT client utility.

The subscription is discarded because, unless you change the defaults, the MQTT client utility connects with a clean session; see Clean sessions.

To make it easier to do the task, type your own `ClientIdentifier`, rather than use the generated `ClientIdentifier` created by the MQTT client utility.

a) Click **Disconnect** to disconnect the MQTT client utility from the telemetry channel.

The **Client History** records a `Disconnected` event

b) Change the **Client Identifer** to `MyClient`.

c) Click **Connect**.

The **Client History** records a `Connected` event

2. Check that the MQTT client utility no longer receives publication for the `MQTTExampleTopic`.

a) Click the Queue Managers*QmgrName*\Topics folder in the IBM MQ Explorer.

b) Right-click MQTTExampleTopic > **Test publication...**

c) Type Hello World! into the **Message data** field > **Publish message** > Switch to the MQTT Client Utility window.

No event is recorded in the **Client history**.

3. Create a remote queue definition for the client.

   Set the ClientIdentifier, MyClient, as the remote queue manager name in the remote queue definition. Use any name you like as the remote queue name. The remote queue name is passed to an MQTT client as the topic name.

   a) Right-click the Queue Managers*QmgrName*\Queues folder> **New** > **Remote queue definition**.

   b) Name the definition, MyClientRemoteQueue > **Next**.

   c) Type MQTTExampleQueue in the **Remote queue** field.

   d) Type MyClient in the **Remote queue manager** field.

   e) Type SYSTEM.MQTT.TRANSMIT.QUEUE in the **Transmission queue** field > **Finish**.

4. Put a test message onto MyClientRemoteQueue.

   a) Right-click **MyClientRemoteQueue** > **Put test message...**

   b) Type Hello queue! into the Message data field > **Put message** > **Close**

   The **Client history** records a Received event.

5. Remove SYSTEM.MQTT.TRANSMIT.QUEUE as the default transmit queue.

   a) Right-click the Queue Managers*QmgrName* folder > **Properties...**

   b) Click **Communication** in the navigator.

   c) Remove SYSTEM.MQTT.TRANSMIT.QUEUE from the **Default transmission queue** field > **OK**.

6. Redo step "4" on page 124.

   MyClientRemoteQueue is a remote queue definition that explicitly names the transmission queue. You do not need a to define default transmission queue to send a message to MyClient.

What to do next

With the default transmission queue no longer set to SYSTEM.MQTT.TRANSMIT.QUEUE, the MQTT Client Utility is unable to create a new subscription unless a queue manager alias is defined for the ClientIdentifier, MyClient. Restore the default transmission queue to SYSTEM.MQTT.TRANSMIT.QUEUE.

Windows Linux AIX Publishing a message to a specific MQTT v3 client

Publish a message from one MQTT v3 client to another, using ClientIdentifier as the topic name and IBM MQ as the publish/subscribe broker.

Before you begin

Do the task, "Publishing a message to the MQTT client utility from IBM MQ Explorer" on page 119. Leave the MQTT client utility connected.

About this task

The task demonstrates two things:

1. Subscribing to a topic in one MQTT client, and receiving a publication from another MQTT client.
2. Setting up "point-to-point" subscriptions by using ClientIdentifier as the topic string.

Procedure

1. Discard any existing subscriptions by disconnecting and reconnecting the MQTT client utility.

   The subscription is discarded because, unless you change the defaults, the MQTT client utility connects with a clean session; see Clean sessions.

   To make it easier to do the task, type your own `ClientIdentifier`, rather than use the generated `ClientIdentifier` created by the MQTT client utility.

   a) Click **Disconnect** to disconnect the MQTT client utility from the telemetry channel.

      The **Client History** records a `Disconnected` event

   b) Change the **Client Identifer** to `MyClient`.

   c) Click **Connect**.

   The **Client History** records a `Connected` event

2. Create a subscription to the topic, `MyClient`

   `MyClient` is the `ClientIdentifier` of this client.

   a) Type `MyClient` into the **Subscription\Topic** field> **Subscribe**.

   The **Client history** records a `Subscribed` event.

3. Start another MQTT client utility.

   a) Open the `Queue Managers\`*`QmgrName`*`\Telemetry\channels` folder.

   b) Right-click the **PlainText** channel> **Run MQTT Client Utility...**

   c) Click **Connect**.

   The **Client History** records a `Connected` event

4. Publish `Hello MyClient!` to the topic `MyClient`.

   a) Copy the subscription topic, `MyClient`, from the MQTT client utility running with the `ClientIdentifier`, `MyClient`.

   b) Paste `MyClient` into the **Publication\Topic** field of each of the MQTT client utility instances.

   c) Type `Hello MyClient!` into the **Publication\message** field.

   d) Click **Publish** in both instances.

Results

The **Client history** in the MQTT client utility with the `ClientIdentifier`, `MyClient`, records two **Received** events and one **Published** event. The other MQTT client utility instance records one **Published** event.

If you see only one **Received** event, check the following possible causes:

1. Is the default transmission queue for the queue manager set to `SYSTEM.MQTT.TRANSMIT.QUEUE` ?
2. Have you created queue manager aliases or remote queue definitions referencing `MyClient` in doing the other exercises? In case you have a configuration problem, delete any resources that reference `MyClient`, such as a queue manager aliases or transmission queues. Disconnect the client utilities, stop, and restart the telemetry (MQXR) service.

Windows Linux AIX Sending a message to an IBM MQ application from an MQTT client

An IBM MQ application can receive a message from an MQTT v3 client by subscribing to a topic. The MQTT client connects to IBM MQ using a telemetry channel, and sends a message to the IBM MQ application by publishing to the same topic.

Do the task, "Publishing a message to IBM MQ from an MQTT client" on page 126, to learn how to send a publication from an MQTT client to a subscription defined in IBM MQ.

If the topic is clustered, or distributed using a publish/subscribe hierarchy, the subscription can be on a different queue manager to the queue manager that the MQTT client is connected to.

Windows Linux AIX Publishing a message to IBM MQ from an MQTT client

Create a subscription to a topic using IBM MQ Explorer and publish to the topic using MQTT client utility.

Before you begin

Do the task, "Publishing a message to the MQTT client utility from IBM MQ Explorer" on page 119. Leave the MQTT client utility connected.

About this task

The task demonstrates publishing a message with an MQTT client and receiving the publication using an unmanaged durable subscription created using IBM MQ Explorer.

Procedure

1. Create a durable subscription to the topic string `MQTT Example`.

   Do the following steps to create the queue, and subscription using IBM MQ Explorer.

   a) Right-click the `Queue Managers\`*`QmgrName`*`\Queues` folder in the IBM MQ Explorer> **New** > **Local queue...**.

   b) Type `MQTTExampleQueue` as the queue name > **Finish**.

   c) Right-click the `Queue Managers\`*`QmgrName`*`\Subscriptions` folder in the IBM MQ Explorer> **New** > **Subscription...**.

   d) Type `MQTTExampleSubscription` as the queue name > **Next**.

   e) Click **Select...** > `MQTTExampleTopic` > **OK**.

   You have already created the topic, `MQTTExampleTopic` in step "4" on page 120 of "Publishing a message to the MQTT client utility from IBM MQ Explorer" on page 119.

   f) Type `MQTTExampleQueue` as the destination name > **Finish**.

2. As an optional step, set the queue up for use by a different user, without `mqm` authority.

   If you are setting up the configuration for users with less authority than `mqm`, you must give `put` and `get` authority to `MQTTExampleQueue`. Access to the topic and to the transmission queue was configured in "Publishing a message to the MQTT client utility from IBM MQ Explorer" on page 119.

   a) Authorize a user to put and get to the queue `MQTTExampleQueue`:

   ```
   setmqaut -m qMgrName -t queue -n MQTTExampleQueue -p User ID -all +put +get
   ```

3. Publish `Hello IBM MQ!` to the topic `MQTT Example` using the MQTT client utility.

   If you have not left the MQTT client utility connected, right-click the **PlainText** channel> **Run MQTT Client Utility...** > **Connect**.

   a) Type `MQTT Example` into the **Publication\Topic** field.

b) Type `Hello IBM MQ!` into the **Publication\Message** field> **Publish**.

4. Open the `Queue Managers\`*`QmgrName`*`\Queues` folder and find `MQTTExampleQueue`.

   The **Current queue depth** field is 1

5. Right-click `MQTTExampleQueue` > **Browse messages...** and examine the publication.

Windows Linux AIX MQTT publish/subscribe applications

Use topic-based publish/subscribe to write MQTT applications.

When the MQTT client is connected, publications flow in either direction between the client and server. The publications are sent from the client when information is published at the client. Publications are received at the client when a message is published to a topic that matches a subscription created by the client.

The IBM MQ publish/subscribe broker manages the topics and subscriptions created by MQTT clients. The topics created by MQTT clients share the same topic space as topics created by IBM MQ applications.

Publications that match the topic string in an MQTT client subscription are placed on `SYSTEM.MQTT.TRANSMIT.QUEUE` with the remote queue manager name set to the `ClientIdentifier` of the client. The telemetry (MQXR) service forwards the publications to the client that created the subscription. It uses `ClientIdentifier`, which has been set as the remote queue manager name to identify the client.

Typically, `SYSTEM.MQTT.TRANSMIT.QUEUE` must be defined as the default transmission queue. It is possible, but onerous, to configure MQTT not to use the default transmission queue; see Configure distributed queuing to send messages to MQTT clients.

An MQTT client can create a persistent session; see “MQTT stateless and stateful sessions” on page 130. Subscriptions created in a persistent session are durable. Publications that arrive for a client with a persistent session are stored in `SYSTEM.MQTT.TRANSMIT.QUEUE`, and forwarded to the client when it reconnects.

An MQTT client can also publish and subscribe to retained publications; see Retained publications and MQTT clients. A subscriber to a retained publication topic receives the latest publication to the topic. The subscriber receives the retained publication when it creates a subscription, or when it reconnects to its earlier session.

Windows Linux AIX Telemetry applications

Write telemetry applications using IBM MQ or IBM Integration Bus message flows.

Use JMS, MQI, or other IBM MQ programming interfaces to program telemetry applications in IBM MQ.

The telemetry (MQXR) service converts between MQTT v3 messages and IBM MQ messages. It creates subscriptions and publications on behalf of MQTT clients, and forwards publications to MQTT clients. A publication is the payload of an MQTT v3 message. The payload comprises message headers and a byte array in `jms-bytes` format. The telemetry server maps the headers between an MQTT v3 message and an IBM MQ message; see “Integration of MQ Telemetry with queue managers” on page 127.

Use the Publication, MQInput, and JMSInput nodes to send and receive publications between IBM Integration Bus and MQTT clients.

Using message flows you can integrate telemetry with websites using HTTP, and with other applications using IBM MQ and WebSphere Adapters.

Windows Linux AIX Integration of MQ Telemetry with queue managers

The MQTT client is integrated with IBM MQ as a publish/subscribe application. It can either publish or subscribe to topics in IBM MQ, creating new topics, or using existing topics. It receives publications from

IBM MQ as a result of MQTT clients, including itself, or other IBM MQ applications publishing to the topics of its subscriptions. Rules are applied to decide the attributes of a publication.

Many of the attributes associated with topics, publications, subscriptions, and messages that are provided by IBM MQ, are not supported. "MQTT client to IBM MQ publish/subscribe broker" on page 128 and "IBM MQ to an MQTT client" on page 129 describe how attributes of publications are set. The settings depend on whether the publication is going to or from the IBM MQ publish/subscribe broker.

In IBM MQ publish/subscribe topics are associated with administrative topic objects. The topics created by MQTT clients are no different. When an MQTT client creates a topic string for a publication the IBM MQ publish/subscribe broker associates it with an administrative topic object. The broker maps the topic string in the publication to the nearest administrative topic object parent. The mapping is the same as for IBM MQ applications. If there is no user created topic, the publication topic is mapped to SYSTEM.BASE.TOPIC. The attributes that are applied to the publication are derived from the topic object.

When an IBM MQ application, or an administrator creates a subscription, the subscription is named. List subscriptions using IBM MQ Explorer, or by using **runmqsc** or PCF commands. All MQTT client subscriptions are named. They are given a name of the form: *ClientIdentifier*:*Topic name*

MQTT client to IBM MQ publish/subscribe broker

An MQTT client has sent a publication to IBM MQ. The telemetry (MQXR) service converts the publication to an IBM MQ message. The IBM MQ message contains three parts:

1. MQMD
2. RFH2
3. Message

MQMD properties are set to their default values, except where noted in Table 9 on page 128.

Table 9. Settings for MQMD properties

MQMD field	Type	Value
Format	MQCHAR8	MQFMT_RF_HEADER_2
UserIdentifier	MQCHAR12	Set to one of: MqttClient.ClientIdentifier MqttConnectOptions.UserName A user ID set by the IBM MQ administrator for the telemetry channel.
Priority	MQLONG	MQPRI_PRIORITY_AS_Q_DEF (Default for IBM MQ, which is different to JMS that has a default of 4.)
Persistence	MQLONG	QoS=0→MQPER_NOT_PERSISTENT QoS=1→MQPER_PERSISTENT QoS=2→MQPER_PERSISTENT

The RFH2 header does not contain an <msd> folder to define the type of the JMS message. The telemetry (MQXR) service creates the IBM MQ message as a default JMS message. The default JMS message-type is a jms-bytes message. An application can access additional header information as message properties; see Message properties.

RFH2 values are set as shown in Table 10 on page 129. The Format property is set in the RFH2 fixed header and the other values are set in RFH2 folders.

Table 10. Settings for RFH2 properties		
RFH2 property	**Type/Folder**	**Header**
`Format`	`MQCHAR8`	`MQFMT_NONE`
`ClientIdentifier`	`mqtt/clientId`	Copy `MqttClient.ClientIdentifier` with a length of 1...23 bytes.
`QoS`	`mqtt/qos`	Copy `QoS` from incoming MQTT message.
`Message ID`	`mqtt/msgid`	Copy `Message ID` from incoming MQTT message, if `QoS` is 1 or 2.
`MQIsRetained`	`mqps/Ret`	Set if the original MQTT publication was sent with the `RETAIN` property set and the message is received as a retained publication.
`MQTopicString`	`mqps/Top`	The topic to which the MQTT message was published.

The payload in an MQTT publication is mapped to the contents of an IBM MQ message:

Table 11. How the payload in an MQTT publication maps to the IBM MQ message contents		
Message contents	**Type**	**Contents of IBM MQ message**
`Buffer`	`MQBYTE` *n*	Copy of bytes from incoming MQTT message. The length can be zero.

IBM MQ to an MQTT client

A client has subscribed to a publication topic. An IBM MQ application has published to the topic, resulting in a publication being sent to the MQTT subscriber by the IBM MQ publish/subscribe broker. Alternatively, an IBM MQ application has sent an unsolicited message directly to an MQTT client. Table 12 on page 129 describes how the fixed message headers are set in the message that is sent to the MQTT client. Any other data in the IBM MQ message header, or any other headers, are discarded. The message data in the IBM MQ message is sent as the message payload in the MQTT message, with no alteration. The MQTT message is sent to the MQTT client by the telemetry (MQXR) service.

Table 12. How fixed message headers are set in an IBM MQ message sent to the MQTT client		
MQTT field	**Type**	**Value**
DUP	`boolean`	Set if `QoS` = 1 or 2, and the message was sent to this client in a previous transmission, and the message has not been acknowledged after a time.

Table 12. How fixed message headers are set in an IBM MQ message sent to the MQTT client (continued)		
MQTT field	**Type**	**Value**

QoS	`int`	The way the value of QoS in an outgoing publication from the publish/subscribe broker in IBM MQ is set depends on the incoming publication. It depends on whether the incoming publication was sent from an MQTT client, or from an IBM MQ application.
		MQTT
		Lower value of the QoS in the incoming publication, and in the QoS requested by the subscriber.
		IBM MQ
		Lower value of the QoS derived from the incoming publication:
		`MQPER_NOT_PERSISTENT→QoS=0`
		`MQPER_PERSISTENT→QoS=2`
		and the QoS requested by the subscriber. If the message is sent to the client without a subscription, QoS is set by default to 2. A client can alter this value by subscribing to `DEFAULT.QoS` with a different QoS.

RETAIN	`boolean`	Set if the incoming publication has the retained property set.

Table 13 on page 130 describes how the variable message headers are set in the MQTT message that is sent to the MQTT client.

Table 13. How MQTT variable header properties are set in an MQTT message sent to the MQTT client		
MQTT field	**Type**	**Value**
Topic name	`String`	The topic string the message was published with.
Message ID	`String`	The last 2 bytes of the `MQMD.MsgId` property of the publication when it is placed in `SYSTEM.MQTT.TRANSMIT.QUEUE`.
Payload	`byte[]`	Direct copy of bytes from incoming publication to the publish/subscribe broker. The length can be zero.

Windows Linux AIX MQTT stateless and stateful sessions

MQTT clients can create a stateful session with the queue manager. When a stateful MQTT client disconnects, the queue manager maintains the subscriptions created by the client, and in-flight messages. When the client reconnects, it resolves in-flight message. It sends any messages that are queued for delivery, and receives any messages published for its subscriptions while it was disconnected.

When an MQTT client connects to a telemetry channel it either starts a new session, or resumes an old session. A new session has no outstanding messages that have not been acknowledged, no subscriptions, and no publications awaiting delivery. When a client connects, it specifies whether to start with a clean session, or to resume an existing session; see Clean sessions.

If the client resumes an existing session, it continues as if the connection had not been broken. Publications awaiting delivery are sent to the client, and any message transfers that had not been committed, are completed. When a client in a persistent session disconnects from the telemetry (MQXR) service, any subscriptions the client created remain. Publications for the subscriptions are sent to the client when it reconnects. If it reconnects without resuming the old session, the publications are discarded by the telemetry (MQXR) service.

Session state information is saved by the queue manager in the SYSTEM.MQTT.PERSISTENT.STATE queue.

The IBM MQ administrator can disconnect and purge a session.

Windows Linux AIX When an MQTT client is not connected

When a client is not connected the queue manager can continue to receive publications on its behalf. They are forwarded to the client when it reconnects. A client can create a "Last will and testament", which the queue manager publishes on behalf of the client, if the client disconnects unexpectedly.

If you want to be notified when the client unexpectedly disconnects, you can register a last will and testament publication; see Last will and testament publication. It is sent by the telemetry (MQXR) service, if it detects the connection to the client has broken without the client requesting it.

A client can publish a retained publication at any time; see Retained publications and MQTT clients. A new subscription to a topic can request to be sent any retained publication associated with topic. If you create the last will and testament as a retained publication, you can use it to monitor the status of a client.

For example, the client publishes a retained publication, when it connects, advertising its availability. At the same time, it creates a retained last will and testament publication that announces its unavailability. In addition, just before it makes a planned disconnection, it publishes its unavailability as a retained publication. To find out whether the client is available, you would subscribe to the topic of the retained publication. You would always receive one of the three publications.

If the client is to receive messages published when it is disconnected, then reconnect the client to its previous session; see “MQTT stateless and stateful sessions” on page 130. Its subscriptions are active until they are deleted, or until the client creates a clean session.

Windows Linux AIX Loose coupling between MQTT clients and IBM MQ applications

The flow of publications between MQTT clients and IBM MQ applications is loosely coupled. Publications might originate from either an MQTT client or an IBM MQ application, and in no set order. Publishers and subscribers are loosely coupled. They interact with each other indirectly through publications and subscriptions. You can also send messages directly to an MQTT client from an IBM MQ application.

MQTT clients and IBM MQ applications are loosely coupled in two senses:

1. Publishers and subscribers are loosely coupled by the association of a publication and a subscription with a topic. Publishers and subscribers are not normally aware of the address or identity of the other source of a publication or subscription.
2. MQTT clients publish, subscribe, receive publications, and process delivery acknowledgments on separate threads.

An MQTT client application does not wait until a publication has been delivered. The application passes a message to the MQTT client, and then the application continues on its own thread. A delivery-token is used to synchronize the application with the delivery of a publication; see Delivery tokens.

After passing a message to the MQTT client, the application has the choice of waiting on the delivery-token. Rather than waiting, the client can provide a callback method that is called when the publication is delivered to IBM MQ. It can also ignore the delivery-token.

Depending on the quality of service associated with the message, the delivery-token is returned immediately to the callback method, or possibly after some considerable time. The delivery-token might even be returned after the client has disconnected and reconnected. If the quality of service is *fire and forget*, the delivery-token is returned immediately. In the other two cases, the delivery token is returned only when the client receives acknowledgment that the publication has been sent to subscribers.

Publications sent to an MQTT client as a result of a client subscription, are delivered to the `messageArrived` callback method. `messageArrived` runs on a different thread to the main application.

Sending messages directly to an MQTT client

You can send a message to a particular MQTT client in one of two ways.

1. An IBM MQ application can send a message directly to an MQTT client without a subscription; see Sending a message to a client directly.
2. An alternative approach is to use your `ClientIdentifier` naming convention. Make all MQTT subscribers create subscriptions using their unique `ClientIdentifier` as a topic. Publish to *ClientIdentifier*. The publication is sent to the client that subscribed to the topic *ClientIdentifier*. Using this technique you can send a publication to a particular MQTT subscriber.

Windows Linux AIX MQ Telemetry security

Securing telemetry devices can be important, as the devices are likely to be portable, and used in places that cannot be carefully controlled. You can use VPN to secure the connection from the MQTT device to the telemetry (MQXR) service. MQ Telemetry provides two other security mechanisms, TLS and JAAS.

TLS is principally used to encrypt communications between the device and the telemetry channel, and to authenticate the device is connecting to the correct server; see Telemetry channel authentication using TLS. You can also use TLS to check that the client device is permitted to connect to the server; see MQTT client authentication using TLS.

JAAS is principally used to check that the user of the device is permitted to use a server application; see MQTT client authentication using a password. JAAS can be used with LDAP to check a password using a single sign-on directory.

TLS and JAAS can be used in conjunction to provide two factor authentication. You can restrict the ciphers used by TLS to ciphers that meet FIPS standards.

With at least tens of thousands of users, it is not always practical to provide individual security profiles. Nor is it always practical to use the profiles to authorize individual users to access IBM MQ objects. Instead group users into classes for authorizing publication and subscription to topics, and sending publications to clients.

Configure each telemetry channel to map clients to common client user IDs. Use a common user ID for every client that connects on a specific channel; see MQTT client identity and authorization.

Authorizing groups of users does not compromise authentication of each individual. Each individual user can be authenticated, at the client or server, with their `Username` and `Password`, and then authorized at the server using a common user ID.

Windows Linux AIX MQ Telemetry globalization

The message payload in the MQTT v3 protocol is encoded as byte-array. Generally, applications handling text create the message payload in UTF-8. The telemetry channel describes the message payload as UTF-8, but does not do any code page conversions. The publication topic string must be UTF-8.

The application is responsible for converting alphabetic data to the correct code page and numeric data to the correct number encoding.

The MQTT Java client has a convenient `MqttMessage.toString` method. The method treats the message payload as being encoded in the local platform default character set, which is generally UTF-8. It converts the payload to a Java String. Java has a String method, `getBytes` that converts a string into a byte array encoded using the local platform default character set. Two MQTT Java programs exchanging text in the message payload, between platforms with the same default character set do so easily and efficiently in UTF-8.

If the default character set of one of the platforms is not UTF-8, then the applications must establish a convention for exchanging messages. For example, the publisher specifies conversion from a string to UTF-8 using the `getBytes("UTF8")` method. To receive the text of a message, the subscriber assumes that the message is encoded in the UTF-8 character set.

The telemetry (MQXR) service describes the encoding of all incoming publications from MQTT clients messages as being UTF-8. It sets MQMD.CodedCharSetId to UTF-8, and RFH2.CodedCharSetId to MQCCSI_INHERIT ; see “Integration of MQ Telemetry with queue managers” on page 127. The format of the publication is set to MQFMT_NONE, so no conversion can be performed by channels, or by MQGET.

Windows Linux AIX Performance and scalability of MQ Telemetry

Consider the following factors when managing large numbers of clients and improving scalability of MQ Telemetry.

Capacity Planning

For information about performance reports for MQ Telemetry, see MQ Performance documents.

Connections

Costs involved with connections include

- The cost of setting up a connection itself in terms of processor usage and time.
- Network costs.
- Memory used when keeping a connection open but not using it.

There is an extra load incurred when clients stay connected. If a connection is kept open, TCP/IP flows and MQTT messages use the network to check that the connection is still there. Additionally, memory is used in the server for each client connection that is kept open.

If you are sending messages more than one per minute, keep your connection open to avoid the cost of initiating a new connection. If you are sending messages less than one every 10 - 15 minutes, consider dropping your connection to avoid the cost of keeping it open. You might want to keep a TLS connection open, but idle, for longer periods because it is more expensive to set up.

Additionally, consider the capability of the client. If there is a store and forward facility on the client then you might batch up messages and drop the connection between sending the batches. However, if the client is disconnected, then it is not possible for the client to receive a message from the server. Therefore the purpose of your application has a bearing on the decision.

If your system has one client sending many messages, for example file transfers, do not wait for a server response per message. Instead, send all messages and check at the end that they have all been received. Alternatively, use Quality of Service (QoS).

You can vary the QoS by message, delivering unimportant messages using QoS 0 and important messages using a QoS of 2. The message throughput can be around twice as high with a QoS of 0 than with a QoS of 2.

Naming conventions

If you are designing your application for many clients, implement an effective naming convention. In order to map each client to the correct ClientIdentifier, make the ClientIdentifier meaningful. A good naming convention makes it easier for the Administrator to work out which clients are running. A naming convention helps the administrator filter a long list of clients in IBM MQ Explorer, and helps with problem determination; see Client identifier.

Throughput

The length of topic names affects the number of bytes that flow across the network. When publishing or subscribing, the number of bytes in a message might be important. Therefore limit the number of characters in a topic name. When an MQTT client subscribes for a topic IBM MQ gives it a name of the form:

```
ClientIdentifier: TopicName
```

To view all of the subscriptions for an MQTT client, you can use the IBM MQ MQSC **DISPLAY** command:

```
DISPLAY SUB(' ClientID1:*')
```

Defining resources in IBM MQ for use by MQTT clients

An MQTT client connects to an IBM MQ remote queue manager. There are two basic methods for an IBM MQ application to send messages to an MQTT client: set the default transmission queue to SYSTEM.MQTT.TRANSMIT.QUEUE or use queue manager aliases. Define the default transmission queue of a queue manager, if there are large numbers of MQTT clients. Using the default transmission queue setting simplifies the administration effort; see Configure distributed queuing to send messages to MQTT clients.

Improving scalability by avoiding subscriptions.

When an MQTT V3 client subscribes to a topic, a subscription is created by the telemetry (MQXR) service in IBM MQ. The subscription routes publications for the client onto SYSTEM.MQTT.TRANSMIT.QUEUE. The remote queue manager name in the transmission header of each publication is set to the `ClientIdentifier` of the MQTT client that made the subscription. If there are many clients, each making their own subscriptions, this results in many proxy subscriptions being maintained throughout the IBM MQ publish/subscribe cluster or hierarchy. For information about not using publish/subscribe, but using a point to point based solution instead, see Sending a message to a client directly.

Managing large numbers of clients

To support many concurrently connected clients, increase the memory available for the telemetry (MQXR) service by setting the JVM parameters **-Xms** and **-Xmx**. Follow these steps:

1. Find the `java.properties` file in the telemetry service configuration directory; see Telemetry (MQXR) service configuration directory on Windows or Telemetry service configuration directory on Linux .
2. Follow the directions in the file; a heap of 1 GB is sufficient for 50,000 concurrently connected clients.

   ```
   # Heap sizing options - uncomment the following lines to set the heap to 1G
   #-Xmx1024m
   #-Xms1024m
   ```

3. Add other command-line arguments to pass to the JVM running the telemetry (MQXR) service in the `java.properties` file; see Passing JVM parameters to the telemetry (MQXR) service.

To increase the number of open file descriptors on Linux, add the following lines to `/etc/security/limits.conf/`, and log in again.

```
@mqm soft nofile 65000
@mqm hard nofile 65000
```

Each socket requires one file descriptor. The telemetry service require some additional file descriptors, so this number must be larger than the number of open sockets required.

The queue manager uses an object handle for each nondurable subscription. To support many active, nondurable subscriptions increase the maximum number of active handles in the queue manager; for example:

```
echo ALTER QMGR MAXHANDS(999999999) | runmqsc qMgrName
```

Figure 48. Alter maximum number of handles on Windows

```
echo "ALTER QMGR MAXHANDS(999999999)" | runmqsc qMgrName
```

Figure 49. Alter maximum number of handles on Linux

Other considerations

When planning your system requirements, consider the length of time taken to restart the system. The planned downtime might have implications for the number of messages that queue up, waiting to be processed. Configure the system so that the messages can be successfully processed in an acceptable time. Review disk storage, memory, and processing power. With some client applications, it might be possible to discard messages when the client reconnects. To discard messages, set `CleanSession` in the client connection parameters; see Clean sessions. Alternatively, publish and subscribe using the best effort Quality of Service, `0`, in an MQTT client; see Quality of service. Use `non-persistent` messages when sending messages from IBM MQ. Messages with these qualities of service are not recovered when the system or connection restarts.

Windows Linux AIX Devices supported by MQ Telemetry

MQTT clients can run on a range of devices, from sensors and actuators, to hand held devices and vehicle systems.

MQTT clients are small, and run on devices constrained by little memory and low processing power. The MQTT protocol is reliable and has small headers, which suits networks constrained by low bandwidth, high cost, and intermittent availability.

MQ Telemetry communicates with telemetry devices through MQTT client applications. These applications use the following resources, all of which implement the MQTT v3 protocol:

- The following client libraries:
  - The *MQTT client for Java*, which is used for building native applications for (for example) Android, OS X, Linux or Windows devices. Applications that use this client library can run on all variations of Java from the smallest CLDC (Connected Limited Device Configuration)/MIDP (Mobile Information Device Profile) through CDC (Connected Device Configuration)/Foundation, J2SE (Java Platform, Standard Edition), and J2EE (Java Platform, Enterprise Edition). IBM jclRM customized class library is also supported. The Java ME platform is generally used on small devices, such as actuators, sensors, mobile phones, and other embedded devices. The Java SE platform is generally installed on higher end embedded devices, such as desktop computers and servers.
  - The *MQTT client for C*, which is used for building native applications for (for example) iOS, OS X, Linux or Windows devices. This client library provides a C reference implementation together with prebuilt native client for Windows and Linux systems. The C reference implementation enables MQTT to be ported to a wide range of devices and platforms. Some Windows systems on Intel, including Windows 7, RedHat, Ubuntu, and some Linux systems on ARM platforms such as Eurotech Viper, implement versions of Linux that run the C client, but IBM does not provide service support for the platforms. You must reproduce problems with the client on a supported platform if you intend to call your IBM support centre.
  - The *MQTT client for Java*, which is used for building browser-based web applications.

MQTT client libraries are freely available from Eclipse Paho and MQTT.org. See IBM MQ Telemetry Transport sample programs.

Security in IBM MQ

In IBM MQ, there are several methods of providing security: the authorization service interface; user-written, or third party, channel exits; channel security using Transport Layer Security (TLS), channel authentication records , and message security.

Authorization service interface

Authorization for using MQI calls, commands, and access to objects is provided by the **object authority manager** (OAM), which by default is enabled. Access to IBM MQ entities is controlled through IBM MQ user groups and the OAM. Administrators can use a command-line interface to grant or revoke authorizations as required.

For more information about creating authorization service components, see Setting up security on AIX, Linux, and Windows systems.

User-written or third party channel exits

Channels can use user-written or third party channel exits. For more information, see Channel-exit programs for messaging channels.

Channel security using TLS

The Transport Layer Security (TLS) protocol provides industry-standard channel security, with protection against eavesdropping, tampering, and impersonation.

TLS uses public key and symmetric techniques to provide message confidentiality and integrity and mutual authentication.

For a comprehensive review of security in IBM MQ including detailed information about TLS, see Securing. For an overview of TLS, including pointers to the commands described in this section, see Cryptographic security protocols: TLS.

Channel authentication records

Use channel authentication records to exercise precise control over the access granted to connecting systems at a channel level. For more information, see Channel authentication records.

Message security

Use Advanced Message Security, which is a separately installed and licensed component of IBM MQ, to provide cryptographic protection to messages sent and receive using IBM MQ. See Advanced Message Security.

Related tasks

Securing

Planning for your security requirements

IBM MQ.NET managed client TLS support

The IBM MQ.NET fully managed client provides Transport Layer Security (TLS) support that is based on the Microsoft.NET SSLStreams kit. This is different from the other IBM MQ clients, which are based on IBM Global Security Kit (GSKit).

You can develop IBM MQ.NET applications to run in managed mode or unmanaged mode.

- In managed mode, .NET applications work within the .NET CLR (Common Language Runtime) without any cross platform invocation such as invoking the C MQI.
- In unmanaged mode, the C MQI is invoked for the underlying MQI operations. Basically, the unmanaged mode interface comprises the .NET wrapper classes on top of the C MQI.

The managed IBM MQ.NET client uses the Microsoft.NET Framework libraries to implement TLS secure socket protocols. The System.NET.Security.SSLStream class from Microsoft is used for implementing Security (TLS) in IBM MQ.NET.

The unmanaged IBM MQ.NET client mode already supports the TLS feature, which is based on C MQI (and GSKit). That is, the TLS operations are handled by the C MQI. In this case, GSKit implements the TLS secure socket protocols.

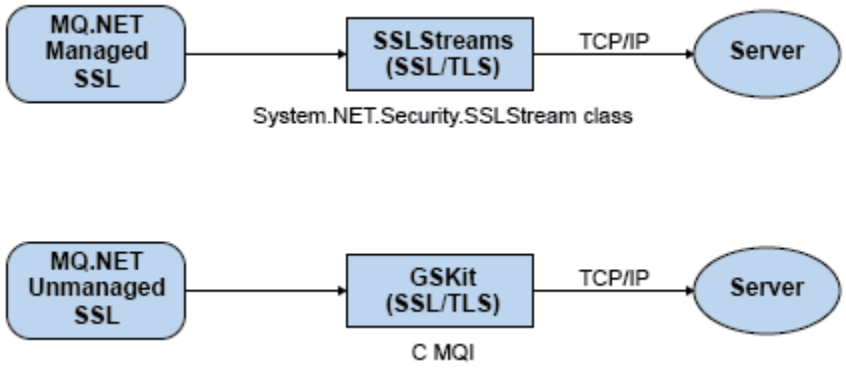


Figure 50. IBM MQ.NET managed and unmanaged TLS comparison

The following table summarizes the differences between the managed and unmanaged implementations:

Table 14. Differences between managed and unmanaged implementations

Mode	Protocols	Implementation	Comments
IBM MQ.NET managed SSL	TLS	System.NET.Security.SSLStream class SSLStream class operates as a stream over a connected TCP socket	TLS 1.0 TLS 1.2 (with Microsoft.NET Framework v4.5 only)
IBM MQ.NET unmanaged SSL	TLS	GSKit and C-MQI	TLS secure socket protocols

Related concepts

Secure Sockets Layer (SSL) and Transport Layer Security (TLS) support for .NET

IBM MQ MQI clients

An IBM MQ MQI client is a component of the IBM MQ product that can be installed on a system on which no queue manager runs.

An IBM MQ MQI *client* is a component that allows an application running on a system to issue MQI calls to a queue manager running on another system. The output from the call is sent back to the client, which passes it back to the application.

Using an IBM MQ MQI client, an application running on the same system as the client can connect to a queue manager that is running on another system. The application can issue MQI calls to that queue manager. Such an application is called an IBM MQ MQI client application and the queue manager is called a *server queue manager*.

An IBM MQ *server* is a queue manager that provides queuing services to one or more clients. All the IBM MQ objects, for example queues, exist only on the queue manager machine (the IBM MQ server machine), and not on the client. An IBM MQ server can also support local IBM MQ applications.

The difference between an IBM MQ server and an ordinary queue manager is that a server has a dedicated communications link with each client. For more information about creating channels for clients and servers, see Configuring distributed queuing.

An IBM MQ MQI client application and a server queue manager communicate with each other by using an *MQI channel*. An MQI channel starts when the client application issues an **MQCONN** or **MQCONNX** call to connect to the queue manager and ends when the client application issues an **MQDISC** call to disconnect from the queue manager. The input parameters of an MQI call flow in one direction on an MQI channel and the output parameters flow in the opposite direction.

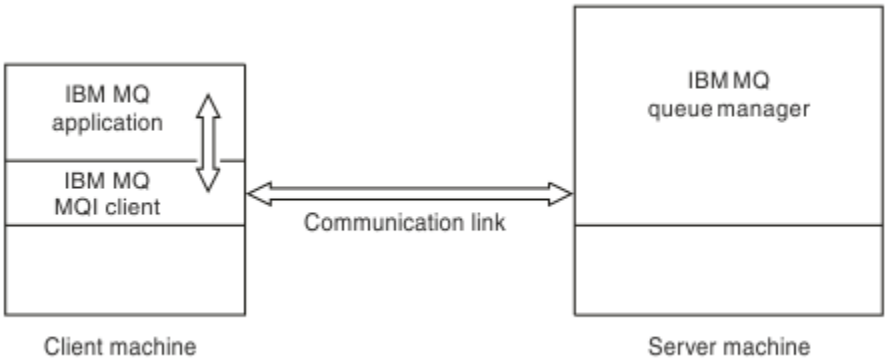


Figure 51. Link between a client and server

The following platforms can be used. The combinations depend on which IBM MQ product you are using and are described in "Platform support for IBM MQ clients" on page 139.

IBM MQ MQI client	**IBM MQ server**
AIX and Linux Windows IBM i	AIX and Linux Windows IBM i z/OS

The MQI is available to applications running on the client platform; the queues and other IBM MQ objects are held on a queue manager that you have installed on a server.

An application that you want to run in the IBM MQ MQI client environment must first be linked with the relevant client library. When the application issues an MQI call, the IBM MQ MQI client directs the request to a queue manager, where it is processed and from where a reply is sent back to the IBM MQ MQI client.

The link between the application and the IBM MQ MQI client is established dynamically at run time.

You can also develop client applications using the IBM MQ classes for .NET, IBM MQ classes for Java or IBM MQ classes for Java Message Service (JMS). You can use Java and JMS clients on the following platforms:

- IBM i
- AIX
- Linux
- Windows

The use of Java and JMS is not described here. For full details on how to install, configure, and use IBM MQ classes for Java and IBM MQ classes for JMS see Using IBM MQ classes for Java and Using IBM MQ classes for JMS.

IBM MQ applications in a client-server environment

When linked to a server, client IBM MQ applications can issue most MQI calls in the same way as local applications. The client application issues an MQCONN call to connect to a specified queue manager. Any additional MQI calls that specify the connection handle returned from the connect request are then processed by this queue manager.

You must link your applications to the appropriate client libraries. See Building applications for IBM MQ MQI clients.

Related concepts

"Why use IBM MQ clients?" on page 139
Using IBM MQ clients is an efficient way of implementing IBM MQ messaging and queuing.

"What is an extended transactional client?" on page 141
An IBM MQ extended transactional client can update resources managed by another resource manager, under the control of an external transaction manager.

"How the client connects to the server" on page 142
A client connects to a server using MQCONN or MQCONNX, and communicates through a channel.

"Transaction management and support" on page 143
An introduction to transaction management and how IBM MQ supports transactions.

"Extending queue manager facilities" on page 145
You can extend queue manager facilities by using user exits, API exits, or installable services.

Related information

How to set up an IBM MQ MQI client

Why use IBM MQ clients?

Using IBM MQ clients is an efficient way of implementing IBM MQ messaging and queuing.

You can have an application that uses the MQI running on one machine and the queue manager running on a different machine (either physical or virtual). The benefits of doing this are:

- There is no need for a full IBM MQ implementation on the client machine.
- Hardware requirements on the client system are reduced.
- System administration requirements are reduced.
- An IBM MQ application running on a client can connect to multiple queue managers on different systems.
- Alternative channels using different transmission protocols can be used.

Platform support for IBM MQ clients

IBM MQ on all supported server platforms accepts client connections from IBM MQ MQI clients on a number of platforms.

IBM MQ installed as a *Base product and Server* on all supported server platforms can accept connections from the IBM MQ MQI clients on the following platforms:

- IBM i
- AIX
- Linux
- Windows

Client connections are subject to differences in coded character set identifier (CCSID) and communications protocol.

What applications run on an IBM MQ MQI client?

The full MQI is supported in the client environment. This enables almost any IBM MQ application to be configured to run on an IBM MQ MQI client system by linking the application on the IBM MQ MQI client to the MQIC library, rather than to the MQI library. The exceptions are:

- MQGET with signal
- An application that needs sync point coordination with other resource managers must use an extended transactional client

If read ahead is enabled, to improve non persistent messaging performance, not all MQGET options are available. The table shows the options that are allowed, and whether they can be altered between MQGET calls.

Table 15. MQGET options permitted when read ahead is enabled

Values	Permitted when read ahead is enabled and can be altered between MQGET calls	Permitted when read ahead is enabled but cannot be altered between MQGET calls [1]	MQGET options that are not permitted when read ahead is enabled [2]
MQGET MD values	MsgId [3] CorrelId [3]	Encoding CodedCharSetId	
MQGET MQGMO options	MQGMO_WAIT MQGMO_NO_WAIT MQGMO_FAIL_IF_QUIESCING MQGMO_BROWSE_FIRST [4] MQGMO_BROWSE_NEXT [4] MQGMO_BROWSE_MESSAGE_UNDER_CURSOR [4]	MQGMO_SYNCPOINT_IF_PERSISTENT MQGMO_NO_SYNCPOINT MQGMO_ACCEPT_TRUNCATED_MSG MQGMO_CONVERT MQGMO_LOGICAL_ORDER MQGMO_COMPLETE_MSG MQGMO_ALL_MSGS_AVAILABLE MQGMO_ALL_SEGMENTS_AVAILABLE MQGMO_MARK_BROWSE_HANDLE MQGMO_MARK_BROWSE_CO_OP MQGMO_UNMARK_BROWSE_CO_OP MQGMO_UNMARK_BROWSE_HANDLE MQGMO_UNMARKED_BROWSE_MSG MQGMO_PROPERTIES_FORCE_MQRFH2 MQGMO_NO_PROPERTIES MQGMO_PROPERTIES_IN_HANDLE MQGMO_PROPERTIES_COMPATIBILITY	MQGMO_SET_SIGNAL MQGMO_SYNCPOINT MQGMO_MARK_SKIP_BACKOUT MQGMO_MSG_UNDER_CURSOR [4] MQGMO_LOCK MQGMO_UNLOCK
MQGMO values		MsgHandle	

1. If these options are altered between MQGET calls an MQRC_OPTIONS_CHANGED reason code is returned.
2. If these options are specified on the first MQGET call then read ahead is disabled. If these options are specified on a subsequent MQGET call a reason code MQRC_OPTIONS_ERROR is returned.
3. The client applications need to be aware that if the MsgId and CorrelId values are altered between MQGET calls messages with the previous values might have already been sent to the client and remain in the client read ahead buffer until consumed (or automatically purged).
4. The first MQGET call determines whether messages are to be browsed or got from a queue when read ahead is enabled. If the application attempts to use a combination of browse and get an MQRC_OPTIONS_CHANGED reason code is returned.
5. MQGMO_MSG_UNDER_CURSOR is not possible with read ahead. Messages can be browsed or got when read ahead is enabled but not a combination of both.

An application running on an IBM MQ MQI client can connect to more than one queue manager concurrently, or use a queue manager name with an asterisk (*) on an MQCONN or MQCONNX call (see the examples in Connecting IBM MQ MQI client applications to queue managers).

What is an extended transactional client?

An IBM MQ extended transactional client can update resources managed by another resource manager, under the control of an external transaction manager.

If you are not familiar with the concepts of transaction management, see “Transaction management and support” on page 143.

Note that the XA transactional client is now supplied as part of IBM MQ.

A client application can participate in a unit of work that is managed by a queue manager to which it is connected. Within the unit of work, the client application can put messages to, and get messages from, the queues that are owned by that queue manager. The client application can then use the **MQCMIT** call to commit the unit of work or the **MQBACK** call to back out the unit of work. However, within the same unit of work, the client application cannot update the resources of another resource manager, the tables of a Db2® database, for example. Using an IBM MQ extended transactional client removes this restriction.

An IBM MQ extended transactional client is an IBM MQ MQI client with some additional function. Using this function a client application, within the same unit of work, can perform the following tasks:

- Put messages to, and get messages from, queues that are owned by the queue manager to which it is connected
- Update the resources of a resource manager other than an IBM MQ queue manager

This unit of work must be managed by an external transaction manager that is running on the same system as the client application. The unit of work cannot be managed by the queue manager to which the client application is connected. This means that the queue manager can act only as a resource manager, not as a transaction manager. It also means that the client application can commit or back out the unit of work using only the application programming interface (API) provided by the external transaction manager. The client application cannot, therefore, use the MQI calls, **MQBEGIN**, **MQCMIT**, and **MQBACK**.

The external transaction manager communicates with the queue manager as a resource manager using the same MQI channel as used by the client application that is connected to the queue manager. However, in a recovery situation following a failure, when no applications are running, the transaction manager can use a dedicated MQI channel to recover any incomplete units of work in which the queue manager was participating at the time of the failure.

In this section, an IBM MQ MQI client that does not have the extended transactional function is referred to as an IBM MQ base client. You can consider, therefore, an IBM MQ extended transactional client to consist of an IBM MQ base client with the addition of the extended transactional function.

Note: IBM i IBM MQ MQI client on IBM i does not support the IBM MQ extended transactional function.

Platform support for extended transactional clients

Multi

Extended transactional clients are available for all Multiplatforms that support a base client. The clients are not available for z/OS.

A client application that is using an extended transactional client can connect to a queue manager of the following IBM MQ 9.0, or later, products only:

- AIX IBM MQ for AIX
- IBM i IBM MQ for IBM i
- Linux IBM MQ for Linux

- Windows IBM MQ for Windows

z/OS Although there are no extended transactional clients that run on z/OS, a client application that is using an extended transactional client can connect to a queue manager that runs on z/OS.

For each platform, the hardware and software requirements for the extended transactional client are the same as those requirements for the IBM MQ base client. A programming language is supported by an extended transactional client if it is supported by the IBM MQ base client and by the transaction manager you are using.

For information about the external transaction managers for all platforms, see System Requirements for IBM MQ.

How the client connects to the server

A client connects to a server using MQCONN or MQCONNX, and communicates through a channel.

An application running in the IBM MQ client environment must maintain an active connection between the client and server machines.

The connection is made by an application issuing an MQCONN or MQCONNX call. Clients and servers communicate through *MQI channels*, or, when using sharing conversations, conversations each share an MQI channel instance. When the call succeeds, the MQI channel instance or conversation remains connected until the application issues a MQDISC call. This is the case for every queue manager that an application needs to connect to.

Client and queue manager on the same machine

You can also run an application in the IBM MQ MQI client environment when your machine also has a queue manager installed.

In this situation, you have the choice of linking to the queue manager libraries or the client libraries, but remember that if you link to the client libraries, you still need to define the channel connections. This can be useful during the development phase of an application. You can test your program on your own machine, with no dependency on others, and be confident that it will still work when you move it to an independent IBM MQ MQI client environment.

Clients on different platforms

In this example, the server machine communicates with three IBM MQ MQI clients on different platforms.

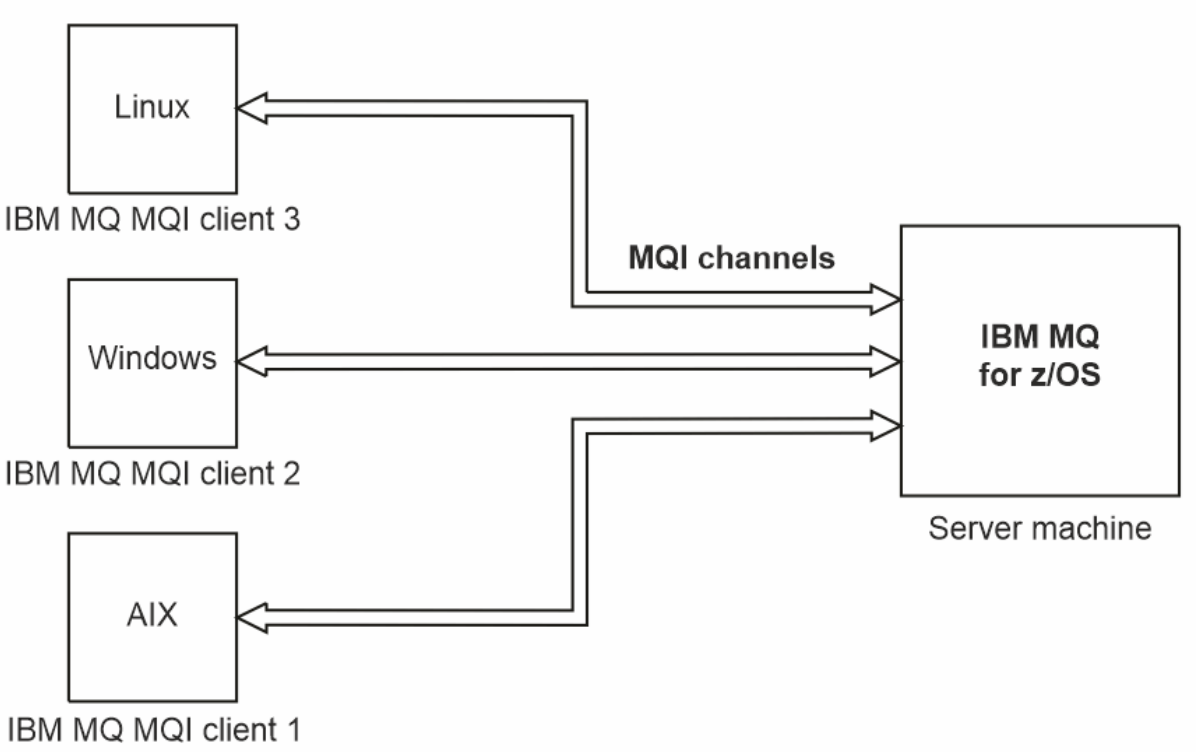


Figure 52. IBM MQ server connected to clients on different platforms

Other more complex environments are possible. For example, an IBM MQ client can connect to more than one queue manager, or any number of queue managers connected as part of a queue sharing group.

Using different versions of client and server software

If you are using previous versions of IBM MQ products, make sure that code conversion from the CCSID of your client is supported by the server.

An IBM MQ client can connect to all supported versions of queue manager. If you are connecting to an earlier version queue manager, you cannot use features and structures from a later version of the product in your IBM MQ application on the client.

An IBM MQ queue manager can communicate with clients at different versions to itself by negotiating down to the highest mutually supported protocol level. This means that older clients may be used with later queue manager levels. It is recommended that both the client and server are at versions of IBM MQ that are currently in support to facilitate problem diagnosis and enable support by IBM.

For more information, see the programming languages supported in Developing applications.

Transaction management and support

An introduction to transaction management and how IBM MQ supports transactions.

A *resource manager* is a computer subsystem that owns and manages resources that can be accessed and updated by applications. Here are examples of resource managers:

- An IBM MQ queue manager, with resources that are its queues
- A Db2 database, with resources that are its tables

When an application updates the resources of one or more resource managers, there might be a business requirement to ensure that certain updates all complete successfully as a group, or none of them complete. The reason for this kind of requirement is that the business data would be left in an inconsistent state if some of these updates completed successfully, but others did not.

Updates to resources that are managed in this way are said to occur within a *unit of work*, or a *transaction*. An application program can group a set of updates into a unit of work.

During a unit of work, an application issues requests to resource managers to update their resources. The unit of work ends when the application issues a request to commit all the updates. Until the updates are committed, none of them become visible to other applications that are accessing the same resources. Alternatively, if the application decides that it cannot complete the unit of work for any reason, it can issue a request to back out all the updates it has requested up to that point. In this case, none of the updates ever become visible to other applications. These updates are usually logically related and must all be successful for data integrity to be preserved. If one update succeeds while another fails, data integrity is lost.

When a unit of work completes successfully, it is said to *commit*. Once committed, all updates made within that unit of work are made permanent and irreversible. However, if the unit of work fails, all updates are instead *backed out*. This process, where units of work are either committed or backed out with integrity, is known as *sync point coordination*.

The point in time when all the updates within a unit of work are either committed or backed out is called a *sync point*. An update within a unit of work is said to occur *within sync point control*. If an application requests an update that is *outside of sync point control*, the resource manager commits the update immediately, even if there is a unit of work in progress, and the update cannot be backed out later.

The computer subsystem that manages units of work is called a *transaction manager*, or a *point coordinator*.

A *local* unit of work is one in which the only resources updated are those of the IBM MQ queue manager. Here sync point coordination is provided by the queue manager itself using a single-phase commit process.

A *global* unit of work is one in which resources belonging to other resource managers, such as XA-compliant databases, are also updated. Here, a two-phase commit procedure must be used and the unit of work can be coordinated by the queue manager itself, or externally by another XA-compliant transaction manager such as IBM TXSeries®, or BEA Tuxedo.

A transaction manager is responsible for ensuring that all updates to resources within a unit of work complete successfully, or none of them complete. It is to a transaction manager that an application issues a request to commit or back out a unit of work. Examples of transaction managers are CICS and WebSphere Application Server, although both of these possess other function as well.

Some resource managers provide their own transaction management function. For example, an IBM MQ queue manager can manage units of work involving updates to its own resources and updates to Db2 tables. The queue manager does not need a separate transaction manager to perform this function, although one can be used if it is a user requirement. If a separate transaction manager is used, it is referred to as an *external transaction manager*.

For an external transaction manager to manage a unit of work, there must be a standard interface between the transaction manager and every resource manager that is participating in the unit of work. This interface allows the transaction manager and a resource manager to communicate with each other. One of these interfaces is the *XA Interface*, which is a standard interface supported by a number of transaction managers and resource managers. The XA Interface is published by The Open Group in *Distributed Transaction Processing: The XA Specification*.

When more than one resource manager participates in a unit of work, a transaction manager must use a *two-phase commit* protocol to ensure that all the updates within the unit of work complete successfully or none of them complete, even if there is a system failure. When an application issues a request to a transaction manager to commit a unit of work, the transaction manager does the following:

Phase 1 (Prepare to commit)

The transaction manager asks each resource manager participating in the unit of work to ensure that all the information about the intended updates to its resources is in a recoverable state. A resource manager normally does this by writing the information to a log and ensuring that the information is written through to hard disk. Phase 1 completes when the transaction manager receives notification

from each resource manager that the information about the intended updates to its resources is in a recoverable state.

Phase 2 (Commit)
When Phase 1 is complete, the transaction manager makes the irrevocable decision to commit the unit of work. It asks each resource manager participating in the unit of work to commit the updates to its resources. When a resource manager receives this request, it must commit the updates. It does not have the option to back them out at this stage. Phase 2 completes when the transaction manager receives notification from each resource manager that it has committed the updates to its resources.

The XA Interface uses a two-phase commit protocol.

For more information, see Transactional support scenarios.

IBM MQ also provides support for the Microsoft Transaction Server (COM+). Using the Microsoft Transaction Server (COM+) provides information on how to set up IBM MQ to take advantage of COM+ support.

Extending queue manager facilities

You can extend queue manager facilities by using user exits, API exits, or installable services.

User exits

User exits provide a mechanism for you to insert your own code into a queue manager function. The user exits supported include:

Channel exits
These exits change the way that channels operate. Channel exits are described in Channel-exit programs for messaging channels.

Data conversion exits
These exits create source code fragments that can be put into application programs to convert data from one format to another. Data conversion exits are described in the Writing data-conversion exits.

The cluster workload exit
The function performed by this exit is defined by the provider of the exit. Call definition information is given in MQ_CLUSTER_WORKLOAD_EXIT - Call description.

API exits

API exits let you write code that changes the behavior of IBM MQ API calls, such as MQPUT and MQGET, and then insert that code immediately before or immediately after those calls. The insertion is automatic; the queue manager drives the exit code at the registered points. For more information about API exits, see Using and writing API exits.

Installable services

Installable services have formalized interfaces (an API) with multiple entry points.

An implementation of an installable service is called a *service component*. You can use the components supplied with IBM MQ, or you can write your own component to perform the functions that you require.

Currently, the following installable services are provided:

Authorization service
The authorization service allows you to build your own security facility.

The default service component that implements the service is the object authority manager (OAM). By default, the OAM is active, and you do not have to do anything to configure it. You can use the authorization service interface to create other components to replace or augment the OAM. For more information about the OAM, see Setting up security on AIX, Linux, and Windows systems.

Name service
The name service enables applications to share queues by identifying remote queues as though they were local queues.

You can write your own name service component. You might want to do this if you intend to use the name service with IBM MQ, for example. To use the name service you must have either a component that is either user-written, or supplied by a different software vendor. By default, the name service is inactive.

Related concepts
User exits, API exits, and IBM MQ installable services

IBM MQ Java language interfaces

IBM MQ provides three application programming interfaces (APIs) for use in Java applications: IBM MQ classes for Jakarta Messaging, IBM MQ classes for JMS, and IBM MQ classes for Java.

IBM supports, and is an active participant in, open standards.

- From IBM MQ 8.0, the product implements the JMS 2.0 standard, which introduced a new simplified API together with features such as shared subscriptions.
- From IBM MQ 9.3.0, Jakarta Messaging 3.0 is also supported.
- In addition, WebSphere Liberty supports JMS 2.0 and Jakarta Messaging 3.0 with IBM MQ.

Within IBM MQ there are three APIs for use in Java applications:

JMS 3.0 **IBM MQ classes for Jakarta Messaging**
IBM MQ classes for Jakarta Messaging is a Jakarta Messaging provider that implements the Jakarta Messaging interfaces for IBM MQ as the messaging system. The Jakarta Connectors Architecture provides a standard way of connecting applications running in a Jakarta EE environment to an Enterprise Information System (EIS) such as IBM MQ or Db2.

JMS 2.0 **IBM MQ classes for JMS**
IBM MQ classes for JMS is a JMS provider that implements the JMS interfaces for IBM MQ as the messaging system. The Java Platform, Enterprise Edition Connector Architecture (JCA) provides a standard way of connecting applications running in a Java EE environment to an Enterprise Information System (EIS) such as IBM MQ or Db2.

IBM MQ classes for Java
IBM MQ classes for Java enable you to use IBM MQ in a Java environment. IBM MQ classes for Java allow a Java application to connect to IBM MQ as an IBM MQ client, or connect directly to an IBM MQ queue manager.

Note:

- JMS 2.0 has been superseded by Jakarta Messaging. IBM MQ classes for JMS continues to support the JMS 2.0 standard, but future enhancements to Java messaging will only emerge in Jakarta Messaging, hence in the IBM MQ classes for Jakarta Messaging. IBM MQ classes for JMS are only recommended for maintaining and extending existing JMS 2.0 applications. IBM MQ classes for Jakarta Messaging should be the preferred technology for new development.
- Stabilized IBM MQ classes for Java are functionally stabilized at the level shipped in IBM MQ 8.0. Existing applications that use the IBM MQ classes for Java will continue to be fully supported, but this API is stabilized, so new features will not be added and requests for enhancements rejected. Fully supported means that defects will be fixed together with any changes necessitated by changes to IBM MQ System Requirements.

JMS 3.0 From IBM MQ 9.3, the IBM MQ classes for Java, IBM MQ classes for JMS, and IBM MQ classes for Jakarta Messaging are built with Java 8. Java runtime environments at or above these levels must be used to run applications using these interfaces.

Related concepts

Accessing IBM MQ from Java - Choice of API

Why should I use IBM MQ classes for Jakarta Messaging?

Why should I use IBM MQ classes for JMS?

Why should I use IBM MQ classes for Java?

IBM MQ classes for JMS/Jakarta Messaging

IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging are the messaging providers that are supplied with IBM MQ. Each of these providers also provides two sets of extensions to the messaging API. Both Java Platform, Standard Edition (Java SE) and Java Platform, Enterprise Edition (Java EE) applications can use these messaging providers.

JMS 3.0 IBM MQ 9.3.0 introduced support for Jakarta Messaging 3.0. JMS 2.0 is still fully supported.

The JMS and Jakarta Messaging specifications define a set of interfaces that applications can use to perform messaging operations. The product supports the JMS 2.0 version of the JMS standard. This implementation offers all the features of the classic API but requires fewer interfaces and is simpler to use. For more information, see "JMS and Jakarta Messaging model" on page 150 and the JMS 2.0 specification at Java.net. JMS 3.0 From IBM MQ 9.3.0, Jakarta Messaging is also supported.

The jakarta.jms (Jakarta Messaging 3.0) or javax.jms (JMS 2.0) package specifies the details of the messaging interfaces, and a messaging provider implements these interfaces for a specific messaging product. For example:

- IBM MQ classes for JMS is a JMS provider that implements the JMS interfaces for IBM MQ and also provides the following two sets of extensions to the JMS API:
  - IBM MQ JMS extensions
  - IBM JMS extensions
- A connection factory, queue, or topic object created using the javax.dims, or jakarta.jms, interfaces or either set of JMS extensions can be addressed using any of these APIs; that is, it can be cast to any of the interfaces. To maintain application portability at the highest level, use the most generic API that is suitable for your requirements.

Because JMS and Jakarta Messaging share much in common, further references to JMS in this topic can be taken as referring to both. Any differences are highlighted as necessary.

IBM MQ JMS extensions

IBM MQ classes for JMS also provides extensions to the JMS API. IBM MQ classes for JMS contains extensions that are implemented in MQConnectionFactory, MQQueue, and MQTopic objects. These objects have properties and methods that are specific to IBM MQ. The objects can be administered objects, or an application can create the objects dynamically at run time. These extensions are termed the IBM MQ JMS extensions. Note that, in this documentation, objects that are created dynamically by an application at run time are not considered to be administered objects.

IBM JMS extensions

In addition to the IBM MQ JMS extensions, IBM MQ classes for JMS provides a more generic set of extensions to the JMS API or Java as the programming language used. These extensions are termed the IBM JMS extensions, and have the following broad objectives:

- To provide a greater level of consistency across IBM JMS providers.
- To make it easier to write a bridge application between two IBM messaging systems.
- To make it easier to port an application from one IBM JMS provider to another.

The main focus of these extensions concerns creating and configuring connection factories and destinations dynamically at run time, but the extensions also provide function that is not directly related to messaging, such as function for problem determination.

Related tasks

Using IBM MQ classes for JMS/Jakarta Messaging

Configuring JMS and Jakarta Messaging resources

JMS 3.0 IBM MQ classes for Jakarta Messaging: an overview

IBM MQ 9.3.0 introduces support for Jakarta Messaging. For Jakarta Messaging 3.0, control of the JMS specification moved from Oracle to the Java Community Process. However, Oracle retains control of the "javax" name, which is used in other Java technologies. So although Jakarta Messaging 3.0 is functionally equivalent to JMS 2.0, there are some differences in naming. The official name for version 3.0 is Jakarta Messaging rather than Java Message Service, and the package and constant names are prefixed with `jakarta` rather than `javax`.

Background

For many years, the Java platform has come in two forms – Standard Edition and Enterprise Edition.

Java Platform, Standard Edition (sometimes abbreviated as Java SE) is the core language and class libraries, capable of being run in a stand-alone context. Most Java packages in Java SE have names starting with "java.".

Java Platform, Enterprise Edition (Java EE) extends this, adding functionality like Messaging, various Beans, transactionality and so on. Some of these technologies can also be used in a Java SE context. Most Java packages in Java EE historically have names starting with "javax." – there is some crossover, however, so some Java SE packages have "javax." as the prefix to their name.

The Java Message Service (JMS) is part of Java Platform, Enterprise Edition. Java EE 7 incorporates JMS 2.0.

Up to Java EE 7, the technologies were under the stewardship of Oracle.

The Java EE technologies have recently moved from the stewardship of Oracle to a community process overseen by the Eclipse Foundation.

As the "javax." name could not be moved to the new project, new naming has been adopted – all packages and property names are now prefixed with "jakarta." and the Java Platform, Enterprise Edition will be called "Jakarta EE" in future. The version numbering has continued: Version 8 was an interim version which can largely be ignored, and Jakarta EE 9 is the point at which the "jakarta." prefix takes effect.

The main Jakarta EE technology that applies in the IBM MQ context is Jakarta Messaging 3.0 – the successor to Java Message Service (JMS) 2.0. So Jakarta EE 9 incorporates Jakarta Messaging 3.0.

IBM MQ continues to support Java EE 7 and JMS 2.0, while introducing support for Jakarta EE 9 and Jakarta Messaging 3.0.

What is delivered: Java SE

For the Java Platform, Standard Edition, in addition to the IBM MQ classes for JMS (which support JMS 2.0 operations with IBM MQ) IBM MQ 9.3.0 and later versions provide IBM MQ classes for Jakarta Messaging. These classes provide a Jakarta Messaging 3.0 provider that integrates with IBM MQ, allowing use of IBM MQ queue managers to facilitate Jakarta Messaging operations.

These are provided as a standard JAR file, `com.ibm.mq.jakarta.client.jar`, in the `java/lib` subdirectory of the IBM MQ installation.

For use in OSGi containers, such as Apache Felix or Eclipse Equinox, IBM MQ also provides a pair of OSGi bundles:

- `com.ibm.mq.osgi.jms30.clientprereqs_`*`V.R.M.F`*`.jar`

- `com.ibm.mq.osgi.jms30.client_V.R.M.F.jar`

where *V.R.M.F* represents the version of IBM MQ, for example 9.3.0.0. These bundles can be found in the `java/lib/OSGi` subdirectory of the IBM MQ installation.

What is delivered: Jakarta EE 9

To support IBM MQ-based messaging in a Jakarta EE 9 compatible application server, IBM MQ provides a Jakarta EE 9-compatible Resource Adapter: `wmq.jakarta.jmsra.rar`. This can be found in the in the `java/lib/jca` subdirectory of the IBM MQ installation.

IBM MQ continues to provide a Java EE 7 compatible Resource Adapter, `wmq.jmsra.rar`, in the `java/lib/jca` subdirectory of the IBM MQ installation.

How these artifacts are delivered

These JARs and the RAR file for the Resource Adapter are packaged with the preexisting artifacts in the usual IBM MQ installation media – both the platform-specific installation media, such as "`.rpm`" files, and the redistributable media, such as the self-extracting redistributable client JAR files.

What has changed between JMS 2.0 and Jakarta Messaging 3.0

Jakarta EE 9 and Jakarta Messaging 3.0 introduce no new functionality. All that changes is names. For example, where you use "javax.jms.Connection" in JMS 2.0, you use "jakarta.jms.Connection" in Jakarta Messaging 3.0.

As the Eclipse Foundation takes the Jakarta EE platform forward, it will build on this foundation and this naming convention will be used for new functionality introduced in future.

What has changed between IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging

Summary

IBM MQ classes for JMS, which provide support for JMS 2.0, remain available and are recommended primarily for maintaining and extending existing applications. They are fully supported.

IBM MQ classes for Jakarta Messaging, which provide support for Jakarta Messaging 3.0, are recommended for new development.

At IBM MQ 9.3.0, these two offerings were functionally equivalent. Only naming differs. However, new messaging functionality is more likely to emerge in IBM MQ classes for Jakarta Messaging than in IBM MQ classes for JMS.

The two offerings are interoperable. Messages produced by IBM MQ classes for JMS can be consumed by IBM MQ classes for Jakarta Messaging, and vice versa. But the two offerings must not coexist in a single application.

Naming changes

Table 16. Changes to package names

IBM MQ classes for JMS package name	IBM MQ classes for Jakarta Messaging package name
com.ibm.mq.jms[.*]	com.ibm.mq.jakarta.jms[.*]
com.ibm.jms	com.ibm.jakarta.jms
com.ibm.msg.client.jms.*	com.ibm.msg.client.jakarta.jms.*
com.ibm.msg.client.wmq.*	com.ibm.msg.client.jakarta.wmq.*

The packages relating to common services (trace, logging, national language support etc) and the JMQI implementations (local and remote) are common to both IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging, so no changes are necessary in these areas.

Note that property names have also changed. For example, the property to enable IBM MQ extensions in IBM MQ classes for Jakarta Messaging is **com.ibm.mq.jakarta.jms.SupportMQExtensions**.

Property names which are independent of IBM MQ classes for JMS or IBM MQ classes for Jakarta Messaging, such as the various **com.ibm.msg.client.commonservices.trace.*** properties, apply equally to both offerings.

Administrative utilities

The **crtmqenv** and **setmqenv** utilities now accept an option to specify whether the classpath should be configured for IBM MQ classes for JMS (`-j 2.0`) or IBM MQ classes for Jakarta Messaging (`-j 3.0`), and there are IBM MQ classes for Jakarta Messaging variants of the **runjms** utilities, called **runjms30** and similar names.

The **dspmqver** utility, when requested to report on Java components, includes IBM MQ classes for Jakarta Messaging in its output.

To configure IBM MQ classes for Jakarta Messaging objects to be retrieved via JNDI, the new **JMS30Admin** utility is equivalent to the **JMSAdmin** utility for IBM MQ classes for JMS.

Note that as the underlying objects are from different packages. JNDI definitions created by **JMSAdmin** cannot be used by IBM MQ classes for Jakarta Messaging, nor can those created by **JMS30Admin** be used by IBM MQ classes for JMS.

Note: There is no support for IBM MQ classes for Jakarta Messaging objects provided by IBM MQ Explorer; its JNDI integration is for IBM MQ classes for JMS only.

Related concepts

Why should I use IBM MQ classes for Jakarta Messaging?

JMS and Jakarta Messaging model

The JMS and Jakarta Messaging model defines a set of interfaces that Java applications can use to perform messaging operations. IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging are messaging providers that define how Java messaging objects are related to IBM MQ concepts. The JMS and Jakarta Messaging specifications expect certain messaging objects to be administered objects.

From IBM MQ 8.0, the product supports the JMS 2.0 version of the JMS standard, which introduced a simplified API, while also retaining the classic API, from JMS 1.1.

JMS 3.0 IBM MQ 9.3.0 introduced support for Jakarta Messaging 3.0. JMS 2.0 is still fully supported. Because JMS and Jakarta Messaging share much in common, further references to JMS in this topic can be taken as referring to both. Any differences are highlighted as necessary.

Simplified API

JMS 2.0 introduced the simplified API, while also retaining the domain specific and domain independent interfaces from JMS 1.1. The simplified API reduces the number of objects that are needed to send and receive messages and consists of the following interfaces:

ConnectionFactory
A ConnectionFactory is an administered object that is used by a JMS client to create a Connection. This interface is also used in the classic API.

JMSContext
This object combines the Connection and Session objects of the classic API. JMSContext objects can be created from other JMSContext objects, with the underlying connection being duplicated.

JMSProducer
A JMSProducer is created by a JMSContext and is used to send messages to a queue or topic. The JMSProducer object causes the creation of objects that are required to send the message.

JMSConsumer
A JMSConsumer is created by a JMSContext and is used to receive messages from a topic or a queue.

The simplified API has a number of effects:

- The JMSContext object always automatically starts the underlying connection.
- JMSProducers and JMSConsumers can now work directly with message bodies, without having to get the whole message object, by using the Message's getBody method.
- Message properties can be set on the JMSProducer object, using method chaining, before sending a 'body', a messages content. The JMSProducer will handle the creation of all objects that are needed to send the message. Using JMS 2.0, properties can be set, and a message sent as follows:

```
context.createProducer().
setProperty("foo", "bar").
setTimeToLive(10000).
setDeliveryMode(NON_PERSISTENT).
setDisableMessageTimestamp(true).
send(dataQueue, body);
```

JMS 2.0 also introduced shared subscriptions where messages can be shared between multiple consumers. All JMS 1.1 subscriptions are treated as unshared subscriptions.

Classic API

The following list summarizes the main JMS interfaces of the classic API:

Destination
A destination is where an application sends messages, or it is a source from which an application receives messages, or both.

ConnectionFactory
A ConnectionFactory object encapsulates a set of configuration properties for a connection. An application uses a connection factory to create a connection.

Connection
A Connection object encapsulates an application's active connection to a messaging server. An application uses a connection to create sessions.

Session
A session is a single threaded context for sending and receiving messages. An application uses a session to create messages, message producers, and message consumers. A session is either transacted or not transacted.

Message
A Message object encapsulates a message that an application sends or receives.

MessageProducer
An application uses a message producer to send messages to a destination.

MessageConsumer
An application uses a message consumer to receive messages sent to a destination.

Figure 53 on page 152 shows these objects and their relationships.

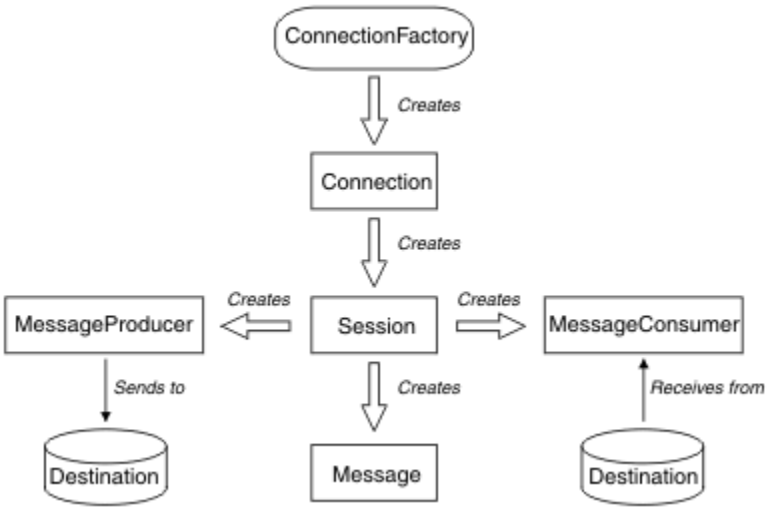


Figure 53. JMS objects and their relationships

The diagram shows the main interfaces: ConnectionFactory, Connection, Session, MessageProducer, MessageConsumer, Message, and Destination. An application uses a connection factory to create a connection, and uses a connection to create sessions. The application can then use a session to create messages, message producers, and message consumers. The application uses a message producer to send messages to a destination, and uses a message consumer to receive messages sent to a destination.

A Destination, ConnectionFactory, or Connection object can be used concurrently by different threads of a multithreaded application, but a Session, MessageProducer, or MessageConsumer object cannot be used concurrently by different threads. The simplest way of ensuring that a Session, MessageProducer, or MessageConsumer object is not used concurrently is to create a separate Session object for each thread.

JMS support two styles of messaging:

- Point-to-point messaging
- Publish/subscribe messaging

These styles of messaging are also referred to as *messaging domains*, and you can combine both styles of messaging in an application. In the point-to-point domain, a destination is a queue and, in the publish/subscribe domain, a destination is a topic.

With versions of JMS before JMS 1.1, programming for the point-to-point domain uses one set of interfaces and methods, and programming for the publish/subscribe domain uses another set. The two sets are similar, but separate. From JMS 1.1, you can use a common set of interfaces and methods that support both messaging domains. The common interfaces provide a domain independent view of each messaging domain. Table 17 on page 152 lists the JMS domain independent interfaces and their corresponding domain specific interfaces.

Table 17. The JMS domain independent and their corresponding domain specific interfaces

Domain independent interfaces	**Domain specific interfaces for the point-to-point domain**	**Domain specific interfaces for the publish/subscribe domain**
ConnectionFactory	QueueConnectionFactory	TopicConnectionFactory
Connection	QueueConnection	TopicConnection
Destination	Queue	Topic
Session	QueueSession	TopicSession
MessageProducer	QueueSender	TopicPublisher

Table 17. The JMS domain independent and their corresponding domain specific interfaces (continued)		
Domain independent interfaces	**Domain specific interfaces for the point-to-point domain**	**Domain specific interfaces for the publish/subscribe domain**
MessageConsumer	QueueReceiver QueueBrowser	TopicSubscriber

JMS 2.0 IBM MQ classes for JMS 2.0 supports both the earlier JMS 1.1 domain specific interfaces and the simplified API of JMS 2.0. IBM MQ classes for JMS 2.0 can therefore be used for maintaining existing applications, including developing new function in existing applications.

JMS 3.0 IBM MQ classes for Jakarta Messaging 3.0 supports the Jakarta Messaging versions of the same interfaces, and is recommended for new application development.

In IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging, JMS objects are related to IBM MQ concepts in the following ways:

- A Connection object has properties that are derived from the properties of the connection factory that was used to create the connection. These properties control how an application connects to a queue manager. Examples of these properties are the name of the queue manager and, for an application that connects to the queue manager in client mode, the host name or IP address of the system on which the queue manager is running.
- A Session object encapsulates an IBM MQ connection handle, which therefore defines the transactional scope of the session.
- A MessageProducer object and a MessageConsumer object each encapsulates an IBM MQ object handle.

When using IBM MQ classes for JMS or IBM MQ classes for Jakarta Messaging, all the normal rules of IBM MQ apply. Note, in particular, that an application can send a message to a remote queue but it can receive a message only from a queue that is owned by the queue manager to which the application is connected.

The JMS specification expects ConnectionFactory and Destination objects to be administered objects. An administrator creates and maintains administered objects in a central repository, and a JMS application retrieves these objects using the Java Naming and Directory Interface (JNDI).

In IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging, the implementation of the Destination interface is an abstract superclass of Queue and Topic, and so an instance of Destination is either a Queue object or a Topic object. The domain independent interfaces treat a queue or a topic as a destination. The messaging domain for a MessageProducer or MessageConsumer object is determined by whether the destination is a queue or a topic.

In IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging therefore, objects of the following types can be administered objects:

- ConnectionFactory
- QueueConnectionFactory
- TopicConnectionFactory
- Queue
- Topic
- XAConnectionFactory
- XAQueueConnectionFactory
- XATopicConnectionFactory

IBM MQ classes for JMS/Jakarta Messaging architecture

IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging have a layered architecture. The topmost layer of code is a common layer that any IBM Java messaging provider can use.

JMS 3.0 IBM MQ 9.3.0 introduced support for Jakarta Messaging 3.0. JMS 2.0 is still fully supported.

IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging have a layered architecture as shown in the diagram Figure 54 on page 154. The topmost layer of code is a common layer that can be used by any IBM JMS or Jakarta Messagingprovider. When an application calls a JMS or Jakarta Messagingmethod, any processing of the call that is not specific to a messaging system is performed by the common layer, which also provides a consistent response to the call. Any processing of the call that is specific to a messaging system is delegated to a lower layer. In the following diagram, the IBM MQ messaging provider is shown in the lower layer, together with two further messaging providers (Messaging provider A and Messaging provider B.)

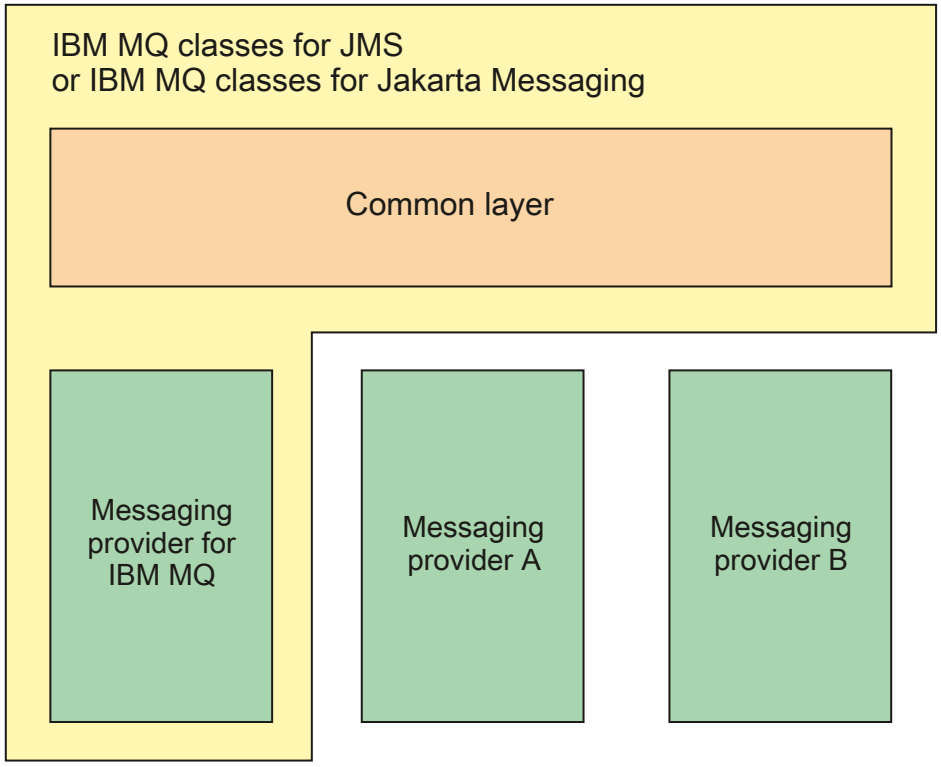


Figure 54. The layered architecture for IBM JMS and Jakarta Messaging providers

A layered architecture fulfills following objectives:

- To improve the consistency of behavior of the various IBM JMS and Jakarta Messaging providers
- To make it easier to write a bridge application between two IBM messaging systems
- To make it easier to port an application from one IBM JMS or Jakarta Messaging provider to another

Related tasks

Using IBM MQ classes for JMS/Jakarta Messaging

Support for administered objects

IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging support the use of administered objects.

JMS 3.0 From IBM MQ 9.3.0, Jakarta Messaging 3.0 is supported for developing new applications. IBM MQ 9.3.0 and later continue to support JMS 2.0 for existing applications. It is not supported to use both the Jakarta Messaging 3.0 API and the JMS 2.0 API in the same application. For more information, see Using IBM MQ classes for JMS/Jakarta Messaging.

The flow of logic within a JMS or IBM MQ classes for Jakarta Messaging application starts with ConnectionFactory and Destination objects. The application uses a ConnectionFactory object to create a Connection object, which represents the active connection from the application to a messaging server. The application uses the Connection object to create a Session object, which is a single threaded context for producing and consuming messages. The application can then use the Session object and a Destination object to create a MessageProducer object, which the application uses to send messages to the specified destination. The destination is either a queue or a topic in the messaging system and is encapsulated by the Destination object. The application can also use the Session object and a Destination object to create a MessageConsumer object, which the application uses to receive messages that have been sent to the specified destination.

The JMS and Jakarta Messaging specifications expect ConnectionFactory and Destination objects to be administered objects. An administrator creates and maintains administered objects in a central repository, and a JMS or Jakarta Messaging application retrieves these objects using the Java Naming Directory Interface (JNDI). The repository of administered objects can range from a simple file to a Lightweight Directory Access Protocol (LDAP) directory.

IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging support the use of administered objects. An application can use all the features of IBM MQ classes for JMS or IBM MQ classes for Jakarta Messaging that are exposed through IBM MQ without having any IBM MQ-specific information hard coded into the application itself. This arrangement provides the application with a degree of independence from the underlying IBM MQ configuration.

To achieve this independence, the application can use JNDI to retrieve connection factories and destinations that are stored as administered objects, and use only the interfaces defined in the `javax.jms` (JMS 2.0) or `jakarta.jms` (Jakarta Messaging 3.0) package to perform messaging operations.

JMS 2.0 For JMS 2.0, an administrator can use the IBM MQ JMS administration tool **JMSAdmin**, or IBM MQ Explorer, to create and maintain administered objects in a central repository.

JMS 3.0 For Jakarta Messaging 3.0, you cannot administer JNDI using IBM MQ Explorer. JNDI administration is supported by the Jakarta Messaging 3.0 variant of **JMSAdmin**, which is **JMS30Admin**.

An application server typically provides its own repository for administered objects, and its own tools for creating and maintaining the objects. A Java EE JMS 3.0 or Jakarta EE application can therefore use JNDI to retrieve administered objects either from the applications server repository or from a central repository.

Related tasks

Configuring JMS and Jakarta Messaging resources

Supported communication types on Java EE and Jakarta EE platforms

On the Java EE and Jakarta EE platforms, IBM MQ classes for JMS and IBM MQ classes for Jakarta Messaging support two types of communication between a component of an application and an IBM MQ queue manager.

JMS 3.0 IBM MQ 9.3.0 introduced support for Jakarta Messaging 3.0. JMS 2.0 is still fully supported. Because JMS and Jakarta Messaging share much in common, further references to JMS in this topic can be taken as referring to both. Any differences are highlighted as necessary.

The following two types of communication between a component of an application and an IBM MQ queue manager are supported:

- Outbound communication
- Inbound communication

Outbound communication

Using the JMS or Jakarta Messaging API directly, an application component creates a connection to a queue manager, and then sends and receives messages.

For example, the application component can be an application client, a servlet, a Java Server Page (JSP), an enterprise Java bean (EJB), or a message driven bean (MDB). In this type of communication, the application server container provides only low-level functions in support of messaging operations, such as connection pooling and thread management.

Inbound communication

In the case of inbound communication, a message arriving at a destination is delivered to an MDB, which then processes the message.

Java EE JMS 3.0 and Jakarta EE applications use MDBs to process messages asynchronously. An MDB acts as a JMS message listener and is implemented by an onMessage() method, which defines how a message is processed. An MDB is deployed in the EJB container of an application server. The precise way in which an MDB is configured depends on which application server you are using, but the configuration information must specify which queue manager to connect to, how to connect to the queue manager, which destination to monitor for messages, and the transactional behavior of the MDB. This information is then used by the EJB container. When a message satisfying the selection criteria of the MDB arrives at the specified destination, the EJB container uses IBM MQ classes for JMS or IBM MQ classes for Jakarta Messaging to retrieve the message from the queue manager, and then delivers the message to the MDB by calling its onMessage() method.

Relationship with IBM MQ classes for Java

IBM MQ classes for Java, IBM MQ classes for Jakarta Messaging and IBM MQ classes for JMS are peers that use a common Java interface to the MQI.

Figure 55 on page 157 shows the relationship between IBM MQ classes for JMS, IBM MQ classes for Jakarta Messaging and IBM MQ classes for Java.

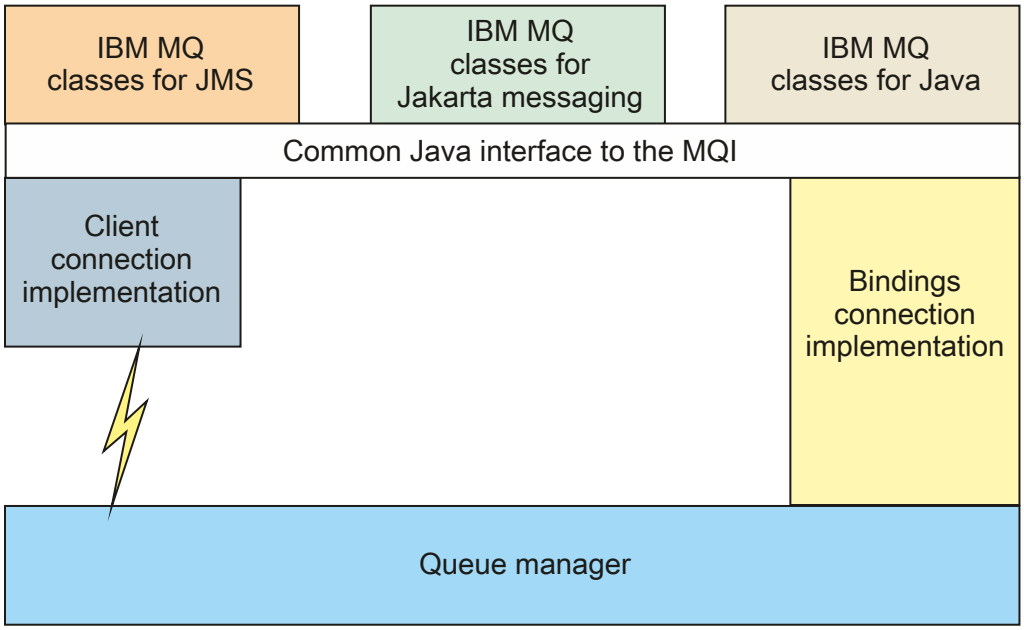


Figure 55. The relationship between IBM MQ classes for JMS, IBM MQ classes for Jakarta Messaging and IBM MQ classes for Java

In general, Java programs should use only one interface to interface with IBM MQ – IBM MQ classes for Java, IBM MQ classes for Jakarta Messaging or IBM MQ classes for JMS. Mixing interfaces is not supported, with one exception. To maintain compatibility with releases before IBM WebSphere MQ 7.0, channel exit classes that are written in Java can still use the IBM MQ classes for Java interfaces, even if the channel exit classes are called from IBM MQ classes for JMS. However, using the IBM MQ classes for Java interfaces means that your applications are still dependent on either:

- JMS 2.0 The IBM MQ classes for Java JAR file, `com.ibm.mq.jar`. If you do not want `com.ibm.mq.jar` in your class path, you can use the set of interfaces in the `com.ibm.mq.exits` package instead.
- JMS 3.0 Use of the `com.ibm.mq.jakarta.client.jar`, when interoperating with IBM MQ classes for Jakarta Messaging.

Related concepts

Why should I use IBM MQ classes for Jakarta Messaging?

Why should I use IBM MQ classes for JMS?

Why should I use IBM MQ classes for Java?

IBM MQ messaging provider

The IBM MQ messaging provider has three modes of operation: normal mode, normal mode with restrictions, and migration mode.

The IBM MQ messaging provider has three modes of operation:

- IBM MQ messaging provider normal mode
- IBM MQ messaging provider normal mode with restrictions
- IBM MQ messaging provider migration mode

The IBM MQ messaging provider normal mode uses all the features of an IBM MQ queue manager to implement JMS. This mode is optimized to use the JMS 2.0 JMS 3.0 or Jakarta Messaging 3.0 API and functionality.

If:

- The client specifies a provider version of 6 on a **ConnectionFactory**, the client behaves in a way compatible with the client provided with IBM WebSphere MQ 6.0. Only JMS 1.1 and JMS 2 interfaces are supported but some JMS 2 functionality, such as shared subscriptions, delivery delay and asynchronous send, is disabled. There is no connection sharing.
- The client specifies a provider version of 7 on a **ConnectionFactory**, both JMS 1.1 and JMS 2 interfaces are fully supported.
- No provider version is specified, an attempt is made to connect with provider version 7. If this fails, a further attempt is made with provider version 6.

If you want to connect to IBM Integration Bus by using IBM MQ Enterprise Transport, use the migration mode. If you use IBM MQ Real-Time Transport, the migration mode is automatically selected because you have explicitly selected properties in the connection factory object. Connection to IBM Integration Bus using the IBM MQ Enterprise Transport follows the general rules for mode selection that is described in Configuring the JMS **PROVIDERVERSION** property.

Related tasks

Configuring JMS resources

z/OS IBM MQ for z/OS concepts

Some of the concepts used by IBM MQ for z/OS are unique to the z/OS platform. For example, the logging mechanism, the storage management techniques, unit of recovery disposition, and queue sharing groups are provided only with IBM MQ for z/OS. Use this topic as an introduction to further information about these concepts.

The concepts include an overview of the objects that IBM MQ for z/OSuses, including:

- The queue manager
- The channel initiator
- Shared queues and queue sharing groups
- Intra-group queuing

The following topics also cover various procedures you need, including:

- System definitions on z/OS
- Storage management
- Recovery and restart
- Security concepts in IBM MQ for z/OS

Related concepts

“The queue manager on z/OS” on page 159
Before you can let your application programs use IBM MQ on your z/OS system, you must install the IBM MQ for z/OS product and start a queue manager. The queue manager owns and manages the set of resources that are used by IBM MQ.

“The channel initiator on z/OS” on page 160
The channel initiator provides and manages resources that enable IBM MQ distributed queuing. IBM MQ uses *Message Channel Agents* (MCAs) to send messages from one queue manager to another.

“Terms and tasks for managing IBM MQ for z/OS” on page 162
Use this topic as an introduction to the terminology, and tasks that are specific to IBM MQ for z/OS.

“Shared queues and queue sharing groups” on page 164
You can use shared queues and queue sharing groups, to implement high availability of IBM MQ resources. Shared queues and queue sharing groups are functions unique to IBM MQ for z/OS on the z/OS platform.

“Intra-group queuing” on page 208

This section describes intra-group queuing, an IBM MQ for z/OS function unique to the z/OS platform. This function is only available to queue managers defined to a queue sharing group.

"Storage management on z/OS" on page 221
IBM MQ for z/OS requires permanent and temporary data structures and uses page sets and memory buffers to store this data. These topics give more details on how IBM MQ uses these page sets and buffers.

"Logging in IBM MQ for z/OS" on page 225
IBM MQ maintains *logs* of data changes and significant events as they occur. These logs can be used to recover data to a previous state if required.

"Recovery and restart on z/OS" on page 246
Use the links in this topic to find out about the features of IBM MQ for z/OS for restart and recovery.

"Security concepts in IBM MQ for z/OS" on page 262
Use this topic to understand the importance of security for IBM MQ, and the implications of not having adequate security settings on your system.

"Availability on z/OS" on page 269
IBM MQ for z/OS has many features for high availability. This topic describes some of the considerations for availability.

"Unit of recovery disposition on z/OS" on page 273
Certain transactional applications can use a GROUP, rather than a QMGR, unit of recovery disposition when connected to a queue manager in a queue sharing group (QSG) by specifying the QSG name when they connect instead of the queue manager name. This allows transaction recovery to be more flexible and robust by removing the requirement to reconnect to the same queue manager in the QSG.

Related reference

"System definition on z/OS" on page 236
IBM MQ for z/OS uses many default object definitions, and provides sample JCL to create those default objects. Use this topic to understand these default objects, and the sample JCL.

"Monitoring and statistics on IBM MQ for z/OS" on page 272
IBM MQ for z/OS has a set of facilities for monitoring the queue manager, and gathering statistics.

z/OS The queue manager on z/OS

Before you can let your application programs use IBM MQ on your z/OS system, you must install the IBM MQ for z/OS product and start a queue manager. The queue manager owns and manages the set of resources that are used by IBM MQ.

The queue manager

A *queue manager* is a program that provides messaging services to applications. Applications that use the Message Queue Interface (MQI) can put messages on queues and get messages from queues. The queue manager ensures that messages are sent to the correct queue or are routed to another queue manager. The queue manager processes both the MQI calls that are issued to it, and the commands that are submitted to it (from whatever source). The queue manager generates the appropriate completion codes for each call or command.

The resources managed by the queue manager include:

- Page sets that hold the IBM MQ object definitions and message data
- Logs that are used to recover messages and objects in the event of queue manager failure
- Processor storage
- Connections through which different application environments (CICS, IMS, and Batch) can access the IBM MQ API
- The IBM MQ channel initiator, which allows communication between IBM MQ on your z/OS system and other systems

The queue manager has a name, and applications can connect to it using this name.

Figure 56 on page 160 illustrates a queue manager, showing connections to different application environments, and the channel initiator.

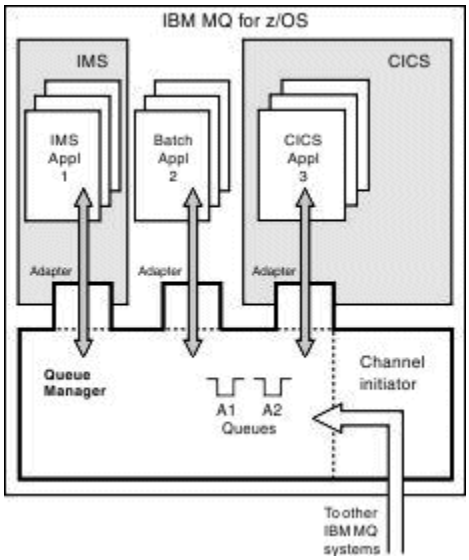


Figure 56. Overview of IBM MQ for z/OS

The queue manager subsystem on z/OS

On z/OS, IBM MQ runs as a z/OS subsystem that is started at IPL time. In the subsystem, the queue manager is started by executing a JCL procedure that specifies the z/OS data sets that contain information about the logs, and that hold object definitions and message data (the page sets). The subsystem and the queue manager have the same name, of up to four characters. All queue managers in your network must have unique names, even if they are on different systems, sysplexes, or platforms.

z/OS The channel initiator on z/OS

The channel initiator provides and manages resources that enable IBM MQ distributed queuing. IBM MQ uses *Message Channel Agents* (MCAs) to send messages from one queue manager to another.

To send messages from queue manager A to queue manager B, a *sending* MCA on queue manager A must set up a communications link to queue manager B. A *receiving* MCA must be started on queue manager B to receive messages from the communications link. This one-way path consisting of the sending MCA, the communications link, and the receiving MCA is known as a *channel*. The sending MCA takes messages from a transmission queue and sends them down a channel to the receiving MCA. The receiving MCA receives the messages and puts them on to the destination queues.

In IBM MQ for z/OS, the sending and receiving MCAs all run inside the channel initiator (the channel initiator is also known as the *mover*). The channel initiator runs as a z/OS address space under the control of the queue manager. There can be only a single channel initiator connected to a queue manager and it is run inside the same z/OS image as the queue manager. There can be thousands of MCA processes running inside the channel initiator concurrently.

Figure 57 on page 161 shows two queue managers within a sysplex. Each queue manager has a channel initiator and a local queue. Messages sent by queue managers on AIX and Windows are placed on the local queue, from where they are retrieved by an application. Reply messages are returned by a similar route.

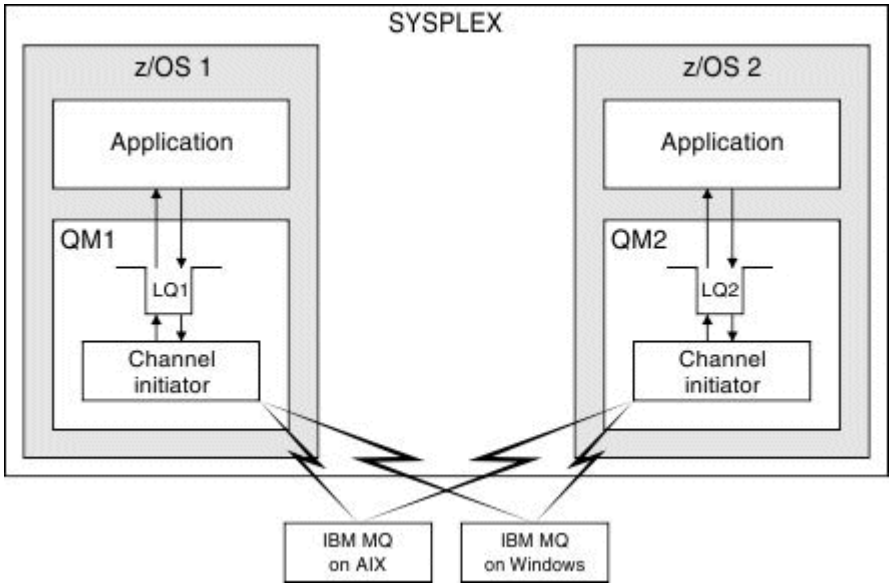


Figure 57. Communication between queue managers

The channel initiator also contains other processes concerned with the management of the channels. These processes include:

Listeners
These processes listen for inbound channel requests on a communications subsystem such as TCP, and start a named MCA when an inbound request is received.

Supervisor
This manages the channel initiator address space, for example it is responsible for restarting channels after a failure.

Name server
This is used to resolve TCP names into addresses.

TLS tasks
These are used to perform encryption and decryption and check certificate revocation lists.

z/OS SMF records for the channel initiator

The channel initiator (CHINIT) can produce SMF statistics records and accounting records with information on tasks and channels.

The CHINIT can produce SMF statistics records and accounting records with the following types of information:

- The tasks: dispatcher, adapter, Domain Name Server (DNS), and SSL. These tasks form what is called CHINIT statistics.
- Channels: provides accounting information similar to that available with the DIS CHSTATUS command. This is called channel accounting.

IBM MQ for Multiplatforms provides similar information by writing PCF messages to the SYSTEM.ADMIN.STATISTICS.QUEUE. See Channel statistics message data for further information on how statistics information is recorded on IBM MQ for Multiplatforms.

Statistics data

You can use this information to find out the following information:

- Whether you need more of the CHINIT tasks, such as number of SSL TCBs and how much CPU is used by these tasks.

- The average time for requests on these tasks.
- The longest duration request in the interval, and the time of day this occurred, for DNS and SSL tasks. You can correlate this time of day with problems you may experience with the channel.

Accounting data

You can use this information to monitor channel usage and find out the following information:

- The channels with the highest throughput.
- The rate at which messages were sent, and the rate of sending data in MB/second.
- The achieved batch size. If the achieved batch size is close to the batch size specified for the channel, the channel might be close to its limit for sending messages.

You use the START TRACE and STOP TRACE commands to control the collection of the accounting trace and the statistics trace. You can use the STATCHL and STATACLS options on the channel and queue manager to control whether channels produce SMF data.

z/OS Terms and tasks for managing IBM MQ for z/OS

Use this topic as an introduction to the terminology, and tasks that are specific to IBM MQ for z/OS.

Some of the terms and tasks required for managing IBM MQ for z/OS are specific to the z/OS platform. The following list contains some of these terms and tasks.

- Shared queues
- Page sets and buffer pools
- Logging
- Tailoring the queue manager environment
- Restart and recovery
- Security
- Availability
- Manipulating objects
- Monitoring and statistics
- Application environments

Shared queues

Queues can be *non-shared*, owned by and accessible to only one queue manager, or *shared*, owned by a *queue sharing group*. A queue sharing group consists of a number of queue managers, running within a single z/OS sysplex, that can access the same IBM MQ object definitions and message data concurrently. Within a queue sharing group, the shareable object definitions are stored in a shared Db2 database. The shared queue messages are held inside one or more coupling facility structures (CF structures). If the message data is too large to store directly in the structure (more than 63 KB in size), or if the message is large enough that installation-defined rules select it for offloading, the message control information is still stored in the coupling facility entry, but the message data is offloaded to a shared message data set (SMDS) or to a shared Db2 database. The shared message data sets, the shared Db2 database, and the coupling facility structures are resources that are jointly managed by all of the queue managers in the group.

Pages sets and buffer pools

When a message is put on to a non-shared queue, the queue manager stores the data on a page set in such a way that it can be retrieved when a subsequent operation gets a message from the same queue. If

the message is removed from the queue, space in the page set that holds the data is later freed for reuse. As the number of messages held on a queue increases, so the amount of space used in the page set increases, and as the number of messages on a queue reduces, the space used in the page set reduces.

To reduce the performance cost of writing data to and reading data from the page sets, the queue manager buffers the updates into processor storage. The amount of storage used to buffer the page set access is controlled through IBM MQ objects called *buffer pools*.

For more information about page sets and buffer pools, see Storage management.

Logging

Any changes to objects held on page sets, and operations on persistent messages, are recorded as log records. These log records are written to a log data set called the *active log*. The name and size of the active log data set is held in a data set called the *bootstrap data set* (BSDS).

When the active log data set fills up, the queue manager switches to another log data set so that logging can continue, and copies the content of the full active log data set to an *archive log* data set. Information about these actions, including the name of the archive log data set, is held in the bootstrap data set. Conceptually, there is a ring of active log data sets that the queue manager cycles through; when an active log is filled, the log data is offloaded to an archive log, and the active log data set is available for reuse.

For more information about the log and bootstrap data sets, see “Logging in IBM MQ for z/OS” on page 225.

Tailoring the queue manager environment

When the queue manager is started, a set of initialization parameters that control how the queue manager operates are read. In addition, data sets containing IBM MQ commands are read, and the commands they contain are executed. Typically, these data sets contain definitions of the system objects required for IBM MQ to run, and you can tailor these to define or initialize the IBM MQ objects necessary for your operating environment. When these data sets have been read, any objects defined by them are stored, either on a page set or in Db2.

For more information about initialization parameters and system objects, see “System definition on z/OS” on page 236.

Recovery and restart

At any time during the operation of IBM MQ, there might be changes held in processor storage that have not yet been written to the page set. These changes are written out to the page set that is the least recently used by a background task within the queue manager.

If the queue manager terminates abnormally, the recovery phase of queue manager restart can recover the lost page set changes because persistent message data is held in log records. This means that IBM MQ can recover persistent message data and object changes right up to the point of failure.

If a queue manager that is a member of a queue sharing group encounters a coupling facility failure, the persistent messages on that queue can be recovered only if you have backed up your coupling facility structure.

For more information about recovery and restart, see “Recovery and restart on z/OS” on page 246.

Security

You can use an external security manager, such as Security Server (previously known as RACF) to protect the resources that IBM MQ owns and manages from access by unauthorized users. You can also use Transport Layer Security (TLS) for channel security. TLS is included as part of the IBM MQ product.

For more information about IBM MQ security, see “Security concepts in IBM MQ for z/OS” on page 262.

Availability

There are several features of IBM MQ that are designed to increase system availability in the event of queue manager or communications subsystem failure. For more information about these features, see “Availability on z/OS” on page 269.

Manipulating objects

When the queue manager is running, you can manipulate IBM MQ objects either through a z/OS console interface, or through an administration utility that uses ISPF services under TSO. Both mechanisms enable you to define, alter, or delete IBM MQ objects. You can also control and display the status of various IBM MQ and queue manager functions.

For more information about these facilities, see Sources from which you can issue MQSC and PCF commands on IBM MQ for z/OS.

You can also manipulate IBM MQ objects using the IBM MQ Explorer, a graphical user interface that provides a visual way of working with queues, queue managers, and other objects.

Monitoring and statistics

Several facilities are available to monitor your queue managers and channel initiators. You can also collect statistics for performance evaluation and accounting purposes.

For more information about these facilities, see “Monitoring and statistics on IBM MQ for z/OS” on page 272.

Application environments

When the queue manager has started, applications can connect to it and start using the IBM MQ API. These can be CICS, IMS, Batch, or WebSphere Application Server applications. IBM MQ applications can also access applications on CICS and IMS systems that are not aware of IBM MQ, using the CICS and IMS bridges.

For more information about these facilities, see “IBM MQ and other z/OS products” on page 275.

For information about writing IBM MQ applications, see the following documentation:

- Developing applications
- Using C++
- Using IBM MQ classes for Java

z/OS Shared queues and queue sharing groups

You can use shared queues and queue sharing groups, to implement high availability of IBM MQ resources. Shared queues and queue sharing groups are functions unique to IBM MQ for z/OS on the z/OS platform.

This section describes the attributes and benefits, and offers information about how several queue managers can share the same queues and the messages on those queues.

What is a shared queue?

A shared queue is a type of local queue. The messages on that queue can be accessed by one or more queue managers that are in a sysplex.

A queue sharing group

The queue managers that can access the same set of shared queues form a group called a *queue sharing group*.

Any queue manager can access messages

Any queue manager in the queue sharing group can access a shared queue. This means that you can put a message on to a shared queue on one queue manager, and get the same message from the queue from a different queue manager. This provides a rapid mechanism for communication within a queue sharing group that does not require channels to be active between queue managers.

IBM MQ supports the offloading of messages to Db2 or a shared message data set (SMDS). The offloading of messages of any size is configurable.

Figure 58 on page 165 shows three queue managers and a coupling facility, forming a queue sharing group. All three queue managers can access the shared queue in the coupling facility.

An application can connect to any of the queue managers within the queue sharing group. Because all the queue managers in the queue sharing group can access all the shared queues, the application does not depend on the availability of a specific queue manager; any queue manager in the queue sharing group can service the queue.

This gives greater availability because all the other queue managers in the queue sharing group can continue processing the queue if one of the queue managers has a problem.

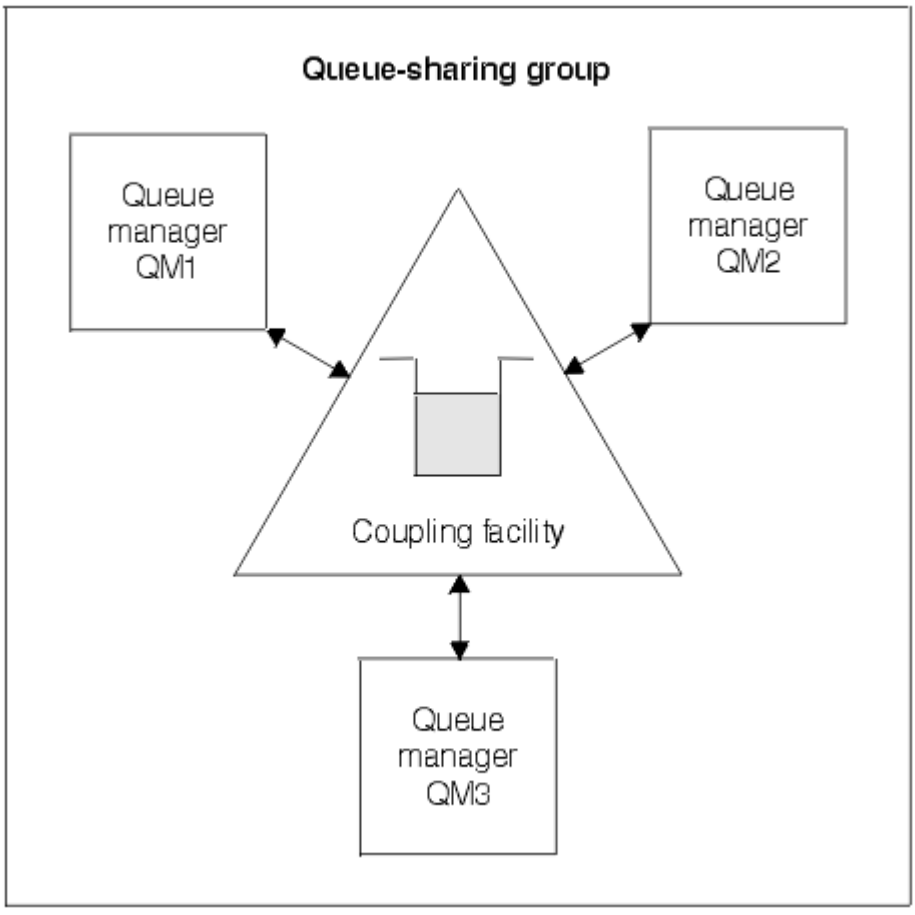


Figure 58. A queue sharing group

Queue definition is shared by all queue managers

Shared queue definitions are stored in the Db2 database table OBJ_B_QUEUE. Because of this, you need to define the queue only once and then it can be accessed by all the queue managers in the queue sharing group. This means that there are fewer definitions to make.

By contrast, the definition of a non-shared queue is stored on page set zero of the queue manager that owns the queue (as described in Page sets).

You cannot define a shared queue if a queue with that name has already been defined on the page sets of the defining queue manager. Likewise, you cannot define a local version of a queue on the queue manager page sets if a shared queue with the same name exists.

What is a queue sharing group?

A group of queue managers that can access the same shared queues is called a queue sharing group. Each member of the queue sharing group has access to the same set of shared queues.

Queue sharing groups have a name of up to four characters. The name must be unique in your network, and must be different from any queue manager names.

Figure 59 on page 166 illustrates a queue sharing group that contains two queue managers. Each queue manager has a channel initiator and its own local page sets and log data sets.

Each member of the queue sharing group must also connect to a Db2 system. The Db2 systems must all be in the same Db2 data-sharing group so that the queue managers can access the Db2 shared repository used to hold shared object definitions. These are definitions of any type of IBM MQ object (for example, queues and channels) that are defined only once and then any queue manager in the group can use them. These are called *global* definitions and are described in Private and global definitions.

More than one queue sharing group can reference a particular data-sharing group. You specify the name of the Db2 subsystem and which data-sharing group a queue manager uses in the IBM MQ system parameters at startup.

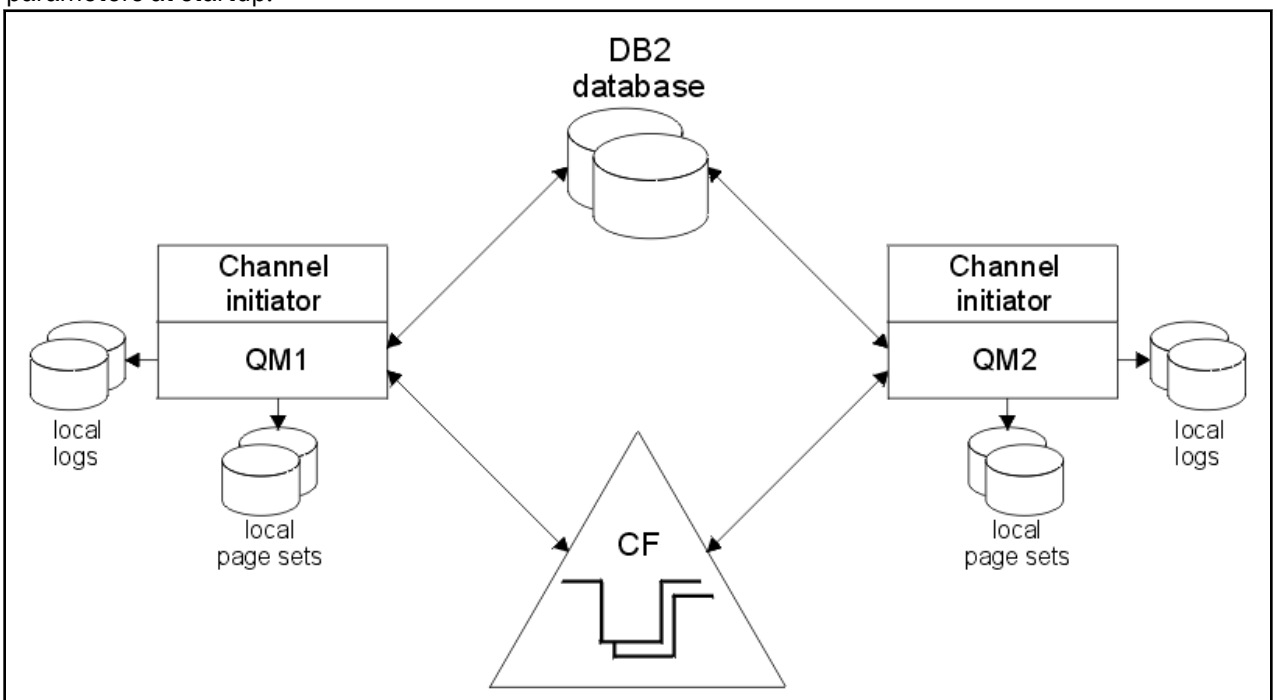


Figure 59. The components of queue managers in a queue sharing group

When a queue manager has joined a queue sharing group, it has access to the shared objects defined for that group, and you can use that queue manager to define new shared objects within the group. If shared queues are defined within the group, you can use this queue manager to put messages to and get messages from those shared queues. Any queue manager in the group can retrieve the messages held on a shared queue.

You can enter an MQSC command once, and have it executed on all queue managers within the queue sharing group as if it had been entered at each queue manager individually. The *command scope* attribute is used for this. This attribute is described in Directing commands to different queue managers.

When a queue manager runs as a member of a queue sharing group it must be possible to distinguish between IBM MQ objects defined privately to that queue manager and IBM MQ objects defined globally that are available to all queue managers in the queue sharing group. The *queue sharing group disposition* attribute is used for this. This attribute is described in Private and global definitions.

You can define a single set of security profiles that control access to IBM MQ objects anywhere within the group. This means that the number of profiles you have to define is greatly reduced.

A queue manager can belong to only one queue sharing group, and all queue managers in the group must be in the same sysplex. You specify which queue sharing group the queue manager belongs to in the system parameters at startup.

Related concepts

"Where are shared queue messages held?" on page 167
Each message on a shared queue is represented by an entry in a z/OS coupling facility list structure. If the message data is too large to fit in the same entry, it is offloaded either to a shared message data set (SMDS) or to Db2.

"Advantages of using shared queues" on page 183
Shared queue allows for IBM MQ applications to be scalable, highly available, and allows workload balancing to be implemented.

"Distributed queuing and queue sharing groups" on page 203
Distributed queuing and queue sharing groups are two techniques that you can use to increase the availability of your application systems. Use this topic to find further information about these techniques.

"Influencing workload distribution with shared queues" on page 206
Use this topic to understand the factors that affect workload distribution with shared queues in a queue sharing group.

Related reference

"Where to find more information about shared queues and queue sharing groups" on page 207
Use the table in this topic to find more information about how IBM MQ for z/OS uses shared queues and queue sharing groups.

z/OS Where are shared queue messages held?

Each message on a shared queue is represented by an entry in a z/OS coupling facility list structure. If the message data is too large to fit in the same entry, it is offloaded either to a shared message data set (SMDS) or to Db2.

If the CF structure has been configured to use System Class Memory (SCM), IBM MQ can use this with no additional configuration.

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

Shared queue message storage

Messages that are put onto shared queues are not stored on page sets and do not use buffer pools.

The messages in shared queues have entries on list structures in the z/OS coupling facility (CF). Many queue managers in the same sysplex can access those messages using the CF list structure.

The message data for small shared queue messages is normally included in the coupling facility entry. For larger messages, the message data can be stored either in a shared message data set (SMDS), or as one or more binary large objects (BLOBs) in a Db2 table which is shared by a Db2 data sharing group.

Message data exceeding 63 KB is always offloaded to SMDS or Db2. Smaller messages can also optionally be offloaded in the same way to save space in the coupling facility structure. See “Specifying offload options for shared messages” on page 169 for more details.

Messages put on a shared queue are referenced in a coupling facility structure until they are retrieved by an MQGET. Coupling facility operations are used to:

- Search for the next retrievable message
- Lock uncommitted messages on shared queues
- Notify interested queue managers about the arrival of committed messages

MQPUT and MQGET operations on persistent messages are recorded on the log of the queue manager performing that operation. This minimizes the risk of data loss in the event of a coupling facility failure.

The coupling facility

The messages held on shared queues are referenced inside a coupling facility. The coupling facility lies outside any of the z/OS images in the sysplex and is typically configured to run on a different power supply. The coupling facility is therefore resilient to software failures and you can configure it so that it is resilient to hardware failures or power-outages. This means that messages stored in the coupling facility are highly available.

Each coupling facility list structure used by IBM MQ is dedicated to a specific queue sharing group, but a coupling facility can hold structures for more than one queue sharing group. Queue managers in different queue sharing groups cannot share data. Up to 32 queue managers in a queue sharing group can connect to a coupling facility list structure at the same time.

A single coupling facility list structure can contain up to 512 shared queues. The total amount of message data stored in the structure is limited by the structure capacity. However, with **CFLEVEL(5)** you can use the offload parameters to offload data for messages less than 63 KB thereby increasing the number of messages which can be stored in the structure, although each message still requires at least a coupling facility entry plus at least 768 bytes of data, made up of 256 bytes for the entry and 512 bytes for the two elements of header and descriptor.

The size of the list structure is restricted by the following factors:

- It must lie within a single coupling facility.
- It might share the available coupling facility storage with other structures for IBM MQ and other products.

Coupling facility list structures can have storage class memory associated with them. In certain situations this storage class memory can be useful when used with shared queues. See “Use of storage class memory with shared queues” on page 185 for more information.

Planning the CF structure size

If you require guidance on the sizing of your CF structures you can use the MP16: IBM MQ for z/OS Capacity planning and tuning supportpac. You can also use the web-based tool CFSizer, which is provided by IBM to assist with CF sizes.

The CF structure object

The queue manager's use of a coupling facility structure is specified in a CF structure (CFSTRUCT) IBM MQ object.

These structure objects are stored in Db2.

When using z/OS commands or definitions relating to a coupling facility structure, the first four characters of the name of the queue sharing group are required. However, an IBM MQ CFSTRUCT object always exists

within a single queue sharing group, and so its name does not include the first four characters of the name of the queue sharing group. For example, CFSTRUCT(MYDATA) defined in queue sharing group starting with SQ03 would use coupling facility list structure SQ03MYDATA.

CF structures have a CFLEVEL attribute that determines their functional capability:

- 1, 2 - can be used for nonpersistent messages less than 63 KB
- 3 - can be used for persistent and nonpersistent messages less than 63 KB
- 4 - can be used for persistent and nonpersistent messages up to 100 MB
- 5 - can be used for persistent and nonpersistent messages up to 100 MB and selectively offloaded to shared message data sets (SMDS) or Db2.

Note: When using IBM MQ you can encrypt a coupling facility structure. See Encrypting coupling facility structure data for more information.

Backup and recovery of the coupling facility

You can back up coupling facility list structures using the IBM MQ command BACKUP CFSTRUCT. This puts a copy of the persistent messages currently within the CF structure onto the active log data set of the queue manager making the backup, and writes a record of the backup to Db2.

If coupling facility fails, you can use the IBM MQ command RECOVER CFSTRUCT. This uses the backup record from Db2 to locate and restore persistent messages from the backup of the CF structure. Any activity since the last backup is replayed using the logs of all the queue managers in the queue sharing group, and the CF structure is then restored up to the point before the failure.

See the BACKUP CFSTRUCT and RECOVER CFSTRUCT commands for more details.

Related concepts

“Specifying offload options for shared messages” on page 169
You can choose where the message data for a shared queue message is stored, either in a Db2 table or a shared message data set (SMDS). You can also select which messages are offloaded, based on the size of the message and the current usage of the coupling facility structure (CF).

“Managing your shared message data set (SMDS) environment” on page 171
If you select shared message data sets to offload large messages then you must also be aware of the information that IBM MQ uses to manage these data sets and the commands used to work with this information. Use this topic to understand how to manage shared message data sets.

z/OS *Specifying offload options for shared messages*

You can choose where the message data for a shared queue message is stored, either in a Db2 table or a shared message data set (SMDS). You can also select which messages are offloaded, based on the size of the message and the current usage of the coupling facility structure (CF).

The message data for shared queues can be offloaded from the coupling facility and stored in either a Db2 table or in an IBM MQ managed data set called a *shared message data set* (SMDS).

For messages larger than the coupling facility entry size of 63 KB, offloading message data to a SMDS can have a significant performance improvement compared with offloading to Db2.

Every shared queue message is still managed using a list entry in a coupling facility structure, but when the message data is offloaded to the SMDS, the coupling facility entry only contains some control information and a list of references to the relevant disk blocks where the message is stored. Using this mechanism means the amount of coupling facility element storage required for each message is only a fraction of the actual size of the message.

Selecting where the shared queue messages are stored

The selection of SMDS or Db2 shared message storage is controlled with the **OFFLOAD(SMDS|DB2)** parameter on the **CFSTRUCT** definition. **OFFLOAD(SMDS)** is the default value.

This parameter also requires the **CFSTRUCT** to use **CFLEVEL(5)** or greater.

The **OFFLOAD** parameter is only valid from **CFLEVEL(5)**. See DEFINE CFSTRUCT for more details.

OFFLOAD(DB2) is supported primarily for migration purposes.

Selecting which shared queue messages are offloaded

Message data is offloaded to SMDS or Db2 based on the size of the message data, and the current usage of the coupling facility structure. There are three rules, and each rule specifies a matching pair of parameters. These parameters are a corresponding coupling facility structure usage threshold percentage (**OFFLDnTH**) and a message size limit (**OFFLDnSZ**).

The current implementation of the three rules is specified using the following pairs of keywords:

- OFFLD1TH and OFFLD1SZ
- OFFLD2TH and OFFLD2SZ
- OFFLD3TH and OFFLD3SZ

Rule pair	Default value	Description
Rule pair 1	OFFLD1TH(70) and OFFLD1SZ(32K)	If the coupling facility structure is more than 70% full offload data for messages exceeding 32 KB
Rule pair 2	OFFLD2TH(80) and OFFLD2SZ(4K)	If the coupling facility structure is more than 80% full offload data for messages exceeding 4 KB
Rule pair 3	OFFLD3TH(90) and OFFLD3SZ(0K)	If the coupling facility structure is more than 90% full offload data for messages exceeding 0 KB (all messages)

If an offload rule has the OFFLD *x* SZ value of 64K this indicates that the rule is not in effect. In this case messages will only be offloaded if another offload rule is in effect, or if the message is greater than 63.75 KB and so, too large to store in the structure.

Each message which is offloaded still requires 0.75 KB of storage in the coupling facility.

The three offload rules which can be specified for each structure are intended to be used as follows.

- Performance
  - When there is plenty of space in the application structure, message data should only be offloaded if it is too large to store in the structure, or if it exceeds some lower message size threshold such that the performance value of storing it in the structure is not worth the amount of structure space that it would need.
  - If a specific message size threshold is required, it is conventionally specified using the first offload rule.
- Capacity
  - When there is very little space in the application structure, the maximum amount of message data should be offloaded so as to make the best use of the remaining space.
  - The third offload rule is conventionally used to indicate that when the structure is nearly full, most messages should be offloaded, so the entries in the application structure will be typically of the minimum size (requiring about 0.75K bytes).
  - The usage threshold parameter should be chosen based on the application structure size and the maximum anticipated backlog. For example, if the maximum anticipated backlog is 1M messages, then the amount of structure storage required for this number of messages is about 0.75G bytes. This means for example that if the structure is about 10G bytes, the usage threshold for offloading all messages must be set to 92% or lower.

  - Structure space is divided into elements and entries, and even though there may be enough space overall, one of these may run out before the other. The system provides AUTOALTER capabilities to adjust the ratio when necessary, but this is not very sensitive, so the amount of space actually available may be somewhat less. It may be better therefore to aim to use not more than 90% of the maximum structure space, so in the previous example, the usage threshold for offloading all messages would be better set around 80%.
- Cushioned transition:
  - As the amount of space left in the coupling facility structure decreases, it would be undesirable to have a large sudden change in the performance characteristics. It is also undesirable for coupling facility management to have a sudden threshold change in the typical ratio of entries to elements being used.
  - The second offload rule is conventionally used to provide some intermediate cushion between the performance and capacity biased offload rules. It can be set to cause a significant increase in offload activity when the space used in the coupling facility structure exceeds an intermediate threshold. This means that the remaining space is used up more slowly, and gives the coupling facility automatic alter processing more time to adapt to the higher usage levels.

If the coupling facility structure cannot be expanded, and there is a need to store at least some predetermined number of messages, the third rule can be modified as necessary to ensure that offloading of data for all messages starts at an appropriate threshold to ensure space is reserved for that predetermined number of messages.

For example, if the coupling facility structure size is 4 GB, and the predetermined number of messages is 1 million, then 1,000,000 * 0.75 KB are needed, which is 768 MB, 18.75% of 4 GB. In this case the threshold for offloading all messages needs to be set around 80% rather than 90%. This gives parameters OFFLD3TH(80) and OFFLD3SZ(0K) . The other offload parameters would also need to be adjusted.

If it is found that offloading very small messages has a significant performance impact, but the relative impact is less for larger messages, then the usage thresholds for the other rules can be reduced to offload larger messages earlier, leaving more space in the structure for small messages before they need to be offloaded.

For example, if messages exceeding 32KB occur frequently but the elapsed time performance for offloading them (as determined from RMF statistics or application performance) is very similar to that for keeping them in the coupling facility, then the threshold for the first rule could be set to 0% to offload all such messages. This gives parameters OFFLD1TH(0) and OFFLD1SZ(32K). Again the other offload parameters would need to be adjusted.

If there are many messages around specific intermediate sizes, such as 16 KB and 6 KB, then it might be useful to change the message size option for the second rule so that the larger ones get offloaded at a fairly low usage threshold, saving a significant amount of space, but the smaller ones still get stored only in the coupling facility.

z/OS *Managing your shared message data set (SMDS) environment*

If you select shared message data sets to offload large messages then you must also be aware of the information that IBM MQ uses to manage these data sets and the commands used to work with this information. Use this topic to understand how to manage shared message data sets.

SMDS objects

The properties and status of each shared message data set are tracked in a shared SMDS object which can be updated through any queue manager in the queue sharing group.

There is one shared message data set for each queue manager that can access each coupling facility application structure. The shared message data set is identified by the owning queue manager name, specified using the SMDS keyword, and by the application structure name, specified using the CFSTRUCT keyword.

Note: When defining SMDS data sets for a structure, you must have one for each queue manager.

The SMDS object is stored in an array (with one entry per queue manager in the group) which forms an extension of the corresponding CFSTRUCT object stored in Db2.

There is no command to DEFINE or DELETE the SMDS object because it is created or deleted as part of the CFSTRUCT object, but there is a command to ALTER it to change settings for an individual owning queue manager.

For further information on SMDS commands, see "SMDS related commands" on page 182

SMDSCONN information

It is possible for a shared message data set to be in a normal state, but for one or more queue managers to be unable to connect to it, for example because of a problem with a security definition or with direct access device connectivity. It is therefore necessary for each queue manager to keep track of connection status, and availability information for each shared message data set, indicating for example whether it can currently connect to it, and if not why not.

The SMDSCONN information represents a queue manager connection to a shared message data set. As for the shared message data set itself, it is identified by the queue manager which owns the shared message data set (as specified on the SMDS keyword for the shared object itself) combined with the CFSTRUCT name.

There is no parameter to identify the connecting queue manager because commands addressed to a specific queue manager can only refer to SMDSCONN information for that same queue manager.

The SMDSCONN information entries are maintained in main storage in the owning queue manager, and are re-created when the queue manager is restarted. However, if a connection from an individual queue manager has been explicitly stopped, this information is also stored as a flag in a connection array in the corresponding CFSTRUCT or SMDS object, so that it persists across a queue manager restart.

Status and availability information

Status information indicates the state of a resource or connection (for example, whether it is not yet being used, is in normal use or is in need of recovery). It is usually described using the STATUS keyword. The possible values depend on the type of object.

Status information is normally updated automatically, for example when an error is detected while using the resource or connection. However, in some cases a command can also be used to update the status, to allow for cases when it is not possible for a queue manager to determine the correct status automatically.

Availability information indicates whether the resource or connection can be used, and is usually primarily determined by the status information. For the resource or connection types used in shared message data set support, three levels of availability are implemented:

Available
: This means that the resource is available to be used normally. This does not necessarily mean that it is in use at present (which can be determined instead from the STATUS value). For a data set, if it requires restart processing, this allows the owning queue manager to open it, but other queue managers must wait until the data set is back in the ACTIVE state.

Unavailable because of error
: This means that the resource has been made unavailable automatically because of an error and is not expected to be available again until some form of repair or recovery processing has been performed. However, attempts to make it available again are permitted without operator intervention. Such an attempt can also be triggered by a command to mark the resource as enabled, or a command which changes the status in such a way as to indicate that recovery processing has been completed.

  The reason that the resource has been made unavailable is normally obvious from the related STATUS value, but in some cases there may be other reasons to make the resource unavailable, in which case a separate REASON value is provided to indicate the reason.

Unavailable because of operator command
This means that access to the resource has been explicitly disabled by a command. It can only be made available by using a command to enable it again.

SMDS availability

For the shared SMDS object, the availability is described by the ACCESS keyword, with the possible values ENABLED, SUSPENDED and DISABLED.

The availability can be updated using a **RESET SMDS** command for the relevant shared object from any queue manager in the group to set ACCESS(ENABLED) or ACCESS(DISABLED).

If the availability was previously ACCESS(SUSPENDED), changing it to ACCESS(ENABLED) will trigger a new attempt to use the shared message data set, but if the previous error is still present, the availability will be reset back to ACCESS(SUSPENDED).

SMDSCONN availability

For a local SMDSCONN information entry, the availability is described by the AVAIL keyword, with the possible values NORMAL, ERROR or STOPPED. The availability can be updated using a **START SMDSCONN** or **STOP SMDSCONN** command addressed to a specific queue manager to enable or disable its connection.

If the availability was previously AVAIL(ERROR), changing it to AVAIL(NORMAL) will trigger a new attempt to use the shared message data set, but if the previous error is still present, the availability will be reset back to AVAIL(ERROR).

Shared message data set shared status and availability

The availability of each shared message data set is managed within the group using shared status information, which can be displayed using the **DISPLAY CFSTATUS** command with TYPE(SMDS). This displays status information for each queue manager that has activated a data set for each structure. Each data set can be in one of the following states:

NOTFOUND
This means that the corresponding data set has not yet been activated. This status only appears when a specific queue manager is specified, as data sets which have not been activated are skipped when all queue managers are selected.

NEW
The data set is being opened and initialized for the first time, ready to be made active.

ACTIVE
This means that the data set is fully available and should be allocated and opened by all active queue managers for the structure.

FAILED
This means the data set is not available at all (except for recovery processing) and must be closed and deallocated by all queue managers.

INRECOVER
This means that media recovery (using RECOVER CFSTRUCT) is in progress for this data set.

RECOVERED
This indicates that a command has been issued to switch a failed data set back to the active state, but further restart processing is required which is not yet complete, so the data set can only be opened by the owning queue manager for restart processing.

EMPTY
The data set contains no messages. The data set is put into this state if it is closed normally by the owning queue manager, at a time when it does not contain any messages. It can also be put into EMPTY state when the previous data set contents are to be discarded because the application structure has been emptied (using **RECOVER CFSTRUCT** with TYPE PURGE or, for a nonrecoverable structure only, by deleting the previous instance of the structure). The next time the data set is opened by its owning queue manager, the space map is reset to empty, and the status is changed to ACTIVE. As the previous data set contents are no longer required, a data set in this state can be

replaced with a newly allocated data set, for example to change the space allocation or move it to another volume.

The command output includes the date and time at which recovery logging was enabled, if any, and the date and time at which the data set failed, if it is not currently active.

A shared message data set can be put into a FAILED state either by a **RESET SMDS** command or automatically when any of the following types of error are detected:

- The data set cannot be allocated or opened by the owning queue manager.
- Validation of the data set header fails after it has been successfully opened by any queue manager.
- A permanent I/O error occurs when the owning queue manager is reading or writing data.
- A permanent I/O error occurs when another queue manager is reading data from a data set which had successfully completed open processing and validation.

When a data set is in the FAILED or INRECOVER state, it not available for normal use, so if the availability state is ACCESS(ENABLED) it is changed to ACCESS(SUSPENDED).

If a data set has been put into the the FAILED state but no media recovery is required, for example because the data was still valid but the storage device was temporarily offline, then the **RESET SMDS** command can be used to request changing the status directly to the RECOVERED state.

When the data set enters the RECOVERED state, either on completion of recovery processing or as a result of the **RESET SMDS** command, then it is ready to be used again once restart processing has been completed. If it was in the ACCESS(SUSPENDED) state, it is automatically switched back to the ACCESS(ENABLED) state, which allows the owning queue manager to perform restart processing. When restart processing completes, the state is changed to ACTIVE and all other queue managers can then connect to the data set again.

Shared message data set connection status and availability

Each queue manager maintains local status and availability information for its connection to each shared message data set owned by itself and by other queue managers in the group. This information can be displayed using the **DISPLAY SMDSCONN** command.

If it is unable to access a shared message data set in the ACTIVE state which belongs to another queue manager it flags the connection as being unavailable from its own point of view.

If the error definitely indicates a problem with the data set itself, the queue manager also automatically changes the shared status to indicate that the data set is now in a FAILED state. However, if the error could be caused by an environmental problem, such as not being authorized to open the data set, the queue manager issues error messages and treats the data set as being unavailable, but it does not modify the shared data set status. If the environmental error turns out to be a problem with the data set anyway (for example it has been allocated on a device which cannot be accessed by some of the queue managers) then an operator can use the RESET SMDS command specifying STATUS(FAILED) to allow the data set to be recovered or repaired as necessary.

If a connection to a shared message data set could not be established but the data set appears to be valid, a new attempt to use it can be triggered by issuing a **START SMDSCONN** command for the owning queue manager.

If there is an operational need to terminate the connection between a specific queue manager and a data set temporarily, but the data set itself is not damaged, then the data set can be closed and deallocated using the **STOP SMDSCONN** command. If the data set is in use, the queue manager will close it normally (although any requests for data in that data set will be rejected with a return code). If it is the owned data set, the queue manager will save the space map during CLOSE processing, avoiding the need for restart processing.

If a data set needs to be taken out of service temporarily from all queue managers (for example to move it) but is not damaged, then it is best to use **STOP SMDSCONN** for the relevant data set with the option CMDSCOPE(*) to stop the queue managers using it first, as this will avoid the need for restart processing when the data set is brought back into service. In contrast, if the data set is marked as FAILED this tells

queue managers that they must stop using it immediately, which means that the space map will not be saved and will need to be rebuilt by restart processing.

Access to any shared message data sets previously in the ACCESS(SUSPENDED) state will be retried if the queue manager is restarted.

Shared message data set recovery logging

Persistent shared messages are logged for media recovery purposes. This means that the messages can be recovered after any failure of coupling facility structures or shared message data sets, provided that the recovery logs are still intact. Persistent messages can also be re-created from the recovery logs at another site for disaster recovery purposes.

When the message data is written to a shared message data set, each block written to the data set is logged separately followed by the message entry (including the data map) as written to the coupling facility. The recovery process always recovers the coupling facility structure, but it does not need to recover individual shared message data sets except when the data set status is FAILED, or when the status is ACTIVE but the data set header record is no longer valid, indicating that the data set has been re-created. A data set is not selected for recovery if its status is ACTIVE and the data set header is still valid, nor if its status is EMPTY, indicating that no messages were stored in it at the time of the failure.

Shared message data set backups

When BACKUP CFSTRUCT is used to make a backup of the shared messages in an application structure, any data for persistent messages stored in shared message data sets is backed up at the same time, as for persistent shared messages previously stored in DB.

Shared message data set recovery

If a shared message data set is corrupted or lost, then it needs to be put into the FAILED state to stop the queue managers from using it until it has been repaired. This normally happens automatically, but can also be done using the **RESET SMDS** command specifying STATUS(FAILED).

If the shared message data set contained any persistent messages, these can be recovered using the RECOVER CFSTRUCT command. This command first restores any persistent message data for that shared message data set from the most recent BACKUP CFSTRUCT command, then applies all logged changes since that time. If no **BACKUP CFSTRUCT** command has been performed since the time that the data set was first activated, it is reset to empty then all changes since activation are applied.

If the CFSTRUCT contents and all of the shared message data sets are unavailable, for example in a disaster recovery situation, they can all be recovered in a single **RECOVER CFSTRUCT** command.

If a shared message data set is damaged but recovery was not active for the CFSTRUCT, or the log containing the latest BACKUP CFSTRUCT is unavailable or unusable, then the messages offloaded to that data set cannot be recovered. In this case, the **RECOVER CFSTRUCT** command with the parameter TYPE(PURGE) can be used to mark the shared message data set as empty and delete any messages from the structure which had data stored in that data set.

When the **RECOVER CFSTRUCT** command is issued, the shared message data set status is changed from FAILED to INRECOVER. If recovery completes successfully, the status is automatically changed to RECOVERED, otherwise it changes back to FAILED.

When the data set is changed to the RECOVERED state, this tells the owning queue manager that it can now try to open the data set and perform restart processing.

Shared message data set recovery and syncpoints

The shared message data set recovery process reapplies the changes for all complete log records up to the end of the log, regardless of syncpoints.

If changes were made within syncpoint, restart or recovery processing for the CFSTRUCT may result in backing out of uncommitted requests, so some of the recovered changes may not actually be used, but there is no harm in recovering them anyway.

It is also possible that an uncommitted MQPUT message may have been written to the structure but the corresponding data may not have been written to the data set or the log (as I/O completion is only forced at the start of syncpoint processing). This is harmless because restart processing will back out the message entry in the structure, so the fact that it refers to unrecovered data does not matter.

Shared message data set restart processing

If a queue manager connection to a CFSTRUCT terminates normally, the queue manager writes out the free block space map for each shared message data set to a checkpoint area within the data set, just before the data set is closed. The space map can then be read in again at connection restart time, provided that neither the CFSTRUCT nor the shared message data set require any recovery processing before the next restart.

However, if a queue manager terminates abnormally, or the structure or data set require any recovery processing, then additional processing is required to rebuild the space map dynamically when the queue manager connection to the structure is restarted.

Provided that the data set itself did not need to be recovered, queue manager restart simply scans the current contents of the structure to locate references to message data owned by the current queue manager, and marks the relevant data blocks as owned in the space map. Other queue managers can continue to use the structure and read the data owned by the restarting queue manager while the space map is being rebuilt.

Shared message data set restart after recovery

If a shared message data set had to be recovered from a backup, then all nonpersistent messages stored in the data set will have been lost, and if the data set was recovered using TYPE(PURGE) then all messages stored in the data set will have been lost. Until recovery has completed, the data set will be marked as FAILED or INRECOVER so any attempt to read one of the affected messages from another queue manager returns an error code indicating that the data set is temporarily unavailable.

When the data set has been recovered, the status is changed to RECOVERED, which allows the owning queue manager to open it for restart processing, but the data set remains unavailable to other queue managers. Queue manager restart scans the structure to rebuild the space map for any remaining messages. The scan also checks for messages for which the data has been lost, and deletes them from the structure (or if necessary flags them as lost, to be deleted later).

The data set status is automatically changed from RECOVERED to ACTIVE when this restart scan completes, at which point other queue managers can start using it again.

Shared message data set usage information

The DISPLAY USAGE command now also shows information about shared message data set space and buffer pool usage for any currently open shared message data sets. This information is displayed if either the new option TYPE(SMDS) or the existing option TYPE(ALL) is specified.

Shared message data performance and capacity considerations

Monitoring data set usage

The current percentage full of each owned shared message data set can be displayed by the **DISPLAY USAGE** command with the option **TYPE(SMDS)**.

The queue manager will normally automatically expand a shared message data set when it reaches 90% full, provided that the option **DSEXPAND(YES)** is in effect for the SMDS definition. This applies when either the SMDS option is set to **DSEXPAND(YES)** or the SMDS option is set to **DSEXPAND(DEFAULT)** and the CFSTRUCT default option is set to **DSEXPAND(YES)**.

If the expansion attempt fails because no secondary allocation size was specified when the data set was created (giving message IEC070I with reason code 203) the queue manager repeats the expansion request using an override secondary allocation of approximately 20% of the current size.

When a data set is expanded, the new data set extents are formatted as part of the expansion processing, which can take tens of seconds, or even minutes for very large extents. The new space becomes available for use after formatting is complete and the catalog has been updated to show the new high used control interval.

If new messages are being created very rapidly, it is possible for the existing data set to become full before expansion processing completes. In this case, any request which could not allocate space is temporarily suspended until the expansion attempt completes and the new space becomes available for use. If the expansion was successful the request is retried automatically.

If an expansion attempt fails, because of a lack of available space or because the maximum extents have already been reached, a message is issued giving the reason for the failure, then the override option for the affected SMDS is automatically altered to **DSEXPAND(NO)** to prevent further expansion attempts. In this case, there is a risk that the data set may become full, in which case further action may be needed as described in Data set becomes full.

Monitoring application structure usage

The usage level of an application structure can be displayed using the MVS **DISPLAY XCF,STRUCTURE** command specifying the full name of the application structure (including the queue sharing group prefix). The IXC360I response message shows current usage of elements and entries.

When the structure usage exceeds the **FULLTHRESHOLD** value specified in the CFRM policy, the system issues message IXC585E and may perform automatic **ALTER** actions if specified, which may either alter the entry to element ratio or increase the structure size.

Optimising buffer pool sizes

Each buffer in a shared buffer pool is used to read or write a contiguous range of pages for one message of up to the logical block size. If the message spills over into further blocks, each range of pages in a separate block requires a separate buffer.

Buffers containing message data after a write or read operation are retained in storage and reused using a least-recently-used (LRU) cache scheme so that a request to read the same data again shortly afterwards will not need to go to disk. This provides a significant optimization when shared messages are written and then read back soon afterwards by applications running on the same system. If messages owned by another queue manager are browsed for selection purposes then retrieved, this also avoids the need to reread the message from disk.

This means that the number of buffers required for each application structure is one for each concurrent API request which reads or writes large messages for that application structure plus some number of additional buffers which will be used to save recently accessed data in order to optimize subsequent read accesses.

For shared buffer pools, if there are insufficient buffers, API requests will simply wait if a buffer is not immediately available. However, this situation should be avoided as it can cause significantly degraded performance.

The statistics from the **DISPLAY USAGE** command for shared buffer pools show whether there have been any buffer waits within the current statistics interval, and also shows the lowest number of free buffers (or a negative value indicating the maximum number of threads which waited for a buffer at any time), the number of buffers which have saved data, and the percentage of the times that a buffer request has successfully found saved data on the LRU chain ("LRU hits") instead of having to read it ("LRU misses") [1] .

- If there have been any waits, the number of buffers should be increased.
- If there are many unused buffers, the number of buffers may be reduced to make more storage available in the region for other purposes.

[1] `(Hits / (Hits+Misses))* 100`

- If there are many buffers containing saved data but the proportion of reads which were hits against that saved data is very small, the number of buffers may be reduced if the storage could be better used for other purposes. The number of buffers should not however be reduced by more than the lowest number of free buffers, as that could trigger waits, and it should preferably be high enough that the lowest free buffer count is normally well above zero.

Deleting shared message data sets

The DELETE CFSTRUCT command (which is only allowed when all shared queues in the structure are empty and closed) does not delete the shared message data sets themselves, but they can be deleted in the usual way after this command has completed. If the same data set is to be reused as a shared message data set, it must be reformatted first to reset it to the empty state.

Exception situations for shared message data sets

There are a number of exception situations which can occur during normal use, even when no software or hardware error is present.

Data set becomes full

If a data set becomes full but cannot be expanded, or the expansion attempt fails, applications using the corresponding queue manager to write large messages to the corresponding application structure will receive error 2192, `MQRC_STORAGE_MEDIUM_FULL` (also known as `MQRC_PAGESET_FULL`).

A data set could become full because of a failure in the application which is supposed to process the data, causing a large backlog of messages to accumulate. If so, expanding the data set any further will only be a temporary solution, and it is important to get the processing application going again as soon as possible.

If more space can be made available the **ALTER SMDS** command can then be used to set **DSEXPAND(YES)** or **DSEXPAND(DEFAULT)** (assuming that YES has been set or assumed as the **DSEXPAND** default for the CFSTRUCT definition) to trigger a retry. If the reason for the failure was however that maximum extents had been reached, the new expansion attempt will be rejected with a message and **DSEXPAND(NO)** will be set again. In this case, the only way to expand it any further is to reallocate it, which involves making it temporarily unavailable, as described next.

Data set needs to be moved or reallocated

If a data set needs to be moved or expanded but is otherwise in normal use, it can be taken out of use temporarily to allow it to be moved or reallocated. Any API request which attempts to use the data set while it is unavailable will receive the reason code `MQRC_DATA_SET_NOT_AVAILABLE.`

1. Use the **RESET SMDS** command to mark the data set as **ACCESS(DISABLED)**. This will cause it to be closed normally and deallocated by all currently connected queue managers.
2. Move or reallocate the data set as necessary, copying the old contents to the newly allocated data set, for example using the Access Method Services (AMS) **REPRO** command.

   Do not attempt to preformat the new data set before copying the old data into it, as this would result in the copied data being appended to the end of the formatted data set.
3. Use the **RESET SMDS** command to mark the data set as **ACCESS(ENABLED)** again, to bring it back into use.

   If the old contents are smaller than the size of the new data set, the rest of the space will be preformatted automatically when the new data set is opened.

   If the old contents were larger than the size of the new data set then the queue manager has to scan the messages in the coupling facility structure and rebuild the space map to ensure that none of the active data has been lost. If any reference is found to a data block which is outside the new extents, the data set is marked as **STATUS(FAILED)** and must be repaired by replacing the data

set with one of the correct size and either copying the old data set into it again or using **RECOVER CFSTRUCT** to recover any persistent messages.

Coupling facility structure is low on space

If the coupling facility structure is running out of space, causing message IXC585E, it is worth checking whether the offload rules have been set to ensure that the maximum amount of data is being offloaded in this case. If not, the offload rules can be modified using the **ALTER CFSTRUCT** command.

Error situations for shared message data sets

There are a number of problems to be aware of, which can only be caused by errors and not occur in normal operational situations.

Owned data set cannot be opened

If the queue manager which owns a shared message data set cannot allocate it or open it, or the data set attributes are not supported, the queue manager sets an appropriate **SMDSCONN** status value of **ALLOCFAIL** or **OPENFAIL** and sets the **SMDSCONN** availability to **AVAIL(ERROR)**. It also sets the SMDS availability to **ACCESS(SUSPENDED)**. When the error has been corrected, use the **RESET SMDS** command to set **ACCESS(ENABLED)** to trigger a retry, or issue the **START SMDSCONN** command to the owning queue manager.

Read-only data set cannot be opened

If a queue manager cannot allocate or open a shared message data set owned by another queue manager and marked as **STATUS(ACTIVE)**, it assumes that this is probably due to a specific problem with its connection to the data set (represented by the **SMDSCONN** object) rather than a problem with the data set itself.

It marks the **SMDSCONN** as **STATUS(ALLOCFAIL)** or **STATUS(OPENFAIL)** as appropriate and marks the **SMDSCONN** availability as AVAIL(ERROR) to prevent further attempts to use it.

If the problem can been corrected without affecting the status of the data set itself, use the **START SMDSCONN** command to trigger a retry.

If the problem turns out to be a problem with the data set itself, then the **RESET SMDS** command can be used to mark the data set as **STATUS(FAILED)** until it it has been recovered. When the data set has been recovered, the action of changing the status back to **STATUS(ACTIVE)** will cause other queue managers to be notified. If the **SMDSCONN** is marked as **AVAIL(ERROR)**, it will automatically be changed back to **AVAIL(NORMAL)** to trigger a new attempt to open the data set.

Data set header is corrupt

If the data set was successfully opened but the format of the header information is incorrect, the queue manager closes and deallocates the data set and sets the status set to **STATUS(FAILED)** and the availability to **ACCESS(SUSPENDED)**. This allows **RECOVER CFSTRUCT** to be used to recover the contents.

If the error arose because the data set contained residual data from another use and had not been subsequently preformatted, then preformat the data set and use the **RESET SMDS** command to change the status to **STATUS(RECOVERED)**.

Otherwise, the data set must be recovered.

Data set is unexpectedly empty

If the queue manager opens a data set which is marked as **STATUS(ACTIVE)** but finds that it is uninitialized or newly preformatted but otherwise valid, the queue manager closes and deallocates the shared message data set then sets the status to **STATUS(FAILED)** and the availability to **ACCESS(SUSPENDED)**.

Data set has permanent I/O errors

If a data set has permanent I/O errors after successful **OPEN** processing, it probably needs recovery. The queue manager will mark the data set as **STATUS(FAILED)** so that all currently connected queue managers will close and deallocate it.

Data set has recoverable I/O errors

If there are hardware problems with the data set, it is possible that this might result in recoverable I/O errors which are not reflected back to the queue manager but which cause significant performance degradation, and also indicate a risk of permanent I/O errors in the near future.

In this case, the data set may be taken off line for recovery by using the **RESET SMDS** command to mark it as **STATUS(FAILED)**. This will cause it to be closed and deallocated by all queue managers, so for example it could be moved to a new volume before being made available again.

When a data set is made unavailable in this way, the space map is not saved so the queue manager connection restart processing will need to scan the coupling facility structure to locate messages in the data set and rebuild the space map before the data set can be made available again. As an alternative, if the shared message data set is still usable, it set can be made unavailable more gently by using the **RESET SMDS** command to mark the data set **ACCESS(DISABLED)** until it is ready to be made available again.

Data set contents are incorrect

The queue manager cannot detect directly that a data set contains incorrect data or is not up to date, for example because a volume including that data set had to be restored from backups. However, it performs integrity checks which make it very unlikely that any such errors could result in incorrect message data being seen by application programs.

For integrity checking purposes, each message block in the data set is prefixed with a copy of the corresponding coupling facility entry ID, including a unique time stamp, which is checked whenever the message block is read, before the message data is passed to the user program. If the message block prefix does not match the entry ID (and the coupling facility entry was not deleted in the mean time) the message block is assumed to be damaged and unusable.

If the damaged message was persistent, the data set is marked as **STATUS(FAILED)** and the structure contents must be recovered using the **RECOVER CFSTRUCT** command. If the damaged message was non-persistent, there is no way to recover it, so a diagnostic message is issued and the corresponding coupling facility message entry is deleted.

If no saved space map is available when the data set is opened, it is rebuilt by scanning the coupling facility structure for references to data in the data set. During this scan, the queue manager performs a number of actions:

1. The queue manager determines the location of the most recent message (if any) currently remaining in the data set.
2. The queue manager then reads that message from the data set to ensure that the block prefix matches the message entry id

These actions ensure that the queue manager detects any case where the data set is down-level, and marks the data set as FAILED. This check does however tolerate the case where the data set was restored from a previous copy and either no new messages had been added since then or all messages added since that copy had been subsequently read and deleted.

To protect against down-level data in the case where the data set was closed normally, the queue manager performs a number of actions:

1. The queue manager saves a copy of the space map time stamp in the SMDS object within Db2 when the data set is closed normally.
2. The queue manager then checks the space map time stamp is the same, when the data set is opened again

If the time stamp does not match, this suggests that a down-level copy of the data set might have been used, so the queue manager ignores the existing space map and rebuilds it, which will succeed only if no message data was actually lost.

Note: These integrity checks do not guarantee to detect a down-level or damaged data set in all theoretically possible cases. For example, they will not detect a case where the start of a message block is valid but the rest of the data has been partly overwritten.

Recovery scenarios for shared message data sets

This section described shared message data set recovery scenarios.

Data set recovery where no data was lost

In some cases, the correct contents of a failed data set can be restored without needing actual recovery. One example is where a data set contains residual data from a previous use and has not been preformatted again, which can be fixed by preformatting it. Another case is when a data set has been moved, but there was an error in the process of copying the data across, which can be fixed by copying the data again correctly.

In such cases, the corrected data set can be made available again by using the **RESET SMDS** command to set **STATUS(RECOVERED)**. If the availability is currently **ACCESS(SUSPENDED)** this will automatically set it back to **ACCESS(ENABLED)**.

When the owning queue manager is notified that the data set has been recovered, it scans the structure contents to reconstruct the space map, then changes the status to **STATUS(ACTIVE)**. The other queue managers can then start reading the data set again.

Data set recovery with TYPE(NORMAL)

If the contents of a data set have been lost, but the application structure was defined with **RECOVER(YES)** and the appropriate recovery logs are available, the **RECOVER CFSTRUCT** command can be used to recover any persistent messages stored in the structure including persistent message data offloaded to shared message data sets. This command restores the current state using information logged by the **BACKUP CFSTRUCT** command plus all logged changes to persistent messages since the backup time.

The **RECOVER CFSTRUCT** command always recovers all persistent messages in the coupling facility structure together with offloaded message data stored in Db2. For offloaded data stored in shared message data sets, each data set is only selected for recovery processing if it is already marked as **STATUS(FAILED)** or if it is found to be unexpectedly empty or otherwise invalid when opened by recovery processing. Any shared message data set which is marked as active and which passes the validation checks does not need to be recovered, as the existing message data is already correct, but the header is updated to indicate that any saved space map will need to be rebuilt after recovery.

Recovery processing is only possible when the structure has been marked as failed, as the complete contents of the structure need to be reconstructed by recovery processing. However, if at least one shared message data set has been marked as failed the **RECOVER CFSTRUCT** command will automatically mark the structure as failed if necessary to allow recovery processing to proceed.

Recovery may be performed from any queue manager in the queue sharing group, provided that it has been given write access to the relevant data sets.

Only persistent messages are backed up and logged, so normal recovery processing will restore all persistent messages, but will cause any non-persistent messages in the structure to be lost.

When recovery has completed, any data set which was selected for recovery is automatically changed to **STATUS(RECOVERED)**, and if the availability was **ACCESS(SUSPENDED)** it is changed to **ACCESS(ENABLED)**. The queue manager rebuilds the space map for each data set by scanning the messages in the coupling facility, then marks the data set as **STATUS(ACTIVE)** so that it can be used again.

Data set recovery with TYPE(PURGE)

For a recoverable structure, if the data set contents have been lost, but recovery is not possible for some reason, for example because recovery logs are not available or recovery would take too long, the **RECOVER CFSTRUCT** command can be used with **TYPE(PURGE)** to get the structure back to a usable state. This resets the structure to the empty state and marks all of the associated data sets as **STATUS(EMPTY)**.

Deleting the application structure

If a non-recoverable application structure is deleted using the MVS **SETXCF FORCE** command, or as a result of structure failure, then the next time the structure is connected, message CSQE028I is issued to say that the structure has been reset and all existing messages have been discarded, and any existing data sets are automatically reset to **STATUS(EMPTY)** as well. This action makes a non-recoverable structure usable again after loss of data either in the structure or in any of the associated data sets.

If a recoverable application structure is deleted, it will be treated in the same way as if the structure had failed.

Data set recovery fails

If **RECOVER CFSTRUCT** cannot complete for some reason, for example because a log data set is no longer available, or because the queue manager terminated while recovery was in progress, then any data set for which recovery was at least started will be marked in the header to show that partial recovery has been attempted, and the data set will be left in the **STATUS(FAILED)** state.

In this case, the options are to repeat the original recovery request or to recover with **TYPE(PURGE)** instead, discarding the existing data.

If an attempt is made to mark the data set as **STATUS(RECOVERED)** without actually recovering it, then the next time it is opened the queue manager will see that the header indicates incomplete recovery and mark it as **STATUS(FAILED)** again.

Off site disaster recovery

For off site disaster recovery, persistent shared messages can be re-created using only the logs and the Db2 shared objects containing the CFSTRUCT definitions and associated SMDS status information.

After setting up the Db2 tables containing the definitions, the application structure and the shared message data sets can be set up as empty. When a queue manager connects to them and finds that they are unexpectedly empty, it will mark them as failed, after which a single **RECOVER CFSTRUCT** command can be used to recover all persistent messages for all affected structures.

z/OS *SMDS related commands*

This topic describes and provides access to the commands relating to shared message data sets.

Display and alter the **CFSTRUCT** options relating to large message offload (**OFFLOAD** and offload rules) and shared message data sets (**DSGROUP, DSBLOCK, DSBUFS, DSEXPAND)**:

- DISPLAY CFSTRUCT
- DEFINE CFSTRUCT
- ALTER CFSTRUCT
- DELETE CFSTRUCT

Display **CFSTRUCT** status relating to large message offload **(OFFLDUSE)**:

- DISPLAY CFSTATUS

Display and alter override data set options (**DSEXPAND** and **DSBUFS**) for individual queue managers:

- DISPLAY SMDS
- ALTER SMDS

Display or modify the status and availability of the data sets within the queue sharing group:

- DISPLAY CFSTATUS TYPE(SMDS)
- RESET SMDS

Display SMDS data set space usage and buffer usage information for a queue manager:

- DISPLAY USAGE TYPE(SMDS)

Display or modify the status and availability of the connections (**SMDSCONN**) to the data sets from an individual queue manager:

- DISPLAY SMDSCONN
- START SMDSCONN
- STOP SMDSCONN

Backup and recover shared messages, including large message data in SMDS when necessary:

- BACKUP CFSTRUCT
- RECOVER CFSTRUCT

z/OS ***Advantages of using shared queues***

Shared queue allows for IBM MQ applications to be scalable, highly available, and allows workload balancing to be implemented.

The advantages of shared queues

The shared queue architecture, where cloned servers pull work from a single shared queue, has some useful properties:

- It is scalable, by adding new instances of the server application, or even adding a new z/OS image with a queue manager (in the queue sharing group) and a copy of the application.
- It is highly available.
- It naturally performs *pull* workload balancing, based on the available processing capacity of each queue manager in the queue sharing group.

Using shared queues for high availability

The following examples illustrate how you can use a shared queue to increase application availability.

Consider an IBM MQ scenario where client applications running in the network want to make requests of server applications running on z/OS. The client application constructs a request message and places it on a request queue. The client then waits for a reply from the server, sent to the reply-to queue named in the message descriptor of the request message.

IBM MQ manages the transportation of the request message from the client machine to the server's input queue on z/OS and of the response from the server back to the client. By defining the server's input queue as a shared queue, any messages put to the queue can be retrieved on any queue manager in the queue sharing group. This means that you can configure a queue manager on each z/OS image in the sysplex and, by connecting them all to the same queue sharing group, any one of them can access messages on the server's input queue.

Messages on the input queue of the server are still available, even if one of the queue managers terminates abnormally or you have to stop it for administrative reasons. You can take an entire z/OS image offline and the messages will still be available.

To take advantage of this availability of messages on a shared queue, run an instance of the server application on each z/OS image in the sysplex to provide higher server application capacity and availability, as shown in Figure 60 on page 184.

One instance of the server application retrieves a request message from the shared queue and, based on the content, performs its processing, producing a result that is sent back to the client as an IBM MQ message. The response message is destined for the reply-to queue and reply-to queue manager named in the message descriptor of the request message.

There are a number of options that you can use to configure the return path. For more information about these options, see “Distributed queuing and queue sharing groups” on page 203.

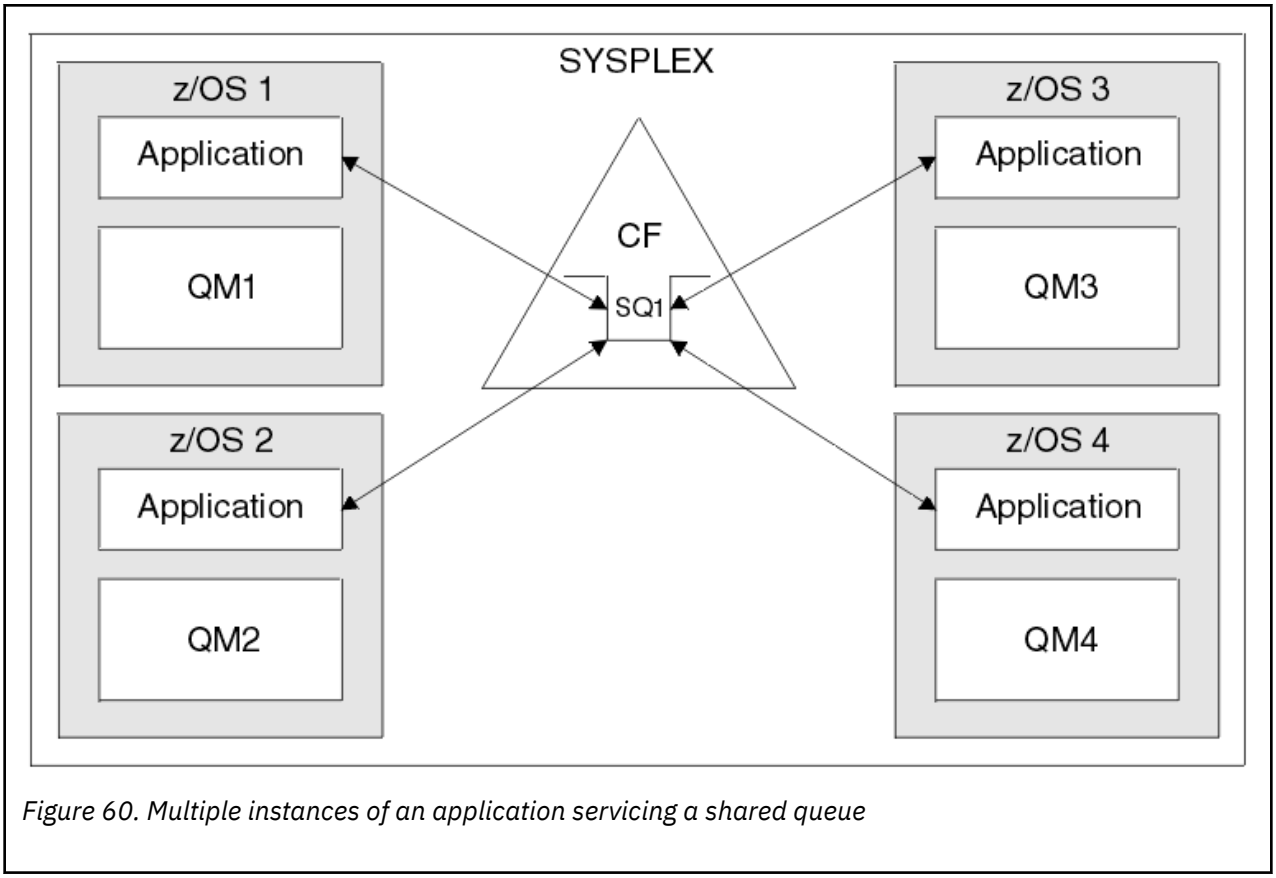


Figure 60. Multiple instances of an application servicing a shared queue

Peer recovery

To further enhance the availability of messages in a queue sharing group, IBM MQ detects if another queue manager in the group disconnects from the coupling facility abnormally and completes units of work for that queue manager that are still pending, where possible. This feature is known as *peer recovery.*

Suppose a queue manager terminates abnormally at a point where an application has retrieved a request message from a queue in sync point, but has not yet put the response message or committed the unit of work. Another queue manager in the queue sharing group detects the failure, and backs out the in-flight units of work being performed on the failed queue manager. This means that the request message is put back on to the request queue and is available for one of the other server instances to process, without waiting for the failed queue manager to restart.

If IBM MQ cannot resolve a unit of work automatically, you can resolve the shared portion manually to enable another queue manager in the queue sharing group to continue processing that work.

z/OS *Use of storage class memory with shared queues*

The use of storage class memory (SCM) can be advantageous when used with IBM MQ for z/OS shared queues.

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

The z13, zEC12, and zBC12 machines allow the installation of Flash Express cards. These cards contain flash solid-state drives (SSD). After installation, flash storage from the cards can be allocated to one or more LPARs where it is typically known as SCM.

SCM sits between real storage and direct access storage device (DASD) in terms of both I/O latency and cost. Because SCM has no moving parts, it exhibits much lower I/O latencies than DASD.

SCM is also much cheaper than real storage. As a result, a large amount of storage can be installed for a relatively low cost; for example, a pair of Flash Express cards contains 1424 GB of usable storage.

These characteristics mean that SCM is useful when a large amount of data must be taken from real storage in a short period of time, because that data can be written to SCM much quicker than it can be written to DASD. This specific point can be very useful when using coupling facility (CF) list structures containing IBM MQ shared queues.

Why list structures fill up

When a CF structure is defined, it is configured with a SIZE attribute that describes the maximum size of the structure. Because CF structures are always permanently resident in real storage, the sum of the SIZE attributes of the structures that are defined on a CF should be less than the amount of the real storage allocated to the CF.

As a result, there is a constant pressure to keep the SIZE value of any given structure to the minimum value possible, so that more structures can fit into the CF. However, ensuring structures are large enough to achieve their purpose can result in a conflicting pressure, because making a structure too small means that it might fill up, disrupting the applications or subsystems making use of it.

There is a strong need to accurately size a structure based on its expected usage. However, this task is difficult to do because workloads can change over time and accounting for their fluctuations is not easy.

IBM MQ shared queues use CF list structures to store messages. IBM MQ calls CF structures, which contain messages and application structures.

Application structures are referenced using the information stored in IBM MQ CFSTRUCT objects. When a message that is smaller than 63 KB is put on a shared queue, the message is stored entirely in an application structure as a single list entry, and zero or more list elements.

Because IBM MQ shared queues use list structures, the pressures described also affect shared queues. In this case, the maximum number of messages that can be stored on a shared queue is a function of the:

- Size of the messages on the queue
- Maximum size of the structure
- Number of entries and elements available in the structure

Because up to 512 shared queues can use the same structure, and effectively compete for entries and elements, this complicates matters even further

IBM MQ queues are used for the transfer of data between applications, so a common situation is an application putting messages to a queue, when the partner application, which should be getting those messages, is not running.

When this happens the number of messages on the queue increase over time until one or more of the following situations occur:

- The putting application stops putting messages.
- The getting application starts getting messages.
- Existing messages on the queue start expiring, and are removed from the queue.
- The queue reaches its maximum depth in which case an MQRC_Q_FULL reason code is returned to the putting application.
- The structure containing the shared queue reaches its maximum size, or the CF containing the structure runs out of available storage. In either case, an MQRC_STORAGE_MEDIUM_FULL reason code is returned to the putting application.

In the last three cases the queue is full. At this point the putting application has a problem because there is nowhere for its messages to go. The putting application typically solves this problem by using one or more of the following solutions:

- Repeatedly retry putting the message, optionally with a delay between retries.
- Put the messages somewhere else, such as a database or a file. The messages can be accessed later and put to the queue as normal.
- Discard the message if it is nonpersistent.

However, for some classes of applications, for example those with a large volume of incoming messages, or no access to a file system, these solutions are not practical. There is a real need to ensure that queues never, or are extremely unlikely to, fill up in the first place and this is especially pertinent to shared queues.

SMDS and offload rules

The offload rules introduced in IBM WebSphere MQ 7.1 provide a way of reducing the likelihood of an application structure filling up.

Each application structure has three rules associated with it, specified using three pairs of keywords:

- OFFLD1SZ and OFFLD1TH
- OFFLD2SZ and OFFLD2TH
- OFFLD3SZ and OFFLD3TH

Each rule specifies the conditions that must be met for message data to be offloaded to the storage mechanism that is associated with the application structure. Two types of storage mechanisms are currently available:

- Db2
- Group of Virtual Storage Access Method (VSAM) linear data sets, which IBM MQ calls a shared message data set (SMDS).

The following example shows the MQSC command to create an application structure named LIST1, using the DEFINE CFSTRUCT command.

This structure has the default offload rules in place, and uses SMDS as the offload mechanism. This means that when the structure is 70% full (OFFLD1TH), all messages that are 32 KB or larger (OFFLD1SZ) are offloaded to SMDS.

Similarly, when the structure is 80% full (OFFLD2TH) all messages that are 4 KB or larger (OFFLD2SZ) are offloaded. When the structure is 90% full (OFFLD3TH) all messages (OFFLD3SZ) are offloaded.

```
DEFINE CFSTRUCT(LIST1)
CFLEVEL(5)
OFFLOAD(SMDS)
OFFLD1SZ(32K) OFFLD1TH(70)
OFFLD2SZ(4K) OFFLD2TH(80)
OFFLD3SZ(0K) OFFLD3TH(90)
```

An offloaded message is stored in the offload medium, and a pointer to the message is stored in the structure. While the offload rules reduce the chance of the structure filling up, by putting less message

data in the structure as it runs out of storage, some data is still written to the structure for each message. That is, the pointer to the offloaded message.

Additionally, the offload rules come with a performance cost. Writing a message to a structure is relatively quick and is largely dominated by the time spent to send the request for the write to the CF. The actual writing to the structure is fast, happening at real storage speeds.

Writing a message to SMDS is much slower because it includes writing to the structure for the message pointer, and writing the message data to SMDS. This second write operation is done at DASD speed and has the potential to add latency. If Db2 is used as the offload mechanism the performance cost is much greater.

z/OS *How storage class memory works with IBM MQ for z/OS*

An overview of the use of storage class memory (SCM) with IBM MQ for z/OS shared queues.

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

A coupling facility (CF) that is at CFLEVEL 19, or greater, can have SCM allocated to it. The structures defined in that CF can then be configured to make use of SCM to reduce the chances of the structures filling up (known as a structure full condition). When a structure configured to make use of SCM fills up past a system-determined point, the CF starts moving data from the structure into SCM, which frees space in the structure for new data.

Note: Because SCM itself can fill up, allocating SCM to a structure reduces only the likelihood of a structure full condition, but does not entirely remove the chance of one occurring.

A structure is configured to use SCM by specifying both the **SCMALGORITHM** and **SCMMAXSIZE** keywords in the coupling facility resource manager (CFRM) policy, containing the definition of that structure.

Note that after these keywords are specified, and the CFRM policy is applied, the structure must be rebuilt, or deallocated so that they can take effect.

SCMALGORITHM keyword

Because the input/output speed of SCM is slower than that of real storage, the CF uses an algorithm that is tailored to the expected use of the structure in order to reduce the impact of writing to, or reading from, SCM.

The algorithm is configured by the **SCMALGORITHM** keyword in the CFRM policy for the structure, using the *KEYPRIORITY1* value. Note that you should use the *KEYPRIORITY1* value only with list structures used by IBM MQ shared queues.

The *KEYPRIORITY1* algorithm works by assuming that most applications will get messages from a shared queue in priority order; that is, when an application gets a message, it gets the oldest message with the highest priority.

When a structure starts to fill past the system-defined threshold of 90%, the CF starts asynchronously migrating messages that are least likely to be got next. These are messages with lower priorities that were more recently put on the queue.

This asynchronous migration of messages from the structure into SCM is known as "pre-staging".

Pre-staging reduces the performance cost of using SCM because it reduces the chance of an application being blocked during the occurrence of synchronous input/output to SCM.

In addition to pre-staging, the *KEYPRIORITY1* algorithm also asynchronously brings back messages from SCM and into the structure when sufficient free space is available. For the *KEYPRIORITY1* algorithm, this means that when the structure is less than or equal to 70% full.

The act of bringing messages from SCM into the structure is known as "pre-fetching".

Pre-fetching reduces the likelihood of an application trying to get a message that has been pre-staged to SCM and having to wait while the CF synchronously brings back the message into the structure.

SCMMAXSIZE keyword

The **SCMMAXSIZE** keyword defines the maximum amount of SCM that can be used by a structure. Because SCM is allocated to the structure by the CF when it is required, it is possible to specify a **SCMMAXSIZE** that is greater than the total amount of free SCM available. This is known as "over-committing".

Important: Never over-commit SCM. If you do, the applications that are relying on it will not obtain the behavior that they expect. For example, IBM MQ applications using shared queues might get unexpected MQRC_STORAGE_MEDIUM_FULL reason codes.

The CF uses various data structures to track its use of SCM. These data structures reside in the real storage that is allocated to the CF and, as a result, reduce the amount of real storage that can be used by structures. The storage used by these data structures is known as "augmented space".

When a structure is configured with SCM, a small amount of real storage is allocated from the CF to the structure known as fixed augmented space. This is allocated even if the structure never actually uses any SCM. As data from the structure is stored into SCM, extra dynamic augmented space will be allocated from the spare real storage in the CF.

When the data is removed from SCM, the dynamic augmented space is returned to the CF. Augmented space, either fixed or dynamic, is never taken from the real storage that is allocated to a structure.

In addition to augmented storage, when a structure is configured to use SCM, the amount of control storage used by that structure increases. This means that a list structure configured with SCM can contain fewer entries and elements than a structure of the same size without SCM being configured.

To understand the impact of SCM on new or existing structures, use the CFSizer tool.

A final important point to note is that after data is moved from the structure into SCM, and dynamic augmented space has been used, the structure cannot be altered either manually or automatically.

That is, the amount of storage allocated to the structure cannot be increased or decreased, the entry-to-element ratio that is used by the structure cannot be changed, and so on. To make the structure alterable again, the structure must not have any data stored in SCM and must not be making use of dynamic augmented storage.

z/OS *Why use SCM*

Emergency storage and improved performance are two use cases for using SCM with IBM MQ for z/OS.

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

This section introduces the theory behind the two possible scenarios. For further details on how you set up the scenarios, see:

- “Emergency storage - basic configuration” on page 191
- “Improved performance - basic configuration” on page 197

Important: The use of SCM with CF structures is not dependent on any specific version of IBM MQ. However the emergency storage scenario works only with IBM WebSphere MQ 7.1 and later, because it requires SMDS and the offload rules.

Emergency storage

SMDS and message offloading can be used in conjunction with SCM to reduce the likelihood of an MQRC_STORAGE_MEDIUM_FULL reason code being returned to an IBM MQ application during an extended outage.

Overview

A single shared queue is configured on an application structure. The putting application puts messages onto the shared queue; the getting application gets messages from the shared queue.

During normal running, the queue depth is expected to be close to zero, but a business requirement indicates that the system must be able to tolerate a two-hour outage of the getting application. This means that the shared queue must be able to contain two hours of messages from the putting application.

Currently, this process is achieved by using the default offload rules, and SMDS, so that the size of the structure is minimized, while reducing the performance cost that is associated with offloading.

The rate of messages being sent to the shared queue is expected to double in the short to medium term. Although the requirement that the system be able to tolerate a two-hour outage still exists, not enough real storage is available in the CF to double the size of the structure.

Because the CF, which contains the application structure, resides on a zEC12 machine, the possibility exists to associate sufficient SCM with the structure to store enough messages so that a two-hour outage can be tolerated.

Consider what happens over a period of time:

1. Initially, the system is in its steady state. Both the putting and getting application are running normally and the queue depth is close to, or at, zero. The result is that the application structure is largely empty.
2. At a certain time, the getting application suffers an unexpected failure and stops. The putting application continues to put messages to the queue and the application structure starts to fill up.
3. After the structure reaches 70% full, the conditions of the first offload rule are met and all messages with a size greater than or equal to 32 KB are offloaded to SMDS.

   See “SMDS and offload rules” on page 186 for an overview of the offload rules.
4. As messages continue to be put to the shared queue, the structure continues to fill (either because of the message data being stored in the structure, or as a result of the pointers to the offloaded messages being stored in the structure).

   When the structure reaches 80% full, the second offload rule starts to apply and messages that are 4 KB or greater are offloaded to SMDS.
5. When the structure is past 90% full, all messages are offloaded to SMDS and only the message pointers are being placed in the structure.

   About this time, the pre-staging algorithm starts to run, and begins moving data from the structure into SCM. Assuming all messages on the queue are the same priority, the newest messages are pre-staged.

   Because all messages are now being offloaded to SMDS, the data being moved into SCM is not actual message data, but instead the pointers to the messages on SMDS.

   As a result, the number of messages that can be stored on the combination of the structure, and the SCM and SMDS associated with the structure, is very large.

   Performance: During this stage of the outage, the putting application can suffer a degree of performance degradation because of having to write to SMDS. In this case, the use of SCM should not be a limiting factor on the putting application in terms of performance. SCM provides extra space to prevent the structure filling up.
6. Eventually the getting application is available again and the outage is over.

   However SCM is still being used by the structure. The getting application starts reading messages off the queue, getting the oldest, highest priority messages first.

   Because these messages were written before the structure started to fill up, they come out entirely from the real storage portion of the structure.
7. As the structure starts to empty, it goes below the threshold at which pre-staging is active, and so pre-staging stops.

8. The structure usage reduces below the point at which the offload rules take effect, so messages are no longer offloaded to SMDS unless they are more than 63 KB.

   At about this time, the pre-fetch algorithm starts moving data from SCM in to the structure. Because the getting application gets messages from the queue in the order expected by the SCM algorithms, messages are brought in before the getting application needs them.

   The result is that the getting application never needs to wait for messages to be brought in synchronously from SCM.
9. As the getting application continues to move down the queue, it starts retrieving messages that were offloaded to SMDS.
10. Finally, the system is in a steady state again. No messages are stored in SCM or SMDS, and the queue depth is close to zero.

Improved performance

This scenario describes using SCM to increase the number of messages that can be stored on a shared queue without incurring the performance cost of using SMDS.

Description

For this scenario, a putting and getting application communicate through a shared queue which is stored in application structure.

The putting application tends to run in bursts, when it puts a large number of messages in a short amount of time. Then, in an extended period of time, it produces no messages at all.

The getting application sequentially processes each message, and performs complex processing on each one. As a result, most of the time the queue depth is zero, except for when the putting application starts to run, where the queue depth starts increasing as messages are being put faster than they are being got.

The queue depth increases until the putting application stops, and the getting application has enough time to process all the messages on the queue.

Notes:

1. In this scenario, the key factor is performance. The messages being sent to the queue are always less than 63 KB and so never need to be offloaded to SMDS.
2. The application structure has been sized so that it is large enough to contain all of the messages that will be placed on it by the putting application in a single "burst."
3. The offload rules must all be disabled so that, even when the structure starts to fill, the messages are not offloaded to SMDS. This is because the performance costs that are associated with writing messages to, and reading messages from, SMDS are deemed unacceptable.

Over time, the number of messages that the putting application send in a burst must increase by several orders of magnitude. Because the getting application must process each message sequentially, the number of messages on the queue increases to the point where the structure fills up.

At this point, the putting application receives a reason code (MQRC_STORAGE_MEDIUM_FULL) when putting a message, and the put operation fails. The putting application can only briefly tolerate periods when it is unable to put messages to the queue. If the period is too long, the application ends.

Assuming that you do not have the time, or skills available, to rewrite either the putting application or getting application, this problem has three possible solutions:

1. Increase the size of the application structure.
2. Add offload rules to the application structure so that messages are offloaded to SMDS as the queue starts to fill up.
3. Associate SCM with the structure.

The first solution is quick to implement, but not enough real storage is available on the CF.

The second solution might also be quick to implement, but the performance impact of offloading to SMDS is considered too significant to use this option.

The third solution, associating SCM with the structure, provides an acceptable balance of cost and performance.

Associating SCM with a structure results in a higher use of real storage in the CF because of the augmented storage that get operations used. However, the actual amount of real storage will be less than the amount used in the first option.

Another consideration is the cost of SCM. However this cost is much cheaper than real storage. These factors combine to make the third option cheaper than the first option.

Although the third option, potentially, might not perform as well as the first option, the pre-fetch and pre-staging algorithms used by the CF can combine to make the differences in performance acceptable, or in some cases negligible.

Certainly the performance can be much better than using SMDS to offload messages.

Consider what happens over a period of time:

1. Initially, the getting application is active and waiting for messages to be delivered to the shared queue. The putting application is not active and the shared queue is empty.
2. At a certain time, the putting application becomes active, and starts putting a large number of messages to the shared queue. The getting application starts getting the messages, but the queue depth rapidly starts to increase because the getting application is slower than the putting application.

   As a result, the application structure starts to fill up.
3. As the time increases, the putting application is still active. The application structure fills up to approximately 90%.

   This is when the SCM pre-staging algorithm starts to move messages from the structure into SCM, freeing space in the structure.

   Because the getting application gets the oldest, highest priority messages from the queue first, it is always getting messages from the structure and does not need to wait for messages to be brought synchronously from SCM in to the structure.
4. The putting application is still active and putting messages to the shared queue. However, the application never receives an MQRC_STORAGE_MEDIUM_FULL reason code, because enough space exists in SCM to store all the messages that do not fit in the structure.
5. Eventually, the putting application stops because it has no more messages to put.

   The pre-staging algorithm stops because the structure falls below 90% in use, and the getting application continues processing the messages in the queue.
6. As the getting application starts to free space in the structure, the pre-fetch algorithm starts to bring messages back from SCM in to the structure.

   Because the getting application processes messages in the order expected by the pre-fetch algorithm, the getting application never becomes blocked waiting for message data to be brought synchronously from SCM in to the structure.
7. Finally, the getting application processes all the messages on the shared queue, and waits until the next message is available. The structure and SCM are empty of messages.

z/OS *Emergency storage - basic configuration*

How you set up a basic scenario for emergency storage on IBM MQ.

About this task

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

SMDS and message offloading can be used in conjunction with SCM to reduce the likelihood of an MQRC_STORAGE_MEDIUM_FULL reason code being returned to an IBM MQ application during an extended outage.

For example, your enterprise has an application that puts messages onto the queue and an application that gets messages from the queue. During normal running, you expect the queue depth to be close to zero, but a business requirement indicates that the system be able to tolerate a two-hour outage of the application that gets the messages.

This means that the shared queue being used must be able to contain two hours of messages from the putting application. Currently you achieve this by using the default offload rules, and SMDS.

You expect the rate of messages being sent to the shared queue to double in the short to medium term. Although your requirement that the system be able to tolerate a two-hour outage still exists, not enough real storage is available in the CF to double the size of the structure. Because the CF containing the application structure resides on a zEC12 machine, you have the capability of associating sufficient SCM with the structure to store enough messages, so that a two-hour outage can be tolerated

This initial scenario uses a:

- Queue sharing group, `IBM1`, that contains a single queue manager, `CSQ3`. In addition to the administration structure, the queue sharing group defined a single application structure, `SCEN1`.
- Coupling facility (CF) `CF01`, in which the `SCEN1` application structure is stored as the `IBM1SCEN1` structure. This structure has a maximum size of 1 GB.
- Single shared queue, `SCEN1.Q` that the application structure uses.

This configuration is illustrated in Figure 61 on page 192.

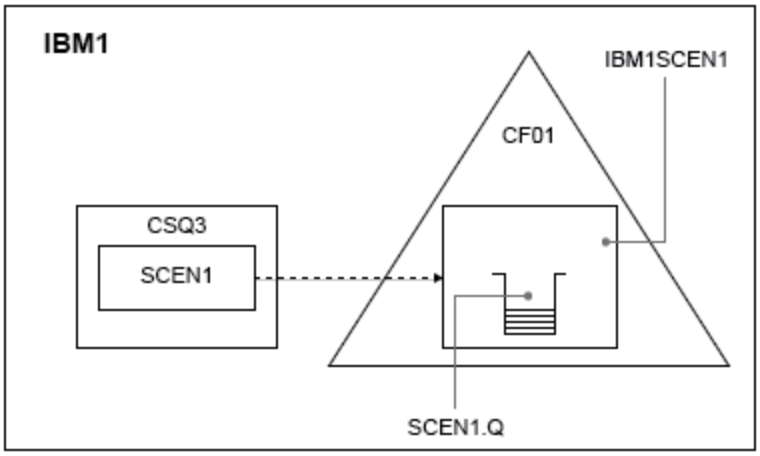


Figure 61. Basic configuration

Furthermore, assume that queue manager `CSQ3` is already the only member of queue sharing group `IBM1`.

You must add the definition for structure `IBM1SCEN1` to the coupling facility resource manager (CFRM) policy. For simplicity, the structure is defined so that it can be created in only a single coupling facility, `CF01`, by specifying `PREFLIST(CF01)`.

Attention: To allow for high availability in your production system, you should include at least two CFs in the PREFLIST for any structures that are used by IBM MQ.

Procedure

1. Refresh the CFRM policy by using the following command:

```
SETXCF START,POLICY,TYPE=CFRM,POLNAME=IBM1SCEN1
```

Sample CFRM policy for structure IBM1SCEN1:

```
STRUCTURE
NAME(IBM1SCEN1)
SIZE(1024M)
INITSIZE(512M)
ALLOWAUTOALT(YES)
FULLTHRESHOLD(85)
PREFLIST(CF01)
ALLOWREALLOCATE(YES)
DUPLEX(DISABLED)
ENFORCEORDER(NO)
```

2. Verify that the structure has been created correctly, by using the following command:

```
D XCF,STR,STRNAME=IBM1SCEN1
```

At this point, your structure has not been allocated, shown by the STATUS line, to the queue sharing group.

3. Configure IBM MQ to make use of the structure defined in the CFRM policy.
   a. Use the DEFINE CFSTRUCT command, with the structure name of SCEN1 to create an IBM MQ CFSTRUCT object:

```
DEFINE CFSTRUCT(SCEN1)
CFCONLOS(TOLERATE)
CFLEVEL(5)
DESCR('Structure for SCM scenario 1')
RECOVER(NO)
RECAUTO(YES)
OFFLOAD(DB2)
OFFLD1SZ(64K) OFFLD1TH(70)
OFFLD2SZ(64K) OFFLD2TH(80)
OFFLD3SZ(64K) OFFLD3TH(90)
```

   .
   b. Validate the structure, using the DISPLAY CFSTRUCT command.
   c. Define the SCEN1.Q shared queue, to use the SCEN1 structure, using the following MQSC command:

```
DEFINE QLOCAL(SCEN1.Q) QSGDISP(SHARED) CFSTRUCT(SCEN1) MAXDEPTH(999999999)
```

4. Use IBM MQ Explorer to put a single message to the queue SCEN1.Q and take the message off again.
5. Issue the following command to check that the structure is now allocated:

```
D XCF,STR,STRNAME=IBM1SCEN1
```

Check in the output from the command, that the STATUS line shows ALLOCATED.

Results

You have created the basic configuration. You can now obtain an idea of the baseline performance of your configuration using whatever method you select.

What to do next

Add SMDS and SCM to the initial structure

Related concepts

“Use of storage class memory with shared queues” on page 185

The use of storage class memory (SCM) can be advantageous when used with IBM MQ for z/OS shared queues.

z/OS *Adding SMDS and SCM to the initial structure*
How you add SMDS and SCM for emergency storage on IBM MQ.

About this task

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

This part of the task uses the basic configuration described in "Emergency storage - basic configuration" on page 191. The scenario describes the addition of shared message data sets (SMDS), and then of SCM to the initial structure.

This final configuration is illustrated in Figure 62 on page 194.

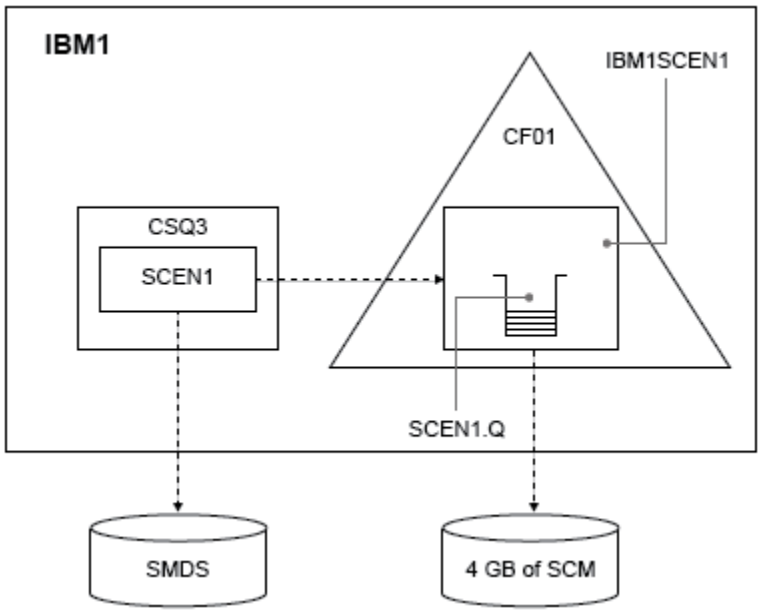


Figure 62. Configuration adding SMDS and SCM for emergency storage

Procedure

1. Create the SMDS data set that the SCEN1 application structure uses, by editing the **CSQ4SMDS** sample JCL, as shown:

```
//CSQ4SMDS JOB NOTIFY=&SYSUID
//*
//* Allocate SMDS
//*
//DEFINE EXEC PGM=IDCAMS,REGION=4M
//SYSPRINT DD SYSOUT=*
//SYSIN DD *
DEFINE CLUSTER           -
(NAME(CSQSMDS.SCEN1.CSQ3.SMDS) -
MEGABYTES(5000 3000)     -
LINEAR                   -
SHAREOPTIONS(2 3) )      -
DATA                  -
(NAME(CSQSMDS.SCEN1.CSQ3.SMDS.DATA) )
/*
//*
//* Format the SMDS
```

```
//*
//FORM   EXEC PGM=CSQJUFMT,COND=(0,NE),REGION=0M
//STEPLIB DD DSN=MQ800.SCSQANLE,DISP=SHR
//     DD DSN=MQ800.SCSQAUTH,DISP=SHR
//SYSUT1  DD DISP=OLD,DSN=CSQSMDS.SCEN1.CSQ3.SMDS
//SYSPRINT DD SYSOUT=*
```

2. Issue the ALTER CFSTRUCT command to change the SCEN1 application structure, to use SMDS for offloading, implementing the default offload rules:

```
ALTER CFSTRUCT(SCEN1) OFFLOAD(SMDS) OFFLD1SZ(32K) OFFLD2SZ(4K) OFFLD3SZ(0K)
DSGROUP('CSQSMDS.SCEN1.*.SMDS') DSBLOCK(1M)
```

   Note the following:

   - Because SCEN1.Q is the only shared queue on the SCEN1 application structure, the **DSBLOCK** value has been set to 1M, the largest value possible. This should be the most efficient setting for our scenario.
   - Because the messages sent by the putting application are 30 KB, offloading to SMDS does not start until the second offload rule is met, when the structure is 80% full.

3. Run your test application again.

   Note the increased storage of messages on the queue.

4. Add 4 GB of SCM to structure IBM1SCEN1 by carrying out the following procedure:

   a) Check how much SCM is installed, and allocated to CF01, by issuing the following command:

```
D CF,CFNAME=CF01
```

   b) Check the STORAGE-CLASS MEMORY figures in the STORAGE CONFIGURATION section of the displayed output to see the available storage.

   c) Update the CFRM policy with the SCMMAXSIZE and SCMALGORITHM keywords as shown:

```
STRUCTURE
NAME(IBM1SCEN1)
SIZE(1024M)
INITSIZE(512M)
ALLOWAUTOALT(YES)
FULLTHRESHOLD(85)
PREFLIST(CF01)
ALLOWREALLOCATE(YES)
DUPLEX(DISABLED)
ENFORCEORDER(NO)
SCMMAXSIZE(4G)
SCMALGORITHM(KEYPRIORITY1)
```

5. Activate the CFRM policy by issuing the following command:

```
SETXCF START,POLICY,TYPE=CFRM,POLNAME=polname
```

6. Rebuild the IBM1SCEN1 structure.

   You must carry out this procedure because the structure was allocated when you made the previous changes.

   Issue the following command to rebuild the structure:

```
SETXCF START,REBUILD,STRNM=IBM1SCEN1
```

Results

You have successfully added SCM to your configuration.

What to do next

Optimize the performance of your system. See “Optimizing storage class memory usage” on page 196 for more information.

z/OS *Optimizing storage class memory usage*

How you improve your use of storage class memory (SCM).

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

Run the following command:

```
D XCF,STR,STRNAME=IBM1SCEN1
```

As the structure was already full with message data, because of the previous tests, part of the rebuild involved pre-staging some of the messages from the structure into SCM. This process was initiated by using the previous command.

The output from this command produces, for example:

```
ACTIVE STRUCTURE
----------------
ALLOCATION TIME: 06/17/2014 09:28:50
CFNAME : CF01
COUPLING FACILITY: 002827.IBM.02.00000000B8D7
PARTITION: 3B CPCID: 00
STORAGE CONFIGURATION ALLOCATED MAXIMUM %
ACTUAL SIZE: 1024 M 1024 M 100
AUGMENTED SPACE: 3 M 142 M 2
STORAGE-CLASS MEMORY: 88 M 4096 M 2
ENTRIES: 120120 1089536 11
ELEMENTS: 240240 15664556 1
SPACE USAGE IN-USE TOTAL %
ENTRIES: 84921 219439 38
ELEMENTS: 2707678 3149050 85
EMCS: 2 282044 0
LOCKS: 1024
SCMHIGHTHRESHOLD : 90
SCMLOWTHRESHOLD : 70
ACTUAL SUBNOTIFYDELAY: 5000
PHYSICAL VERSION: CD5186A0 2BD8B85C
LOGICAL VERSION: CD515C50 CE2ED258
SYSTEM-MANAGED PROCESS LEVEL: 9
XCF GRPNAME : IXCLO053
DISPOSITION : KEEP
ACCESS TIME : NOLIMIT
MAX CONNECTIONS: 32
# CONNECTIONS : 1
CONNECTION NAME ID VERSION  SYSNAME JOBNAME  ASID STATE
--------------- -- -------  ------- -------  ---- ----------------
CSQEIBM1CSQ301  01 00010059 SC61    CSQ3MSTR 0091 ACTIVE
```

Note the following from the output of the command:

- That STORAGE_CLASS MEMORY provides confirmation that a **MAXIMUM** of 4096 MB of SCM has been added to the structure.
- The ALLOCATED figure for the amount of STORAGE-CLASS MEMORY used for pre-staging. There is now free space in the structure where there was none before SCM was added.
- The amount of AUGMENTED SPACE used to track SCM usage.
- The point at which the pre-staging algorithm starts to move data from the structure into SCM is when the structure is 90% full. This is indicated by the non-configurable **SCMHIGHTHRESHOLD** property.
- The point below which the prefetching algorithm starts to move data from SCM into the structure is when the structure is 70% full. This is indicated by the non-configurable **SCMLOWTHRESHOLD** property.

You can now test various ways to optimize the use of SCM. Note the following:

- After SCM is used to store messages, you cannot alter the structure until you have removed all the data from SCM.

  In this case, that means that the entry-to-element ratio is frozen at the value that was in place when SCM was first used. You must carefully ensure that the structure is in the state you want, before the pre-staging algorithm starts moving data into SCM.
- Is the current structure size correct before using SCM?

  For example, have you increased **INITSIZE** from 512 MB to a SIZE of 1 GB?

  If you do not do this, it is possible that although you enabled your structure for auto-alteration, the pre-staging algorithm will start to move data into SCM before the alteration has a chance to start. As a result, the structure is frozen using 512 MB of real storage.
- Is the entry-to-element ratio correct before using SCM?

  The goal of this scenario is to increase the number of offloaded message pointers that can be stored in the structure and SCM as a whole, as well as keeping as many messages entirely in structure storage as possible. Accessing these messages is faster than accessing messages on SMDS.

  Therefore, you need to have a structure that starts with an entry-to-element ratio that is good for storing messages, and then transitions to a ratio that is good for storing message pointers before the prestage algorithm first starts. This transition can be achieved, in part, by making use of the IBM MQ offload rules.

Change the offload rules by issuing the following command:

```
ALTER CFSTRUCT(SCEN1) OFFLD1SZ(0K)
```

You might have to carry out several runs to optimize the entry-to-element ratios.

The following table shows possible improvements in the number of messages put on the queue during the different phases of the emergency storage scenario.

Table 18. Comparison of results for the emergency storage scenario

Test description	Number of messages	Time to fill queue (seconds)
Basic configuration	27,850	3.2
SMDS with default offload rules	205,000	158
SCM with default offload rules	828,610	469
SCM with adjusted offload rules	1,135,775	679

The last row in the table shows that adjusting the offload rules had the required effect.

You need to examine your system to see if you can improve on these figures in any way. For example, you might run out of available SMDS storage. If you can allocate more SMDS storage you should be able to increase the number of messages on the queue quite significantly.

z/OS *Improved performance - basic configuration*

How you set up a basic scenario for improved performance using shared queues on IBM MQ.

About this task

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

This scenario describes the use of SCM to increase the number of messages that can be stored on a shared queue without incurring the performance cost of using SMDS.

This initial scenario is very similar to that used for emergency storage and uses a:

- Queue sharing group, IBM1, that contains a single queue manager, CSQ3. In addition to the administration structure, the queue sharing group defined a single application structure, SCEN2.
- Coupling facility (CF) CF01, in which the SCEN2 application structure is stored as the IBM1SCEN2 structure. This structure has a maximum size of 2 GB.
- Single shared queue, SCEN2.Q, which is configured to use the application structure.

This configuration is illustrated in Figure 63 on page 198.

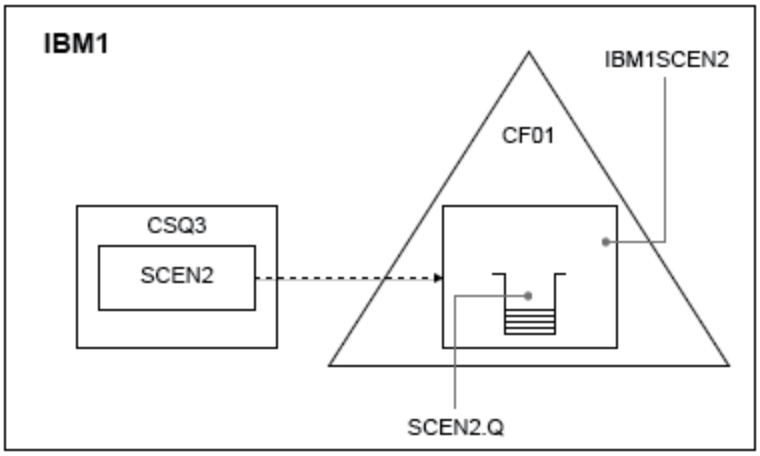


Figure 63. Basic configuration

Furthermore, assume that queue manager CSQ3 is already the only member of queue sharing group IBM1.

You must add the definition for structure IBM1SCEN2 to the coupling facility resource manager (CFRM) policy. For simplicity, the structure is defined so that it can be created in only a single coupling facility, CF01, by specifying PREFLIST(CF01).

Sample CFRM policy for structure IBM1SCEN2:

```
STRUCTURE
NAME(IBM1SCEN2)
SIZE(2048M)
INITSIZE(2048M)
ALLOWAUTOALT(YES)
FULLTHRESHOLD(85)
PREFLIST(CF01)
ALLOWREALLOCATE(YES)
DUPLEX(DISABLED)
ENFORCEORDER(NO)
```

Both the **INITSIZE** and **SIZE** keywords have the value 2048M so that the structure cannot resize.

Procedure

1. Refresh the CFRM policy by using the following command:

   ```
   SETXCF START,POLICY,TYPE=CFRM,POLNAME=IBM1SCEN2
   ```

2. Verify that the structure has been created correctly, by using the following command:

   ```
   D XCF,STR,STRNAME=IBM1SCEN2
   ```

   Issuing the preceding command gives the following output:

```
RESPONSE=SC61
IXC360I 07.58.51 DISPLAY XCF 581
STRNAME: IBM1SCEN2
STATUS: NOT ALLOCATED
POLICY INFORMATION:
POLICY SIZE : 2048 M
POLICY INITSIZE: 2048 M
POLICY MINSIZE : 1536 M
FULLTHRESHOLD : 85
ALLOWAUTOALT : YES
REBUILD PERCENT: N/A
DUPLEX : DISABLED
ALLOWREALLOCATE: YES
PREFERENCE LIST: CF01
ENFORCEORDER : NO
EXCLUSION LIST IS EMPTY

EVENT MANAGEMENT: MESSAGE-BASED   MANAGER SYSTEM NAME: SC53
MANAGEMENT LEVEL : 01050107
```

At this point, your structure has not been allocated, shown by the STATUS line, to the queue sharing group.

3. Configure IBM MQ to make use of the structure defined in the CFRM policy.
   a. Use the DEFINE CFSTRUCT command, with the structure name of SCEN2 to create an IBM MQ CFSTRUCT object.

```
DEFINE CFSTRUCT(SCEN2)
CFCONLOS(TOLERATE)
CFLEVEL(5)
DESCR('Structure for SCM scenario 2')
RECOVER(NO)
RECAUTO(YES)
OFFLOAD(DB2)
OFFLD1SZ(64K) OFFLD1TH(70)
OFFLD2SZ(64K) OFFLD2TH(80)
OFFLD3SZ(64K) OFFLD3TH(90)
```

   b. Check the structure, using the DISPLAY CFSTRUCT command.
   c. Define the SCEN2.Q shared queue, to use the SCEN2 structure, using the following MQSC command:

```
DEFINE QLOCAL(SCEN2.Q) QSGDISP(SHARED) CFSTRUCT(SCEN2) MAXDEPTH(999999999)
```

4. Use IBM MQ Explorer to put a single message to the queue SCEN2.Q and take the message off again.
5. Issue the following command to check that the structure is now allocated:

```
D XCF,STR,STRNAME=IBM1SCEN2
```

Review the output from the command, a portion of which is shown, and ensure that the STATUS line shows ALLOCATED.

```
RESPONSE=SC61
IXC360I 08.31.27 DISPLAY XCF 703
STRNAME: IBM1SCEN2
STATUS: ALLOCATED
EVENT MANAGEMENT: MESSAGE-BASED
TYPE: SERIALIZED LIST
POLICY INFORMATION:
POLICY SIZE : 2048 M
POLICY INITSIZE: 2048 M
POLICY MINSIZE : 1536 M
FULLTHRESHOLD : 85
ALLOWAUTOALT : YES
REBUILD PERCENT: N/A
DUPLEX : DISABLED
ALLOWREALLOCATE: YES
PREFERENCE LIST: CF01
```

```
ENFORCEORDER : NO
EXCLUSION LIST IS EMPTY
```

Additionally, note the values of the fields in the SPACE USAGE section:

- ENTRIES
- ELEMENTS
- EMCS
- LOCKS

An example of the values follows:

```
SPACE USAGE   IN-USE      TOTAL    %
ENTRIES:      344686     345242   99
ELEMENTS:    6548455    6548467   99
EMCS:              2     780318    0
LOCKS:          1024
```

Results

You have created the basic configuration. You can now obtain an idea of the baseline performance of your configuration using whatever method you select.

What to do next

You should test the basic scenario. As an example, you can use the following three applications, starting the applications in the order shown and, running them concurrently.

1. Use a PCF application to request the current depth (**CURDEPTH**) value for SCEN2.Q every five seconds. The output can be used to plot the depth of the queue over time.
2. A single threaded getting application repeatedly gets messages from SCEN2.Q, using a get with an infinite wait. To simulate processing of the messages that were removed, the getting application pauses for four milliseconds for every ten messages that it removed.
3. A single threaded putting application puts a total of one million 4 KB non-persistent messages to SCEN2.Q. This application does not pause between putting each message so messages are put on SCEN2.Q faster than the getting application can get them.

   As a result, when the putting application is running, the depth of SCEN2.Q increases.

   When structure IBM1SCEN2 is filled, and the putting application receives a MQRC_STORAGE_MEDIUM_FULL reason code, the putting application sleeps for five seconds before attempting to put the next message to the queue.

You can plot the results of the CURDEPTH application over a period of time. You obtain some form of saw-tooth wave output as the putting application pauses to allow the queue to partially empty.

Go to “Adding SCM to the initial structure” on page 200.

Related concepts

“Use of storage class memory with shared queues” on page 185

The use of storage class memory (SCM) can be advantageous when used with IBM MQ for z/OS shared queues.

z/OS *Adding SCM to the initial structure*

How you add SCM for improved performance on IBM MQ.

About this task

Important: IBM z16 is planned to be the last generation of IBM Z® to support the use of Virtual Flash Memory (also known as Storage Class Memory, or SCM) for Coupling Facility images. For more information see: IBM Z and IBM LinuxONE 4Q 2023 Statements of Direction.

As an alternative, you should either use larger structures or offload messages to SMDS.

This part of the task uses the basic configuration described in “Improved performance - basic configuration” on page 197. The scenario describes the addition of SCM to the initial structure.

This final configuration is illustrated in Figure 64 on page 201.

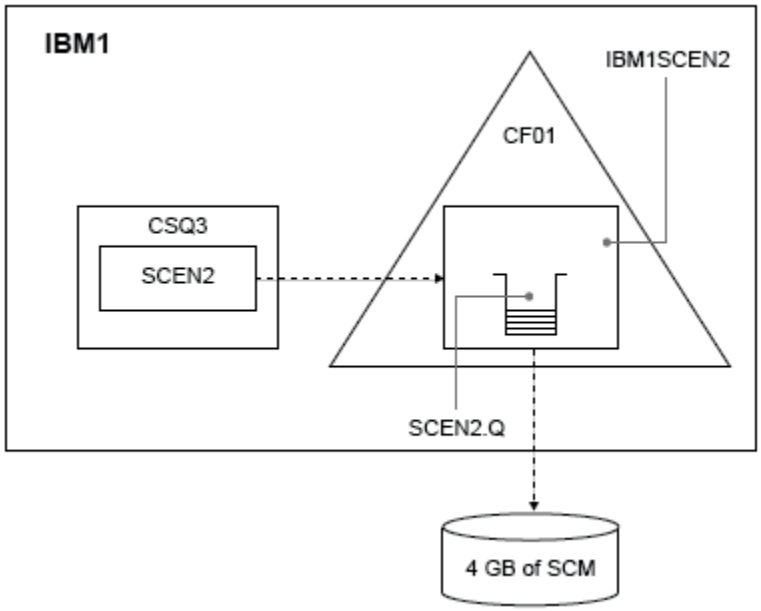


Figure 64. Configuration adding SCM for improved performance

Procedure

1. Add 4 GB of SCM to structure IBM1SCEN2 by carrying out the following procedure:
   a) Check how much SCM is installed, and allocated to CF01, by issuing the following command:

```
D CF,CFNAME=CF01
```

   b) Check the STORAGE-CLASS MEMORY figures in the STORAGE CONFIGURATION section of the displayed output to see the available storage.
   c) Update the CFRM policy with the SCMMAXSIZE and SCMALGORITHM keywords as shown:

```
STRUCTURE
NAME(IBM1SCEN2)
SIZE(2048M)
INITSIZE(2048M)
ALLOWAUTOALT(YES)
FULLTHRESHOLD(85)
PREFLIST(CF01)
ALLOWREALLOCATE(YES)
DUPLEX(DISABLED)
ENFORCEORDER(NO)
SCMMAXSIZE(4G)
SCMALGORITHM(KEYPRIORITY1)
```

2. Activate the CFRM policy by issuing the following command:

```
SETXCF START,POLICY,TYPE=CFRM,POLNAME=IBM1SCEN2
```

3. Rebuild the IBM1SCEN2 structure.

   You must carry out this procedure because the structure was allocated when you made the previous changes.

   Issue the following command to rebuild the structure:

```
SETXCF START,REBUILD,STRNM=IBM1SCEN2
```

4. Issue the following command to confirm the new configuration of the structure:

```
D XCF,STR,STRNAME=IBM1SCEN2
```

Review the output of the command, a portion of which follows:

```
SPACE USAGE     IN-USE       TOTAL      %
ENTRIES:          33         342684     0
ELEMENTS:         48        6503697     0
EMCS:              2         575600     0
LOCKS:                         1024
```

Results

Calculate the change in the use of real storage by the increase in control storage required to use SCM.

- Before SCM is added to the structure, the structure has these totals as shown in “Improved performance - basic configuration” on page 197:
  - 345,242 entries
  - 6,548,467 elements
  - 780,318 EMCS
- After SCM is added to the structure, the structure has these totals:
  - 342,684 entries
  - 6,503,697 elements
  - 575,600 EMCS

Using these figures, after the SCM was added, the structure is reduced in size by:

- 2558 entries
- 44,770 elements
- 204,718 EMCS

The amount of structure storage that is used to manage SCM, is as follows for a 2 GB structure with 4 GB of SCM allocated:

```
(2558 + 44,770 + 204,718) * 256 = 61.5 MB
```

Note that adding more SCM is likely to achieve only a marginal reduction of the size of the structure, because the amount of control storage used to track SCM increases, both as the structure size, and the amount of allocated SCM increases.

What to do next

Repeat the tests described in the final section of “Improved performance - basic configuration” on page 197.

You can plot the results of the revised application over a period of time. Comparing the plot to the one obtained previously, you now obtain an output without a saw-tooth wave, as the putting application no longer has to wait for the queue to partially empty.

For more information, refer to MP16: WebSphere MQ for z/OS - Capacity planning & tuning.

z/OS Distributed queuing and queue sharing groups

Distributed queuing and queue sharing groups are two techniques that you can use to increase the availability of your application systems. Use this topic to find further information about these techniques.

To complement the high availability of messages on shared queues, the distributed queuing component of IBM MQ has additional functions to provide the following:

- Higher availability to the network.
- Increased capacity for inbound network connections to the queue sharing group.

Figure 65 on page 203 illustrates distributed queuing and queue sharing groups. It shows two queue managers within a sysplex, both of which belong to the same queue sharing group. They can both access shared queue SQ1. Queue managers in the network (on AIX and Windows for example) can put messages onto this queue through the channel initiator of either queue manager. Cloned applications on both queue managers service the queue.

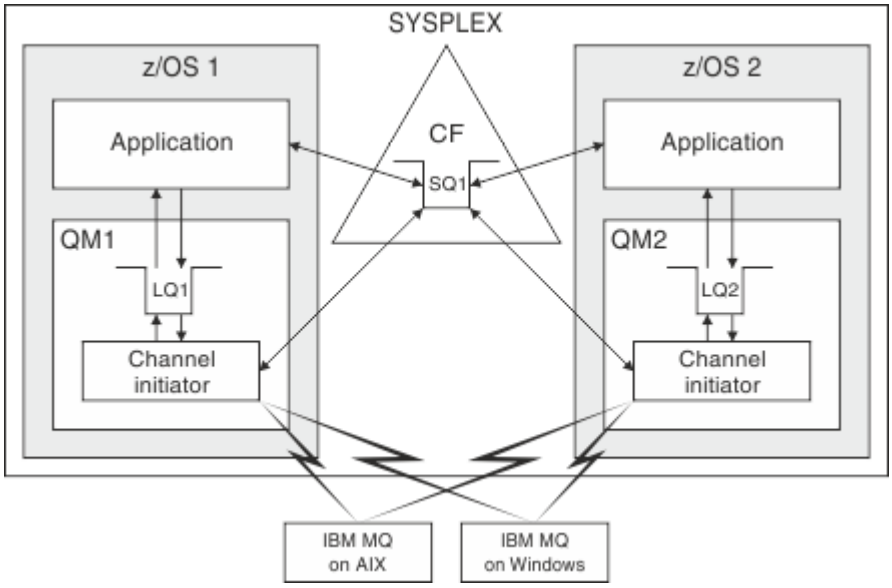


Figure 65. Distributed queuing and queue sharing groups

Related concepts

"Shared channels" on page 203
Use this topic to understand the concepts of shared channels and their use with IBM MQ for z/OS.

"Intra-group queuing" on page 208
This section describes intra-group queuing, an IBM MQ for z/OS function unique to the z/OS platform. This function is only available to queue managers defined to a queue sharing group.

"Clusters and queue sharing groups" on page 205
Use this topic to understand how you can use queue sharing groups with clusters.

z/OS *Shared channels*

Use this topic to understand the concepts of shared channels and their use with IBM MQ for z/OS.

A number of networking products provide a mechanism to hide server failures from the network, or to balance inbound network requests across a set of eligible servers. The network products make a *generic port* available for inbound network connection requests, and the inbound request can be satisfied by connecting to one of the eligible servers.

These networking products include:

- VTAM generic resources

- SYSPLEX Distributor

The channel initiator takes advantage of these products to use the capabilities of shared queues

There are two types of shared channels, *shared inbound channel*, and the *shared outbound channel*.

- Shared inbound channels
- Shared outbound channels

For further information about channels see

- Shared channel summary
- Shared channel status

Shared inbound channels

Each channel initiator in the queue sharing group starts an additional listener task to listen on a *generic port*. This generic port is made available to the network by one of the supporting technologies (VTAM, TCP/IP). Inbound network attach requests to the generic port are dispatched by the network technology, to any one of the listeners in the queue sharing group (QSG) that are listening on the generic port.

You can start a channel on the channel initiator to which the inbound attach is directed if the channel initiator has access to a channel definition for a channel with that name. You can define a channel definition to be private to a queue manager or stored on the shared repository and so available anywhere (a global definition). This means that you can make a channel definition available on any channel initiator in the queue sharing group by defining it as a global definition.

There is an additional difference when starting a channel through the generic port; channel synchronization is with the queue sharing group and not with an individual queue manager. For example, consider a remote queue manager starting a channel through the generic port. When the channel first starts, it might start on queue manager QM1 and messages flow. If the channel stops and is restarted on queue manager QM2, information about the number of messages that have flowed is still correct because the synchronization is with the queue sharing group.

You can use an inbound channel started through the generic port to put messages to any queue. The remote queue manager does not know whether the target queue is shared or not. If the target queue is a shared queue, the remote queue manager connects through any available channel initiator in a load-balanced fashion and the messages are put to the shared queue.

If the target queue is a private queue, the messages are put to the private queue owned by which ever queue manager the current instance of the channel is connected to. In this environment, known as *replicated local queues*, each queue manager must have the same set of private queues defined.

Configuring SVRCONN channels for a queue sharing group

The optimal configuration for SVRCONN channels in a queue sharing group is to set up private listeners in each CHINIT which use a different port number from the point to point channels. These listener ports are then used as the 'back-end' resources for a new workload distribution mechanism such as Sysplex Distributor using Virtual IP addresses (VIPA). The external VIPA address is then used as the target address for the CLNTCONN definitions in the network. The SVRCONN channel can be defined with QSGDISP(GROUP) so the same definition is available to all queue managers in the QSG. This configuration avoids using a shared listener, and therefore reduces the performance effect of the queue sharing group maintaining shared channel state, which is not needed for client/server channels.

Shared outbound channels

An outbound channel is considered to be a shared channel if it is taking messages from a shared transmission queue. If it is shared, it holds synchronization information at queue sharing group level. This means that the channel can be restarted on a different queue manager and channel initiator instance

within the queue sharing group if the communications subsystem, channel initiator, or queue manager fails. Restarting failed channels in this way is a feature of shared channels called *peer channel recovery*.

Workload balancing for shared outbound channels

An outbound shared channel is eligible for starting on any channel initiator within the queue sharing group, if you have not specified that you want it to be started on a particular channel initiator. The channel initiator selected by IBM MQ is determined using the following criteria:

- Is the communications subsystem required currently available to the channel initiator?
- Is a Db2 connection available to the channel initiator?
- Which channel initiator has the lowest current workload? The workload includes channels that are active and retrying.

Shared channel summary

Shared channels differ from private channels in the following ways:

Private channel
Tied to a single channel initiator.

- Outbound channel uses a local transmission queue.
- Inbound channel started through a local port.
- Synchronization information held in SYSTEM.CHANNEL.SYNCQ queue.

Shared Channel
Workload balanced with high availability.

- Outbound channel uses a shared transmission queue.
- Inbound channel started through a generic port.
- Synchronization information held in SYSTEM.QSG.CHANNEL.SYNCQ queue.

You specify whether a channel is private or shared when you start the channel by using CHLDISP options with the START CHANNEL command. A shared channel can be started by triggering in the same way as a private channel. However, when a shared channel is started, IBM MQ performs workload balancing and starts the channel on the most appropriate channel initiator within the queue sharing group. (If required, you can specify that a shared channel is to be started on a particular channel initiator.)

Shared channel status

The channel initiators in a queue sharing group maintain a shared channel-status table in Db2. This records which channels are active on which channel initiators. The shared channel-status table is used if there is a channel initiator or communications system failure. It indicates which channels need to be restarted on a different channel initiator in the queue sharing group.

z/OS *Clusters and queue sharing groups*

Use this topic to understand how you can use queue sharing groups with clusters.

You can make your shared queues available to a cluster in a single definition. To do this you specify the name of the cluster when you define the shared queue.

Users in the network see the shared queue as being hosted by each queue manager within the queue sharing group (the shared queue is not advertised as being hosted by the queue sharing group). Clients can start sessions with any members of the queue sharing group to put messages to the same shared queue.

Figure 66 on page 206 shows how members of a cluster can access a shared queue through any member of the queue sharing group.

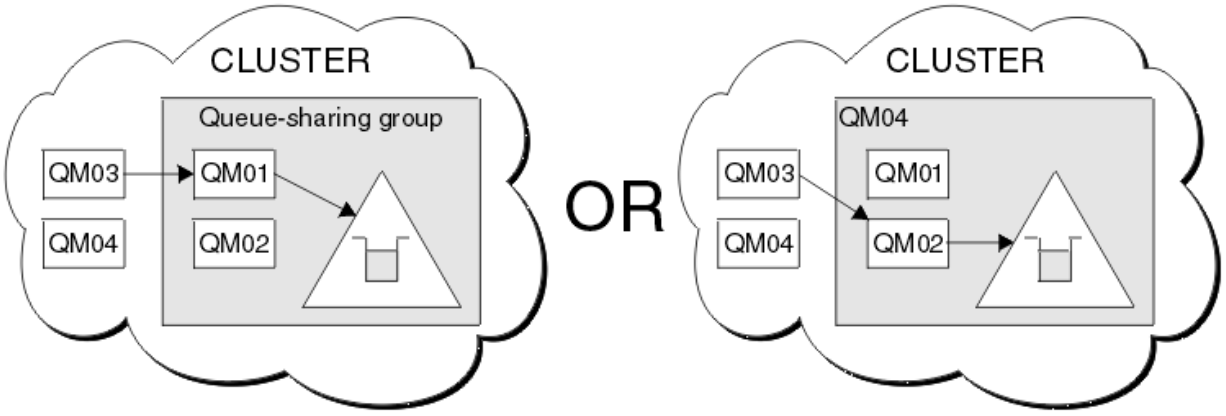


Figure 66. A queue sharing group as part of a cluster

z/OS Influencing workload distribution with shared queues

Use this topic to understand the factors that affect workload distribution with shared queues in a queue sharing group.

IBM MQ does not provide workload balancing for shared queues. However, workload distribution in a queue sharing group (QSG) can be influenced in *a pull based fashion*. The choice of which queue manager services a queue (receives a message written to a shared queue) is affected by the available processing capacity of each queue manager in the queue sharing group and the workload management goals defined across the sysplex.

However, it is important to appreciate, the queue manager that performs the MQPUT of a message can also have a large influence in deciding which queue manager gets the message.

A local queue manager is more likely to perform the MQGET

For an application performing an MQPUT, the local queue manager is said to be the queue manager to which the application is connected.

Exactly which queue manager services an MQPUT of a message by performing an MQGET on behalf of a getting application is influenced by the following considerations.

When a message is put to an empty shared queue, the local queue manager is typically posted before any of the other queue manager in the queue sharing group is notified. If the local queue manager is in a position to process the message, it receives a list transition notification from the coupling facility (CF) before any other queue manager in the QSG. (A list transition notification is a notification that the shared queue has changed state from empty to non-empty.)

The possible scenarios, in this case, are as follows:

1. MQPUT of nonpersistent message out of sync point and *fast put to waiting getter*.

   If there is an application with an *MQGET with wait* on the local queue manager for the queue, then the MQPUT of the message is passed directly to the getting application's buffer and not written to the queue. This is true for shared and non-shared queues. This feature is often called *fast put to a waiting getter* mechanism. In the case of shared queues, no other queue manager in the QSG is notified as there is no transition from empty to non-empty of the queue. This means, for example, that provided this queue manager can service all the puts from this application and assuming that no other applications are putting messages to the queue, then no other queue manager in the queue sharing group assists in draining this queue. If however there is no MQGET with wait on the local queue manager, and a message is put to the shared queue then the CF will notify other queue managers in the queue sharing group according to its rules for notifications of list transitions.
2. MQPUT of a persistent or in-syncpoint message.

In this case, if there is an application with an *MQGET with wait* on the local queue manager, then the message is put to the shared queue and the CF notifies other queue managers in the queue sharing group according to its rules for notifications of list transitions. However, the local queue manager does not wait for a transition notification from the CF but honors any local *MQGET with wait* first and usually performs the get of this message on behalf of the application before any other queue manager in the queue sharing group can respond to a CF notification. This is dependent on how busy the local queue manager is. Otherwise, any queue manager notified by the CF due to the arrival of the message on the empty queue will try to service the get first. The first queue manager to respond processes the new message.

3. Finally, if the queue is not drained of messages, where the CF has sent a notification of a state change from empty to non-empty for the queue, all connected queue managers will have an opportunity to assist in the processing of the queue. In this event, the workload is said to be *pull based*.

This design allows for the improved performance over a purely pull based workload distribution. The aim is to take advantage of the high availability offered by queues held in the CF while allowing the queue manager, where possible, to perform the MQGET without needing to reference the CF and so to process the message workload as efficiently as possible.

Alternative approaches can be adopted where emphasis on balance of the workload is more important than the previously described performance enhancements. For example, ensuring that none of the getting applications are connected to the same queue manager that the putting application is connected to. Using this design all messages are put to the queue and all queue managers in the QSG are notified when the queue moves from empty to non-empty, in accordance with the CF algorithm for handling such transitions. In addition, the *fast put to waiting getter* mechanism is not applicable.

z/OS Where to find more information about shared queues and queue sharing groups

Use the table in this topic to find more information about how IBM MQ for z/OS uses shared queues and queue sharing groups.

Table 19. Where to find more information about shared queues and queue sharing groups

Topic	Where to look
Queue sharing group recovery	“Recovery and restart on z/OS” on page 246
Queue sharing group security	“Security concepts in IBM MQ for z/OS” on page 262
Private and global object definitions Directing commands to different queue managers	Sources from which you can issue commands on z/OS
Planning your coupling facility environment	Defining coupling facility resources
Planning your SMDS environment	Planning your shared message data set (SMDS) environment
Planning your Db2 environment	Planning your Db2 environment
Setting up your shared queues System parameters	“Shared queues and queue sharing groups” on page 164
Utility programs Migrating queues	IBM MQ utilities on z/OS reference

Table 19. Where to find more information about shared queues and queue sharing groups (continued)	
Topic	**Where to look**
Console messages	Messages for IBM MQ for z/OS
MQSC commands	MQSC commands
IBM MQ clusters	Configuring a queue manager cluster
IBM MQ distributed queuing Channel names	Introduction to distributed queue management
Writing applications	Overview of application design
MQCONNX call	MQCONNX

z/OS Intra-group queuing

This section describes intra-group queuing, an IBM MQ for z/OS function unique to the z/OS platform. This function is only available to queue managers defined to a queue sharing group.

For information about queue sharing groups, see “Shared queues and queue sharing groups” on page 164.

Intra-group queuing concepts

You can perform fast message transfer between queue managers in a queue sharing group without defining channels. This uses a system queue called the SYSTEM.QSG.TRANSMIT.QUEUE, which is a shared transmission queue. Each queue manager in the queue sharing group starts a task called the intra-group queuing agent, which waits for messages to arrive on this queue that are destined for their queue manager. When such a message is detected, it is removed from the queue and placed on the correct destination queue.

Standard name resolution rules are used but, if intra-group queuing (IGQ) is enabled and the target queue manager is within the queue sharing group, the SYSTEM.QSG.TRANSMIT.QUEUE is used to transfer the message to the correct destination queue manager instead of using a transmission queue and channel.

You enable intra-group queuing through a queue manager attribute. Intra-group queuing moves nonpersistent messages outside sync point, and persistent messages within sync point. If it finds a problem delivering messages to the target queue, intra-group queuing tries to put them to the dead-letter queue. If the dead-letter queue is full or undefined, nonpersistent messages are discarded, but persistent messages are backed out and returned to the SYSTEM.QSG.TRANSMIT.QUEUE, and the IGQ agent tries to deliver the messages until it is successful.

An inbound shared channel that receives a message destined for a queue on a different queue manager in the queue sharing group can use intra-group queuing to *hop* the message to the correct destination.

There might be times when you want the local queue manager to put a message directly to the target queue if the target queue is a shared queue, rather than the message first being transferred to the target queue manager. You can use the queue manager attribute SQQMNAME to control this. If you set the value of SQQMNAME to USE, the MQOPEN command is performed on the queue manager specified by the **ObjectQMgrName**.

However, if the target queue is a shared queue and you set the value of SQQMNAME to IGNORE, and the **ObjectQMgrName** is that of another queue manager in the queue sharing group, the shared queue is opened on the local queue manager. If the local queue manager cannot open the target queue, or put a

message to the queue, the message is transferred to the specified **ObjectQMgrName** through either IGQ or an IBM MQ channel.

Intra-group queuing can be used to deliver, more efficiently, small messages to queues residing on remote queue managers within a queue sharing group. Intra-group queuing also supports large messages, the largest being 100 MB *minus* the length of the transmission queue header.

Note: If you use this feature, users must have the same access to the queues on each queue manager in the queue sharing group.

The following diagram shows a typical example of intra-group queuing.

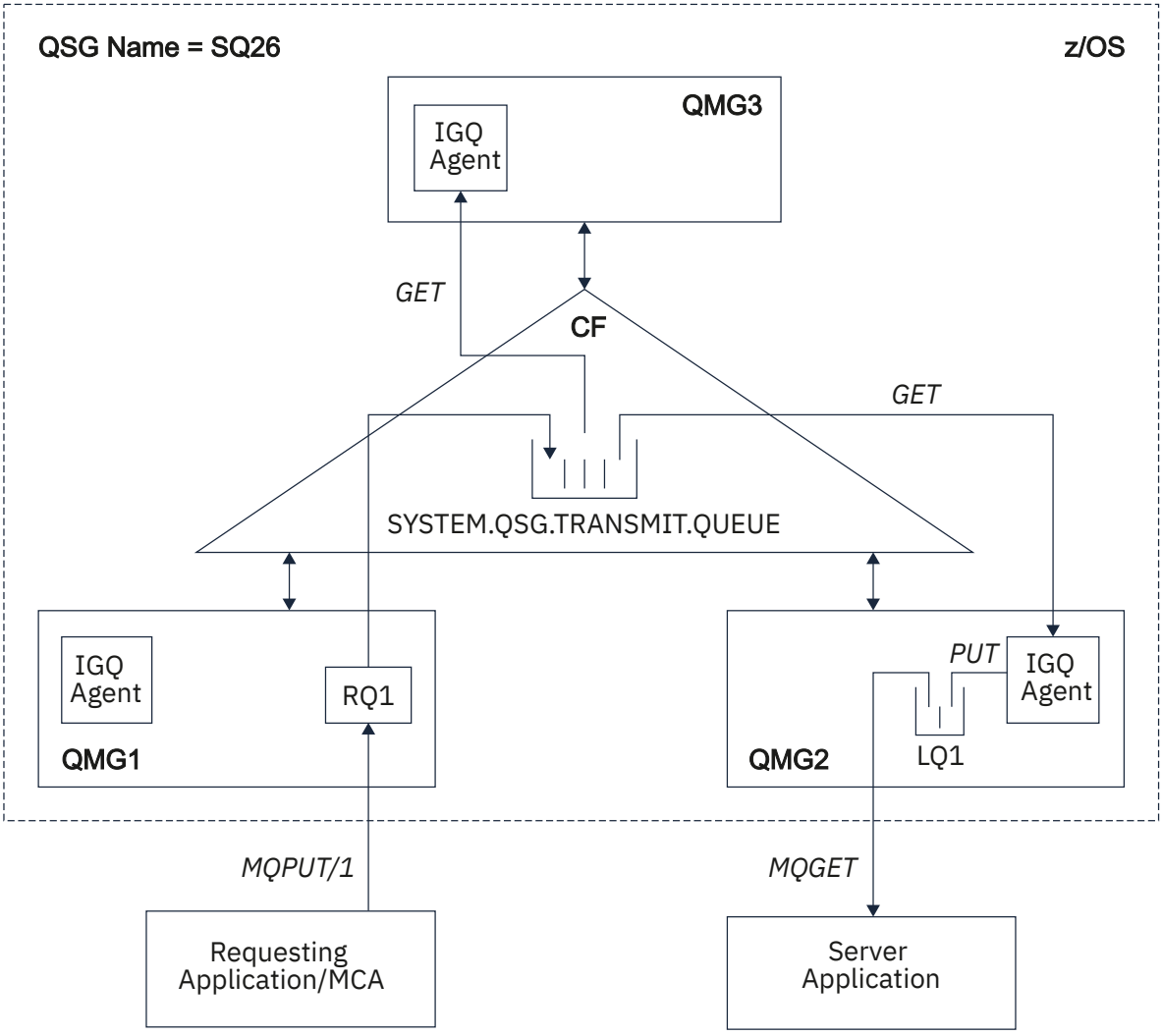


Figure 67. An example of intra-group queuing

The diagram shows:

- IGQ agents running on three queue managers (QMG1, QMG2, and QMG3) that are defined to a queue sharing group called SQ26.
- Shared transmission queue SYSTEM.QSG.TRANSMIT.QUEUE that is defined in the coupling facility (CF).
- A remote queue definition that is defined in queue manager QMG1.
- A local queue that is defined in queue manager QMG2.
- A requesting application (this application could be a Message Channel Agent (MCA)) that is connected to queue manager QMG1.

- A server application that is connected to queue manager QMG2.
- A request message being placed on to the SYSTEM.QSG.TRANSMIT.QUEUE.

Intra-group queuing and the intra-group queuing agent

An IGQ agent is started during queue manager initialization. When applications open and put messages to remote queues, the local queue manager determines whether intra-group queuing is used for message transfer. If intra-group queuing is to be used, the local queue manager places the message on to the SYSTEM.QSG.TRANSMIT.QUEUE. The IGQ agent on the target remote queue manager retrieves the message and places it on to the destination queue.

Intra-group queuing terminology

Explanations of the terminology: intra-group queuing, shared transmission queue for use by intra-group queuing, and intra-group queuing agent.

Intra-group queuing

Intra-group queuing can effect potentially fast and less expensive message transfer between queue managers in a queue sharing group, without the need to define channels.

Shared transmission queue for use by intra-group queuing

Each queue sharing group has a shared transmission queue called SYSTEM.QSG.TRANSMIT.QUEUE for use by intra-group queuing. If intra-group queuing is enabled, SYSTEM.QSG.TRANSMIT.QUEUE appears in the name resolution path when opening remote queues. When applications (including Message Channel Agents (MCAs)) put messages to a remote queue, the local queue manager determines the eligibility of messages for fast transfer and places them on SYSTEM.QSG.TRANSMIT.QUEUE.

Intra-group queuing agent

The IGQ agent is the task, started at queue manager initialization, that waits for suitable messages to arrive on the SYSTEM.QSG.TRANSMIT.QUEUE. The IGQ agent retrieves suitable messages from this queue and delivers them to the destination queues.

The IGQ agent for each queue manager is always started because intra-group queuing is used by the queue manager itself for its own internal processing.

z/OS Benefits of intra-group queuing

The benefits of intra-group queuing are: reduced system definitions, reduced system administration, improved performance, supports migration, and delivery of messages when multi-hopping between queue managers in a queue sharing group.

The benefits of intra-group queuing are:

Reduced system definitions
: Intra-group queuing removes the need to define channels between queue managers in a queue sharing group.

Reduced system administration
: Because there are no channels defined between queue managers in a queue sharing group, there is no requirement for channel administration.

Improved performance
: Because there is only one IGQ agent needed for the delivery of a message to a target queue (instead of two intermediate sender and receiver agents), the delivery of messages using intra-group queuing can be less expensive than the delivery of messages using channels. In intra-group queuing there is only a receiving component, because the need for the sending component has been removed. This saving is because the message is available to the IGQ agent at the destination queue manager for

delivery to the destination queue once the put operation at the local queue manager has completed and, in the case of messages put in sync point scope, committed.

Supports migration

Applications external to a queue sharing group can deliver messages to a queue residing on any queue manager in the queue sharing group, while being connected only to a particular queue manager in the queue sharing group. This is because messages arriving on a receiver channel, destined for a queue on a remote queue manager, can be transparently sent to the destination queue using intra-group queuing. This facility allows applications to be deployed among the queue sharing group without the need to change any systems that are external to the queue sharing group.

A typical configuration is illustrated by the following diagram, in which:

- A requesting application connected to queue manager QMG1 needs to send a message to a local queue on queue manager QMG3.
- Queue manager QMG1 is connected only to queue manager QMG2.
- Queue managers QMG2 and QMG3, which were previously connected using channels, are now members of queue sharing group SQ26.

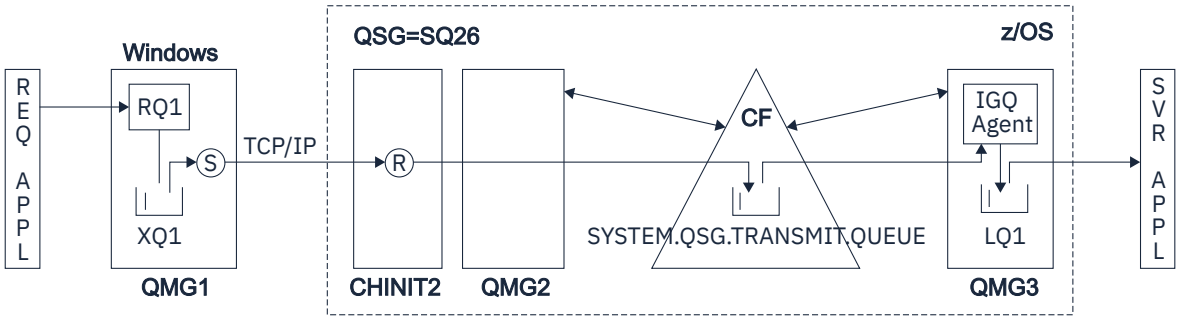


Figure 68. An example of migration support

The flow of operations is as follows:

1. The requesting application puts a message, destined for local queue LQ1 at remote queue manager QMG3, on to remote queue definition RQ1.
2. Queue manager QMG1, running on a Windows NT workstation, places the message on to the transmission queue XQ1.
3. Sender MCA (S) on QM1 transmits the message, using TCP/IP, to the receiver MCA (R) on channel initiator CHINIT2.
4. Receiver MCA (R) on channel initiator CHINIT2 places the message on to the shared transmission queue SYSTEM.QSG.TRANSMIT.QUEUE.
5. IGQ agent on queue manager QMG3 retrieves the message from the SYSTEM.QSG.TRANSMIT.QUEUE and places it on to the target local queue LQ1.
6. The server application retrieves the message from the target local queue and processes it.

Delivery of messages when multi-hopping between queue managers in a queue sharing group

The previous diagram in Supports migration also illustrates the delivery of messages when multi-hopping between queue managers in a queue sharing group. Messages arriving on a queue manager within the queue sharing group, but destined for a queue on another queue manager in the queue sharing group, can be easily transmitted to the destination queue on the destination queue manager, using intra-group queuing.

z/OS Limitations of intra-group queuing

The limitations of intra-group queuing are: messages eligible for transfer using intra-group queuing, number of intra-group queuing agents per queue manager, and starting and stopping the intra-group queuing agent.

This topic describes the limitations of intra-group queuing.

Messages eligible for transfer using intra-group queuing
Because intra-group queuing uses a shared transmission queue that is defined in the coupling facility (CF), intra-group queuing is limited to delivering messages of the maximum supported message length for shared queues minus the length of a transmission queue header (MQXQH).

Number of intra-group queuing agents per queue manager
Only one IGQ agent is started per queue manager in a queue sharing group.

Starting and stopping the intra-group queuing agent
The IGQ agent is started during queue manager initialization and terminated during queue manager shut-down. It is designed to be a long running, self recovering (in the event of abnormal termination), task. If there is an error with the definition of the SYSTEM.QSG.TRANSMIT.QUEUE (for example, if this queue is Get inhibited) the IGQ agent keeps retrying. If the IGQ agent encounters an error that results in normal termination of the agent while the queue manager is still active, it can be restarted by issuing an ALTER QMGR IGQ(ENABLED) command. This command avoids the need to recycle the queue manager.

Setting the queue manager attribute IGQ to ENABLED or DISABLED
If the queue manager attribute IGQ is set to ENABLED or DISABLED, existing object handles may be invalidated with reason code MQRC_OBJECT_CHANGED. See Getting started with intra-group queueing for more information.

z/OS Getting started with intra-group queuing

You can enable, disable, and use intra-group queuing as described in this topic.

Enabling intra-group queuing
To enable intra-group queuing on your queue managers, you need to do the following:

- Define a shared transmission queue called SYSTEM.QSG.TRANSMIT.QUEUE. The definition of this queue can be found in thlqual.SCSQPROC(CSQ4INSS), the CSQINP2 sample for SYSTEM objects for queue sharing groups. This queue must be defined with the correct attributes, as stated in thlqual.SCSQPROC(CSQ4INSS), for intra-group queuing to work properly.
- Because the IGQ agent is always started at queue manager initialization, intra-group queuing is always available for inbound message processing. The IGQ agent processes any messages that are placed on the SYSTEM.QSG.TRANSMIT.QUEUE. However, to enable intra-group queuing for outbound processing, the queue manager attribute IGQ must be set to ENABLED.

  Important: If the queue manager attribute IGQ is set to ENABLED, existing object handles may be invalidated with reason code MQRC_OBJECT_CHANGED. See “Specific properties of intra-group queuing” on page 220 for more information. As described in the 'Programmer response' section for this reason code, applications need to be coded to handle this situation (see 2041 (07F9) (RC2041): MQRC_OBJECT_CHANGED for more details).

Additionally, as IGQ is designed as a long running and self-recovering task, which starts during initialization and terminates with shutdown, see “Limitations of intra-group queuing” on page 212 for further information.

Disabling intra-group queuing

To disable intra-group queuing for outbound message transfer, set the queue manager attribute IGQ to DISABLED. If intra-group queuing is disabled for a particular queue manager, the IGQ agent on that queue manager can still process inbound messages that have been placed on the SYSTEM.QSG.TRANSMIT.QUEUE by a queue manager that does have intra-group queuing enabled for outbound transfer.

Important: If the queue manager attribute IGQ is set to ENABLED, existing object handles may be invalidated with reason code MQRC_OBJECT_CHANGED. See “Specific properties of intra-group queuing” on page 220 for more information. As described in the 'Programmer response' section for this reason code, applications need to be coded to handle this situation (see 2041 (07F9) (RC2041): MQRC_OBJECT_CHANGED for more details).

Additionally, as IGQ is designed as a long running and self-recovering task, which starts during initialization and terminates with shutdown, see “Limitations of intra-group queuing” on page 212 for further information.

Using intra-group queuing

Once intra-group queuing is enabled, it is available for use and a queue manager uses it whenever possible. That is, when an application puts a message to a remote queue definition, to a fully qualified remote queue, or to a cluster queue, the queue manager determines if the message is eligible to be delivered using intra-group queuing and if it is, places the message on to SYSTEM.QSG.TRANSMIT.QUEUE. There is no need to change user applications, or to application queues, because for eligible messages the queue manager uses the SYSTEM.QSG.TRANSMIT.QUEUE, in preference to any other transmission queue.

z/OS Intra-group queuing configurations

In addition to the typical intra-group queuing configuration, other configurations are possible.

“Intra-group queuing concepts” on page 208 describes the typical configuration.

Related concepts

“Distributed queuing with intra-group queuing (multiple delivery paths)” on page 213
For applications that process short messages it might be feasible to configure intra-group queuing only for delivering messages between queue managers in a queue sharing group.

“Clustering with intra-group queuing (multiple delivery paths)” on page 215
It is possible to configure queue managers so that they are in a cluster as well as in a queue sharing group.

“Clustering, intra-group queuing and distributed queuing” on page 217
It is possible to configure a queue manager that is a member of a cluster as well as a queue sharing group and is connected to a distributed queue manager using a sender/receiver channel pair.

z/OS *Distributed queuing with intra-group queuing (multiple delivery paths)*

For applications that process short messages it might be feasible to configure intra-group queuing only for delivering messages between queue managers in a queue sharing group.

The choice of intra-group queuing over channel communications can be controlled by the CFSTRUCT type level. (3 instead of 4 or 5). The maximum message length as set on the SYSTEM.QSQ.TRANSMIT.QUEUE.

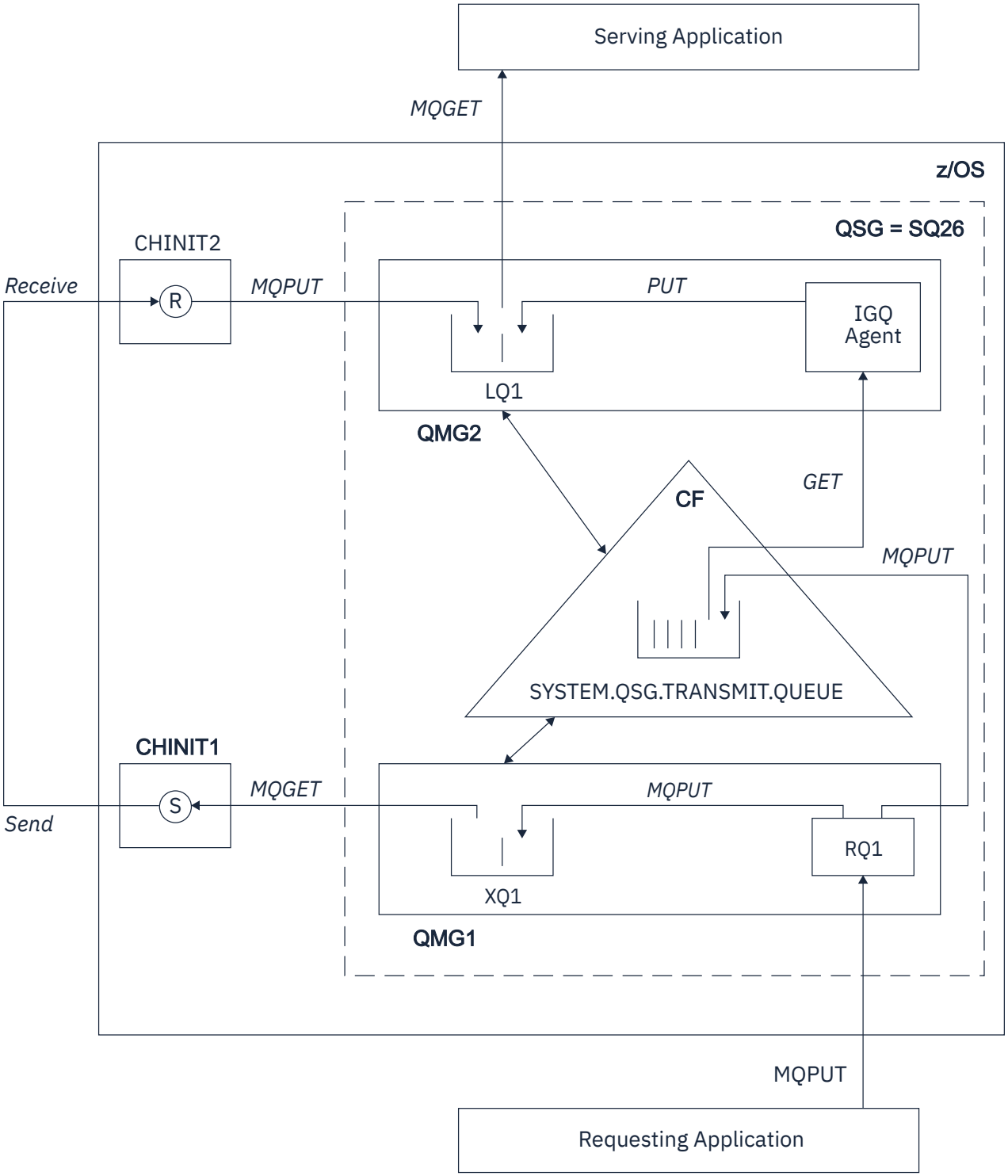


Figure 69. An example configuration

Open/Put processing

1. It is important to note that when the requesting application opens remote queue RQ1, name resolution occurs for both the non-shared transmission queue XQ1 and the shared transmission queue SYSTEM.QSG.TRANSMIT.QUEUE.
2. When the requesting application puts a message on to the remote queue, based on whether intra-group queuing is enabled for outbound transfer on the queue manager and on the message characteristics, the message is put to transmission queue XQ1, or to transmission queue

SYSTEM.QSG.TRANSMIT.QUEUE. The queue manager places all large messages on to transmission queue XQ1, and all small messages on to transmission queue SYSTEM.QSG.TRANSMIT.QUEUE.

3. If transmission queue XQ1 is full, or is not available, put requests for large messages fail synchronously with a suitable return and reason code. However, put requests for small messages continue to succeed and are placed on transmission queue SYSTEM.QSG.TRANSMIT.QUEUE.
4. If transmission queue SYSTEM.QSG.TRANSMIT.QUEUE is full, or cannot be put to, put requests for small messages fail synchronously with a suitable return and reason code. However, put requests for large messages continue to succeed and are placed on transmission queue XQ1. In this case, no attempt is made to put the small messages on to a transmission queue.

Flow for large messages

1. The requesting application puts large messages to remote queue RQ1.
2. Queue manager QMG1 puts the messages on to transmission queue XQ1.
3. Sender MCA (S) on queue manager QMG1 retrieves the messages from transmission queue XQ1 and sends them to queue manager QMG2.
4. Receiver MCA (R) on queue manager QMG2 receives the messages and places them on to destination queue LQ1.
5. The serving application retrieves and then processes the messages from queue LQ1.

Flow for small messages

1. The requesting application puts small messages on to remote queue RQ1.
2. Queue manager QMG1 puts the messages on to transmission queue SYSTEM.QSG.TRANSMIT.QUEUE.
3. IGQ on queue manager QMG2 retrieves the messages and places them on to the destination queue LQ1.
4. The serving application retrieves the messages from queue LQ1.

Points to note

1. The requesting application does not need to be aware of the underlying mechanism used for the delivery of messages.
2. A potentially faster message delivery mechanism can be achieved for small messages.
3. Multiple paths are available for message delivery (that is, the normal channel route and the intra-group queuing route).
4. The intra-group queuing route, being potentially faster, is selected in preference to the normal channel route. Depending on the message characteristics, message delivery might be divided across the two paths. Hence, messages might be delivered out of sequence (though this delivery is also possible if messages are delivered using only the normal channel route).
5. When a route has been selected, and messages have been placed on to the transmission queues, only the selected route is used for message delivery. Any unprocessed messages on the SYSTEM.QSG.TRANSMIT.QUEUE are not diverted to transmission queue XQ1.

z/OS *Clustering with intra-group queuing (multiple delivery paths)*

It is possible to configure queue managers so that they are in a cluster as well as in a queue sharing group.

When messages are sent to a cluster queue and the local and remote destination queue managers are in the same queue sharing group, intra-group queuing is used for the delivery of small messages (using the SYSTEM.QSG.TRANSMIT.QUEUE), and the delivery of large messages if intra-group queuing supports the size of the message. Also, the SYSTEM.CLUSTER.TRANSMIT.QUEUE is used for the delivery of messages to any queue manager that is in the cluster, but outside the queue sharing group. The following diagram illustrates this configuration (the channel initiators are not shown).

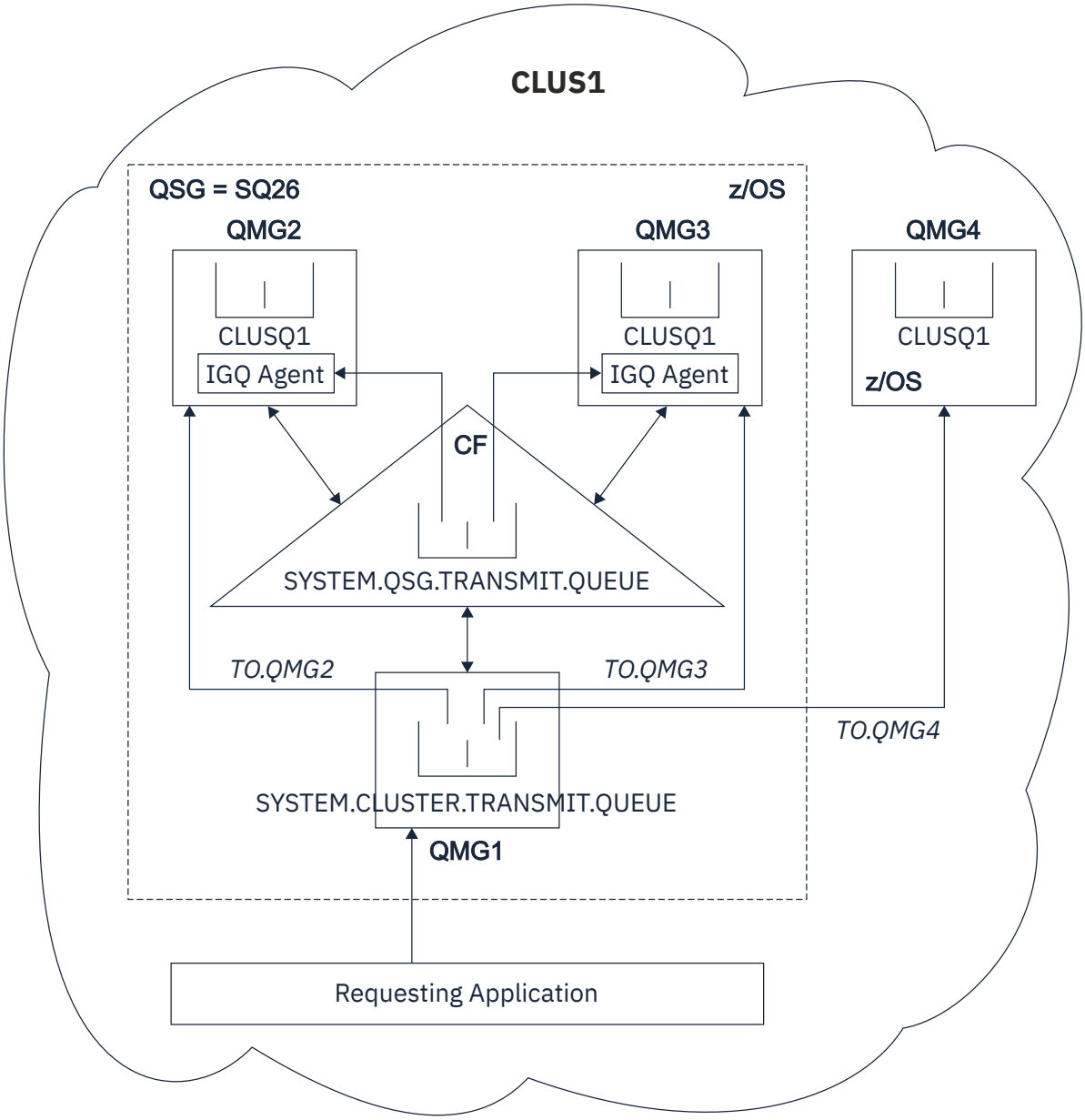


Figure 70. An example of clustering with intra-group queuing

The diagram shows:

- Four z/OS queue managers QMG1, QMG2, QMG3, and QMG4 configured in a cluster CLUS1.
- Queue managers QMG1, QMG2, and QMG3 configured in a queue sharing group SQ26.
- IGQ agents running on queue managers QMG2 and QMG3.
- The local SYSTEM.CLUSTER.TRANSMIT.QUEUE defined in QMG1.

  Note: For clarity, the SYSTEM.CLUSTER.TRANSMIT.QUEUE on the other queue managers not shown.
- The shared SYSTEM.QSG.TRANSMIT.QUEUE defined in the CF, which is in an IBM MQ structure configured with the CFLEVEL(3) RECOVER(YES) attribute.
- Cluster channels TO.QMG2 (connecting QMG1 to QMG2), TO.QMG3 (connecting QMG1 to QMG3), and TO.QMG4 (connecting QMG1 to QMG4).
- Cluster queue CLUSQ1 being hosted on queue managers QMG2, QMG3, and QMG4.

Assume that the requesting application opens the cluster queue with the MQOO_BIND_NOT_FIXED option, so that the target queue manager for the cluster queue is selected at put time.

If the selected target queue manager is QMG2:

- All large messages put by the requesting application are:
  - Put to the SYSTEM.CLUSTER.TRANSMIT.QUEUE on QMG1, because SYSTEM.QSG.TRANSMIT.QUEUE is in a CFLEVEL(3) structure; therefore supports messages only up to 63 KB in size.
  - Transferred to cluster queue CLUSQ1 on QMG2 using cluster channel TO.QMG2
- All small messages put by the requesting application are
  - Put to the shared transmission queue SYSTEM.QSG.TRANSMIT.QUEUE. This queue is in a structure configured with the RECOVER(YES) attribute, so is used for both persistent, and non-persistent, small messages.
  - Retrieved by the IGQ agent on QMG2
  - Put to the cluster queue CLUSQ1 on QMG2

If the selected target queue manager is QMG4:

- Because QMG4 is not a member of queue sharing group SQ26, all messages put by the requesting application are
  - Put to the SYSTEM.CLUSTER.TRANSMIT.QUEUE on QMG1
  - Transferred to cluster queue CLUSQ1 on QMG4 using cluster channel TO.QMG4

Points to note

- The requesting application does not need to be aware of the underlying mechanism used for the delivery of messages.
- A potentially faster delivery mechanism is achieved for the transfer of small non-persistent messages between queue managers in a queue sharing group (even if the same queue managers are in a cluster).
- Multiple paths are available for message delivery (that is, both the cluster route and the intra-group queuing route).
- The intra-group queuing route, being potentially faster, is selected in preference to the cluster route. Depending on the message characteristics, message delivery might be divided across the two paths. Hence, messages might be delivered out of sequence. It is important to note that this delivery is possible without regard to the MQOO_BIND_* option specified by the application. Intra-group queuing distributes messages in the same way as clustering does, depending on whether the MQOO_BIND_NOT_FIXED, MQOO_BIND_ON_OPEN, MQOO_BIND_ON_GROUP, or MQOO_BIND_AS_Q_DEF is specified on open.
- When a route has been selected, and messages have been placed on to the transmission queues, only the selected route is used for message delivery. Any unprocessed messages on the SYSTEM.QSG.TRANSMIT.QUEUE are not diverted to the SYSTEM.CLUSTER.TRANSMIT.QUEUE.

z/OS *Clustering, intra-group queuing and distributed queuing*

It is possible to configure a queue manager that is a member of a cluster as well as a queue sharing group and is connected to a distributed queue manager using a sender/receiver channel pair.

This configuration is a combination of distributed queuing with intra-group queuing and clustering with intra-group queuing.

Intra-group queuing is described in “Distributed queuing with intra-group queuing (multiple delivery paths)” on page 213.

Clustering with intra-group queuing is described in “Clustering with intra-group queuing (multiple delivery paths)” on page 215.

z/OS Intra-group queuing messages

This section describes the messages put to the SYSTEM.QSG.TRANSMIT.QUEUE.

Message structure

Like all other messages that are put to transmission queues, messages that are put to the SYSTEM.QSG.TRANSMIT.QUEUE are prefixed with the transmission queue header (MQXQH).

Message persistence

In IBM WebSphere MQ 5.3 and above, shared queues support both persistent and non-persistent messages.

If the queue manager terminates while the IGQ agent is processing non-persistent messages, or if the IGQ agent terminates abnormally while in the middle of processing messages, non-persistent messages being processed might be lost. Applications must make arrangements for the recovery of non-persistent messages if their recovery is required.

If a put request for a non-persistent message, issued by the IGQ agent, fails unexpectedly, the message being processed is lost.

Delivery of messages

The IGQ agent retrieves and delivers all nonpersistent messages outside of sync point scope, and all persistent messages within sync point scope. In this case, the IGQ agent acts as the sync point coordinator. The IGQ agent therefore processes nonpersistent messages like the way fast, nonpersistent messages are processed on a message channel. See Fast, nonpersistent messages.

Batching of messages

The IGQ agent uses a fixed batch size of 50 messages. Any persistent messages retrieved within a batch are committed at intervals of 50 messages. The agent commits a batch consisting of persistent messages when there are no more messages available for retrieval on the SYSTEM.QSG.TRANSMIT.QUEUE.

Message size

The maximum size of message that can be put to the SYSTEM.QSG.TRANSMIT.QUEUE is the maximum supported message length for shared queues minus the length of a transmission queue header (MQXQH).

Default message persistence and default message priority

If the SYSTEM.QSG.TRANSMIT.QUEUE is in the queue name resolution path established at open time, then for messages that are put with default persistence and default priority (or with default persistence or default priority), the normal rules are applied in the selection of the queue that has default priority and persistence values that are used. (See the IBM MQ messages section for more information about the rules of queue selection).

Related concepts

“Undelivered/unprocessed messages” on page 218
This topic describes what happens to undelivered and unprocessed messages on the SYSTEM.QSG.TRANSMIT.QUEUE.

“Report messages - Intra Group Queuing” on page 219
This topic describes the report messages: Confirmation of arrival, confirmation of delivery, expiry report, and exception report.

z/OS *Undelivered/unprocessed messages*

This topic describes what happens to undelivered and unprocessed messages on the SYSTEM.QSG.TRANSMIT.QUEUE.

If an IGQ agent cannot deliver a message to the destination queue, the IGQ agent:

- Honors the MQRO_DISCARD_MSG report option (if the Report options field of the MQMD for the undelivered message indicates that it must) and discards the undelivered message.

- Attempts to place the undelivered message on to the dead letter queue for the destination queue manager, if the message has not already been discarded. The IGQ agent prefixes the message with a dead letter queue header (MQDLH).

If a dead letter queue is not defined, or if an undelivered message cannot be put to the dead letter queue, and if the undelivered message is:

- persistent, the IGQ agent backs out the current batch of persistent messages that it is processing, and enters a state of retry. For more information, see "Specific properties of intra-group queuing" on page 220.
- non-persistent, the IGQ agent discards the message and continues to process the next message.

If a queue manager in a queue sharing group is terminated before its associated IGQ agent has had time to process all its messages, the unprocessed messages remain on the SYSTEM.QSG.TRANSMIT.QUEUE until the queue manager is next started. The IGQ agent then retrieves and delivers the messages to the destination queues.

If the coupling facility fails before all the messages on the SYSTEM.QSG.TRANSMIT.QUEUE have been processed, any unprocessed non-persistent messages are lost.

IBM recommends that applications do not put messages directly to transmission queues. If an application does put messages directly to the SYSTEM.QSG.TRANSMIT.QUEUE, the IGQ agent might not be able to process these messages and they remain on the SYSTEM.QSG.TRANSMIT.QUEUE. Users then have to use their own methods to deal with these unprocessed messages.

z/OS *Report messages - Intra Group Queuing*

This topic describes the report messages: Confirmation of arrival, confirmation of delivery, expiry report, and exception report.

Confirmation of arrival (COA)/confirmation of delivery (COD) report messages
COA and COD messages are generated by the queue manager, when intra-group queuing is used.

Expiry report messages
Expiry report messages are generated by the queue manager.

Exception report messages

Depending on the MQRO_EXCEPTION_* report option specified in the *Report options* field of the message descriptor for the undelivered message, the IGQ agent generates the required exception report and places it on the specified reply-to queue. Intra-group queuing can be used to deliver the exception report to the destination reply-to queue.

The persistence of the report message is the same as the persistence of the undelivered message. If the IGQ agent fails to resolve the name of the destination reply-to queue, or if it fails to put the reply message to a transmission queue (for subsequent transfer to the destination reply-to queue) it attempts to put the exception report to the dead letter queue of the queue manager on which the report message is generated. If it is not possible, then if the undelivered message is:

- persistent, the IGQ agent discards the exception report, backs out the current batch of messages, and enters a state of retry. For more information, see "Specific properties of intra-group queuing" on page 220.
- non-persistent, the IGQ agent discards the exception report and continues processing the next message on the SYSTEM.QSG.TRANSMIT.QUEUE.

z/OS Security for intra-group queuing

This topic describes the security arrangements for intra-group queuing.

Queue manager attributes IGQAUT (IGQ authority) and IGQUSER (IGQ agent user ID) can be set to control the level of security checking that is performed when the IGQ agent opens destination queues.

Intra-group queuing authority (IGQAUT)

The IGQAUT attribute can be set to indicate the type of security checks to be performed, and hence to determine the userids to be used by the IGQ agent when it establishes the authority to put messages on to the destination queue.

The IGQAUT attribute is analogous to the PUTAUT attribute that is available on channel definitions.

Intra-group queuing user identifier (IGQUSER)

The IGQUSER attribute can be used to nominate a user ID to be used by the IGQ agent when it establishes the authority to put messages on to a destination queue.

The IGQUSER attribute is analogous to the MCAUSER attribute that is available on channel definitions.

z/OS Specific properties of intra-group queuing

This section describes the specific properties of intra-group queuing including Invalidation of object handles, self recovery and retry capability of the intra-group queuing agent, and the intra-group queuing agent and serialization.

Invalidation of object handles (MQRC_OBJECT_CHANGED)

If the attributes of an object are found to have changed after the object is opened, the queue manager invalidates the object handle with MQRC_OBJECT_CHANGED on its next use.

Intra-group queuing introduces the following rules for object handle invalidation:

- If the SYSTEM.QSG.TRANSMIT.QUEUE was included in the name resolution path during open processing because intra-group queuing was ENABLED at open time, but intra-group queuing is found to be DISABLED at put time, then the queue manager invalidates the object handle and fails the put request with MQRC_OBJECT_CHANGED.
- If the SYSTEM.QSG.TRANSMIT.QUEUE was not included in the name resolution path during open processing because intra-group queuing was DISABLED at open time, but intra-group queuing is found to be ENABLED at put time, then the queue manager invalidates the object handle and fails the put request with MQRC_OBJECT_CHANGED.
- If the SYSTEM.QSG.TRANSMIT.QUEUE was included in the name resolution path during open processing because intra-group queuing was enabled at open time, but the SYSTEM.QSG.TRANSMIT.QUEUE definition is found to have changed by put time, then the queue manager invalidates the object handle and fails the put request with MQRC_OBJECT_CHANGED.

Self recovery of the intra-group queuing agent

If the IGQ agent terminates abnormally, message CSQM067E is issued and the IGQ agent starts again.

Retry capability of the intra-group queuing agent

If the IGQ agent encounters a problem accessing the SYSTEM.QSG.TRANSMIT.QUEUE (because it is not defined, for example, or is defined with incorrect attributes, or is inhibited for Gets, or for some other reason), the IGQ agent goes into the state of retry.

The IGQ agent observes short and long retry counts and intervals. The values for these counts and intervals, which cannot be changed, are as follows:

Table 20. Short and long retry counts and intervals values

Constant	Value
Short retry count	10
Short retry interval	60 seconds = 1 min
Long retry count	999,999,999

Table 20. Short and long retry counts and intervals values (continued)	
Constant	**Value**
Long retry interval	1200 seconds = 20 min

The intra-group queuing agent and serialization

An attempt, by the IGQ agent to serialize access to shared queues while peer recovery is still in progress might fail.

If there is a failure of a queue manager in a queue sharing group while the IGQ agent is dealing with uncommitted messages on a shared queue or queues, the IGQ agent ends, and shared queue peer recovery takes place for the failing queue manager. Because shared queue peer recovery is an asynchronous activity, it leaves the possibility for the failing queue manager, and also the IGQ agent for that queue manager, to restart before shared queue peer recovery is complete. Which in turn leaves the possibility for any committed messages to be processed ahead of and out of sequence with the messages still being recovered. To ensure that messages are not processed out of sequence, the IGQ agent serializes access to shared queues by issuing the MQCONNX API call.

An attempt, by the IGQ agent to serialize access to shared queues while peer recovery is still in progress might fail. An error message is issued and the IGQ agent is put into retry state. When queue manager peer recovery is complete, for example at the time of the next retry, the IGQ agent can start.

z/OS Storage management on z/OS

IBM MQ for z/OS requires permanent and temporary data structures and uses page sets and memory buffers to store this data. These topics give more details on how IBM MQ uses these page sets and buffers.

Related concepts

"Page sets for IBM MQ for z/OS" on page 221
Use this topic to understand how IBM MQ for z/OS uses pages sets to store messages.

"Storage classes for IBM MQ for z/OS" on page 222
A storage class is an IBM MQ for z/OS concept that allows the queue manager to map queues to page sets. You can use storage classes to control which data sets are used by which queues.

"Buffers and buffer pools for IBM MQ for z/OS" on page 224
IBM MQ for z/OS uses buffers and buffer pools to temporarily cache data. Use this topic to further understand how buffers are organized, and used.

Related reference

"Where to find more information about storage management for IBM MQ for z/OS" on page 225
Use this topic as a reference to find further information about storage management for IBM MQ for z/OS.

z/OS Page sets for IBM MQ for z/OS

Use this topic to understand how IBM MQ for z/OS uses pages sets to store messages.

A *page set* is a VSAM linear data set that has been specially formatted to be used by IBM MQ. Page sets are used to store most messages and object definitions.

The exceptions to this are global definitions, which are stored in a shared repository on Db2, and the messages on shared queues. These are not stored on the queue manager page sets. For more information about shared queues, see "Shared queues and queue sharing groups" on page 164, and for more information about global definitions, see Private and global definitions.

IBM MQ page sets can be up to 64 GB in size. Each page set is identified by a page set identifier (PSID), an integer in the range 00 through 99. Each queue manager must have its own page sets.

IBM MQ uses page set zero (PSID=00) to store object definitions and other important information relevant to the queue manager. For normal operation of IBM MQ it is essential that page set zero does not become full, so do not use it to store messages.

To improve the performance of your system, you should also separate short-lived messages from long-lived messages by placing them on different page sets.

You must format page sets, and IBM MQ provides a FORMAT utility for this; see Formatting page sets (FORMAT). Page sets must also be defined to the IBM MQ subsystem.

IBM MQ for z/OS can be configured to expand a page set dynamically if it becomes full. IBM MQ continues to expand the page set if required until 123 logical extents exist, if there is sufficient disk storage space available. The extents can span volumes if the linear data set is defined in this way, however, IBM MQ cannot expand the page sets beyond 64 GB.

You cannot use page sets from one IBM MQ queue manager on a different IBM MQ queue manager, or change the queue manager name. If you want to transfer the data from one queue manager to another, you must unload all the objects and messages from the first queue manager and reload them onto another.

It is not possible to use page sets greater than 4 GB in a queue manager running a release earlier than V6. During the migration period, when it is likely that you might need to fall back to a previous release of code:

- Do not change page set 0 to be greater than 4 GB.
- Other page sets greater than 4 GB will be left offline when restarting a queue manager with a previous release.

For further information about migrating existing page sets capable of expanding beyond 4 GB, see Defining a page set to be larger than 4 GB.

It is possible for an administrator to dynamically add page sets to a running queue manager, or remove page sets from a running queue manager (except for page set zero). The DEFINE PSID command can run after the queue manager restart has completed, only if the command contains the DSN keyword.

z/OS Storage classes for IBM MQ for z/OS

A storage class is an IBM MQ for z/OS concept that allows the queue manager to map queues to page sets. You can use storage classes to control which data sets are used by which queues.

Introducing storage classes

A *storage class* maps one or more queues to a page set. This means that messages for that queue are stored on that page set.

Storage classes allow you to control where non-shared message data is stored for administrative, data set space and load management, or application isolation purposes. You can also use storage classes to define the XCF group and member name of an IMS region if you are using the IMS bridge (described in “IBM MQ and IMS” on page 277).

Shared queues do not use storage classes to obtain a page set mapping because the messages on them are not stored on page sets.

How storage classes work

- You define a storage class, using the DEFINE STGCLASS command, specifying a page set identifier (PSID).
- When you define a queue, you specify the storage class in the STGCLASS attribute.

In the following example, the local queue QE5 is mapped to page set 21 through storage class ARC2.

```
DEFINE STGCLASS(ARC2) PSID(21)
DEFINE QLOCAL(QE5) STGCLASS(ARC2)
```

This means that messages that are put on the queue QE5 are stored on page set 21 (if they stay on the queue long enough to be written to DASD).

More than one queue can use the same storage class, and you can define as many storage classes as you like. For example, you can extend the previous example to include more storage class and queue definitions, as follows:

```
DEFINE STGCLASS(ARC1) PSID(05)
DEFINE STGCLASS(ARC2) PSID(21)
DEFINE STGCLASS(MAXI) PSID(05)
DEFINE QLOCAL(QE1) STGCLASS(ARC1) ...
DEFINE QLOCAL(QE2) STGCLASS(ARC1) ...
DEFINE QLOCAL(QE3) STGCLASS(MAXI) ...
DEFINE QLOCAL(QE4) STGCLASS(ARC2) ...
DEFINE QLOCAL(QE5) STGCLASS(ARC2) ...
```

In Figure 71 on page 223, both storage classes ARC1 and MAXI are associated with page set 05. Therefore, the queues QE1, QE2, and QE3 are mapped to page set 05. Similarly, storage class ARC2 associates queues QE4 and QE5 with page set 21.

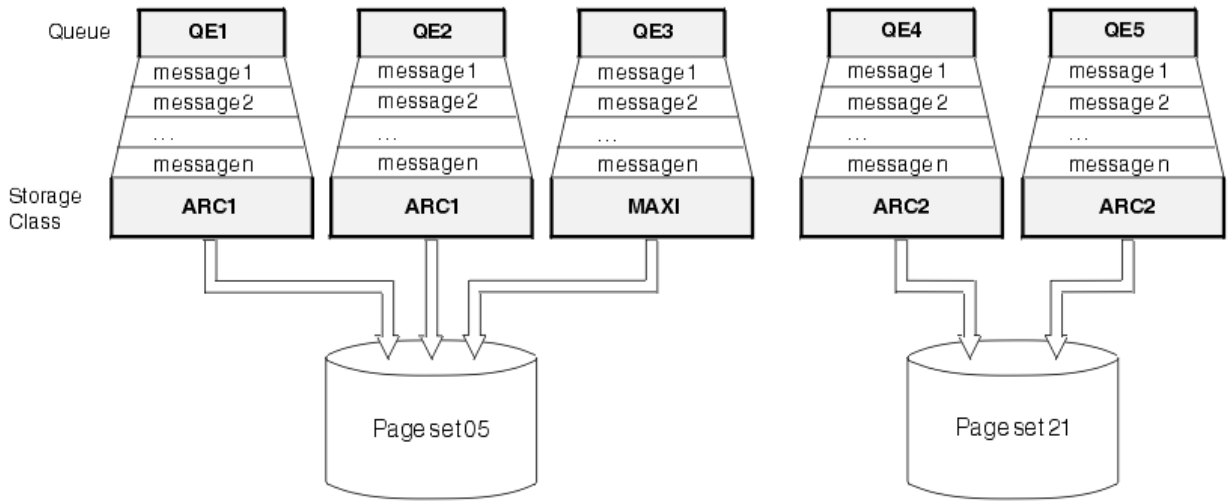


Figure 71. Mapping queues to page sets through storage classes

If you define a queue without specifying a storage class, IBM MQ uses a default storage class.

If a message is put on a queue that names a nonexistent storage class, the application receives an error. You must alter the queue definition to give it an existing storage class name, or create the storage class named by the queue.

You can change a storage class only when:

- All queues that use this storage class are empty, and have no uncommitted activity.
- All queues that use this storage class are closed.

z/OS Buffers and buffer pools for IBM MQ for z/OS

IBM MQ for z/OS uses buffers and buffer pools to temporarily cache data. Use this topic to further understand how buffers are organized, and used.

For efficiency, IBM MQ uses a form of caching whereby messages (and object definitions) are stored temporarily in buffers before being stored in page sets on DASD. Short-lived messages, that is, messages that are retrieved from a queue shortly after they are received, might only ever be stored in the buffers. This caching activity is controlled by a buffer manager, which is a component of IBM MQ.

The buffers are organized into *buffer pools*. You can define up to 100 buffer pools (0 through 99) for each queue manager.

You are recommended to use the minimal number of buffer pools consistent with the object and message type separation outlined in Figure 72 on page 224, and any data isolation requirements your application might have. Each buffer is 4 KB long. Buffer pools use 31 bit storage by default, in this mode, the maximum number of buffers is determined by the amount of 31 bit storage available in the queue manager address space; do not use more than about 70% for buffers. Alternatively, buffer pool storage allocation can be made from 64 bit storage (use the LOCATION attribute of the **DEFINE BUFFPOOL** command). Using LOCATION(ABOVE) so that 64 bit storage is used has two benefits. Firstly, there is much more 64 bit storage available so buffer pools can be much bigger, and secondly, 31 bit storage is made available for use by other functions. Typically, the more buffers you have, the more efficient the buffering and the better the performance of IBM MQ.

Figure 72 on page 224 shows the relationship between messages, buffers, buffer pools, and page sets. A buffer pool is associated with one or more page sets; each page set is associated with a single buffer pool.

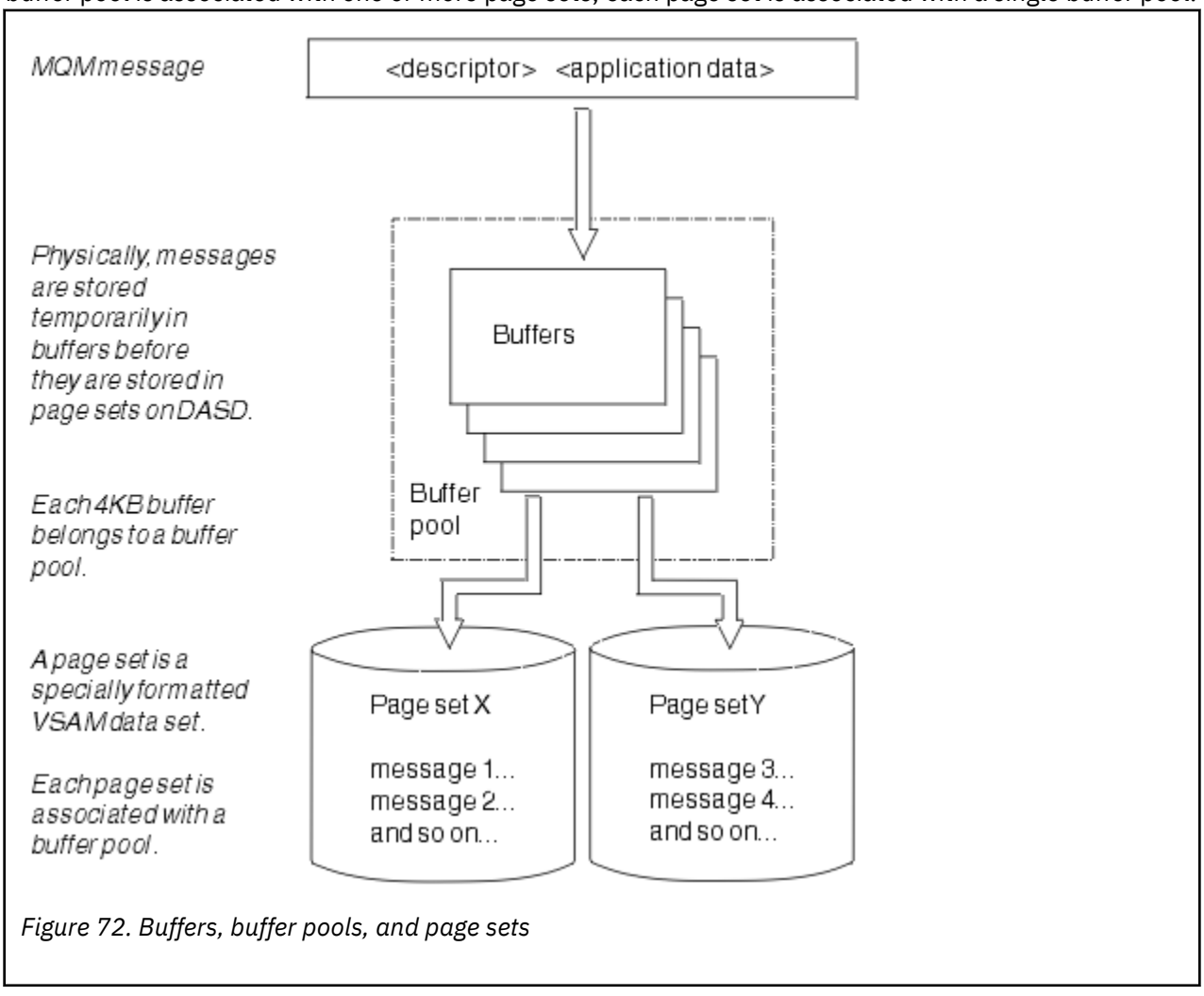


Figure 72. Buffers, buffer pools, and page sets

You can dynamically issue commands to modify buffer pool size, and location, using the **ALTER BUFFPOOL** command. Page sets can be dynamically added by using the **DEFINE PSID** command, or deleted by using the **DELETE PSID** command.

If a buffer pool is too small, IBM MQ issues message CSQP020E. You can then dynamically add more buffers to the affected buffer pool (note that you may have to remove buffers from other buffer pools to do this).

You specify the number of buffers in a pool with the **DEFINE BUFFPOOL** command, and you can dynamically resize buffer pools with the **ALTER BUFFPOOL** command. You determine the current number of buffers in a pool dynamically by displaying a page set that uses the buffer pool, using the **DISPLAY USAGE** command.

For performance reasons, do not put messages and object definitions in the same buffer pool. Use one buffer pool (say number zero) exclusively for page set zero, where the object definitions are kept. Similarly, keep short-lived messages and long-lived messages in different buffer pools and therefore on different page sets, and in different queues.

The **DEFINE BUFFPOOL** command cannot be used after restart to create a new buffer pool. Instead, if a **DEFINE PSID** command uses the DSN keyword, it can explicitly identify a buffer pool that is not currently defined. That new buffer pool will then be created.

z/OS Where to find more information about storage management for IBM MQ for z/OS

Use this topic as a reference to find further information about storage management for IBM MQ for z/OS.

You can find more information about the topics in this section from the following sources:

Table 21. Where to find more information about storage management

Topic	Where to look
How much storage you need	Planning your storage and performance requirements on z/OS
How large to make your page sets and buffer pools	Plan your page sets and buffer pools
Managing page sets	Managing page sets
MQSC commands	The MQSC commands

z/OS Logging in IBM MQ for z/OS

IBM MQ maintains *logs* of data changes and significant events as they occur. These logs can be used to recover data to a previous state if required.

The *bootstrap data set* (BSDS) stores information about the data sets that contain the logs.

The log does not contain information for statistics, traces, or performance evaluation. For further details about the statistical and monitoring information that IBM MQ collects, see Monitoring and statistics.

For more information about logging, see the following topics:

- “Log files in IBM MQ for z/OS” on page 226
- “How the log is structured” on page 230
- “How the IBM MQ for z/OS logs are written” on page 230
- “Larger log Relative Byte Address” on page 233
- “The bootstrap data set” on page 234

Related tasks

Planning your logging environment

Setting logs using the system parameter module

z/OS Administering z/OS

Related reference

z/OS Messages for IBM MQ for z/OS

z/OS Log files in IBM MQ for z/OS

Log files contain information needed for transaction recovery. Active log files can be archived so that you can keep log data for a long period.

What is a log file

IBM MQ records all significant events as they occur in an *active log*. The log contains the information needed to recover:

- Persistent messages
- IBM MQ objects, such as queues
- The IBM MQ queue manager

The active log comprises a collection of data sets (up to 310) which are used cyclically.

You can enable log archiving so that when an active log fills a copy is made in an archive data set. Using archiving allows you to keep log data for an extended period. If you do not use archiving, the logs wrap and earlier data is overwritten. To recover a page set, or recover data in a CF structure, you need log data from when the backup of the page set or structure was taken. An archive log can be created on disk or on tape.

Archiving

Because the active log has a fixed size, IBM MQ copies the contents of each log data set periodically to an *archive log*, which is normally a data set on a direct-access storage device (DASD) or a magnetic tape. If there is a subsystem or transaction failure, IBM MQ uses the active log and, if necessary, the archive log for recovery.

The archive log can contain up to 1000 sequential data sets. You can catalog each data set using the z/OS integrated catalog facility (ICF).

Archiving is an essential component of IBM MQ recovery. If a unit of recovery is a long-running one, log records within that unit of recovery might be found in the archive log. In this case, recovery requires data from the archive log. However, if archiving is disabled, the active log with new log records wraps, overwriting earlier log records. This means that IBM MQ might not be able to back out the unit of recovery and messages might be lost. The queue manager then terminates abnormally.

Therefore, in a production environment, **never switch archiving off**. If you do, you run the risk of losing data after a system or transaction failure. Only if you are running in a test environment can you consider switching archiving off. If you need to do this, use the CSQ6LOGP macro, which is described in Using CSQ6LOGP.

To help prevent problems with unplanned long-running units of work, IBM MQ issues a message (CSQJ160I or CSQJ161I) if a long-running unit of work is detected during active log offload processing.

Dual logging

In dual logging, each log record is written to two different active log data sets to minimize the likelihood of data loss problems during restart.

You can configure IBM MQ to run with either *single logging* or *dual logging*. With single logging, log records are written once to an active log data set. Each active log data set is a single-extent VSAM linear data set (LDS). With dual logging, each log record is written to two different active log data sets. Dual logging minimizes the likelihood of data loss problems during restart.

Log shunting

Log shunting causes the log records for some units of work to be written further down the log. This reduces the amount of log data that must be read at queue manager restart, or backout, for long running or long term in-doubt units of work.

When a unit of work is considered to be long, a representation of each log record is written further down the log. This technique is known as *shunting*. When the whole of the unit of work has been processed, the unit of work is in a *shunted* state. Any backout or restart activity relating to the shunted unit of work can use the shunted log records instead of using the original unit of work log records.

Detecting a long-running unit of work is a function of the checkpoint process. At checkpoint time, each active unit of work is checked to establish whether it needs to be shunted. If the unit of work has been through two prior checkpoints since it was created, or since it was last shunted, the unit of work is suitable to be shunted. This means that a single unit of work might be shunted more than once. This is known as a *multi-shunted* unit of work.

A unit of work is shunted every three checkpoints. However the checkpoint is performed asynchronously to the log-switch (or the writing of the log record which caused LOGLOAD to be exceeded).

There is only a single checkpoint taking place at a time, so there might be multiple log-switches before a checkpoint completes.

This means that if there are not enough active logs, or if they are too small, then shunting of a large unit of work might not complete before all the logs are filled.

Message CSQR027I results if shunting is unable to complete.

If log archiving is turned off, ABEND 5C6 with reason 00D1032A occurs if there is an attempt to back out the unit of work for which shunting failed. To avoid this problem you should use OFFLOAD=YES.

Log shunting is always active, and runs whether log archiving is enabled or not.

Note: Although all log records for a unit of work are shunted, the entire content of each record is not shunted, only the part that is necessary for backout. This means that the amount of log data written is kept to a minimum, and that shunted records cannot be used if a page set failure occurs. A long running unit of work is one that has been running for more than three queue manager checkpoints.

For more information about log shunting, see Managing the logs.

Log compression

You can configure IBM MQ for z/OS to compress and decompress log records as they are written and read from the log data set.

Log compression can be used to reduce the amount of data written to the log for persistent messages on private queues. The amount of compression that is achieved depends on the type of data contained within messages. For example, Run Length Encoding (RLE) works by compacting repeated instances of bytes which can give good results efficiently for structured or record oriented data.

Attention: Persistent messages that are being put to a shared queue are not subject to log compression.

You can use fields within the Log manager section of the System Management Facility 115 (SMF) records to monitor how much data compression is achieved. For more information about SMF, see Using the System Management Facility and Accounting and statistics messages.

Log compression increases the processor utilization of the system. You should only consider using compression if throughput of your queue manager is constrained by the IO bandwidth writing to the

log data sets or you are constrained by the disk storage needed to hold log data sets. If you are using shared queues then IO bandwidth constraints can be relieved by adding additional queue managers to the queue sharing group and distributing the workload across more queue managers.

The log compression option can be enabled and disabled as required without the need to stop and restart the queue manager. The queue manager can read any compressed log records regardless of the current log compression setting.

The queue manager supports 3 settings for log compression.

NONE
No log data compression is used. This is the default value.

RLE
Log data compression is performed using run-length encoding (RLE).

ANY
Enable the queue manager to select the compression algorithm that gives the greatest degree of log record compression. This option results in RLE compression.

You can control the compression of log records using one of the following:

- The SET and DISPLAY LOG commands in MQSC; see SET LOG and DISPLAY LOG
- The Set Log and Inquire Log functions in the PCF interface; see Set log and Inquire log
- The CSQ6LOGP macro in the system parameter module; see Using CSQ6LOGP

In addition the Log Print utility CSQ1LOGP has support for expanding any compressed log records.

Log data

The log can contain up to 18 million million million ($1.8*10^{19}$) bytes. Each byte can be addressed by its offset from the beginning of the log, and that offset is known as its *relative byte address* (RBA).

The RBA is referenced by a 6-byte or 8-byte field giving a total addressable range of 2^{48} bytes, or 2^{64} bytes, depending on whether 6-byte or 8-byte log RBAs are in use.

However, when IBM MQ detects that the used range is beyond F00000000000 (if 6-byte RBAs are in use) or FFFF800000000000 (if 8-byte log RBAs are in use), messages CSQI045, CSQI046, CSQI047, and CSQJ032 are issued, warning you to reset the log RBA.

If the RBA value reaches FFF800000000 (if 6-byte log RBAs are in use) or FFFFFFC000000000 (if 8-byte log RBAs are in use) the queue manager terminates with reason code 00D10257.

Once the warning messages about the used log range are being issued, you should plan a queue manager outage during which the queue manager can be converted to use 8-byte log RBAs, or the log can be reset. The procedure to reset the log is documented in Resetting the queue manager's log.

If your queue manager is using 6-byte log RBAs, consider converting the queue manager to use 8-byte log RBAs rather than resetting the queue manager's log, following the procedure documented in Implementing the larger log Relative Byte Address.

The log consists of *log records*, each of which is a set of log data treated as a single unit. A log record is identified either by the RBA of the first byte of its header, or by its log record sequence number (LRSN). The RBA or LRSN uniquely identifies a record that starts at a particular point in the log.

Whether you use the RBA or LRSN to identify log points depends on whether you are using queue sharing groups. In a queue-sharing environment, you cannot use the relative byte address to uniquely identify a log point, because multiple queue managers can update the same queue at the same time, and each has its own log. To solve this, the log record sequence number is derived from a timestamp value, and does not necessarily represent the physical displacement of the log record within the log.

Each log record has a header that gives its type, the IBM MQ subcomponent that made the record, and, for unit of recovery records, a unit of recovery identifier.

There are four types of log record, described under the following headings:

- Unit of recovery log records
- Checkpoint records
- Page set control records
- CF structure backup records

Unit of recovery log records

Most of the log records describe changes to IBM MQ queues. All such changes are made within units of recovery.

IBM MQ uses special logging techniques involving *undo/redo* and *compensating log records* to reduce restart times and improve system availability.

One effect of this is that the restart time is bounded. If a failure occurs during a restart so that the queue manager has to be restarted a second time, all the recovery activity that completed to the point of failure in the first restart does not need to be reapplied during a second restart. This means that successive restarts do not take progressively longer times to complete.

Checkpoint records

To reduce restart time, IBM MQ takes periodic checkpoints during normal operation. These occur as follows:

- When a predefined number of log records has been written. This number is defined by the checkpoint frequency operand called LOGLOAD of the system parameter macro CSQ6SYSP, described in Using CSQ6SYSP.
- At the end of a successful restart.
- At normal termination.
- Whenever IBM MQ switches to the next active log data set in the cycle.

At the time a checkpoint is taken, IBM MQ issues the DISPLAY CONN command (described in DISPLAY CONN) internally so that a list of connections currently in doubt is written to the z/OS console log.

Page set control records

These records register the page sets and buffer pools known to the IBM MQ queue manager at each checkpoint, and record information about the log ranges required to perform media recovery of the page set at the time of the checkpoint.

Certain dynamic changes to page sets and buffer pools are also written as page set control records, so that the changes can be recovered and automatically reinstated at the next queue manager restart.

CF structure backup records

These records hold data read from a coupling facility list structure in response to a BACKUP CFSTRUCT command. In the unlikely event of a coupling facility structure failure, these records are used, together with unit of recovery records, by the RECOVER CFSTRUCT command to perform media recovery of the coupling facility structure to the point of failure.

Related tasks

Implementing the larger log Relative Byte Address

z/OS How the log is structured

Use this topic to understand the terminology used to describe log records.

Each active log data set must be a VSAM linear data set (LDS). The physical output unit written to the active log data set is a 4 KB control interval (CI). Each CI contains one VSAM record.

Physical and logical log records

One VSAM CI is a *physical* record. The information logged at a particular time forms a *logical* record, with a length that varies independently of the space available in the CI. So one physical record might contain:

- Several logical records
- One or more logical records and part of another logical record
- Part of one logical record only

The term *log record* refers to the *logical* record, regardless of how many *physical* records are needed to store it.

z/OS How the IBM MQ for z/OS logs are written

Use this topic to understand how IBM MQ processes log file records.

IBM MQ writes each log record to a DASD data set called the *active log*. When the active log is full, IBM MQ copies its contents to a DASD or tape data set called the *archive log*. This process is called *offloading*.

Figure 73 on page 231 illustrates the process of logging. Log records typically go through the following cycle:

1. IBM MQ notes changes to data and significant events in recovery log records.
2. IBM MQ processes recovery log records and breaks them into segments, if necessary.
3. Log records are placed sequentially in *output log buffers*, which are formatted as VSAM Controls Intervals (CI). Each log record is identified by a relative byte address in the range zero through $2^{64}-1$.
4. The CIs are written to a set of predefined DASD active log data sets, which are used sequentially and recycled.
5. If archiving is active, as each active log data set becomes full, its contents are automatically offloaded to a new archive log data set.

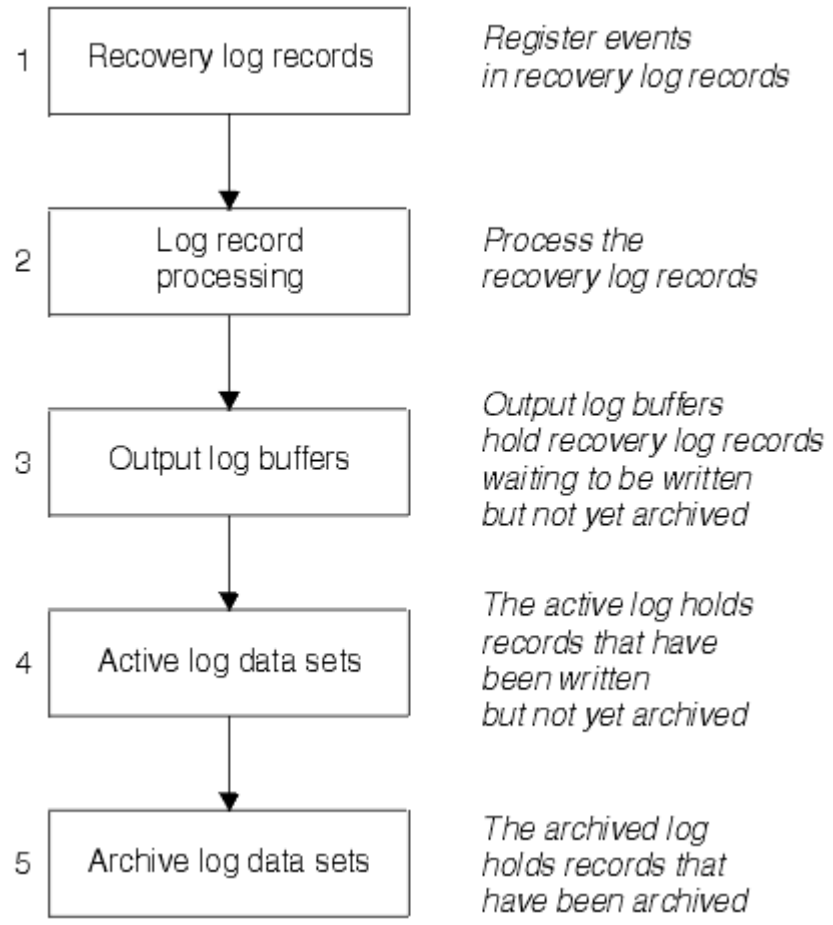


Figure 73. The logging process

When the active log is written

The in-storage log buffers are written to an active log data set whenever any of the following occur:

- The log buffers become full.
- The write threshold is reached (as specified in the CSQ6LOGP macro).
- Certain significant events occur, such as a commit point, or when an IBM MQ BACKUP CFSTRUCT command is issued.

When the queue manager is initialized, the active log data sets named in the BSDS are dynamically allocated for exclusive use by the queue manager and remain allocated exclusively to IBM MQ until the queue manager terminates.

Dynamically adding log data sets

It is possible to dynamically define new active log data sets while the queue manager is running. This feature alleviates the problem of a queue manager hang when archiving is not able to offload active logs due to a transient problem. See the DEFINE LOG command for more information.

Note: To redefine or remove active logs you must terminate and restart the queue manager.

IBM MQ and Storage Management Subsystem

IBM MQ parameters enable you to specify Storage Management Subsystem (MVS™/DFP SMS) storage classes when allocating IBM MQ archive log data sets dynamically. IBM MQ initiates the archiving of log data sets, but you can use SMS to perform allocation of the archive data set.

Related reference

“When the IBM MQ for z/OS archive log is written” on page 232
Use this topic to understand the process of copying active logs to archive logs, and when the process occurs.

z/OS *When the IBM MQ for z/OS archive log is written*

Use this topic to understand the process of copying active logs to archive logs, and when the process occurs.

The process of copying active logs to archive logs is called *offloading*. The relation of offloading to other logging events is shown schematically in Figure 74 on page 232.

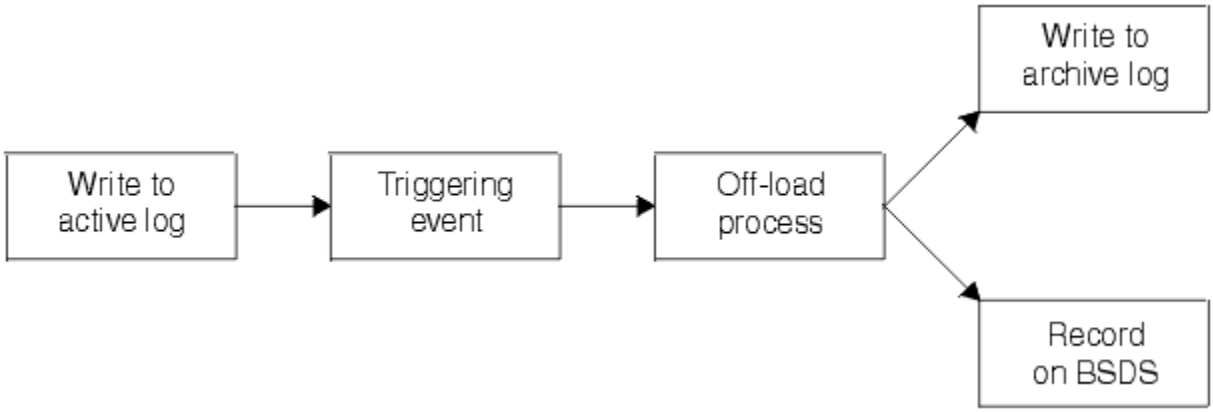


Figure 74. The offloading process

Triggering the offloading process

The offload process of an active log to an archive log can be triggered by several events. For example:

- Filling an active log data set.
- Using the MQSC ARCHIVE LOG command.
- An error occurring while writing to an active log data set.

The data set is truncated before the point of failure, and the record that was not written becomes the first record of the new data set. Offloading is triggered for the truncated data set as for a normal full log data set. If there are dual active logs, both copies are truncated so that the two copies remain synchronized.

Message CSQJ110E is issued when the last available active log is 5% full and at 5% increments thereafter, stating the percentage of the log's capacity that is in use. If all the active logs become full, IBM MQ stops processing, until offloading occurs, and issues this message:

```
CSQJ111A +CSQ1 OUT OF SPACE IN ACTIVE LOG DATA SETS
```

The offload process

When all the active logs become full, IBM MQ runs the offloading process and halts processing until the offloading process has been completed. If the offload processing fails when the active logs are full, IBM MQ abends.

When an active log is ready to be offloaded, a request is sent to the z/OS console operator to mount a tape or prepare a DASD unit. The value of the ARCWTOR logging option (for further information, see Using CSQ6ARVP) determines whether the request is received. If you are using tape for offloading, specify ARCWTOR=YES. If the value is YES, the request is preceded by a WTOR (message number CSQJ008E) telling the operator to prepare an archive log data set to be allocated.

The operator need not respond to this message immediately. However, delaying the response delays the offload process. It does not affect IBM MQ performance unless the operator delays the response for so long that IBM MQ runs out of active logs.

The operator can respond by canceling the offload process. In this case, if the allocation is for the first copy of dual archive data sets, the offload process is merely delayed until the next active log data set becomes full. If the allocation is for the second copy, the archive process switches to single copy mode, but for this data set only.

Interruptions and errors while offloading

A request to stop the queue manager does not take effect until offload processing has finished. If IBM MQ fails while offloading is in progress, offloading begins again when the queue manager is restarted.

Messages during offload processing

Offloaded messages are sent to the z/OS console by IBM MQ and the offloading process. You can use these messages to find the RBA ranges in the various log data sets.

z/OS Larger log Relative Byte Address

This function improves the availability of the queue manager by increasing the period of time before you have to reset the log.

Recovery data is written to the log so that persistent messages are available when the queue manager is restarted. The term log Relative Byte Address (log RBA) is used to refer to the location of data as an offset from the beginning of the log.

Before IBM MQ 8.0, the 6 byte log RBA could address up to 256 terabytes of data. Before this quantity of log records has been written, you have to reset the queue manager's log by following the procedure documented in Resetting the queue manager's log.

Resetting the logs of queue managers is not a quick process, and can require an extended outage, due to the need to reset the page sets as part of the process. For a high use queue manager this operation might typically be done once a year.

From IBM MQ 8.0, the log RBA can be 8 bytes long and the queue manager can now address over 64,000 times as much data (16 exabytes) before the log RBA needs to be reset. The impact of using the larger log RBA is that the size of the log data written increases by a few bytes.

When is this function enabled?

Queue managers created at IBM MQ 9.3.0 or later already have this function enabled.

If the current log RBA is approaching the end of the log RBA range, consider converting the queue manager to use an 8 byte log RBA rather than resetting the queue manager's log. Converting a queue manager to use 8 byte log RBAs requires a shorter outage than resetting the log, and significantly increases the period of time before you have to reset the log.

Message CSQJ034I, issued during queue manager initialization, indicates the end of the log RBA range for the queue manager as configured, and can be used to determine whether 6 byte or 8 byte log RBAs are in use.

How is this function enabled?

8 byte log RBA is enabled by starting the queue manager with a version 2 format BSDS. In summary, this is achieved by:

1. Ensuring that all queue managers in the queue sharing group meet the requirements for enabling 8 byte log RBA
2. Shutting down the queue manager cleanly
3. Running the BSDS conversion utility to create a copy of the BSDS in version 2 format.
4. Restarting the queue manager with the converted BSDS.

Once a queue manager has been converted to use 8 byte log RBAs, it cannot go back to using 6 byte log RBA.

See Implementing the larger log Relative Byte Address for the detailed procedure on how to enable 8 byte log RBAs.

Related tasks

Planning to increase the maximum addressable log range

Related reference

The BSDS conversion utility (CSQJUCNV)

z/OS The bootstrap data set

The bootstrap data set is required by IBM MQ as a mechanism to reference log data sets, and log records. This information is required during normal processing, and restart recovery.

What the bootstrap data set is for

The *bootstrap data set* (BSDS) is a VSAM key-sequenced data set (KSDS) that holds information needed by IBM MQ. It contains the following:

- An inventory of all active and archived log data sets known to IBM MQ. IBM MQ uses this inventory to:
  - Track the active and archived log data sets
  - Locate log records so that it can satisfy log read requests during normal processing
  - Locate log records so that it can handle restart processing

  IBM MQ stores information in the inventory each time an archive log data set is defined or an active log data set is reused. For active logs, the inventory shows which are full and which are available for reuse. The inventory holds the relative byte address (RBA) of each portion of the log held in that data set.
- A *wrap-around* inventory of all recent IBM MQ activity. This is needed if you have to restart the queue manager.

The BSDS is required if the queue manager has an error and you have to restart it. IBM MQ **must** have a BSDS. To minimize the likelihood of problems during a restart, you can configure IBM MQ with dual BSDSs, each recording the same information. Using dual BSDSs is known as running in *dual mode*. If possible, place the copies on separate volumes. This reduces the risk of them both being lost if the volume is corrupted or destroyed. Use dual BSDSs rather than dual write to DASD.

The BSDS is set up when IBM MQ is customized and you can manage the inventory using the change log inventory utility (CSQJU003). For more information about this utility, see Administering IBM MQ for z/OS. It is referenced by a DD statement in the queue manager startup procedure.

Normally, IBM MQ keeps duplicate copies of the BSDS. If an I/O error occurs, it deallocates the failing copy and continues with a single BSDS. You can restore dual-mode operation, this is described in the Administering IBM MQ for z/OS.

The active logs are first registered in the BSDS when IBM MQ is installed. You cannot replace the active logs without terminating and restarting the queue manager.

Archive log data sets are allocated dynamically. When one is allocated, the data set name is registered in the BSDS. The list of archive log data sets expands as archives are added, and wraps when a user-determined number of entries has been reached. The maximum number of entries is 1000 for single archive logging and 2000 for dual logging.

You can use a tape management system to delete the archive log data sets (IBM MQ does not have an automated method). Therefore, the information about an archive log data set can be in the BSDS long after the archive log data set has been deleted by the system administrator.

Conversely, the maximum number of archive log data sets could have been exceeded, and the data from the BSDS dropped long before the data set has reached its expiry date.

You can use the following MQSC command to determine the extent of the log, and the name of the active or archive log data set holding the earliest log RBA, required for various types of media or queue manager recovery:

```
DISPLAY USAGE TYPE(DATASET)
```

If the system parameter module specifies that archive log data sets are cataloged when allocated, the BSDS points to the integrated catalog facility (ICF) catalog for the information needed for later allocations. Otherwise, the BSDS entries for each volume register the volume serial number and unit information that is needed for later allocations.

The BSDS version

The format of the BSDS varies according to its version. Increasing the version of the BSDS allows new features to be used. The following BSDS versions are supported by IBM MQ:

Version 1
Supported by all releases of IBM MQ. A version 1 BSDS supports 6-byte log RBA values.

Version 2
Supported by IBM MQ 8.0 and later. A version 2 BSDS enables 8-byte log RBA values, and up to 310 data sets in each active log copy.

Enabled by default for queue managers created at IBM MQ 9.3.0 or later.

Version 3
Supported by IBM MQ 8.0 and later. The BSDS is automatically converted to version 3, from version 2, when more than 31 data sets are added to either active log copy.

You can determine the version of a BSDS by running the print log map utility (CSQJU004). To convert a BSDS from Version 1 to Version 2, run the BSDS conversion utility (CSQJUCNV).

See “Larger log Relative Byte Address” on page 233 for more information on 6-byte and 8-byte log RBAs.

Archive log data sets and BSDS copies

Each time a new archive log data set is created, a copy of the BSDS is also created. If the archive log is on tape, the BSDS is the first data set on the first output volume. If the archive log is on DASD, the BSDS is a separate data set.

The data set names of the archive log and the BSDS copy are the same, except that the lowest-level qualifier of the archive log name begins with A and the BSDS copy begins with B, for example:

Archive log name
CSQ.ARCHLOG1.E00186.T2336229. *A* 0000001

BSDS copy name
CSQ.ARCHLOG1.E00186.T2336229. *B* 0000001

If there is a read error while copying the BSDS, the copy is not created, message CSQJ125E is issued, and the offloading to the new archive log data set continues without the BSDS copy.

z/OS System definition on z/OS

IBM MQ for z/OS uses many default object definitions, and provides sample JCL to create those default objects. Use this topic to understand these default objects, and the sample JCL.

Setting system parameters

In IBM MQ for z/OS, a system parameter module controls the logging, archiving, tracing, and connection environments that IBM MQ uses in its operation. The system parameters are specified by three assembler macros, as follows:

CSQ6SYSP
System parameters, including setting the connection and tracing environment.

CSQ6LOGP
Logging parameters.

CSQ6ARVP
Log archive parameters.

Default parameter modules are supplied with IBM MQ for z/OS. If these do not contain the values that you want to use, you can create your own parameter modules using the sample supplied with IBM MQ. The sample is `thlqual.SCSQPROC(CSQ4ZPRM)`.

You can alter some system parameters while a queue manager is running. See the SET SYSTEM, SET LOG, and SET ARCHIVE commands in The MQSC commands.

For more information about defining , see the following topics:

- “Defining system objects for IBM MQ for z/OS” on page 236
- “Tuning your queue manager on IBM MQ for z/OS” on page 241
- “Sample definitions supplied with IBM MQ for z/OS” on page 242

Related concepts
Customize the sample initialization input data sets
Sources from which you can issue MQSC and PCF commands on IBM MQ for z/OS
Related tasks
Administering z/OS
Configuring clusters
Monitoring IBM MQ

z/OS Defining system objects for IBM MQ for z/OS

IBM MQ for z/OS requires additional predefined objects for publish/subscribe applications, cluster, and channel control and other system administration functions.

The system objects required by IBM MQ for z/OS can be divided into the following categories:

- Publish/subscribe objects
- System default objects
- System command objects
- System administration objects
- Channels queues
- Cluster queues

- Queue sharing group queues
- Storage classes
- Defining the system object dead-letter queue
- Default transmission queue
- Internal queues
- “Channel authentication queue” on page 240

Publish/subscribe objects

There are several system objects that you need to define before you can use publish/subscribe applications with IBM MQ for z/OS. Sample definitions are supplied with IBM MQ to help you define these objects. These samples are described in CSQ4INSG.

To use publish/subscribe you need to define the following objects:

- A local queue called SYSTEM.RETAINED.PUB.QUEUE, which is used to hold a copy of each retained publication in the queue manager. Each full topic name could have up to one retained publication stored on this queue. If your applications will make use of retained publications on many different topics, or if your retained publication messages are large messages, the requirements for storage for this queue should be carefully planned, including assigning it to its own page set if the storage requirements for it are large. To improve performance, you should define this queue with an index type of MSGID (as shown in the supplied sample queue definition).
- A local queue called SYSTEM.DURABLE.SUBSCRIBER.QUEUE, which is used to hold a persistent copy of the durable subscriptions in the queue manager. To improve performance, you should define this queue with an index type of CORRELID (as shown in the supplied sample queue definition).
- A local queue called SYSTEM.DURABLE.MODEL.QUEUE, which is used as a model for managed durable subscriptions.
- A local queue called SYSTEM.NDURABLE.MODEL.QUEUE, which is used as a model for managed non-durable subscriptions.
- A namelist called SYSTEM.QPUBSUB.QUEUE.NAMELIST, which contains a list of queue names monitored by the queued publish/subscribe interface.
- A namelist called SYSTEM.QPUBSUB.SUBPOINT.NAMELIST, which contains a list of topic objects used by the queued publish/subscribe interface to match topic objects to subscription points.
- A topic called SYSTEM.BASE.TOPIC, which is used as a base topic for resolving attributes.
- A topic called SYSTEM.BROKER.DEFAULT.STREAM, which is the default stream used by the queued publish/subscribe interface.
- A topic called SYSTEM.BROKER.DEFAULT.SUBPOINT, which is the default RFH2 subscription point used by the queued publish/subscribe interface.
- A topic called SYSTEM.BROKER.ADMIN.STREAM, which is the admin stream used by the queued publish/subscribe interface.
- A subscription called SYSTEM.DEFAULT.SUB, which is a default subscription object used to provide default values on DEFINE SUB commands.

System default objects

System default objects are used to provide default attributes when you define an object and do not specify the name of another object to base the definition on.

The names of the default system object definitions begin with the characters "SYSTEM.DEFAULT" or "SYSTEM.DEF." For example, the system default local queue is named SYSTEM.DEFAULT.LOCAL.QUEUE.

These objects define the system defaults for the attributes of these IBM MQ objects:

- Local queues

- Model queues
- Alias queues
- Remote queues
- Processes
- Namelists
- Channels
- Storage classes
- Authentication information

Shared queues are a special type of local queue, so when you define a shared queue, the definition is based on the SYSTEM.DEFAULT.LOCAL.QUEUE. You need to remember to supply a value for the Coupling Facility structure name because one is not specified in the default definition. Alternatively, you could define your own default shared queue definition to use as a basis for shared queues so that they all inherit the required attributes. Remember that you need to define a shared queue on one queue manager in the queue sharing group only.

System command objects

The names of the system command objects begin with the characters SYSTEM.COMMAND. You must define these objects before you can use the IBM MQ operations and control panels to issue commands to an IBM MQ subsystem.

There are two system command objects:

1. The system-command input queue is a local queue on which commands are put before they are processed by the IBM MQ command processor. It must be called SYSTEM.COMMAND.INPUT. An alias named SYSTEM.ADMIN.COMMAND.QUEUE should also be defined, for compatibility with IBM MQ for Multiplatforms, and for use by the IBM MQ Console and administrative REST API.
2. SYSTEM.COMMAND.REPLY.MODEL is a model queue that defines the system-command reply-to queue.

There are two extra objects for use by the IBM MQ Explorer:

- SYSTEM.MQEXPLORER.REPLY.MODEL queue
- SYSTEM.ADMIN.SVRCONN channel

SYSTEM.REST.REPLY.QUEUE is the reply queue used by the IBM MQ administrative REST API.

Commands are normally sent using nonpersistent messages so both the system command objects should have the DEFPSIST(NO) attribute so that applications using them (including the supplied applications like the utility program and the operations and control panels) get nonpersistent messages by default. If you have an application that uses persistent messages for commands, set the DEFTYPE(PERMDYN) attribute for the reply-to queue, because the reply messages to such commands are persistent.

System administration objects

The names of the system administration objects begin with the characters SYSTEM.ADMIN.

There are seven system administration objects:

- The SYSTEM.ADMIN.CHANNEL.EVENT queue
- The SYSTEM.ADMIN.COMMAND.EVENT queue
- The SYSTEM.ADMIN.CONFIG.EVENT queue
- The SYSTEM.ADMIN.PERFM.EVENT queue
- The SYSTEM.ADMIN.QMGR.EVENT queue

- The SYSTEM.ADMIN.TRACE.ROUTE.QUEUE queue
- The SYSTEM.ADMIN.ACTIVITY.QUEUE queue

Channels queues

To use distributed queuing, you need to define the following objects:

- A local queue with the name SYSTEM.CHANNEL.SYNCQ, which is used to maintain sequence numbers and logical units of work identifiers (LUWID) of channels. To improve channel performance, you should define this queue with an index type of MSGID (as shown in the supplied sample queue definition).
- A local queue with the name SYSTEM.CHANNEL.INITQ, which is used for channel commands.

You cannot define these queues as shared queues.

Cluster queues

To use IBM MQ clusters, you need to define the following objects:

- A local queue called the SYSTEM.CLUSTER.COMMAND.QUEUE, which is used to communicate repository changes between queue managers. Messages written to this queue contain updates to the repository data to be applied to the local copy of the repository, or requests for repository data.
- A local queue called SYSTEM.CLUSTER.REPOSITORY.QUEUE, which is used to hold a persistent copy of the repository.
- A local queue called SYSTEM.CLUSTER.TRANSMIT.QUEUE, which is the transmission queue for all destinations in the cluster. For performance reasons, you should define this queue with an index type of CORRELID (as shown in the sample queue definition).

These queues typically contain large numbers of messages.

You cannot define these queues as shared queues.

Queue sharing group queues

To use shared channels and intra-group queuing, you need to define the following objects:

- A shared queue with the name SYSTEM.QSG.CHANNEL.SYNCQ, which is used to hold synchronization information for shared channels.
- A shared queue with the name SYSTEM.QSG.TRANSMIT.QUEUE, which is used as the transmission queue for intra-group queuing. If you are running in a queue sharing group, you must define this queue, even if you are not using intra-group queuing.

Storage classes

You are recommended to define the following six storage classes. You must define four of them because they are required by IBM MQ. The other storage class definitions are recommended because they are used in the sample queue definitions.

DEFAULT (required)
This storage class is used for all message queues that are not performance critical and that don't fit in to any of the other storage classes. It is also the supplied default storage class if you do not specify one when defining a queue.

NODEFINE (required)
This storage class is used if the storage class specified when you define a queue is not defined.

REMOTE (required)
This storage class is used primarily for transmission queues, that is, system related queues with short-lived performance-critical messages.

SYSLNGLV
This storage class is used for long-lived, performance-critical messages.

SYSTEM (required)
This storage class is used for performance critical, system related message queues, for example the SYSTEM.CHANNEL.SYNQ and the SYSTEM.CLUSTER.* queues.

SYSVOLAT
This storage class is used for short-lived, performance-critical messages.

You can modify their attributes and add other storage class definitions as required.

Defining the system object dead-letter queue

The dead-letter queue is used if the message destination is not valid. IBM MQ puts such messages on a local queue called the dead-letter queue. Although having a dead-letter queue is not mandatory, you should regard it as essential, especially if you are using distributed queuing or one of the IBM MQ bridges.

Do **not** define the dead-letter queue as a shared queue. A put to a local queue on one queue manager might get put to the dead letter queue. If the dead letter queue was a shared queue, a dead letter queue handler on a different system could process the message and put it on a queue with the same name, but because this is on a different queue manager, it would be the wrong queue, or have a different security profile. If the queue did not exist, it would fail to reprocess it.

If you decide to define a dead-letter queue, you must also tell the queue manager its name. To do this use the ALTER QMGR DEADQ(*queue-name*) command. For more information see Displaying and altering queue manager attributes.

Default transmission queue

The default transmission queue is used when no other suitable transmission queue is available for sending messages to another queue manager. If you define a default transmission queue, you must also define a channel to serve the queue. If you do not do this, messages that are put on to the default transmission queue are not transmitted to the remote queue manager and remain on the queue.

If you decide to define a default transmission queue, you must also tell the queue manager its name. To do this use the ALTER QMGR command.

Internal queues

- **Pending data queue**
  - A queue defined for internal use, SYSTEM.PENDING.DATA.QUEUE, supports the use of durable subscriptions in a JMS publish/subscribe environment.
- **JMS 2.0 delivery delay staging queue**
  - If the delivery delay functionality provided by JMS 2.0 is used then an internal staging queue, SYSTEM.DDELAY.LOCAL.QUEUE, must be defined. This queue is used by the queue manager to temporarily store messages sent with a non-zero delivery delay until the delivery delay is completed, and the message is put to its target destination. A sample definition for this queue is provided, commented out, in CSQ4INSG.
  - When you define the SYSTEM.DDELAY.LOCAL.QUEUE queue, you must set the STGCLASS, MAXMSGL and MAXDEPTH attributes for the anticipated number of messages that will be sent with a delivery delay. Additionally when defining the SYSTEM.DDELAY.LOCAL.QUEUE queue ensure that only the queue manager can put messages to this queue. Care should be taken to ensure that no user identifier has the authority to put messages to this queue.

Channel authentication queue

For internal use of channel authentication the SYSTEM.CHLAUTH.DATA.QUEUE queue is required. Sample definitions are supplied with IBM MQ to help you define these objects. This sample is described in CSQ4INSA, which also defines some default rules.

z/OS Tuning your queue manager on IBM MQ for z/OS

There are few simple steps that you can take to ensure that your queue manager is tuned to avoid basic performance problems.

There are a number of ways in which you can improve the performance of your queue manager, which are controlled by queue manager attributes set by the ALTER QMGR command. This section contains information about how you can do this by setting the maximum number of messages allowed on the queue manager, or by performing 'housekeeping' on the queue manager. IBM MQ SupportPac MP16 - IBM MQ for z/OS Capacity planning & tuning gives more information on performance and tuning.

Syncpoints

One of the roles of the queue manager is syncpoint control within an application. An application constructs a unit of work containing any number of MQPUT or MQGET calls terminated with an MQCMIT call.

As the number of MQPUT or MQGET calls within the scope of one MQCMIT increases, the performance cost of the commit increases significantly. Applications, in general, should be designed to not MQPUT/MQGET a large number of messages in a single synchpoint.

You can administratively limit the number of messages within any single syncpoint by using the MAXUMSGS queue manager attribute. If an application exceeds this limit it receives MQRC_SYNCPOINT_LIMIT_REACHED on the MQPUT,MQPUT1, or MQGET call which exceeds the limit. The application should then issue MQCMIT or MQBACK as appropriate.

The default value of MAXUMSGS is 10000. This value can be lowered if you want to enforce a lower limit, which can also help protect against looping applications. Before reducing MAXUMSGS make sure you understand your existing applications to ensure they do not exceed the limit, or can tolerate the MQRC_SYNCPOINT_LIMIT_REACHED return code

Expired messages

Messages that have expired are discarded by the next appropriate MQGET call. However, if no such call occurs, the expired messages are not discarded, and, for some queues, particularly those where message retrieval is done by MessageId, CorrelId, or GroupId and the queue is indexed for performance, many expired messages can accumulate. The queue manager can periodically scan any queue for expired messages, which are then deleted. You can choose how often this scanning takes place, if at all. There are two ways of doing this:

Explicit request
: You can control which queues are scanned and when. Issue the REFRESH QMGR TYPE(EXPIRY) command, specifying the queue or queues that you want to be scanned.

Periodic scan
: You can specify an expiry interval in the queue manager object by using the EXPRYINT attribute. The queue manager maintains information about the expired messages on each queue, and knows at what time a scan for expired messages is worthwhile. Each time that the EXPRYINT interval is reached, the queue manager looks for candidate queues that are worth scanning for expired messages, and scans only those queues that it deems to be worthwhile. It does not scan all queues. This avoids any processor time being wasted on unnecessary scans.

  Shared queues are only scanned by one queue manager in the queue sharing group. Generally, the first queue manager to restart or the first to have the EXPRYINT set performs the scan.

Note: You must set the same EXPRYINT value for all queue managers within a queue sharing group.

z/OS Sample definitions supplied with IBM MQ for z/OS

Use this topic as a reference for the sample JCL, and code supplied with IBM MQ for z/OS.

The following sample definitions are supplied with IBM MQ in the thlqual.SCSQPROC library. You can use them to define the system objects and to customize your own objects. You can include some of them in the initialization input data sets (described in Initialization commands).

Table 22. IBM MQ sample definitions for system objects

Initialization input data set	Sample name
CSQINP1	CSQ4INP1 CSQ4INPR
CSQINP2	CSQ4INSA CSQ4INYS [1] CSQ4INSX CSQ4INSG CSQ4INSR CSQ4INSS CSQ4INSJ CSQ4INSM CSQ4INYG CSQ4INYR CSQ4INYC CSQ4INYD CSQ4INSC
CSQINPT	CSQ4INST CSQ4INYT
Other	CSQ4DISP CSQ4INPX CSQ4IVPQ CSQ4IVPG CSQ4MSTR CSQ4MSRR CSQ4QMIN

Note:

1. The order of these sample definitions is important: an error occurs if INYS, INSX, and INSG are ordered incorrectly.

CSQINP1 samples

Use the sample CSQINP1 data set thlqual.SCSQPROC(CSQ4INP1) when you are using one page set for each class of message, or thlqual.SCSQPROC(CSQ4INPR) when using multiple page sets for the major classes of message. It contains definitions of buffer pools, page set to buffer pool associations, and an ALTER SECURITY command. Include the sample in the CSQINP1 concatenation of your queue manager started task procedure.

CSQINP2 samples

CSQ4INSG system object sample

The sample CSQINP2 data set thlqual.SCSQPROC(CSQ4INSG) contains definitions for the following system objects for general use:

- System default objects
- System command objects
- System administration objects
- Other objects for system use

You must define the objects in this sample, but you need to do it only once when the subsystem is first started. Including the definitions in the CSQINP2 data set is the best way to do this. They are maintained across queue manager shutdown and restart. You must not change the object names, but you can change their attributes if required.

When the following conditions are met, one message is put to the SYSTEM.DURABLE.SUBSCRIBER.QUEUE queue (even if publish subscribe is not active):

- The QMGR attribute PSMODE is set to DISABLED
- The sample object CSQ4INST statement `DEFINE SUB('SYSTEM.DEFAULT.SUB')` is present.

To avoid this, delete or comment out the `DEFINE SUB('SYSTEM.DEFAULT.SUB')` statement.

The JMS 2.0 delivery delay staging queue, SYSTEM.DDELAY.LOCAL.QUEUE only need be defined if JMS 2.0 delivery delay is used. By default, the queue definition is commented out, which you can uncomment if required.

CSQ4INSA system object and authentication sample

The sample CSQINP2 data set thlqual.SCSQPROC(CSQ4INSA) contains the channel authentication system queue definition. This queue holds the channel authentication records. It also contains the default channel authentication rules.

You must define the objects in this sample if CHLAUTH is ENABLED on the queue manager and you want to run channels, or you want to SET or DISPLAY CHLAUTH record. You only need to define them once when the subsystem is first started. Including the definitions in the CSQINP2 data set is the best way to do this. They are maintained across a queue manager shutdown and restart, you must not change the queue name.

CSQ4INSS system object sample

You can define additional system objects if you are using queue sharing groups.

Sample data set thlqual.SCSQPROC(CSQ4INSS) contains sample commands for use with CF structures and a set of definitions for the system objects required for shared channels and intra-group queuing.

You cannot use this sample as is; you must customize it before use. Then you can include this member in the CSQINP2 DD concatenation of the queue manager startup procedure, or you can use it as input to the COMMAND function of the CSQUTIL utility to issue the required commands.

When you are defining group or shared objects, you need to include them in the CSQINP2 DD concatenation for only one queue manager in the queue sharing group.

CSQ4INSX system object sample

You must define additional system objects if you are using distributed queuing and clustering.

Sample data set thlqual.SCSQPROC(CSQ4INSX) contains the queue definitions required. You can include this member in the CSQINP2 DD concatenation of the queue manager startup procedure, or

you can use it as input to the COMMAND function in CSQUTIL utility to issue the required DEFINE commands.

There are two types of object definitions:

- SYSTEM.CHANNEL.xx, needed for any distributed queuing
- SYSTEM.CLUSTER.xx, needed for clustering

CSQ4INSJ system JMS object sample

Defines queues used in the JMS publish/subscribe domain.

CSQ4INSM system object sample

If you are using advanced message security you must define additional system objects. Sample data set thlqual.SCSQPROC(CSQ4INSM) contains the queue definitions required.

CSQ4INSR object sample

Defines queues used by WebSphere Application Server and brokers.

CSQ4INYD object sample

If you are using distributed queuing and you need to set up your own queues, processes, and channels.

Sample data set thlqual.SCSQPROC(CSQ4INYD) contains sample definitions that you can use for customizing your distributed queuing objects. It comprises:

- A set of definitions for the sending end
- A set of definitions for the receiving end
- A set of definitions for using clients

You cannot use this sample as is - you must customize it before use. Then you can include this member in the CSQINP2 DD concatenation of the queue manager startup procedure, or you can use it as input to the COMMAND function of the CSQUTIL utility to issue the required DEFINE commands. (This is preferable because it means that you don't have to redefine these objects each time you restart the queue manager).

CSQ4INYC object sample

If you are using clustering, definitions equivalent to the channel definitions and remote queue definitions of distributed queuing are created automatically, when needed. However, some manual channel definitions are needed - a cluster-receiver channel for the cluster and a cluster-sender definition to at least one cluster repository queue manager.

The sample data set: thlqual.SCSQPROC(CSQ4INYC) contains the following sample definitions that you can use for customizing your clustering objects:

- Definitions for the queue manager
- Definitions for the receiving channel
- Definitions for the sending channel
- Definitions for cluster queues
- Definitions for lists of clusters

You cannot use this sample as is - you must customize it before use. Then you can include this member in the CSQINP2 DD concatenation of the queue manager startup procedure, or you can use it as input to the COMMAND function of the CSQUTIL utility to issue the required DEFINE commands. This is preferable because it means that you don't have to redefine these objects each time that you restart IBM MQ.

CSQ4INYG object sample

The sample data set: thlqual.SCSQPROC(CSQ4INYG) contains the following sample definitions that you can use for customizing your own objects for general use:

- Dead-letter queue
- Default transmission queue
- CICS adapter objects

You cannot use this sample as is - you must customize it before use. Then you can include this member in the CSQINP2 DD concatenation of the queue manager startup procedure, or you can use it as input to the COMMAND function of the CSQUTIL utility to issue the required DEFINE commands. This is preferable because it means that you don't have to redefine these objects each time that you restart IBM MQ.

In addition to the sample definitions here, you can use the system object definitions as the basis for your own resource definitions. For example, you can make a working copy of SYSTEM.DEFAULT.LOCAL.QUEUE and name it MY.DEFAULT.LOCAL.QUEUE. You can then change any of the parameters in this copy as required. You could then issue a DEFINE command by whichever method you choose, provided you have the authority to create resources of that type.

Default transmission queue
Read the Default transmission queue description before you decide whether you want to define a default transmission queue.

- If you decide that you do want to define a default transmission queue, remember that you must also define a channel to serve it.
- If you decide that you do not want to define one, remember to remove the DEFXMITQ statement from the ALTER QMGR command in the sample.

CICS adapter objects
The sample defines an initiation queue named CICS01.INITQ. This queue is used by the IBM MQ -supplied CKTI transaction. You can change the name of this queue; however it must match the name specified in the CICS system initialization table (SIT) or SYSIN override in the INITPARM statement.

CSQ4INYS/CSQ4INYR object samples

Storage class definitions for using:

- one page set for each class of message
- multiple page sets for major classes of message

For example, SYSTEM.COMMAND.INPUT uses STGCLASS('SYSVOLAT'), and SYSTEM.CLUSTER.TRANSMIT.QUEUE uses STGCLASS('REMOTE'). In CSQ4INYS, both of those storage classes use the same page set. In CSQ4INYR, those storage classes use different page sets in order to lessen the impact of the transmission queue filling.

CSQINPT samples

CSQ4INST
The sample data set: thlqual.SCSQPROC(CSQ4INST) contains the definition for the system default subscription.

You must define the object in this sample, but you need to do it only once when the publish/subscribe engine is first started. Including the definition in the CSQINPT data set is the best way to do this. It is maintained across queue manager shutdown and restart. You must not change the object name, but you can change their attributes if required.

CSQ4INYT
The sample data set: thlqual.SCSQPROC(CSQ4INYT) contains a set of commands that you might want to run when the publish/subscribe engine is started. This sample displays Topic and Subscription information.

Other

CSQ4DISP display sample

The sample data set: thlqual.SCSQPROC(CSQ4DISP) contains a set of generic DISPLAY commands that display all the defined resources on your queue manager. This includes the definitions for all IBM MQ objects and definitions such as storage classes and trace. These commands can generate a large amount of output. You can use this sample in the CSQINP2 data set or as input to the COMMAND function of the CSQUTIL utility.

CSQ4INPX sample

The sample data set: thlqual.SCSQPROC(CSQ4INPX) contains a set of commands that you might want to execute each time the channel initiator starts. You must customize this sample before use; you can then include it in the CSQINPX data set for the channel initiator.

CSQ4IVPQ and CSQ4IVPG samples

The sample data sets: thlqual.SCSQPROC(CSQ4IVPQ) and thlqual.SCSQPROC(CSQ4IVPG) contain sets of DEFINE commands that are required to run the installation verification programs (IVPs).

You can include these samples in the CSQINP2 data set. When you have run the IVPs successfully, you do not need to run them again each time the queue manager is restarted. Therefore, you do not need to keep these samples in the CSQINP2 concatenation permanently.

CSQ4MSTR and CSQ4MSRR samples

These are sample started task procedures for the queue manager: thlqual.SCSQPROC(CSQ4MSTR) and thlqual.SCSQPROC(CSQ4MSRR).

CSQ4MSRR uses CSQ4INYR in the CSQINP2 concatenation so that important queues are spread across different page sets.

You can remove the comments, so that you can use the CSQMINI card for newly created queue managers if required.

CSQ4QMIN sample

A sample QMINI data set, thlqual.SCSQPROC(CSQ4QMIN).

See QMINI data set for details of the QMINI data set and the **TransportSecurity** stanza.

z/OS Recovery and restart on z/OS

Use the links in this topic to find out about the features of IBM MQ for z/OS for restart and recovery.

IBM MQ for z/OS has robust features for restart and recovery. For information about how a queue manager recovers after it has stopped, and what happens when it is restarted, see the following subtopics:

- “How changes are made to data in IBM MQ for z/OS” on page 247
- “How consistency is maintained in IBM MQ for z/OS” on page 248
- “What happens during termination in IBM MQ for z/OS” on page 250
- “What happens during restart and recovery in IBM MQ for z/OS” on page 252
- “How in-doubt units of recovery are resolved” on page 254
- “Shared queue recovery” on page 256

Related concepts

z/OS IBM MQ for z/OS recovery actions

Related tasks

Planning for backup and recovery

z/OS Administering z/OS

Related reference

z/OS Messages for IBM MQ for z/OS

z/OS How changes are made to data in IBM MQ for z/OS

IBM MQ for z/OS must interact with other subsystems to keep all the data consistent. This topic contains information about *units of recovery*, what they are and how they are used in *back outs*.

Units of recovery

A *unit of recovery* is the processing done by a single queue manager for an application program, that changes IBM MQ data from one point of consistency to another. A *point of consistency* - also called a *syncpoint* or *commit point* - is a point in time when all the recoverable data that an application program accesses is consistent.

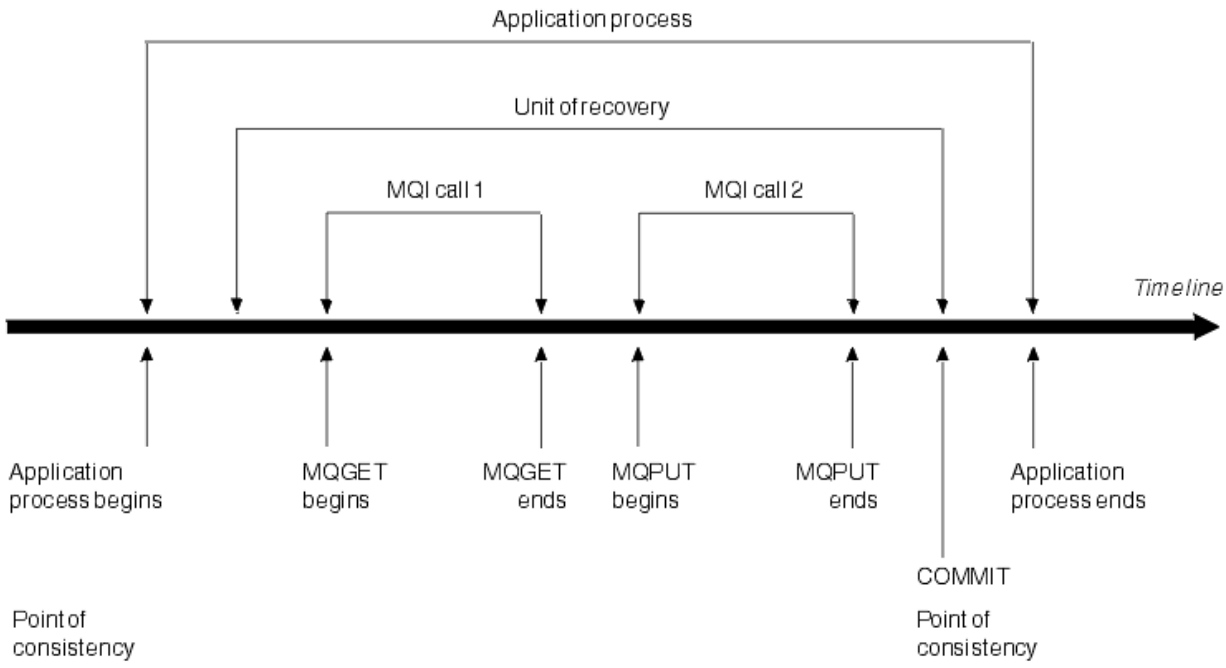


Figure 75. A unit of recovery within an application program

A unit of recovery begins with the first change to the data after the beginning of the program or following the previous point of consistency; it ends with a later point of consistency. Figure 75 on page 247 shows the relationship between units of recovery, the point of consistency, and an application program. In this example, the application program makes changes to queues through MQI calls 1 and 2. The application program can include more than one unit of recovery or just one. However, any complete unit of recovery ends in a commit point.

For example, a bank transaction transfers funds from one account to another. First, the program subtracts the amount from the first account, account A. Then, it adds the amount to the second account, B. After subtracting the amount from A, the two accounts are inconsistent and IBM MQ cannot commit. They become consistent when the amount is added to account B. When both steps are complete, the program can announce a point of consistency through a commit, making the changes visible to other application programs.

Normal termination of an application program automatically causes a point of consistency. Some program requests in CICS and IMS programs also cause a point of consistency, for example, EXEC CICS SYNCPOINT.

Backing out work

If an error occurs within a unit of recovery, IBM MQ removes any changes to data, returning the data to its state at the start of the unit of recovery; that is, IBM MQ backs out the work. The events are shown in Figure 76 on page 248.

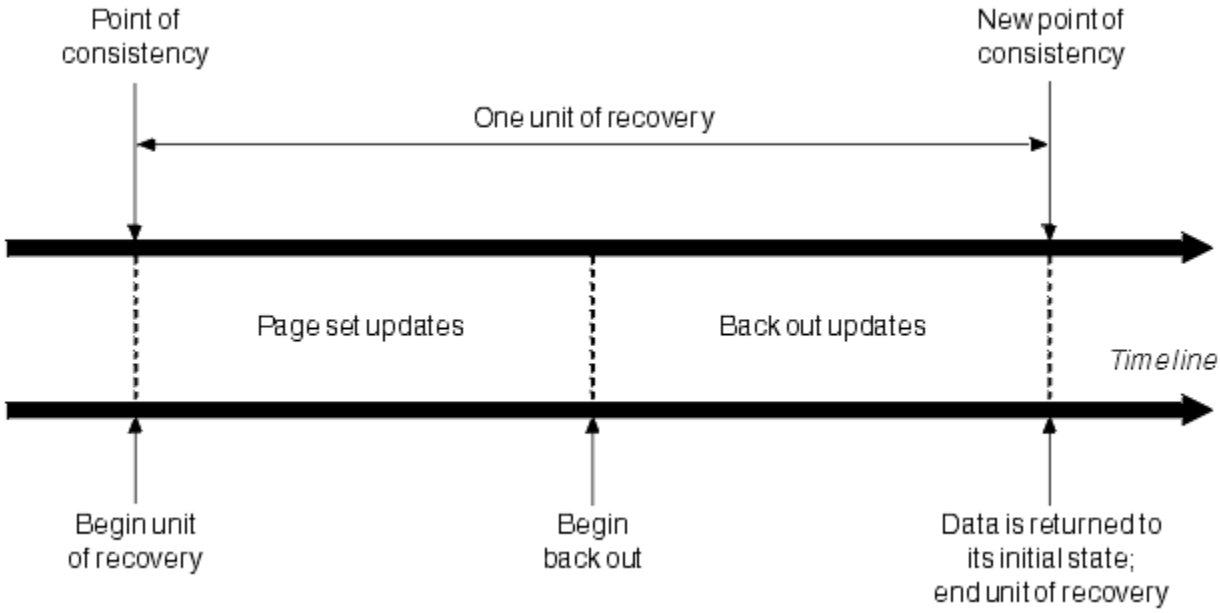


Figure 76. A unit of recovery showing back out

z/OS How consistency is maintained in IBM MQ for z/OS

Data in IBM MQ for z/OS must be consistent with batch, CICS, IMS, or TSO. Any data changed in one must be matched by a change in the other.

Before one system commits the changed data, it must know that the other system can make the corresponding change. So, the systems must communicate.

During a *two-phase commit* (for example under CICS), one subsystem coordinates the process. That subsystem is called the *coordinator*; the other is the *participant*. CICS or IMS is always the coordinator in interactions with IBM MQ, and IBM MQ is always the participant. In the batch or TSO environment, IBM MQ can participate in two-phase commit protocols coordinated by z/OS RRS.

During a *single-phase commit* (for example under TSO or batch), IBM MQ is always the coordinator in the interactions and completely controls the commit process.

In a WebSphere Application Server environment, the semantics of the JMS session object determine whether single-phase or two-phase commit coordination is used.

Consistency with CICS or IMS

The connection between IBM MQ and CICS or IMS supports the following syncpoint protocols:

- Two-phase commit - for transactions that update resources owned by more than one resource manager.

This is the standard distributed syncpoint protocol. It involves more logging and message flows than a single-phase commit.

- Single-phase commit - for transactions that update resources owned by a single resource manager (IBM MQ).

  This protocol is optimized for logging and message flows.

- Bypass of syncpoint - for transactions that involve IBM MQ but which do nothing in the queue manager that requires a syncpoint (for example, browsing a queue).

In each case, CICS or IMS acts as the syncpoint manager.

The stages of the two-phase commit that IBM MQ uses to communicate with CICS or IMS are as follows:

1. In phase 1, each system determines independently whether it has recorded enough recovery information in its log, and can commit its work.

   At the end of the phase, the systems communicate. If they agree, each begins the next phase.
2. In phase 2, the changes are made permanent. If one of the systems abends during phase 2, the operation is completed by the recovery process during restart.

Illustration of the two-phase commit process

Figure 77 on page 249 illustrates the two-phase commit process. Events in the CICS or IMS coordinator are shown on the upper line, events in IBM MQ on the lower line.

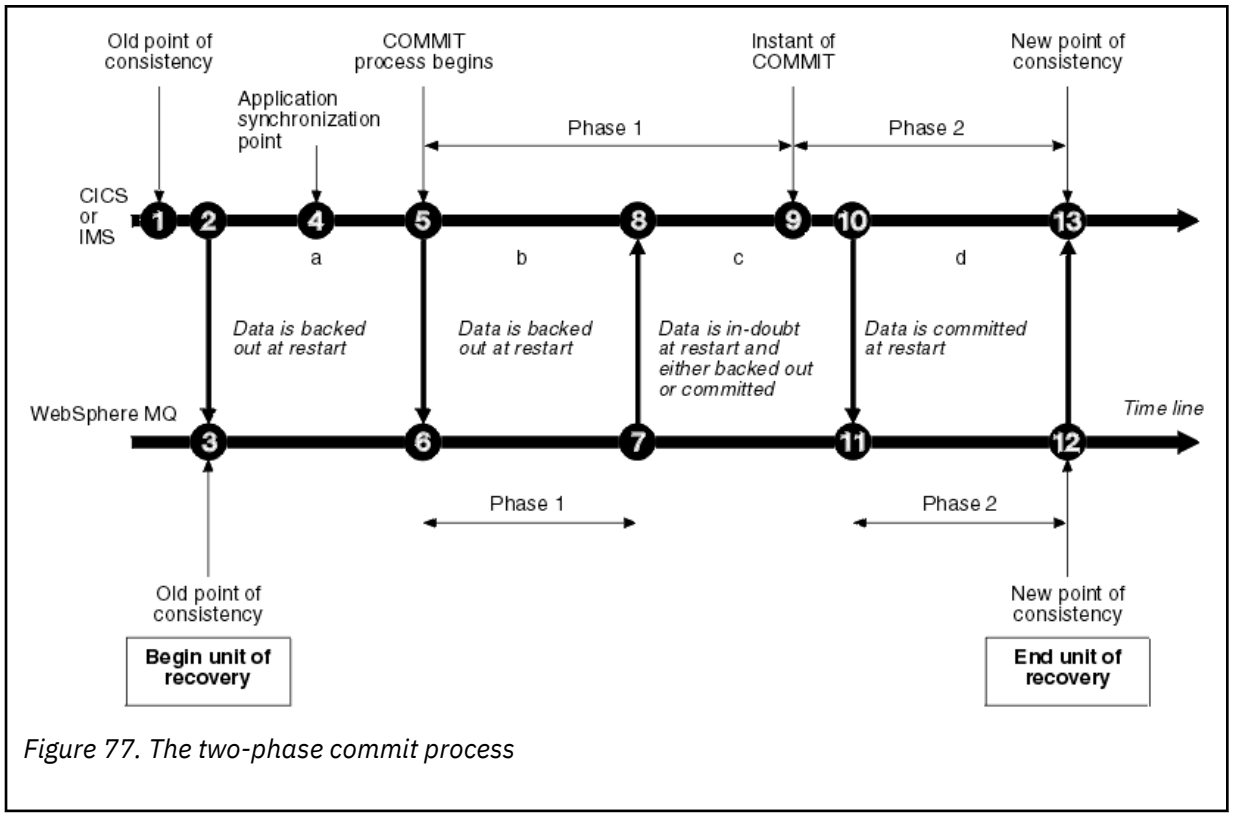


Figure 77. The two-phase commit process

The numbers in the following section are linked to those shown in the figure.

1. The data in the coordinator is at a point of consistency.
2. An application program in the coordinator calls IBM MQ to update a queue by adding a message.
3. This starts a unit of recovery in IBM MQ.
4. Processing continues in the coordinator until an application synchronization point is reached.
5. The coordinator then starts commit processing. CICS programs use a SYNCPOINT command or a normal application termination to start the commit. IMS programs can start the commit by using

a CHKP call, a SYNC call, a GET UNIQUE call to the IOPCB, or a normal application termination. Phase 1 of commit processing begins.

6. As the coordinator begins phase 1 processing, so does IBM MQ.
7. IBM MQ successfully completes phase 1, writes this fact in its log, and notifies the coordinator.
8. The coordinator receives the notification.
9. The coordinator successfully completes its phase 1 processing. Now both subsystems agree to commit the data changes, because both have completed phase 1 and could recover from any errors. The coordinator records in its log the instant of commit - the irrevocable decision of the two subsystems to make the changes.

   The coordinator now begins phase 2 of the processing - the actual commitment.
10. The coordinator notifies IBM MQ to begin its phase 2.
11. IBM MQ logs the start of phase 2.
12. Phase 2 is successfully completed, and this is now a new point of consistency for IBM MQ. IBM MQ then notifies the coordinator that it has finished its phase 2 processing.
13. The coordinator finishes its phase 2 processing. The data controlled by both subsystems is now consistent and available to other applications.

How consistency is maintained after an abnormal termination

When a queue manager is restarted after an abnormal termination, it must determine whether to commit or to back out units of recovery that were active at the time of termination. For some units of recovery, IBM MQ has enough information to make the decision. For others, it does not, and must get information from the coordinator when the connection is reestablished.

Figure 77 on page 249 shows four periods within the two phases: a, b, c, and d. The status of a unit of recovery depends on the period in which termination happened. The status can be one of the following:

In flight
The queue manager ended before finishing phase 1 (period a or b); during restart, IBM MQ backs out the updates.

In doubt
The queue manager ended after finishing phase 1 and before starting phase 2 (period c); only the coordinator knows whether the error happened before or after the commit (point 9). If it happened before, IBM MQ must back out its changes; if it happened after, IBM MQ must make its changes and commit them. At restart, IBM MQ waits for information from the coordinator before processing this unit of recovery.

In commit
The queue manager ended after it began its own phase 2 processing (period d); it makes committed changes.

In backout
The queue manager ended after a unit of recovery began to be backed out but before the process was complete (not shown in the figure) during restart, IBM MQ continues to back out the changes.

z/OS What happens during termination in IBM MQ for z/OS

A queue manager terminates normally in response to the STOP QMGR command. If a queue manager stops for any other reason, the termination is abnormal.

Note, that during queue manager termination, IBM MQ internally issues the command

```
DISPLAY CONN(*) TYPE(CONN) ALL WHERE (APPLTYPE NE SYSTEMAL)
```

so that you are aware of what threads might prevent the queue manager from completing shutdown.

SYSTEMAL matches APPLTYPES of either SYSTEM or CHINIT, so the DISPLAY CONN command filtering application types not matching SYSTEMAL, returns to the joblog information about threads that could be preventing normal shutdown.

Normal termination

In a normal termination, IBM MQ stops all activity in an orderly way. You can stop IBM MQ using either quiesce, force, or restart mode. The effects are given in Table 23 on page 251.

Table 23. Termination using QUIESCE, FORCE, and RESTART

Thread type	QUIESCE	FORCE	RESTART
Active threads	Run to completion	Back out	Back out
New threads	Can start	Not permitted	Not permitted
New connections	Not permitted	Not permitted	Not permitted

Batch applications are notified if a termination occurs while the application is still connected.

With CICS, a current thread runs only to the end of the unit of recovery. With CICS, stopping a queue manager in quiesce mode stops the CICS adapter, and so if an active task contains more than one unit of recovery, the task does not necessarily run to completion.

If you stop a queue manager in force or restart mode, no new threads are allocated, and work on connected threads is rolled back. Using these modes can create in-doubt units of recovery for threads that are between commit processing phases. They are resolved when IBM MQ is reconnected with the controlling CICS, IMS, or RRS subsystem.

When you stop a queue manager, in any mode, the steps are:

1. Connections are ended.
2. IBM MQ ceases to accept commands.
3. IBM MQ ensures that any outstanding updates to the page sets are completed.
4. The DISPLAY USAGE command is issued internally by IBM MQ so that the restart RBA is recorded on the z/OS console log.
5. The shutdown checkpoint is taken and the BSDS is updated.

Terminations that specify quiesce mode do not affect in-doubt units of recovery. Any unit that is in doubt remains in doubt.

Abnormal termination

An abnormal termination can leave data in an inconsistent state, for example:

- A unit of recovery has been interrupted before reaching a point of consistency.
- Committed data has not been written to page sets.
- Uncommitted data has been written to page sets.
- An application program has been interrupted between phase 1 and phase 2 of the commit process, leaving the unit of recovery in doubt.

IBM MQ resolves any data inconsistencies arising from abnormal termination during restart and recovery.

z/OS What happens during restart and recovery in IBM MQ for z/OS

IBM MQ uses its recovery log and the bootstrap data set (BSDS) to determine what to recover when it restarts. The BSDS identifies the active and archive log data sets, and the location of the most recent IBM MQ checkpoint in the log.

Introduction to restart and recovery

After IBM MQ has been initialized, the queue manager restart process takes place as follows:

- Log initialization
- Current status rebuild
- Forward log recovery
- Backward log recovery
- Queue index rebuilding

When recovery has been completed:

- Committed changes are reflected in the data.
- In-doubt activity is reflected in the data. However, the data is locked and cannot be used until IBM MQ recognizes and acts on the in-doubt decision.
- Interrupted in-flight and in-abort changes have been removed from the queues. The messages are consistent and can be used.
- A new checkpoint has been taken.
- New indexes have been built for indexed queues containing persistent messages (described in “Rebuilding queue indexes” on page 253).

If dual BSDSs are in use, IBM MQ checks the consistency of the time stamps in the BSDS:

- If both copies of the BSDS are current, IBM MQ tests whether the two time stamps are equal. If they are not, IBM MQ issues message CSQJ120E and terminates. This can happen when the two copies of the BSDS are maintained on separate DASD volumes and one of the volumes was restored while the queue manager was stopped. IBM MQ detects the situation at restart.
- If one copy of the BSDS was de-allocated, and logging continued with a single BSDS, a problem could arise. If both copies of the BSDS are maintained on a single volume, and the volume was restored, or if both BSDS copies were restored separately, IBM MQ might not detect the restoration. In that case, log records not noted in the BSDS would be unknown to the system.

Batch applications are not notified when restart occurs *after* the application has requested a connection.

Understanding the log range required for recovery

During restart, the range of log data which must be read is dependent on many factors:

- At the time of an abnormal termination, there are typically many incomplete units of work in the system. As described earlier, restart processing will bring the system to a state of consistency, which may involve backing out inflight units of work, or recovering locks on indoubt units of work. Unit of work recovery requires that all unit of work log records for inflight, in-backout, and in-doubt units of work are available. IBM MQ will 'shunt' old units of work, so that unit of work recovery can be performed using a much smaller range of log data.
- At the time of an abnormal termination, there are typically many persistent updates which are only held in the buffer pool cache. They have not yet been written to disk. These changes must be read from the log, and reapplied to the data held in page sets. Page set recovery RBAs in the checkpoint describe the lowest log RBA required for updating the page sets to a consistent state.
- If old page sets have been introduced into the system, for example, a page set backup has been introduced to recover from a media failure, all the changes must be read from the log from the time the backup was taken. These changes are reapplied to the data held in the page set being recovered.

Page set recovery RBAs held in page 0 of the page set describe the lowest log RBA required for media recovery of a page set.

- If using persistent messages on shared queues, a range of log data is required to recover CFSTRUCTs which are holding persistent messages. The earliest log data that would be required to perform a CFSTRUCT recovery, is from around the time of the old CFSTRUCT BACKUP.

During normal running, the DISPLAY USAGE TYPE(DATASET) command can be used to view the recovery log range associated with these factors (it is unable to provide information due to reintroducing old page sets, of course). To avoid any issues that might prolong a queue manager restart in the event of an abnormal termination, regularly monitor the values output from DISPLAY USAGE TYPE(DATASET).

In addition, the queue manager issues informational messages relating to these factors:

- CSQJ160I and CSQJ161I warn of long running units of work.
- CSQR026I and CSQR027I provide information about whether these long running units of work have been successfully shunted.
- CSQE040I and CSQE041E warn that structure backups are getting old, and consequently a RECOVER CFSTRUCT operation would take a long time.

Determining which application has a long running unit of work

It is possible to determine the application with the long-running unit of work. To do this, you use the DISPLAY CONN command.

The DISPLAY CONN command returns connection information for all the applications connected to the queue manager, together with additional information that helps you determine which application(s) currently have a long-running unit of work. The information returned by the DISPLAY CONN command is similar to the information returned by the DISPLAY QSTATUS command, but the main difference is that DISPLAY CONN displays information about objects, and transactional information for a particular connection, rather than details of which connections are associated with a particular object.

For each connected application, the DISPLAY CONN command returns the following information:

- Basic information including the Connection Id and PID.
- Transactional information for that connection, including the time and date when the transaction was created (that is, when the first MQGET/PUT was made under syncpoint), and when the transaction first wrote to the log.
- Log time information indicating which application still has a long running unit of work.
- A list of all objects that the connection currently has open. Details for each object are returned as a separate message, with the Connection Id used as a key. Because there are different types of object such as queues and queue managers, the information displayed with the object is specific to its object type.

Rebuilding queue indexes

To increase the speed of MQGET operations on a queue where messages are not retrieved sequentially, you can specify that you want IBM MQ to maintain an index of the message or correlation identifiers or groupid for all the messages on that queue.

When a queue manager is restarted, these indexes are rebuilt for each queue. This applies only to persistent messages; nonpersistent messages are deleted at restart. If your indexed queues contain large numbers of persistent messages, this increases the time taken to restart the queue manager.

You can choose to have indexes rebuilt asynchronously to queue manager startup by using the QINDXBLD parameter of the CSQ6SYSP macro. If you set QINDXBLD=NOWAIT, IBM MQ restarts without waiting for indexes to rebuild.

z/OS How in-doubt units of recovery are resolved

If IBM MQ loses its connection to another resource manager, it typically attempts to recover all inconsistent objects at restart.

If IBM MQ loses its connection to CICS, IMS, or RRS, it normally attempts to recover all inconsistent objects at restart. The information required to resolve in-doubt units of recovery must come from the coordinating system. The next sections describe the process of resolution for different environments.

- How in-doubt units of recovery are resolved from CICS
- How in-doubt units of recovery are resolved from IMS
- How in-doubt units of recovery are resolved from RRS
- How in-doubt units of recovery with a GROUP unit of recovery disposition are resolved

How in-doubt units of recovery are resolved from CICS

Under some circumstances, CICS cannot run the IBM MQ process to resolve in-doubt units of recovery. When this happens, IBM MQ sends one of the following messages:

- CSQC404E
- CSQC405E
- CSQC406E
- CSQC407E

followed by the message CSQC408I.

For details of what these messages mean, see the IBM MQ for z/OS messages, completion, and reason codes manual.

The resolution of in-doubt units does not effect CICS resources. CICS is in control of recovery coordination and, when it restarts, automatically commits or backs out each unit, depending on whether there was a log record marking the beginning of the commit. The existence of in-doubt objects does not lock CICS resources while IBM MQ is being reconnected.

One of the functions of the CICS adapter is to keep data synchronized between CICS and IBM MQ. If a queue manager abends while connected to CICS, it is possible for CICS to commit or back out work without IBM MQ being aware of it. When the queue manager restarts, that work is termed *in doubt*.

IBM MQ cannot resolve these in-doubt units of recovery (that is, commit or back out the changes made to IBM MQ resources) until the connection to CICS is restarted or reconnected.

A process to resolve in-doubt units of recovery is initiated during startup of the CICS adapter. The process starts when the adapter requests a list of in-doubt units of recovery. Then:

- The adapter receives a list of in-doubt units of recovery for this connection ID from IBM MQ, and passes them to CICS for resolution.
- CICS compares entries from this list with entries in its own log. CICS determines from its own list what action it took for each in-doubt unit of recovery.

For all resolved units, IBM MQ updates the queues as necessary and releases the corresponding locks. Unresolved units can remain after restart. Resolve them by the methods described in the Administering IBM MQ for z/OS.

How in-doubt units of recovery are resolved from IMS

Resolving in-doubt units of recovery in IMSdoes not effect DL/I resources. IMS is in control of recovery coordination and, when it restarts, automatically commits or backs out incomplete DL/I work. The decision to commit or back out for online regions (non-fast-path) is on the presence or absence of IMS log record types X'3730' and X'3801'. The existence of in-doubt units of recovery does not imply that DL/I records are locked until IBM MQ connects.

During queue manager restart, IBM MQ makes a list of in-doubt units of recovery. IMS builds its own list of residual recovery entries (RREs). The RREs are logged at IMS checkpoints until all entries are resolved.

During reconnection of an IMS region to IBM MQ, IMS indicates to IBM MQ whether to commit or back out units of work marked in IBM MQ as in doubt.

When in-doubt units are resolved:

1. If IBM MQ recognizes that it has marked an entry for commit and IMS has marked it to be backed out, IBM MQ issues message CSQQ010E. IBM MQ issues this message for all inconsistencies of this type between IBM MQ and IMS.
2. If IBM MQ has any remaining in-doubt units, the adapter issues message CSQQ008I.

For all resolved units, IBM MQ updates queues as necessary and releases the corresponding locks.

IBM MQ maintains locks on in-doubt work that was not resolved. This can cause a backlog in the system if important locks are being held. The connection remains active so you can resolve the IMS RREs. Recover the in-doubt threads by the methods described in the Administering IBM MQ for z/OS.

All in-doubt work should be resolved unless there are software or operating problems, such as with an IMS cold start. In-doubt resolution by the IMS control region takes place in two circumstances:

1. At the start of the connection to IBM MQ, during which resolution is done synchronously.
2. When a program abends, during which the resolution is done asynchronously.

How in-doubt units of recovery are resolved from RRS

One of the functions of the RRS adapter is to keep data synchronized between IBM MQ and other RRS-participating resource managers. If a failure occurs when IBM MQ has completed phase one of the commit and is waiting for a decision from RRS (the commit coordinator), the unit of recovery enters the in-doubt state.

When communication is reestablished between RRS and IBM MQ, RRS automatically commits or backs out each unit of recovery, depending on whether there was a log record marking the beginning of the commit. IBM MQ cannot resolve these in-doubt units of recovery (that is, commit or back out the changes made to IBM MQ resources) until the connection to RRS is reestablished.

Under some circumstances, RRS cannot resolve in-doubt units of recovery. When this happens, IBM MQ sends one of the following messages to the z/OS console:

- CSQ3011I
- CSQ3013I
- CSQ3014I
- CSQ3016I

For details of what these messages mean, see the IBM MQ for z/OS messages, completion, and reason codes manual.

For all resolved units of recovery, IBM MQ updates the queues as necessary and releases the corresponding locks. Unresolved units of recovery can remain after restart. Resolve them by the method described in the Administering IBM MQ for z/OS.

How in-doubt units of recovery with a GROUP unit of recovery disposition are resolved

In-doubt transactions that have a GROUP unit of recovery disposition can be resolved by the transaction coordinator by any queue manager in the queue sharing group (QSG) where the GROUPUR queue manager attribute is enabled. Whenever a transaction coordinator reconnects it typically requests a list of any outstanding in-doubt transactions and then resolves them using information from its logs.

When a transaction coordinator, that has connected with a GROUP unit of recovery disposition, requests the list of in-doubt transactions, the list returned comprises all in-doubt transactions with a GROUP unit of recovery disposition that exist throughout the queue sharing group. This list is not dependent on which queue manager those in-doubt transactions were started on. A queue manager processing such a request compiles the list by communicating with all other active queue managers in the queue sharing group using the SYSTEM.QSG.UR.RESOLUTION.QUEUE. The queue manager then reads the logs of any inactive queue managers, from their last checkpoint, to identify any additional in-doubt transactions that they would have reported had they been active.

When a transaction coordinator requests the resolution of an in-doubt transaction, the queue manager to which it is connected identifies whether the transaction was originated on itself and if so resolves it in the same way as transactions with a QMGR unit of recovery disposition. If the transaction was originated on another active queue manager in the QSG, a request to complete the resolution is routed to that queue manager using the SYSTEM.QSG.UR.RESOLUTION.QUEUE. In the case where the transaction was originated on an inactive queue manager in the QSG, any shared-queue work is resolved immediately, and a request to resolve any remaining private queue work is placed on the SYSTEM.QSG.UR.RESOLUTION.QUEUE. The inactive queue manager processes this request upon start-up before accepting new work. In this scenario, the original queue manager's logs still reflect that the unit of recovery is in doubt until it has restarted and processed the request.

z/OS Shared queue recovery

Use this topic to understand IBM MQ recovery and resilience of various components in the queue sharing group environment.

Transactional recovery

When an application issues a MQBACK call or terminates abnormally (for example, because of an EXEC CICS ROLLBACK or an IMS abend) thread-level information stored in the queue manager ensures that the in-flight unit of work is rolled back. MQPUT and MQGET operations within syncpoint on shared queues are rolled back in the same way as updates to non-shared queues.

Peer recovery

If a queue manager fails, it disconnects abnormally from the coupling facility structures that it is currently connected to. If the connection between the z/OS instance and the coupling facility fails (for example, physical link failure or power-off of a coupling facility or partition) this is also detected as an abnormal termination of the connection between the queue manager and the coupling facility structures involved. Other queue managers in the same queue sharing group that remain connected to that structure detect the abnormal disconnection and all attempt to initiate *peer recovery* for the failed queue manager on that structure. Only one of these queue managers initiates peer recovery successfully, but all the other queue managers cooperate in the recovery of units of work that were owned by the queue manager that failed.

If a queue manager fails when there are no peers connected to a structure, recovery is performed when another queue manager connects to that structure, or when the queue manager that failed restarts.

Peer recovery, often referred to as Peer Level Recovery (PLR), is performed on a structure by structure basis and it is possible for a single queue manager to participate in the recovery of more than one structure at the same time. However, the set of peers cooperating in the recovery of different structures might vary depending on which queue managers were connected to the different structures at the time of failure.

When the failed queue manager restarts, it reconnects to the structures that it was connected to at the time of failure, and recovers any remaining unresolved units of work that were not recovered by peer recovery.

Peer recovery is a multi-phase process. During the first phase, units of work that had progressed beyond the in-flight phase are recovered; this might involve committing messages for units of work that are in-commit and locking messages for units of work that are in-doubt. During the second phase, queues that had threads active against them in the failing queue manager are checked, uncommitted messages related to in-flight units of work are rolled back, and information about active handles on shared queues in the failed queue manager are reset. This means that IBM MQ resets any indicators that the failing queue manager had a shared queue open for input-exclusive, allowing other active queue managers to open the queue for input.

Shared queue definitions

The queue objects that represent the attributes of a shared queue are held in the shared Db2 repository used by the queue sharing group. Ensure that adequate procedures are in place for the backup and recovery of the Db2 tables used to hold IBM MQ objects. You can also use the IBM MQ CSQUTIL utility to create MQSC commands for replay into a queue manager to redefine IBM MQ objects, including shared queue and group definitions stored in Db2.

Logging

Queue sharing groups can support persistent messages, because the messages on shared queues can be logged in the queue manager logs.

Coupling facility and structure failures

There are two types of failure that can be reported for a coupling facility (CF) structure: structure failure and loss of connectivity. Sysplex services for data sharing (XES) inform IBM MQ of a CF structure failure or a CF failure with a structure failure event. If XES creates a loss of connectivity event this does not necessarily indicate that there is a problem with the structure, it might be that there is no connection available to communicate with the structure. It is possible that not all of the queue managers receive a loss of connectivity event for the structure; it depends on the configuration of connections to the CF. A loss of connectivity event can also be received because of operator commands, for example VARY PATH OFFLINE or CONFIG CHP OFFLINE.

The CF structures that are used by IBM MQ can be configured to use system-managed duplexing. This means that if there is a single failure, system-managed failover processing hides the failure of a structure or the loss of connectivity, and the queue manager is not informed of the failure. If there is a failure of both instances of a duplexed structure or connection, the queue manager receives the appropriate event and handles it in the same way as a failure event for a simplex structure. Details of how the queue manager handles the events are described in Scenarios.

In the unlikely event of a CF or structure failure, any nonpersistent messages stored in the affected application structures are lost. You can recover persistent messages using the RECOVER CFSTRUCT command. If a recoverable application structure has failed, any further application activity to this structure is prevented until the structure has been recovered.

To ensure that you can recover a CF structure in a reasonable period of time, take frequent backups, using the BACKUP CFSTRUCT command. You can choose to perform the backups on any queue managers in the queue sharing group or dedicate one queue manager to perform all the backups. Automate the process of taking backups to ensure that they are taken on a regular basis.

Each backup is written to the active log data set of the queue manager taking the backup. The shared queue Db2 repository records the name of the CF structure being backed up, the name of the queue manager doing the backup, the RBA range for this backup on that queue manager's log, and the backup time.

The administration structure contains information about incomplete units of work on shared queues at the time of any application structure failure so the administration structure must be available during RECOVER CFSTRUCT processing. If the administration structure has failed, all the queue managers in the queue sharing group must have rebuilt their administration structure entries before you can issue the RECOVER CFSTRUCT command.

Queue managers rebuild their administration structure entries automatically and without terminating. If a queue manager is not running at the time of the failure, its administration structure entries can be rebuilt by another queue manager in the queue sharing group that is running at the same or higher level.

To recover an application structure, issue a RECOVER CFSTRUCT command to the queue manager that you want to perform the recovery. You can recover a single CF structure or you can recover several CF structures simultaneously. You can recover using any queue manager in the queue sharing group, it does not have to be the one that performed the backup, or one that has been connected previously to the failed structure.

The RECOVER CFSTRUCT command uses the backup, located through the Db2 repository information (Db2 must therefore be available on the queue manager where recovery is being carried out), and recovers this to the point of failure.

The RECOVER CFSTRUCT command does this by applying log records from every queue manager in the queue sharing group that has performed an MQPUT or MQGET between the start of the backup and the time of failure, to any shared queue that maps to the CF structure. The resulting merging of the logs might require reading a considerable amount of log data because all the log data written by participating queue managers since the backup is read. You are strongly recommended to make frequent (for example, hourly) backups, especially if there are large messages within the backup.

Structure failure scenarios

Scenarios

If a failure is reported for a CF structure, the action taken by connected queue managers depends on the following:

- The type of failure reported by the XES component of z/OS to IBM MQ.
- The structure type (application or administration)
- The queue manager level
- The CFLEVEL of the IBM MQ CFSTRUCT object (2, 3, 4 or 5. This is not the CFLEVEL of the CFCC microcode)
- The RECAUTO attribute of an IBM MQ CFSTRUCT object at CFLEVEL(5)

The following scenarios describe what happens when a failure is reported for the administration structure:

- If a structure failure event is received for the administration structure, the structure is reallocated and rebuilt automatically without the queue manager terminating. A new instance of the structure is allocated by XES when a queue manager attempts to connect to it.

  When the queue manager has connected to the new instance of the structure, the queue manager writes the entries for itself into the structure. This processing is carried out by the queue manager and is not part of XES rebuild processing.

If a queue manager was not running at the time of the failure, or terminates before recovery of its part of the administration structure has been completed, its administration structure entries can be rebuilt by another queue manager in the queue sharing group.

Administration structure entries of a queue manager can only be rebuilt by another queue manager running at the same level or higher. If administration structure entries of a queue manager cannot be rebuilt by another queue manager in the queue sharing group, restart the queue manager so that it can complete the rebuild of its part of the structure.

Certain actions are suspended until the administration structure entries for all queue managers have been rebuilt. The suspended actions include the following:

- Opening and closing of shared queues.
- Committing or backing out units of recovery.
- Serialized applications connecting to or disconnecting from the queue manager.
- Backing up or recovering an application structure.

Any serialized applications that have already connected to the queue manager can continue processing. Any serialized application attempting to connect with the MQCNO_SERIALIZE_CONN_TAG_QSG or MQCNO_RESTRICT_CONN_TAG_QSG parameters receive the MQRC_CONN_TAG_NOT_USABLE return code.

When the administration structure entries for the queue manager have been rebuilt, the suspended actions are resumed.

The following scenarios describe what happens when a failure is reported for an application structure:

- If a structure failure event is received for an application structure, and the CFLEVEL is 1 or 2, the queue manager terminates. Restart the queue manager. The first queue manager to attempt to connect to the structure again causes XES to allocate a new instance of the structure.
- If a structure failure event is received for an application structure, and the CFLEVEL is 3, 4, or 5 the queue managers connected to the structure continue to run. Applications that do not use the queues in the failed structure can continue normal processing.

  However, applications that attempt operations on queues in the failed structure receive an MQRC_CF_STRUC_FAILED error until the structure has been successfully rebuilt, at which point the application can open the queues again.

  Structure rebuild is started automatically for CFLEVEL(5) application structures defined with RECAUTO(YES). Otherwise, the structure will be rebuilt when the RECOVER CFSTRUCT command is issued.

Resilience to coupling facility connectivity failures

What is resilience to coupling facility connectivity failures?

Resilience to coupling facility connectivity failures refers to the ability of queue managers in a queue sharing group to tolerate loss of connectivity to a coupling facility structure without terminating. This function also attempts to rebuild the structure in another coupling facility with better connectivity in order to regain access to shared queues as soon as possible.

What is partial loss of connectivity?

IBM MQ defines partial loss of connectivity as a situation where one or more systems in the sysplex lose connectivity to the coupling facility where the structure being accessed by the system is allocated, but at least one system in the sysplex maintains connectivity to the same coupling facility.

What is total loss of connectivity?

IBM MQ defines a total loss of connectivity as a situation where no systems in the sysplex have connectivity to the coupling facility and the structure allocated within it.

Why would you enable this function?

Resilience to coupling facility connectivity failures improves the availability of IBM MQ, allowing non-shared queues to remain available after a queue manager has lost connectivity to one or more coupling facility structures. Additionally, queue managers that lose connectivity to a coupling facility structure automatically attempt to rebuild the structure in another available coupling facility, improving the availability of the shared queues within the queue sharing group.

Considerations when enabling this function

A queue manager that tolerates loss of connectivity to coupling facility structures without terminating may not be able to reconnect to a coupling facility structure for some time if there is no alternative coupling facility available. Shared queues defined on a structure that has suffered loss of connectivity remain unavailable until connectivity to the structure is restored. In this situation, applications that connect into members of the queue sharing group in order to perform shared queue work may find that the shared queues they need to access are not available. To avoid this situation it is recommended that queue managers should be configured to terminate when connectivity to a coupling facility structure is lost. This termination forces applications to connect to another member of the queue sharing group that has connectivity to the coupling facility structures where the shared queues the application requires are defined.

Managing Resilience to coupling facility connectivity failures

How do I enable this functionality?

The following steps must be performed in order to enable resilience to coupling facility connectivity

1. Ensure that the CFRM couple data set has been formatted to support system-managed rebuild. This allows queue managers to initiate a system-managed rebuild to re-create a structure into an available coupling facility. Use the **DISPLAY XCF,COUPLE,TYPE=CFRM** command to determine the format of the CFRM couple data set. To support system-managed rebuild, the CFRM couple data set should be formatted by specifying:

   ```
   "ITEM NAME(SMREBLD) NUMBER(1)"
   ```

   Refer to the z/OS MVS Setting Up a Sysplex documentation for more information on formatting a CFRM couple data set.
2. Ensure that an alternative coupling facility is available and is in the CFRM preference list for all IBM MQ coupling facility structures. This enables the queue managers to attempt to rebuild structures into an alternative available coupling facility to restore access to the structures as soon as possible.

   IBM MQ structures must be defined with ENFORCEORDER(NO) in CFRM policy, so that XCF is able to choose the optimum CF in the configuration if IBM MQ needs to reallocate the structure.

   Refer to the z/OS MVS Setting Up a Sysplex documentation for more information about structure preference lists.
3. Alter all application coupling facility structures that need to tolerate loss of connectivity to CFLEVEL(5). This is the minimum level that can tolerate a loss of connectivity.
4. Determine the values required for the **QMGR CFCONLOS** and the **CFSTRUCT CFCONLOS** attributes and alter these accordingly. The **QMGR CFCONLOS** attribute controls whether loss of connectivity to the administration structure is tolerated, and the **CFSTRUCT CFCONLOS** attribute controls whether loss of connectivity is tolerated by each application coupling facility structure. If the default values for these attributes are retained, the queue manager terminates following loss of connectivity to any coupling facility structure.
5. Determine the values required for the **CFSTRUCT RECAUTO** attribute for each application coupling facility structure, and alter these accordingly. This attribute controls whether coupling facility structures should be automatically recovered using logged data following total loss of connectivity. If the default value for this attribute is retained, no automatic recovery is performed for application structures following total loss of connectivity.

Scenario 1 - Loss of connectivity to the administration structure

Queue managers can tolerate loss of connectivity to the administration structure without terminating.

When connectivity to the administration structure is lost by any queue manager that has been configured to tolerate loss of connectivity to the administration structure, all members of the queue sharing group disconnect from the administration structure. All active queue managers in the queue sharing group then attempt to reconnect to the administration structure, causing it to be reallocated in the coupling facility with the best connectivity to all systems in the sysplex, and rebuild the administration structure data.

Note: This may not necessarily be the coupling facility which has the best connectivity to all systems that have active queue managers.

If a queue manager cannot reconnect to the administration structure, for example because none of the coupling facilities in the CFRM preference list for the administration structure are available, some shared queue operations remain unavailable until the queue manager can successfully reconnect to the administration structure and rebuild its administration structure data. Reconnection occurs automatically when a suitable coupling facility becomes available on the system.

Failure to connect to the administration structure during queue manager startup as a result of a lack of connectivity to the coupling facility, or no suitable coupling facility available to allocate the structure, is not tolerated. All active queue managers in the queue sharing group then attempt to reconnect to the administration structure, causing it to be reallocated in another coupling facility if one is available, and rebuild the administration structure data.

Scenario 2- Loss of connectivity to the application structure

Loss of connectivity to application structures at **CFLEVEL(5)** or higher can be tolerated without the queue manager terminating. Queue managers connected to application structures at **CFLEVEL(4)** or lower, or structures at **CFLEVEL(5)** that have not been configured to tolerate loss of connectivity, abend with reason code 00C510AB when connectivity to the structure is lost.

When connectivity is lost to an application structure that has been configured to tolerate loss of connectivity, all queue managers that lost connectivity to the structure disconnect. The subsequent behavior of the queue manager depends on whether the loss of connectivity is partial or total.

Partial loss of connectivity to an application structure

If the loss of connectivity is determined to be partial, queue managers that have lost connectivity to the structure attempt to initiate a system-managed rebuild in order to move the structure to another coupling facility with improved connectivity. If this rebuild is successful, both persistent and non-persistent messages in the structure are copied to the other coupling facility, and access to queues on the structure is restored. Queue managers that did not lose connectivity remain connected to the structure, however, operations that access the structure are delayed during the system-managed rebuild process.

If an application structure cannot be rebuilt to another coupling facility with improved connectivity, or some queue managers still do not have connectivity to the structure after it has been rebuilt in another coupling facility, queues defined on the structure remain unavailable on the queue managers that do not have connectivity to the structure until connectivity is restored to the coupling facility. Queue managers automatically reconnect to the structure when it becomes available and access to the shared queues defined on the structure are restored.

Total loss of connectivity to an application structure

If all MVS systems in the sysplex have lost connectivity to the coupling facility that the application structure is allocated in, z/OS deallocates the structure from the coupling facility whenever an attempt is made to reconnect to the structure. It is possible for the queue manager to attempt to reconnect to the structure for several reasons, such as an attempt by an application to open a shared queue, or a notification from the system that new coupling facility resources may have become available. It is therefore likely that all non-persistent messages in the affected structure are lost following total loss of connectivity to an application structure.

Recoverable application structures are automatically recovered following total loss of connectivity, if they have been defined with **RECAUTO(YES)**. The recovery starts almost immediately if an alternative coupling facility is available to allocate the structure in, or whenever such a coupling facility becomes available. If a structure has not been defined with **RECAUTO(YES)**, recovery can be started by issuing the **RECOVER CFSTRUCT** command. This recovers all persistent messages in the structure, but all non-persistent messages are lost. As this process involves reading the queue manager log it can take some time to complete, therefore it is recommended that structure backups be taken regularly to reduce the time until access to the shared queues on the structure is restored.

Queue managers attempt to reconnect to non-recoverable application structures as soon as an application attempts to open a shared queue that is defined on the structure or a notification is received from the system that new coupling facility resources have become available. If a suitable coupling facility is available to allocate the structure in, a new structure is allocated and access to the shared queues defined on the structure is restored. As persistent messages cannot be put to queues defined in non-recoverable structures, all messages on the shared queues are lost.

Operational behavior

If an IBM WebSphere MQ 7.1, or later, queue manager, configured to tolerate loss of connectivity to a particular coupling facility structure loses connectivity, the members of the queue sharing group attempt to automatically recover from the failure and reconnect to the structure. This activity may involve reallocating the structure in another coupling facility with better connectivity if one is available. However, operator intervention may still be required to recover from the loss of connectivity.

Typically the required operator action is to:

1. Resolve the cause of the failure that resulting in the loss of connectivity.
2. Ensure that a coupling facility where the IBM MQ structures can be allocated is available on all systems in the sysplex

Any structures that have been automatically reallocated in another coupling facility after the loss of connectivity event, can be moved to the coupling facility with the optimal connectivity to all queue managers in the queue sharing group. If required, this can be done by initiating the system-managed rebuild command **SETXCF START,REBUILD** as documented in z/OS MVS System Commands Reference.

In the case of a partial loss of connectivity to an application structure, the queue managers that lost connectivity to the structure attempt to initiate a system-managed rebuild. This process only allocates the structure in another coupling facility if that coupling facility has connectivity to all active queue managers currently connected to the structure. Therefore, it is possible that where the majority of queue managers in a queue sharing group have lost connectivity to an application structure, they are unable to rebuild the structure into another coupling facility due to the queue managers that are still connected to the original structure. In this situation the queue managers that are still connected to the original structure can be shut down to allow the structure to be rebuilt, or the **RESET CFSTRUCT ACTION(FAIL)** command can be issued to fail the structure. Recovery can be initiated on applicable structures by issuing the **RECOVER CFSTRUCT** command.

Note: When failing and recovering the structure, all non-persistent messages on the structure are lost.

z/OS Security concepts in IBM MQ for z/OS

Use this topic to understand the importance of security for IBM MQ, and the implications of not having adequate security settings on your system.

Why you must protect IBM MQ resources

IBM MQ handles the transfer of information that is potentially valuable. Applying security ensures that the resources IBM MQ owns and manages are protected from unauthorized access. Such access might lead to the loss or disclosure of the information.

You should ensure that none of the following resources are accessed or changed by any unauthorized user or process:

- Connections to IBM MQ
- IBM MQ objects such as queues, processes, and namelists
- IBM MQ transmission links, that is, IBM MQ channels
- IBM MQ system control commands
- IBM MQ messages
- Context information associated with messages

To provide the necessary security, IBM MQ uses the z/OS system authorization facility (SAF) to route authorization requests to an External Security Manager (ESM), for example Security Server (previously known as RACF). IBM MQ does no security verification of its own. Where distributed queuing or clients are being used, you might require additional security measures, for which IBM MQ provides channel authentication records, channel exits, the MCAUSER channel attribute, and TLS.

The decision to allow access to an object is made by the ESM and IBM MQ follows that decision. If the ESM cannot make a decision, IBM MQ prevents access to the object.

What happens if you do not protect IBM MQ resources

If you do nothing about security, the most likely effect is that *all* users can access and change *every* resource. This includes not only local users, but also those on remote systems using distributed queuing or clients, where the logon security controls might be less strict than is normally the case for z/OS.

To enable security checking you must do the following:

- Install and activate an ESM (for example, Security Server).
- Define the MQADMIN class if you are using an ESM other than Security Server.
- Activate the MQADMIN class.

You must consider whether using mixed-case resource names would be beneficial to your enterprise. If you do use mixed-case resource names in your ESM profiles you must define and activate the MXADMIN class.

z/OS Data Set Encryption

Data Set Encryption (DSE) provides the capability to encrypt z/OS data sets, so that the data they contain can only be viewed or modified by user IDs granted the specific permission. This provides encryption of data at rest in the file system, and prevents inadvertent disclosure of sensitive information to users who have a legitimate business need and permissions to manage the data sets themselves.

Prior to IBM MQ for z/OS 9.1.4, IBM MQ for z/OS does not support use of DSE with the active logs, page sets, and shared message data sets (SMDS) that provide the primary persistence mechanisms for IBM MQ messages.

Instead, Advanced Message Security provides an end-to-end encryption solution for IBM MQ messaging, which encompasses the entire IBM MQ network, encryption of data in flight, at rest, and even inside the runtime IBM MQ processes.

Other VSAM and sequential data sets used in an IBM MQ subsystem can be encrypted using DSE. For example:

- Bootstrap data set (BSDS)
- Sequential files holding system configuration (MQSC) commands read at startup using CSQINPx DDNAMEs
- IBM MQ archive logs, often used for long term archival of IBM MQ log data for audit purposes.

You can encrypt using DSE by allocating a dataclass that is defined with a data set key label. For more information, see Planning your log archive storage.

From IBM MQ for z/OS 9.1.4, IBM MQ for z/OS supports use of DSE with the active logs and page sets in addition to the support provided in earlier releases.

IBM MQ for z/OS does not support use of DSE for shared message data sets (SMDS).

See the section, confidentiality for data at rest on IBM MQ for z/OS with data set encryption. for more information.

Related concepts
Security concepts
Channel authentication records
Authority to work with IBM MQ objects on z/OS
Cryptographic security protocols: TLS
Related tasks
Setting up security on z/OS
Comparing link level security and application level security
Related reference
Messages for IBM MQ for z/OS

z/OS Security controls and options in IBM MQ for z/OS

You can specify whether security is turned on for the whole IBM MQ subsystem, and whether you want to perform security checks at queue manager or queue sharing group level. You can also control the number of user IDs checked for API-resource security.

Subsystem security

Subsystem security is a control that specifies whether any security checking is done for the whole queue manager. If you do not require security checking (for example, on a test system), or if you are satisfied with the level of security on all the resources that can connect to IBM MQ (including clients and channels), you can turn security checking off for the queue manager or queue sharing group so that no further security checking takes place.

This is the only check that can turn security off completely and determine whether any other security checks are performed or not. That is, if you turn off checking for the queue manager or queue sharing group, no other IBM MQ checking is done; if you leave it turned on, IBM MQ checks your security requirements for other IBM MQ resources.

You can also turn security on or off for particular sets of resources, such as commands.

Queue manager or queue sharing group level checking

You can implement security at queue manager level or at queue sharing group level. If you implement security at queue sharing group level, all the queue managers in the group share the same profiles. This means that there are fewer profiles to define and maintain, making security management easier. It also makes it easy to add a new queue manager to the queue sharing group because it inherits the existing security profiles.

It is also possible to implement a combination of both if your installation requires it, for example, during migration or if you have one queue manager in the queue sharing group that requires different levels of security to the other queue managers in the group.

Queue sharing group level security

Queue sharing group level security checking is performed for the entire queue sharing group. It enables you to simplify security administration because it requires you to define fewer security profiles. The authorization of a user ID to use a particular resource is handled at the queue sharing group level, and is independent of which queue manager that user ID is using to access the resource.

For example, say a server application runs under user ID SERVER and wants access to a queue called SERVER.REQUEST, and you want to run an instance of SERVER on each z/OS image in the sysplex. Rather than permitting SERVER to open SERVER.REQUEST on each queue manager individually (queue manager level security), you can permit access only at the queue sharing group level.

You can use queue sharing group level security profiles to protect all types of resource, whether local or shared.

Queue manager level security
You can use queue manager level security profiles to protect all types of resource, whether local or shared.

Combination of both levels
You can use a combination of both queue manager and queue sharing group level security.

You can override queue sharing group level security settings for a particular queue manager that is a member of that group. This means that you can perform a different level of security checks on an individual queue manager to those performed on the other queue managers in the group.

For more information, see Profiles to control queue sharing group or queue manager level security.

Controlling the number of user IDs checked

RESLEVEL is a Security Server profile that controls the number of user IDs checked for IBM MQ resource security. Normally, when a user attempts to access an IBM MQ resource, Security Server checks the relevant user ID or IDs to see if access is allowed to that resource. By defining a RESLEVEL profile you can control whether zero, one or, where applicable, two user IDs are checked.

These controls are done on a connection by connection basis, and last for the life of the connection.

There is only one RESLEVEL profile for each queue manager. Control is implemented by the access that a user ID has to this profile.

Mixed case or uppercase IBM MQ RACF classes

You can now use mixed case RACF profile support, which allows you to use mixed case resource names and define IBM MQ RACF profiles to protect them.

You can choose to either:

- Continue using uppercase only IBM MQ RACF Classes as in previous releases, or
- Use the new mixed case IBM MQ RACF classes.

Without the use of mixed case RACF profiles, you can still use mixed case resource names in IBM MQ for z/OS ; however, these resource names can only be protected by generic RACF profiles in the uppercase IBM MQ classes. When using mixed case IBM MQ RACF profile support you can provide a more granular level of protection by defining IBM MQ RACF profiles in the mixed case IBM MQ classes.

z/OS Resources you can protect in IBM MQ for z/OS

When a queue manager starts, or when instructed by an operator command, IBM MQ for z/OS determines which resources you want to protect.

You can control which security checks are performed for each individual queue manager. For example, you can implement a number of security checks on a production queue manager, but none on a test queue manager.

Connection security

Connection security checking is carried out either when an application program tries to connect to a queue manager. It is done by issuing an MQCONN or MQCONNX request, or when the channel initiator, or CICS or IMS adapter issues a connection request.

If you are using queue manager level security, you can turn connection security checking off for a particular queue manager. However, if you do this any user can connect to that queue manager.

For the CICS adapter, only the CICS address space user ID is used for the connection security check, not the individual CICS terminal user ID. For the IMS adapter, when the IMS control or dependent regions connect to IBM MQ, the IMS address space user ID is checked. For the channel initiator, the user ID used by the channel initiator address space is checked.

You can turn connection security checking on or off at either queue manager or queue sharing group level.

Command security

Command security checking is carried out when a user issues an MQSC command from any of the sources described in Sources from which you can issue MQSC and PCF commands on IBM MQ for z/OS. You can make a separate check on the resource specified by the command as described in “Command resource security” on page 266.

If you turn off command checking, issuers of commands are not checked to see whether they have the authority to issue the command.

If MQSC commands are entered from a console, the console must have the z/OS SYS console authority attribute. Commands that are issued from the CSQINP1 or CSQINP2 data sets, or internally by the queue manager, are exempt from all security checking while those for CSQINPX use the user ID of the channel initiator address space. You must control who is allowed to update these data sets through normal data set protection.

You can turn command security checking on or off at either queue manager or queue sharing group level.

Command resource security

Some MQSC commands, for example defining a local queue, involve the manipulation of IBM MQ resources. When command resource security is active, each time a command involving a resource is issued, IBM MQ checks to see if the user is allowed to change the definition of that resource.

You can use command resource security to help enforce naming standards. For example, a payroll administrator might be allowed to delete and define only queues with names beginning "PAYROLL". If command resource security is inactive, no security checks are made on the resource that is being manipulated by the command. Do not confuse command resource security with command security; the two are independent.

Turning off command resource security checking does not affect the resource checking that is done specifically for other types of processing that do not involve commands.

You can turn command resource security checking on or off at either queue manager or queue sharing group level.

Channel security considerations

Channel security

When you are using channels, the security features available depend on which communications protocol you are going to use. If you use TCP, there are no security features provided with the communications protocol, although you can use TLS. If you are using APPC, you can flow user ID information from the sending MCA through the network to the destination MCA for verification.

For both protocols, you can specify which user IDs you want to check for security purposes, and how many. Again, the choices available to you depend on which protocol you are using, what you specify when you define the channel, and the RESLEVEL settings for the channel initiator.

For more information about the types of channel security available see Channel authentication records and Security exit overview

Related reference

"API-resource security in IBM MQ for z/OS" on page 267
Resources are checked when an application opens an object with an MQOPEN or an MQPUT1 call. The access needed to open an object depends on what open options are specified when the queue is opened.

z/OS *API-resource security in IBM MQ for z/OS*

Resources are checked when an application opens an object with an MQOPEN or an MQPUT1 call. The access needed to open an object depends on what open options are specified when the queue is opened.

API-resource security is subdivided into the following checks:

- Queue
- Process
- Namelist
- Alternate user
- Context

No security checks are performed when opening the queue manager object or when accessing storage class objects.

Queue

Queue security checking controls who is allowed to open which queue, and what options they are allowed to open it with. For example, a user might be allowed to open a queue called PAYROLL.INCREASE.SALARY to browse the messages on the queue (using the MQOO_BROWSE option), but not to remove messages from the queue (using one of the MQOO_INPUT_* options).
If you turn checking for queues off, any user can open any queue with any valid open option (that is, any valid MQOO_* option on an MQOPEN or MQPUT1 call).

You can turn queue security checking on or off at either queue manager or queue sharing group level.

Process

Process security checking is carried out when a user opens a process definition object. If you turn checking for processes off, any user can open any process.

You can turn process security checking on or off at either queue manager or queue sharing group level.

Namelist

Namelist security checking is carried out when a user opens a namelist. If you turn checking for namelists off, any user can open any namelist.

You can turn namelist security checking on or off at either queue manager or queue sharing group level.

Alternate user

Alternate user security controls whether one user ID can use the authority of another user ID to open an IBM MQ object.

For example:

- A server program running under user ID PAYSERV retrieves a request message from a queue that was put on the queue by user ID USER1.
- When the server program gets the request message, it processes the request and puts the reply back into the reply-to queue specified with the request message.
- Instead of using its own user ID (PAYSERV) to authorize opening the reply-to queue, the server can specify some other user ID, in this case, USER1. In this example, alternate user security would control whether user ID PAYSERV is allowed to specify user ID USER1 as an alternative user ID when opening the reply-to queue.

The alternative user ID is specified in the *AlternateUserId* field of the object descriptor (MQOD).

You can use alternative user IDs on any IBM MQ object, for example, processes or namelists. It does not affect the user ID used by any other resource managers, for example, for CICS security or for z/OS data set security.

If alternate user security is not active, any user can use any other user ID as an alternative user ID.

You can turn alternate user security checking on or off at either queue manager or queue sharing group level.

Context

Context is information that is applicable to a particular message and is contained in the message descriptor (MQMD) that is part of the message. The context information comes in two sections:

Identity section
The user of the application that first put the message to a queue. It consists of the following fields:

- *UserIdentifier*
- *AccountingToken*
- *ApplIdentityData*

Origin section
The application that put the message on the queue where it is currently stored. It consists of the following fields:

- *PutApplType*
- *PutApplName*
- *PutDate*
- *PutTime*
- *ApplOriginData*

Applications can specify the context data when either an MQPUT or an MQPUT1 call is made. The application might generate the data, the data might be passed on from another message, or the queue manager might generate the data by default. For example, server programs can use context data to check the identity of the requester, that is, did this message come from the correct application? Typically, the *UserIdentifier* field is used to determine the user ID of an alternative user.

You use context security to control whether the user can specify any of the context options on any MQOPEN or MQPUT call. For information about the context options, see the MQOPEN options relating to message context. For descriptions of the message descriptor fields relating to context, see MQMD - Message descriptorMQMD - Message descriptor.

If you turn context security checking off, any user can use any of the context options that the queue security allows.

You can turn context security checking on or off at either queue, queue manager or queue sharing group level.

z/OS Availability on z/OS

IBM MQ for z/OS has many features for high availability. This topic describes some of the considerations for availability.

Several features of IBM MQ can increase system availability if the queue manager or channel initiator fails. For more information about these features, see the following sections:

- Sysplex considerations
- Shared queues
- Shared channels
- IBM MQ network availability
- Using the z/OS Automatic Restart Manager (ARM)
- Using the z/OS Extended Recovery Facility (XRF)
- Using the z/OS GROUPUR attribute for recovery in a queue sharing group
- Where to find more information about availability

Sysplex considerations

In a *sysplex*, a number of z/OS operating system images collaborate in a single system image and communicate using a coupling facility. IBM MQ can use the facilities of the sysplex environment for enhanced availability.

Removing the affinities between a queue manager and a particular z/OS image allows a queue manager to be restarted on a different z/OS image in the event of an image failure. The restart mechanism can be manual, use ARM, or use system automation, if you ensure the following:

- All page sets, logs, bootstrap data sets, code libraries, and queue manager configuration data sets are defined on shared volumes.
- The subsystem definition has sysplex scope and a unique name within the sysplex.
- The level of *early code* installed on every z/OS image at IPL time is at the same level.
- TCP virtual IP addresses (VIPA) is available on each TCP stack in the sysplex, and you have configured IBM MQ TCP listeners and inbound connections to use VIPAs rather than default host names.

For more information about using TCP in a sysplex, see *TCP/IP in a sysplex*, SG24-5235, an IBM Redbooks® publication.

You can additionally configure multiple queue managers running on different operating system images in a sysplex to operate as a queue sharing group, which can take advantage of shared queues and shared channels for higher availability and workload balancing.

Shared queues

In the queue sharing group environment, an application can connect to any of the queue managers within the queue sharing group. Because all the queue managers in the queue sharing group can access the same set of shared queues, the application does not depend on the availability of a particular queue manager; any queue manager in the queue sharing group can service any queue. This gives greater availability if a queue manager stops because all the other queue managers in the queue sharing group can continue processing the queue. For information about high availability of shared queues, see “Advantages of using shared queues” on page 183.

To further enhance the availability of messages in a queue sharing group, IBM MQ detects if another queue manager in the group disconnects from the coupling facility abnormally, and completes units of work for that queue manager that are still pending, where possible. This is known as *peer recovery* and is described in “Peer recovery” on page 256.

Peer recovery cannot recover units of work that were in doubt at the time of the failure. You can use the Automatic Restart Manager (ARM) to restart all the systems involved in the failure (CICS, Db2, and IBM MQ for example), and to ensure that they are all restarted on the same new processor. This means that they can resynchronize, and gives rapid recovery of in-doubt units of work. This is described in "Using the z/OS Automatic Restart Manager (ARM)" on page 270.

Shared channels

In the queue sharing group environment, IBM MQ provides functions that give high availability to the network. The channel initiator enables you to use networking products that balance network requests across a set of eligible servers and hide server failures from the network (for example, VTAM generic resources). IBM MQ uses a generic port for inbound requests so that attach requests can be routed to any available channel initiator in the queue sharing group. This is described in "Shared channels" on page 203.

Shared outbound channels take the messages they send from a shared transmission queue. Information about the status of a shared channel is held in one place for the whole queue sharing group level. This means that a channel can be restarted automatically on a different channel initiator in the queue sharing group if the channel initiator, queue manager, or communications subsystem fails. This is called *peer channel recovery* and is described in Shared outbound channels.

IBM MQ network availability

IBM MQ messages are carried from queue manager to queue manager in an IBM MQ network using channels. You can change the configuration at a number of levels to improve the network availability of a queue manager, and the ability of an IBM MQ channel to detect a network problem and to reconnect.

TCP *Keepalive* is available for TCP/IP channels. It causes TCP to send packets periodically between sessions to detect network failures. The KAINT channel attribute determines the frequency of these packets for a channel.

AdoptMCA allows a channel, blocked in receive processing as a result of a network outage, to be terminated and replaced by a new connection request. You control AdoptMCA using the ADOPTMCA queue manager property with the MQSC utility or the AdoptNewMCAType property with the Programmable Command Formats interface.

ReceiveTimeout prevents a channel from being permanently blocked in a network receive call. The RCVTIME and RCVTMIN channel initiator parameters, determine the receive timeout characteristics for channels, as a function of their heartbeat interval. See Queue manager parameter for more details.

Using the z/OS Automatic Restart Manager (ARM)

You can use IBM MQ for z/OS in conjunction with the z/OS automatic restart manager (ARM). If a queue manager or a channel initiator has failed, ARM restarts it on the same z/OS image. If z/OS fails, a whole group of related subsystems and applications also fail. ARM can restart all the failed systems automatically, in a predefined order, on another z/OS image within the sysplex. This is called a cross-system restart.

ARM enables rapid recovery of in-doubt transactions in the shared queue environment. It also gives higher availability if you are not using queue sharing groups.

You can use ARM to restart a queue manager on a different z/OS image within the sysplex in the event of z/OS failure.

To enable automatic restart, you must do the following:

1. Set up an ARM coupling data set.
2. Define the automatic restart actions that you want z/OS to perform in an *ARM policy*.

3. Start the ARM policy.

If you want to restart queue managers in different z/OS images automatically, every queue manager in each z/OS image on which that queue manager might be restarted must be defined with a sysplex-wide unique 4-character subsystem name.

Using ARM with IBM MQ is described in Using ARM in an IBM MQ network.

Using the z/OS Extended Recovery Facility (XRF)

You can use IBM MQ in an extended recovery facility (XRF) environment. All IBM MQ-owned data sets (executable code, BSDSs, logs, and page sets) must be on DASD shared between the active and alternative XRF processors.

If you use XRF for recovery, you must stop the queue manager on the active processor and start it on the alternative processor. For CICS, you can do this using the command list table (CLT) provided by CICS, or the system operator can do it manually. For IMS, this is a manual operation and you must do it after the coordinating IMS system has completed the processor switch.

IBM MQ utilities must be completed or terminated before the queue manager can be switched to the alternative processor. Consider the effect of this potential interruption carefully when planning your XRF recovery plans.

Take care to prevent the queue manager starting on the alternative processor before the queue manager on the active processor terminates. A premature start can cause severe integrity problems in data, the catalog, and the log. Using global resource serialization (GRS) helps avoid the integrity problems by preventing simultaneous use of IBM MQ on the two systems. You must include the BSDS as a protected resource, and you must include the active and alternative XRF processors in the GRS ring.

Using the z/OS GROUPUR attribute for recovery in a queue sharing group

Queue sharing groups (QSG) allow additional transactional facilities which are described in this topic. The GROUPUR attribute allows XA client applications to have any in-doubt transaction recovery that may be required, performed on any member of the QSG.

If an XA client application connects to a queue sharing group (QSG) through a Sysplex it cannot guarantee which specific queue manager it connects to. Use of the GROUPUR attribute by queue managers within the queue sharing group can enable any in-doubt transaction recovery that may be necessary to occur on any member of the QSG. Even if the queue manager to which the application was initially connected is not available, transaction recovery can take place.

This feature frees the XA client application from any dependency on specific members of the QSG and thus extends the availability of the queue manager. The queue sharing group appears to the transactional application as a single entity providing all the IBM MQ features and without a single queue manager point of failure.

This functionality is not apparent to the transactional application.

Where to find more information about availability

You can find more information about these topics from the following sources:

Table 24. Where to find more information about availability

Topic	Where to look
Queue sharing groups	“Shared queues and queue sharing groups” on page 164
System parameters	Configuring system parameters

Table 24. Where to find more information about availability (continued)	
Topic	**Where to look**
Using the Automatic Restart Manager Utility programs	Using ARM in an IBM MQ network
MQSC commands	MQSC commands

z/OS Monitoring and statistics on IBM MQ for z/OS

IBM MQ for z/OS has a set of facilities for monitoring the queue manager, and gathering statistics.

IBM MQ supplies facilities for monitoring the system and collecting statistics. For further information about these facilities, see the following sections:

- "Online monitoring" on page 272
- "IBM MQ trace" on page 272
- "Events" on page 273

Online monitoring

IBM MQ includes the following commands for monitoring the status of IBM MQ objects:

- DISPLAY CHSTATUS displays the status of a specified channel.
- DISPLAY QSTATUS displays the status of a specified queue.
- DISPLAY CONN displays the status of a specified connection.

For more information about these commands, see The MQSC commands.

IBM MQ trace

IBM MQ supplies a trace facility that you can use to gather the following information while the queue manager is running:

Performance statistics

The statistics trace gathers the following information to help you monitor performance and tune your system:

- Counts of different MQI requests (message manager statistics)
- Counts of different object requests (data manager statistics)
- Information about Db2 usage (Db2 manager statistics)
- Information about Coupling Facility usage (Coupling Facility manager statistics)
- Information about SMDS usage (shared message data set statistics)
- Information about buffer pool usage (buffer manager statistics)
- Information about logging (log manager statistics)
- Information about storage usage (storage manager statistics)
- Information about lock requests (lock manager statistics)

Accounting data

- The accounting trace gathers information about the processor time spent processing MQI calls and about the number of MQPUT and MQGET requests made by a particular user.

- IBM MQ can also gather information about each task using IBM MQ. This data is gathered as a thread-level accounting record. For each thread, IBM MQ also gathers information about each queue used by that thread.

The data generated by the trace is sent to the System Management Facility (SMF) or the generalized trace facility (GTF).

Events

IBM MQ events provide information about errors, warnings, and other significant occurrences in a queue manager. By incorporating these events into your own system management application, you can monitor the activities across many queue managers, for multiple IBM MQ applications. In particular, you can monitor all the queue managers in your system from a single queue manager.

Events can be reported through a user-written reporting mechanism to an administration application that supports the presentation of the events to an operator. Events also enable applications acting as agents for other administration networks, for example NetView®, to monitor reports and create the appropriate alerts.

Related tasks

Using IBM MQ trace

Using IBM MQ events

z/OS Unit of recovery disposition on z/OS

Certain transactional applications can use a GROUP, rather than a QMGR, unit of recovery disposition when connected to a queue manager in a queue sharing group (QSG) by specifying the QSG name when they connect instead of the queue manager name. This allows transaction recovery to be more flexible and robust by removing the requirement to reconnect to the same queue manager in the QSG.

Transactions started by applications that have connected using the queue sharing group name also have a GROUP unit of recovery disposition.

When a transactional application connects with a GROUP unit of recovery disposition it is logically connected to the queue sharing group and does not have an affinity to any specific queue manager. Any 2-phase commit transactions that it has started that have completed phase-1 of the commit process, that is, they are in doubt, can be inquired and resolved, when connected to any queue manager within the QSG. In a recovery scenario this means that the transaction coordinator does not have to reconnect to the same queue manager, which may be unavailable at that time.

Applications that connect with a QMGR unit of recovery disposition have a direct affinity to the queue manager to which they are connected. In a recovery scenario the transaction coordinator must reconnect to the same queue manager to resolve any in-doubt transactions, irrespective of whether the queue manager belongs to a queue sharing group.

When applications specify a queue sharing group name, and thus connect to a queue manager in a QSG with a GROUP unit of recovery disposition, the queue sharing group is logically a separate resource manager. This means that in-doubt transactions are only visible to an application if it reconnects with the same unit of recovery disposition. In-doubt transactions with a QMGR unit of recovery disposition are not visible to applications that have connected with a GROUP unit of recovery disposition and vice versa.

Related concepts

“Enabling GROUP units of recovery” on page 274
A queue sharing group can configure and enable support for GROUP units of recovery.

“Application support” on page 274

Use this page to determine which applications can connect with a GROUP unit of recovery disposition.

z/OS Enabling GROUP units of recovery

A queue sharing group can configure and enable support for GROUP units of recovery.

To use GROUP units of recovery on a queue manager within a QSG, enable the GROUPUR queue manager attribute. For more information about this concept, see “Unit of recovery disposition on z/OS” on page 273 before reading the rest of this topic.

When the GROUPUR queue manager attribute is enabled, the queue manager accepts new connections with a GROUP unit of recovery disposition. If you disable this attribute new connections with this disposition are not accepted, although applications already connected is unaffected until they disconnect.

When an application connects with a GROUP unit of recovery disposition and either inquires what transactions are in doubt or attempts to resolve a transaction that was started elsewhere in the queue sharing group (QSG), the queue manager to which it is now connected must be able to communicate with the other members of the queue sharing group so that it can process the request. To do this it uses a shared queue called SYSTEM.QSG.UR.RESOLUTION.QUEUE. This queue must be on a recoverable application structure called CSQSYSAPPL. The structure must be recoverable because persistent messages are stored on this queue when processing resolution requests.

Before you can enable GROUP units of recovery, you must ensure that the coupling facility structure and the shared queue are defined. You can use the definitions in the CSQ4INSS sample. When the queue is defined, or detected during startup, each queue manager in the queue sharing group opens the queue so that it can receive incoming requests. If you want to delete or move the queue because it has been defined incorrectly you can request that the queue managers close their open handles on it by updating the queue object to inhibit MQGET requests. When you have made the necessary corrections, permitting applications to get messages from the queue once more directs each queue manager to reopen it. Use the DISPLAY QSTATUS command to identify what handles are open on a queue.

When you have completed this setup you can then enable GROUP units of recovery on each queue manager that you want transactional applications to be able to connect to with a GROUP unit of recovery disposition. This need not be all of the queue managers within the queue sharing group but if you choose to only enable this functionality on a subset of the queue sharing group you must ensure that your applications only attempt to connect to queue managers on which you have enabled it. For more information, see “Application support” on page 274.

When you attempt to enable the GROUPUR queue manager attribute, a number of configuration checks are performed. The queue manager checks that:

- It belongs to a queue sharing group.
- The shared-queue called SYSTEM.QSG.UR.RESOLUTION.QUEUE has been defined, according to the the definition in CSQ4INSS.
- The SYSTEM.QSG.UR.RESOLUTION.QUEUE is on a recoverable CF structure called CSQSYSAPPL.

If any of the above checks fail, the GROUPUR attribute remains disabled and a message code is returned.

These configuration checks are also performed at queue manager startup if the queue manager attribute is enabled. If any of the checks fail during startup GROUP units of recovery is disabled and the queue manager issues a message identifying which check failed. When you have performed the necessary corrective action you must then re-enable the queue manager attribute.

z/OS Application support

Use this page to determine which applications can connect with a GROUP unit of recovery disposition.

Support for the GROUP unit of recovery disposition is limited to certain types of transactional applications for which IBM MQ for z/OS is a resource manager but not the transaction coordinator. Currently supported transactional applications are:

- IBM MQ extended transactional client applications

- IBM MQ classes for JMS applications running in an application server, such as WebSphere Application Server.
- CICS applications running in CICS Transaction Server 4.2 or later, when the CICS MQCONN resource definition is configured with RESYNCMEMBER(GROUPRESYNC).

Related concepts

" IBM MQ extended transactional client applications" on page 275
Use this page to determine how IBM MQ extended transactional client applications can use the GROUP unit of recovery disposition.

"CICS applications" on page 275
Use this page to determine how CICS can use the GROUP unit of recovery disposition.

z/OS *IBM MQ extended transactional client applications*

Use this page to determine how IBM MQ extended transactional client applications can use the GROUP unit of recovery disposition.

An example of an IBM MQ extended transactional client application is one that uses JMS and runs in WebSphere Application Server, connecting to IBM MQ over TCP/IP, rather than local bindings. These client applications connect to IBM MQ for z/OS over network connections, such as via TCP/IP. For these applications, it is the value specified for the QMNAME parameter of the xa_info string passed in the xa_open call that specifies whether a QMGR or GROUP unit of recovery disposition is used. For more information about xa_open, see The format of an xa_open string and Additional error processing for xa_open. For JMS applications this is done by specifying the name of the queue sharing group (QSG) in the ConnectionFactory instead of the name of a specific queue manager.

For XA client applications to take advantage of using the GROUP unit of recovery disposition you must configure your TCP/IP setup to allow your client applications to be routed to the queue managers in the queue sharing group that have the GROUPUR attribute enabled, rather than a specific queue manager. One of the dynamic virtual IP address technologies that you can use to do this is the z/OS SysPlex Distributor. See z/OS Communications Server and z/OS Basic Skills: Dynamic virtual addressing for more details. If you want to enable GROUP units of recovery on a subset of the queue managers in your queue sharing group, ensure that your client applications cannot be routed to those on which it is not enabled.

Your client applications do not have to connect to the queue sharing group using shared channels.

z/OS *CICS applications*

Use this page to determine how CICS can use the GROUP unit of recovery disposition.

CICS 4.2 and later provides the group resynchronization option, RESYNCMEMBER(GROUPRESYNC) in an MQCONN resource definition. A CICS configured with this option can connect to any suitable queue manager in a queue sharing group which is running on the same LPAR as that CICS region. To support the CICS GROUPRESYNC option, a queue manager must be running at MQ V7.1 or later, and be enabled for GROUPUR support.

Transactions running within a CICS region connected to MQ using GROUPRESYNC create units of work with GROUP unit of recovery disposition.

You can use RESYNCMEMBER(GROUPRESYNC) to enable faster recovery after a queue manager failure as it enables the CICS region to immediately connect to an alternative eligible queue manager running on the same LPAR, resolving any indoubt transactions as necessary, without waiting for queue manager restart.

RESYNCMEMBER(GROUPRESYNC) also enables more flexible restart options for CICS. A CICS region with its MQ connection configured to use GROUPRESYNC and MQ shared queues can be restarted on any LPAR where there is a queue manager running as a member of the same queue sharing group.

z/OS IBM MQ and other z/OS products

Use this topic to understand how IBM MQ can work with other z/OS products.

Related concepts

"IBM MQ and CICS" on page 276

All the CICS versions supported by IBM MQ 9.0.0, and later, use the CICS supplied version of the adapter and bridge.

"IBM MQ for z/OS and WebSphere Application Server" on page 282
Use this topic to understand the use of IBM MQ for z/OS by the WebSphere Application Server.

Related reference

"IBM MQ and IMS" on page 277
Use this topic to understand how IBM MQ works with IMS. The IMS adapter allows you to connect your queue manager to IMS, and enables IMS applications to use the MQI.

"IBM MQ and the z/OS Batch, TSO, and RRS adapters" on page 281
Use this topic to understand how IBM MQ works with the z/OS Batch, TSO, and RRS adapters.

z/OS IBM MQ and CICS

All the CICS versions supported by IBM MQ 9.0.0, and later, use the CICS supplied version of the adapter and bridge.

For more information about configuring the IBM MQ CICS adapter, and the IBM MQ CICS bridge components, see the Configuring connections to IBM MQ section of the CICS documentation.

Related tasks

Using IBM MQ with CICS

z/OS CICS group attach

CICS group attach provides the ability for a CICS region to connect to any active member of an IBM MQ queue sharing group on the same LPAR rather than specifying an individual queue manager. CICS still connects to a single queue manager at a time.

You require at least two queue managers on the LPAR to support CICS group attach. Using group attach provides higher availability as you do not need a particular queue manager to be active. CICS connects to any queue manager in the queue sharing group on the LPAR.

For more information, see the CICS documentation on the MQCONN resource.

CICS attempts to connect to MQNAME passed as if it were a queue manager:

- If the queue manager exists and is active, the connection will work.
- If the connection fails, CICS queries the status of queue managers in the group to ascertain which are active on same LPAR.
- If multiple queue managers are active, CICS checks for RESYNCMEMBER(YES) and the UOW status to determine whether CICS needs to connect, or should connect, to a particular member, or wait if not active.
- If there is no need to connect to a particular member, CICS selects a queue manager (using a randomizing algorithm).
- CICS attempts to connect to chosen queue manager.
- If the attempt fails then, depending upon the return code, CICS chooses the next member, then goes through the selection loop again.
- If no queue managers are active, CICS issues multiple connections to the list of queue managers and waits on ECBLIST until the first queue manager becomes available.

Related concepts

"Group units of recovery (GROUPUR) for CICS" on page 277
The IBM MQ GROUPUR for CICS provides peer recovery for in-doubt units of work in a queue sharing group (QSG). One IBM MQ queue manager can resolve in-doubt units of work on behalf of another queue manager in the queue sharing group. This means that if CICS reconnects through group attach to a different queue manager in the QSG, it can resolve indoubt transactions from a previous IBM MQ connection.

Related information

Support for IBM MQ queue sharing groups

z/OS Group units of recovery (GROUPUR) for CICS

The IBM MQ GROUPUR for CICS provides peer recovery for in-doubt units of work in a queue sharing group (QSG). One IBM MQ queue manager can resolve in-doubt units of work on behalf of another queue manager in the queue sharing group. This means that if CICS reconnects through group attach to a different queue manager in the QSG, it can resolve indoubt transactions from a previous IBM MQ connection.

If a CICS region is working with a queue manager, and the queue manager ends abnormally, then any indoubt transactions are recovered. This eliminates the need for the CICS region to wait for the queue manager that it was working with to restart, and then resolve any in doubt units of work. This means that you need at least two queue managers on the LPAR, so that CICS can connect to another queue manager in the event of an abnormal termination of the first queue manager.

The new RESYNCMEMBER(GROUPRESYNC) setting on the CICS MQCONN definition:

- Uses the IBM MQ group attach function and peer recovery.
- Requires a queue manager with the GROUPUR attribute enabled.
- Still supports the existing CICS MQCONN RESYNCMEMBER settings (YES and NO):
  - Uses the existing CICS group attach function and no peer recovery.
  - Changing RESYNCMEMBER settings takes effect next time CICS connects to IBM MQ.

Related concepts

“Enabling GROUP units of recovery” on page 274
A queue sharing group can configure and enable support for GROUP units of recovery.

z/OS IBM MQ and IMS

Use this topic to understand how IBM MQ works with IMS. The IMS adapter allows you to connect your queue manager to IMS, and enables IMS applications to use the MQI.

The optional additional IBM MQ - IMS bridge enables applications to run an IMS application that does not use the MQI. This means that you can use your legacy applications with IBM MQ, without the need to rewrite them.

For more information about these components, see the following subtopics:

Related concepts

IMS and IMS bridge applications on IBM MQ for z/OS

Related tasks

Setting up the IMS adapter

Setting up the IMS bridge

Operating the IMS adapter

Related reference

MQIIH - IMS information header

z/OS The IMS adapter

The IMS adapter is an interface between IMS application programs and an IBM MQ subsystem.

The IBM MQ adapters enable different application environments to send and receive messages through a message queuing network. The IMS adapter is the interface between IMS application programs and an IBM MQ subsystem. It makes it possible for IMS application programs to use the MQI.

The IMS adapter receives and interprets requests for access to IBM MQ using the External Subsystem Attach Facility (ESAF) provided by IMS. Usually, IMS connects to IBM MQ automatically without operator intervention.

The IMS adapter provides access to IBM MQ resources for programs running in the following modes or states:

- Task (TCB) mode
- Problem state
- Non-cross-memory mode
- Non-access register mode

The adapter provides a connection thread from an application task control block (TCB) to IBM MQ.

The adapter supports a two-phase commit protocol for changes made to resources owned by IBM MQ with IMS acting as the syncpoint coordinator. Conversations where IMS is not the syncpoint coordinator, for example APPC- protected (SYNCLVL=SYNCPT) conversations, are not supported by the IMS adapter.

The adapter also provides a trigger monitor transaction (CSQQTRMN). This is described in "The IMS trigger monitor" on page 278.

You can use IBM MQ with the IMS Extended Recovery Facility (XRF) to aid recovery from a IMS error.

Note: As of IMS 15.2 Extended Recovery Facility (XRF) is no longer supported. See the IMS documentation for more information.

Using the adapter

The application programs and the IMS adapter run in the same address space. The queue manager is separate, in its own address space.

You must link-edit each program that issues one or more MQI calls to a suitable IMS language interface module, and, unless it uses dynamic MQI calls, the IBM MQ-supplied API stub program, CSQQSTUB. When the application issues an MQI call, the stub transfers control to the adapter through the IMS external subsystem interface, which manages the processing of the request by the message queue manager.

System administration and operation with IMS

An authorized IMS terminal operator can issue IMS commands to control and monitor the connection to IBM MQ. However, the IMS terminal operator has no control over the IBM MQ address space. For example, the operator cannot shut down IBM MQ from an IMS address space.

Restrictions

The following IBM MQ API calls are not supported within an application using the IMS adapter:

- MQCB
- MQCB_FUNCTION
- MQCTL

The IMS trigger monitor

The IMS trigger monitor (**CSQQTRMN**) is an IBM MQ-supplied IMS application that starts an IMS transaction when an IBM MQ event occurs, for example, when a message is put onto a specific queue.

How it works

When a message is put onto an application message queue, a trigger is generated if the trigger conditions are met. The queue manager then writes a message (containing some user-defined data), known as a *trigger message*, to the initiation queue that has been specified for that message queue. In an IMS environment, you can start an instance of CSQQTRMN to monitor an initiation queue and to retrieve the trigger messages from it as they arrive. Typically, CSQQTRMN schedules another IMS transaction by an INSERT (ISRT) to the IMS message queue. The started IMS application reads the message from the application message queue and then processes it. CSQQTRMN must run as a non-message BMP.

Each copy of CSQQTRMN services a single initiation queue. When it has started, the trigger monitor runs until IBM MQ or IMS ends.

The APPLCTN macro for CSQQTRMN must specify SCHDTYP=PARALLEL.

Because the trigger monitor is a batch-oriented BMP, IMS transactions that are started by the trigger monitor contain the following:

- Blanks in the LTERM field of the IOPCB
- The PSB name of the trigger monitor BMP in the Userid field of the IOPCB

If the target IMS transaction is protected by Security Server (previously known as RACF), you might need to define CSQQTRMN as a user ID to Security Server.

z/OS The IBM MQ - IMS bridge

The IBM MQ - IMS bridge is the component of IBM MQ for z/OS that allows direct access from IBM MQ applications to applications on your IMS system.

The IBM MQ - IMS bridge enables *implicit MQI support*. This means that you can re-engineer legacy applications that were controlled by 3270-connected terminals to be controlled by IBM MQ messages, without having to rewrite, recompile, or re-link them. The bridge is an IMS *Open Transaction Manager Access* (OTMA) client.

In bridge applications there are no IBM MQ calls within the IMS application. The application gets its input using a GET UNIQUE (GU) to the IOPCB and sends its output using an ISRT to the IOPCB. IBM MQ applications use the IMS header (the MQIIH structure) in the message data to ensure that the applications can execute as they did when driven by nonprogrammable terminals. If you are using an IMS application that processes multi-segment messages, note that all segments should be contained within one IBM MQ message.

The IMS bridge is illustrated in Figure 78 on page 280.

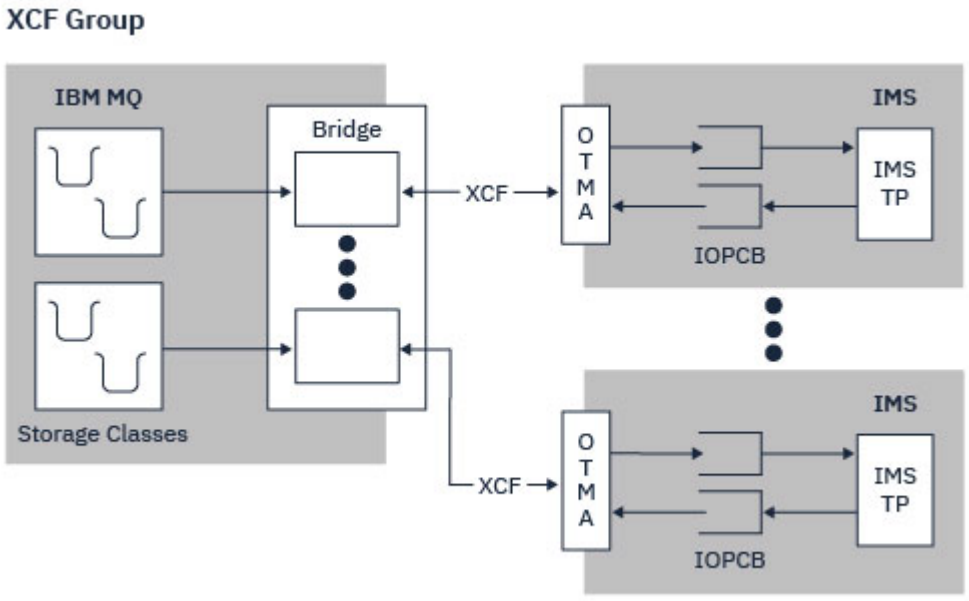


Figure 78. The IBM MQ - IMS bridge

A queue manager can connect to one or more IMS systems, and more than one queue manager can connect to one IMS system. The only restriction is that they must all belong to the same XCF group and must all be in the same sysplex.

See Setting up the IMS bridge for information on setting up an IMS bridge and adding an additional IMS connection to the same queue manager.

What is OTMA?

The IMS OTMA facility is a transaction-based connectionless client/server protocol that runs on IMS. It functions as an interface for host-based communications servers accessing IMS TM applications through the z/OS Cross Systems coupling facility (XCF).

OTMA enables clients to connect to IMS to provide high performance for interactions between clients and IMS for a large network or large number of sessions. OTMA is implemented in a z/OS sysplex environment. Therefore, the domain of OTMA is restricted to the domain of XCF.

OTMA Resource Monitoring

Support for the x'3C' OTMA protocol messages, available in IMS v10 or higher, is included in the IBM MQ - IMS bridge in IBM MQ for z/OS. These messages are sent to OTMA clients by IMS to report its health status.

If an IMS partner is unable to process the volume of transaction requests being sent then it will notify IBM MQ that a flood warning has occurred. In response IBM MQ will slow down the rate at which requests are sent over the bridge.

If IMS is still unable to process the transaction requests and a full flood condition occurs all TPIPEs to the IMS partner are suspended. Upon notification from the IMS partner that the flood or flood-warning condition has been relieved IBM MQ will resume all suspended TPIPEs, if appropriate, and gradually increase the rate at which transaction requests are sent until the maximum rate is achieved. Console messages are issued by IBM MQ in response to a change in the status of IMS partners.

If IMS v10 partners are being used you should ensure that PTF UK45082 has been applied.

Submitting IMS transactions from IBM MQ

To submit an IMS transaction that uses the bridge, applications put messages on an IBM MQ queue as usual. The messages contain IMS transaction data; they can have an IMS header (the MQIIH structure) or allow the IBM MQ - IMS bridge to make assumptions about the data in the message.

IBM MQ then puts the message to an IMS queue (it is queued in IBM MQ first to enable the use of syncpoints to assure data integrity). The storage class of the IBM MQ queue determines whether the queue is an *OTMA queue* (that is, a queue used to transmit messages to the IBM MQ - IMS bridge) and the particular IMS partner to which the message data is sent.

Remote queue managers can also start IMS transactions by writing to these OTMA queues on IBM MQ for z/OS.

Data returned from the IMS system is written directly to the IBM MQ reply-to queue specified in the message descriptor structure (MQMD). (This might be a transmission queue to the queue manager specified in the **ReplyToQMgr** field of the MQMD.)

Related concepts

IMS and IMS bridge applications on IBM MQ for z/OS

Related tasks

Customizing the IMS bridge

Related reference

"IBM MQ and IMS" on page 277

Use this topic to understand how IBM MQ works with IMS. The IMS adapter allows you to connect your queue manager to IMS, and enables IMS applications to use the MQI.

z/OS IBM MQ and the z/OS Batch, TSO, and RRS adapters

Use this topic to understand how IBM MQ works with the z/OS Batch, TSO, and RRS adapters.

Introduction to the Batch adapters

The Batch/TSO adapters are the interface between IBM MQ and z/OS application programs running under JES, TSO, or z/OS UNIX System Services. These adaptors enable z/OS application programs to use the MQI.

The adapters provide access to IBM MQ resources for programs running in the following modes or states:

- Task (TCB) mode
- Problem or supervisor state
- Non-cross-memory mode
- Non-access register mode

Connections between application programs and IBM MQ are at the task level. The adapters provide a connection thread from an application task control block (TCB) to IBM MQ.

The Batch/TSO adapter supports a single-phase commit protocol for changes made to resources owned by IBM MQ. It does not support multi-phase commit protocols. The RRS adapter enables IBM MQ applications to participate in two-phase commit protocols with other RRS-enabled products, coordinated by z/OS Resource Recovery Services (RRS).

The adapters use the z/OS STIMERM service to schedule an asynchronous event every second. This event runs an interrupt request block (IRB) that does not involve any waiting by the batch application's task. This IRB checks to see if the IBM MQ termination ECB has been posted. If the termination ECB has been posted, the IRB posts any application ECBs that are waiting on an event in IBM MQ (for example, a signal or a wait).

The Batch/TSO adapter

The IBM MQ Batch/TSO adapter provides IBM MQ support for z/OS Batch and TSO applications. All application programs that run under z/OS Batch or TSO must have the API stub program CSQBSTUB link-edited with them. The stub provides the application with access to all MQI calls. You use single-phase commit and backout for applications by issuing the MQI calls **MQCMIT** and **MQBACK**.

The RRS adapter

Resource Recovery Services (RRS) is a subcomponent of z/OS that provides a system-wide service for coordinating two-phase commit across z/OS products. The IBM MQ Batch/TSO RRS adapter (the RRS adapter) provides IBM MQ support for z/OS Batch and TSO applications that want to use these services. The RRS adapter enables IBM MQ to become a full participant in RRS coordination. Applications can participate in two-phase commit processing with other products that support RRS (for example, Db2).

The RRS adapter provides two stubs; you must link-edit application programs that want to use RRS with one of these stubs.

CSQBRSTB
: This stub allows you to use two-phase commit and backout for applications by using the RRS callable resource recovery services instead of the MQI calls **MQCMIT** and **MQBACK**.

  You must also link-edit module ATRSCSS from library SYS1.CSSLIB with your application. If you use the MQI calls **MQCMIT** and **MQBACK**, you will receive return code MQRC_ENVIRONMENT_ERROR.

CSQBRRSI
: This stub allows you to use MQI calls **MQCMIT** and **MQBACK** ; IBM MQ actually implements these calls as the **SRRCMIT** and **SRRBACK** RRS calls.

For information about building application programs that use the RRS adapter, see The RRS batch adapter.

Where to find more information about the z/OS Batch, TSO, and RRS adapters

You can find more information about the topics in this section in the following sources:

Table 25. Where to find more information about using z/OS Batch with IBM MQ

Topic	Where to look
Setting up the Batch adapters	Task 19: Set up Batch, TSO, and RRS adapters
RRS callable resource recovery services	*MVS Programming: Callable Services for High Level Languages*

z/OS IBM MQ for z/OS and WebSphere Application Server

Use this topic to understand the use of IBM MQ for z/OS by the WebSphere Application Server.

Applications written in Java that are running under WebSphere Application Server can use the Java Message Service (JMS) specification to perform messaging. Point-to-point messaging in this environment can be provided by an IBM MQ for z/OS queue manager.

A benefit of using an IBM MQ for z/OS queue manager to provide the messaging is that connecting JMS applications can participate fully in the functionality of an IBM MQ network. For example, they can use the IMS bridge, or exchange messages with queue managers running on other platforms.

Connection between WebSphere Application Server and a queue manager

See Using IBM MQ and WebSphere Application Server together for more information.

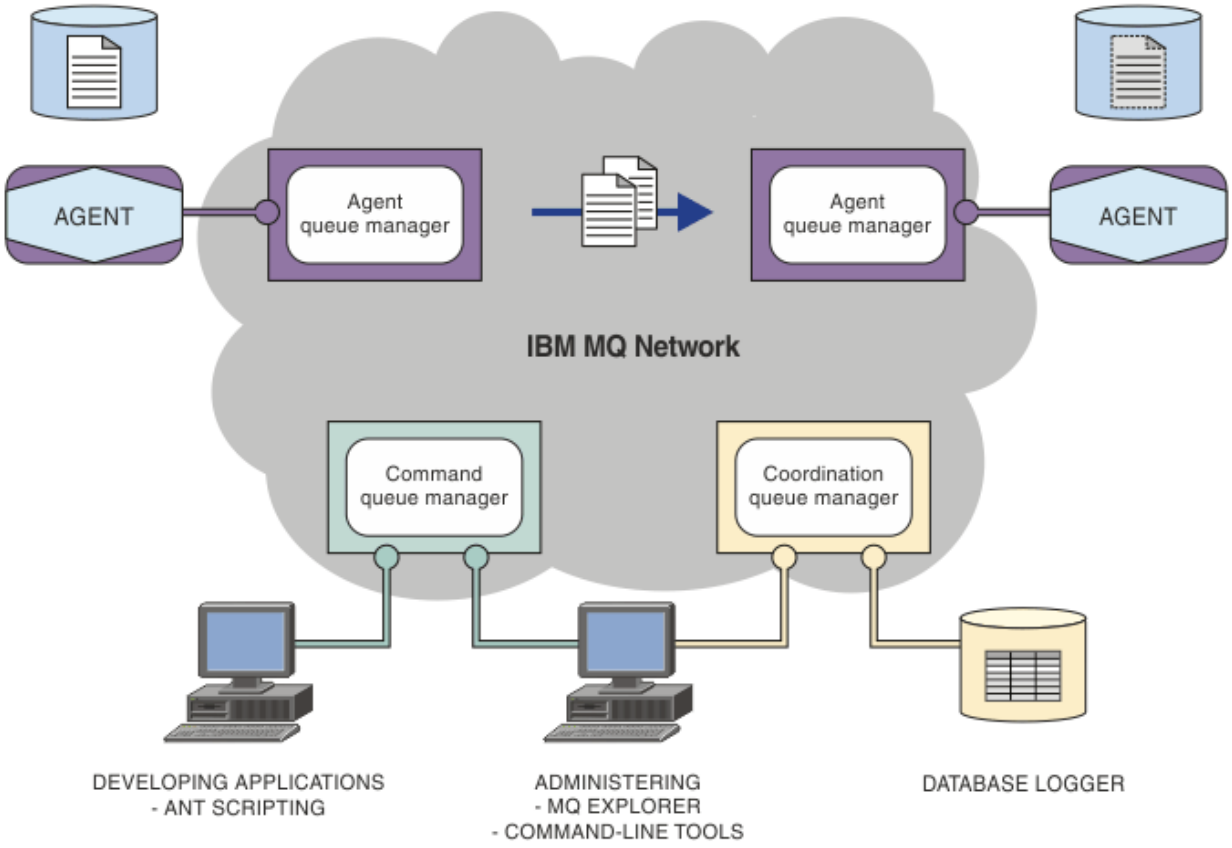
Using IBM MQ functions from JMS applications

By default, JMS messages held on IBM MQ queues use an MQRFH2 header to hold some of the JMS message header information. Many legacy IBM MQ applications cannot process messages with these headers, and require their own characteristic headers, for example the MQCIH for CICS Bridge, or MQWIH for IBM MQ Workflow applications. For more details about these special considerations, see Mapping JMS messages onto IBM MQ messages.

Managed File Transfer

Managed File Transfer transfers files between systems in a managed and auditable way, regardless of file size or the operating systems used.

You can use Managed File Transfer to build a customized, scalable, and automated solution that enables you to manage, trust, and secure file transfers. Managed File Transfer eliminates costly redundancies, lowers maintenance costs, and maximizes your existing IT investments.



The diagram shows a simple Managed File Transfer topology. There are two agents, each connect to their own agent queue manager in an IBM MQ network. A file is transferred from the agent on the one side of the diagram, through the IBM MQ network, to the agent on the other side of the diagram. Also in the IBM MQ network are the coordination queue manager and a command queue manager. Applications and tools connect to these queue managers to configure, administer, operate, and log Managed File Transfer activity in the IBM MQ network.

Managed File Transfer can be installed as four different options, depending on your operating system and overall setup. These options are Managed File Transfer Agent, Managed File Transfer Logger, Managed

File Transfer Service, or Managed File Transfer Tools. For more information, see Managed File Transfer product options.

You can use Managed File Transfer to perform the following tasks:

- Create managed file transfers
  - Windows Linux Create new file transfers from IBM MQ Explorer on Linux or Windows platforms.
  - Create new file transfers from the command line on all supported platforms.
  - Integrate file transfer function into the Apache Ant tool.
  - Write applications that control Managed File Transfer by putting messages on agent command queues.
  - Schedule file transfers to take place at a later time. You can also trigger scheduled file transfers based on a range of file system events, for example a new file being created.
  - Continually monitor a resource, for example a directory, and when the contents of that resource meet some predefined condition, start a task. This task can be a file transfer, an Ant script, or a JCL job.
  - Transfer files to and from IBM MQ queues.
  - Transfer files to and from FTP, FTPS, or SFTP servers.
  - Transfer files to and from Connect:Direct® nodes.
  - Transfer both text and binary files. Text files are automatically converted between the code pages and end-of-line conventions of the source and destination systems.
  - Transfers can be secured, using the industry standards for Secure Socket Layer (SSL) based connections.
- View transfers in progress and log information about all transfers in your network
  - Windows Linux View the status of transfers in progress from IBM MQ Explorer on Linux or Windows platforms.
  - Windows Linux Check the status of completed transfers by using the IBM MQ Explorer on Linux or Windows platforms.
  - Use the Managed File Transfer database logger feature to save log messages to a Db2 or Oracle database.

Managed File Transfer is built on IBM MQ, which provides assured, once-only delivery of messages between applications. You can take advantage of various features of IBM MQ. For example, you can use channel compression to compress the data that you send between agents over IBM MQ channels and use SSL channels to secure the data that you send between agents. Files are transferred reliably and can tolerate the failure of the infrastructure over which the file transfer is carried out. If you experience a network outage, the file transfer restarts from where it left off when connectivity is restored.

By consolidating file transfer with your existing IBM MQ network, you can avoid spending the resources required to maintain two separate infrastructures. If you are not already an IBM MQ customer, by creating an IBM MQ network to support Managed File Transfer you are building the backbone for a future SOA implementation. If you are already an IBM MQ customer, Managed File Transfer can take advantage of your existing IBM MQ infrastructure including IBM MQ Internet Pass-Thru and IBM Integration Bus.

You can take advantage of IBM MQ high availability solutions to improve the resiliency of your Managed File Transfer configuration. If your agents use replicated data queue managers (RDQMs), then you must configure them to use the floating IP address feature. This means that agents use the same IP address to communicate with whichever of the three RDQM instances is currently running and automatically reconnect on failover (see RDQM high availability and Creating and deleting a floating IP address). If you use the multi-instance queue manager solution, then applications use a different IP address to communicate with each instance, which is handled by client reconnect on failover (see Multi-instance queue managers and Channel and client reconnection).

Managed File Transfer integrates with a number of other IBM products:

IBM Integration Bus

Process files that have been transferred by Managed File Transfer as part of an IBM Integration Bus flow. For more information, see Working with MFT from IBM Integration Bus.

IBM Sterling Connect:Direct

Transfer files to and from an existing Connect:Direct network by using the Managed File Transfer Connect:Direct bridge. For more information, see The Connect:Direct bridge.

IBM Tivoli® Composite Application Manager

IBM Tivoli Composite Application Manager provides an agent that you can use to monitor information that is published to the coordination queue manager.

Related concepts

Managed File Transfer product options

"MFT topology overview" on page 286
An overview of how Managed File Transfer agents are connected with the coordination queue manager in an IBM MQ network.

"How does MFT work with IBM MQ?" on page 285
Managed File Transfer interacts in a number of ways with IBM MQ.

How does MFT work with IBM MQ?

Managed File Transfer interacts in a number of ways with IBM MQ.

- Managed File Transfer transfers files between agent processes by dividing each file into one or more messages and transmitting the messages through your IBM MQ network.
- The agent processes move file data by using nonpersistent messages to minimize the impact on your IBM MQ logs. By communicating with one another the agent processes regulate the flow of messages containing file data. This prevents messages containing file data building up on IBM MQ transmission queues and ensures that if any of the nonpersistent messages are not delivered, the file data is sent again.
- Managed File Transfer agents use a number of IBM MQ queues. For more information, see MFT system queues and the system topic.
- Although some of these queues are strictly for internal use, an agent can accept requests in the form of specially formatted command messages sent to a specific queue that the agent reads from. Both the command-line commands and the IBM MQ Explorer plugin send IBM MQ messages to the agent to instruct the agent to perform the wanted action. You can write IBM MQ applications that interact with the agent in this way. For more information, see Controlling MFT by putting messages on the agent command queue.
- Managed File Transfer agents send information about their state and the progress and outcome of transfers to an MQ queue manager that has been designated as the coordination queue manager. This information is published by the coordination queue manager and can be subscribed to by applications that want to monitor transfer progress or keep records of the transfers that have occurred. Both the command-line commands and the IBM MQ Explorer plug-in can use the information that is published. You can write IBM MQ applications that use this information. For more information about the topic that the information is published to, see SYSTEM.FTE topic.
- Key components of Managed File Transfer take advantage of the capability of IBM MQ queue managers to store and forward messages. This means that if you suffer an outage, unaffected parts of your infrastructure can continue to transfer files. This extends to the coordination queue manager, where a combination of store and forward and durable subscriptions allow the coordination queue manager to tolerate becoming unavailable without losing key information about the file transfers that have taken place.

MFT topology overview

An overview of how Managed File Transfer agents are connected with the coordination queue manager in an IBM MQ network.

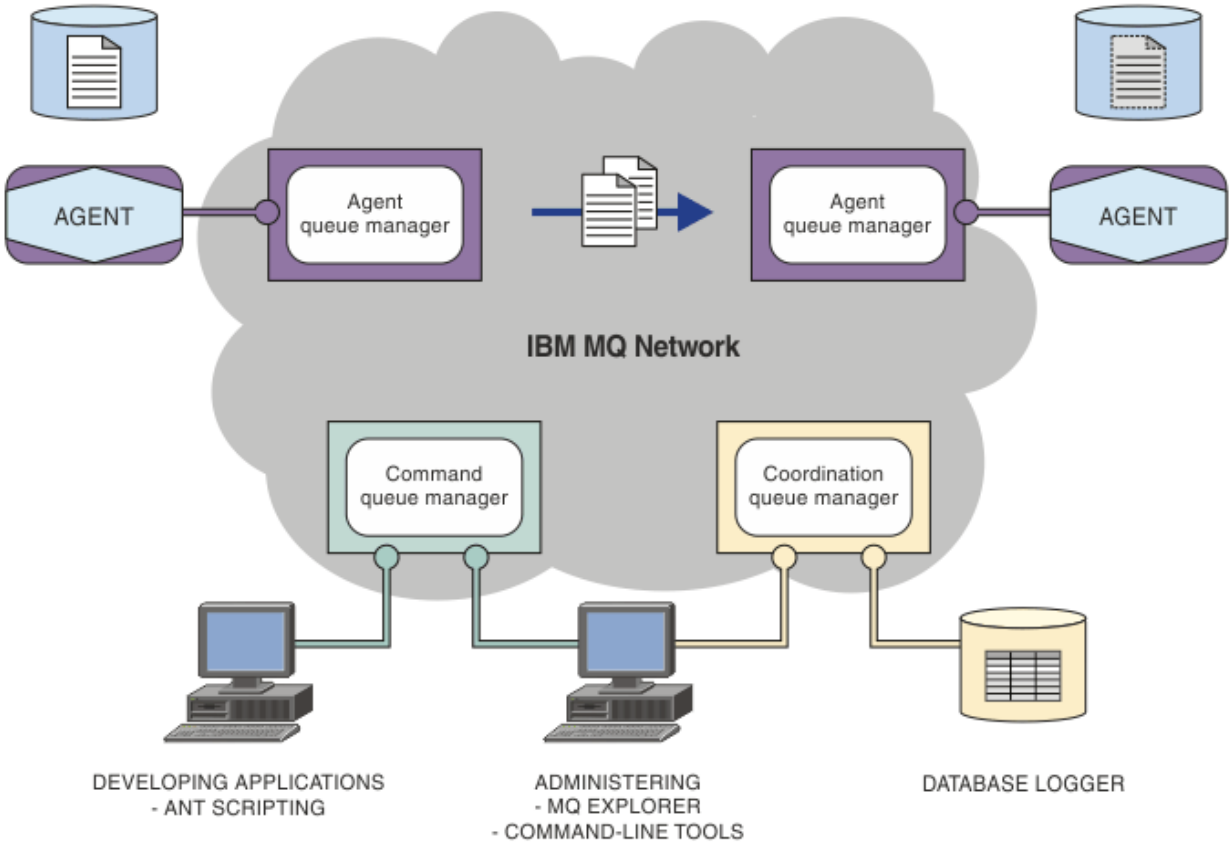
Managed File Transfer agents send and receive the files that are transferred. Each agent has its own set of queues on its associated queue manager and the agent is attached to its queue manager in either bindings or client mode. An agent can also use the coordination queue manager as its queue manager.

The coordination queue manager broadcasts audit and file transfer information. The coordination queue manager represents a single point for the collection of agent, transfer status, and transfer audit information. The coordination queue manager is not required to be available in order for transfers to take place. If the coordination queue manager temporarily becomes unavailable, transfers continue as normal. Audit and status messages are stored in the agent queue managers until the coordination queue manager became available, and can then be processed as normal.

Agents register with the coordination queue manager and publish their details to that queue manager. This agent information is used by the Managed File Transfer plugin to enable the start of transfers from the IBM MQ Explorer. The agent information collected on the coordination queue manager is also used by the commands to display agent information and agent status.

Transfer status and transfer audit information is published on the coordination queue manager. The transfer status and transfer audit information is used by the Managed File Transfer plug-in to monitor the progress of transfers from the IBM MQ Explorer. The transfer audit information stored on the coordination queue manager can be retained to provide auditability.

The command queue manager is used to connect to the IBM MQ network and is the queue manager connected to when you issue Managed File Transfer commands.



Related concepts

"Managed File Transfer" on page 283

Managed File Transfer transfers files between systems in a managed and auditable way, regardless of file size or the operating systems used.

"How does MFT work with IBM MQ?" on page 285
Managed File Transfer interacts in a number of ways with IBM MQ.

Managed File Transfer scenario

MFT REST API overview

The REST API supports certain Managed File Transfer commands, including listing transfers, and details about file transfer agents.

The REST API includes options to list all current Managed File Transfer transfers and to query the status of Managed File Transfer agents. For more information, see Getting started with the REST API MFT.

IBM MQ Internet Pass-Thru

IBM MQ Internet Pass-Thru (MQIPT) is an optional component of IBM MQ that can be used to implement messaging solutions between remote sites across the internet.

To obtain the MQIPT installation files for IBM MQ 9.4.x, go to IBM Fix Central for IBM MQ.

You can use MQIPT to connect any supported version of IBM MQ. You do not have to install any other IBM MQ components at the same version as MQIPT.

If you have purchased IBM MQ entitlement, you can install as many copies as required of MQIPT. MQIPT installations are not counted against your purchased IBM MQ entitlement. For more information about IBM MQ licensing, see IBM MQ license information.

Note: This documentation relates to MQIPT in IBM MQ 9.4. For the MQIPT support pack (version 2.1) documentation in IBM Documentation, see MQIPT (SupportPac MS81) in the IBM MQ 9.0 documentation.

Note: If you are using MQIPT 2.1 or earlier, you are encouraged to upgrade to MQIPT for IBM MQ 9.4, as the end of support date for the MQIPT support pack was 30th September 2020.

IBM MQ Internet Pass-Thru runs as a stand-alone service that can receive and forward IBM MQ message flows, either between two IBM MQ queue managers or between an IBM MQ client and an IBM MQ queue manager.

MQIPT enables this connection when the client and server are not on the same physical network.

One or more instances of MQIPT can be placed in the communication path between two IBM MQ queue managers, or between an IBM MQ client and an IBM MQ queue manager. The instances of MQIPT allow the two IBM MQ systems to exchange messages without needing a direct TCP/IP connection between the two systems. This architecture is useful if the firewall configuration prohibits a direct TCP/IP connection between the two systems.

MQIPT listens on one or more TCP/IP ports for incoming connections. These connections can carry either normal IBM MQ messages, IBM MQ messages tunneled inside HTTP, or messages encrypted using Transport Layer Security (TLS) or Secure Sockets Layer (SSL). MQIPT can handle multiple concurrent connections.

The IBM MQ channel that makes the initial TCP/IP connection request is referred to as the *caller*, the channel to which it is attempting to connect as the *responder*, and the queue manager that it is ultimately trying to contact as the *destination queue manager*.

MQIPT holds data in memory as it forwards it from its source to its destination. No data is saved on disk (except for memory that the operating system pages to disk). The only time that MQIPT accesses the disk explicitly is to read its configuration file and to write connection log and trace records.

The full range of IBM MQ channel types can connect through one or more instances of MQIPT. The presence of MQIPT in a communication path has no effect on the functional characteristics of the connected IBM MQ components. However, the performance of message transfer might be affected.

MQIPT can be used with IBM MQ as described in "Possible configurations of MQIPT" on page 291.

To install MQIPT, see Installing MQIPT.

Related tasks
Configuring IBM MQ Internet Pass-Thru
Administering and configuring IBM MQ Internet Pass-Thru
Related reference
IBM MQ Internet Pass-Thru configuration reference

Uses of MQIPT

There are a number of potential uses for IBM MQ Internet Pass-Thru (MQIPT).

MQIPT can be used as a channel concentrator

By using MQIPT in this way, channels to or from multiple separate hosts can appear to a firewall as if they are all to or from the MQIPT host. This makes it easier to define and manage firewall filtering rules.

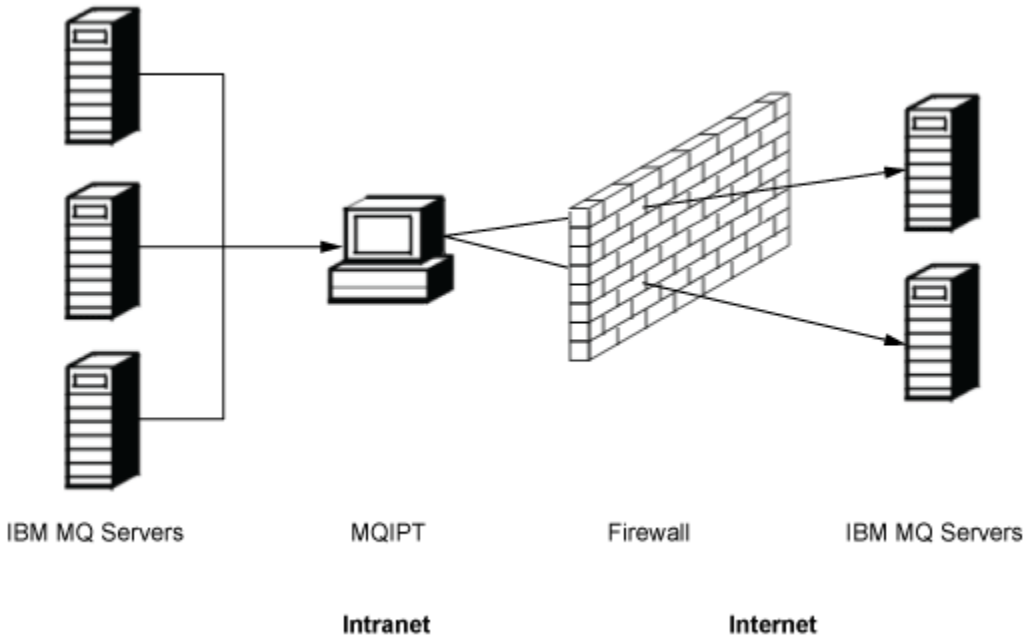


Figure 79. Example of MQIPT as a channel concentrator

MQIPT can be placed in a DMZ to provide a single point of access

If MQIPT is placed within a DMZ firewall (a firewall configuration for securing local area networks), on a computer with a known and trusted internet protocol (IP) address, MQIPT can be used to listen for incoming IBM MQ channel connections which it can then forward to the trusted intranet; the inner firewall must allow this trusted computer to make inbound connections. In this configuration, MQIPT prevents external requests for access from receiving the true IP addresses of the computers in the trusted intranet. In this way, MQIPT provides a single point of access. If required, MQIPT can be configured to accept TLS connections, and forward data to the destination using a separate TLS connection, therefore terminating the TLS session in the DMZ.

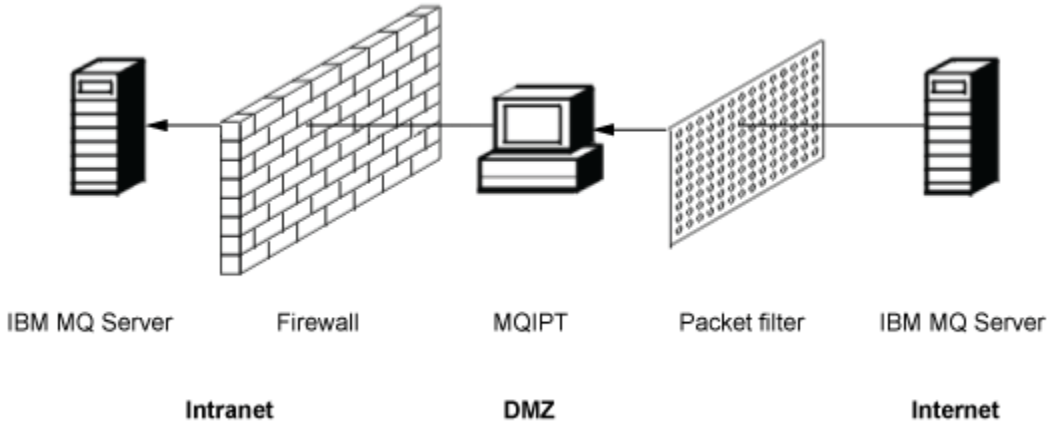


Figure 80. Example of MQIPT in a DMZ firewall

MQIPT can communicate by means of HTTP tunneling

If two instances of MQIPT are deployed in line, they can communicate by using HTTP. The HTTP tunneling feature enables requests to be transmitted through firewalls, by the use of existing HTTP proxies. The first MQIPT inserts the IBM MQ protocol into HTTP and the second extracts the IBM MQ protocol from its HTTP wrapper and forwards it to the destination queue manager.

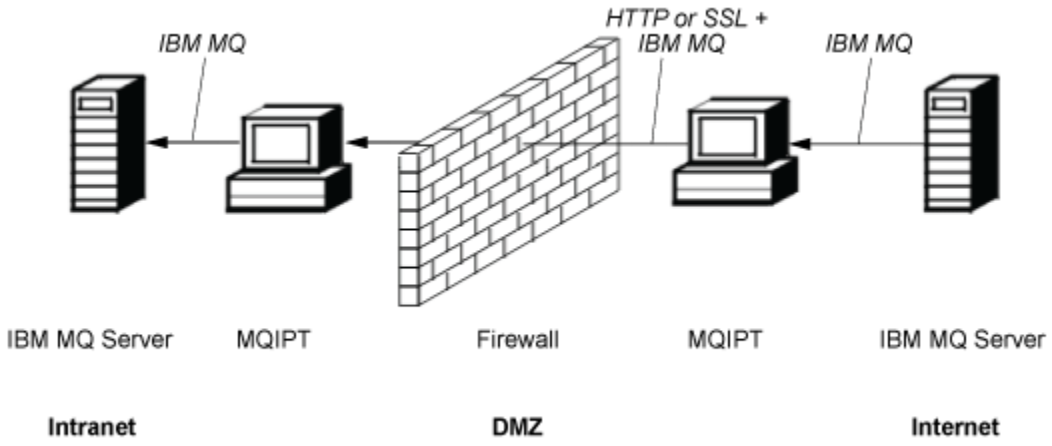


Figure 81. Example of MQIPT and HTTP tunneling

MQIPT can encrypt messages

If MQIPT is configured as in the previous example, requests can be encrypted before transmission through firewalls. The first MQIPT encrypts the data and the second decrypts it using SSL/TLS before sending it to the destination queue manager.

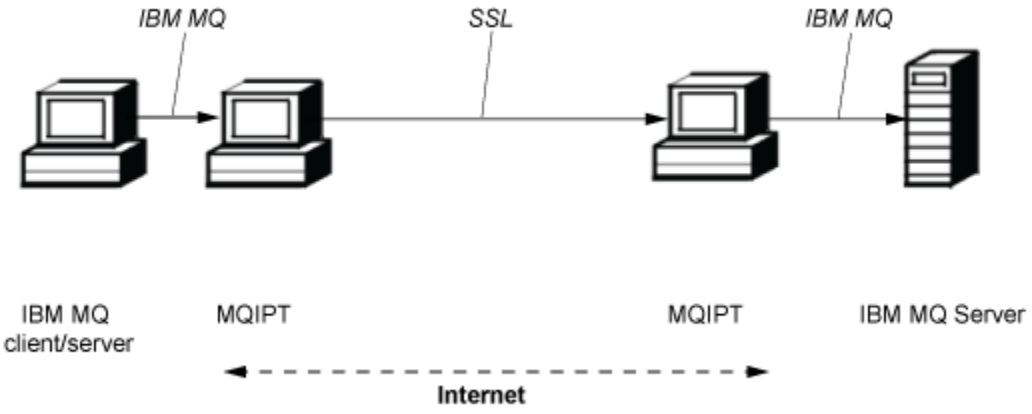


Figure 82. Example of MQIPT and SSL/TLS

How MQIPT works

In its simplest configuration, MQIPT acts as an IBM MQ protocol forwarder. It listens on a TCP/IP port and accepts connection requests from IBM MQ channels.

If a well-formed request is received, MQIPT establishes a further TCP/IP connection between itself and the destination IBM MQ queue manager. It then passes all protocol packets it receives from its incoming connection on to the destination queue manager, and it returns protocol packets from the destination queue manager back to the original incoming connection.

No change to the IBM MQ protocol (client/server or queue manager to queue manager) is involved because neither end is directly aware of the presence of the intermediary. New versions of the IBM MQ client or server code are not required.

To use MQIPT, the caller channel must be configured to use the MQIPT host name and port, not the host name and port of the destination queue manager. This is defined with the **CONNAME** property of the IBM MQ channel. MQIPT reads the incoming data and simply passes it through to the destination queue manager. Other configuration fields, such as the user ID and password in a client/server channel, are similarly passed to the destination queue manager.

Multiple queue managers

MQIPT can be used to allow access to more than one destination queue manager. For this to work, there must be a mechanism to tell MQIPT which queue manager to connect to, so MQIPT uses the incoming TCP/IP port number to determine which queue manager to connect to.

You can therefore configure MQIPT to listen on multiple TCP/IP ports. Each listening port is mapped to a destination queue manager through an MQIPT *route*. You can define up to 100 such routes, which associate a listening TCP/IP port with the host name and port of the destination queue manager. This means that the host name (IP address) of the destination queue manager is never visible to the originating channel. Each route can handle multiple connections between its listening port and destination, each connection acting independently.

MQIPT configuration file

MQIPT uses a configuration file called `mqipt.conf`. This file contains definitions of all routes and their associated properties. See Administering and configuring IBM MQ Internet Pass-Thru for more information about `mqipt.conf`.

When MQIPT is launched, it starts each route that is listed in the configuration file. Messages are written to the system console showing the status of each route. When message MQCPI078 is shown for a route, that route is ready to accept connection requests.

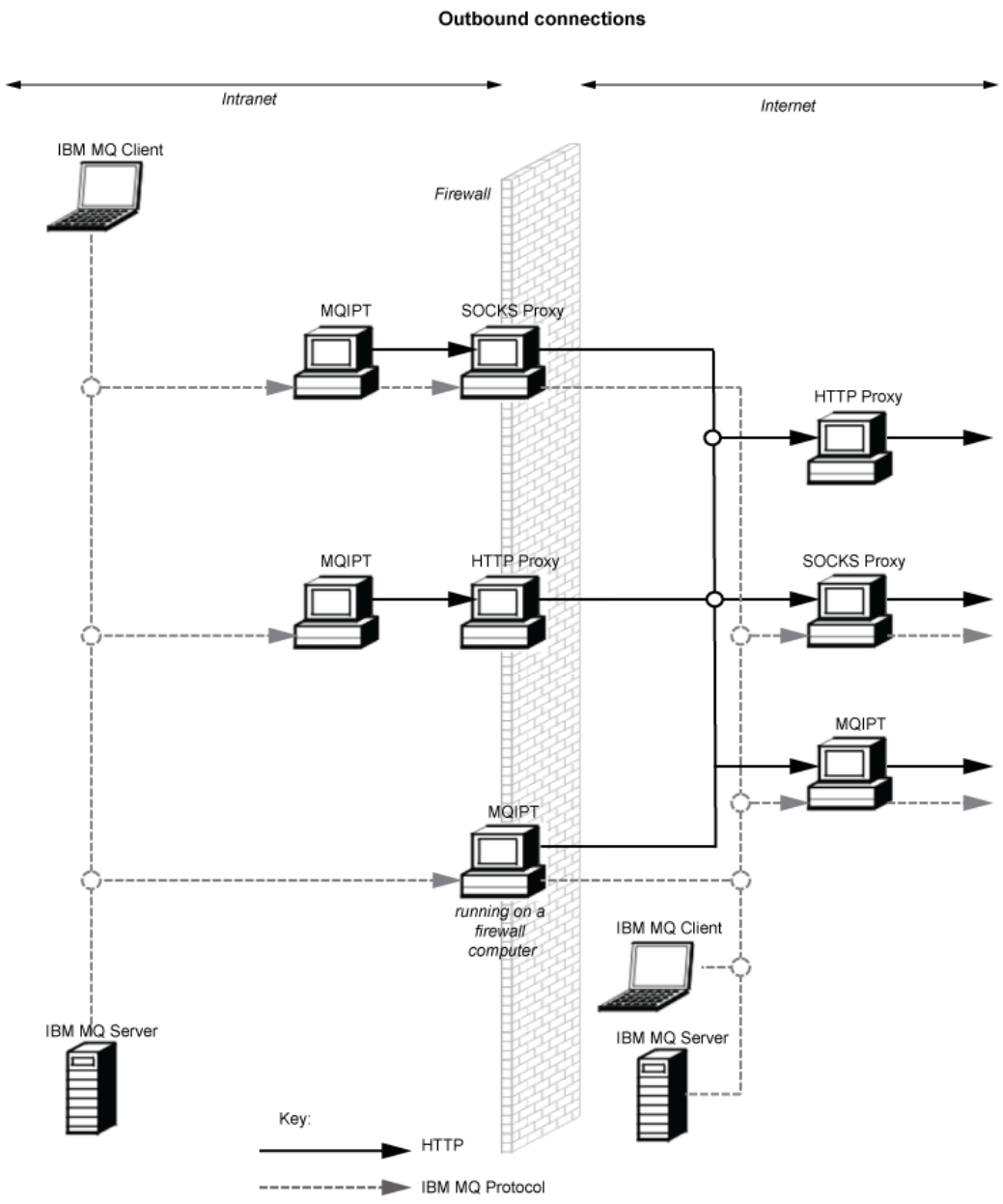
Possible configurations of MQIPT

MQIPT can be used in conjunction with IBM MQ and IBM Integration Bus.

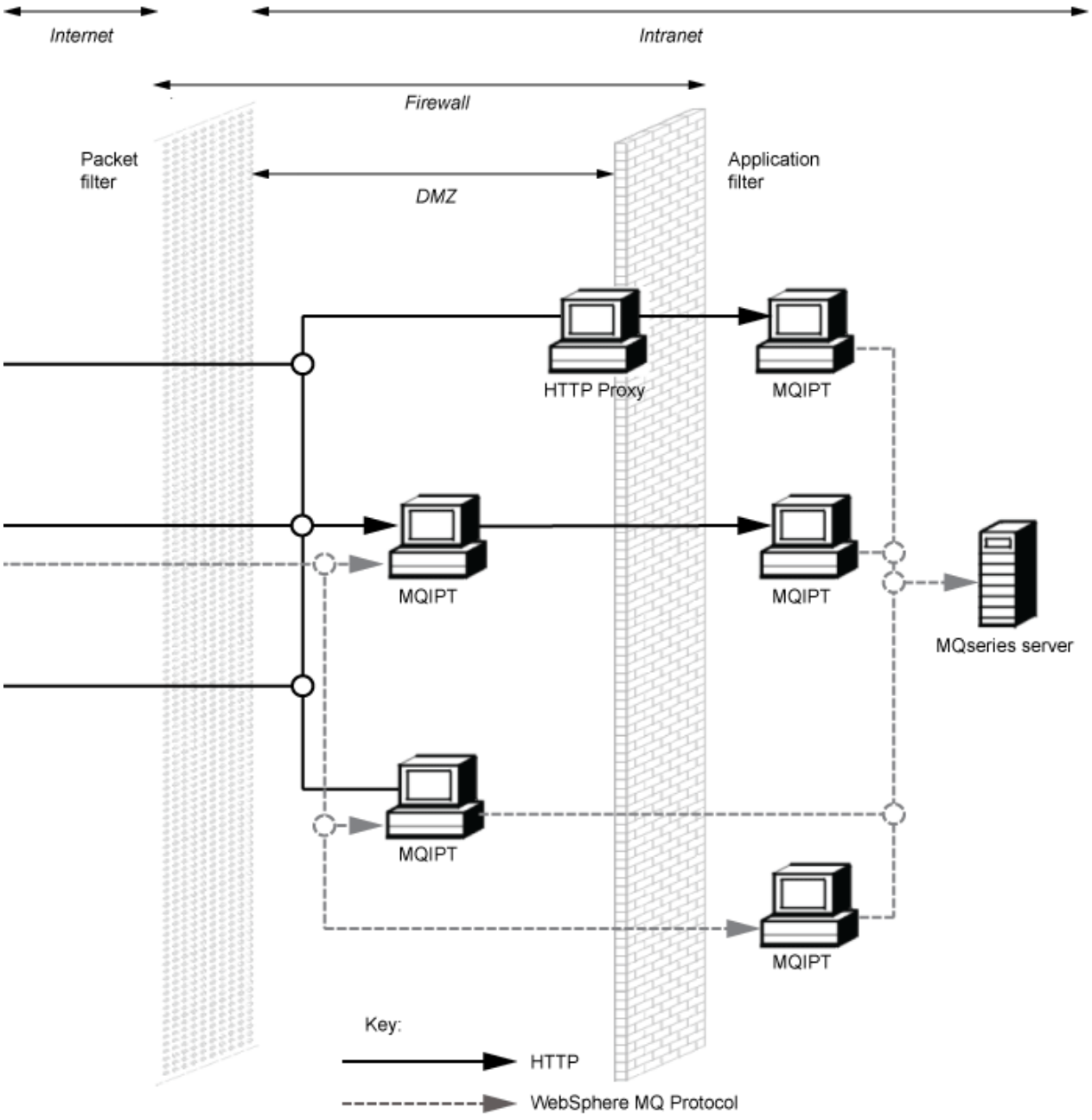
The following multi-part figure shows many of the possible configurations for MQIPT in an IBM MQ topology. It illustrates different ways in which MQIPT can send messages. It shows clients and servers on an intranet, inside a firewall, and on the Internet outside the firewall, passing messages to MQIPT, HTTP proxy, or SOCKS proxy, which forwards them.

The messages are received by an MQIPT proxy or an HTTP proxy in a DMZ before passing the message through the inbound firewall to a server.

Note that the HTTP proxy, SOCKS proxy, and MQIPT computers on the intranet side of the firewall represent the possibility of multiple computers chained together on the internet. For example, an MQIPT computer could communicate through one or more SOCKS or HTTP proxy computers, or further MQIPT computers, before reaching its target.


Outbound connections
Intranet
Internet
IBM MQ Client
Firewall
MQIPT
SOCKS Proxy
HTTP Proxy
MQIPT
HTTP Proxy
SOCKS Proxy
MQIPT
MQIPT
running on a firewall computer
IBM MQ Client
IBM MQ Server
IBM MQ Server
Key:
HTTP
IBM MQ Protocol

Inbound connections



Compatible configurations

Compatible connection scenarios where an IBM MQ client or queue manager communicates with MQIPT. The same or a second MQIPT route is used to communicate with a destination queue manager.

Compatible configurations with a single MQIPT route

You can use a single MQIPT route to communicate with IBM MQ.

The columns in Table 26 on page 294 contain the following information:

1. The protocol used between IBM MQ and the MQIPT route. The connection can be created by either an IBM MQ client or queue manager, and can use either IBM MQ Formats and Protocols (FAP) or a SSL/TLS protocol.
2. The mode in which the MQIPT route operates. The format of the communication across the Internet between MQIPT and IBM MQ, is determined by the configuration of the MQIPT route. Note that where the table mentions SSL, you can also use TLS.
3. The protocol used between the MQIPT route and the destination queue manager.

Table 26. Valid configurations with a single instance of MQIPT

1. IBM MQ source protocol	**2. Mode of the MQIPT route**	**3. IBM MQ destination protocol**
FAP	FAP-proxy (default)	FAP
	FAP-server and SSL-client	SSL/TLS
SSL/TLS	SSL-proxy	SSL/TLS
	SSL-server and FAP-client	FAP
	SSL-server and SSL-client	SSL/TLS

Compatible configurations with more than one MQIPT route

You might choose to use more than one route, on one or more instances of MQIPT, to communicate with IBM MQ.

The columns in Table 27 on page 295 contain the following information:

1. The protocol used between IBM MQ and the first MQIPT route. The connection can be created by either an IBM MQ client or queue manager, and can use either IBM MQ Formats and Protocols (FAP) or a SSL/TLS protocol.
2. The mode in which the first MQIPT route operates. The format of the communication across the Internet between MQIPT and IBM MQ, is determined by the configuration of the MQIPT route. Note that where the table mentions SSL, you can also use TLS.
3. The mode in which the second MQIPT route operates.
4. The protocol used between the second MQIPT route and the destination queue manager.

Table 27. Valid configurations with multiple instances of MQIPT			
1. IBM MQ source protocol	**2. Mode of the first MQIPT route**	**3. Mode of the second MQIPT route**	**4. IBM MQ destination protocol**
FAP (default)	FAP-proxy (default)	FAP-proxy (default)	FAP
	FAP-server and SSL-client	SSL-proxy	SSL/TLS
		SSL-server and FAP-client	FAP
		SSL-server and SSL-client	SSL/TLS
	HTTP-client	HTTP-server and SSL-client	SSL/TLS
	HTTPS-client	HTTPS-server and SSL-client	SSL/TLS
	HTTP-client	HTTP-server	FAP
	HTTPS-client	HTTPS-server	FAP
SSL/TLS	SSL-proxy	SSL-proxy	SSL/TLS
		SSL-server and FAP-client	FAP
		SSL-server and SSL-client	SSL/TLS
	HTTP-client	HTTP-server	FAP
	HTTPS-client	HTTPS-server	SSL/TLS
	HTTP-client	HTTP-server and SSL-client	FAP
	HTTPS-client	HTTPS-server and SSL-client	SSL/TLS

Supported channel configurations

All IBM MQ channel types are supported, but configuration is restricted to TCP/IP connections. To an IBM MQ client or queue manager, MQIPT appears as if it is the destination queue manager. Where channel configuration requires a destination host and port number, the MQIPT host name and listener port number are specified.

Client/server channels

MQIPT listens for incoming client connection requests, and then forwards them by using either HTTP tunneling, SSL/TLS, or as standard IBM MQ protocol packets. If MQIPT is using HTTP tunneling or SSL/TLS it forwards them on a connection to a second MQIPT. If it is not using HTTP tunneling, it forwards them on a connection to what it sees as the destination queue manager (although this could in turn be a further MQIPT). When the destination queue manager has accepted the client connection, packets are relayed between client and server.

Cluster sender/receiver channels

If MQIPT receives an incoming request from a cluster-sender channel, it assumes the queue manager has been SOCKS-enabled and the true destination address will be obtained during the SOCKS handshaking process. It forwards the request to the next MQIPT or destination queue manager in exactly the same way as for client connection channels. This also includes auto-defined cluster-sender channels.

Sender/receiver
If MQIPT receives an incoming request from a sender channel, it forwards it to the next MQIPT or destination queue manager in exactly the same way as for client connection channels. The destination queue manager validates the incoming request and starts the receiver channel if appropriate. All communications between sender and receiver channel (including security flows) are relayed.

Requester/server
This combination is handled in the same manner as the preceding configurations. Validation of the connection request is performed by the server channel at the destination queue manager.

Requester/sender
The "callback" configuration could be of use if the two queue managers are not allowed to establish direct connections to each other, but are both allowed to connect to MQIPT and to accept connections from it.

Server/requester and server/receiver
These are handled by MQIPT in the same way that it handles the `Sender/Receiver` configuration.

Channel termination and failure conditions

When MQIPT detects closure (either normal or abnormal) of an IBM MQ channel, it propagates the channel closure. If you close a route by using MQIPT, all channels going through that route are closed.

MQIPT provides an optional idle-timeout facility. If MQIPT detects that a channel has been idle for a period of time exceeding the timeout, it performs an immediate shutdown on the two connections in question.

The IBM MQ systems at either end of the channel observe these abnormal shutdown conditions either as network failures or as termination of the channel by their partner. The channel is then able to restart and recover (if the failure happens during a protocol in-doubt period) as if MQIPT was not being used.

Safety of messages

IBM MQ distributed queue management ensures that messages are delivered properly. This is still the case when MQIPT is present between the two ends of the channel. MQIPT does not store any message data or participate in the sync point procedure that ensures correct message delivery.

When using fast, non-persistent IBM MQ messages, if the MQIPT route fails or is restarted when an IBM MQ message is in transit, the message might be lost. Before restarting the route, make sure that all IBM MQ channels using the MQIPT route are inactive.

For more information about the safety of messages in IBM MQ, see Safety of messages.

Multi-instance queue managers and high availability

MQIPT can be used with multi-instance queue managers in high availability environments.

MQIPT has no persistent state and so there is no benefit in failing over MQIPT to another system. Instead, have multiple instances of MQIPT with identical `mqipt.conf` configuration files running on different systems. Monitor each instance of MQIPT for availability and restart it (on the same system) if necessary. This provides a set of identical MQIPT instances that can be used to route connections. You must then ensure that IBM MQ can route connections to MQIPT and that MQIPT can forward those connections to the destination queue manager.

Outbound IBM MQ channels can be directed to an available MQIPT instance in various ways, for example:

- Use a load balancer or high availability router, such as the IBM Network Dispatcher from the WebSphere Edge Components product.
- Specify multiple connection names in the IBM MQ channel definition using a comma-separated list. IBM MQ then tries to connect to each MQIPT address in turn until it finds an available MQIPT instance.

You must also direct connections from MQIPT to the destination queue manager. If the high-availability configuration ensures that the IP address fails over with the destination queue manager, then no special

MQIPT configuration is required: specify the destination IP address in the **Destination** route property and allow the failover operation to move the IP address with the queue manager.

However, if the IP address of the queue manager changes after a failover then you must arrange for MQIPT to forward the connection to the correct destination. This could be done in one of several ways:

- Write a routing exit that checks which IP address and port number are accessible, and then override the route destination for each connection. Some sample routing exits are provided with MQIPT; they can be adapted for this purpose.
- Use a high availability load balancer to redirect the connection.
- Define multiple MQIPT routes, one for each IP address and port where the queue manager might be running. Then direct the IBM MQ connections to the various MQIPT routes, for example by listing all of the route IP addresses and port numbers in a comma-separated list in the connection name of the outbound channel.

It is also important to tune all of the end-to-end components on the network path:

1. Connection attempts to unavailable systems must fail promptly so that reconnect attempts can move on to the first available destination.

   For MQIPT SSL routes, tune the **SSLClientConnectTimeout** route property to ensure prompt connection failure for unavailable destinations. Refer to the IBM MQ documentation for details of IBM MQ tuning parameters. Also, consult your operating system documentation for details of TCP/IP tuning for the operating system. In all cases, failed connection attempts should quickly return a network failure (for example, a TCP reset packet), or should time out without undue delay.
2. Active connections to a failed system must be severed promptly so that new connections can be established.

   You should also consider the impact of a failover at a time when connections are actively using MQIPT. It is likely that network connections will be severed during a failover. For client applications, you can use the IBM MQ automatic client reconnection feature to re-establish severed connections. For message channels, you can specify a short retry interval so that the channel reconnects promptly. Consult the IBM MQ documentation for more information about automatic client reconnection and message channel retry configuration.

The IBM MQ Console and REST API

You can use the IBM MQ Console and REST API to administer IBM MQ, and perform messaging operations, by using HTTP.

- You can use the IBM MQ Console to perform basic administration tasks from a web browser. For more information, see Administration using the IBM MQ Console.
- You can use the administrative REST API to administer IBM MQ objects, such as queue managers and queues, and Managed File Transfer agents and transfers. For more information, see Administration using the REST API.
- You can use the messaging REST API to perform simple point-to-point and publish messaging. For more information, see Messaging using the REST API.

Installation options

The IBM MQ Console and REST API run in a WebSphere Liberty server, called mqweb. From IBM MQ 9.3.5, you can install the mqweb server either as an optional component in an IBM MQ installation, or as a stand-alone IBM MQ Web Server installation.

Linux V 9.4.0 **Stand-alone IBM MQ Web Server installation**

From IBM MQ 9.4.0, the mqweb server can run in a stand-alone installation of IBM MQ Web Server. A stand-alone IBM MQ Web Server installation enables you to install and run the mqweb server on systems that are separate to your IBM MQ installations. Installing a stand-alone IBM MQ Web Server gives greater flexibility as to which systems, and the number of systems, that you choose to run

your mqweb servers on. If required, several instances of the mqweb server can be run on different machines to provide the scalability and availability that you need.

If you have purchased IBM MQ entitlement, you can install as many copies as required of the stand-alone IBM MQ Web Server. IBM MQ Web Server installations are not counted against your purchased IBM MQ entitlement. For more information on IBM MQ licensing, see IBM MQ license information.

The following restrictions apply in a stand-alone IBM MQ Web Server installation:

- The IBM MQ Console can be used to administer only remote queue managers.
- The messaging REST API can be used only with remote queue managers.
- The administrative REST API is not available.

The stand-alone IBM MQ Web Server is supported only on Linux platforms.

For more information about installing the stand-alone IBM MQ Web Server, see Installing the stand-alone IBM MQ Web Server.

Optional component of an IBM MQ installation

You can choose to install the IBM MQ Console and REST API component as part of an IBM MQ installation.

All IBM MQ Console and REST API features are available when the mqweb server runs in an IBM MQ installation.

- The IBM MQ Console can be used to administer local and remote queue managers.
- The messaging REST API can be used with local and remote queue managers.
- The administrative REST API can be used to administer local and remote queue managers.

To use the IBM MQ Console and REST API component, install the following component as part of your IBM MQ installation:

- AIX On AIX, install the `mqm.web.rte` fileset.
- IBM i On IBM i, install the WEB component.
- Linux On Linux, install the `MQSeriesWeb` component.
- Windows On Windows, install the `Web Administration` feature.
- z/OS On z/OS, install the `IBM MQ for z/OS UNIX System Services Web Components` feature.

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