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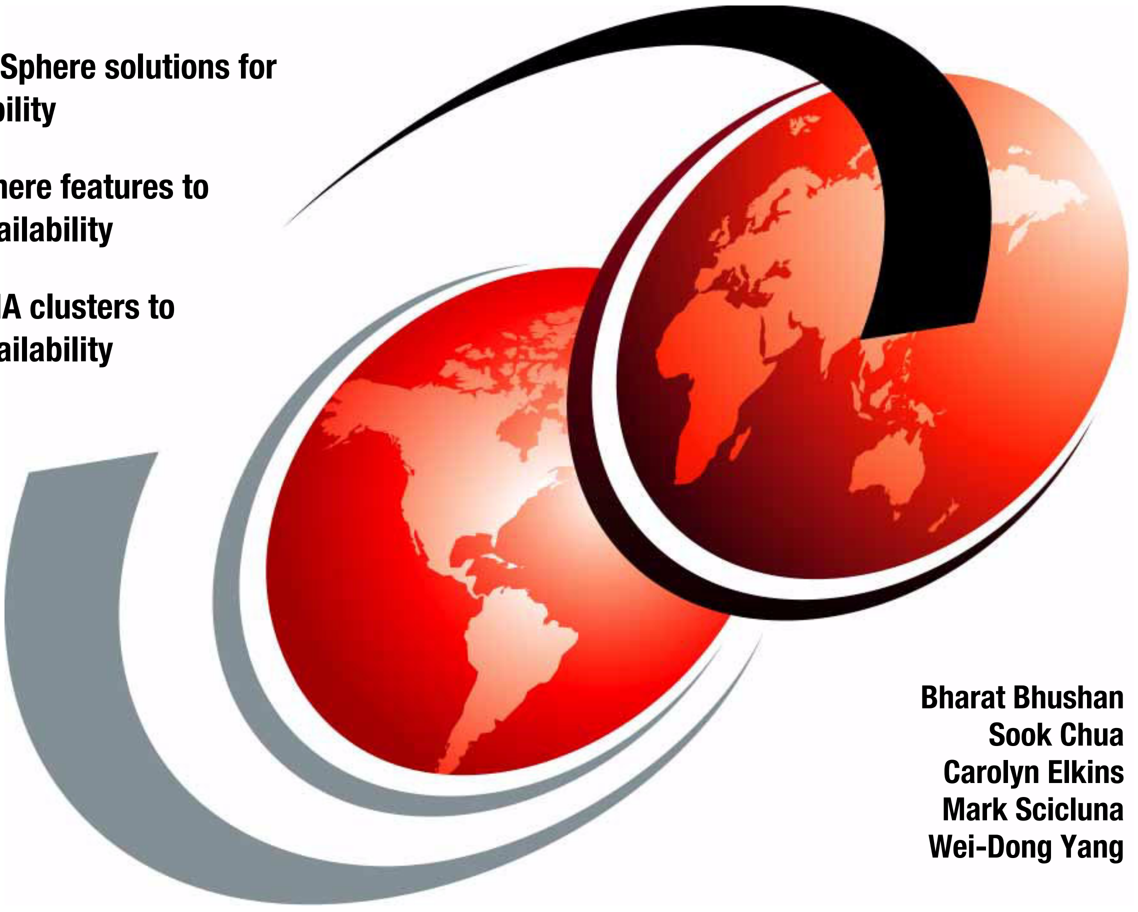
High Availability in WebSphere Messaging Solutions



Design WebSphere solutions for high availability

Use WebSphere features to increase availability

Use PowerHA clusters to increase availability

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International Technical Support Organization

High Availability in WebSphere Messaging Solutions

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

First Edition (April 2010)

This edition applies to WebSphere Message Broker V7, WebSphere MQ V7, IBM DataPower Appliance XI50 3.8.0.

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Preface

This IBM® Redbooks® publication is for anyone needing to increase WebSphere® messaging availability, especially people interested in the new capabilities of WebSphere MQ and WebSphere Message Broker. It discusses and demonstrates solutions to provide high availability for WebSphere Messaging solutions. For the distributed platforms, this ranges from the traditional PowerHA™ for AIX® to the new WebSphere MQ multi-instance queue managers and WebSphere Message Broker multi-instance brokers. For the appliance users, we included solutions for WebSphere DataPower®. For enterprises that need continuous availability of WebSphere MQ messages, MQ Queue Sharing Groups and the CICS® Group Attach features are demonstrated.

The book includes guidance on HA options, such as when you might need PowerHA (or a similar solution for your platform), when the multi-instance features work for your applications, and when duplexing the coupling facility structures might be appropriate.

The team who wrote this book

This book was produced by a team of specialists from around the world working at the International Technical Support Organization, Raleigh Center.

Bharat Bhushan has over 13 years experience in the IT industry, which includes design, development, and consulting of real-time, mission-critical applications. His interests include Information Security, Integration, Messaging, SOA, and Web 2.0-based technologies. Since joining IBM in July 2007, Bharat has lead complex and multifaceted programs of work for high profile clients. Before joining IBM, Bharat worked across Europe, the Middle East, and Africa in various technical and client management roles.

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Mark Scicluna is an IT Specialist in the Application Management Services Practice in Australia. He has 14 years of experience in the analysis, design, and implementation of software solutions, primarily in the integration of distributed systems. He has a broad range of expertise including middleware technologies, Java/J2EE, XML, and Web Services but is primarily focussed on WebSphere MQ and WebSphere Message Broker. He holds a degree in Mathematical and Computer Science at the University of Adelaide.

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Part 1

High availability concepts

This part provides information about high availability concepts and includes an overview of techniques and products that can be used to achieve high availability.

1

Introduction to availability

At one time or another, most of us have experienced an ATM service not being available to dispense cash or an online service being unavailable for access due to maintenance. Or a time when a customer service representative asks you to call back later because their system is down. Or you click a button and receive a `500 Internal Server Error` response.

These scenarios are typical system outages. The ATM and online service examples are typically planned outages intended for maintenance work. These outages are usually scheduled at quiet times with low activity for a predetermined amount of time. The customer service representative (CSR) and transaction error examples, however, are unplanned outages due to hardware or software failures. Occurrences during peak time have significant impacts and serious consequences where critical systems are involved.

As IT becomes more pervasive in businesses and our daily lives, the impact of downtime is increasingly significant. Outages affect productivity, create inconveniences, and result in loss of business. Increased dependence on IT increases needs for highly available systems. Globalization of business places a new demand for systems to be highly available and continuously operational. This 24X7 availability calls for the elimination of unplanned and planned outages.

This chapter begins with definitions of system availability terms followed by causes of unplanned outages. It includes a discussion on high availability measurement, failover strategies, and software and hardware redundancies. The chapter concludes with a discussion on factors to consider in the design of a high availability system.

1.1 System availability terms and definitions

In this section, we define high availability and continuous availability as well as discussing the differences between these two availability concepts.

This IBM Redbooks publication focuses on high availability for IBM WebSphere Messaging products.

1.1.1 Availability

Availability in this context is a measure of the accessibility of a system or application, not including scheduled downtime. It can be measured as a ratio of expected system up-time relative to the total system time, which includes uptime and recovery time when the system is down. The following formula illustrates this concept:

```
A = [MTBF/(MTBF + MTTR)] x 100%
```

The following definitions apply to terms in the this equation:

- MTBF: Mean Time Between Failure. This is the average elapsed time between failures
- MTTR: Mean Time To Recover, This is the average time required to recover from a failure

1.1.2 High availability

High availability refers to the ability of a system or component to be operational and accessible when required for use for a specified period of time. The system or component is equipped to handle faults in an unplanned outage gracefully to continue providing the intended functionality.

1.1.3 Continuous availability

Continuous availability refers to the ability of a system or component to be operational and accessible when required for use at all times. The system or component is designed such that a user experiences zero downtime.

Although high availability compensates for unplanned outages, continuous availability handles both planned and unplanned outages. Therefore, continuous availability extends high availability with continuous operation.

1.2 Causes of downtime

System downtime results from planned or unplanned events. Planned downtime can often account for a significant amount of the total downtime. The optimal situation is for systems to be in continuous operation without scheduled down time for maintenance work. However, a long running system is more prone to failures that result in unplanned outages. Such unplanned outages are costly, with significant impacts. Naturally, a user wants to reduce or eliminate these outages.

Studies show that software failures and human errors are the major causes of unplanned outages. Other causes include hardware or infrastructure failures, site disasters, and natural calamities.

The key to implementing a high availability system is to identify and eliminate single points of failure through redundancies, clustering, and failover mechanisms.

1.3 Availability classes

Availability is usually in “9s” notation. Table 1-1 shows six classes of “9s” and their corresponding downtime hours.

Table 1-1 Six classes using 9s notation

9s	Percentage of uptime	Downtime per year	Downtime per week	Downtime per day
One 9	90%	36.5 days	16.9 hours	2.4 hours
Two 9s	99%	3.65 days	1.7 hours	14.4 minutes
Three 9s	99.9%	8.76 hours	10.1 minutes	1.4 minutes
Four 9s	99.99%	52 minutes	1 minute	8.6 seconds
Five 9s	99.999%	5 minutes	6 seconds	86.4 milliseconds
Six 9s	99.999999%	32 seconds	604.8 milliseconds	8.6 milliseconds

A 99% highly available system has a 1% of downtime in its useful life. A more accurate translation of downtime depends upon the system's scheduled operational hours. For example:

- System A is scheduled for 24 hours per day, 365 days per year. A 1% downtime equals 87.6 hours.
- System B is scheduled for 8 hours per day, 5 days per week. A 1% downtime equals 20.8 hours.

These hours, however, do not indicate system's maximum downtime at one time and frequency of downtime.

Continuing with these examples, we can calculate the potential downtime in terms of days:

- System A's 87.6 hours of downtime is equal to 3.65 days of unavailability at one time.
- System B's 20.8 hours of downtime is equal to 0.87 days of unavailability at one time.

Depending upon the business nature, these maximum downtime durations might not be acceptable.

Another important parameter is the frequency of downtime. Consider System C, which is allowed 2.4 hours downtime per day. If the system is down on average for one minute, this means it can go down 144 times a day. Reliability of this system can be considered questionable. As you can see, high availability does not imply reliability.

Understanding these distinctions is important when designing a system that satisfies agreements reached between clients and providers with regard to availability. As companies move towards a service-oriented architecture (SOA), the availability aspect of these service level agreements becomes critical. The ideal service is available to business processes at all times.

1.4 Redundancy

Consider a system made up of three serial components with two linkages, as shown in Figure 1-1.

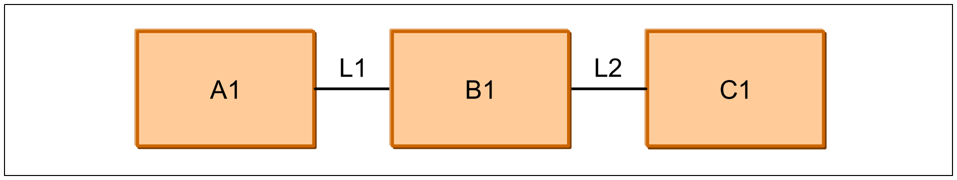


Figure 1-1 System redundancy example

In Figure 1-1, the system = A1 + B1 + C1 + L1 + L2.

All components and links have 99.999% availability, except for B1 which has 90% availability. The system's availability is calculated as shown in the following equation:

```
System Availability = (0.99999) * (0.99999) * (0.90) * (0.99999) *
(0.99999) = 89.96%
```

The system availability drops drastically below 90%. All the “five 9s” components do not compensate for the single “one 9” component. The old saying that a chain is only as strong as its weakest link is certainly true of a system with serial components. Besides, each serial component is a single point of failure.

Suppose the system configures a pair of B components in parallel fashion for redundancy, as in Figure 1-2.

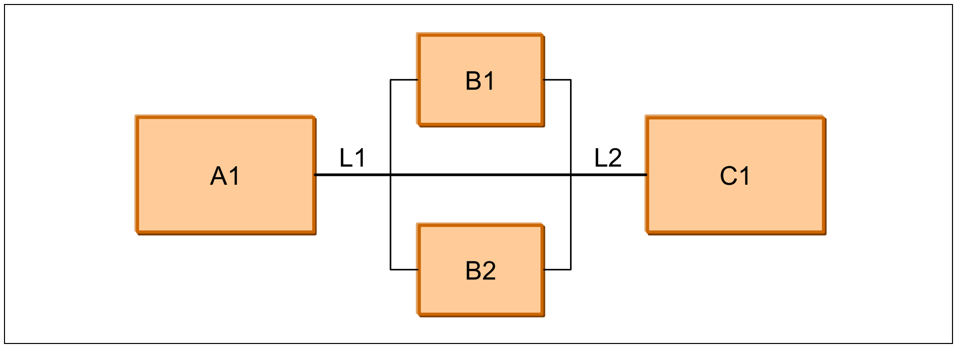


Figure 1-2 System redundancy example

The availability of this parallel configuration is as shown in the following equation:

```
Availability of B1/B2 = 1 – [(1-0.90) * (1-0.90)] = 0.99
```

With the parallel configuration, the system availability is recalculated as shown in the following equation:

```
System Availability = (0.99999) * (0.99999) * (0.99) * (0.99999) *
(0.99999) = 98.99%
```

Redundancy eliminates single points of failure and increases availability. It is a key design consideration in a highly available system. 1.5, "Failover strategies" on page 8 explores the failover strategies available in redundancy.

1.5 Failover strategies

Redundancies mask system and component failures from users. The transparency of failure masking depends upon the following failover strategies:

- Cold standby

  In this failover strategy, the primary component runs actively while the secondary or backup component stays dormant. When the primary component fails, the secondary component is activated to assume an active role. The interruption is visible to users.

- Warm standby

  In this failover strategy, the primary component runs actively with the secondary or backup component running without active participation in workload management. The secondary component receives frequent data updates from the primary component, which means that there are times when both components are not synchronized. When the primary component fails, the secondary component assumes an active role. Because the secondary component has been running passively with partial data, the fail over is faster than a cold standby, with minimal interruption to users.

- Hot standby

  In this failover strategy, the primary and secondary components are actively running as a single, unified system. Active data replication happens between the primary and secondary components. When the primary component fails, the secondary component continues functioning without interruption to users.

Each of these strategies can be applied to hardware and software clustering.

1.6 Software clustering

Clustering is a technique to create multiple copies of components running actively and collaborating seamlessly to present a single, unified system. There are three modes of clustering:

- Vertical clustering

  In vertical clustering (Figure 1-3), multiple copies of the components are running actively on the same physical machine. The components are hot standby or in active replication. This means that failure of one component presents no visible interruption to users. This clustering technique optimizes use of the machine. However, the single physical machine presents a single point of failure.

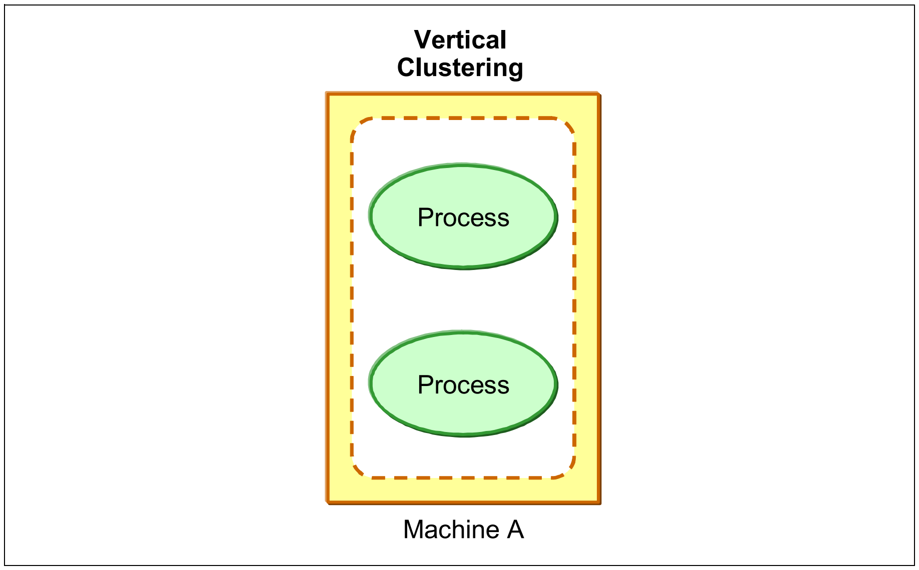


Figure 1-3 Vertical clustering

- Horizontal clustering

  In horizontal clustering (Figure 1-4), components are created on multiple physical machines. This clustering mode achieves similar software redundancy in vertical clustering with the additional benefit of hardware redundancy.

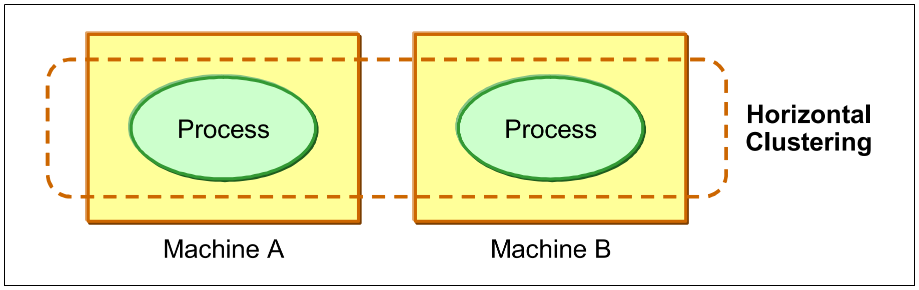


Figure 1-4 Horizontal clustering

- Vertical and horizontal clustering

  Combining vertical and horizontal clustering techniques maximizes use of individual physical machines to achieve high availability, performance throughput and scalability. See Figure 1-5.

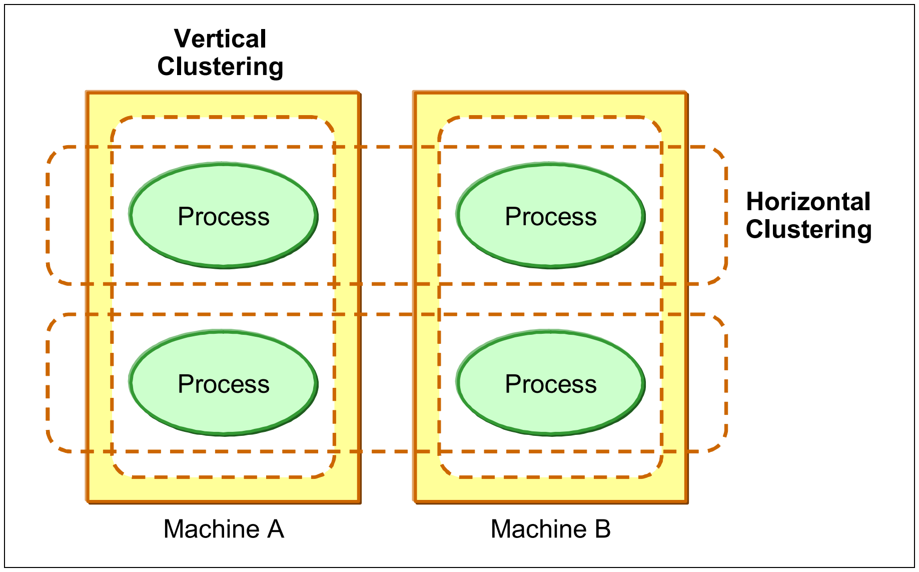


Figure 1-5 Vertical and horizontal clustering

IBM WebSphere products have inherent support for clustering. The clustering techniques supported by the WebSphere products in this book are as shown in Table 1-2.

Table 1-2 Clustering techniques supported by IBM WebSphere products

	Clustering techniques		
Product	**Vertical**	**Horizontal**	**Vertical + Horizontal**
WebSphere Message Broker	x	x	x
WebSphere MQ	x	x	x
WebSphere Application Server	x	x	x
WebSphere DataPower		x	

Besides inherent clustering capability, IBM WebSphere products can also be used with external clustering software such as IBM PowerHA for AIX and IBM Tivoli® System Automation to achieve redundancy.

For more detailed information about PowerHA for AIX setup, see the PowerHA for AIX documentation available in the PowerHA for AIX library at the following Web page:

http://www.ibm.com/servers/eserver/pseries/library/hacmp_docs.html

For more information about Tivoli System Automation Resource Managers, see the IBM Tivoli System Automation for Multiplatforms Guide and Reference at the following Web page:

http://publib.boulder.ibm.com/tividd/td/ITSAFL/SC33-8210-03/en_US/PDF/halgre11.pdf

1.7 Hardware redundancy

Fault tolerance refers to the ability of a system to continue operation in case of failure of one or more of its components. This term is usually referenced with high availability, particularly at the hardware level. Hardware redundancy (the addition of extra hardware for fault detection and toleration) is commonly employed in fault tolerant systems. In this section, we address hardware redundancies at the component, storage, and server levels.

1.7.1 Component redundancy

Component-level devices include, but are not limited to, processors, power supplies, network equipment, and so forth. The processor is the heart of an IT system and a failure constitutes a “machine stops” situation. Resilience can be achieved through multiple processors (SMP) and advanced coupled systems such as IBM Parallel Sysplex®.

An uninterruptible power supply (UPS) protects a system against power fluctuations and main power failure. It continues to supply power from a few minutes to several hours during a power outage. This increases system availability with minimal disruption to users.

Redundancies for network equipment is made through duplication. A backbone network can also be used to increase protection against hardware failures. The backbone network eliminates single point of failure by providing multiple, alternative traffic paths for communication. A redundant backbone further enhances high availability.

1.7.2 Storage redundancy

A system is rendered unusable without data, though it might be highly available or continuously operational. A comprehensive design for storage redundancy should be considered with the system’s data flows, data components, and data availability.

At a high level, storage redundancy can be achieved through the following approaches:

- Disk mirroring and duplexing
- Storage Area Network (SAN)
- Redundant Arrays of Inexpensive Disks (RAID)
- Duplicate data centers to avoid natural disasters.

IBM products such as IBM TotalStorage®, IBM System Storage™ provide solution offerings to develop resilient and secure infrastructures for data storage.

1.7.3 Server redundancy

Server redundancy through hardware clustering mitigates hardware and operating system-level failures. There are generally two modes of hardware clustering:

- Active/active (also known as high availability clusters or HA clusters)

  A HA cluster consists of redundant computer nodes that are used to provide service when the primary system component fails. HA clustering uses heartbeats to monitor the health and status of each computer node in the cluster. When a failure occurs, the application is restarted on the backup node automatically, a process known *failover*. The failover procedure generally involves reassignment of the failed server IP-Address to the backup server, setting file system access, and synchronization of state with the failed server before restarting the application on the backup server.

  There are extensive commercial implementations of HA cluster technologies, (such as IBM PowerHA for AIX) and those that are inherent with IBM Parallel Sysplex.

- Active/passive (also known as load balancing clusters)

  In a load balancing cluster, multiple, homogeneous computer nodes are linked to share computational workload. The cluster provides a logical view of a single virtual machine. It behaves like an HA cluster except that all computer nodes in the cluster are actively participating in the system's workload. When a component fails, there is no failover process. Instead, the request is routed to a node in the cluster.

1.8 Cost of high availability

Enterprises increasingly demand systems and applications be highly available. Globalization of businesses has evolved this need into continuous availability. When enterprises invest in achieving high availability, the focus is on increasing redundancy in the infrastructure. However, component redundancy is only one variable in the equation. As mentioned in 1.2, “Causes of downtime” on page 5, software failures and human errors are the major causes of unplanned downtime. These can be mitigated through a series of IT management processes, such as the following examples:

- Change management

  This process improves system quality through better planning, testing, evaluating change impact, coordinating and scheduling of application, and IT infrastructure changes.

- Problem management

  This process facilitates problem logging, expedites problem identification, isolation, escalation, root cause determination with resolution, and prevention of future occurrence.

- Configuration management

  This process is a comprehensive understanding of relationships among IT infrastructure, applications, and business processes. Configuration management allows for a better understanding of a change's impact and facilitates problem identification and resolution.

- Performance management

  This process tracks end-to-end system's health and performance. This knowledge provides faster turnaround time in problem diagnosis and resolution, thus reducing downtime.

- Capacity planning

  This process anticipates future IT resource needs to avoid shortages and satisfy its service-level objectives.

- Availability Management

  This process collects and correlates information from networks, systems, and applications to be proactive in identifying potential problems and fix them to avoid failures and downtime.

- Help Desk Support system

  This process provides a mechanism for users to seek assistance with system usage issues, problem reporting, problem tracking, and issue resolution.

- Training

  This process equips IT operational team with the skills and knowledge required to support systems. Operational team members can back up each other. Otherwise, reliance on a single resource constitutes a single point of failure.

Operational considerations are described in greater detail in Chapter 4, "Operational considerations" on page 55.

The costs for highly available systems include component redundancies and IT management processes. The cost increases with higher "9s". It is important to understand the business needs and the impact of downtime to the business to balance the highly available solution with the investment.

2

Application design for availability

This chapter discusses aspects of application and infrastructure design that can affect high availability. The reader can then make an informed judgment on choosing a certain design, configuration, or deployment model to ensure the systems deliver their availability requirements.

2.1 Introduction

In Chapter 1, “Introduction to availability” on page 3, we introduced availability concepts, defined availability, and looked at the distinction between High Availability and Continuous Availability. In this chapter we expand on these concepts and consider design considerations for availability.

When designing a solution we need to consider the availability requirements of the system. This typically is derived by the business stakeholders after assessing the value of the service to the business, the impact on the business of an outage, legal or statutory requirements, and the impact on customers of an outage or poor quality of service.

Performance, quality, and availability criteria are documented as non-functional requirements (NFRs). NFRs include those attributes of an application other than its core function. The following list details attributes that might affect the availability of an application:

- Security
- Performance
- Maintainability
- Scalability
- Compliance

Well-documented non-functional requirements are essential to the availability of the application, because they are key drivers for architecture and design decisions.

If performance or scalability requirements are not clearly understood and well-defined, there is a risk that the solution might not be able to handle the volume of requests. This might result in poor quality of service, slow response, or (in the worst case) an application outage.

In the rest of this chapter we expand on the concepts discussed in Chapter 1, including redundancy, workload balancing, failover, and message design and how these concepts impact high availability.

2.2 Message design and high availability

This section discusses considerations for message design with a focus on high availability. In particular, we discuss the impact of high availability designs on the following concepts:

- Synchronous versus asynchronous messaging. See page 17.
- Affinity. See page 18.
- Sequencing. See page 21.
- Transactionality. See page 23.

2.2.1 Synchronous versus asynchronous messaging

A synchronous request-reply pattern involves services that respond over the same network socket on which the request was received. The receiving application keeps the network socket open while it processes the request and when the request is ready, the receiving application responds using the same network socket.

The calling application might time out if no response is received. In this situation the network socket is closed at each end and might be reused by other processes. Applications must resend the original request as required.

The advantage of synchronous processing is its simplicity, as there is no need to have special programming to handle asynchronous responses. This is shown in Figure 2-1. Requests that receive a response within the timeout period are processed. Any responses received after the timeout must be re-sent.

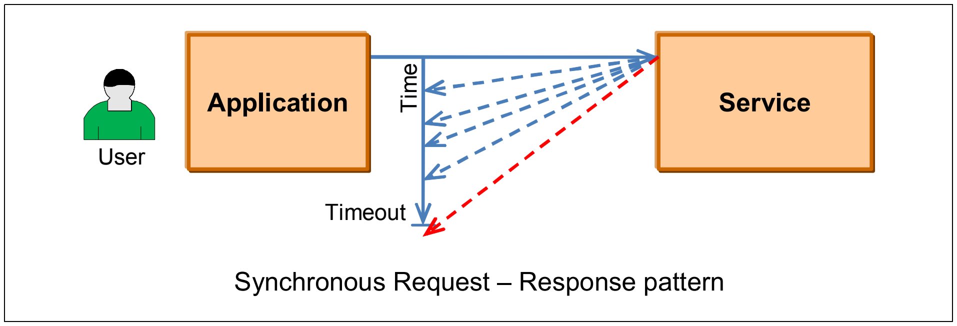


Figure 2-1 Synchronous messaging

Asynchronous messaging, on the other hand is a mechanism in which a user might submit a request but does not require an immediate response. The recipient system usually acknowledges receipt of the request message with a protocol-level acknowledgement that can be sent synchronously.

The advantage of asynchronous messaging is that it is more resilient to outages in certain parts of the architecture, as it decouples the sender from the receiver.

For example, consider a service provided by an enterprise service bus (ESB) that must interface with several back-end systems. The consumer of the service can invoke the service by passing the request to the ESB. The ESB is then responsible for ensuring that the back-end system processing is performed. If there are outages in the back-end systems or network issues preventing communication, the ESB can queue the work to be performed when the interfacing systems are reachable. After processing is completed, the ESB can send an asynchronous reply to the consumer system if required.

The asynchronous request-response design pattern is shown in Figure 2-2.

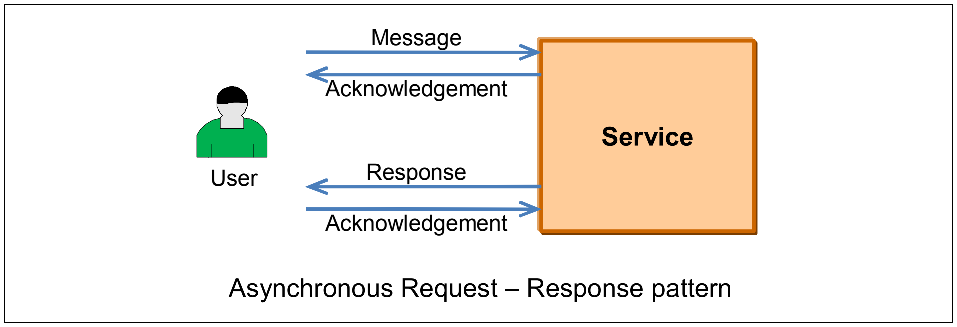


Figure 2-2 Asynchronous request: Response pattern

2.2.2 Affinity

Affinity, often referred as stickiness, is the requirement to favor a particular cluster member after the first request. In a high availability solution with parallel redundant processing streams, affinity might be required to support maintenance of state information, transaction support, or in support of message sequencing.

We discuss four types of affinities that might be relevant to your high availability solution:

- Message affinity. See page 19.
- Server affinity. See page 19.
- Session affinity. See page 19.
- Transaction affinity. See page 20.

Message affinity

When working with WebSphere MQ clusters with multiple definitions for the same queue manager, it is important to be aware of whether the application has any relationships between the messages that require message affinity. In clustered environments a message can be routed to any queue manager that has an instance of the queue.

Where possible, the application should be altered to remove the reliance on message affinities. This can be done, for example, by passing state information within the message body or by storing state information in persistent storage (such as a relational database). This improves the messaging applications scalability and availability. A group of related messages can lock resources at the destination queue manager until all of the messages have arrived and this has the effect of blocking the applications.

If it is not possible to remove message affinities, there are a number of techniques available in WebSphere MQ that support message affinity:

- Specify the remote queue name and the queue manager on the MQOPEN call.
- Use the reply-to queue manager field to specify the queue manager.
- Specify the MQOO_BIND_ON_OPEN option in the MQOPEN call.

For more information about these options see the WebSphere MQ Information Center at the following Web page:

http://publib.boulder.ibm.com/infocenter/wmqv7/v7r0/index.jsp

Server affinity

Server affinity allows a load balancer to remember the server selected for a specific client at the initial request. Subsequent requests are routed to the same server. Although this might sound like it defeats the purpose of a load balancer, server affinity is essential to preserve state across distinct connections from a client (such as a stateful Web application).

To prevent single points of failure, redundancies of hardware load balancers and downstream servers are required. Server affinity configuration in a load balancer must be considered with session affinity for failover.

Session affinity

Session affinity is the preference of one server over others, by the load balancing mechanism in recognition of an existing session. Subsequent requests from the same client always get routed to the same server. This is typical of a Web server plug-in that always attempts to route a request that contains session information to the application server that processed the previous requests. If the preferred application server is down, the plug-in attempts to route the request to an alternate application server in the cluster. The new application server makes use of memory-to-memory replication to retrieve the session information to process the request.

Session affinity is depicted in Figure 2-3. In this example, requests 1 and 2 from John are routed to Service Instance A. All requests from Bob are routed to Service Instance C.

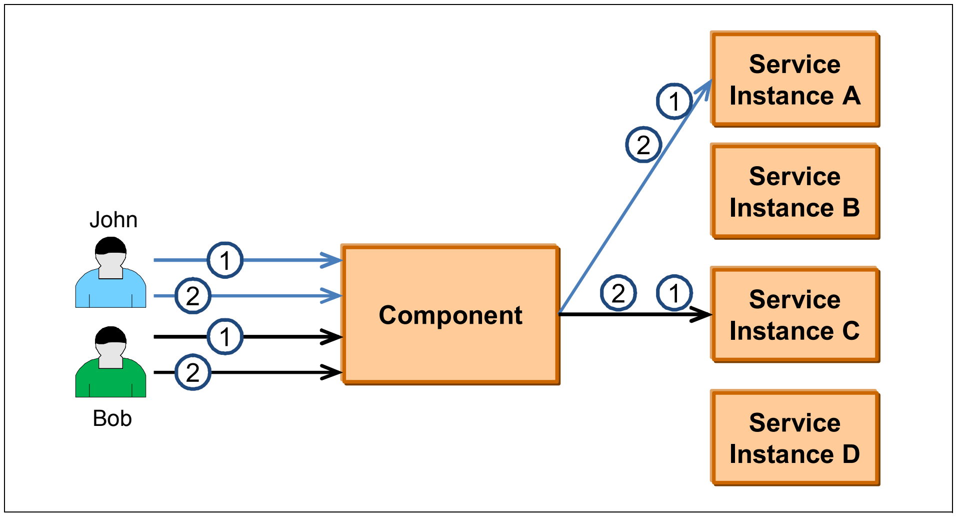


Figure 2-3 Session affinity example

Transaction affinity

Transaction affinity is the preference of one server over others, by the load balancing mechanism in recognition of an existing transaction. An example of use is the entity bean. After an entity bean is instantiated in the EJB container, the workload management service directs all requests from the client towards that entity bean for the duration of the transaction.

For additional information about server affinity, session affinity, and transaction affinity for failover, see IBM Redbooks publication *WebSphere Application Server Network Deployment V6: High Availability Solutions*, SG24-6688.

2.2.3 Sequencing

Asynchronous messaging decouples the sender from the recipient. A sender deposits a message and moves on rather than waiting for a response from the recipient. Messages that are assumed to be independent units can be consumed by any application tuned to listen for them. This allows for faster response time, higher throughput, and better scalability.

Certain business applications, however, require messages to arrive in exactly the same order as they were created and sent from the source system. For example, a banking system requires credits and debits from a bank account to arrive in the correct order to avoid the account becoming overdrawn in error.

In the case of a high availability architecture that has multiple parallel streams to process a request, it can be challenging to keep messages in sequence. Every component in the journey can affect the order in which messages arrive at their final destination, or if they arrive at all.

There are various ways to ensure that messages arrive in order. Sequencing can be provided through the messaging infrastructure or by the sending and receiving applications.

Sequencing support within WebSphere MQ

Messages from a single application end up in the queue in the order in which they were put. However, messages can arrive out of sequence if they take seperate routes through the network, or if they are placed temporarily on a dead-letter queue. If sequencing is essential, WebSphere MQ provides support through message grouping. The sender application can specify that it is sending messages as part of a group. Within the group, messages are given a sequence number starting at 1. Message grouping can be used to ensure that a whole group of messages is available before processing starts. The receiving application can then read the messages from the queue in the sequence order.

Sequencing support within WebSphere Message Broker

Sequencing support has been built into WebSphere Message Broker 7.0 with the introduction of the Sequence node and the Resequence node. The Sequence node provides the ability to add sequence numbers to messages belonging to a group to preserve the order in which the messages arrive. The node property `Path to sequence group identifier` tells the node where to read the group identifier. All messages arriving with this group identifier are allocated a sequence number, which is stored in the `Path to store sequence number` node property, for example, the LocalEnvironment, MQRFH2 header or the message body.

The Resequence node can be used to control the order in which messages are processed. Messages within a sequence group can arrive in any order and are stored by the Resequence node. Messages are then propagated in sequence. If there is a gap in the sequence, the Resequence node waits for the missing messages for a specified period.

To take advantage of this new functionality in a high availability scenario with multiple flow instances spread across multiple brokers, you need to ensure message flow affinity.

Application provided sequencing

The sender and receiver applications can be responsible for message sequencing based on an agreed approach. This might include the sender application placing sequencing information in the message body. The receiving application is then responsible for processing the messages in the correct sequence. Any messages that arrive out of sequence must be buffered until the next message in the sequence is received. In more sophisticated variations on this approach, the sender and receiver might have a set of agreed protocols for handling missing messages including the use of acknowledgements, negative acknowledgements, and requests for a message to be resent.

Error handling and retry mechanisms might result in messages being resent. This can mean that requests are processed more than once. To avoid this, a form of message identification (such as a unique ID) should be built into the message structure. Messages that are resent due to errors retain the same unique identifier. It is the responsibility of the receiving system to monitor the identifiers of messages processed to ensure that messages are not processed twice. The flow of messages in such a design is shown in Figure 2-4 on page 23. In this figure, an intermediate component, Component A, is used to handle message sequencing.

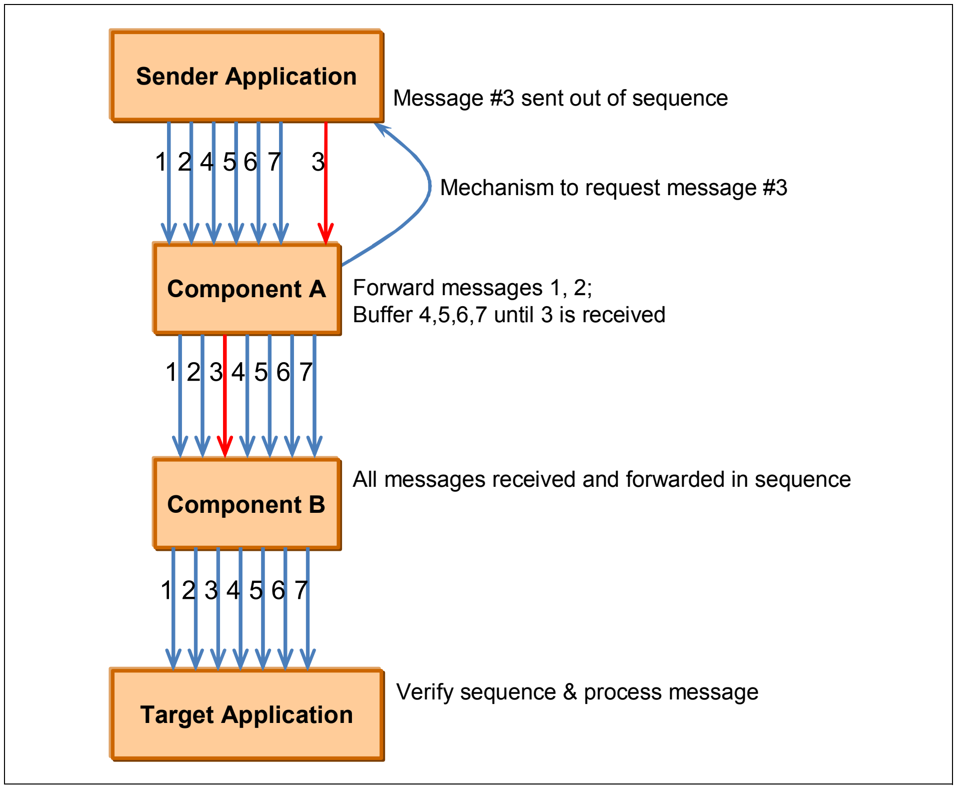

Sender Application
Message #3 sent out of sequence
1 2 4 5 6 7 3
Mechanism to request message #3
Component A
Forward messages 1, 2;
Buffer 4,5,6,7 until 3 is received
1 2 3 4 5 6 7
Component B
All messages received and forwarded in sequence
1 2 3 4 5 6 7
Target Application
Verify sequence & process message

Figure 2-4 Application design to handle message sequencing

2.2.4 Transactionality

Applications and systems transact with other applications and systems using messages containing data that might be proprietary or standards-based. The transaction might cover all parties involved or a sub-set. All applications involved in a transaction must ensure data consistency and integrity. In a transactional system, either all operations must succeed or there must be a way to rollback or undo partial transactions. When the transaction is completed, a commit might be issued that makes all data changes (insert, update, or delete) permanent. A business transaction might be different from a technical messaging transaction. A single business transaction involves at least one message exchange between two parties or systems.

Figure 2-5 represents a simplified transactional model of a debit/credit card authorization.

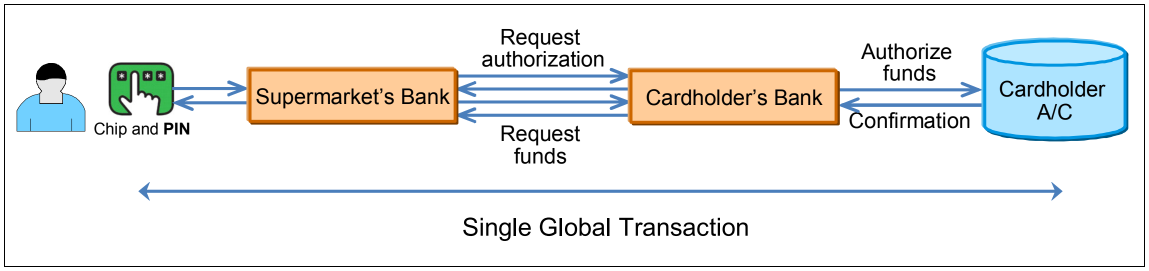


Figure 2-5 Single global transaction

When a customer makes a purchase using a debit card and enters a personal identification number (pin) in the entry device, the transaction is handled by the supermarket's bank which, using a service provider, connects to customer's bank to request authorization of funds. Several small messages are exchanged between all parties and, depending on funds available, the customer's bank makes the decision whether to accept the authorization or decline the payment.

The message delivery mechanism can affect the transactionality. The following options are available for consideration and can be elected based on the criticality:

- One-time delivery with no duplicates.

  In Figure 2-5, an authorization request from the till must be sent only once and in a transactional fashion. A customeris not happy if he is charged twice for the same transaction.

- Guaranteed delivery with the possibility of duplicates.

  An example is a weather update application that issues storm warnings. The warnings must be delivered, but there is no harm if duplicate copies are received. In fact, in this particular example, duplicate messages might even be a good thing.

- No delivery guarantee; the best effort only.

  A Web-based instant messaging system can be designed using this option. If an instant message was lost or undelivered, the user can resend the message instantly.

Application design for a highly available system can be complicated when long-running transactions involving multiple data persistence. An XA transaction is employed to ensure transaction integrity, particularly during a failover of one or more components in the system.

Transactions and HA can coexist in a solution. One exception is where two-phase (XA) commit and failover meet. You need to ensure that the transaction manager can contact the queue manager following a failover. It is vital to get the queue manager running again in these situations. Simple redundancy is not enough.

2.3 Data storage and high availability

Data is an integral part of every system, because without data a system's usefulness diminishes. Many messaging applications make use of data in databases. Consider the availability of the databases as part of your overall high availability solution. In most situations this consists of a highly available database connected to the messaging applications across a network. This is not the only consideration, however. Data can be in-flight, stored on a file system, or stored in a database. In a high-volume, high-concurrency environment, maintaining data consistency and integrity is challenging.

The following list defines three classes of data. We look at ways in which these classes of data can be made highly available. Application data can be broadly classified as follows:

- Static data

  Data resides on a disk and is loaded into memory for caching purposes during the system's operation. Modifications are planned and scheduled. Examples of static data include HTML pages, XSD schema files, and configuration files.

- Transient data

  Data is briefly at rest on a disk when the system is running. An example of transient data is a message briefly at rest in a WebSphere MQ queue before the next hop.

- Volatile data

  Data with frequent accesses and updates while system is running. This data might reside in memory (for example session data, entity bean data, and in-memory JNDI caches) or reside in a back-end database.

Resilience for static data stored on disk can be provided by the use of shared disks or RAID technology.

High availability can be provided for volatile in-memory data through memory-to-memory replication to eliminate single point of failure. For further information about memory-to-memory replication see IBM Redbooks publication *WebSphere Application Server Network Deployment V6: High Availability Solutions*, SG24-6688.

A highly available back-end database is crucial and can be made available through database clustering. Modern database solutions might employ parallel processing or hot standby with active data replication on a horizontal hardware cluster with heartbeat monitoring. The highly available database solution must also preserve transaction integrity during failover.

For details on IBM disk technologies with DB2® database for high availability, see IBM Redbooks publication *High Availability and Disaster Recovery Options for DB2 on Linux, UNIX, and Windows*, SG24-7363.

2.4 Cloud computing and high availability

Many corporations have a strategy to move towards a cloud computing delivery model. Cloud computing provides a delivery and consumption model for IT services where the IT infrastructure is a managed service somewhere on the Internet (hence the cloud). Resources (including hardware, software, and business and Internet applications) can be dynamically allocated or de-allocated in minutes through virtualized environments based on use and demand. This eliminates the need for an organization to buy, maintain, and refresh expensive IT infrastructures (such as networks and servers).

There are pros and cons for cloud computing that are not debated here. From a high availability perspective, however, you must ensure that you are dealing with a reputable service provider that provides the following skill sets:

- Demonstrates that they have the maturity and organizational mechanisms in place to support the infrastructure properly. This includes back-up and recovery, disaster recovery, and support processes.
- Agrees to your organizations service level requirements.
- Meets your organizations service level requirements.

For further information about IBM's cloud offering see the following Web page:

http://www.ibm.com/ibm/cloud/

2.5 Keeping the network available

All organizations have layers of networks protecting their key applications, systems, and data. These layers are often labeled as red, yellow. and green zones. These zones depict perimeters of networks, subnetworks, and associated levels of trust on the systems, connections, data, and users in a zone. Zones closer to the edge have lower levels of trust, so all connections and data are scrutinized. As you get closer to the green zone, there is higher level of trust.

In the early 70's networks were designed as castles; a huge wall (firewall) on the outside and freedom to move anywhere inside. The challenge with this design was that anyone who got past the big wall can do anything they want. They can weaken the wall from inside, steal information, or stay inside the wall and weaken systems and steal information for as long as possible.

Modern networks, however, are designed like airports. There are checks and barriers at various stages of before you are allowed to board the airplane. This concept is illustrated in Figure 2-6 on page 28.

The DMZ (demilitarized zone) is often a part of the network that exposes an organization services to the outside world in such a manner that no one can bypass security policies and can only access exposed services. There are specialty devices (such as firewalls, switches, load balancers, XML firewalls, and anti-virus scanners) that inspect connections and content passing through the connection. Some devices are content-aware and some are stateless devices that check, detect, and stop any potential threats to the protected resources.

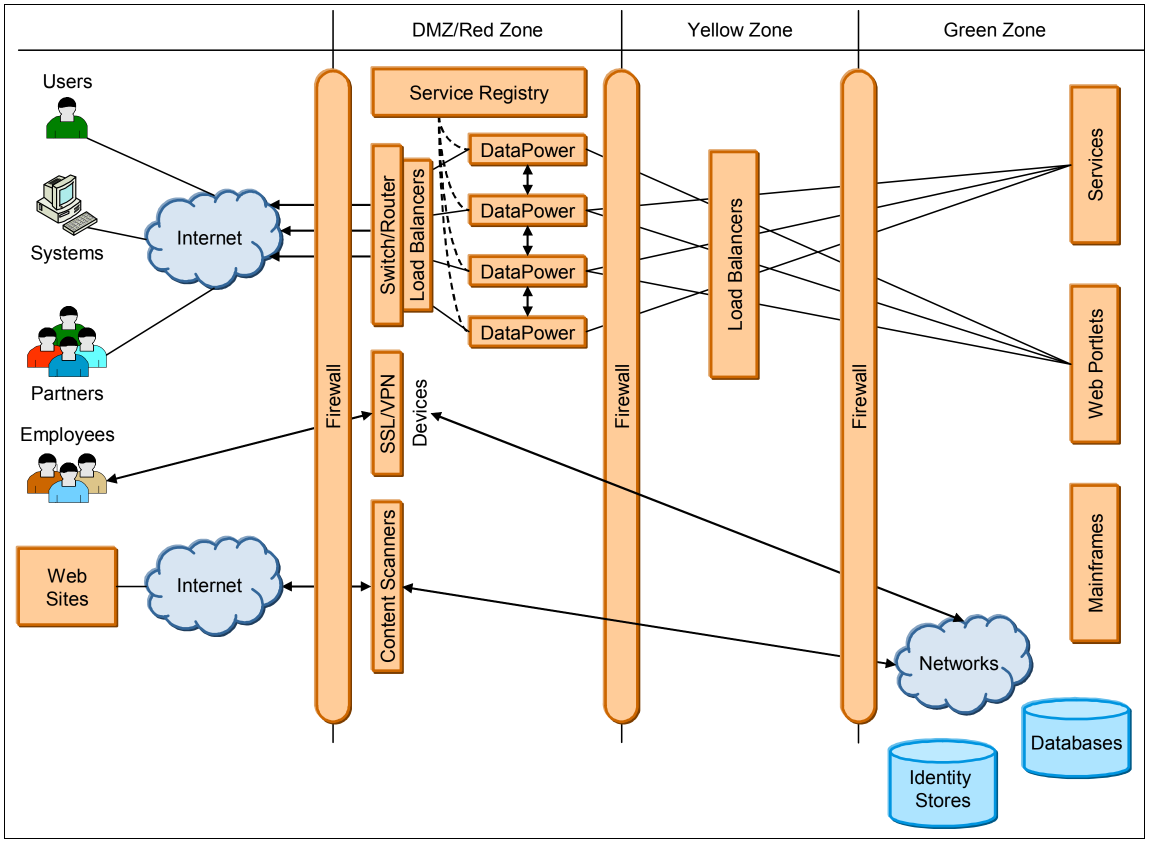


Figure 2-6 Network layers in a topology

Figure 2-6 shows a simplified version of a network topology. The DMZ contains specialist devices (such as DataPower) responsible for the following tasks:

- Service virtualization
- SSL connection initiation/termination
- Cryptographic functions such as encryption, decryption, signature, verification
- Message schema based checks
- Security policy enforcement
- Authentication, Authorization etc.,
- XML threat protection

Other specialized content filters might be scanning for viruses and Trojans within the Web traffic flowing through the organization. The intention is that all threats are detected and stopped as close to the edge of the network as possible. By the time a connection message reaches the application in the trusted domain, it should be a clean, harmless request that the application can process normally.

2.6 Infrastructure patterns

Most IT operations teams use design patterns for hardware and software deployment. These patterns are based on industry-accepted practices, individual experiences, project requirements and policy compliance. Sometimes the technologies used might also influence and dictate the pattern in which it is deployed and managed. Every new deployment must go through an exercise of vetting the applicable patterns and making a choice based on cost, risk, and the value of the service being hosted.

In this sections that follow, we examine infrastructure-related design patterns. In particular we look at the following topics:

- “Cluster patterns”
- “Network patterns” on page 30

2.6.1 Cluster patterns

Section 1.6, “Software clustering” on page 9 discusses software clustering. Software clustering is an important element in the design for redundancy, fault tolerance, resilience, and high availability. A cluster eliminates single points of failure. An important aspect, however, is whether to share state, context, and data between cluster nodes so that failure of a cluster node is invisible to the client applications and that from their point of view, everything continues as normal.

The following four patterns are found in cluster-based deployment:

- Cluster members have their own data stores and file systems where they operate and the data is not shared with other cluster members.

  In this scenario there is a possibility that data might not be recoverable from a failed node. For example, DataPower devices are typically deployed where each device has its own file system. In case of a device failure, all in-flight transactions are lost and any files or data kept on the local file system is also lost.

- Cluster members share common storage (database or file systems) but work as independent nodes.

  In this case, both nodes can be configured as active and they continue to use their own resources and use their own data sets. For example, two nodes might share a database but might have their own tables, views, and so forth.

- Cluster members share common storage and data sets, so two or more nodes might update the same file, database table, or record at the same time.

  Appropriate logic needs to be in place to maintain data integrity and avoid file or record locking.
- Cluster members are deployed in geographically dispersed locations to avoid natural or man-made disasters.

  The distance between cluster nodes might be from a few miles to thousands of miles. Hardware- or software-level data replication technologies are employed to replicate data across sites.

2.6.2 Network patterns

Section 1.4, “Redundancy” on page 7 discusses redundancy and how adding redundant components in the network increases high availability. As shown in Figure 2-7, daisy-chained components represent a single point of failure as they do not allow for an alternative route in the event of a component failure. A failure of any individual component might result in an outage of the entire application infrastructure.

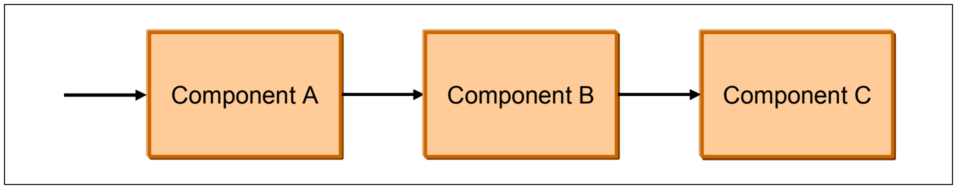


Figure 2-7 Daisy chains: Bad for high availability

To overcome this obstacle, we can employ redundant components (shown in Figure 2-8). Network connectivity between the redundant components ensures that all components in the architecture are reachable even if one or more components fail. Redundant components can be added in an active pattern where they are actively participating in processing transactions. For push-based technologies (such as HTTP), a load balancer can distribute the traffic equally on the available components.

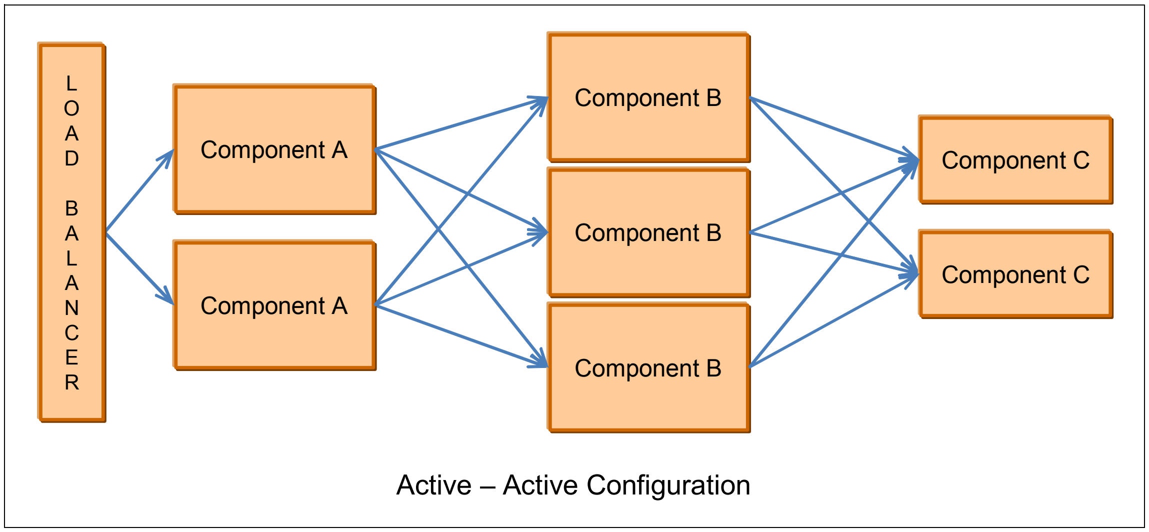


Figure 2-8 Active–active configuration

An active-passive deployment (shown in Figure 2-9) uses hot or cold standby components to take over in the event that the main component fails. The standby components often exchange heartbeat information with the active components at a configurable time. If a specific number of heartbeats are missed, the standby component takes over as the active component. Some hardware components can also take over the MAC addresses of the network interface card, which allows network switches and load balancers to function normally without having to change any network behavior.

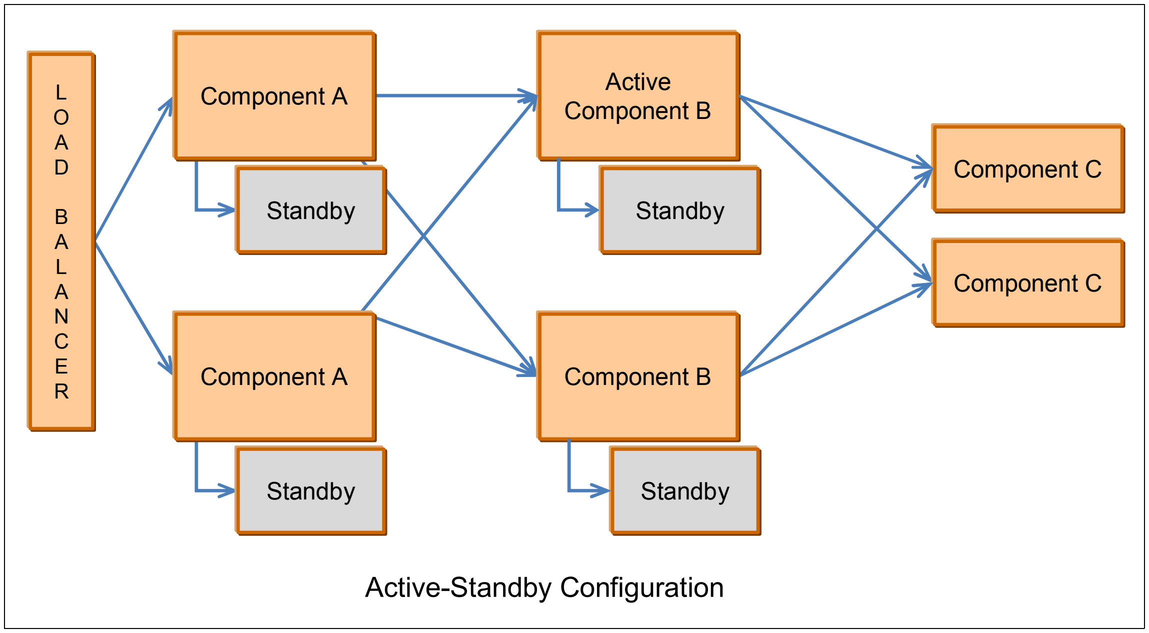


Figure 2-9 Active-Standby configuration

This model also adds to the cost and is not as popular, because the standby component is often idle and waiting for the active component to fail. This might not be viewed as the best use of resources. This is why active-active deployments are more common.

3

Product technologies for high availability

This chapter describes the product technologies that can be used to build a high availability topology. It discusses hardware clustering concepts and the high availability features of the WebSphere messaging products. This includes multi-instance queue manager and multi-instance broker capabilities, WebSphere MQ clusters, and queue sharing groups on z/OS®.

3.1 High availability and failover

High availability is one of the components that contributes to providing continuous service for the application clients. It ensures that the failure of any component of the solution, either hardware, software, or system management, does not cause the application and its data to become permanently unavailable to users.

Failover of an IT system is the capability to switch over automatically to a standby system upon the failure or abnormal termination of the previously active application system.

High availability can be achieved by a combination of two technologies:

- Hardware clustering (for example, PowerHA cluster)
- Software clustering to provide high-service availability (WebSphere MQ with multi-instance queue manager and multi-instance broker) or load balancing (for example, WebSphere MQ cluster)

3.2 Hardware clustering

High-availability clusters are grouped computers in a network that provide high availability for application systems by using hardware redundancy and software monitoring. The cluster is configured with appropriate file systems on shared disk storage, with a heartbeat mechanism to detect a failure on the other system. When a hardware or software failure in the cluster is detected, the application can be restarted on another system.

Figure 3-1 on page 35 illustrates a topology where two computers on a network are used as server nodes in a cluster. Client applications can use this network to communicate with the cluster and use the services provided by the highly available cluster. Highly available clusters often build redundancy into a cluster to eliminate single points of failure. For example, multiple network connections are often used and data storage is multiply connected through heartbeat disk storage.

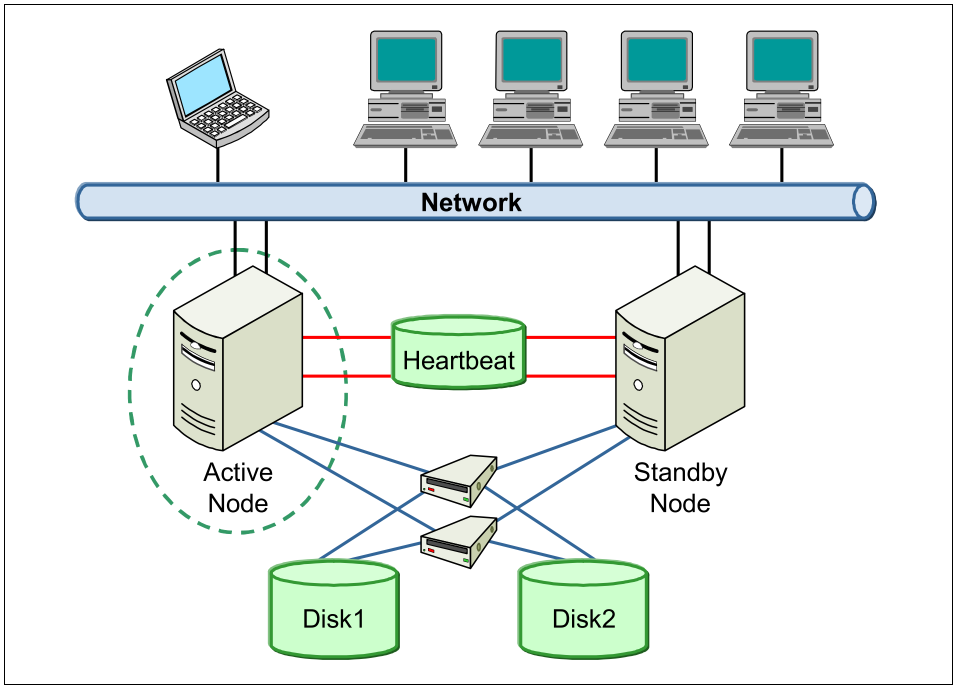


Figure 3-1 Hardware clustering

Highly available clustering uses the concept of resource groups where applications, services IP labels, and even file systems on disk storage are grouped together. When a failure occurs in one of the applications in the group, the entire group is moved to a standby server by the use of cluster services.

The heartbeat private network connection is an additional non-IP network. This is a key component used by the cluster to monitor the health and status of each node in the cluster.

The most commonly used highly available cluster is a two node cluster. The two common configurations are:

- Active/Active

  Traffic intended for the failed node is either passed to an existing node or load balanced across the remaining nodes.

- Active/Passive

  Provides a fully redundant instance of each node, which is only brought online when its associated primary node fails.

3.2.1 IBM PowerHA cluster

PowerHA for AIX is the IBM high availability solution for POWER® systems running AIX. Versions prior to PowerHA 5.5 are referred to as HACMP. A PowerHA cluster is illustrated in Figure 3-2.

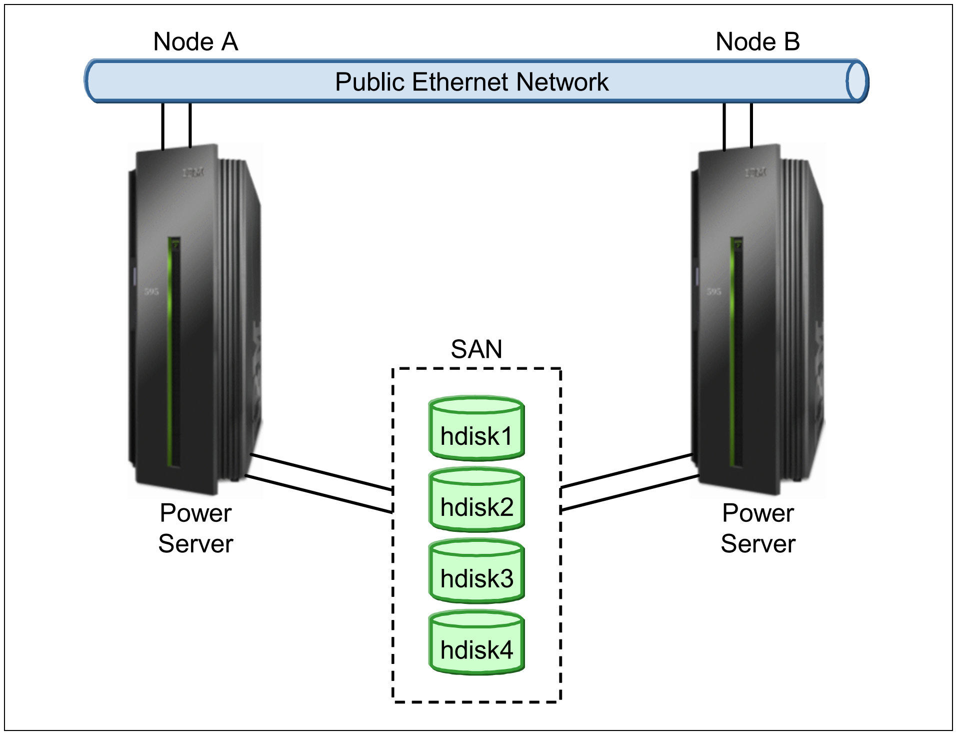


Figure 3-2 PowerHA cluster

High availability and multi-processing components

In addition to providing high availability services, a PowerHA cluster provides multi-processing components (multiple applications running over a number of nodes with shared or concurrent access to the data on shared disk storage). The cluster topology describes the underlying framework: the nodes, networks, and storage, as shown in Figure 3-3 on page 37. PowerHA uses this framework to build up the cluster services to keep the cluster resources (such as the service IP) and application server and file systems highly available.

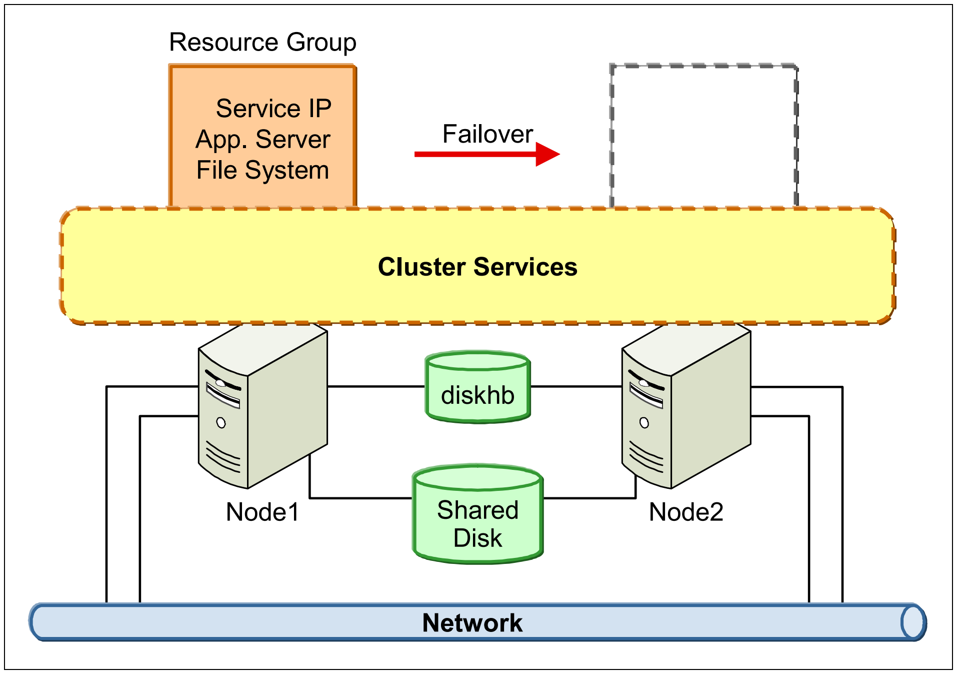


Figure 3-3 Resource Group and Cluster services

The topology represents the physical view of the cluster and how hardware cluster components are connected using networks (IP and non-IP). The components of the topology are as follows:

- PowerHA cluster
- Nodes
- Sites
- Networks
- Communication interfaces/devices
- Persistent node IP labels/addresses
- Network modules
- Topology and group services
- Clients

Cluster resources are those components that PowerHA can move from node to node (for example, service IP labels, file systems, and applications). PowerHA uses the underlying topology to ensure that the applications under its control and the resources they require are kept highly available:

- Service IP labels / addresses
- Physical disks
- Volume groups
- Logical volumes
- File systems
- Network File Systems
- Application servers (applications)
- Communication adapters and links
- Tape resources
- Fast connect resources
- WLM integration

When the cluster is configured, the cluster topology and resource information is entered on one node, a verification process is run, and the data synchronized out to the other nodes defined in the cluster. PowerHA keeps this data in Object Data Manager (ODM) classes on each node in the cluster.

An active-standby configuration

Active-standby clusters include both active and standby nodes. One node is running the applications in a resource group and one node is in the standby state. The standby node monitors the active node by using heartbeats. These are periodic checks by the standby node to ensure that the master node is still responding to requests. The active node also monitors its disks and the processes running on it to ensure that no hardware failure has occurred.

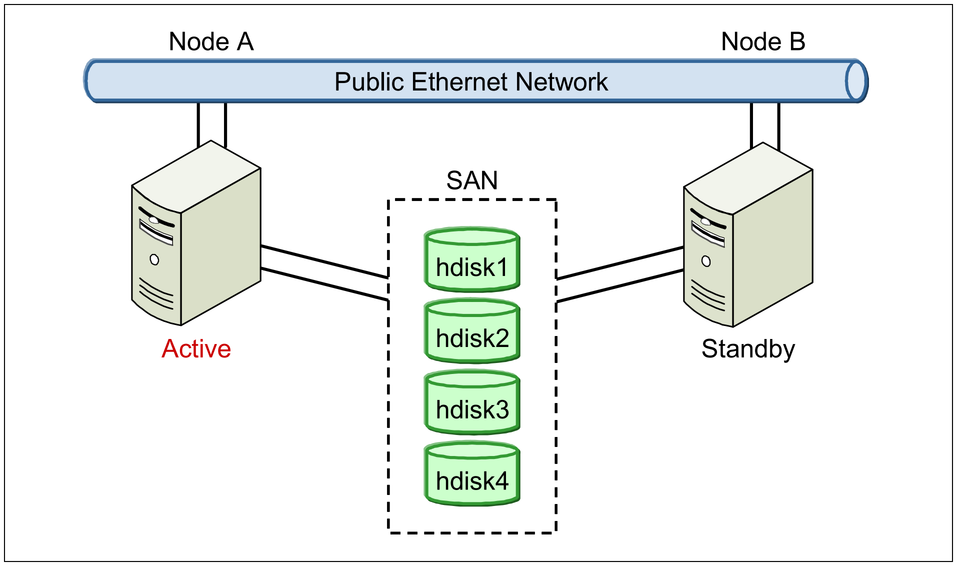


Figure 3-4 Active-standby configuration

If the cluster software detects that there is a problem with the active node, the standby node performs the following tasks:

- Take over the IP address.
- Take over the shared disks.
- Start the applications and associated processes.

An active-active configuration

It is possible to run services on the redundant machine in an active-active configuration (Figure 3-5). In this mode, the servers are both actively running programs and acting as backups for each other. If one server fails, the other continues to run its own services. This type of configuration can also provide load balancing for client applications.

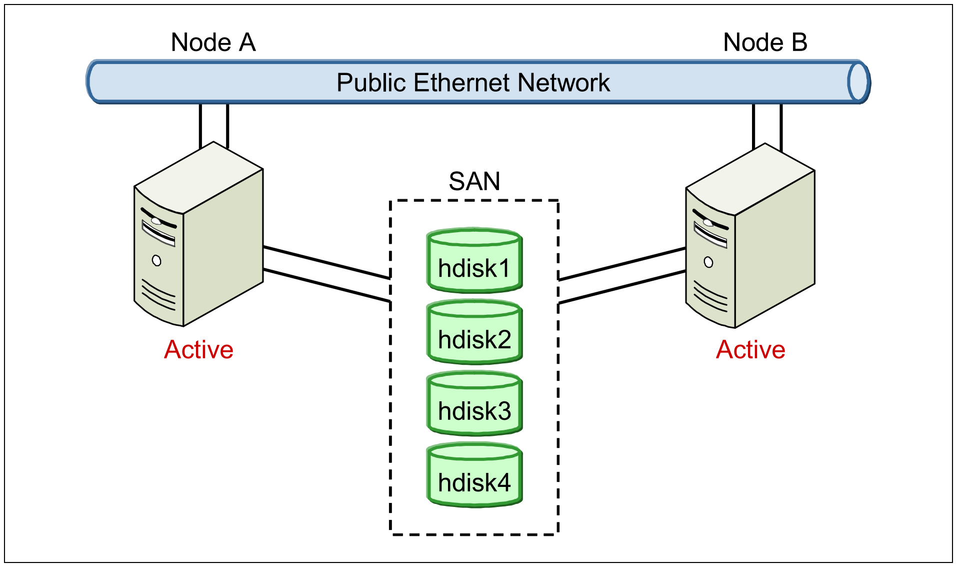


Figure 3-5 Active-active configuration

3.3 Multi-instance queue managers and brokers

WebSphere MQ V7.0.1 introduced the ability to configure multi-instance queue managers. This capability allows you to configure multiple instances of a queue manager on separate machines, providing a highly available active-standby solution.

WebSphere Message Broker V7 builds on this feature to add the concept of multi-instance brokers. This feature works in the same way by hosting the broker's configuration on network storage and making the brokers highly available.

3.3.1 Multi-instance queue managers

Using a multi-instance queue manager improves availability by automatically switching the queue manager instance to a standby server if the active server fails. The active and standby servers each have an instance of the same queue manager, using the same queue manager data hosted on shared network storage. When the active instance fails, the standby instance automatically takes over the configuration.

A multi-instance queue manager is designed to assist you in configuring for availability. One instance of the queue manager is active at a time. Switching over to a standby instance can take anywhere from seconds to minutes, depending on how the system is configured, loaded, and tuned.

3.3.2 Multi-instance brokers

A multi-instance queue manager can give the appearance of nearly uninterrupted service if used with reconnectable WebSphere MQ clients, which are able to continue processing without the application program being aware of a queue manager outage.

The multi-instance broker feature of WebSphere Message Broker works with WebSphere MQ in one of two ways. Each broker instance is embedded into an MQ service so that when the queue manager switches over to the standby system, the broker is automatically started on the standby node. Alternatively, the standby broker can be continually running in a semi-initialized state, waiting for the associated standby queue manager and shared broker configuration to become available.

3.3.3 Highly available hardware solutions versus multi-instance solutions

If you only use WebSphere MQ and broker products and want to make your brokers or queue managers highly available, multi-instances can save the administrative overhead of a high-availability solution such as PowerHA. However, the multi-instance brokers feature does not make any connected resources (such as databases) highly available, so in these scenarios another product that provides high availability is still required. For example, you can use Oracle RAC for the database, and you manage the queue managers' and brokers' availability separately either using an HA cluster or multi-instance.

By using hardware clustering such as a PowerHA cluster, other resources, such as databases, can be included into cluster resource groups and made highly available. The service IP label is also implemented in a resource group. Furthermore, data high availability is ensured by shared disk storage connected to two servers. The data of a cluster application is located on a shared disk storage. In case of failure, the standby server mounts the shared disk and restarts the applications. This type of solution is complicated to use and has a higher administrative overhead. Furthermore, a combination of PowerHA and multi instances of WebSphere MQ and Broker in the application is not necessary.

One consideration for multi-instance queue managers is that they change IP addresses when they failover, so the network configuration needs to be adjusted to reflect this.

Note: Multi-instance queue managers require network-attached storage that supports lease-based locking and is POSIX compliant. Network File System 4 (NFS-4) fulfills this requirement and was used for the scenarios.

3.4 Queue manager cluster

This section describes the use of a WebSphere MQ queue manager cluster in the network to provide workload balancing and increasing high availability for new messages.

3.4.1 Cluster queue managers and repositories

A queue manager cluster is a logical group of queue managers. The queue managers can be on most of the platforms supported by MQ. When queue managers are grouped in a cluster, each queue manager can make the queues (and other resources it hosts) available to every cluster member. For example, any queue manager can route a message to any other queue manager in the same cluster without explicit channel definitions, remote-queue definitions, or transmission queues for each destination.

The queue manager cluster solution provides a highly available messaging service. It allows messages to be forwarded to any queue manager in the cluster hosting the target queue for application processing. If any queue manager in the cluster fails, new incoming messages continue to be processed by the remaining queue managers as long as at least one of the queue managers hosts an instance of the target queue.

A queue manager cluster has the following components:

- Cluster repository

  The cluster-related information, which is maintained in a queue. Usually, two full copies of the repository are used for each cluster.

- Repository queue manager

  The queue manager that manages the cluster repository.

- Cluster queue managers

  The queue manager members of a cluster.

- Cluster transmission queue

  The cluster-specific transmission queue.

Every queue manager in a cluster has a single transmission queue from which it can transmit messages to any other queue manager in the cluster. Each queue manager in a cluster needs to define only the following information:

- One cluster-receiver channel, which tells other members of the cluster how to connect to this queue manager
- One cluster-sender channel, to connect to a repository queue manager

The repository queue managers are the most important members in the cluster. They host a complete set of information about every queue manager in the cluster, and the cluster resources each queue manager owns. The other queue managers in the cluster register with the full repositories, passing information about their cluster resources (queues, topics, and so forth) and build up their own subsets of this information in partial repositories.

A partial repository only contains information about those queue managers and resources that this queue manager has used. If there is a change in the status of any of the resources used, the full repositories notify the partial repositories about the resourcesin which they have expressed an interest previously.

When using queue manager clusters it is possible to have stranded messages. These messages, called orphan messages, were delivered to a cluster queue but cannot be processed because the queue manager hosting it has become unavailable, or the instance of the application processing the queue is not active.

3.4.2 Workload balancing

One of the benefits of queue manager clustering is workload balancing functionality. This algorithm uses the concept of distributed cluster queues. Basically, they are cluster queues that have multiple instances defined in the same cluster. More than one queue manager hosts an instance of the same queue. The workload can be spread between queue managers in the cluster.

The following list details the advantages of using clusters:

- Increased availability of queues

  Because there are multiple instances of them.

- Faster throughput of messages,

  Because messages can be delivered to multiple destinations and processed by multiple applications at the same time.

- More even distribution of workload in your network

The applications need not explicitly name the queue manager when sending messages. The workload management algorithm determines which queue manager handles the message.

In Figure 3-6, an application connected to Qm3 puts a message to a cluster queue. This cluster queue is defined locally on Qm1, Qm4 and Qm6. MQ uses a workload management algorithm to determine the best queue manager to which to route this message. If there is no instance of the queue on the local queue manager, the algorithm determines which destinations are suitable. Suitability is based on the state of the channel (including any priority you might have assigned to the channel), and the availability of the queue manager and queue. The algorithm uses a round-robin approach to finalize its choice between the suitable queue managers.

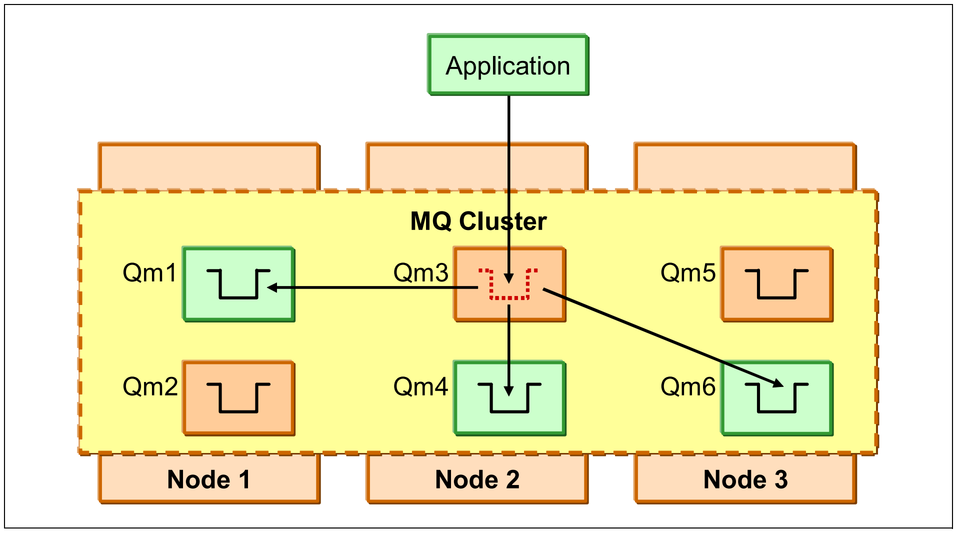


Figure 3-6 Multiple instances of queue

Therefore, one of these queue managers receives the message and processes it. If a queue manager fails, the incoming messages are balanced among the remaining queue managers.

3.5 Queue-sharing groups

Note: Shared queues are only available on WebSphere MQ for z/OS. They rely on z/OS-specific features not available on other platforms.

On z/OS systems, the coupling facility (CF) technology can be used to group queue managers into queue sharing groups (QSGs). All queue managers in a QSG can access shared message queues for sending and receiving messages through the WebSphere MQ API.

QSGs on WebSphere MQ for z/OS consist of the following components:

- A number of z/OS queue managers (running within a single z/OS sysplex) along with their associated channel initiators
- A coupling facility containing two or more coupling facility structures (CF structures) that are used to hold messages on shared queues
- A shared DB2 database (also known as the *DB2 shared repository*) used to hold shared object definitions.

Figure 3-7 illustrates a QSG that contains three queue managers. Each queue manager in the QSG has an associated channel initiator and its own local page sets and log data sets, as well as access to the coupling facility and the DB2 shared repository (not displayed).

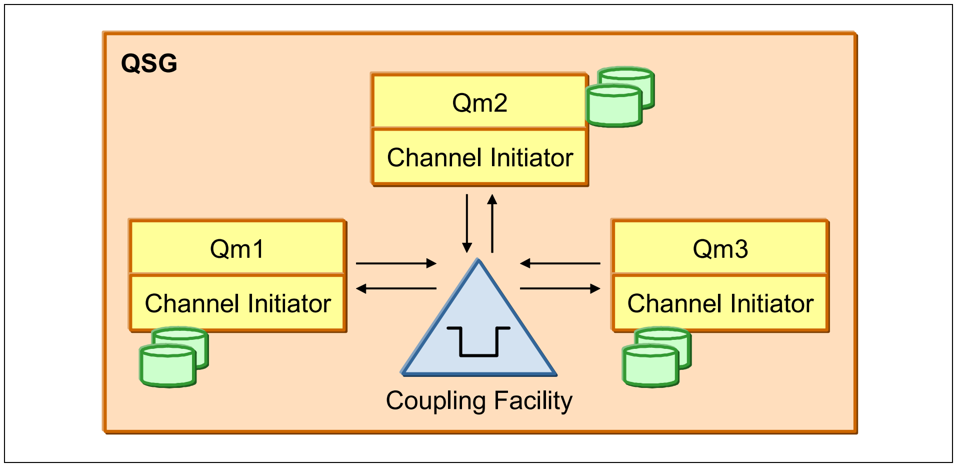


Figure 3-7 A queue sharing group

3.5.1 Benefits of shared message queues

Because applications can connect to any queue manager in a QSG, and all queue managers in a QSG can access shared queues, applications are not dependent on the availability of specific queue managers. In the event of a queue manager failure, applications can continue to service shared queues by connecting to any remaining active queue manager in the QSG.

3.5.2 Benefits of shared channels

Another aspect of queue sharing groups is the ability to implement shared inbound and outbound channels.

Shared inbound channels allow external applications to connect to the queue sharing group rather than to an individual z/OS queue manager. It relies on technology like the Sysplex Distributor to determine which queue manager in the QSG hosts the connection. Each queue manager in the QSG defines two listening ports, one standard listener, and one generic (sometimes called shared) listener that accepts the QSG connection requests.

This enhances availability by eliminating dependency on any one z/OS queue manager for connections. In addition, the connecting application does not have to be concerned about the target queues. Shared queues can be directly accessed by the queue manager where the connection was directed. If the target queues are not shared, the QSG directs the messages to the correct queue manager.

Shared outbound channels allow any channel initiator in the QSG to process outbound messages that are on a shared transmission queue. The availability advantage is that messages can continue to flow if one of the channel initiators in the queue sharing group becomes unavailable. This feature can improve delivery of remote messages, as a shared sender channel normally starts on the least busy channel initiator.

3.5.3 Large messages on shared queues

Prior to WebSphere MQ V6, shared queues had a limit on the length of messages that can be stored on shared queues. This length restriction has now been lifted and messages can be up to 100 Mb in length, which is the same length as private queues.

It is important to understand that although applications do not see any difference when processing long and short messages, the underlying storage mechanism for shared queue messages larger than 63 K is different. This difference can impact application response time and CPU consumption.

Messages shorter than 6 3K are stored in the CF list structures. Messages longer than 63 K use a combination of storage: The message headers are stored in the CF and the message body is stored in a DB2 table in the DB2 data sharing group.

For a comparison of the costs associated with storage of long messages, review the WebSphere MQ for z/OS Performance reports and SupportPac MP16. These can be found at the following Web page:

http://www-01.ibm.com/support/docview.wss?rs=977&uid=swg27007205

Note: Enabling long message support requires that the MQ component of the structure definition (CFSTRUCT) used for MQ queues that contain long messages be set to CFLEVEL(4).

3.6 MQ clients

Clients also can play a role in high availability. This section discusses considerations for clients.

3.6.1 Automatic client reconnection

The new automatic client reconnect feature was introduced in WebSphere MQ V7.0.1. It provides greater messaging availability by masking network and queue manager outages from client-connected applications through automatic detection of connectivity problems and reconnecting to the same or alternative queue managers. In earlier versions of WebSphere MQ, if no changes were made to existing connections, manual reconnection required the client application to recreate a connection using MQCONN or MQCONNX, and reopen objects.

Automatic reconnection can be enabled administratively with a new parameter of the channels stanza in the `mqclient.ini` file. The DefRecon parameter has several settings and can perform the following tasks:

- Disable automatic reconnect
- Enable reconnect but only to the same queue manager
- Allow automatic reconnect
- Allow the client code to override this setting

It can also be enabled through the application code itself, using the MQCONNX calls, or with JMS options (see “Using standalone JMS clients” on page 49).

From an application perspective, automatic reconnect can provide an easy availability solution for message processing styles. Fire and forget messaging, where the client is sending messages to an application for processing without expecting a reply is an ideal candidate.

Enabling automatic reconnection to the same queue manager for clients connected to multi-instance queue managers masks switching between the instances for many clients.

Automatic reconnect returns new reason codes for certain types application processing. For example if the client is processing a message group, it requires reconnection to the same queue manager to complete properly. If reconnection is made to a seperate queue manager the application receives the new MQRC_RECONNECT_INCOMPATABLE return code. Reconnection might not be desirable for other application processing, so we suggest examining how an application is using messaging before implementing this feature.

The automatic reconnection functionality of WebSphere MQ V7.0.1 is different from the way high availability environments such as PowerHA work. PowerHA provides a service IP address (IP alias) for the cluster and transfers this IP address to the active server. However, you still need something like client reconnection to mask the failover from the applications, because even with an highly available cluster the client connections break.

The MQ client reconnection does not change or reroute IP addresses. It reconnects to the network addresses, which are defined in channel definitions and client connections.

Using standalone JMS clients

IBM WebSphere MQ classes for Java™ Message Service (JMS) is a set of Java classes that enables the JMS applications to access WebSphere MQ systems. Both the point-to-point and publish-subscribe models of JMS are supported. These Java classes are available as part of the IBM WebSphere MQ client support.

The JMS-administered objects, such as connection factory, topic and queue, are built using a vendor-supplied administration tool and stored on a JNDI namespace. A JMS application can retrieve these objects from the namespace and use them without needing to know which vendor provided the implementation.

When using IBM WebSphere MQ, the JMSAdmin command line tool or WebSphere MQ Explorer GUI tool can be used to create administered objects. These administered objects are specifically for use with WebSphere MQ classes for JMS.

Figure 3-8 shows the architecture of a Java application that uses the JMS interfaces with an IBM WebSphere MQ JMS provider.

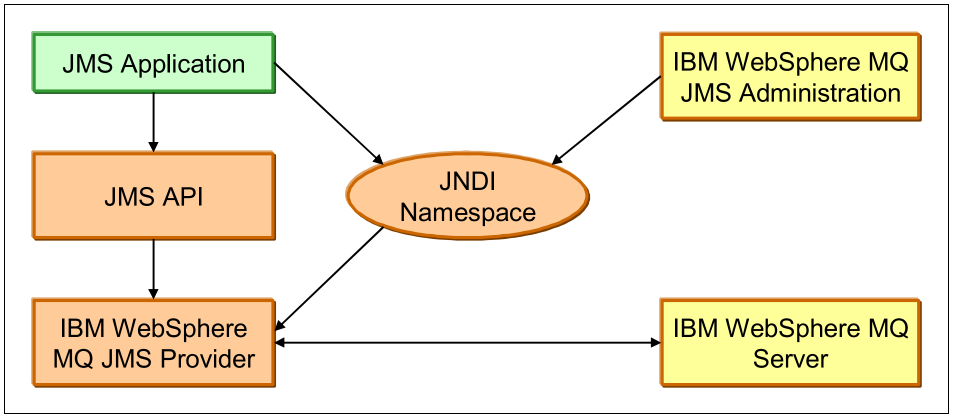

JMS Application
IBM WebSphere MQ JMS Administration
JMS API
JNDI Namespace
IBM WebSphere MQ JMS Provider
IBM WebSphere MQ Server

Figure 3-8 WebSphere MQ JMS architecture

The Java classes of the IBM WebSphere MQ V7.0.1 for JMS contains a set of extensions to the JMS API called the WebSphere MQ JMS extensions. An application can use these extensions to create connection factories and destinations dynamically at run time, and to set the properties of connection factories and destinations. Using these extensions it is possible to cast the generic JMS connection factory to a WebSphere MQ specific object. For example:

```
import com.ibm.mq.jms.MQConnectionFactory
javax.jms.ConnectionFactory cf;
MQConnectionFactory mqcf = (MQQConnectionFactory)cf;
mqcf.getConnectionNameList();
```

Properties can either be set through explicitly dedicated set/get methods for each property, or using a general name.value pair interface.

Use the CONNECTIONNAMELIST and CLIENTRECONNECTOPTIONS properties of the MQClientConnectionFactory class to configure a client connection to reconnect automatically following a connection failure or an administrative request to reconnect client applications after stopping a queue manager.

3.6.2 WebSphere MQ transactional client group unit of recovery

An availability improvement included with WebSphere MQ V7.0.1 is the ability to use group units of recovery on WebSphere MQ for z/OS. Applications using the WebSphere MQ transactional client, or running under WebSphere Application

Server, connecting to a WebSphere MQ queue sharing group can use this feature. When running under WebSphere Application Server you do not need to purchase or install the WebSphere MQ Transaction Client. The functionality is available for free.

The requirement for group units of recovery arose from the way assignment of the connection queue manager is made when using shared inbound channels. When a transactional client connects to a specific queue manager, the unit of recovery that is built is specifically for that client's activity and queue manager. Because that client connects to only one queue manager, if an interruption occurs when the client reconnects to the original queue manager, the unit of recovery can be resolved.

With releases prior to WebSphere MQ V7.0.1 if the client chooses to connect to a queue sharing group, any unit of recovery that is built is owned by the queue manager hosting the connection. As long as there is no interruption this works well. The problem arises when an interruption occurs and the client's reconnection resolves to a seperate queue manager, which can occur if the original queue manager is unavailable or the sysplex distributor determines there is a better host for this connection. The unit of work is unavailable for recovery because it is owned by the original queue manager.

WebSphere MQ V7.0.1 introduced group units of recovery to address this issue. This is implemented in two parts. The simple part is that the client uses the queue sharing group as the queue manager name. The more complicated piece is on the WebSphere MQ for z/OS side. All queue managers eligible for group recovery need to be altered to set a new queue manager property, GROUPUR(ENABLED). The OPMODE must also be set to NEWFUNC at the 701 level or higher. In addition, a new coupling facility list structure named CSQSYSAPPL must be defined, and on that list structure a new queue SYSTEM.QSG.UR.RESOLUTION.QUEUE. The group unit of recovery records are stored in this new queue, and are available to every queue manager in the QSG. In the event of an interruption, the work can be recovered even when the client's reconnection is directed to a seperate queue manager in the QSG.

3.6.3 Client connection balancing

Load balancing is often used to implement failover, providing high availability. Sometimes, load balancing is performed by having a single device receive all requests and determine which server to which to send the request. In other load balancing mechanisms, the request might be sent to all of the servers and each server determines whether it services the request.

For certain applications, it is desirable that communications from the same client go to the same server. This is sometimes called *client affinity* or simply, *affinity*.

For example, if a server is storing shopping cart information related to a client's order and a request from the client is serviced by another server, the shopping cart information or session state might not be available to the other server. Client affinity becomes more complicated in load balanced systems.

Round-robin balancing and weight-based load balancing

A variety of algorithms are used by load balancers to determine which back-end server to which to send a request. Simple algorithms include random choice or round-robin. The round-robin algorithm cycles through a list of server instances in order. Weight-based load balancing improves on the round-robin algorithm by taking into account a pre-assigned weight for each server.

Client affinity

Application request routing provides a client affinity feature that maps a client to a content server behind for the duration of a client session. When this feature is enabled, the load balancing algorithm is applied only for the first request from the client. From that point on, all subsequent requests from the same client are routed to the same content server for the duration of the client session. This feature is useful if the application on the content server is stateful and the client’s requests must be routed to the same content server because the session management is not centralized.

Client affinity is defined between a client connection and a data source. When client affinity is defined, requests from a specified client connection are distributed to a specified data source in a data source pool. The client affinity feature reduces the risk of propagation delay in deployments that use load balancing. Propagation delays can occur when a client makes consecutive requests that target the same entry if those requests are not treated by the same data source. For example, a client might make one request to change an entry and a second request to use the changed entry. If the second request is treated by a data source that has not been updated by the first request, an error occurs.

Client weight

The client weight value can be used to load balance client connections when there are multiple connection options in a client channel definition table (CCDT). The weight value ranges from 00–99, where 00 is a special value indicating that no specific preference is set and the CCDT entries are used in alphabetical order in connection attempts, much like the CCDT was used in prior versions.

The other values (01–99) help weigh the random selection. In the CCDT example in Example 3-1 on page 53, when a connection is attempted a random number between 1 and 31 (the weight totals) is generated.

Example 3-1 Client Channel Definition Table

```
CHLNAME(CLIENT1.TO.MQB5) CHLTYPE(CLNTCONN) QMNAME(MQB5)
CONNAME(9.12.4.153(11419)) CLNTWGHT(1)
CHLNAME(CLIENT2.TO.MQB5) CHLTYPE(CLNTCONN) QMNAME(MQB5)
CONNAME(9.12.4.153(11417)) CLNTWGHT(10)
CHLNAME(CLIENT3.TO.MQB5) CHLTYPE(CLNTCONN) QMNAME(MQB5)
CONNAME(9.12.4.153(11415)) CLNTWGHT(20)
```

If the number generated is 1, the channel CLIENT1.TO.MQB5 is used. If the random number is between 2 and 12, CLIENT2.TO.MQB5 is used. CLIENT3.TO.MQB5 is used for 12–31. As with any random number generation, it is conceivable that it might generate the same integer 20 times in a row.

The client weights in the table can include both 0 and integer values. If that is the case, the 0 weighted channels are attempted first in alphabetical order. If they are not available, the weighted channels are selected as described in the previous paragraph.

3.6.4 Network sprayers

A network sprayer distributes the load it receives to servers contained in a cluster (a set of servers that run the same application and can provide the same contents to its clients). This mechanism is also known as *IP spraying*.

Edge components

An IP sprayer is a type of network sprayer that handles all incoming IP network requests, and sprays those requests across various HTTP servers. IBM Edge Components provides a software package that allows you to set up a machine to act as an IP sprayer. It also provides a variety of caching mechanisms.

Sysplex distributor

The sysplex distributor can be thought of as a network sprayer. From a z/OS perspective it is a marriage between the availability provided by dynamic virtual IP addressing and an interface to the z/OS Workload Manager to help direct connections to the most appropriate target. This z/OS component is described fully in IBM Redbooks publication *TCP/IP in a Sysplex*, SG24-5235.

4

Operational considerations

This chapter describes factors to consider when designing, building, deploying, and managing a highly available messaging application.

4.1 Overview

When designing a highly available messaging solution, the high availability architecture alone does not guarantee high availability. There are a number of additional considerations to ensure that your application remains stable and that availability requirements can be met:

- Monitoring and alerting
- Message dependencies
- Configuration management
- Capacity planning
- Hardware reliability
- Managing the application configuration
- General considerations
  - Service support processes
  - Testing
  - Backups
  - Security

In this chapter we touch on each of these topics and how they influence the availability of your messaging solution.

4.2 Monitoring and alerting

An IT infrastructure has events occurring 24x7. An event can be described as an activity at the hardware or software level and might be software-, application-, or business-related. For example, a power supply failure is a hardware event. An insurance claim arriving in a message queue is a business event. Events can generally be classified into the following types:

- Notification events

  For information only, no action is necessary. For example, an audit log being transferred to a remote destination or files being recycled successfully.

- Error events

  For conditions that might require an action. For example, an occasional message validation failure or authentication error due to invalid data being sent might not require specific action unless the event occurs repeatedly within a short period of time

- Critical events

  For conditions when systems or applications are in a critical state and an immediate action is required. For example, CPU use reaching or exceeding its ceiling, a power supply failure, or a cluster node failure.

Monitoring and alerting is critical to high availability. It allows you to identify potential issues before they arise and to respond quickly to incidents. Monitoring can be as comprehensive or as narrow as needed or desired. Events can be monitored at the hardware, software, and messaging level. For example, a power supply failure of a blade sever, a cluster node crashing, or tracking a transaction from the point it arrives in the infrastructure to the point when it is stored in a file or a database. Events can be correlated for an end-to-end view, tracking, and management.

In an infrastructure, consider monitoring the following components:

- Hardware components
  - Edge components such as firewalls and Internet gateways
  - Networking equipment and connectivity (fiber channels, lease lines and so forth)
  - Specialist devices such as content and virus scanners
- Middleware and messaging components
  - Messaging infrastructure

    For example, WebSphere MQ components such as queue managers and queues. In particular it is essential to monitor the dead letter queue and any application related backout queues if they exist.
  - Enterprise service buses at the integration layer

    For example, WebSphere Message Broker for components such as brokers, execution groups and flows, DataPower for processing policies, and so forth.
  - Application server instances

    For example, monitor WebSphere Application Server cells and clusters for server availability and performance. Monitor server pings, CPU usage, memory and swap space, disk space, and log files.
  - Databases

    Availability, space usage
- Storage systems
  - Static and dynamic file systems
  - SAN, RAID arrays

The monitoring software allows you to define conditions or situations that act as triggers for alerting or invoking remedial actions that rectify the situation. In addition, it allows you to gather statistics and produce reports and graphs to analyze trends and performance.

OMEGAMON® XE for Messaging from IBM is a comprehensive monitoring solution that provides all of these features and is ideally suited to monitoring WebSphere MQ and WebSphere Message Broker solutions. This product is described in detail in IBM Redbooks publication *Implementing OMEGAMON XE for Messaging V6.0*, SG24-7357.

4.3 Configuration management

Configuration management might not seem like an obvious consideration for high availability, however it is important. Consider the scenario in Figure 4-1.

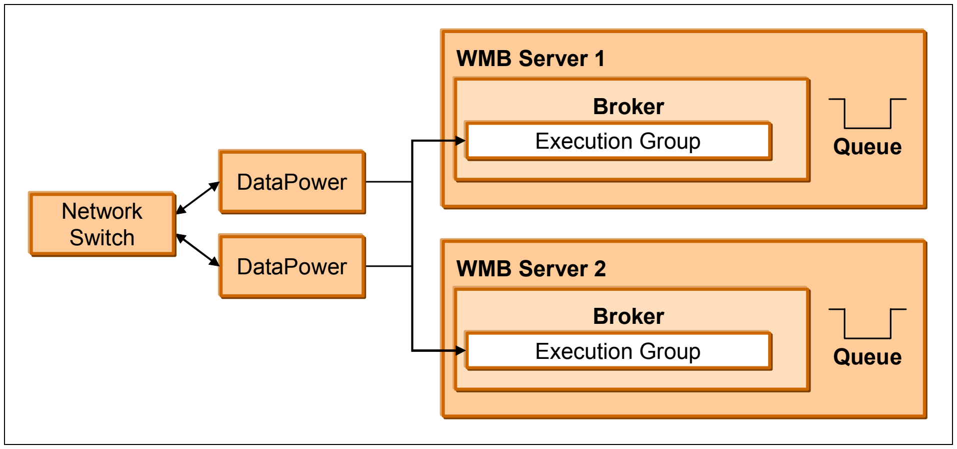


Figure 4-1 Active-active server configuration

In this scenario the high availability architecture is based around an active-active server configuration with each server containing a single broker instance. Incoming requests are load balanced across the two servers. The Superhuge App 1.0 WebSphere Message Broker application is deployed to each of the brokers.

In the following sections, we consider scenarios and options for breaking down the Superhuge App 1.0 application into deployment units.

4.3.1 Deployment scenario 1: The big bang

In the big bang scenario our Superhuge App 1.0 application is packaged for deployment in one single bar file for all of the message flows and message sets. This is depicted in Figure 4-2.

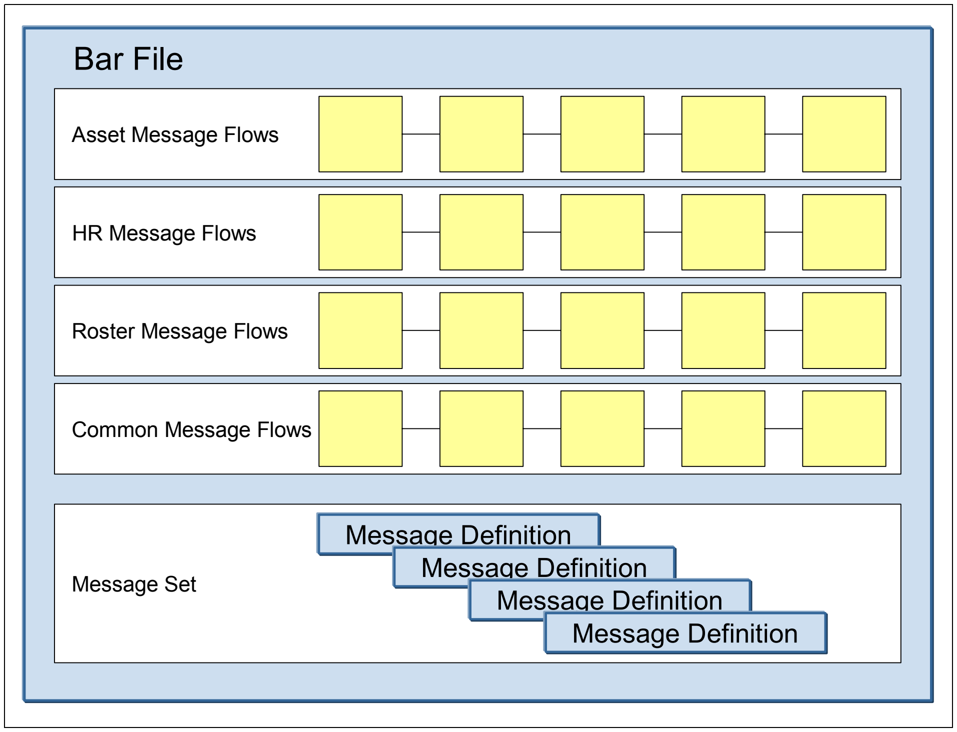


Figure 4-2 Sample application in a single BAR file

A minor patch has been made to one of the message flows. Due to the nature of the change, however, all instances of the application must be at the same patch level. That is, we cannot have requests coming into broker 1 that contain the new patch and requests routed to broker 2 that do not contain the patch. This results in data inconsistencies.

To deploy safely this minor patch for Superhuge App 1.0 using a single bar file, as depicted in Figure 4-2 we need an outage of the entire application. This will violate our availability SLAs.

Note: You can have a separate patch release process that involves special packaging for the patch. This complicates the release process, however, making it more difficult to track versions of flows deployed and introducing a risk that the deployment of the patch impacts the remainder of the application.

4.3.2 Deployment Scenario 2: Multiple deployment units

In this scenario our Superhuge App 1.0 application is packaged for deployment in multiple bar files: one for the message set, one for common infrastructure and utilities, and one for each of the five seperate functional areas within the application. Each of the functional bar files is deployed to a seperate execution group. This is depicted in Figure 4-3

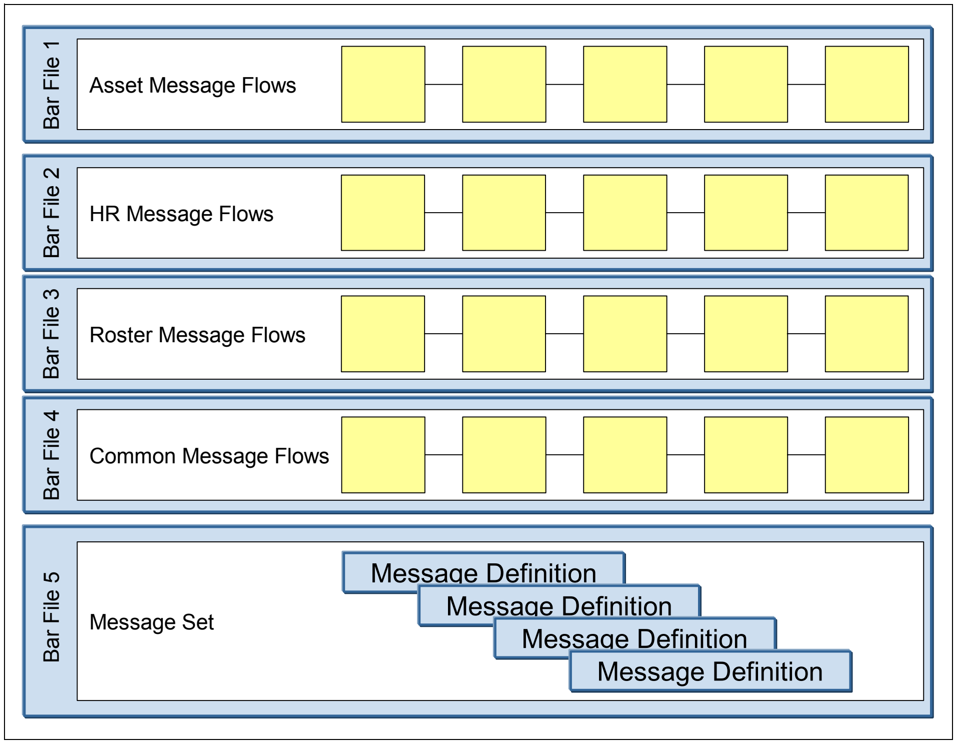


Figure 4-3 Sample application deployed in multiple BAR files

A minor patch has been made to one of the message flows. Due to the nature of the change, however, all instances of the application must be at the same patch level.That is, we cannot have requests coming into broker 1 that contain the new patch and requests routed to broker 2 that do not contain the patch. This results in inconsistencies. In this case, the minor patch is a message flow that has been packaged in bar file 4.

To deploy this minor patch for Superhuge App 1.0 we do not need an outage of the entire application. We can stop execution group 4 on both servers and deploy bar file 4. The use of multiple deployment units means that we have minimized the impact to the users and only a subset of the functions have been impacted. If the functions in bar file 4 are used infrequently, there might be no noticeable impact to users.

4.3.3 Deciding how to break down the application into deployment units

Deploying multiple units is a big improvement compared with the big bang option. There are various ways to break down your application into deployment units and each approach has its trade-offs.

Generally speaking a higher number of deployment units equates to more flexibility in terms of deployment. However the trade-off is that there might be additional configuration management effort.

The key message here is to consider the availability impacts when deciding how to break down your messaging application into deployment units.

4.4 Capacity planning

When planning for redundancy it is essential to perform capacity planning to ensure that in the event of an outage the remaining infrastructure can cope with the full load during peak times. Otherwise there can be performance degradation or an inability to process all client requests.

Gather metrics or calculate estimates for the peak number of requests per hour, current and projected disk space requirements, current and projected memory requirements, and growth rates for each of the metrics considered.

Often this information is difficult to gather, especially for completely new systems, so it is difficult to get specific data. In the absence of specific data you might need to rely on rough estimates. Sources of this data include:

- Subject matter experts
- Analysis of existing systems or existing paper-based processing
- Analysis based on the application functionality/user profiles (for example, the number of message flows, size of messages and the number and type of users)
- Estimating based on educated guesses or industry-wide averages

4.5 Hardware reliability

Use of redundancy to provide high availability is not a replacement for using reliable hardware. With every hardware failure there is a risk that in-flight requests are lost. This impacts the users of the system.

Hardware reliability means the ability of a hardware components to operate correctly over a specified time period. Do not confuse this with fault tolerance, which is the ability to continue operation in the event of failure conditions.

Reliability is measured by the mean time between failures (MTBF) metric, which is calculated as shown in the following equation:

```
MTBF = (uptime hours) / (number of failures)
```

When making a hardware selection for servers, external storage, network infrastructure (such as switches or any other hardware components that form part of your solution), take into account the available reliability data. This might include benchmarking or white papers provided by the vendor or by independent third parties.

Use of generic so-called white-box servers at a fraction of the price of vendor products comes with added risk, because their server reliability characteristics are difficult to gauge.

4.6 Managing the application configuration

When designing a solution, plan how the application is to be configured. Avoid hard-coding configuration parameters, as this requires an application coding change and release to implement the change. This situation can require an outage of the application. The common practice is to externalize all configuration in a properties file so that changes can be made by updating the configuration file. This includes passwords that can be encrypted and stored in an external file.

4.7 General considerations

There are many other aspects of the software development and support processes that must be in place to ensure high availability of your messaging solution. These are of a general nature and apply equally to non-messaging applications.

4.7.1 Service support processes

Poor support processes are a major cause of outages in companies that do not have strict processes in place. Before putting any application into production you must have a robust service support structure in place, which includes the following tactics:

- Documented processes and procedures for change management, incident management, release management, and configuration management.
- A change control board or other organizational structure in place to manage the processes and ensure compliance.
- Tools to support these processes.
- Training for development and support staff.

The industry standard for managing IT services is the Information Technology Infrastructure Library (ITIL®), which is published by the United Kingdom's Office of Government Commerce (OGC). ITIL consists of a comprehensive library of concepts, processes, and practices and encompasses a range of topics for managing IT infrastructure. For more information about ITIL, see the OGC web site:

`http://www.ogc.gov.uk/guidance_itil.asp`

4.7.2 Testing

Most organizations perform functional testing prior to the release of an application that aims to ensure that baseline functionality works as per the specification. But many cut corners on other essential forms of testing, and this often leads to outages following a software release.

Performance testing

In addition to functional testing it is essential to perform operability testing before going into production. Operability testing includes performance testing to ensure that the application can handle the expected peak loads plus an allowance for a growth factor or sudden large request bursts.

There are a number of tools available to automate the performance testing process including IBM Rational® Performance Tester. This tool allows you to perform the following tasks:

- Create and execute performance test scripts.
- Emulate a high load on the system by multiple users.
- Analyze the results to identify performance bottlenecks.
- Compare results against non-functional requirements

For more information about performance and quality tools see the following IBM Web site:

`http://www-01.ibm.com/software/rational/offerings/quality/performance.html`

Security testing

Security testing is another form of testing that is frequently overlooked but is essential, especially for solutions that expose services externally. There have been numerous high profile denial of service attacks that have resulted in application being unavailable.

Large applications in particular benefit from the use of testing tools that automate security analysis and help scale the testing process for thousands of security vulnerabilities. IBM Rational AppScan® is an industry-leading Web application security testing tool that scans and tests for all common Web application vulnerabilities. For more information about the Rational AppScan family of products, see the following IBM Web site:

`http://www-01.ibm.com/software/awdtools/appscan/`

The Open Web Application Security Project (OWASP) provides an excellent security testing framework that can be used as a basis for developing security testing plans and test cases. For more information, see the OWASP Web site:

`http://www.owasp.org`

High availability solution testing

With most large and complex applications that require high availability there are multiple failure points that need to be considered. It is not sufficient to put effort into the design and build of a high availability solution and then perform no testing or to take an ad hoc approach to testing. Your test strategy should incorporate high availability testing to cover a range of possible failure scenarios that are applicable to your particular solution.

Testing should also encompass the end-to-end solution and be tested under the identical network environment that the solution is to be deployed to in production. This is to ensure that the effects of load balancers, firewalls, network switches, and other hardware devices that might impact the network traffic are factored in to test results.

4.7.3 Backup and recovery

There are two aspects of the backup process that need to be considered with respect to high availability. The first is to design a solution that allows online backups to be performed without impacting the application. You want to avoid, for instance, having to take an entire system offline to perform backups because there is a risk that a failure in the remaining online node (for a two node solution) can result in an outage.

It is worthwhile to note the importance of a documented and tested recovery process. Most applications take backups but companies often do not test this process. When they have to recover after a failure, they learn that the backups did not work or that there is a flaw in the process. There are known cases in which this has occurred and resulted in extended outages or even complete loss of data.

4.7.4 Security

As mentioned in 4.7.2, “Testing” on page 63, when discussing security testing, the risk of attack from malicious users is real and is increasing. Denial of service attacks can cause extended application outages. Malicious attacks can target the application data or the application itself, which can cause service disruptions and loss of data and have a major financial impact on companies.

To mitigate this risk, security should be a key focus of architecture, design, and coding plans and practices. Testing is a final checkpoint to verify that the security measures put in place are effective and provide a degree of comfort that the application is secured. Do not rely on testing alone, however. Security is a fundamental consideration and it is far more cost effective if planned for early in the analysis and design phases.

Part 2

Scenarios

This part provides scenarios that illustrate different techniques for introducing high availability into your WebSphere solutions.

5

High availability using PowerHA clusters

This chapter presents a scenario that demonstrates the use of a PowerHA cluster to provide a highly available file transfer solution.

5.1 Scenario overview

The scenario presented in this chapter uses WebSphere messaging products integrated in a PowerHA cluster environment to provide high availability. A file transfer solution is used to illustrate the concepts. In this example, an application on z/OS writes a file to a directory with the intent that the file is transferred to a WebSphere Message Broker system for processing.

The message brokers performing the file processing are placed on multiple AIX systems in a PowerHA cluster, with one broker actively processing the messages and a second broker standing by to pick up the processing in the event the system with the active broker fails. In Figure 5-1, one of the nodes is in the standby mode.

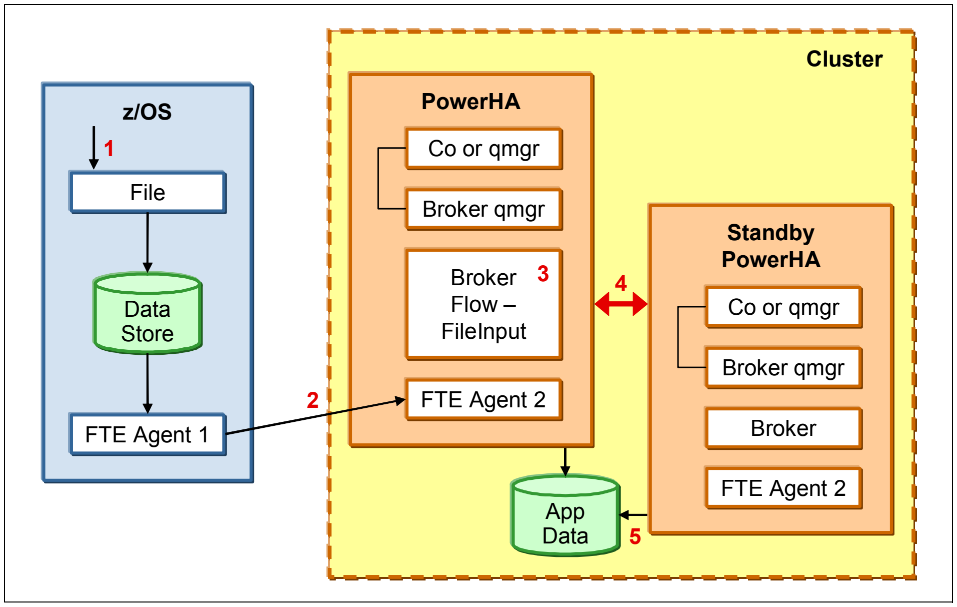


Figure 5-1 High availability in a WebSphere MQ FTE solution

The following process is illustrated in Figure 5-1:

1. The application on z/OS writes a file into a directory being monitored by FTE Agent1.
2. FTE Agent1 sends the file to FTE Agent2, which writes the file to a shared disk.

3. A message flow within the broker of the active node processes the file to perform enrichment and transformation activities on the file. The flow uses the FileInput node to receive the file.
4. The heartbeat-using disk feature (diskhb) is used by the PowerHA systems to exchange heartbeat packets or messages between nodes. It allows the cluster managers to continue communicating if the network fails.
5. The MQ data and log files, and the configuration files of broker and FTE are also stored on shared disks that are available to all cluster nodes.

5.2 High availability characteristics of the scenario

In the architectural design of this scenario, we implemented a failover cluster or a standby configuration. The messaging components of MQ, FTE, and Broker provide high availability of file transfer services. The components are configured in one resource group. By using the cluster standby mode configuration, all resources can be redirected to another node in the cluster when a failure occurs on the active cluster node. Two types of failure (implemented in the PowerHA cluster) can be detected during operation:

- In the event of an application component failure, MQ, FTE, or Broker, the resource group can be taken over by a standby node if the monitoring for the PowerHA application server is configured.
- In case of hardware failure (such as of a IP network, node or network interface), the recovery happens for the whole resource group.

This standby configuration of the cluster is more appropriate for batch file transfer and can fulfill the requirements of the proposed application scenario. If a cluster active-active mode is chosen, the coordination of two cluster nodes for input file processing is a big challenge.

The MQ queue managers on AIX node are the key components of this HA solution. They provide the base functionality for FTE file agents. It is essential to configure them as high available components. We briefly explain the standard recovery concepts of WebSphere MQ and how this method is implemented for a standby configuration in a PowerHA cluster.

WebSphere MQ uses a simple mechanism dealing with recovery of message queues after a failure of a queue manager. To recover persistent messages, MQ saves log messages to disk storage during an MQ transaction. In the event of a failure, message data on the disk and the queue manager logs are used to reconstruct the message queues. This restores the queue manager to a consistent state that existed at the time before the failure occurred.

In the active-standby mode of a PowerHA cluster (as in Figure 5-2), when the original node or queue manager fails, the HA cluster automatically restarts the queue manager, either on the same node or the standby node. The queue manager's data files and logs are stored on shared disk storage accessible to both nodes.

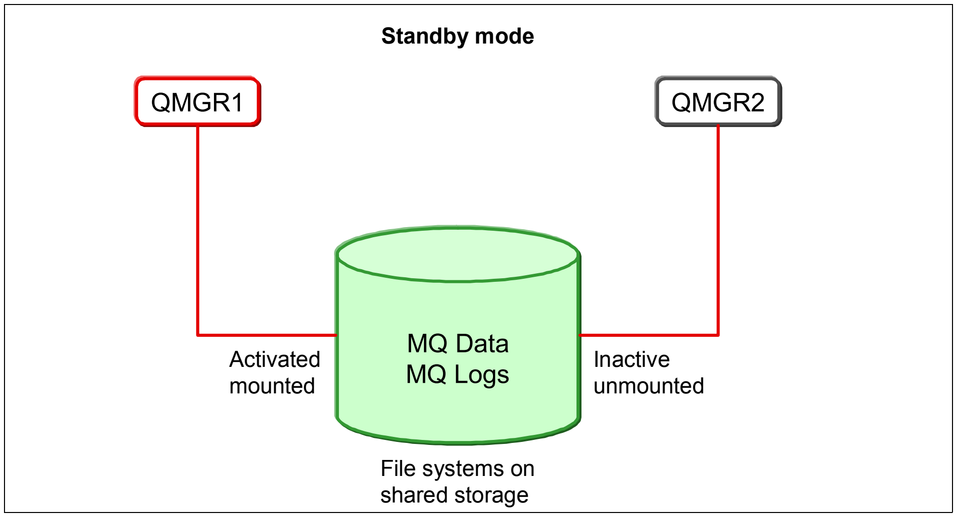


Figure 5-2   MQ log in standby PowerHA cluster

In normal operation, the shared disk is mounted by the master node, which uses the disk storage to run the queue manager as though it were a local disk, storing both the queues and MQ log files on it. When a failure is detected the standby node mounts the shared disk and starts the queue manager. The queue manager replays the logs stored on the shared disk to return the queue manager to the correct state.

In a PowerHA cluster for MQ active-standby mode, only one machine at a time has access to the shared disk partition. Only one instance of the queue manager runs at any one time to protect the data integrity of messages.

Note: In this scenario, only one WebSphere MQ instance is used. The multi-instance capability of WebSphere MQ is discussed in Chapter 6, "Using multi-instances queue managers and brokers for high availability" on page 107.

The FTE agents, as communication components of file transfer, should be configured in a cluster resource group. The broker component is also included in the resource group to provide high availability of message processing.

5.3 PowerHA cluster

In this chapter, we introduce the configuration of our PowerHA cluster environment for the proposed scenario.

A standard two-node cluster configuration is built. The cluster consists of two AIX LPAR nodes and is set up in a Standby takeover configuration. This is a configuration where one node performs work while the other node acts as standby.

5.3.1 HA cluster topology and configuration

In this section, we discuss the cluster components, the topology, and the configurations used to make the cluster resources highly available.

Network overview

Figure 5-3 shows network aspects of the system.

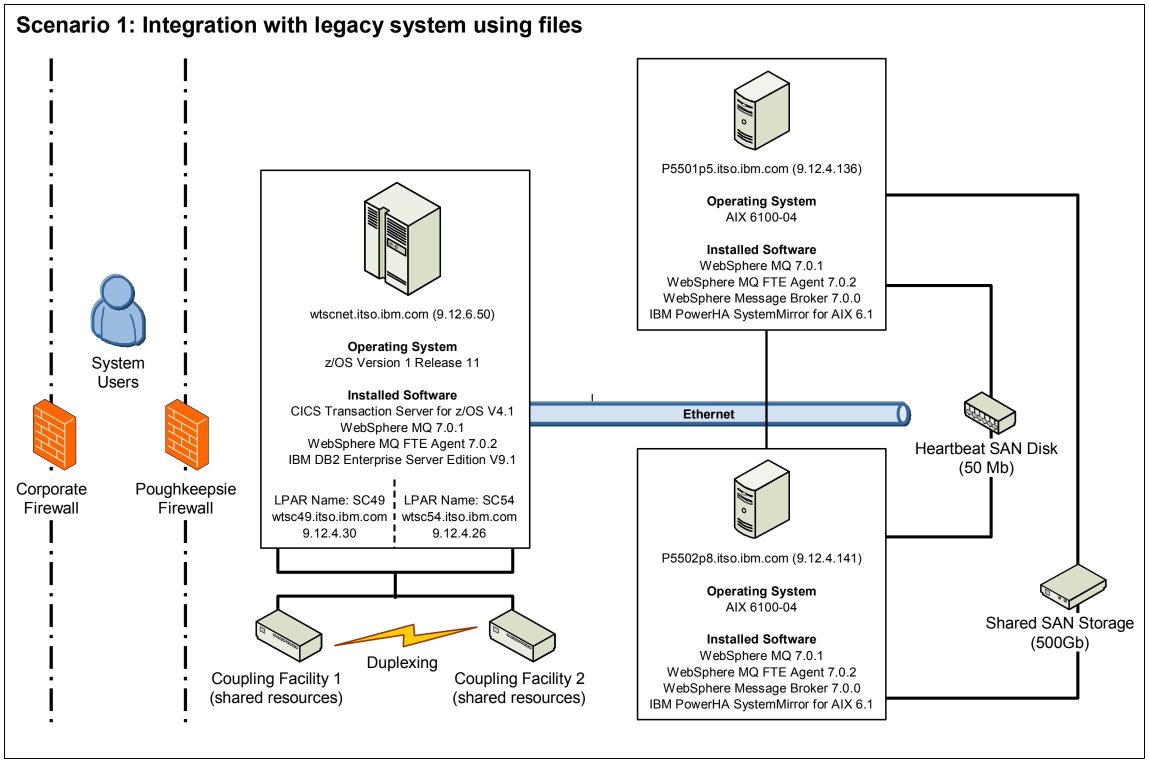

Scenario 1: Integration with legacy system using files
System Users
Corporate Firewall
Poughkeepsie Firewall
wtscnet.itso.ibm.com (9.12.6.50)
Operating System
z/OS Version 1 Release 11
Installed Software
CICS Transaction Server for z/OS V4.1
WebSphere MQ 7.0.1
WebSphere MQ FTE Agent 7.0.2
IBM DB2 Enterprise Server Edition V9.1
LPAR Name: SC49
wtsc49.itso.ibm.com
9.12.4.30
LPAR Name: SC54
wtsc54.itso.ibm.com
9.12.4.26
Coupling Facility 1 (shared resources)
Duplexing
Coupling Facility 2 (shared resources)
Ethernet
P5501p5.itso.ibm.com (9.12.4.136)
Operating System
AIX 6100-04
Installed Software
WebSphere MQ 7.0.1
WebSphere MQ FTE Agent 7.0.2
WebSphere Message Broker 7.0.0
IBM PowerHA SystemMirror for AIX 6.1
P5502p8.itso.ibm.com (9.12.4.141)
Operating System
AIX 6100-04
Installed Software
WebSphere MQ 7.0.1
WebSphere MQ FTE Agent 7.0.2
WebSphere Message Broker 7.0.0
IBM PowerHA SystemMirror for AIX 6.1
Heartbeat SAN Disk (50 Mb)
Shared SAN Storage (500Gb)

Figure 5-3 Network plan

The topology contains the following aspects:

- A z/OS system with two LPARs. The core application components on each each LPAR are WebSphere MQ and WebSphere MQ FTE.
- The IBM Coupling Facility (CF) provides shared resources for the parallel sysplex with the two LPARs.
- Two AIX systems with WebSphere MQ, WebSphere MQ FTE, PowerHA, and WebSphere Message Broker.

  Two shared disks are connected to the AIX PowerHA cluster. One is used for storage of application data. The second is used for the non-IP network disk heartbeat.

Overview of the PowerHA cluster hardware

The AIX LPAR nodes are based on the IBM Logical Partition (LPAR) technology. A system is split into multiple virtual systems (LPARs). Each LPAR is defined as a virtual machine. The system manager determines the resources (CPUs, memory) to be assigned to each partition.

The two LPAR nodes, two POWER5-based machines used in our scenario, use IBM Virtual I/O Server (VIO Server) to perform the mapping between hardware and virtual CPU units. As shown in Figure 5-4 on page 75, the VIO server hosts the physical hardware being presented to the cluster nodes. The VIO server owns the real PCI adapters (Ethernet, SCSI, or SAN) and lets the two LPARs share them using the built-in Hypervisor services. LPARs are also called Virtual I/O client partitions (VIO client). It is unnecessary for these two generated LPARs to have real physical disks or real physical Ethernet adapters.

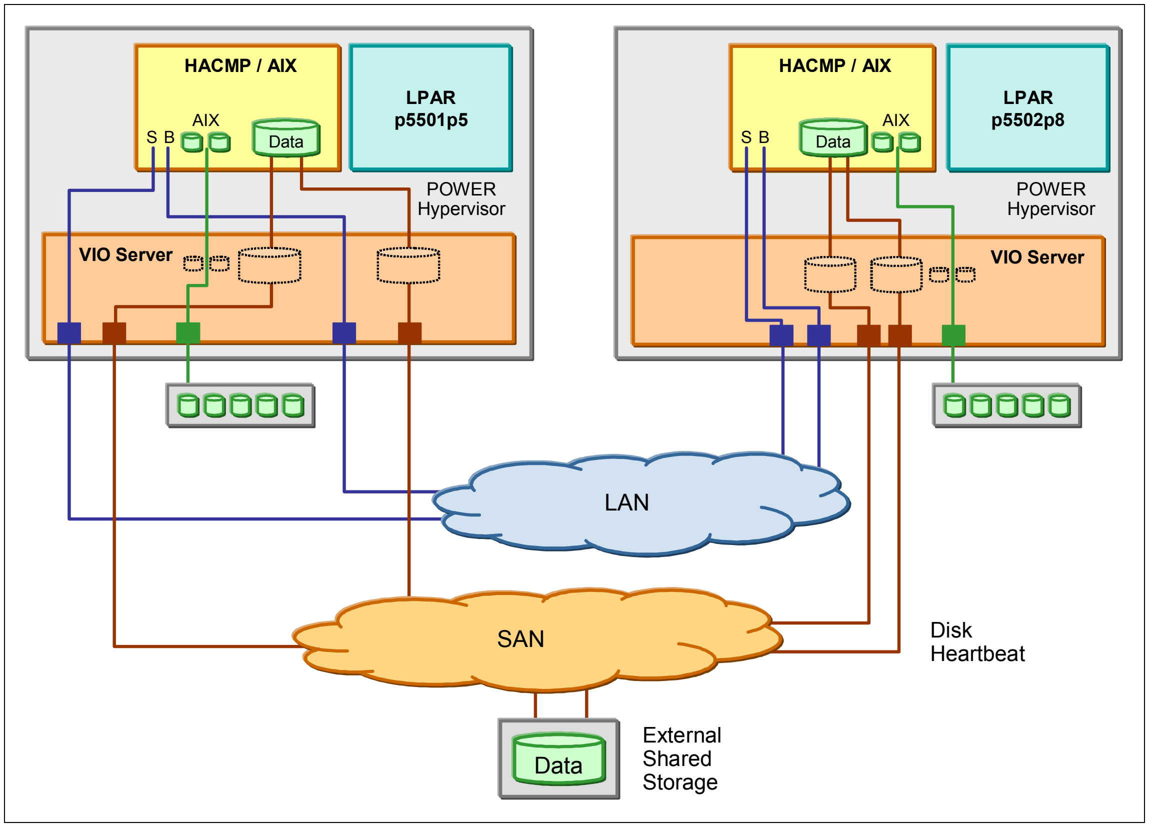


Figure 5-4 HACMP cluster and VIO server

Application software installed on the LPAR node

The software used for the AIX PowerHA cluster is summarized in Table 5-1.

Table 5-1 Installed software

Software	Version
AIX	6.1.4
RSCT	2.5.4
HACMP	5.4.1
WebSphere MQ	7.0.1
WebSphere MQ FTE	7.0.2
WebSphere Message Broker	7.0.0

5.3.2 Topology and resource group

The topology of the cluster represents the physical view of the cluster and how hardware cluster components are connected using networks (IP and non-IP). The resources are those components that PowerHA can move from node to node (for example, service IP labels, file systems, and applications).

Figure 5-5 illustrates the PowerHA cluster system topology.

.

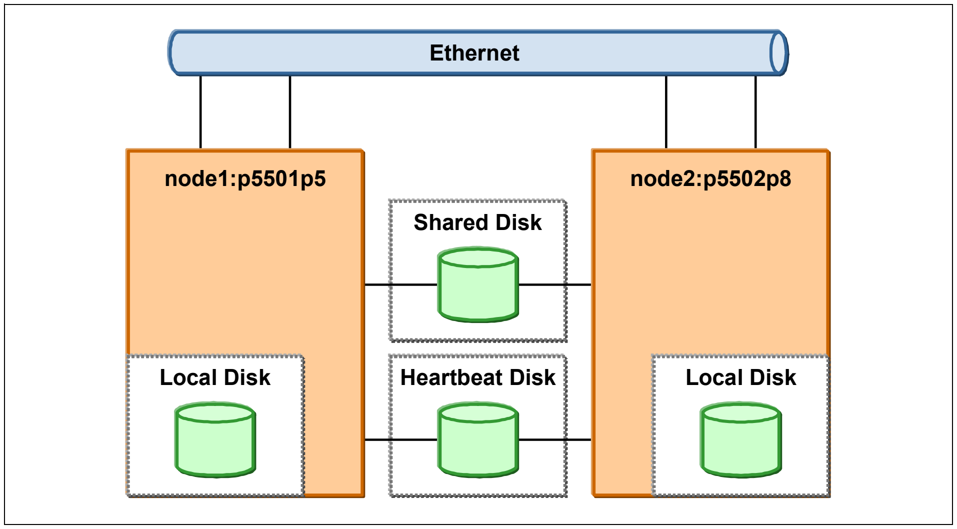


Figure 5-5 HA cluster network

Cluster nodes and networks

The PowerHA cluster with two nodes is configured as an active-passive cluster mode: One node serves the set of resources during normal operations, and the other node provides backup for the first node.

The basic components are defined as follows:

- Two AIX PowerHA nodes
- Two IP networks (PowerHA logical networks) with redundant interfaces on each node. An Ethernet network is used for public access.
- Shared disk using SAN storage.
- Point-to-point non-IP connections (heartbeat disk) between nodes, configured as independent physical networks. The heartbeat disk in the environment is easy to implement because no additional hardware is required.

The heartbeat network provides an additional path for keep alive (or heartbeat) packets and allows the cluster managers to continue communicating if the network fails. This network is not a TCP/IP network. Having this non-TCP/IP network is a important requirement, because it provides system protection against two single points of failure:

- The failure of the TCP/IP software subsystem
- The failure of the single network

IP aliasing

An IP alias is an IP label (address) that is configured onto a network interface card, as an additional method of managing the service IP. The IP alias can be configured through AIX (smitty inetalias) before configuring the HA cluster. Use the persistent alias as the communication path to the node.

Figure 5-6 illustrates the concept of the persistent address. Note that this is another IP address configured on one of the base interfaces.

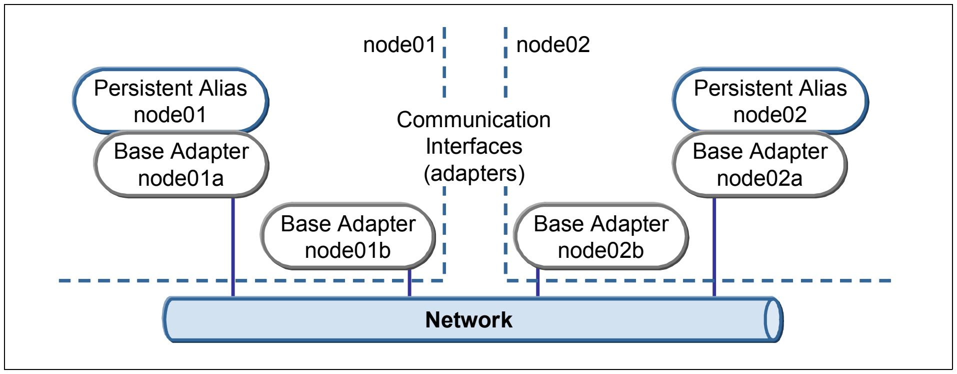


Figure 5-6 IP Alias

Preparing the shared disk

To prepare the shared disk of the PowerHA cluster, shared volume groups must be created. The file systems reside on the shared disk devices. Our configuration has one volume group: data_vg.

The volume groups, logical volumes, and file systems shared by the two nodes in the cluster are created on one node (in our example, node p5501p5). After that, the volume group is exported. On the other node, all components are imported.

The steps for accomplishing this configuration of shared storage are as follows:

1. The **smit mkvg** fastpath command is used to create a shared volume group. Example 5-1 shows the SMIT menu used for defining an original enhanced capable volume group named data_vg, containing hdisk2 and having major number 38.

Example 5-1 Add a volume group

```
Add an Original Volume Group
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                         [Entry Fields]
  VOLUME GROUP name                                   [data_vg]
  Physical partition SIZE in megabytes +
* PHYSICAL VOLUME names                               [hdisk2] +
  Force the creation of a volume group?                no +
  Activate volume group AUTOMATICALLY                  no +
    at system restart?
  Volume Group MAJOR NUMBER                           [38] +#
Create VG Concurrent Capable?                       enhanced concurrent
+
```

   The “Activate volume group AUTOMATICALLY at system restart?” field must be set to **No**, because PowerHA is responsible for activating this volume group by invoking the appropriate **varyonvg** command.

2. After the volume group data_vg has been created, Activate it with the **varyonvg** command, as shown in Example 5-2.

Example 5-2 vary on a volume group

```
# varyonvg data_vg
```

3. To further configure a logical volume group, create a dedicated log logical volume as a part of the shared volume group with jsf2log type. Format it using the **logform** command, as in Example 5-3.

Example 5-3 Create a log for a logical volume

```
$mklv -t jfs2log -y lognfsshared_lv nfsdata_vg 60M
$/sur/sbin/logform /dev/newloglv
y
```

As shown in Example 5-4, issuing the **smitty mklv** command displays the panel for adding a logical volume.

Example 5-4 Add a logical volume on volume group

```
Add a Logical Volume
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
[TOP]                                                   [Entry Fields]
  Logical volume NAME                                [shared_lv]
* VOLUME GROUP name                                   data_vg
* Number of LOGICAL PARTITIONS                       [20] #
  PHYSICAL VOLUME names                              [    ] +
  Logical volume TYPE                                [jfs2] +
  POSITION on physical volume                         middle +
  RANGE of physical volumes                           minimum +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 [] #
    to use for allocation
  Number of COPIES of each logical                    1 +
    partition
  Mirror Write Consistency?                           active +
  Allocate each logical partition copy                yes +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during                  yes +
    reorganization?
  Logical volume LABEL                               []
  MAXIMUM NUMBER of LOGICAL PARTITIONS               [512] #
  Enable BAD BLOCK relocation?                        yes +
  SCHEDULING POLICY for writing/reading               parallel +
    logical partition copies
  Enable WRITE VERIFY?                                no +
  File containing ALLOCATION MAP                     []
  Stripe Size?                                       [Not Striped] +
Serialize IO?                                       no +
  Mirror Pool for First Copy +
  Mirror Pool for Second Copy +
  Mirror Pool for Third Copy +
```

Now the file systems on logical volume shared_lv can be defined.

4. To create the file system, use the SMIT fastpath **smitty crfs** command at the command line. Use the AIX system administration command, as in Example 5-5.

Example 5-5 Create a file system on logical volume

```
$crfs -v jfs2 -p rw -d /dev/shared_lv -m /MQHA -A yes
Output
File system created successfully.
262135796 kilobytes total disk space.
New File System size is 524288000
```

5. Mount the file systems to check that creation has been successful, as shown in Example 5-6.

Example 5-6 Mount file system

```
# mount /MQHA
```

6. Assuming that the file systems mounted without problems, now unmount them. After the shared file systems are unmounted, the shared volume group data_vg can be inactivated off with the command shown in Example 5-7.

Example 5-7 Vary off volume group

```
# varyoffvg data_vg
```

7. On the node where the shared volume group is prepared, volume group data_vg is exported at first, as in Example 5-8.

Example 5-8 Export volume group

```
# exportvg data_vg
```

8. The exported shared volume group, data_vg, is imported on the other cluster node by using the **importvg** command, as in Example 5-9.

Example 5-9 Import volume group

```
# importvg -y data_vg -V 38 hdisk2
```

9. Mount the file systems to check that import has been successful.

Disk heartbeat device

To monitor availability of network interfaces, communication devices, and IP labels (service, non-service, and persistent), a heartbeat disk device as non-IP network is established in the cluster.

The procedure for preparing the heartbeat disk storage is as follows:

1. Create a volume group on a storage device
2. Create a diskhb network and assign the disk-node pair devices to the network, as shown in Figure 5-7 on page 82.

To start the configuration, it is assumed that the shared disks are already made available and configured to two AIX LPAR nodes.

1. To create an enhanced concurrent volume group, heartbeatvg, entering the **`smit mkvg`** command on one of the nodes generates the panel, as shown in Example 5-10.

Example 5-10 Create volume group

```
Add an Original Volume Group
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                      [Entry Fields]
  VOLUME GROUP name                                [heartbeatvg]
  Physical partition SIZE in megabytes +
* PHYSICAL VOLUME names                            [hdisk3] +
  Force the creation of a volume group?             no +
  Activate volume group AUTOMATICALLY               no +
    at system restart?
  Volume Group MAJOR NUMBER                        [37] +#
Create VG Concurrent Capable?                    enhanced concurrent
+
```

   This creates the shared enhanced-concurrent volume group heartbeat used for disk heartbeat device. The volume group major number is 37.

To create a disk network in smit, select **smitty hacmp** → **Extended Configuration** → **Extended Topology** → **Configuration** → **Configure HACMP Networks** → **Add a Network to the HACMP cluster** → **Enter**.

When prompted to select a serial network to add to the cluster, select diskhb, as shown in Example 5-11.

Example 5-11 Add a serial network to cluster

```
Add a Serial Network to the HACMP Cluster
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                        [Entry Fields]
* Network Name                                       [net_diskhb_01]
* Network Type                                        diskhb
```

The network name is `net_diskhb_01` and the type of network is diskhb, as shown in Figure 5-7.

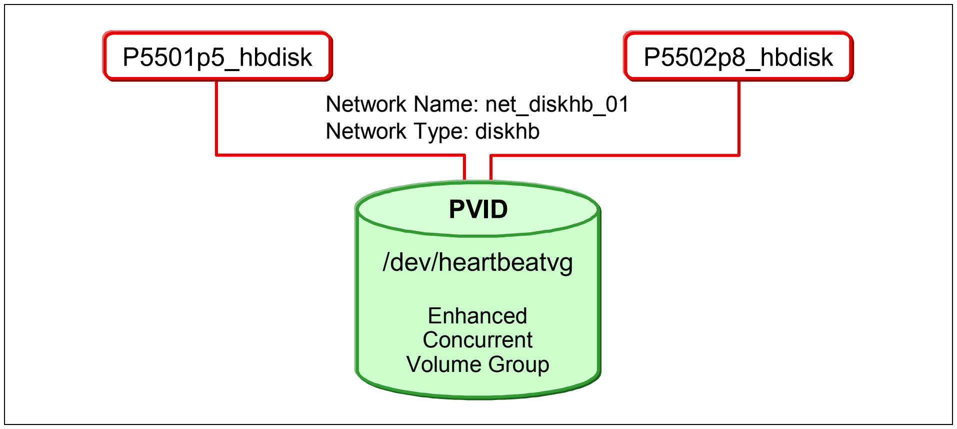


Figure 5-7 Network of Heartbeat Disk

To assign the disk-node pair devices to the network, use **smitty hacmp** → **Extended Configuration** → **Extended Topology** → **Configuration Configure HACMP Communication** → **Interfaces/Devices** → **Add Communication Interfaces/Devices** → **Add Pre-Defined Communication Interfaces and Devices Communication Devices** → **Choose your diskhb Network Name**, as shown in Example 5-12 on page 83.

Example 5-12 Assign the devices to the network

```
Add a Communication Device
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                        [Entry Fields]
* Device Name                                        [p5501p5_hbdisk]
* Network Type                                        diskhb
* Network Name                                        net_diskhb_01
* Device Path [/dev/p5501p5_hbdisk]
* Node Name                                 [p5501p5 ]
+
```

On the other node, the device name is selected to be p5502p8_hbdisk.

Note: The **`dhb_read`** command is used to test the connectivity of the heartbeat device in the HA cluster:

1) Set the first node in receive mode (-r):

```
# /usr/sbin/rsct/bin/dhb_read -p device_name -r
```

2) Set the second node to transmit mode (-t):

```
# /usr/sbin/rsct/bin/dhb_read -p device_name -t
```

Cluster resources

The cluster resource group contains the following resource components:

- Service IP address
- PowerHA Application server
- File systems

As displayed in Figure 5-8, the resource group uses cluster services provided by nodes and other hardware components of the network to make application components highly available.

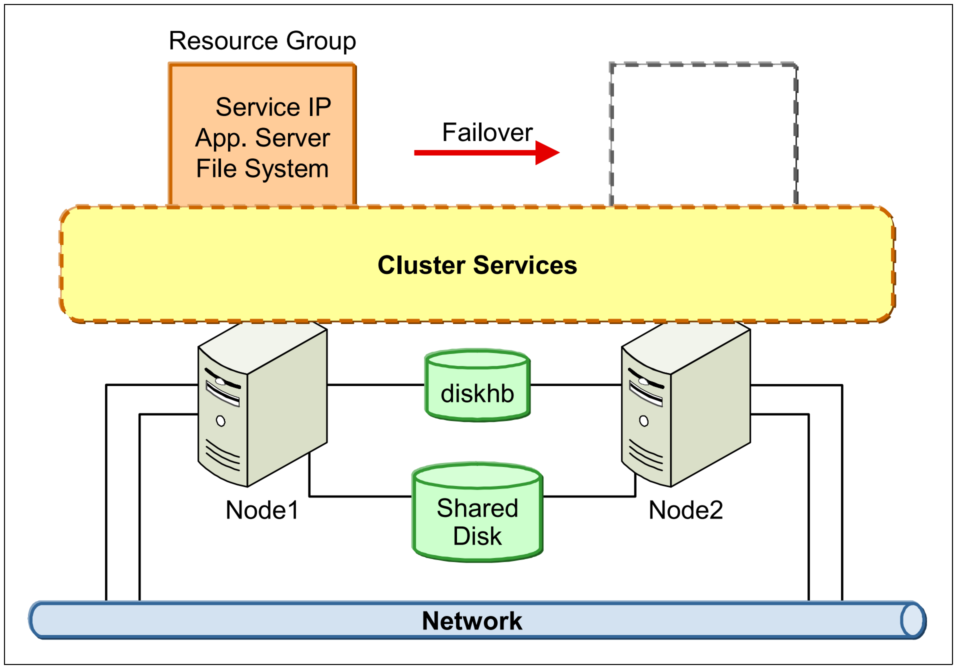


Figure 5-8 Resource group and cluster services

The behavior of the resource group defines the startup, failover, and fallback takeover policy of the cluster.

Service IP address

IP Address Takeover is used by PowerHA to move service addresses between communication interfaces and to provide high availability of service connections. As discussed in "IP aliasing" on page 77, we use IP aliasing method in our configuration.

A service IP label is used to establish communication between the client application and the server node. A service IP label can be placed in a resource group as a resource, which allows the cluster to monitor its health and keep it highly available.

In our cluster configuration, the service IP address of MQ is configured to use IP aliasing, which is under cluster control. When a clustered service moves from one cluster node to the other, it takes its service IP with it. It is different from the stationary physical IP address that is assigned to a cluster node.

Information about servers and their physical IP labels, as well as service IP label information is displayed in Table 5-2.

Table 5-2 Physical IP addresses and service IP label

Servers	Physical IPs	Service IP	Service label
p5501p5	9.12.4.136 192.168.100.76	9.12.4.153	`websherreesb_svc`
p5502p8	9.12.4.141 192.168.100.89		

This service IP label/address is used for creating the connections between queue managers. In the event of a failure, the connecting channels use the same IP address. Using IP aliases is easy to implement and flexible. You can have multiple service addresses on the same adapter at any given time,

Application server

The application components of our PowerHA cluster solution consists of the following elements:

- WebSphere MQ Series
- WebSphere Message Broker
- WebSphere MQ FTE

As the base component, WebSphere MQ establishes the connections for FTE, as well as the processing of broker. WebSphere MQ FTE agents are FTE programs that form the endpoints for file transfer operations.

In our solution, one application server in the cluster resource group is defined and prepared. The start and stop scripts for these three messaging components are implemented in this PowerHA application server.

File systems

The file systems, including journaled file system logs (**jfslogs**) and logical volumes, are prepared on shared volume group of disks. The file systems are configured as cluster resource and are included in the resource group.

5.3.3 Creating a cluster

For the our scenario, the Two-node Cluster Configuration Assistant is used to create the basic configuration.

Running the Two-Node Cluster Configuration Assistant

The assistant can be initiated through SMIT by entering the **`smit cl_configassist`** command.

The panel shown in Example 5-13 is then presented:

Example 5-13 Two-Node Cluster Configuration Assistant

```
Two-Node Cluster Configuration Assistant
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                         [EntryFields]
* Communication Path to Takeover Node                 [p5502p8]
* Application Server Name                             [itso]
* Application Server Start Script[/usr/es/sbin/cluster/start_esb]
* Application Server Stop Script [/usr/es/sbin/cluster/stop_esb]
* Service IP Label [webspheresb_svc]
```

The start and stop scripts specified in the assistant are the start_esb and stop_esb scripts respectively.

The start_esb script (shown in Example 5-14) uses the ha_script to start the cluster.

Example 5-14 start_esb script

```
start_esb/usr/es/sbin/cluster/ha_script start
```

The stop_esb script (shown in Example 5-15) uses the ha_script to stop the PowerHA cluster.

Example 5-15 stop_esb

```
/usr/es/sbin/cluster/ha_script stop
```

Example 5-16 shows the ha_script.

Example 5-16 the ha_script, used to control PowerHA cluster

```
#!/bin/ksh

case $1 in
start)
        su - mqm -c "strmqm MQK5"
        su - mqm -c "strmqm MQB5"
        su - mqm -c "fteStartAgent AGENT02"
        su - eaiadmin -c "mqsistart MQWMB"
        sleep 5
        RC=0
        ;;
stop)
        su - mqm -c "endmqm MQK5"
        su - mqm -c "endmqm MQB5"
        su - mqm -c "fteStopAgent AGENT02"
        su - eaiadmin -c "mqsistop MQWMB"
        sleep 5
        RC=0
        ;;
*)
        RC=255
        ;;
esac
exit $RC
```

You must provide the name of the takeover node, the application server name, the start and stop scripts for the application server, and the service IP label.

The results of the assistant for the new resource group are displayed in Example 5-17.

Example 5-17 Results for the new resource group

```
Change/Show All Resources and Attributes for a Resource Group
Resource Group Name                                           itso_group
  Participating Nodes (Default Node Priority)                   p5501p5 p5502p8
  Startup Policy Online On Home Node Only
  Fallover Policy Fallover To Next Priority Node In>
  Fallback Policy                                               Never Fallback
  Service IP Labels/Addresses                                  [webshereesb_svc]+
  Application Servers                                          [itso] +
  Volume Groups [data_vg heartbeatvg ]                        +
  Use forced varyon of volume groups, if necessary              false +
  Automatically Import Volume Groups                            false +
  Filesystems (empty is ALL for VGs specified)                 [ ] +
  Filesystems Consistency Check                                 fsck +
  Filesystems Recovery Method                                   sequential +
  Filesystems mounted before IP configured                      false +
  Filesystems/Directories to Export (NFSv2/3)                  [] +
  Filesystems/Directories to Export (NFSv4)                    [] +
  Stable Storage Path (NFSv4)                                  [] +
  Filesystems/Directories to NFS Mount                         []
  Network For NFS Mount                                        [] +
  Tape Resources                                               [] +
  Raw Disk PVIDs                                               [] +
  Fast Connect Services                                        [] +
  Communication Links                                          [] +
  Primary Workload Manager Class                               [] +
  Secondary Workload Manager Class                             [] +
  Miscellaneous Data                                           []
  WPAR Name                                                    [] +
```

The following list summarizes the main features of the configuration for the resource group:

- The resource group name is itso_group.
- The participating nodes with default node priority are p5501p5 and p5502p8.
- For the shared resource group, we use the following settings:
  - Startup policy: **Online On HomeNode Only**
  - Fallover policy: **Fallover To the Next Priority Node In the list**
  - Fallback policy: **Never Fallback**
- The Service IP Labels/Addresses is set to websphereesb_svc

- The application server, itso, is created.
- Two volume groups:
  - **data_vg**
  - heartbeatvg

Furthermore, the assistant prepared the following cluster topology features:

- All topology elements (nodes, networks, communication interfaces and devices) including a non-IP disk heartbeat network when it detects a shared enhanced concurrent volume group
- The topology supports one application server and two nodes.
- The topology uses IP takeover by aliasing.

Verification and synchronization of the cluster

The HACMP configuration database must be the same on the second node in the cluster. The synchronization of the generated cluster can be started by using SMIT, as in Example 5-18.

Example 5-18 Start cluster synchronization

```
HACMP Verification and Synchronization

Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                        [EntryFields]
* Verify, Synchronize or Both                        [Both] +
* Automatically correct errors found during          [No] +
  verification?
* Force synchronization if verification fails?       [No] +
* Verify changes only?                               [No] +
* Logging                                            [Standard] +
```

The results of the cluster synchronization is shown in Example 5-19. The command status **OK** shows that the PowerHA cluster for file transfer has been successfully prepared.

Example 5-19   Cluster synchronization results

```
COMMAND STATUS
Command: OK           stdout: yes           stderr: no
Before command completion, additional instructions may appear below.
Verification to be performed on the following:
        Cluster Topology
        Cluster Resources
Verification will automatically correct verification errors.
Retrieving data from available cluster nodes.  This could take a few
minutes.
        Start data collection on node p5502p8
        Start data collection on node p5501p5
        Collector on node p5502p8 completed
        Waiting on node p5501p5 data collection, 15 seconds elapsed
        Collector on node p5501p5 completed
        Data collection complete
Verifying Cluster Topology...
        Completed 100 percent of the verification checks
```

5.4 Integration of application components

The following sections discuss how the WebSphere messaging components are implemented in this scenario.

To provide the high availability services for file transfer and flow message processing, the components are integrated into a cluster resource group. By preparing the start and stop scripts for the application server, the messaging components are controlled and managed by the AIX PowerHA cluster. Figure 5-9 shows how the WebSphere MQ and WebSphere MQ FTE components are configured in the topology.

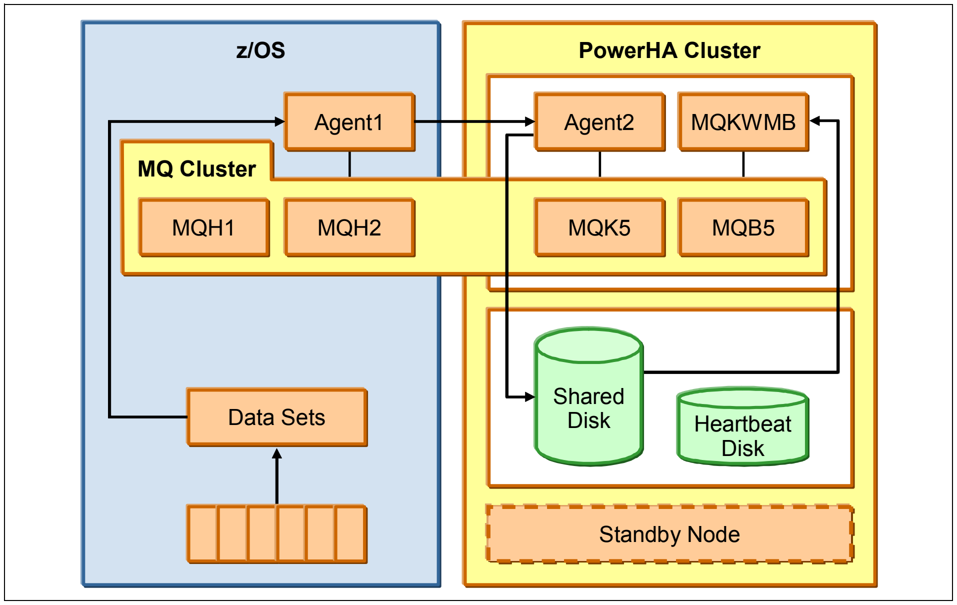


Figure 5-9 Application components view

Figure 5-9 illustrates the following process:

- Agent1 uses WebSphere MQ to transport the contents of files to Agent2.
- MQH1 and MQH2 on z/OS system are full repository queue managers.
- The coordination queue manager, MQK5, is a partial repository queue manager. MQK5 and the broker queue manager, MQB5 on the PowerHA system, join MQH1 and MQH2 in the MQ cluster.
- Files sent by Agent1 to Agent2 are saved on shared disk storage.
- The message flow in broker MQKWMB reads the file from the shared disk storage using a FileInput node and transforms the file to MQ messages.

5.4.1 A solution using one resource group

In this scenario, all of the messaging runtime components (WebSphere MQ, WebSphere MQ FTE, and WebSphere Message Broker) are integrated into one resource group of the PowerHA cluster, as shown in Figure 5-10

As one unit of failover, this resource group can be moved together to the standby node if a failure occurs. The coordination behavior of the components can be investigated.

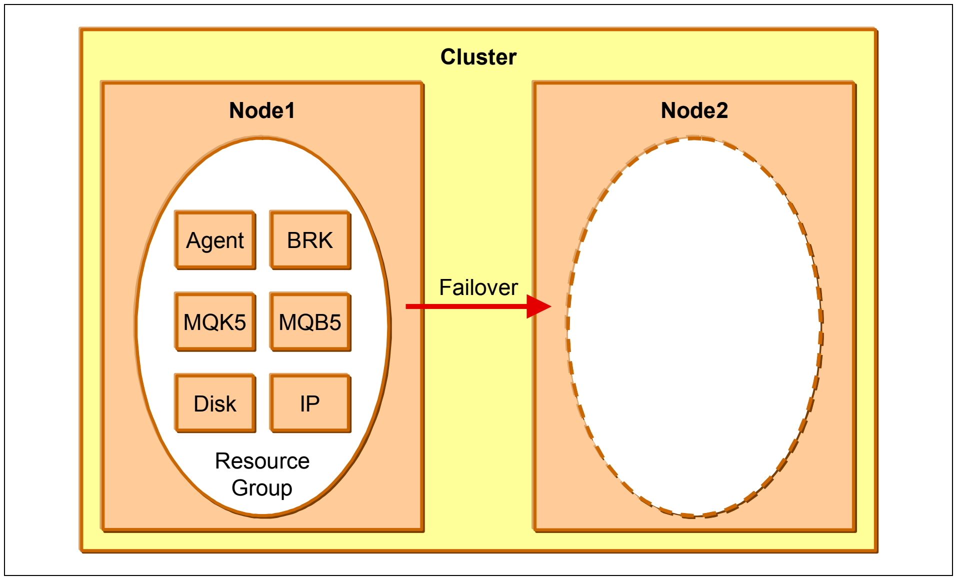


Figure 5-10 All components in one resource group

5.4.2 WebSphere MQ

To set up the WebSphere MQ structure, we need to create the queue managers and add them to the resource group.

Creating the queue managers

With the WebSphere MQ V7.0.1 software installed on each AIX node of PowerHA cluster, the next step is to create the two queue managers:

- MQK5
- MQB5

To integrate the two queue managers into the cluster, the WebSphere MQ data and log files are prepared on the /MQHA file system of the shared disk storage.

The new features in WebSphere MQ V7.0.1 for creating queue managers simplify this procedure.

1. Select a node on which to create the queue manager and mount the queue manager's file systems on the selected node.
2. Create the data and logs directories (/MQHA/MQK5/data and /MQHA/MQK5/log) directories. Use the **crtmqm** command (Example 5-20) to create the MQK5 queue manager on this node.

   Example 5-20 Create the queue manager

   ```
   mkdir -p /MQHA/MQK5/data
   mkdir -p /MQHA/MQK5/log
   crtmqm -md /MQHA/MQK5/data -ld /MQHA/MQK5/log QMK5
   ```

   The **addmqinf** command is executed on the same node to add the queue manager configuration data to another instance of the same queue manager.
3. Use the command in Example 5-21 to add the reference files on the other node.

   Example 5-21 Create the reference files

   ```
   addmqinf -s QueueManager -v Name=MQK5 -v Directory=MQK5 -v
   Prefix=/var/mqm -v DataPath=/MQHA/MQK5/data/MQK5
   ```

The same process can be used to create broker queue manager MQB5.

Note: In our PowerHA solution, only one queue manager is active at a time. PowerHA is responsible for starting and stopping the queue managers to ensure that a queue manager is active at all times and maintains availability.

Configuring the two queue managers in the resource group

The two queue managers are represented in the PowerHA resource group by an application server. In our configuration, the two queue managers (MQK5 and MQB5) are implemented in the same application server of the resource group.

The start and stop scripts for the queue managers are created, as well as the start and stop scripts for the queue manager listeners. To provide the correct routing of channel communications to the queue managers, a seperate queue manager port number for each queue manager is used.

Synchronize the two nodes of the cluster.

5.4.3 WebSphere MQ FTE

In this section, we implement the WebSphere MQ FTE components in our scenario.

Overview of MQ FTE file transfer

This section discusses the file transfer principle of WebSphere MQ FTE.

When a new transfer is started, the FTE Agent1 in Figure 5-11 reads the file's contents, splits it into blocks, and sends it to FTE Agent2 in the form of MQ messages. FTE agents are programs that perform the fundamental file transfer function. They send and receive files from the local system.

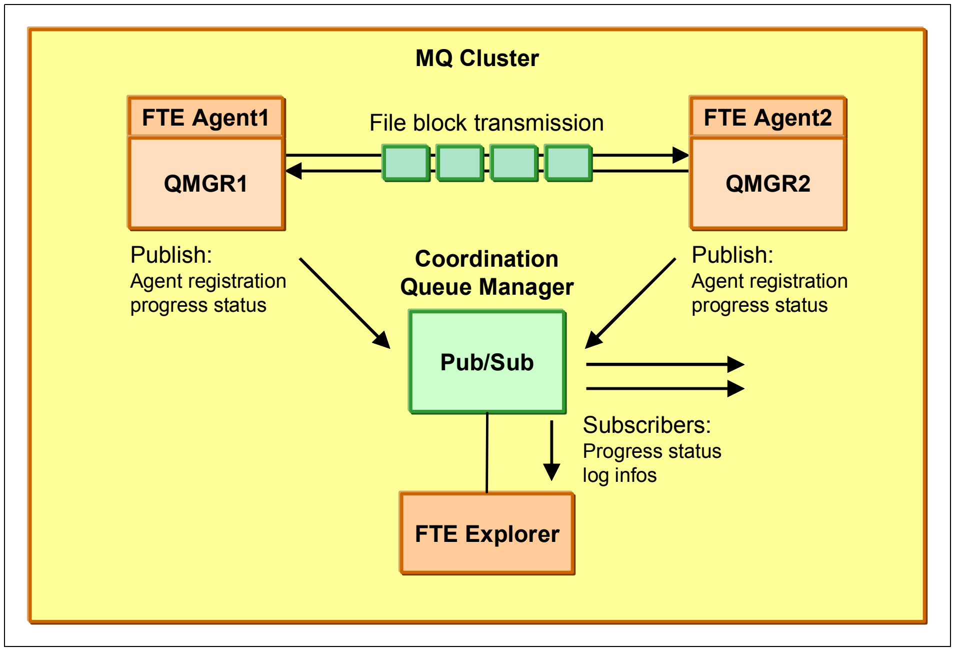


Figure 5-11 Principle of WebSphere MQ FTE

Every agent needs a queue manager to be connected. As standard MQ messages, the file contents are carried by a WebSphere MQ channel across the network where Agent2 receives them. The receiving agent re-assembles the file on the destination system.

In WebSphere MQ FTE, this file transfer process between agents is observed and monitored. The FTE agents send (publish) the status about the file block transmissions as MQ event messages, which are collected by a coordination queue manager. The coordination queue manager uses WebSphere MQ publish/subscribe functionality to publish event messages such as auditing or log components for interested subscribers. In this way the file transfer process is coordinated and controlled. The coordination queue manager's primary role is to collect information about the MQ FTE network.

Each agent connects to its agent queue manager and through it receives file transfer requests and publishes its own file transfer status events to the coordination queue manager.

Agents processing of scenario

Figure 5-12 illustrates the key architectural details of the MQ FTE topology used in this scenario.

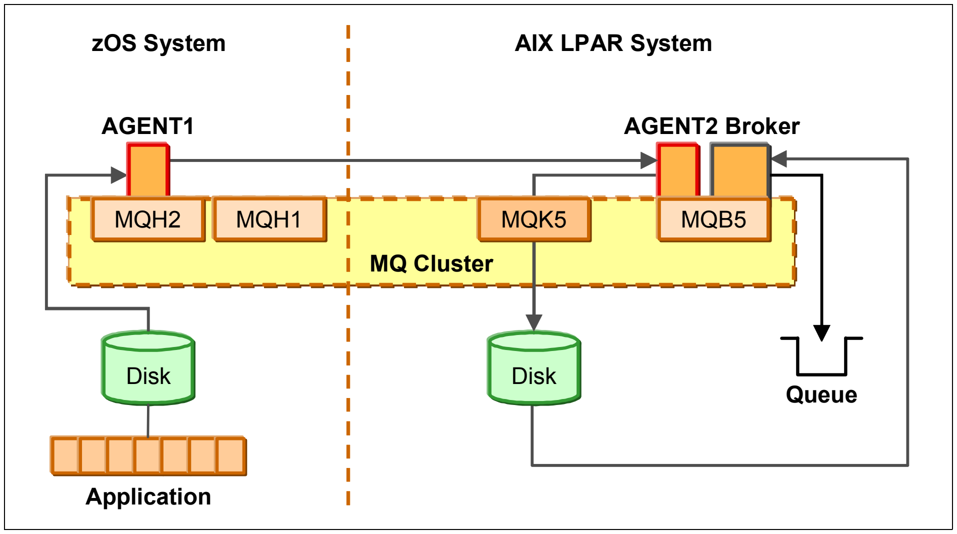


Figure 5-12 FTE agents connections

Figure 5-12 illustrates the following process:

- Coordination queue manager MQK5 is a central queue manager, which resides on one of the AIX nodes in the cluster. This queue manager is the coordination center for pub-sub status messages and registration information.
- The command queue manager and agent queue manager for AGENT2, MQB5, resides on the same AIX node. MQB5 is also the message broker queue manager.
- Each client agent uses client mode to connect to its associated intermediate queue manager using the SVRCONN channel.
- Either client agent can be a source or destination.

Preparing the FTE agents

In the file transfer application, we create the Agent2 component on the AIX node in the PowerHA cluster. Example 5-22 shows the command syntax for fteCreateAgent.

Example 5-22 fteCreateAgent command

```
fteCreateAgent -agentName agent_name -agentQMgr agent_qmgr
                   [-agentQMgrHost agent_qmgr_host]
                   [-agentQMgrPort agent_qmgr_port]
                   [-agentQMgrChannel agent_qmgr_channel]
                   [-agentDesc agent_description]
                   [-ac] [-p ConfigurationOptions] [-f]
```

The **`fteCreateAgent`** command is used on one of the AIX nodes to create the AGENT02 agent, as shown in Example 5-23.

Example 5-23 fteCreateAgent

```
bash-3.00$ fteCreateAgent -agentName AGENT02 -agentQMgr MQB5
-agentQMgrHost 9.12.4.153 -agentQMgrPort 11419 -agentQMgrChannel
SYSTEM.DEF.SVRCONN
```

AGENT02 uses queue manager MQB5. The cluster service IP address is used as the host name.

In Example 5-24 the details of FTE AGENT02 are shown using the **`fteShowAgentDetails`** command.

Example 5-24 fteShowAgentDetails

```
bash-3.00$ fteShowAgentDetails AGENT02
5655-U80, 5724-R10 Copyright IBM Corp.  2008, 2009.  ALL RIGHTS
RESERVED
Agent Information:
    Name:                 AGENT02
    Description:
    Operating System:     AIX
    Time Zone:            Eastern Standard Time

Queue Manager Information:
    Name:                 MQB5
    Transport:            Client
    Host:                 9.12.4.153
    Port:                 11419
    Channel:              SYSTEM.DEF.SVRCONN
```

The connection of AGENT02 to its queue manger MQB5 is defined using MQ FTE client mode. The parameters of host, port and channels are included.

Example 5-25 shows how **fteStartAgent** command is used to start the created AGENT02.

Example 5-25 fteStartAgent

```
bash-3.00$ fteStartAgent AGENT02
5655-U80, 5724-R10 Copyright IBM Corp.  2008, 2009.  ALL RIGHTS
RESERVED
BFGCL0030I: The request to start agent 'AGENT02' on this machine has
been submitted.
BFGCL0031I: Agent log files located at:
/MQHA/WMQFTE/config/MQK5/agents/AGENT02
bash-3.00$
```

The verification of the availability of AGENT02 is checked with the **ftePingAgent** command. The result is displayed in Example 5-26.

Example 5-26 ftePingAgent

```
bash-3.00$ ftePingAgent AGENT02
5655-U80, 5724-R10 Copyright IBM Corp.  2008, 2009.  ALL RIGHTS
RESERVED
BFGCL0212I: Issuing ping request to agent AGENT02
BFGCL0213I: agent AGENT02 responded to ping in 0.532 seconds.
```

5.4.4 Including WebSphere Message Broker

To set up the WebSphere Message Broker components, we need to create the broker, and add it to the resource group.

Preparing broker component

To create the broker component, the **mqsicreatebroker** command is used as shown in Example 5-27. MQB5 is used as the broker queue manager. The file system /MQHA is on the shared storage.

Example 5-27 Create broker

```
$ mqsicreatebroker MQWMB -q MQB5 -e /MQHA/MQWMB
AMQ8110: WebSphere MQ queue manager already exists.
WebSphere MQ queue manager 'MQB5' starting.
13 log records accessed on queue manager 'MQB5' during the log replay
phase.
Log replay for queue manager 'MQB5' complete.
Transaction manager state recovered for queue manager 'MQB5'.
WebSphere MQ queue manager 'MQB5' started.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
.....
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
BIP8071I: Successful command completion.
$
```

On the other node, the broker instance is added using the commands shown in Example 5-28.

Example 5-28 Add broker instance

```
$ mqsiaddbrokerinstance MQWMB -e /MQHA/MQWMB
AMQ7272: WebSphere MQ configuration information already exists.
WebSphere MQ queue manager 'MQB5' starting.
5 log records accessed on queue manager 'MQB5' during the log replay
phase.
Log replay for queue manager 'MQB5' complete.
Transaction manager state recovered for queue manager 'MQB5'.
WebSphere MQ queue manager 'MQB5' started.
BIP8071I: Successful command completion.
$
```

Note: In the PowerHA cluster solution only one broker is active at a time. PowerHA is responsible for starting and stopping the broker to maintain availability.

Implementation in the cluster

The integration of broker component into a PowerHA cluster is straightforward. The broker services are included in the cluster application server of the resource group by adding the start and stop scripts. In WebSphere Message Broker V7.0.1, no configuration manager and separate database are used.

A broker runs as a pair of processes called *bipservice* and *bipbroker*. The latter process, in turn, creates the execution groups that run message flows. It is this collection of processes that are managed by HA software.

Processing of test message flow

Figure 5-13 illustrates a simple test message flow of the scenario. A FileInputNode is used to read the transferred file from the shared storage. Each line of the file contents are processed as single MQ message. The output MQ messages from the file are put into a MQ output queue.

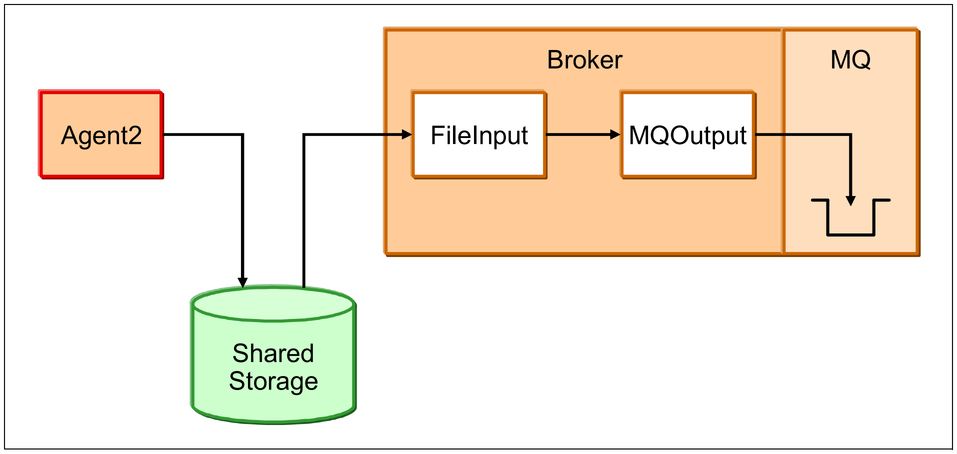


Figure 5-13 Broker message processing

5.5 Making file transfer highly available

This section presents the test scenarios and results of the PowerHA solution for file transfer.

Three test scenarios are performed:

- The basic functionality tests for the PowerHA cluster
- Big file transfer in the cluster operational environment
- A principal take-over test of the PowerHA cluster during the file transfer processing, by moving the complete resource group from one node to another

5.5.1 Testing the basic cluster functions

The basic cluster functionality tests are as follows:

- Starting and stopping the cluster services
- Bringing the resource group online and offline
- Moving the resource group to another node.

Example 5-29 shows the cluster services are started on both cluster nodes by using the SMIT fast path smitty clstart.

Example 5-29 Start cluster services

```
Start Cluster Services
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                        [Entry Fields]
* Start now, on system restart or both                now +
  Start Cluster Services on these nodes              [p5501p5] +
* Manage Resource Groups                              Manually +
  BROADCAST message at startup?                       true +
  Startup Cluster Information Daemon?                 false +
  Ignore verification errors?                         false +
  Automatically correct errors found during           Interactively +
  cluster start?
```

To bring the resource group online, in SMIT, select **HACMP Resource Group and Application Management → Bring a Resource Group Offline**. The picklist appears as in Example 5-30.

Example 5-30 Bring a resource group online

```
Bring a Resource Group Online
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                       [Entry Fields]
  Resource Group to Bring Online                     itso_group
  Node on Which to Bring Resource Group Online       p5501p5
```

Example 5-31 shows how the resource group of the cluster can be moved to another node (graceful resource group takeover) by using **smitty cl_admin → HACMP Resource Group and Application Management → Move a Resource Group to Another Node**:

Example 5-31 Move a resource group

```
Move Resource Group(s) to Another Node
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                       [Entry Fields]
  Resource Group(s) to be Moved                      itso_group
  Destination Node                                   p5502p8
```

The test results are summarized in Table 5-3.

Table 5-3 Basic cluster function tests

Cluster Test Plan			
Test #	**Test Description**	**Comments**	**Results**
Cluster services			
1	Start service on node1.	The cluster service on node1 starts	Status: OK
2	Start service on node2.	The cluster service on node2 starts	Status: OK
Resource group			

Cluster Test Plan			
3	Bring the resource group on node1 online	The resource Group on itso_group goes online.	All application components are stared on node1: ► Two queue managers and two MQ listeners for qmgrs ► Broker service ► FTE agent
4	Move the resource group to node2	The resource group on node1 goes offline. On node2 goes the resource group online.	All application components are stopped on node1: ► Two queue managers and two listeners for qmgrs ► Broker service ► FTE agent All application components are stared on node2: ► Two queue managers and two listeners for qmgrs ► Broker service ► FTE agent
5	Bring the resource group on node2 offline	The resource Group on itso_group goes offline.	All application components are stopped on node2: ► Two queue managers and two listeners for qmgrs ► Broker service ► FTE agent

5.5.2 File transfer tests in the cluster environment

In the second step, the functionality of application components are tested. On both cluster nodes, the cluster services are started. Afterwards, the resource group on one of the node is started and a file transfer from z/OS is started. The test results are displayed in Table 5-4.

Table 5-4 File transfer tests in cluster

Cluster Test Plan			
Test #	**Test Description**	**Comments**	**Results**
Cluster services			
1	Start service on node1.	The cluster service on node1 starts	Status: OK
2	Start service on node2.	The cluster service on node2 starts	Status: OK
Resource group			
3	Bring the resource group on node1 online	The resource Group on itso_group goes online.	All application components are stared on node1: ► Two MQ queue managers and two MQ listeners for Qmgrs ► Broker service ► FTE agent
Legacy file transfer			
4	Start a file transfer from AGENT01 of z/OS to AGENT02	The file transfer processing status can be observed in MQ FTE Explorer	The file is transferred and the contents of the file are transformed by test message flow to MQ messages in output queue of the broker queue manager.

5.5.3 Cluster takeover tests during file transfer

In this step, a takeover of the cluster resource group is tested by moving the resource group from one node to another node during the file transfer. The test results are displayed in Table 5-5.

Table 5-5 Move resource group during file transfer

Cluster Test Plan			
Test #	**Test Description**	**Comments**	**Results**
Cluster services			
1	Start service on node1.	The cluster service on node1 starts	Status: OK
2	Start service on node2.	The cluster service on node2 starts	Status: OK
Resource group			
3	Bring the resource group on node1 online	The resource Group on itso_group goes online.	All application components are stared on node1: ► Two MQ queue managers and two MQ listeners for Qmgrs ► Broker service ► FTE agent
Start a big file transfer			
4	Start a big file transfer from AGENT01 of z/OS to AGENT02	The file transfer processing status can be observed in MQ FTE Explorer.	During the file transfer, a file with the name **filename.part** resides on the shared disk. The size of **filename.part** changes continually. The processing of the message flow does not start.

Cluster Test Plan			
Resource group			
5	Move the resource group from node1 to node2	During the file transfer, a takeover of resource group occurs (by moving the resource group to another node). The resource group on node01 goes offline. On node2 goes the resource group online.	All application components are stopped on node1: ▶ Two queue managers and two listeners for qmgrs ▶ Broker service ▶ FTE agent During takeover, the size of filename.part file does not change. All application components are started on node2: ▶ Two queue managers and two listeners for Qmgrs ▶ Broker service ▶ FTE agent The size of **filename.part** file changes continually.
The big file transfer			
6	The file transfer continues.	The file transfer processing status can be observed in MQ FTE Explorer again.	The file transfer is completed. The file contents are transformed to MQ messages.

5.6 Summary

Our high availability solution consists of two AIX LPAR nodes. To fulfill the requirements of file batch transfer, the cluster is configured in standby mode. The cluster service IP takeover is implemented through an IP aliasing method. To monitor availability of network interfaces, a heartbeat disk storage is included. The cluster is created by using Two-node Cluster Configuration Assistant.

The WebSphere messaging components, such as MQ, FTE and Broker, form one unit for cluster failover and so are grouped in one cluster resource group.

The presented test results show that the basic functions of the cluster are stable. High availability for the file transfer is achieved by the resource group takeover for the cluster.

6

Using multi-instances queue managers and brokers for high availability

This chapter presents a scenario that describes the use of WebSphere MQ multi-instance queue managers and WebSphere Message Broker multi-instance brokers to provide a high availability messaging solution.

6.1 Overview

In this scenario, illustrated in Figure 6-1, messages published by a CICS program on z/OS are retrieved by a multi-instance queue manager on AIX. A multi-instance broker message flow gets the message from the queue and writes it to an output queue.

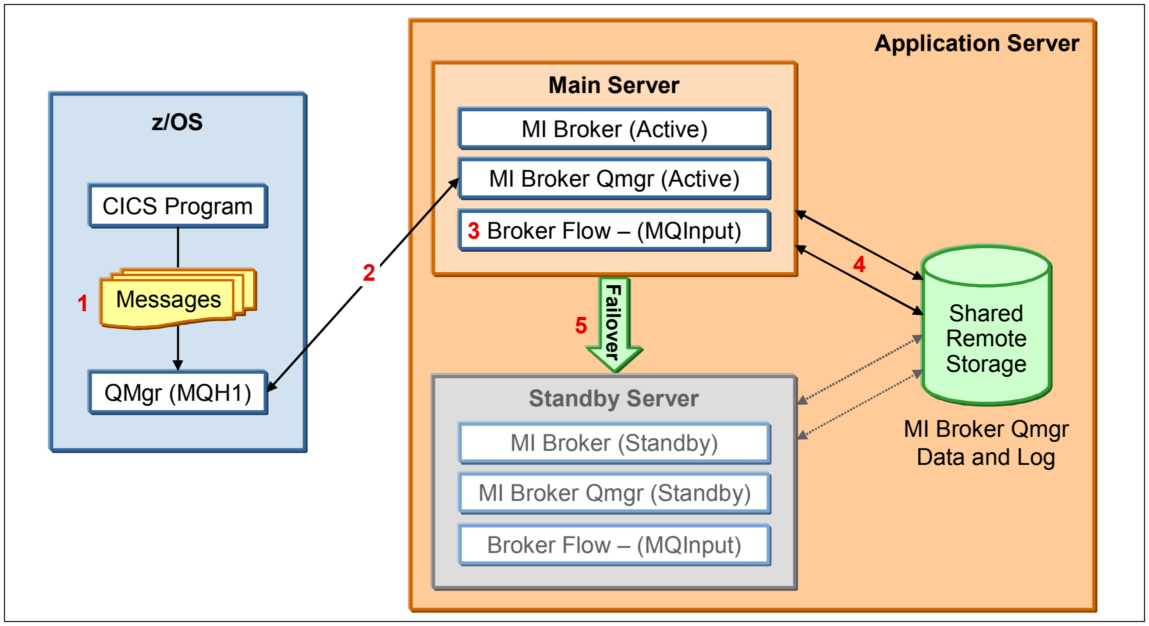


Figure 6-1 High availability in a WebSphere MQ multi-instance solution

Figure 6-1 describes the following process:

1. A CICS program publishes a series of messages to a topic on queue manager MQH1.
2. The multi-instance (MI) broker queue manager has an administrative subscription, so messages are routed to a queue on the shared storage device.
3. The message flow is triggered by the message receipt and reads the message from the queue.
4. The multi-instance broker queue manager's data and logs are stored on shared remote storage which is accessible to the active and standby servers.
5. If the active server crashes, the standby server becomes active. The MI broker queue manager on the standby server has the same administrative subscriptions and other MQ data and logs so processing continues without loss of data.

6.2 System environment and configuration

In this section, we discuss the system components, topology, and configurations that keep the application highly available in this scenario.

6.2.1 Network plan

Figure 6-2 shows the network topology of the system, consisting of two z/OS LPARs and three AIX LPARs.

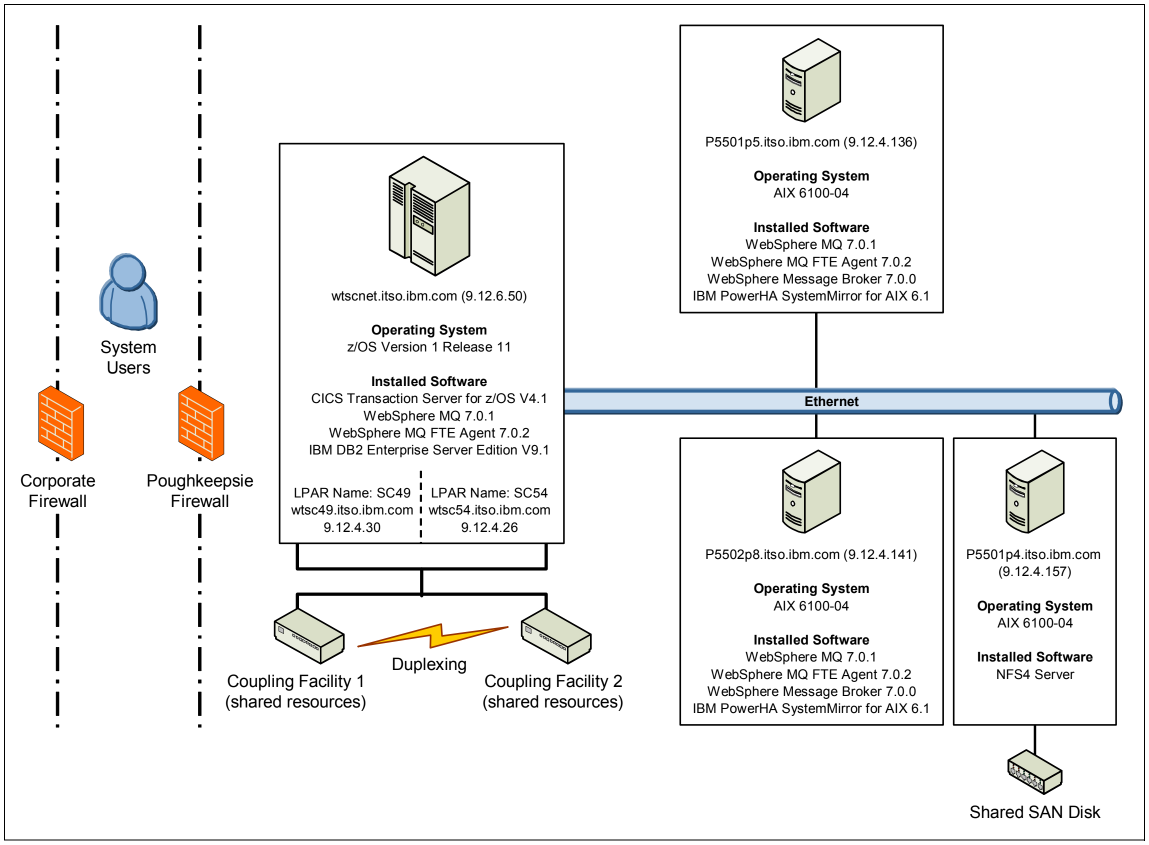

System Users
Corporate Firewall
Poughkeepsie Firewall
wtscnet.itso.ibm.com (9.12.6.50)
Operating System
z/OS Version 1 Release 11
Installed Software
CICS Transaction Server for z/OS V4.1
WebSphere MQ 7.0.1
WebSphere MQ FTE Agent 7.0.2
IBM DB2 Enterprise Server Edition V9.1
LPAR Name: SC49
wtsc49.itso.ibm.com
9.12.4.30
LPAR Name: SC54
wtsc54.itso.ibm.com
9.12.4.26
Coupling Facility 1 (shared resources)
Duplexing
Coupling Facility 2 (shared resources)
P5501p5.itso.ibm.com (9.12.4.136)
Operating System
AIX 6100-04
Installed Software
WebSphere MQ 7.0.1
WebSphere MQ FTE Agent 7.0.2
WebSphere Message Broker 7.0.0
IBM PowerHA SystemMirror for AIX 6.1
Ethernet
P5502p8.itso.ibm.com (9.12.4.141)
Operating System
AIX 6100-04
Installed Software
WebSphere MQ 7.0.1
WebSphere MQ FTE Agent 7.0.2
WebSphere Message Broker 7.0.0
IBM PowerHA SystemMirror for AIX 6.1
P5501p4.itso.ibm.com (9.12.4.157)
Operating System
AIX 6100-04
Installed Software
NFS4 Server
Shared SAN Disk

Figure 6-2 Network Topology

In Figure 6-2, one AIX node (p5501p4) is used as a Network File System (NFS V4) server for SAN Disk storage. The remaining two AIX nodes (p5501p5 and p5502p8) are NFS clients that mount the file system to provide shared storage for the WebSphere MQ multi-instance queue managers and the WebSphere Message Broker multi-instance broker instances. p5501p5 (also referred to as node 1) acts as the active system, with p5502p8 (also referred to as node 2) acting as the standby system.

6.2.2 High availability characteristics

The multi-instance features introduced in WebSphere MQ V7.0.1 and WebSphere Message Broker 7.0 provide a software-based high availability solution. They allow you to define an active instance of the queue manager and broker on one server and a standby instance on a secondary server.

The instances use shared storage for data and logs. The first instance to be started becomes the active instance and obtains locks on the shared files. Control switches to the standby instance when the currently active instance releases its lock on the shared files. This can be initiated in a controlled switch-over from the active node to the standby node or by automatic failover in the event of an unplanned server outage.

Figure 6-3 shows two servers, Node1 and Node2, each of which contain an instance of a queue manager and a broker.

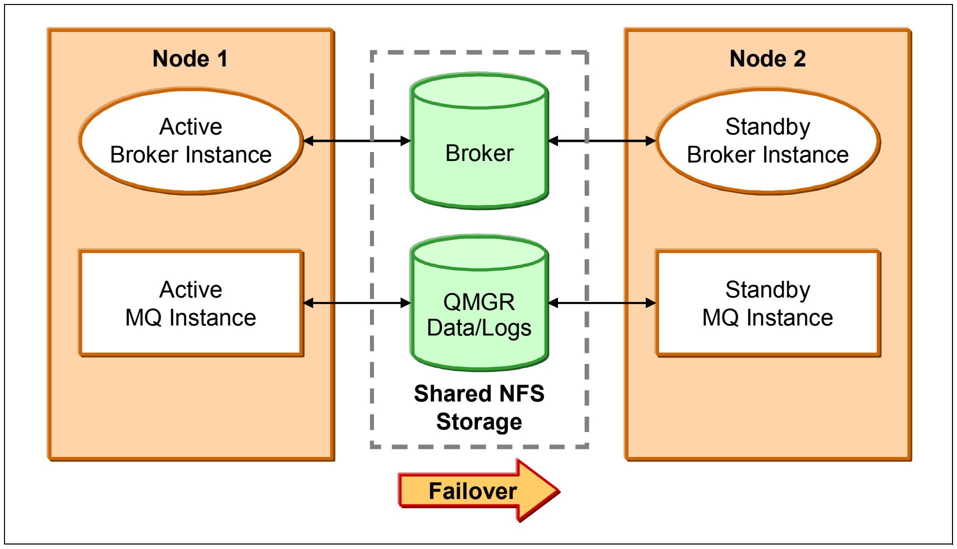


Figure 6-3 Multi-instance queue manager and broker using shared storage

The queue manager instances are started on both machines with one instance being the active instance and the other being the standby instance. Messages and data for the multi-instance queue manager and broker are held on network storage. The active instance holds a lock on the queue manager data to ensure there is only one active instance at a given time. The standby instance periodically checks whether the active queue manager instance is still running. If the active queue manager instance fails or is no longer available, the standby instance acquires the lock on the queue manager data. It performs queue manager restart processing and becomes the active queue manager instance.

6.3 AIX configuration

The AIX configuration used for testing this scenario is depicted in Figure 6-4.

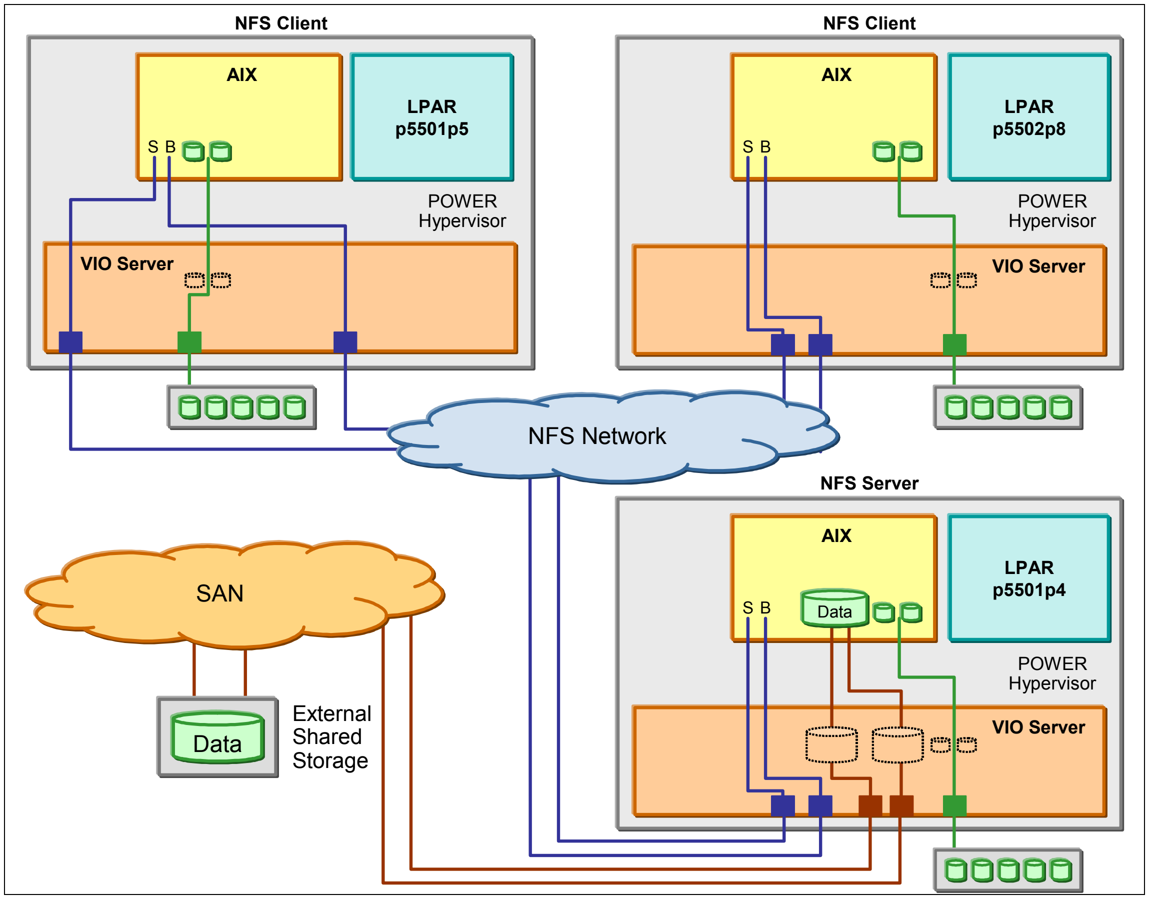


Figure 6-4 Network file system (NFS) in the LPAR environment

In Figure 6-4, one LPAR with the AIX operating system (labelled NFS Server) uses the IBM Virtual I/O Server (VIO Server) software to perform the mapping between the hardware and virtual CPU units. The file system on shared SAN disk storage is exported from one of the LPARs acting as an NFS server. The other two LPAR nodes act as NFS clients and mount the exported file systems on SAN shared disks storage.

6.3.1 Software installed on the AIX systems

The software installed on the active and standby AIX servers are summarized in Table 6-1.

Table 6-1 Installed software for the active and standby AIX servers

Software	Version
AIX	6.1.4
WebSphere MQ	7.0.1
WebSphere Message Broker	7.0.0

6.3.2 Preparing the shared disk on AIX

Our configuration uses one volume group: nfsdata_vg. The volume groups, logical volumes, and file systems shared by the two network file system (NFS) client nodes are created on the NFS server node. After the file systems are prepared, the volume group on the NFS server can be exported and the two NFS client nodes can mount them.

Note: Perform all commands to prepare the shared disk as root user.

The smit mkvg fastpath utility was used to create the volume group, as shown in Example 6-1.

Example 6-1 Create a volume group

```
Add an Original Volume Group
Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                   [Entry Fields]
  VOLUME GROUP name                              [nfsdata_vg]
  Physical partition SIZE in megabytes +
* PHYSICAL VOLUME names                          [hdisk2] +
  Force the creation of a volume group?           no +
  Activate volume group AUTOMATICALLY             no +
    at system restart?
  Volume Group MAJOR NUMBER                      [38] +#
Create VG Concurrent Capable?                   enhanced concurrent +
```

In the Example 6-1 on page 112, an original enhanced-capable volume group named nfsdata_vg is defined on the NFS server node. This volume group contains hdisk2 and has major number 38. The available volume group major number 38 is found by using the **lvlstmajor** command. After the volume group has been created, it must be activated to make it available for use by using the **varyonvg** command, as shown in Example 6-2.

Example 6-2 Activating the volume group

```
# varyonvg data_vg
```

Before the logical volume group can be created, create a log for the logical volume group, as in Example 6-3.

Example 6-3 Creating the log for the logical volume

```
bash-3.00# mklv -t jfs2log -y lognfsshared_lv nfsdata_vg 600M
lognfsshared_lv

bash-3.00# /usr/sbin/logform /dev/lognfsshared_lv
logform: destroy /dev/rlognfsshared_lv (y)?y
```

The **mklv** command is used to create a logical volume named `nfsshared_lv` with 50 GB of storage space, on volume group nfsdata_vg, as shown in Example 6-4.

Example 6-4 Create logical volume

```
bash-3.00# mklv -t jfs2 -y nfsshared_lv nfsdata_vg 50G
nfsshared_lv
```

Next, we use the **crfs** command to create the file systems on this logical volume. The results is shown in Example 6-5.

Example 6-5 Creating the file system

```
bash-3.00# crfs -v jfs2 -p rw -d /dev/nfsshared_lv -m /NFSMQHA -A yes
File system created successfully.
52426996 kilobytes total disk space.
New File System size is 104857600
```

Finally we mount the file systems to check that we have successfully created the NFS file systems on NFS server node. This is shown in Example 6-6:

Example 6-6 Mount file system

```
# mount -o vers=4 /NFSMQHA
```

6.3.3 Exporting the file systems using NFS V4 mount

The NFS is a mechanism for storing files on a network. By using NFS, files and directories located on a remote computers can be treated as though they were local.

Note: NFSv4 with TL2SP6 is required on AIX.

NFS provides its services through a client-server relationship:

- Computers that make their file systems, directories, and other resources available for remote access are called *NFS servers*. The act of making file systems available is called *exporting*.
- Computers and their processes that use server resources are referred to as *NFS clients*. After a client mounts a file system that a server exports, the client can access the individual server files.

To export the `/NFSMQHA` directory on our NFS server p5501p4 and mount that directory on NFS client p5501p5 as the `/mnt` directory, the **`exportfs`** command is used on the NFS server as shown in Example 6-7.

Example 6-7 Export NFS file system

```
exportfs -i -o access=p5501p5 /NFSMQHA
```

This command makes the `/NFFSMQHA` directory available to the client. To complete the process the mount command must also be called on the client nodes. Example 6-8 shows the command used to mount the directory on node 1.

Example 6-8 Mounting the NFS file system on the NFS clients

```
mount -o vers=4 p5501p4:/NFFSMQHA /mnt
```

The directories and files in the /NFSMQHA directory on the NFS server appear as the /mnt directory on the NFS clients. This can be checked by using the mount command, as shown in Example 6-9.

Example 6-9 Mount NFS file system results

```
p5501p5(root)/>  mount
  node       mounted        mounted over    vfs       date        options
-------- ---------------  ---------------  ------ ------------ ---------------
         /dev/hd4         /                jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /dev/hd2         /usr             jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /dev/hd9var      /var             jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /dev/hd3         /tmp             jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /dev/hd1         /home            jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /dev/hd11admin   /admin           jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /proc            /proc            procfs Feb 19 23:55 rw
         /dev/hd10opt     /opt             jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /dev/livedump    /var/adm/ras/livedump jfs2   Feb 19 23:55
rw,log=/dev/hd8
         /dev/download_lv /download        jfs2   Feb 19 23:55 rw,log=/dev/hd8
         /dev/test_lv     /mydir           jfs2   Feb 19 23:55 rw,log=/dev/hd8
p5501p4  /NFSMQHA         /mnt             nfs4   Feb 19 23:58 vers=4
```

This process is repeated to mount the same directory on the second NFS client, p5502p8, as the /mnt directory.

6.4 Configuring the messaging components

In this section we show how to define and implement WebSphere MQ and WebSphere Message Broker in the prepared environment.

6.4.1 WebSphere MQ with multi-instances

First, we create the multi-instance queue manager on the two AIX nodes (the NFS client systems).

Creating the queue manager on node 1

Note: Performm all WebSphere MQ configurations as the mqm user.

On node 1, the queue manager is created using the command shown in Example 6-10.

Example 6-10 Create queue manager

```
$ crtmqm -md /mnt/NFSMQK/data -ld /mnt/NFSMQK/log NFSMQK
WebSphere MQ queue manager created.
Directory '/mnt/NFSMQK/data/NFSMQK' created.
Creating or replacing default objects for NFSMQK.
Default objects statistics : 65 created. 0 replaced. 0 failed.
Completing setup.
Setup completed.
```

Next, run the **dspmqinf** command on the same node. The output of this command is actually a command that can be used to add the additional instance of the queue manager on the second node.

The output of the **dspmqinf** command is shown in Example 6-11.

Example 6-11 Display queue manager configuration information

```
$ dspmqinf -o command NFSMQK
addmqinf -s QueueManager -v Name=NFSMQK -v Directory=NFSMQK -v
Prefix=/var/mqm -v DataPath=/mnt/NFSMQK/data/NFSMQK
```

Creating the standby instance of the queue manager on node 2

We copy the results of the **dspmqinf** command and paste this into the command line on node 2, to create the standby instance of the queue manager, as shown in Example 6-12.

Example 6-12 Add queue manager configuration data

```
$ addmqinf -s QueueManager -v Name=NFSMQK -v Directory=NFSMQK -v
Prefix=/var/mqm -v DataPath=/mnt/NFSMQK/data/NFSMQK
WebSphere MQ configuration information added.
```

Testing the file system on NFS storage using amqmfsck

Correct file locking and concurrency control behavior is a key requirement of multi-instances of queue managers. File locking is used as a mechanism to restrict file system access to one queue manager instance at any time. To check the NFS file system, the **amqmfsck** command was introduced in WebSphere MQ V7. The syntax of this command is displayed in Example 6-13 on page 117.

Example 6-13 Command syntax of amqmfsck

```
$ amqmfsck -h
Usage: amqmfsck [-v] [-c | -w] DirectoryName
where -c tests concurrent writing and -w tests waiting for a file lock,
and -v turns on verbose messages.
```

This command can check the file system in three ways:

- Run **amqmfsck**, without any options, on each system to check basic locking.
- Run **amqmfsck** on both WebSphere MQ systems simultaneously, using the -c option, to test writing to the directory concurrently.
- Run **amqmfsck** on both WebSphere MQ systems at the same time, using the -w option, to test waiting for and releasing a lock on the directory concurrently.

The basic file system checking in displayed in Example 6-14.

Example 6-14 Basic file system checking to support queue manager multi-instances

```
$ amqmfsck /mnt/NFSMQK/data
The tests on the directory completed successfully.
$ amqmfsck /mnt/NFSMQK/log
The tests on the directory completed successfully.
```

In Table 6-2 we have used the -c option of the **amqmfsck** command to test writing to the `/mnt/NFSMQK/data` directory concurrently.

Table 6-2 Test writing to a file in the directory concurrently

Node 1	Node 2

`$ amqmfsck -c /mnt/NFSMQK/data`
`Start a second copy of this program with the same parameters on another server.`
`Writing to test file. This will normally complete within about 60 seconds.`
`.........................................`
`...............`
`The tests on the directory completed successfully.`
	`$ amqmfsck -c /mnt/NFSMQK/data`
	`Writing to test file. This will normally complete within about 60 seconds.`
	`.........................................`
	`..............`
	`The tests on the directory completed successfully.`

Table 6-3 shows the use -w option to test waiting for and releasing a lock on the `/mnt/NFSMQK/data` directory concurrently.

Table 6-3 Test waiting for and releasing locks

Node 1	Node 2

`$ amqmfsck -w /mnt/NFSMQK/data`
`Start a second copy of this program with the`
`same parameters on another server.`
`File lock acquired.`
`Press Enter or terminate this process to`
`release the lock.`	

	`$ amqmfsck -w /mnt/NFSMQK/data`
	`Waiting for the file lock.`
	`Waiting for the file lock.`
	`Waiting for the file lock.`
	`Waiting for the file lock.`
	`Waiting for the file lock.`

`[Return Pressed]`
`File lock released.`	

	`File lock acquired.`
	`Press Enter or terminate this process to`
	`release the lock`

	`[Return Pressed]`

`File lock released.`
`The tests on the directory completed`
`successfully.`	

Start the multi-instance queue managers

To start queue manager, the **`strmqm`** command is used with the -x option. The -x option was introduced in MQ version 7.0.1 to start an instance of a multi-instance queue manager. If an instance of the queue manager is not already running elsewhere, the queue manager starts and the instance becomes active. If a multi-instance queue manager instance is already active on a seperate server the new instance becomes a standby.

Example 6-15, shows the output of the **strmqm** command on the node 1 to start up the active queue manager instance:

Example 6-15 Start active queue manager instance

```
$ strmqm -x NFSMQK
WebSphere MQ queue manager 'NFSMQK' starting.
5 log records accessed on queue manager 'NFSMQK' during the log replay
phase.
Log replay for queue manager 'NFSMQK' complete.
Transaction manager state recovered for queue manager 'NFSMQK'.
WebSphere MQ queue manager 'NFSMQK' started.
```

Starting the standby queue manager instance on node 2 is shown in Example 6-16.

Example 6-16 Starting the standby queue manager instance

```
$ strmqm -x NFSMQK
WebSphere MQ queue manager 'NFSMQK' starting.
A standby instance of queue manager 'NFSMQK' has been started. The
active instance is running elsewhere.
```

Observing a multi-instance queue manager

The status of multi-instance queue manager can be displayed by using the dspmq command with the -x option. The status can be one of Active, Standby, or Running Elsewhere, as shown in Table 6-4.

Table 6-4 Instance status

Status	Meaning
Running	The active instance
Running as Standby	Running as a standby instance
Running Elsewhere	The active instance is running on the other node. The queue manager is not running on the current node. To start the queue manager on the current node you need to execute the **strmqm -x** command. The status is then changed to Running as Standby.

Example 6-17 shows that the active instance is running on the local node and the standby instance is running on the other node.

Example 6-17 Display queue manager status

```
$ dspmq -x -o standby -o status
QMNAME(NFSMQK) STATUS(Running) STANDBY(Permitted)
INSTANCE(p5501p5) MODE(Active)
INSTANCE(p5502p8) MODE(Standby)
```

If we run this command on node 2, we see that the queue manager is running as standby. This is shown in Example 6-18.

Example 6-18 Display queue manager status

```
$ dspmq -x -o standby -o status
QMNAME(NFSMQK) STATUS(Running as standby) STANDBY(Permitted)
    INSTANCE(p5501p5) MODE(Active)
    INSTANCE(p5502p8) MODE(Standby)
```

6.4.2 WebSphere Message Broker with multi-instances

Next, we create the multi-instance broker on the same two AIX nodes.

Creating a broker on node 1

Note: Perform all WebSphere Message Broker configurations as the broker user. In our case the user ID is eaiadmin.

On node 1 the broker can be created as shown in Example 6-19.

Example 6-19 Create broker

```
$ mqsicreatebroker NFSWMB -q NFSMQK -e /mnt/NFSWMB
AMQ8110: WebSphere MQ queue manager already exists.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
.......
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
The setmqaut command completed successfully.
BIP8071I: Successful command completion.
$
$ mqsilist
BIP1292I: The multi-instance Broker 'NFSWMB' on multi-instance queue
manager 'NFSMQK' has stopped.
BIP8071I: Successful command completion.
```

Creating a standby instance of the broker on node 2

On the node 2 we add the second instance of broker as shown in Example 6-20.

Example 6-20 Add broker instance

```
$
$ mqsiaddbrokerinstance NFSWMB -e /mnt/NFSWMB
AMQ7272: WebSphere MQ configuration information already exists.
BIP8071I: Successful command completion.
$
$ mqsilist
BIP1294I: Broker 'NFSWMB' is a multi-instance broker running in standby
mode on multi-instance queue manager 'NFSMQK'. More information will be
available when the broker instance is active.
BIP8071I: Successful command completion.
```

Starting the multi-instance broker

On node 1 we start the broker using the **mqsistart** command and display the broker status using **mqsilist** command. This instance becomes the active instance, as shown in Example 6-21.

Example 6-21 Start the active broker instance and display the broker status

```
$
$ mqsistart NFSWMB
BIP8096I: Successful command initiation, check the system log to ensure
that the component started without problem and that it continues to run
without problem.
$ mqsilist
BIP1295I: Broker 'NFSWMB' is a multi-instance broker running in active
mode on multi-instance queue manager 'NFSMQK'.
BIP8071I: Successful command completion.
```

We execute the same command on the node 2 to start the standby instance and display the broker status, as shown in Example 6-22.

Example 6-22 Starting the standby broker instance

```
$ mqsistart NFSWMB
BIP8236I: A standby instance of Broker NFSWMB has been started against
the standby queue manager NFSMQK. The active broker instance and active
queue manager instance are running elsewhere.
The multi-instance broker has started in standby mode. The broker will
not become active until the current active broker instance and active
queue manager instance end, or are stopped.
No action required.
$
$ mqsilist
BIP1294I: Broker 'NFSWMB' is a multi-instance broker running in standby
mode on multi-instance queue manager 'NFSMQK'. More information will be
available when the broker instance is active.
BIP8071I: Successful command completion.
```

6.5 Publish/subscribe in MQ cluster test environment

Our messaging interface in this scenario is implemented using publish/subscribe messaging of IBM WebSphere MQ V7.0.1. In IBM WebSphere MQ version 7.0.1 publish/subscribe has been streamlined to make it simpler and more intuitive to program and configure. The reason publish/subscribe was selected for this scenario is that it provides a elegant solution for using multi-instance high availability. This is because, in the event of a failover, a client application needs to handle the queue manager reconnection after the standby instance has become active. However, with publish/subscribe, we can rely on IBM WebSphere MQ guaranteed delivery to ensure that during the failover messages are not lost.

Creating a durable subscription, along with persistent messages, ensures the messages remain on the transmission queue until they are delivered.

Note: Based on application requirements you might not want to use durable subscriptions and persistent messages and might prefer to allow messages to expire. This can mean that messages expire while the queue manager is failing over. These messages are not processed.

Consider the publish/subscribe topic hierarchy depicted in Figure 6-5. The hierarchy has a parent topic (NEWS) and three child topics (POLITICS, SPORT and WEATHER).

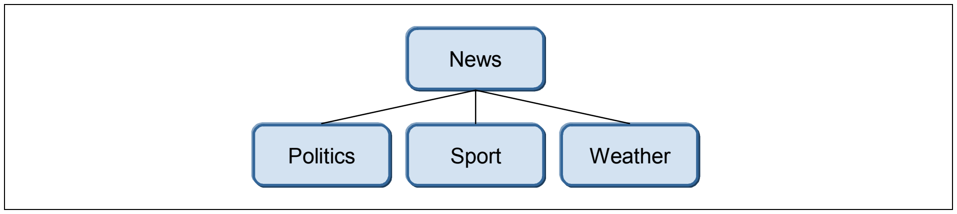


Figure 6-5 Publish/subscribe topic hierarchy

We create the NEWS/POLITICS topic for queue manager MQH1 on z/OS, as this is the one we use in this scenario. The multi-instance queue manager NFSMQK on AIX subscribes to this topic. As the topic is defined in the context of the cluster, it is visible to all queue managers within the cluster.

A logical overview of our publish/subscribe configuration is shown in Figure 6-6.

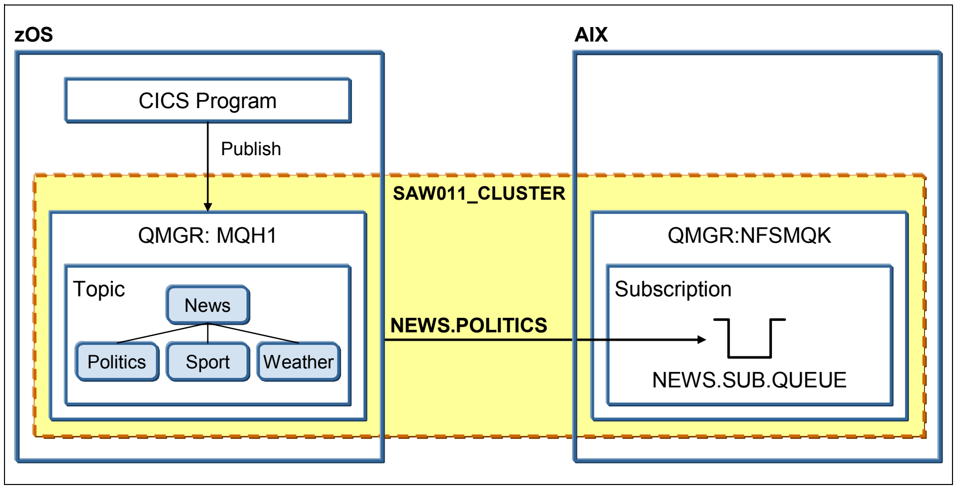


Figure 6-6 Logical overview of the Pub/Sub configuration

The software installed on each of the z/OS LPARs is summarized in Table 6-5.

Table 6-5 Installed software for z/OS Server

Software	Version
z/OS Operating System	Version 1Release 11
CICS Transaction Server for z/OS	V4.1
WebSphere MQ	7.0.1
IBM DB2 Enterprise Server Edition	V9.1

6.5.1 Setting up Queue manager cluster

In our scenario we add the queue manager NFSMQK to an existing WebSphere MQ queue manager cluster, SAW011_CLUSTER. This allows us to define the publish/subscribe topic in the WebSphere MQ queue manager cluster.

This section describes how to add a queue manager to the cluster.

1. In MQ Explorer, right-click the cluster node and select **Add Queue Manager to Cluster**, as shown in Figure 6-7.

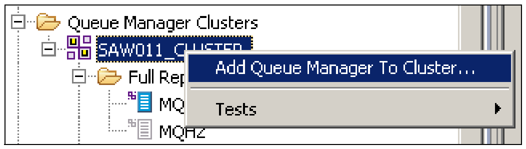
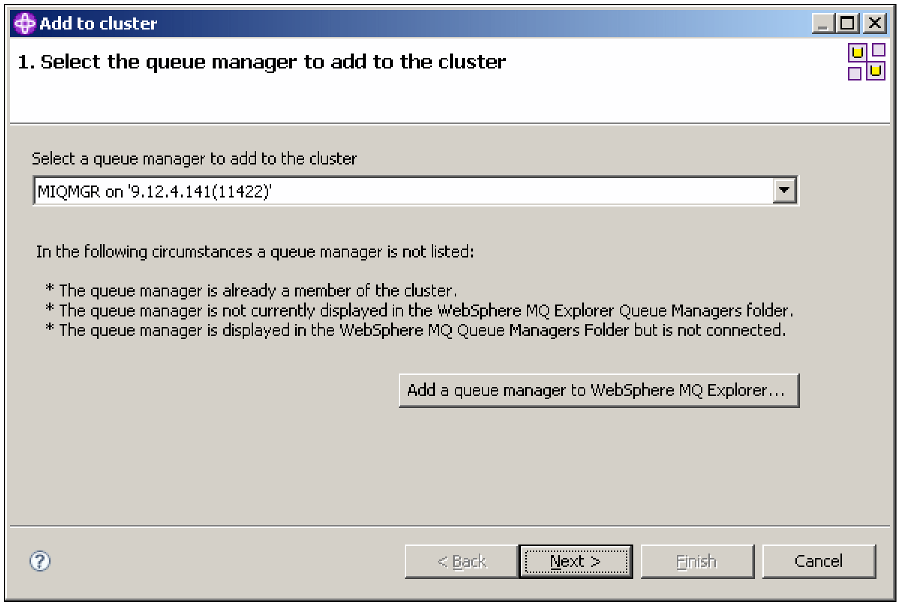


Figure 6-7 Add queue manager to cluster

2. Select the NFSMQK queue manager to add to the cluster, as shown in Figure 6-8.



1. Select the queue manager to add to the cluster

Select a queue manager to add to the cluster

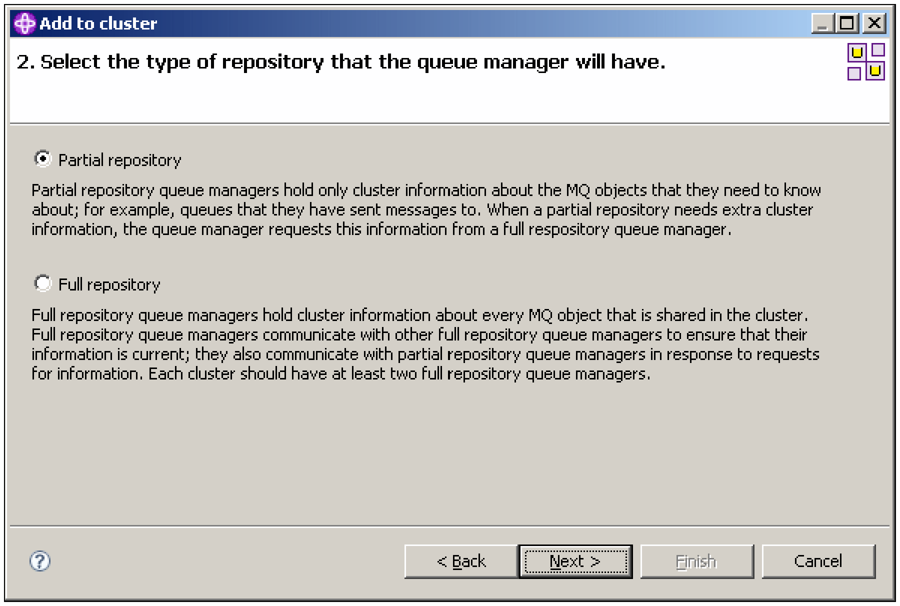
MIQMGR on '9.12.4.141(11422)'

In the following circumstances a queue manager is not listed:

* The queue manager is already a member of the cluster.
* The queue manager is not currently displayed in the WebSphere MQ Explorer Queue Managers folder.
* The queue manager is displayed in the WebSphere MQ Queue Managers Folder but is not connected.

Figure 6-8 Adding a queue manager to the cluster: Part 1 of 5

3. Choose **Partial Repository** (Figure 6-9) as we already have full repositories set up on the queue managers MQH1 and MQH2.


Add to cluster

2. Select the type of repository that the queue manager will have.

(●) Partial repository

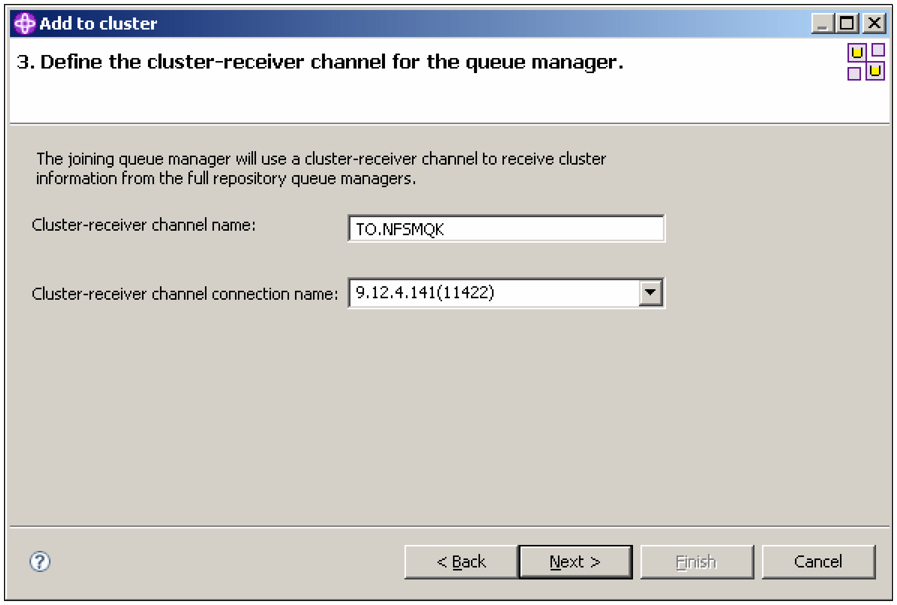
Partial repository queue managers hold only cluster information about the MQ objects that they need to know about; for example, queues that they have sent messages to. When a partial repository needs extra cluster information, the queue manager requests this information from a full respository queue manager.

( ) Full repository

Full repository queue managers hold cluster information about every MQ object that is shared in the cluster. Full repository queue managers communicate with other full repository queue managers to ensure that their information is current; they also communicate with partial repository queue managers in response to requests for information. Each cluster should have at least two full repository queue managers.

Figure 6-9 Adding a queue manager to a cluster: Part 2 of 5

4. Define the cluster-receiver channel. Select the IP address and port of the AIX queue manager (Figure 6-10).


Add to cluster

3. Define the cluster-receiver channel for the queue manager.

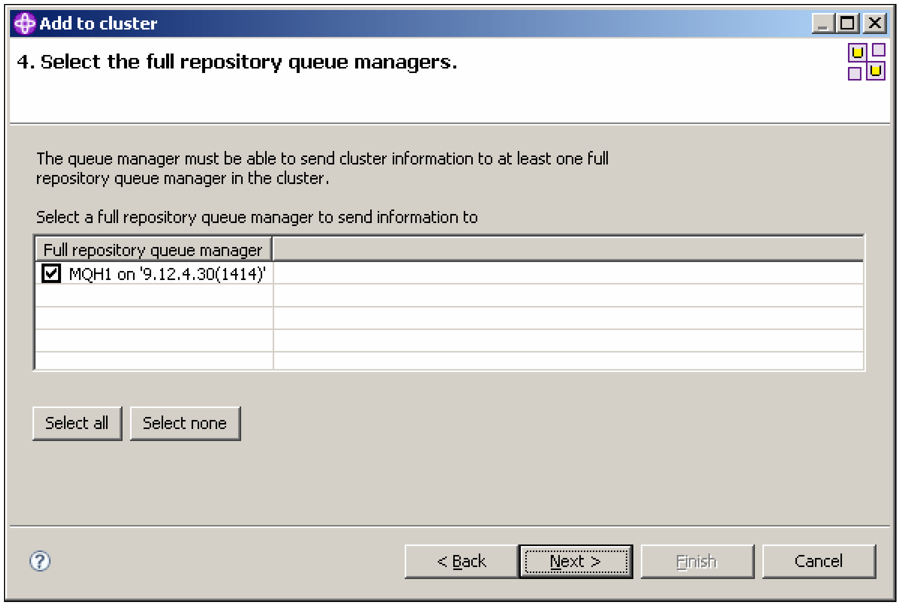
The joining queue manager will use a cluster-receiver channel to receive cluster information from the full repository queue managers.

Cluster-receiver channel name: TO.NFSMQK

Cluster-receiver channel connection name: 9.12.4.141(11422)

Figure 6-10 Adding a queue manager to a cluster: Part 3 of 5

5. Select the full repository queue manager (Figure 6-11).



4. Select the full repository queue managers.

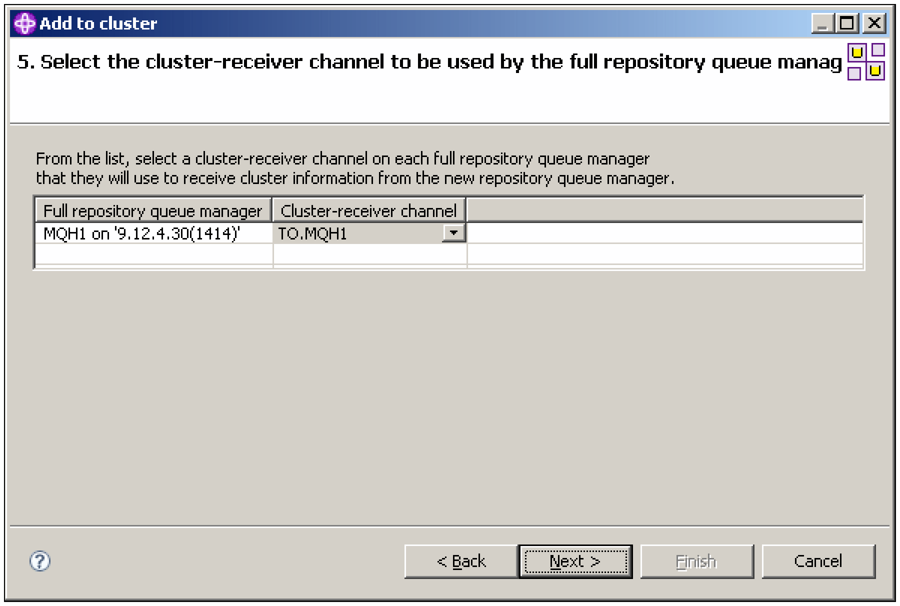
The queue manager must be able to send cluster information to at least one full repository queue manager in the cluster.

Select a full repository queue manager to send information to

Full repository queue manager	
☑ MQH1 on '9.12.4.30(1414)'	

Figure 6-11 Adding a queue manager to a cluster: Part 4 of 5

6. Select the cluster-receiver channel to be used by the full repository queue manager (Figure 6-12).


Add to cluster

5. Select the cluster-receiver channel to be used by the full repository queue manag

From the list, select a cluster-receiver channel on each full repository queue manager that they will use to receive cluster information from the new repository queue manager.

Full repository queue manager	Cluster-receiver channel
MQH1 on '9.12.4.30(1414)'	TO.MQH1

Figure 6-12 Adding a queue manager to a cluster: Part 5 of 5

7. Click **Finish** to add the queue manager to the cluster.

6.5.2 Creating the topic

In this section, we create a topic called NEWS.POLITICS for queue manager MQH1, which is defined in the WebSphere MQ Cluster SAW011_CLUSTER.

The steps to create the topic are as follows:

1. Right-click the Topic folder and select **New** → **Topic**., as shown in Figure 6-13.

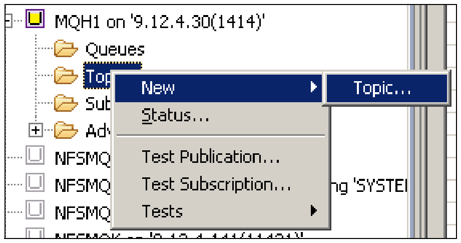
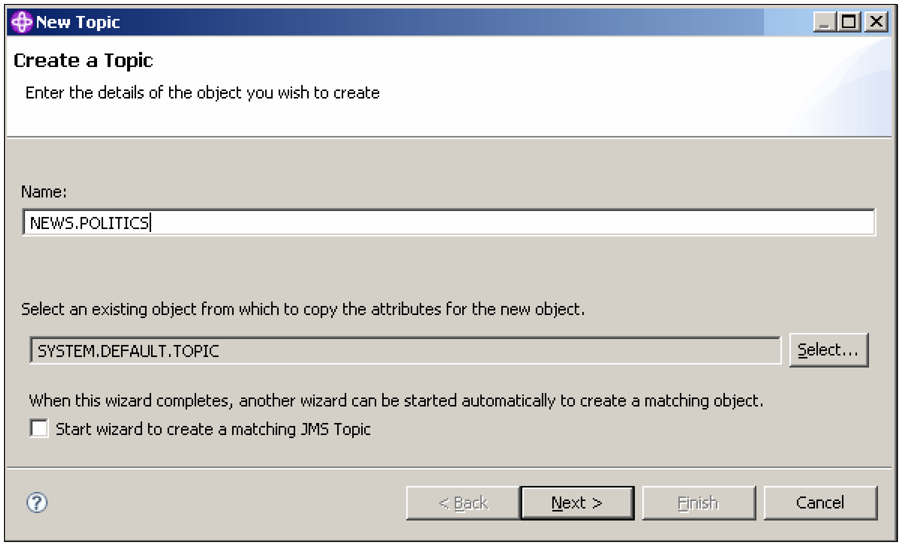


Figure 6-13 Creating a Topic

2. Enter `NEWS.POLITICS as` the topic name, as in Figure 6-14.


New Topic

Create a Topic

Enter the details of the object you wish to create

Name:

NEWS.POLITICS

Select an existing object from which to copy the attributes for the new object.

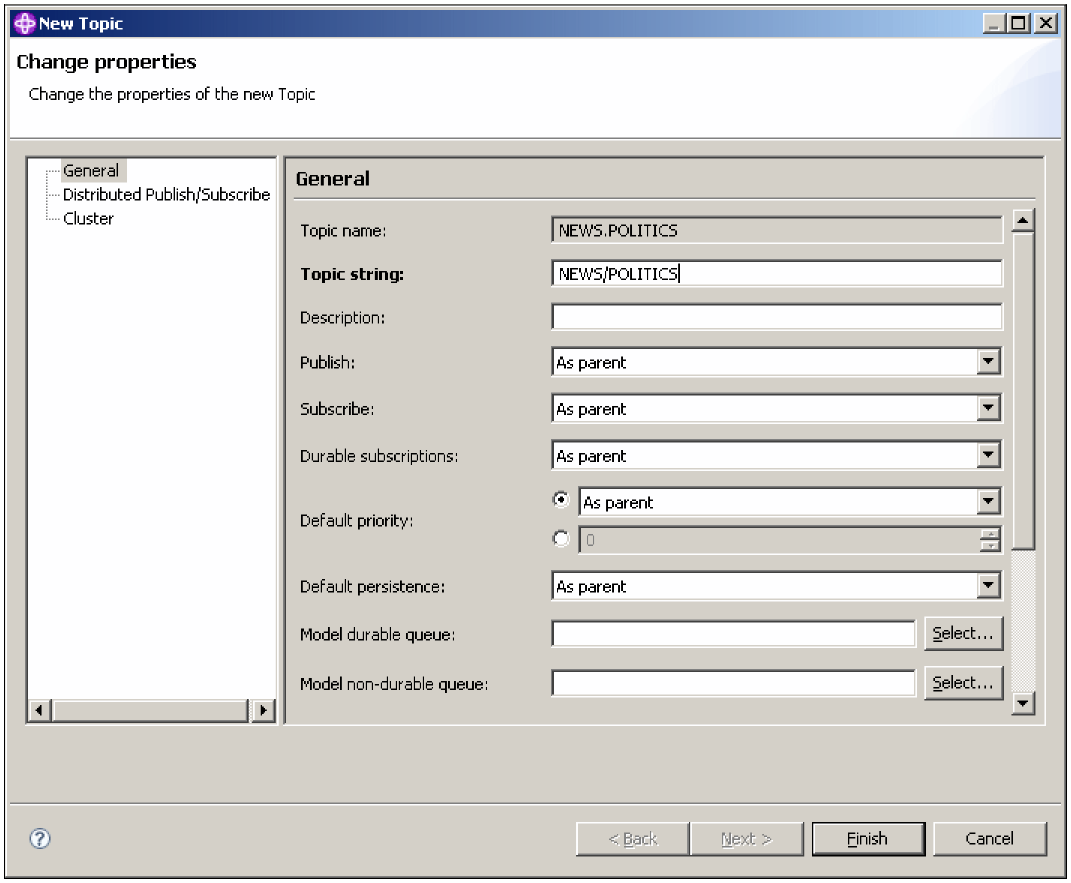
SYSTEM.DEFAULT.TOPIC

When this wizard completes, another wizard can be started automatically to create a matching object.

☐ Start wizard to create a matching JMS Topic

Figure 6-14 Creating a Topic: Part 1 of 4

3. Enter the Topic string `NEWS/POLITICS` to indicate that we are only interested in NEWS messages relating to POLITICS, as shown in Figure 6-15.



Change properties

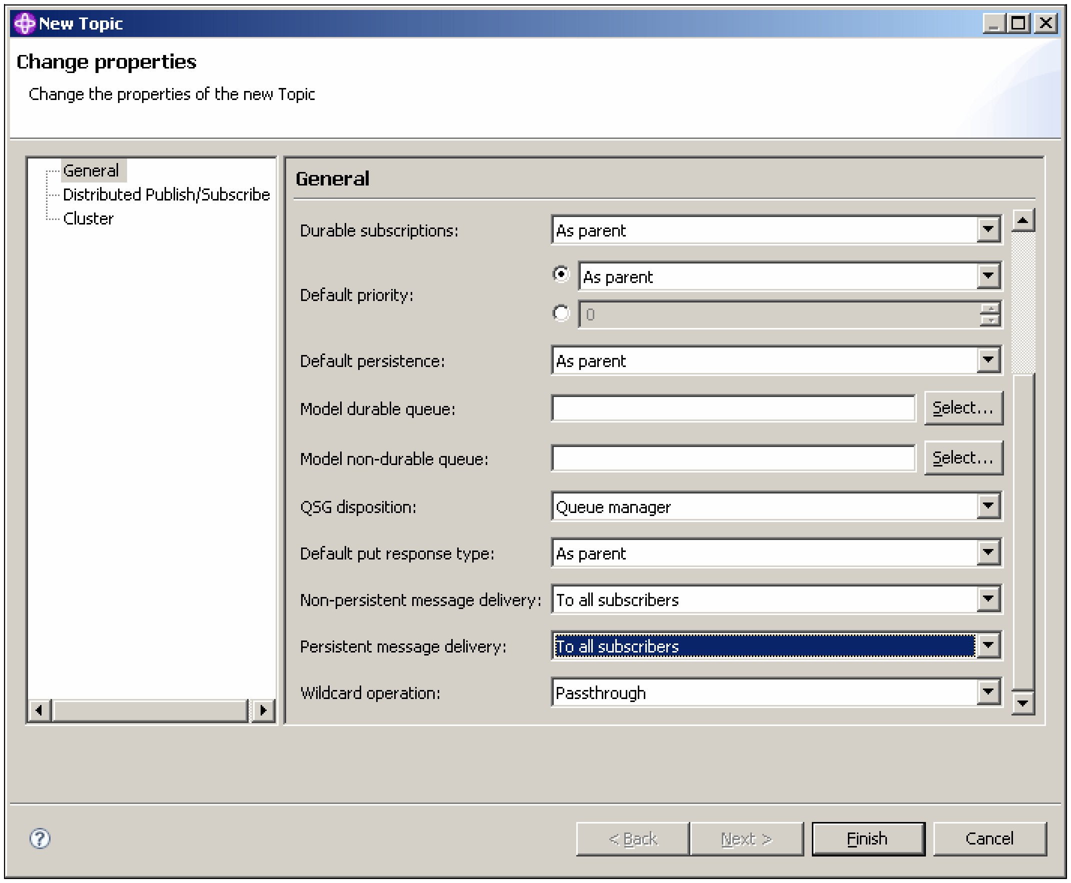
Change the properties of the new Topic

General

Topic name:	NEWS.POLITICS
Topic string:	NEWS/POLITICS
Description:	
Publish:	As parent
Subscribe:	As parent
Durable subscriptions:	As parent
Default priority:	[✓ As parent] / 0
Default persistence:	As parent
Model durable queue:	
Model non-durable queue:	

Figure 6-15 Creating a Topic: Part 1 of 4

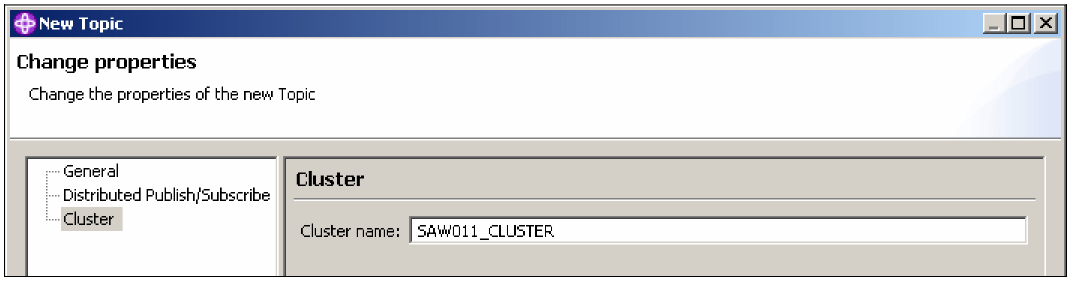
4. Set the QSG disposition field to **Queue manager**, **Non-persistent message delivery**. Set the Persistent message delivery field to **To all subscribers**, as shown in Figure 6-16.



Durable subscriptions: As parent
Default priority: [✓ As parent] 0
Default persistence: As parent
Model durable queue:
Model non-durable queue:
QSG disposition: Queue manager
Default put response type: As parent
Non-persistent message delivery: To all subscribers
Persistent message delivery: To all subscribers
Wildcard operation: Passthrough

Figure 6-16 Creating a Topic: Part 1 of 4

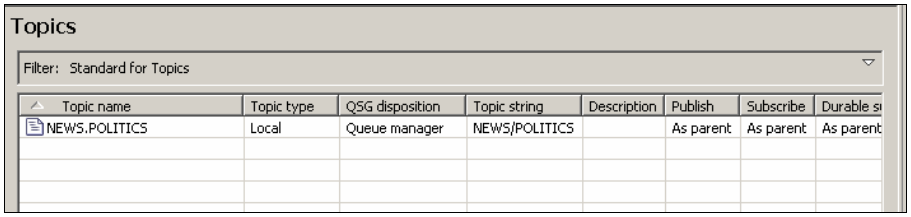
5. Select the **Cluster** section and enter `SAW011_CLUSTER` as the cluster name (Figure 6-17). This ensures that the topic is visible from any queue manager in the cluster. Click **Finish**.


New Topic
Change properties
Change the properties of the new Topic
General
Distributed Publish/Subscribe
Cluster
Cluster

Cluster name: SAW011_CLUSTER

Figure 6-17 Creating a Topic: Part 1 of 4

6. Click **OK** in the confirmation dialog box that displays. You see the topic displayed in WebSphere MQ Explorer, as in Figure 6-18.



Topic name	Topic type	QSG disposition	Topic string	Description	Publish	Subscribe	Durable su
NEWS.POLITICS	Local	Queue manager	NEWS/POLITICS		As parent	As parent	As parent

Figure 6-18 The NEWS.POLITICS topic

7. Click **Finish** to add the queue manager to the cluster.

6.5.3 Creating the subscription

The next step is to create the administrative subscription on queue manager NFSMQK. We create a subscription named NEWS.POLITICS.SUBSCRIPTION that subscribes to messages from the topic NEWS.POLITICS that we have created.

1. Create a persistent local queue on queue manager NFSMQK and name it `NEWS.SUB.QUEUE`. This is where our messages are delivered.
2. Right-click the Subscriptions for queue manager NFSMQK and select **New** → **Subscription**. See Figure 6-19.

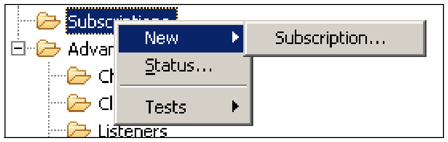
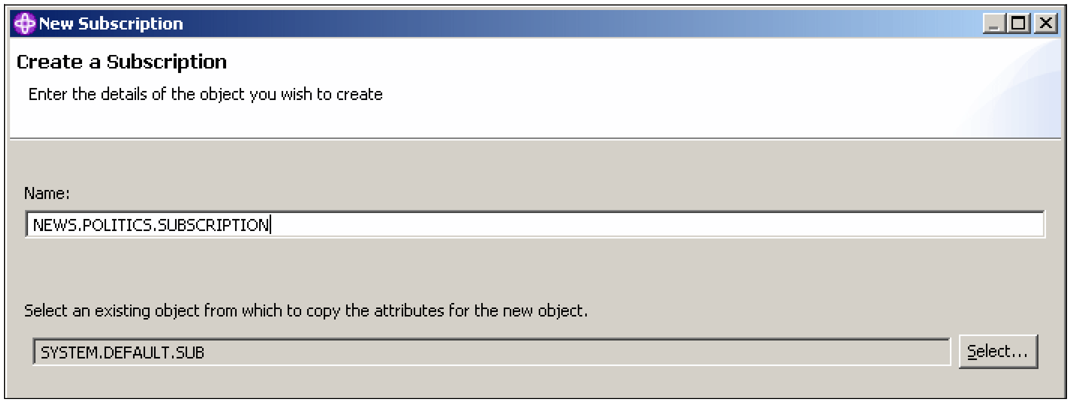


Figure 6-19 Starting the Subscription wizard

3. Enter a subscription name of `NEWS.POLITICS.SUBSCRIPTION` (Figure 6-20).



Create a Subscription

Enter the details of the object you wish to create

Name:

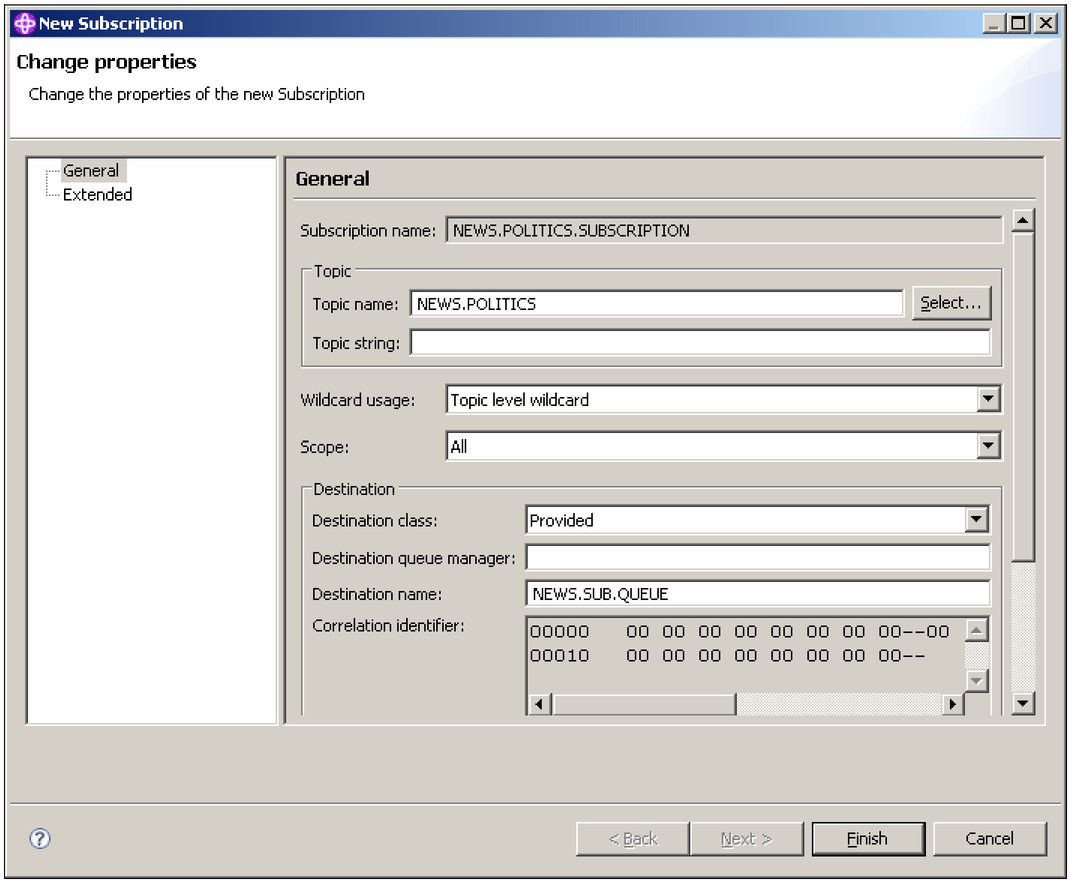
NEWS.POLITICS.SUBSCRIPTION

Select an existing object from which to copy the attributes for the new object.

SYSTEM.DEFAULT.SUB

Figure 6-20 Creating a subscription: Part 1 of 2

4. Enter a topic name of `NEWS.POLITICS` and the Destination Name of the local queue that we created **`NEWS.SUB.QUEUE`**. See Figure 6-21.



Subscription name: NEWS.POLITICS.SUBSCRIPTION

Topic
Topic name: NEWS.POLITICS
Topic string:

Wildcard usage: Topic level wildcard

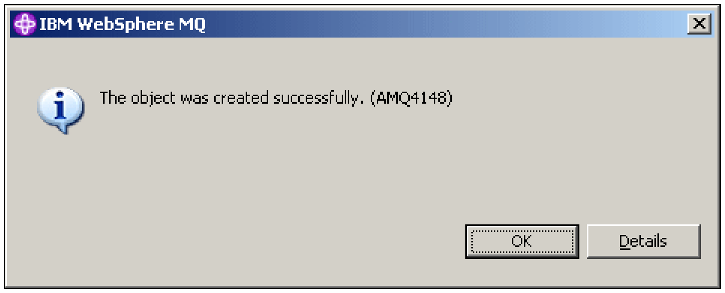
Scope: All

Destination
Destination class: Provided
Destination queue manager:
Destination name: NEWS.SUB.QUEUE
Correlation identifier:

```
00000     00  00  00  00  00  00  00  00--00
00010     00  00  00  00  00  00  00  00--
```

Figure 6-21 Creating a subscription: Part 2 of 2.

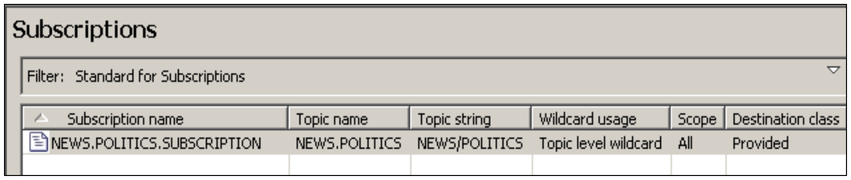
5. Click **OK** in the dialog box shown in Figure 6-22.



The object was created successfully. (AMQ4148)

Figure 6-22 Creating a subscription: Confirmation

Once created, you see the subscription displayed in WebSphere MQ Explorer, as in Figure 6-23.


Subscriptions

Filter: Standard for Subscriptions

Subscription name	Topic name	Topic string	Wildcard usage	Scope	Destination class
NEWS.POLITICS.SUBSCRIPTION	NEWS.POLITICS	NEWS/POLITICS	Topic level wildcard	All	Provided

Figure 6-23 The NEWS.POLITICS subscription

6.6 Testing the topology

This section describes the testing performed on this scenario. The testing aims to validate the failover under the valid failover scenarios described in the documentation.

6.6.1 Testing approach

Our testing considers two types of failover:

- Controlled switch-over from the active node to the standby node. This switch is provided to switch control to the standby node and might be required to apply a software maintenance release. This is done with the **`endmqm -s`** command.
- Automatic failover of the multi-instance queue manager and broker in the event of an unplanned outage.
  - Kill all MQ processes on the active node using **kill -9**.
  - Shutdown and restart the active server using **shutdown -rF**

Figure 6-24 shows the end-to-end test scenario for multi-instance failover.

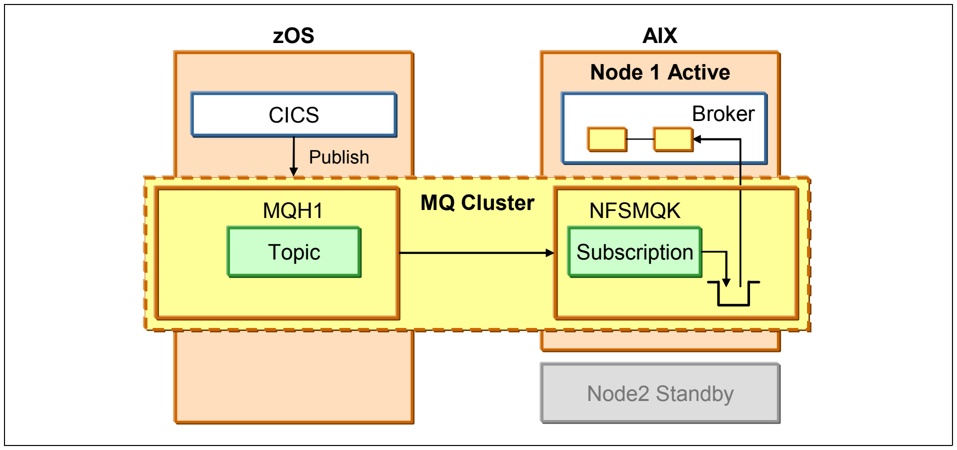


Figure 6-24 End-to-end test scenario for multi-Instance

Figure 6-24 illustrates the following process:

- A CICS program publishes messages to the MQ queue MQH1.
- The multi-instances of queue manager NFSMQK on the AIX nodes have an administrative subscription to subscribe messages published on o a topic on queue manager MQH1.
- The CICS program is configured to generate a continuous stream of messages. Messages routed to NFSMQK are consumed by a WebSphere Message Broker flow that reads the message and writes them to an output queue named MI_OUTPUT.
- When the CICS program is writing messages, a controlled failed over from the active node to the standby node is performed.
- We expect the standby queue manager and broker on Node2 to become active and to resume retrieving the messages published by the CICS program.

Note: During the switch-over period the active queue manager stops without waiting for the standby queue manager to become active. Clients connecting during this period do not get a connection to the queue manager and must re-connect to the Node2 queue manager instance after it becomes active.

In the scenario described in this chapter, the behavior is determined by the publish/subscribe configuration. The subscription is configured to be a durable subscription. Messages are persistent, so there is no loss of messages. After the queue manager instance on Node2 becomes active, it receives the messages that have been published to the topic.

If the subscription was not durable and messages were not persistent there is a risk that messages can be lost during the cut over period if for instance the messages expire or the queue manger goes down.

6.6.2 Verifying the status on the node

Three commands to verify the status of the queue managers and brokers are:

- To verify that the listener process is running, issue the **`ps -ef|grep runmqlsr`** command.
- To display the MQ status and verify that the active and standby Nodes are running, issue the **`dspmq -x`** command.
- To verify that the broker NFSWMB is a multi-instance broker running in active mode on the multi-instance queue manager 'NFSMQK', issue the **`mqsilist`** command.

These commands are illustrated in Example 6-23.

Example 6-23 Verifying the status on the node

```
$ ps -ef|grep runmqlsr
eaiadmin 700428 540678   0 00:19:21      -  0:00 /usr/mqm/bin/runmqlsr
-r -m NFSMQK -t TCP -p 11421
$ dspmq -x
QMNAME(NFSMQK)
STATUS(Running)
    INSTANCE(p5502p8) MODE(Active)
    INSTANCE(p5501p5) MODE(Standby)
$ mqsilist
BIP1295I: Broker 'NFSWMB' is a multi-instance broker running in active
mode on multi-instance queue manager 'NFSMQK'.
BIP8071I: Successful command completion.
```

6.6.3 Test cases and results

This section provides information about the test cases and the results.

Test Case 1: Controlled switch-over

The setup for the first test case, involving a controlled switch-over, was done using the following steps:

1. Verify the status of the active node. Refer 6.6.2, “Verifying the status on the node” on page 138. Start any components on the active node as required.
2. Verify the status of the standby node. Refer 6.6.2, “Verifying the status on the node” on page 138. Start any components on the standby node as required.
3. Ensure that the message flow is running.

Table 6-6 describes the test case.

Table 6-6 Test case 1

Component	**WebSphere Message Broker Multi-Instance Brokers**
Test Case	Controlled switch-over from the active to the standby node
Description	This test case tests the controlled switch-over from the active node to the standby node using the `endmqm` command with the `-s` option. We expect the standby queue manager and broker to become active and to continue consuming the 100000 messages published by the CICS program without loss of messages.

Table 6-7 describes the steps executed in the test case and the results.

Table 6-7 Test steps

Step	Description	Pass/ Fail
1	Invoke the CICS program to publish messages to the NEWS.POLITICS topic on z/OS queue manager MQH1. See Appendix A, “QPUB Transaction” on page 227 for details of the CICS program and how to invoke it. Results: The messages are published to the NEWS.POLITICS topic on z/OS queue manager MQH1 and go to the MI_INPUT queue on queue manager NFSMQK.	Pass

2	Monitor the output queue MI_OUTPUT on the active node through MQ Explorer. After approximately 15000 messages have been processed perform a controlled switch from the active node to the standby node by issuing the **`endmq -s`** command on the active node.
	
	If you are monitoring the queue depth in MQ Explorer you lose connection to the active node instance of the queue manager on Node1 as it stops and switches control to the standby instance on Node2. After Node2 becomes active you must re-connect to the queue manager instance on Node2 to check the queue depth of the output queue.
	
	Results:
	`$ endmqm -s NFSMQK`
	`Waiting for queue manager 'NFSMQK' to end.`
	`Quiesce request accepted. The queue manager will stop when all outstanding work`
	`is complete, permitting switch-over to a standby instance.`
	`$`
	This shows that the queue manager on Node1 is about to stop and has handed control to the standby instance on Node2.
		Pass

Step	Description	Pass/ Fail

3	Verify the status of the active node. Refer 6.6.2, “Verifying the status on the node” on page 138.
	The queue manager stops on Node1 and Node2 becomes the active node.
	
	Results:
	`$ dspmq -x`
	`QMNAME(NFSMQK)                                    STATUS(Running as standby)`
	`    INSTANCE(p5502p8) MODE(Active)`
	`    INSTANCE(p5501p5) MODE(Standby)`
	`$ dspmq -x`
	`QMNAME(NFSMQK)                                    STATUS(Running as standby)`
	`    INSTANCE(p5502p8) MODE(Active)`
	`    INSTANCE(p5501p5) MODE(Standby)`
	`$ dspmq -x`
	`QMNAME(NFSMQK)                                    STATUS(Running as standby)`
	`    INSTANCE(p5502p8) MODE(Active)`
	`    INSTANCE(p5501p5) MODE(Standby)`
	`$ dspmq -x`
	`QMNAME(NFSMQK)                                    STATUS(Running as standby)`
	`    INSTANCE(p5502p8) MODE(Active)`
	`    INSTANCE(p5501p5) MODE(Standby)`
	`$ dspmq -x`
	`QMNAME(NFSMQK)                                           STATUS(Running)`
	`    INSTANCE(p5501p5) MODE(Active)`
	`$ mqsilist`
	`BIP1295I: Broker 'NFSWMB' is a multi-instance broker running in active mode`
	`on multi-instance queue manager 'NFSMQK'.`
	`BIP8071I: Successful command completion.`
	
	When the switch-over was complete the queue manager on Node2 (`p5501p5`) became active and the broker on Node2 became the active instance.
		Pass

4	Connect to the newly active queue manager instance in MQ Explorer on Node2 and monitor the queue depths until all 100000 messages appear on the MI_OUTPUT queue. Results: All 100000 messages were processed and written to MI_OUTPUT.	Pass
Overall Test Status We managed to successfully switch control of the application from Node1 to Node2 without loss of messages. There was a brief interruption during the cut-over period, but this had no impact in this scenario as the publish subscribe configuration meant that our messages were persisted until the queue manager switch over was complete and the Node2 instance of the queue manager was able to retrieve the messages.		Pass

Test Case 2: Automatic failover after killing the MQ processes

The setup for the test involved the following steps:

1. Verify the status of the active node. Refer 6.6.2, “Verifying the status on the node” on page 138. Start any components on the active node as required.
2. Verify the status of the standby node. Refer 6.6.2, “Verifying the status on the node” on page 138. Start any components on the standby node as required.
3. Ensure that the message flow is running.

Table 6-8 describes the test case.

Table 6-8 Test case 2

Component	**WebSphere Message Broker Multi-Instance Brokers**
Test Case	Automatic failover from the active to the standby node after killing the WebSphere MQ processes.
Description	This test case tests the automatic failover from the active node to the standby node during message processing, when we kill all of the WebSphere MQ processes on the active node using kill -9. We expect the standby queue manager and broker to become active and to continue consuming the 100000 messages published by the CICS program without loss of messages.

Table 6-9 describes the steps executed in the test case and the results.

Table 6-9 Test steps with kill -9

Step	Description	Pass/ Fail
1	Invoke the CICS program to publish messages to the NEWS.POLITICS topic on z/OS queue manager MQH1. See Appendix A, "QPUB Transaction" on page 227 for details of the CICS program and how to invoke it. Results: The messages are published to the NEWS.POLITICS topic on z/OS queue manager MQH1 and go to the MI_INPUT queue on queue manager NFSMQK.	Pass

2	Monitor the output queue MI_OUTPUT on the active node through MQ Explorer. After approximately 15000 messages have been processed perform a failover from the active node to the standby node by issuing the following command on the active node:
	
	`kill -9 ``ps -ef | grep amq | grep -v grep | awk '{print $2}'`` `
	`kill -9 ``ps -ef | grep runmqlsr | grep -v grep | awk '{print $2}'`` `
	
	The first command kills the queue manager processes and second command kills the listener.
	
	Results:
	The queue manager on Node1 is stopped and the standby instance on Node2 started automatically. The broker instance on active node stops and on Node2 becomes active broker instance.
		Pass

3	Verify the status of the active node. Refer 6.6.2, "Verifying the status on the node" on page 138.
	The queue manager on Node2 becomes the active node.
	
	Results:
	`$ dspmq -x`
	`QMNAME(NFSMQK)                                            STATUS(Running)`
	`    INSTANCE(p5501p5) MODE(Active)`
	`$ mqsilist`
	`BIP1295I: Broker 'NFSWMB' is a multi-instance broker running in active mode on multi-instance queue manager 'NFSMQK'.`
	`BIP8071I: Successful command completion.`
		Pass

4	Connect to the newly active queue manager instance in MQ Explorer on Node2 and monitor the queue depths until all 100000 messages appear on the MI_OUTPUT queue. Results: All 100000 messages were processed and written to MI_OUTPUT.	Pass

Step	Description	Pass/ Fail
Overall Test Status The failover of queue manager instance and broker instance by using command kill -9 works correct, the application switches processing from Node1 to Node2 without loss of messages. There was a brief interruption during the cut-over period.		Pass

Test case 3: automatic failover at active server shut down

The setup for the test involved the following steps:

1. Verify the status of the active node. Refer 6.6.2, “Verifying the status on the node” on page 138. Start any components on the active node as required.
2. Verify the status of the standby node. Refer 6.6.2, “Verifying the status on the node” on page 138. Start any components on the standby node as required.
3. Ensure that the message flow is running.

Table 6-10 describes the test case.

Table 6-10 Test case 3

Component	WebSphere Message Broker Multi-Instance Brokers
Test Case	Automatic failover from the active to the standby node
Description	This test case tests automatic failover from the active node to the standby node during message processing when a shutdown and restart is performed on the active server using **`shutdown -rF`**. We expect the standby queue manager and broker to become active and to continue consuming the 100000 messages published by the CICS program without loss of messages.

Table 6-11 describes the steps executed in the test case and the results.

Table 6-11 Test steps with shutdown -rF

Step	Description	Pass/ Fail
1	Invoke the CICS program to publish messages to the NEWS.POLITICS topic on z/OS queue manager MQH1. See Appendix A, “QPUB Transaction” on page 227 for details of the CICS program and how to invoke it. Results: The messages are published to the NEWS.POLITICS topic on z/OS queue manager MQH1 and go to the MI_INPUT queue on queue manager NFSMQK.	Pass
2	Monitor the output queue MI_OUTPUT on the active node through MQ Explorer. After approximately 15000 messages have been processed perform a failover of the active node with the `shutdown -rf` command. Results: The queue manager standby instance on Node2 started automatically. The broker instance on Node2 became active.	Pass

3	Verify the status of the active node. Refer 6.6.2, “Verifying the status on the node” on page 138.
	The queue manager on Node2 becomes the active node.
	
	Results:
	`$ dspmq -x`
	`QMNAME(NFSMQK)                                    STATUS(Running)`
	`    INSTANCE(p5501p5) MODE(Active)`
	`$ mqsilist`
	`BIP1295I: Broker 'NFSWMB' is a multi-instance broker running in active mode on multi-instance queue manager 'NFSMQK'.`
	`BIP8071I: Successful command completion.`
		Pass

4	Connect to the newly active queue manager instance in MQ Explorer on Node2 and monitor the queue depths until all 100000 messages appear on the MI_OUTPUT queue. Results: All 100000 messages were processed and written to MI_OUTPUT.	Pass
Overall Test Status The failover of queue manager instance and broker instance when we shutdown and restart the active server works correctly. The message processing restarted on node2 without loss of messages. The time of interruption during the cut-over period was minimal.		Pass

6.7 Summary

In this scenario we were able to demonstrate successfully the use of WebSphere MQ and WebSphere Message Broker multi-instance features to provide a high availability solution.

Our testing showed that the controlled switch-over can be used to change the active instance to allow maintenance of the active node. In addition we looked at two failover scenarios and verified the automatic switch-over from the active node to the standby node in the event of a failure.

The multi-instance features performed well and provided an effective high availability solution.

7

High availability through redundancy

This chapter presents a scenario that demonstrates the use of redundancy to provide high availability.

Redundancy is employed at multiple levels:

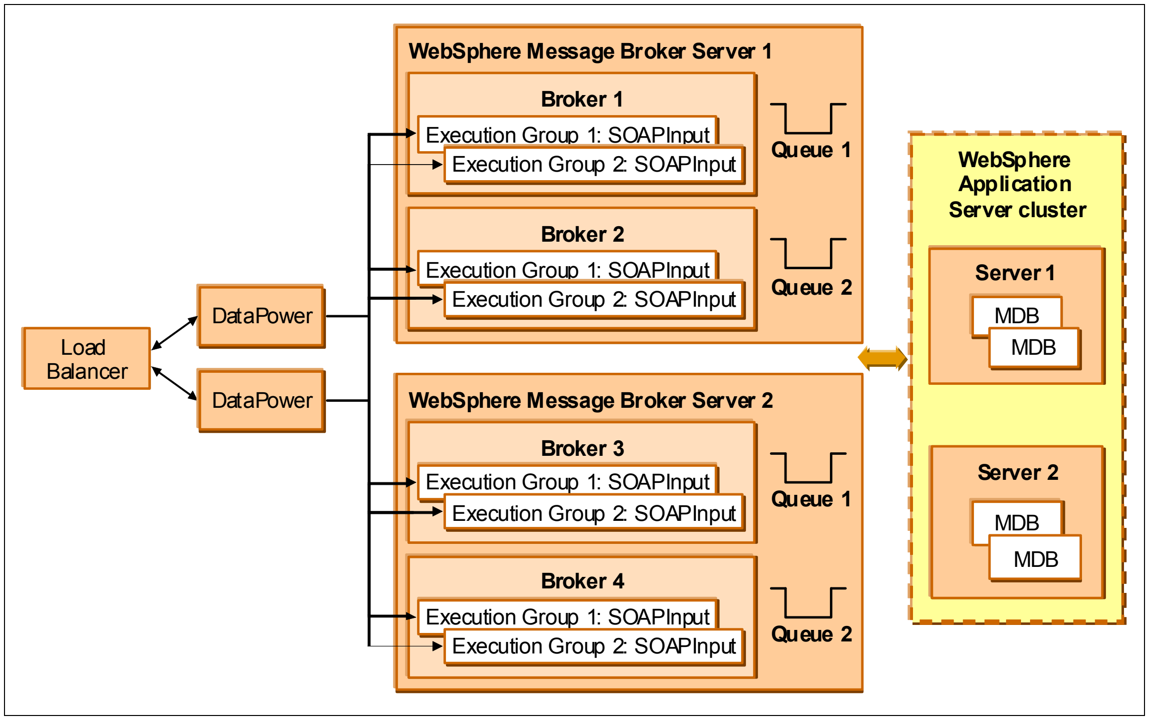
- Multiple DataPower appliances
- Multiple WebSphere Message Broker Servers
- Multiple WebSphere Message Broker brokers within each server
- Multiple execution groups within each broker

7.1 Overview

In this scenario a network load balancer is used to spread traffic across two DataPower XI50 appliances. Both devices are configured as active. DataPower receives SOAP/HTTP requests that are routed by DataPower to a pair of equivalent WebSphere Message Broker servers configured in an active-active configuration. Each request is handled by a message flow that exposes a Web service to receive messages. The flow performs a transformation of the request message and puts it to a WebSphere MQ queue.

Messages placed on the queue might undergo further processing. For example, the message can be consumed by a message-driven bean (MDB) connected to WebSphere MQ using client bindings or through the IBM WebSphere Application Server default messaging provider. To provide end-to-end high availability, the MDB can be deployed into a WebSphere Application Server cluster. Figure 7-1 on page 149 describes this scenario.

Note: The scope of testing for this scenario does not include the WebSphere Application Server cluster and MDB. These components are shown in Figure 7-1 on page 149 for completeness.



WebSphere Message Broker Server 1
Broker 1
Execution Group 1: SOAPInput
Execution Group 2: SOAPInput
Queue 1
Broker 2
Execution Group 1: SOAPInput
Execution Group 2: SOAPInput
Queue 2
WebSphere Application Server cluster
Server 1
MDB
MDB
Load Balancer
DataPower
DataPower
WebSphere Message Broker Server 2
Broker 3
Execution Group 1: SOAPInput
Execution Group 2: SOAPInput
Queue 1
Server 2
MDB
MDB
Broker 4
Execution Group 1: SOAPInput
Execution Group 2: SOAPInput
Queue 2

Figure 7-1 Solution overview

Figure 7-1 illustrates the following process:

1. The network load balancer receives all incoming SOAP/HTTP requests and distributes these requests across the two DataPower XI50 appliances using a round robin algorithm.
2. The DataPower devices perform basic validation and threat protection on the SOAP requests. It also load balances the requests to the WebSphere Message Broker servers in the network.
3. Each broker contains two execution groups running an instance of the message flow. This results in eight instances of the same message flow. DataPower load balances across these eight endpoints.
4. Each request is handled by a message flow beginning with a SOAPInput node that performs transformation of the request.
5. The message flow writes the message to a WebSphere MQ queue.
6. The message is consumed by a MDB connected to WebSphere MQ using client bindings.

The high availability features of the topology are as follows:

- If a DataPower appliance becomes unavailable, traffic can be routed to an alternate appliance.
- If one WebSphere Message Broker server becomes unavailable, all traffic is routed to the alternate server.
- If one or more brokers becomes unavailable, all traffic is routed to the remaining brokers
- If one or more execution groups becomes unavailable, all traffic is routed to the remaining execution groups.

7.1.1 Topology

The topology used for this scenario is depicted in Figure 7-2.

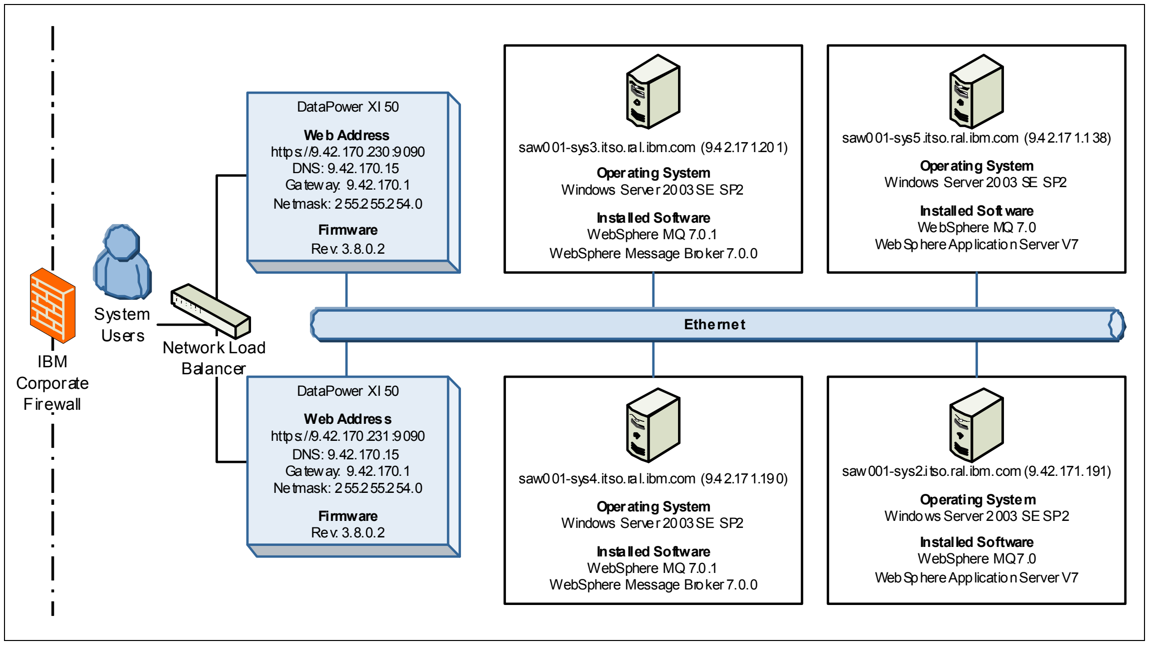


Figure 7-2 Network topology

This topology can be vertically scaled as required by increasing the number of DataPower appliances, IBM WebSphere Message Broker hosts, or the WebSphere Application Server hosts.

Each component in our topology is described in Table 7-1.

Table 7-1 Topology components

Component	Description
Network load balancer	The network load balancer intercepts all inbound requests and load balances them to the available DataPower devices using a round robin algorithm.
DataPower XI50 Appliances	DataPower XI50 appliances are configured as Web services gateways to proxy Web services to the consuming application using SOAP/HTTP. For application-level load balancing to the service endpoint, Load Balancer Group objects are used to route inbound requests dynamically to the WebSphere Message Broker servers. This provides seamless transition of requests to any of the available back-end endpoints.
WebSphere Message Broker servers (saw001-sys3 and saw001-sys4)	These two servers host the WebSphere Message Broker message flows. In this scenario there is a single message flow that exposes a Web service using a SOAPInput node. WebSphere Message Broker is configured with two brokers on each of the application servers making a total of four brokers. Each broker contains two execution groups. Our message flow is deployed to each of these execution groups making a total of eight instances of the message flow.
WebSphere Application Server servers (saw001-sys2 and saw001-sys5)	These two servers host WebSphere Application Server. A cluster of application servers, one on each host, have been defined. The message driven bean is deployed to the cluster.

7.1.2 High availability characteristics and actions

In this scenario, we consider a number of possible failure scenarios. This includes the failure of the following elements:

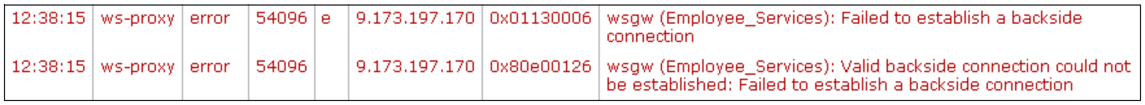
- DataPower appliance
- Single execution group
- Individual broker
- WebSphere Message Broker server

DataPower Appliance outage

If any of the DataPower appliances experiences a failure, the network load balancer detects that a device is unavailable and removes the failed device from its active list of devices. It checks for its availability periodically. During the failover, all traffic is redirected to the remaining active appliances in the environment. A device failure causes all in-flight transactions to be lost. Client applications might be required to re-submit the request in case of HTTP-based requests.

Service failure

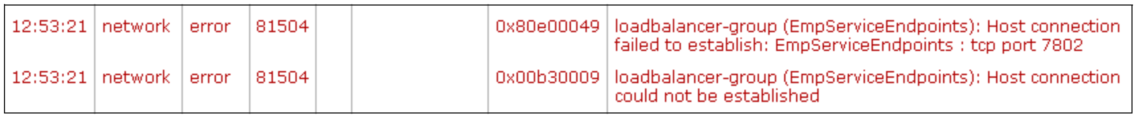
If the DataPower device® is unable to reach the specified back-end service endpoint, the log entry shown in Figure 7-3 is raised in the system log. System logs are available to view in the DataPower control panel under **Status** → **View logs** → **System logs**.



```
12:38:15 | ws-proxy | error | 54096 | e | 9.173.197.170 | 0x01130006 | wsgw (Employee_Services): Failed to establish a backside
         |          |       |       |   |               |            | connection
12:38:15 | ws-proxy | error | 54096 |   | 9.173.197.170 | 0x80e00126 | wsgw (Employee_Services): Valid backside connection could not
         |          |       |       |   |               |            | be established: Failed to establish a backside connection
```

Figure 7-3 DataPower: Error alerts in the system log

Assuming a load balancer group object is used for application-level load balancing and one of the member servers becomes unavailable, DataPower automatically attempts to connect to other member servers and seamlessly route the request to an available member. If none of the back-end servers are available, a SOAP fault is sent to the calling application. This SOAP fault can be customized. Errors relating to member servers availability are not visible in the system log and can only be viewed by selecting **Network** → **Load Balancer Group** → ***object_name*** → **View Log** hyperlink. Figure 7-4 contains a snippet of the log error entries.



```
12:53:21 | network | error | 81504 |  |  | 0x80e00049 | loadbalancer-group (EmpServiceEndpoints): Host connection
         |         |       |       |  |  |            | failed to establish: EmpServiceEndpoints : tcp port 7802
12:53:21 | network | error | 81504 |  |  | 0x00b30009 | loadbalancer-group (EmpServiceEndpoints): Host connection
         |         |       |       |  |  |            | could not be established
```

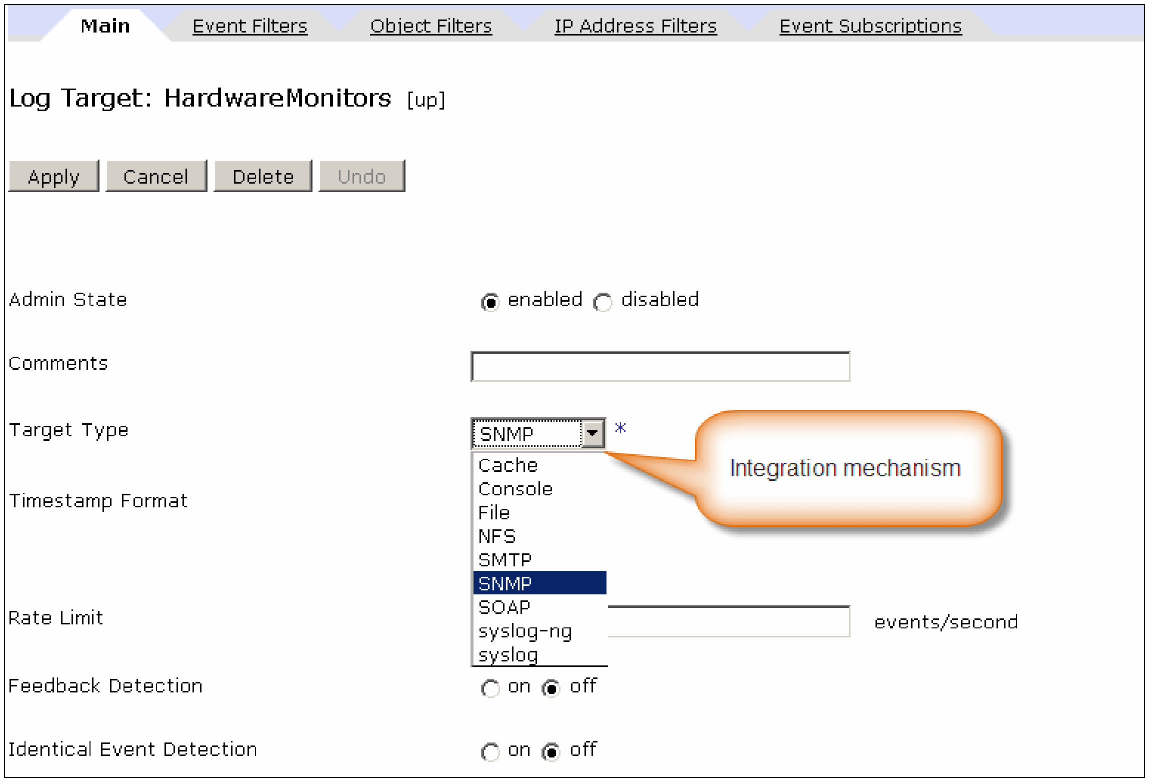
Figure 7-4 Load Balancer Group error entry

Most modern network load balancers can be configured to test DataPower device and service availability in the following way:

1. Test device availability by sending ICMP (ping) requests to the device. If network route and connectivity exists, a successful reply is received.
2. Test service port availability by sending a TCP SYN at the DataPower front side handler (only applies to push-based protocols such as HTTP). If the DataPower front side handler object is up, a TCP ACK is received.
3. Test DataPower service by sending a dummy request to the device and analyzing the response received. An HTTP 500 - SoapFault generally indicates that the device is successfully responding to invalid requests.
4. Test the end-to-end environment by sending a valid request and analyzing the response for a valid service response. An HTTP 200 with a valid SOAP response with certain field values or size generally indicates that the device processing and service endpoints are in working order.

If a DataPower device is unavailable or is not accepting any requests from the load balancer, the network load balancer black-lists the DataPower device for a configurable amount of time while retrying connections in the background. When the device becomes available, it becomes an active member group and load balancer starts to load balance requests again.

Most organizations have an enterprise monitoring suite to monitor hardware and messaging-level alerts in the infrastructure. DataPower provides a standards-based integration with existing monitoring suites and a flexible configuration mechanism to configure the types of alerts and objects to be monitored. This allows organizations to separate concerns and create various monitoring groups with specific responsibilities. For example, a hardware monitoring group might monitor power supplies, network connectivity, temperature, CPU/ Memory use, and so forth, and a business monitoring group might monitor transactions that failed validation, authentication failures, breach of SLAs, and so on. Extensive monitoring options might be configurable using the Log Target page shown in Figure 7-5. The Log Target page can be viewed by navigating to **Objects** → **Logging Configuration** → **Log Target.**



Log Target: HardwareMonitors [up]

Admin State: [✓ enabled] disabled

Comments:

Target Type: SNMP *

Timestamp Format

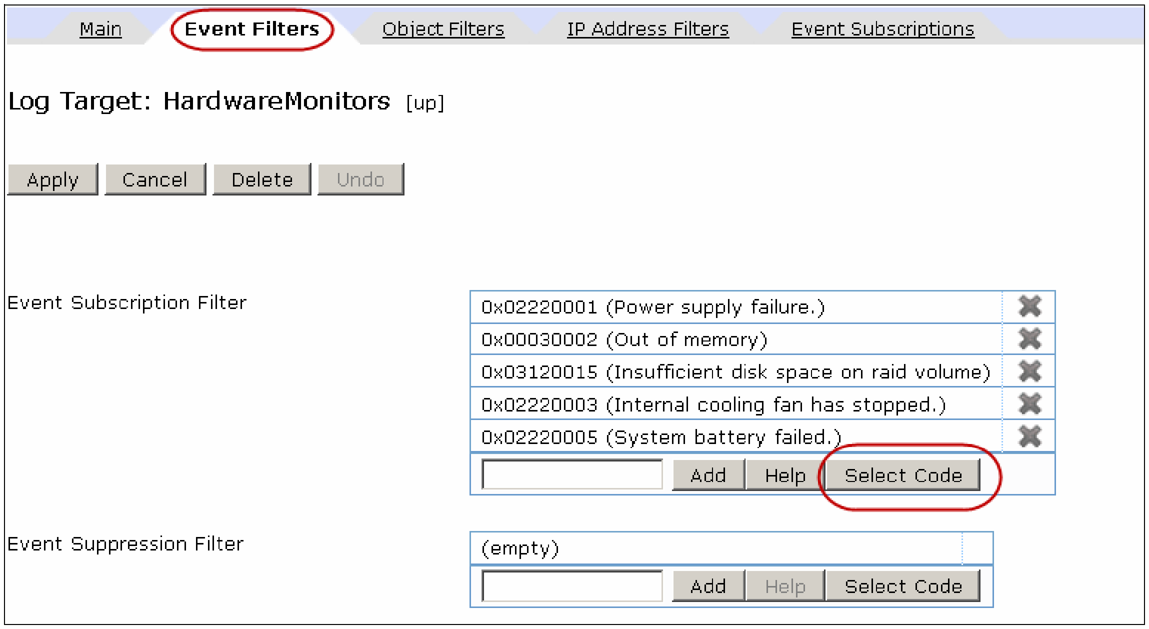
Rate Limit: events/second

Feedback Detection: on [✓ off]

Identical Event Detection: on [✓ off]

Figure 7-5 DataPower log target configuration

The Target Type list offers mechanism to integrate with the target monitoring system. Depending on the option selected, the user sees further options to configure the remote target. Figure 7-6 illustrates the point that certain targets can choose the type of alerts they receive. For example, the Event Filters tab allows the user to subscribe or suppress certain types of events. As a hardware monitoring target, this configuration sends alerts to the remote system of any critical hardware failures using SNMP.



Log Target: HardwareMonitors [up]

Event Subscription Filter

0x02220001 (Power supply failure.)
0x00030002 (Out of memory)
0x03120015 (Insufficient disk space on raid volume)
0x02220003 (Internal cooling fan has stopped.)
0x02220005 (System battery failed.)

Event Suppression Filter

(empty)

Figure 7-6 Configuring DataPower Log Target

This configuration can be further optimized, tuned for specific errors, and set priorities and objects that raise alerts in other tabs available on this page.

Execution group not responsive

If one of the execution groups stops responding either due to an application error or for another reason, the DataPower appliance does not receive a SOAP Reply in the maximum timeout wait period. DataPower therefore blacklists this endpoint and routes traffic to the remaining execution groups (URL s).

DataPower periodically polls the endpoints performing a health check. If they are available they are removed from the blacklist.

Broker is unavailable

If one of the brokers is shutdown or stops responding, the DataPower appliance does not receive a SOAP Reply within the maximum timeout wait period. DataPower therefore blacklists the endpoints for the broker and routes traffic to the endpoints of the remaining brokers.

DataPower periodically polls the endpoints performing a health check. If they are available they are removed from the blacklist.

The Message Broker Server is unavailable

If one of the servers is down or un-reachable, the DataPower appliance detects this and blacklists the endpoints of the server. All traffic is routed to the endpoints of the remaining server.

DataPower periodically checks to see if the server is back up. If the server comes back online and the endpoints are available they are removed from the blacklist.

7.1.3 Recovery

If there is an outage the redundant components can continue processing incoming requests with little or no impact to the clients. The outage can be due to any number of causes (including disk failures, CPU failures, message flow coding defects, network problems and power supply failures). The recovery actions to remedy the outage depend upon the cause of the outage and might require manual intervention. If an outage to a server, broker, or execution group is resolved and the service is restored, DataPower detects this and removes the affected services from the blacklist.

7.2 Message Broker message flow design

Figure 7-7 shows the message flow used for this scenario.

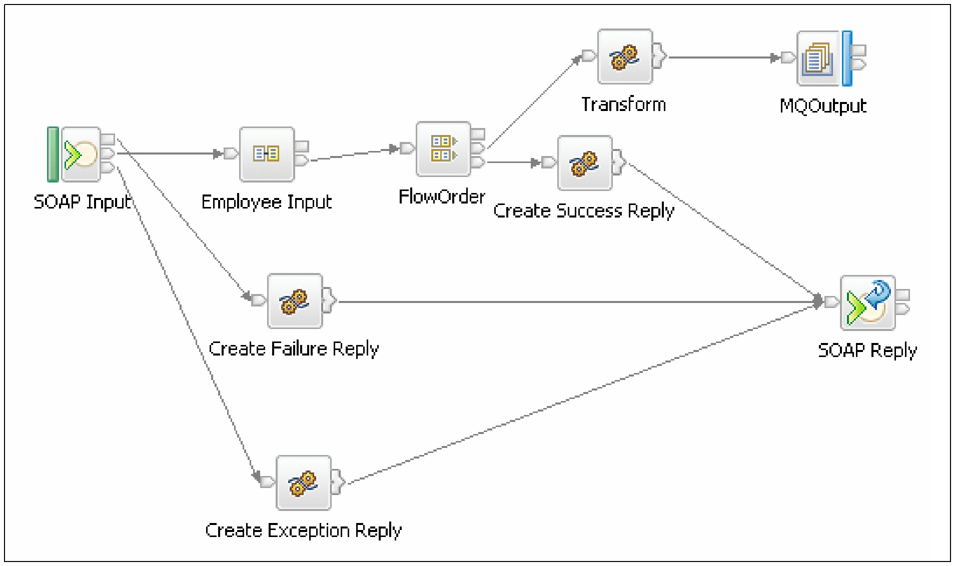


Figure 7-7 WebSphere Message Broker Message flow

Figure 7-7 illustrates the following process:

1. The message flow exposes a Web service through a SOAPInput node.
2. The incoming SOAP requests are validated for schema compliance. WebSphere Message Broker generates a SOAP Fault for non-compliant messages.

3. Valid messages flow through to the EmployeeInput node, which removes the SOAP Envelope from the message, leaving an Employee message. This is shown in Figure 7-8.

```
<?xml version="1.0" encoding="UTF-8"?>
<Employee xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="Employee.xsd">
   <EmployeeNumber>19092817</EmployeeNumber>
   <FirstName>John</FirstName>
   <LastName>Citizen</LastName>
   <Phone>919-867-9876</Phone>
   <Mobile>0418764519</Mobile>
   <Email>John.Citizen@acme.com</Email>
</Employee>
```

Figure 7-8 Employee message example

4. The message passes through a FlowOrder node to the Transform compute node. This node transforms the incoming `Employee.xml` message to the outgoing `EmployeeDetails.xml` format as shown in Figure 7-9.

```
<?xml version="1.0" encoding="UTF-8"?>
<EmployeeDetails
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="EmployeeDetails.xsd">
   <Empnum>19092817</Empnum>
   <Name>John Citizen</Name>
        <ContactDetails>Ph: 919-867-9876, Mob:0418764519,
Email:John.Citizen@acme.com</ContactDetails>
</EmployeeDetails>
```

Figure 7-9 Outgoing EmployeeDetails message example

5. The transformed message is written to the SAW001_EXPORT_EMPLOYEE output queue with an MQOutput node.
6. Control passes to the next step of the flow order node. A reply message is generated in the Create Success Reply compute node, which is passed to the SOAP Reply Node.
7. The message is consumed by a MDB connected to WebSphere MQ using client bindings.

In this scenario we use a fire and forget paradigm: after the flow has put the message to the message queue it sends the SOAP Reply to the client indicating success. This is suitable in situations where the client is not interested in the eventual success or failure of the message in the consumer system and is suitable for the purposes of demonstrating this high availability scenario.

Note: Based on your requirements you might want to alter the flow to invoke the target application before replying to the client. This can be done synchronously within the same message flow, or asynchronously by using a request flow that receives the SOAP/HTTP request and writes the message to a queue. A second flow reads the response and writes the SOAP Reply.

In the latter case, the MQ Correlation ID must be saved in the request. These scenarios are described more thoroughly in the developerWorks® article *SOAP nodes in IBM WebSphere Message Broker V6.1, Part 1: SOAP node basics*, available at the following Web page:

`http://www.ibm.com/developerworks/webservices/library/ws-soapnode/`

The MQOutput node is configured for transactional behavior. If there is an exception (For example, trying to write to the queue), the flow rolls back to the SOAP Input Node. Failures and exceptions result in a fault response being returned in the SOAP Reply.

7.3 WebSphere Message Broker configuration

This section describes how to configure WebSphere Message Broker to provide redundancy for brokers and execution groups.

Two IBM WebSphere Message Broker servers are set up with an almost identical configuration. The following procedure describes the process for one of these servers. You need to repeat the process on the other server.

To configure the topology for the message flow application, perform the following steps:

1. Create the brokers and queue managers on each of the two WebSphere Message Broker servers.
2. Create two execution groups on each broker for a total of four execution groups per server and eight overall.
3. Create the queues required for the message flow application on each qmgr.
4. Deploy the message flow to all eight execution groups.

7.3.1 Creating the brokers and queue managers

Create the two brokers and two queue managers on the first system as shown in Table 7-2.

Table 7-2 Queue managers and brokers on SAW001-SYS3

Broker Name	Broker Queue Manager Name	System
SAW001BKR1	SAW001QMGR1	SAW001-SYS3
SAW001BKR2	SAW001QMGR2	SAW001-SYS3

1. Log in to the server as the Administrator or a user in the mqm group.
2. Start the IBM WebSphere Message Broker command console. Navigate to **Start** → **All Programs** → **WebSphere Message Broker 7.0** → **Command Console**.
3. Create a broker called `SAW001BKR1` on a queue manager called `SAW001QMGR1` by entering the following command:

   ```
   mqsicreatebroker SAW001BKR1 -i username -a pwd -q SAW001QMGR1
   ```

   In this command, *username* and *pwd* are the username and password for the mqm user.
4. Repeat this process to create broker `SAW001BKR2` and queue manager `SAW001QMGR2`.

7.3.2 Creating the execution groups

Create the execution groups as shown in Table 7-3.

Table 7-3 Execution groups

Broker Name	Execution Group Name
SAW001BKR1	EXECUTION_GROUP_1
	EXECUTION_GROUP_2
SAW001BKR2	EXECUTION_GROUP_1
	EXECUTION_GROUP_2

1. Start IBM WebSphere Message Broker Explorer. Navigate to **Start** → **All Programs** → **IBM WebSphere Message Broker 7.0** → **IBM WebSphere Message Broker Explorer**.

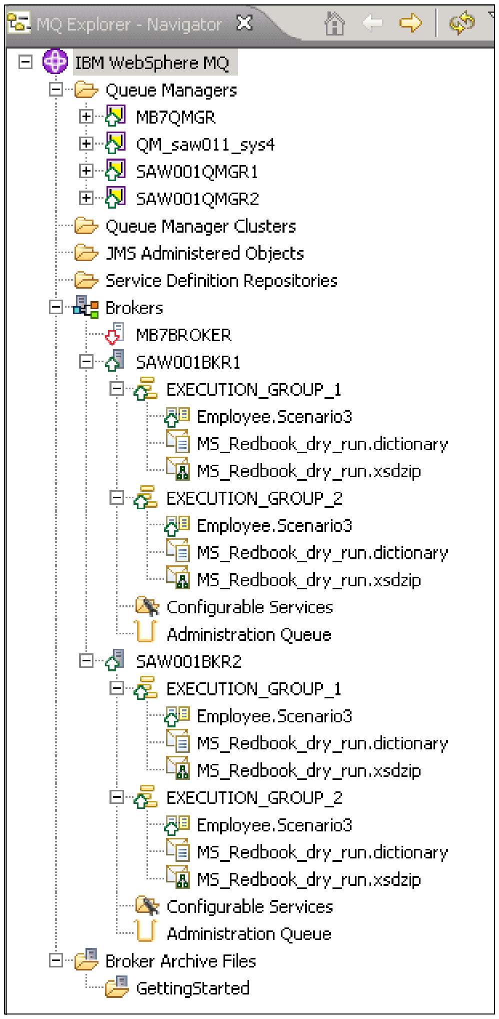
2. In the MQ Explorer window under Brokers right-click broker `SAW001BKR1` and select **New Execution Group**.
3. Enter `EXECUTION_GROUP_ 1` as the name for the execution group and click **OK**.
4. Repeat this process to create the remaining three execution groups.

7.3.3 Deploying the bar file on the server

Deploy the bar file containing the message flow to each of the execution groups.

1. Copy the bar file to a temporary location on the server.
2. In the WebSphere Message Broker Explorer right-click the execution group by selecting **Brokers** → **SAW001BKR1** → **EXECUTION_GROUP_1** and choose **Deploy**.
3. Click **Browse for additional Broker Archives**.
4. Browse to the bar file you saved to the temporary location, select the bar file and click **Open**.
5. Select the bar file in the Deploy Wizard and click **Finish**.
6. Repeat this process for the remaining three execution groups.

When completed, your IBM WebSphere Message Broker Explorer window look like to Figure 7-10 on page 161.


MQ Explorer - Navigator

```
IBM WebSphere MQ
  Queue Managers
    MB7QMGR
    QM_saw011_sys4
    SAW001QMGR1
    SAW001QMGR2
  Queue Manager Clusters
  JMS Administered Objects
  Service Definition Repositories
  Brokers
    MB7BROKER
    SAW001BKR1
      EXECUTION_GROUP_1
        Employee.Scenario3
        MS_Redbook_dry_run.dictionary
        MS_Redbook_dry_run.xsdzip
      EXECUTION_GROUP_2
        Employee.Scenario3
        MS_Redbook_dry_run.dictionary
        MS_Redbook_dry_run.xsdzip
      Configurable Services
      Administration Queue
    SAW001BKR2
      EXECUTION_GROUP_1
        Employee.Scenario3
        MS_Redbook_dry_run.dictionary
        MS_Redbook_dry_run.xsdzip
      EXECUTION_GROUP_2
        Employee.Scenario3
        MS_Redbook_dry_run.dictionary
        MS_Redbook_dry_run.xsdzip
      Configurable Services
      Administration Queue
  Broker Archive Files
    GettingStarted
```

Figure 7-10 Completed WebSphere Message Broker Configuration for server 1

Repeat this process for the second server.

7.3.4 Build the second WebSphere Message Broker server

Build a second WebSphere Message Broker server with the characteristics shown in shown in Table 7-4.

Table 7-4 Queue managers and brokers on SAW001-SYS4

Broker Name	Broker Queue Manager Name	System
SAW001BKR3 ▸ EXECUTION_GROUP_1 ▸ EXECUTION_GROUP_2	SAW001QMGR3	SAW001-SYS4
SAW001BKR4 ▸ EXECUTION_GROUP_1 ▸ EXECUTION_GROUP_2	SAW001QMGR4	SAW001-SYS4

7.3.5 Determining the URLs for the deployed Web services

SOAPInput nodes listen on port 7800 (HTTP) or 7843 (HTTPS) by default. The URL for the first execution group is http://saw001-sys3:7800/Scenario3. Port numbers are incremented for each SOAPInput node deployed. In our case we end up with the URLs listed in Table 7-5. We need these URLs to update the DataPower load balancer configuration (see 7.5, "DataPower configuration" on page 163).

Table 7-5 Web service URLs

Server	Web Service URL
Server 1	http://saw001-sys3:7800/Scenario3
Server 1	http://saw001-sys3:7801/Scenario3
Server 1	http://saw001-sys3:7802/Scenario3
Server 1	http://saw001-sys3:7803/Scenario3
Server 2	http://saw001-sys4:7800/Scenario3
Server 2	http://saw001-sys4:7801/Scenario3
Server 2	http://saw001-sys4:7802/Scenario3
Server 2	http://saw001-sys4:7803/Scenario3

Note: For production systems you might want to set the port numbers for each execution group using the **`mqsichangeproperties`** command. For example:

```
mqsichangeproperties broker_name -e execution_group -o HTTPConnector
-n explicitlySetPortNumber -v port_number (for HTTP)
```

For full details of the **`mqsichangeproperties`** command, see the WebSphere Message Broker Information Center at the following Web page:

`http://publib.boulder.ibm.com/infocenter/wmbhelp/v7r0m0/index.jsp`

7.4 WebSphere MQ configuration

The configuration of WebSphere Message Broker as described in 7.3, “WebSphere Message Broker configuration” on page 158 results in the creation of WebSphere MQ queue managers. This section deals with the additional application-specific MQ configurations required for this scenario.

For this scenario we require that the WebSphere MQ queue SAW001_EXPORT_EMPLOYEE be created on each of the four brokers as specified in Table 7-6. This is the output queue for the message flow.

Table 7-6 Application MQ configuration

Server	Queue Manager	Queue Name
SAW001-SYS3	SAW001QMGR1	SAW001_EXPORT_EMPLOYEE
SAW001-SYS3	SAW001QMGR2	SAW001_EXPORT_EMPLOYEE
SAW001-SYS4	SAW001QMGR3	SAW001_EXPORT_EMPLOYEE
SAW001-SYS4	SAW001QMGR4	SAW001_EXPORT_EMPLOYEE

7.5 DataPower configuration

The DataPower XI50 appliance is configured as a Web Services Gateway responsible for proxy, validation, basic XML threat protection, and load balancing of application requests to WebSphere Message Broker endpoints. Protocols used for front-end interaction between the application and DataPower is SOAP/HTTP. The same applies to connectivity and integration between DataPower and Message Broker endpoints.

The device is configured with an application domain called SA-W001-Redbook to configure, test, and demonstrate the functionality. A developer account is configured with Role Based Access Control with read/write permission on this domain and read-only view of the default domain. To log on the device for configuration, the user points the Web browser to the secure Web management interface and provides valid credentials, selects a relevant domain name from the list and clicks **Login**. The control panel home page shown in Figure 7-11 is displayed with all the key DataPower services on the top, followed by Monitoring and Troubleshooting options, and then icons for Administrative activities. On the left, there are drop-down menus for checking the status of various objects and hardware components plus further object configuration options.

1. Start by creating a Load Balancer Group configuration, as this is used in the Web Service Proxy Gateway configuration as a back-end endpoint. To do this, expand the Network menu option on the left and click **Load Balancer Group**, as shown in Figure 7-11.

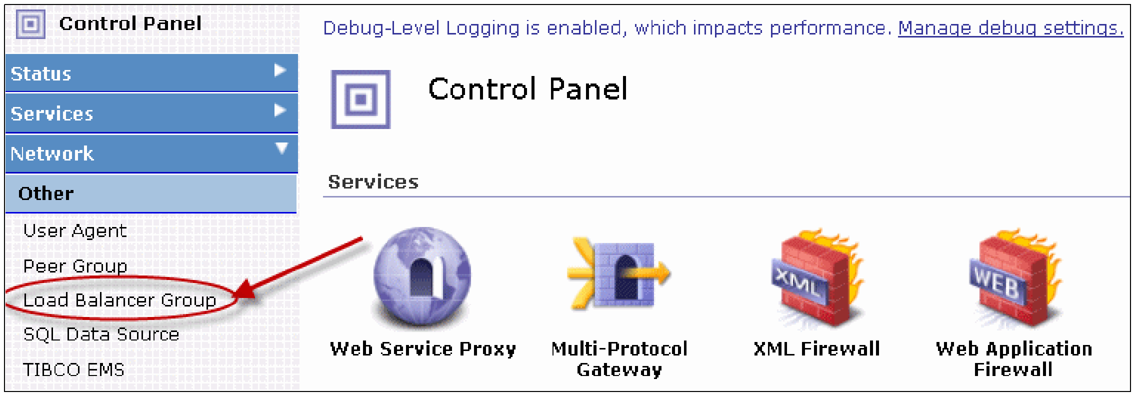
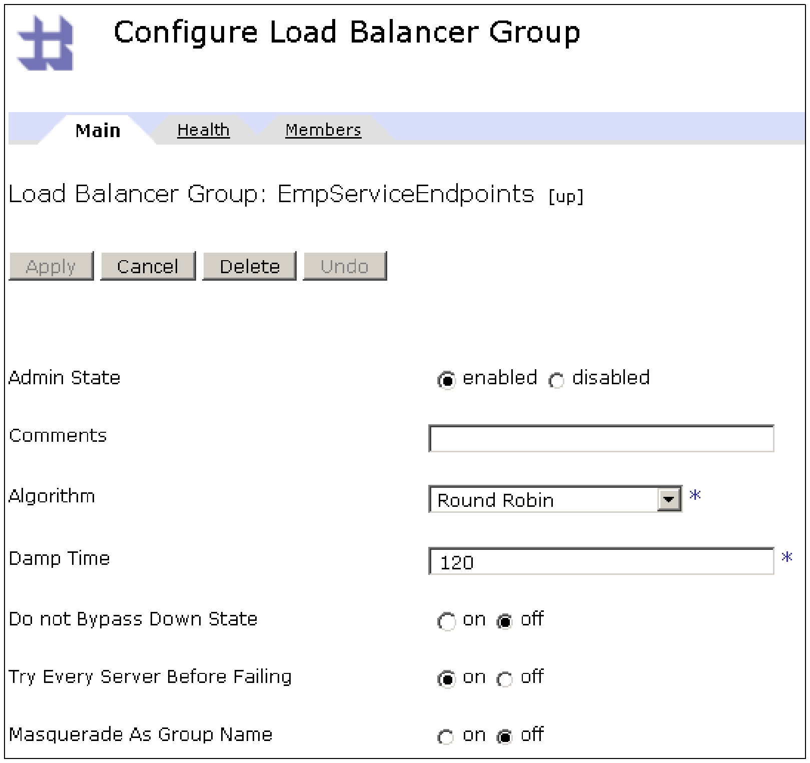

Debug-Level Logging is enabled, which impacts performance. Manage debug settings.

Figure 7-11 DataPower Control Panel home page

2. On the Load Balancer Group configuration page, click **Add** to add a new object.

3. Figure 7-12 shows the configuration options available. Specify the object name, algorithm for load balancing, damp time, and so forth. Damp time specifies the time in seconds for which a member server can be disabled or black-listed if a health check fails.

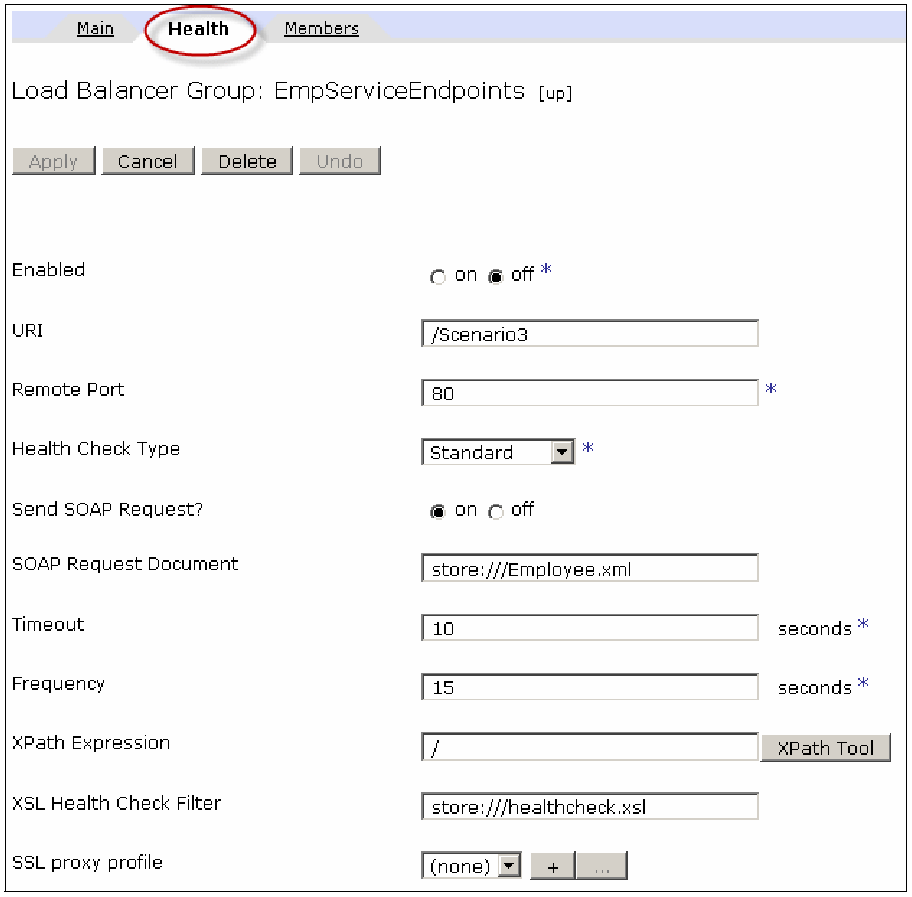


Load Balancer Group: EmpServiceEndpoints [up]

Admin State	[✓ enabled] disabled
Comments	
Algorithm	Round Robin *
Damp Time	120 *
Do not Bypass Down State	on [✓ off]
Try Every Server Before Failing	[✓ on] off
Masquerade As Group Name	on [✓ off]

Figure 7-12 Load Balancer Group object configuration

4. Click the Health tab to configure the configurable health check options, as shown in Figure 7-13.



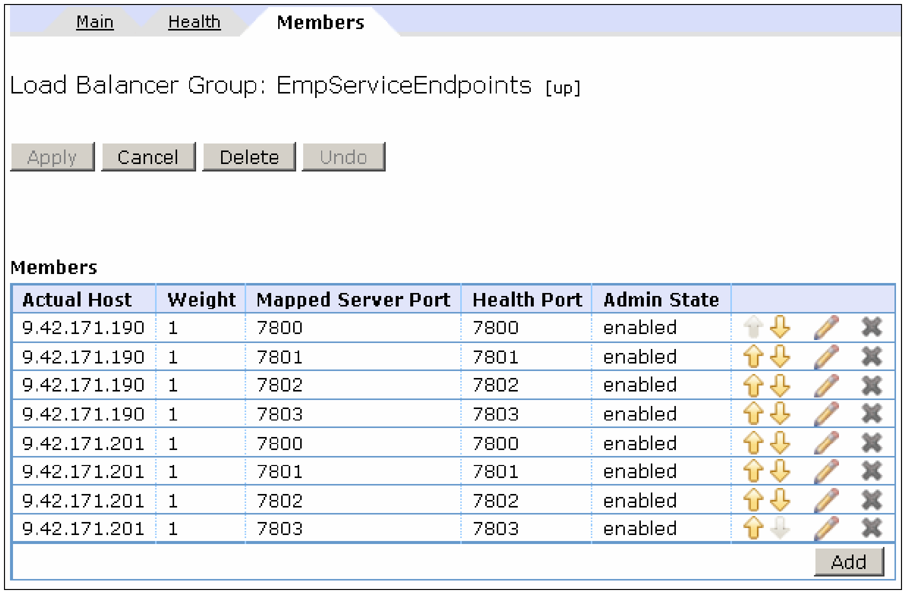
Load Balancer Group: EmpServiceEndpoints [up]

Enabled	on [✓ off] *
URI	/Scenario3
Remote Port	80 *
Health Check Type	Standard *
Send SOAP Request?	[✓ on] off
SOAP Request Document	store:///Employee.xml
Timeout	10 seconds *
Frequency	15 seconds *
XPath Expression	/
XSL Health Check Filter	store:///healthcheck.xsl
SSL proxy profile	(none)

Figure 7-13 Load Balancer Group: Health check configuration

These configuration settings allow users to specify the SOAP request, frequency, and timeout settings while checking for the health of the configured members. The response received for this call can be parsed and analyzed by providing a custom XSL stylesheet.

5. The members tab allows users to add the real back-end endpoints for the services (see Table 7-5 on page 162). In Figure 7-14, you can see we had a total of eight instances of the application running on two seperate hosts. The order of the members can be changed by clicking the **Up** or **Down** arrow icons.



Load Balancer Group: EmpServiceEndpoints [up]

Members

Actual Host	Weight	Mapped Server Port	Health Port	Admin State
9.42.171.190	1	7800	7800	enabled
9.42.171.190	1	7801	7801	enabled
9.42.171.190	1	7802	7802	enabled
9.42.171.190	1	7803	7803	enabled
9.42.171.201	1	7800	7800	enabled
9.42.171.201	1	7801	7801	enabled
9.42.171.201	1	7802	7802	enabled
9.42.171.201	1	7803	7803	enabled

Figure 7-14 Load Balancer Group: Members configuration

Once the members are configured, click **Apply**.

6. Click **View Log** to view any health check errors in the object. Check the status of the object by clicking **View Status**. Both are accessed from the Control Panel.

7. Click **Control Panel** on the top left corner to return to the landing page. Click **Web Service Proxy** to begin configuring the proxy service (Figure 7-15).

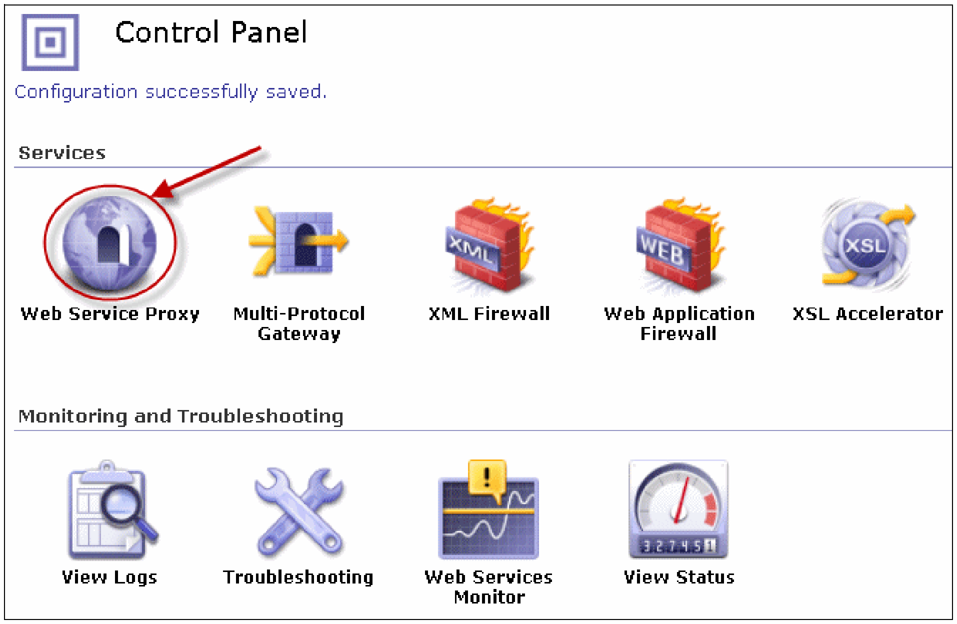
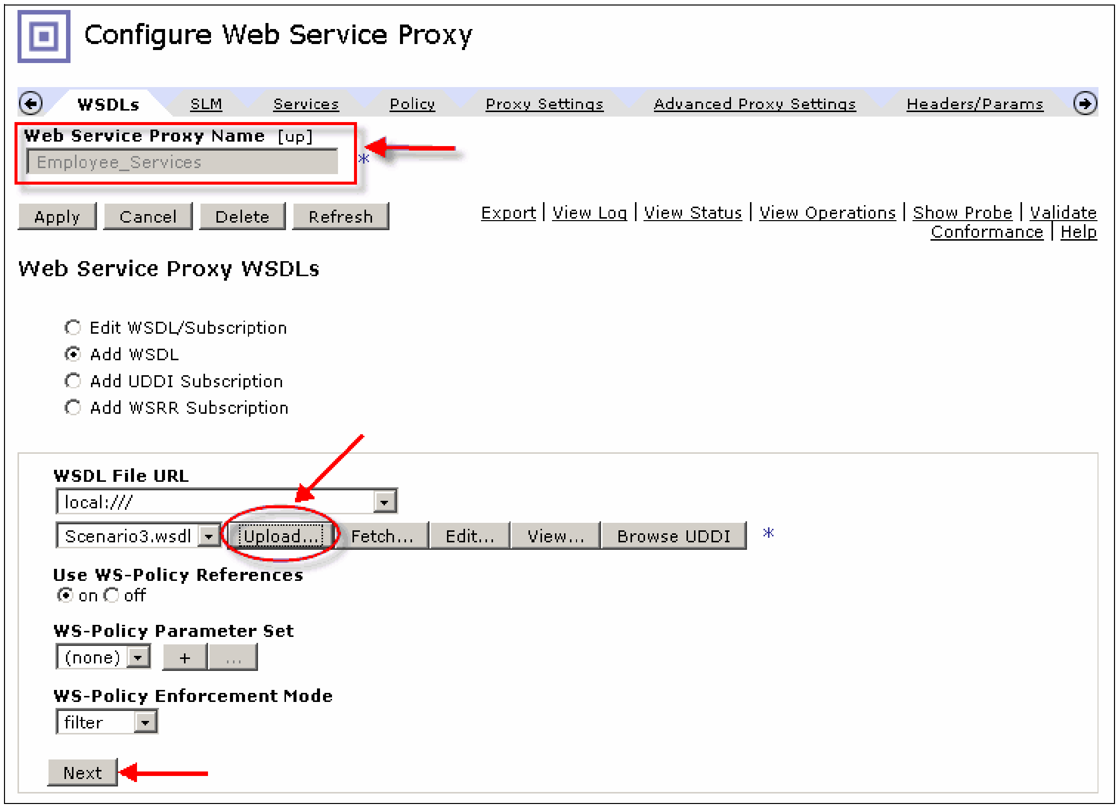


Figure 7-15 DataPower Control Panel home page

8. On the Web Service Proxy landing page, click **Add** to begin configuring a new service. This opens the configuration page shown in Figure 7-16.


Configure Web Service Proxy

Web Service Proxy Name [up]
Employee_Services *

Apply
Cancel
Delete
Refresh
Export | View Log | View Status | View Operations | Show Probe | Validate Conformance | Help

Web Service Proxy WSDLs

Edit WSDL/Subscription
[✓ Add WSDL]
Add UDDI Subscription
Add WSRR Subscription

WSDL File URL
local:///
Scenario3.wsdl

Use WS-Policy References
[✓ on] off

WS-Policy Parameter Set
(none)

WS-Policy Enforcement Mode
filter

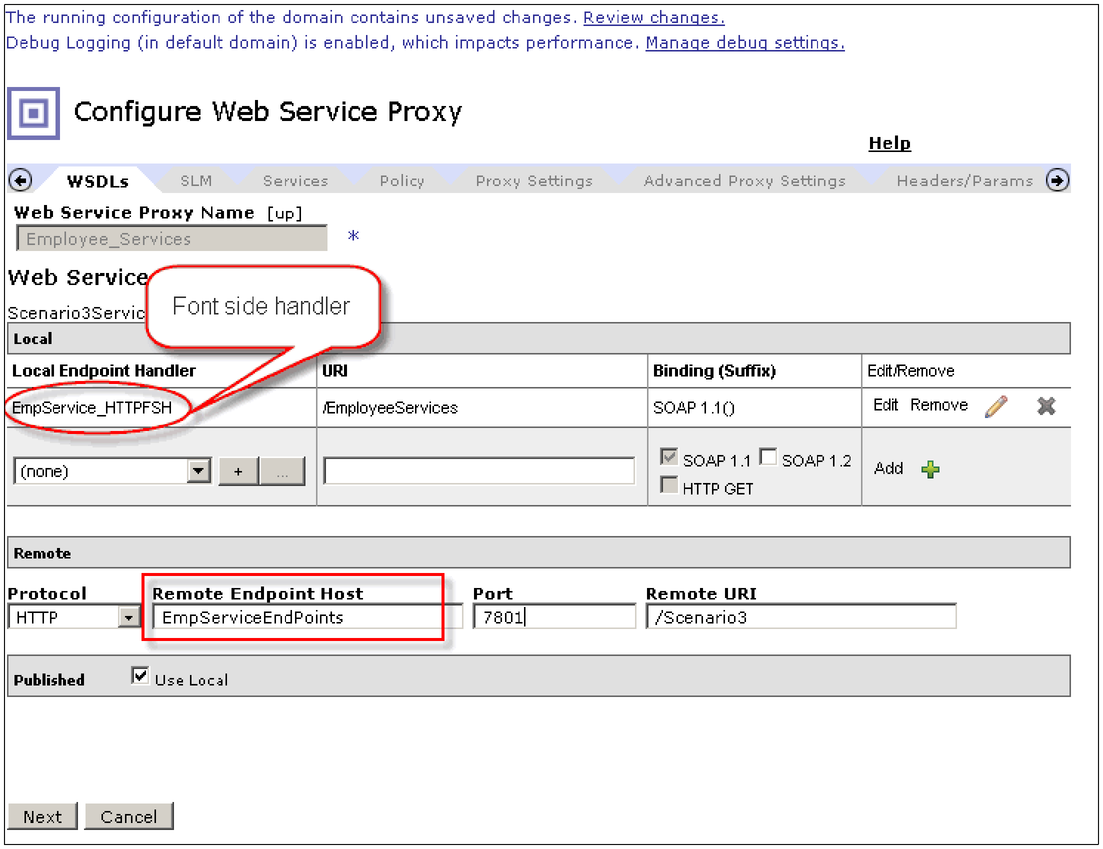
Figure 7-16 Web Service Proxy service configuration

Provide a name for the Web Service Proxy and provide a Web Service Definition Language (WSDL) document location. This can be referenced from a service repository such as WebSphere Registry and Repository (WSRR) or any UDDI compliant registry. The WSDL document can also be uploaded on the device itself.

Click **Next**.

9. Configure a front side handler, protocol bindings, and back-end endpoint host information about the panel shown in Figure 7-17.

   To use the Load Balancer Group created earlier, the user must specify the name of the Load Balancer Group object in the Remote Endpoint Host field. Port and Remote URI fields are appended to the host name and port number configured in the Load Balancer Group - Members object configuration at run-time.



The running configuration of the domain contains unsaved changes. Review changes.
Debug Logging (in default domain) is enabled, which impacts performance. Manage debug settings.

Configure Web Service Proxy

Web Service Proxy Name [up]
Employee_Services *

Web Service
Scenario3Servic

Local

Local Endpoint Handler	URI	Binding (Suffix)	Edit/Remove
EmpService_HTTPFSH	/EmployeeServices	SOAP 1.1()	Edit Remove
(none)		✓ SOAP 1.1 ☐ SOAP 1.2 ☐ HTTP GET	Add

Remote

Protocol	Remote Endpoint Host	Port	Remote URI
HTTP	EmpServiceEndPoints	7801	/Scenario3

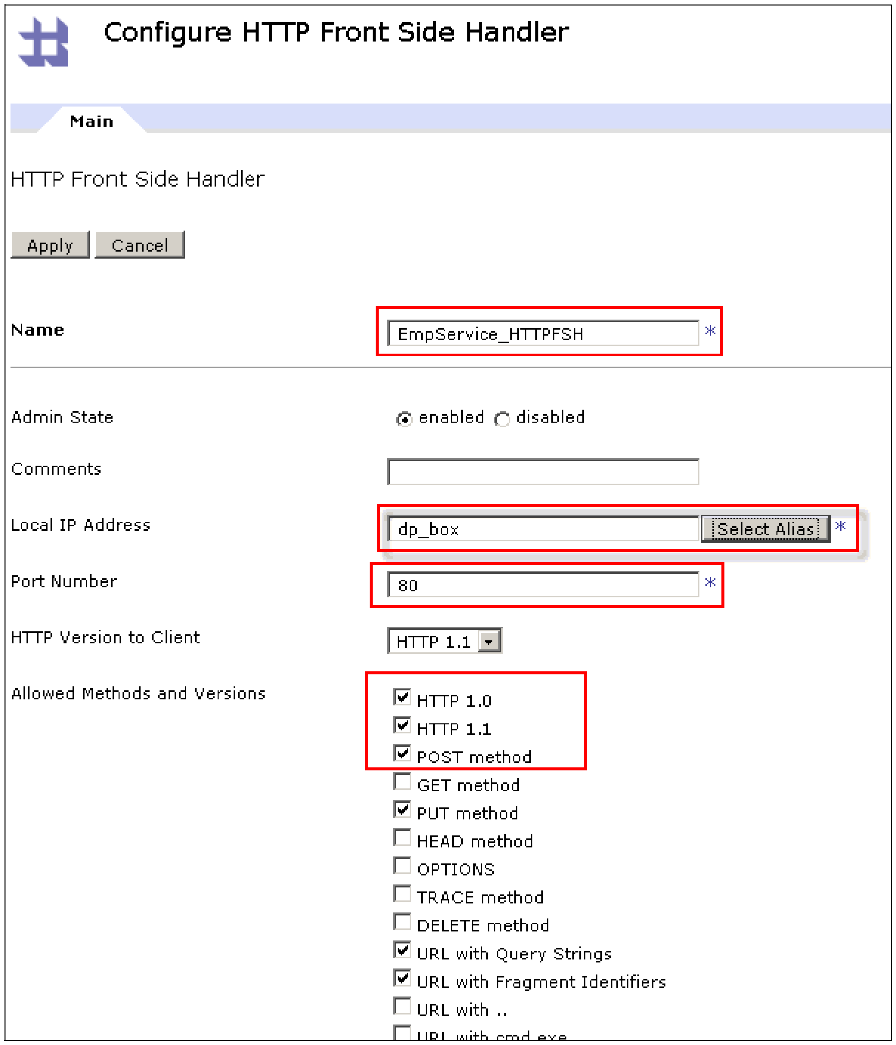
Published ✓ Use Local

Figure 7-17 Web Services Proxy configuration

Click **Next**.

10. Figure 7-18 shows the Front Side handler object configuration where you provide a name for the object, the local IP address to where the service must listen, the port number, and allowed methods.

    Putting a value of 0.0.0.0 in the IP address field configures the service on all available IP addresses. However, it is suggested to specify a host alias for the IP addresses defined on the device. This limits the interfaces where the service is hosted. Thus, the number of IP + Ports to be opened in the firewall is a bare minimum.



Configure HTTP Front Side Handler

Main

HTTP Front Side Handler

Apply Cancel

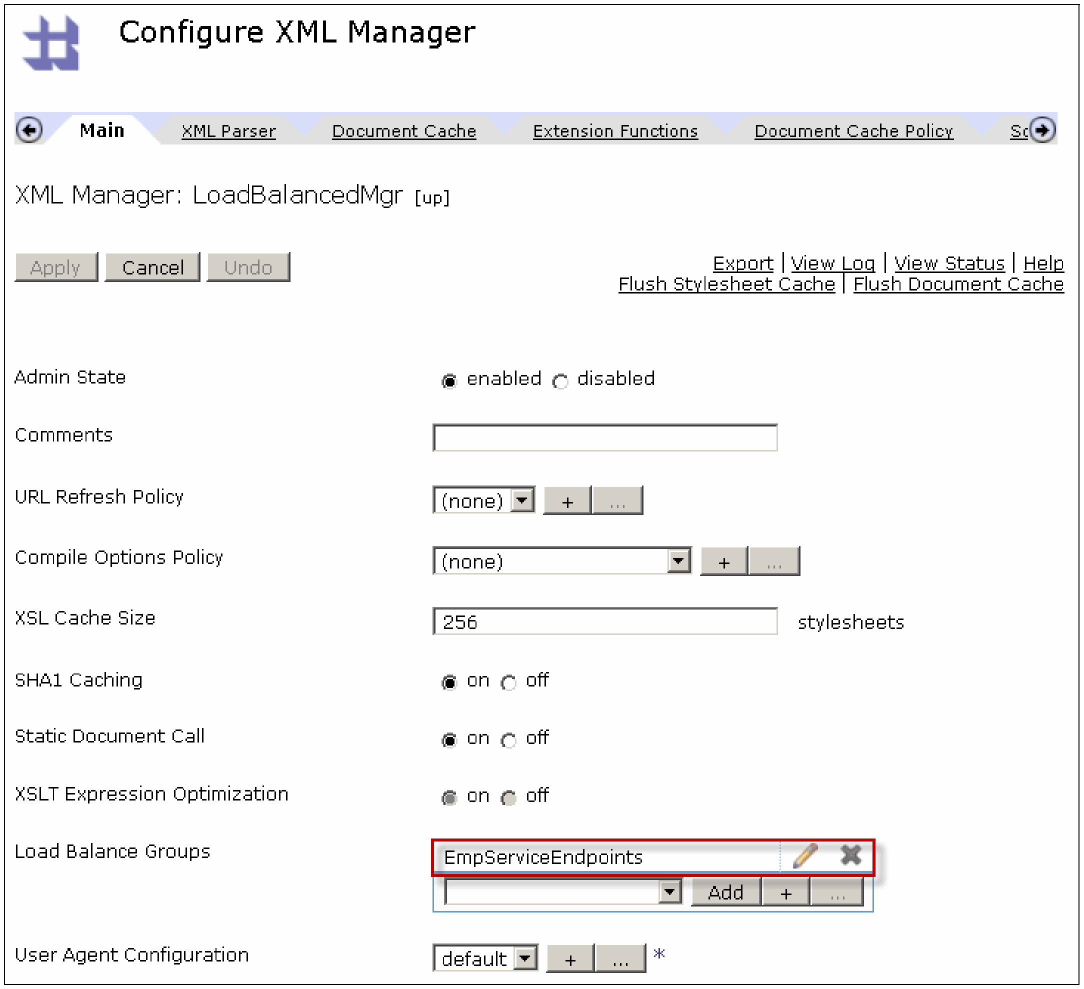
Name	EmpService_HTTPFSH *
Admin State	[✓ enabled] disabled
Comments	
Local IP Address	dp_box Select Alias *
Port Number	80 *
HTTP Version to Client	HTTP 1.1
Allowed Methods and Versions	✓ HTTP 1.0 ✓ HTTP 1.1 ✓ POST method ☐ GET method ✓ PUT method ☐ HEAD method ☐ OPTIONS ☐ TRACE method ☐ DELETE method ✓ URL with Query Strings ✓ URL with Fragment Identifiers ☐ URL with .. ☐ URL with cmd.exe

Figure 7-18 Web Service Proxy: Front side handler configuration

11.Once the front side handler is configured and selected in the Web Service Proxy page, click **Next**. This confirms the entries and selections made on this page and displays the Web Services Proxy Object configuration page.

12.Click the Proxy Settings tab and add a new XML manager by clicking the **+** button. The appliance contains a Default XML manager. Do not change this object.

Figure 7-19 shows the configuration options for an XML manager object.



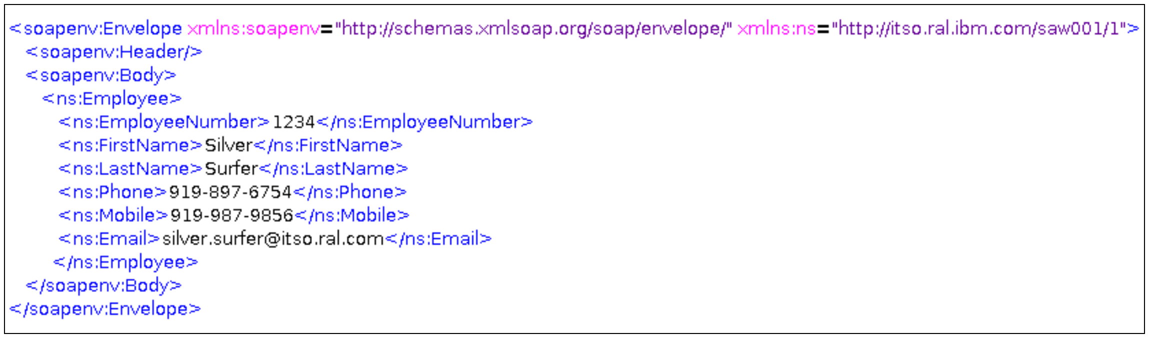
XML Manager: LoadBalancedMgr [up]

Admin State	[✓ enabled] disabled
Comments	
URL Refresh Policy	(none)
Compile Options Policy	(none)
XSL Cache Size	256 stylesheets
SHA1 Caching	[✓ on] off
Static Document Call	[✓ on] off
XSLT Expression Optimization	[✓ on] off
Load Balance Groups	EmpServiceEndpoints
User Agent Configuration	default *

Figure 7-19 Web Service Proxy - XML Manager

From the drop-down list in the Load Balance Groups field, select the name and click **Add**. The selected name appears above the drop-down list.

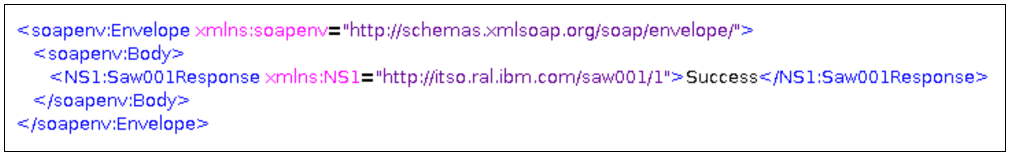
13. Click **Apply**. This creates and associates the XML manager with a Web Service Proxy object and brings the user to the Web Service Proxy page.
14. Click **Apply**.
15. Click the **Save config** link on the top right hand corner to persist all configuration changes.
16. Using any Web services-capable client, sent a Web service request for an operation to the front side handler address. See Figure 7-20.



```
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/" xmlns:ns="http://itso.ral.ibm.com/saw001/1">
  <soapenv:Header/>
  <soapenv:Body>
    <ns:Employee>
      <ns:EmployeeNumber>1234</ns:EmployeeNumber>
      <ns:FirstName>Silver</ns:FirstName>
      <ns:LastName>Surfer</ns:LastName>
      <ns:Phone>919-897-6754</ns:Phone>
      <ns:Mobile>919-987-9856</ns:Mobile>
      <ns:Email>silver.surfer@itso.ral.com</ns:Email>
     </ns:Employee>
  </soapenv:Body>
</soapenv:Envelope>
```

Figure 7-20 Request message

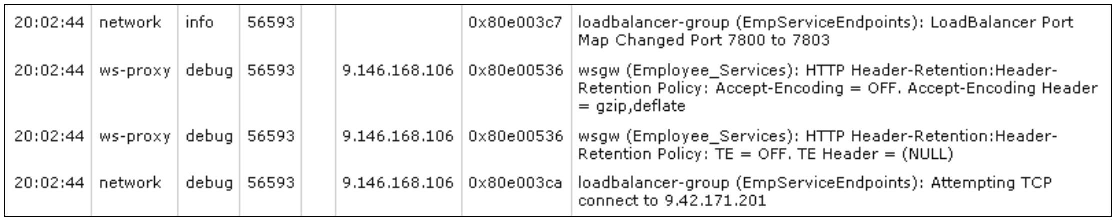
17. DataPower receives the message and applies basic XML checks and validation. It sends the request to an available member in the load balance group using the round robin algorithm. The response shown in Figure 7-21 is received.



```
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">
  <soapenv:Body>
    <NS1:Saw001Response xmlns:NS1="http://itso.ral.ibm.com/saw001/1">Success</NS1:Saw001Response>
  </soapenv:Body>
</soapenv:Envelope>
```

Figure 7-21 Response message

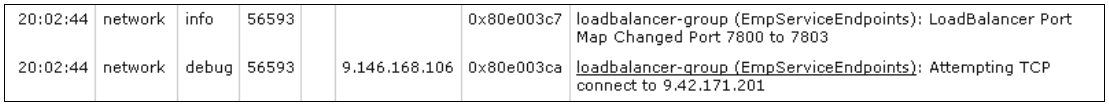
In debug mode, the device captures the events listed in Figure 7-22 in the system for every transaction.



20:02:44	network	info	56593			0x80e003c7	loadbalancer-group (EmpServiceEndpoints): LoadBalancer Port Map Changed Port 7800 to 7803
20:02:44	ws-proxy	debug	56593		9.146.168.106	0x80e00536	wsgw (Employee_Services): HTTP Header-Retention:Header-Retention Policy: Accept-Encoding = OFF. Accept-Encoding Header = gzip,deflate
20:02:44	ws-proxy	debug	56593		9.146.168.106	0x80e00536	wsgw (Employee_Services): HTTP Header-Retention:Header-Retention Policy: TE = OFF. TE Header = (NULL)
20:02:44	network	debug	56593		9.146.168.106	0x80e003ca	loadbalancer-group (EmpServiceEndpoints): Attempting TCP connect to 9.42.171.201

Figure 7-22 DataPower system log

The Load balancer group log contains the matching entry in Figure 7-23 for the same transaction number.



```
20:02:44  network  info   56593                   0x80e003c7  loadbalancer-group (EmpServiceEndpoints): LoadBalancer Port
                                                              Map Changed Port 7800 to 7803
20:02:44  network  debug  56593   9.146.168.106   0x80e003ca  loadbalancer-group (EmpServiceEndpoints): Attempting TCP
                                                              connect to 9.42.171.201
```

Figure 7-23 DataPower audit log

7.6 Operational considerations

When considering the topology used in this scenario, keep in mind the operational considerations outlined in this section.

7.6.1 Capacity planning

When planning for redundancy it is essential to perform capacity planning to ensure that, in the event of an outage, the remaining infrastructure can cope with the full load during peak times. Otherwise, there can be performance degradation or an inability to process all client requests.

7.6.2 Message dependencies

High availability through redundancy is only possible to the extent that the application message set can be processed in parallel in separate threads. If there are message dependencies that make parallel processing difficult to use, then the application needs to handle the sequencing of messages. This can be done by including (for example) a message SequenceId field and a SentTimestamp field in the XML schema. It is the responsibility of the receiving application to buffer the incoming messages and process them in the correct sequence.

7.7 Testing the topology

This section discusses the test approach and the results for this topology.

7.7.1 Testing approach

The testing approach used simulated the failure of each of the components under test while applying a load to the system using a test tool. The result that we expect for each of the tests is that during the component outage, all new messages continue to be processed. It is possible that the component outage causes the in-flight request to be lost, but all new messages are processed.

The components under test are as follows:

- Single execution group
- Individual broker
- WebSphere Message Broker server
- DataPower appliance

WebSphere Message Broker Explorer was used to start and stop brokers and execution groups and to view the queue depths.

Note: We are not performing performance testing to show that there is no impact to the message through-put rate. This is a consideration for production systems and it is essential to ensure that the redundant components can function at peak load without significant impact on performance.

7.7.2 Test cases and results

This section shows each test case and the results.

Test case 1: Outage of individual execution groups

Table 7-7 describes the test case for the loss of an execution group.

Table 7-7 Test case 1

Component	**WebSphere Message Broker Execution Group**
Test Case	Outage of individual execution groups
Description	In this test case we verify that an outage of one or more individual execution groups has no impact on availability. We expect that DataPower detects that the execution groups are down or not responding and blacklists the endpoints corresponding to these execution groups during the outage period. Route all new messages to the available execution groups during the outage.

Table 7-8 describes the steps executed in the test case and the results.

Table 7-8 Test case 1 steps and results

Step	Description	Pass/ Fail
1	Ensure that all four output queues are cleared and that all of the execution groups are running. Apply a load of 400 messages. After processing approximately 200 messages, shutdown execution group EXECUTION_GROUP_1 on broker SAW001BKR1 on server saw001-sys3.	Pass
2	Record the message counts for all four queues. We expect to see that all 400 messages are processed, however fewer messages are written to the queue corresponding to broker SAW001BKR1 on server saw001-sys3. The other three queues have an approximately equal number of messages. Results: SAW001-SYS3 → SAW001QMGR1 - 82 messages SAW001-SYS3 → SAW001QMGR2 - 106 messages SAW001-SYS4 → SAW001QMGR3 - 106 messages SAW001-SYS4 → SAW001QMGR4 - 106 messages Total messages processed: 400	Pass
3	Apply a load of 400 messages. After processing approximately 200 messages, shutdown execution group EXECUTION_GROUP_2 on broker SAW001BKR1 on server saw001-sys3. After shutting down this execution group, verify that the messages are no longer being written to the queue corresponding to broker SAW001BKR1 on server saw001-sys3. Record the message counts for all four queues. The first queue has the fewest messages and the other three queues have an approximately equal number of messages. Results: SAW001-SYS3 → SAW001QMGR1 - 116 messages SAW001-SYS3 → SAW001QMGR2 - 228 messages SAW001-SYS4 → SAW001QMGR3 - 228 messages SAW001-SYS4 → SAW001QMGR4 - 227 messages Total messages processed: 799 Note: One in-flight transaction was rolled back on SAW001-SYS3 → SAW001QMGR1 when we shut down the execution group. We observed the queue depth roll back from 117 to 116. This transaction was not processed but all new messages continued to be processed by the remaining six execution groups.	Pass

Step	Description	Pass/ Fail
4	Apply a load of 400 messages. After processing approximately 200 messages, shutdown execution group EXECUTION_GROUP_1 on broker SAW001BKR4 on server saw001-sys4. Record the message counts for all four queues. We expect to see that all 1200 messages are processed. The queue depth of the first queue remains unchanged. The second and third queues have an approximately equal number of messages. The fourth queue has fewer messages than the second and third queues. Results: SAW001-SYS3 → SAW001QMGR1 - 116 messages SAW001-SYS3 → SAW001QMGR2 - 372 messages SAW001-SYS4 → SAW001QMGR3 - 372 messages SAW001-SYS4 → SAW001QMGR4 - 339 messages Total messages processed: 1199	Pass
5	Apply a load of 400 messages. After processing approximately 300 messages, shutdown execution group EXECUTION_GROUP_2 on broker SAW001BKR4 on server saw001-sys4. Record the message counts for all four queues. We expect to see that all 1200 messages are processed. The queue depth of the first queue remains unchanged. The second queue has fewer messages than the third and fourth queues. The third and fourth queues have an approximately equal number of messages. Results: SAW001-SYS3 → SAW001QMGR1 - 116 messages SAW001-SYS3 → SAW001QMGR2 - 539 messages SAW001-SYS4 → SAW001QMGR3 - 536 messages SAW001-SYS4 → SAW001QMGR4 - 407 messages Total messages processed: 1598 Note: Another in-flight transaction was rolled back when we shut down the execution group. This transaction was not processed but all new messages continued to be processed by the remaining four execution groups.	Pass

Step	Description	Pass/ Fail
6	Apply a load of 1000 messages. After processing approximately 50 messages, restart all of the stopped brokers. Verify that the execution groups are back online and processing requests. (That is, messages are being written to the message queues corresponding to these execution groups.) Note: It depends upon the DataPower configuration as to how long it takes to detect that the execution groups are online. If the all of the messages have been processed and the queue depth of the queues associated with the previously stopped execution groups remains static you might need to use more than 600 messages for this step. Results: SAW001-SYS3 → SAW001QMGR1 - 166 messages SAW001-SYS3 → SAW001QMGR2 - 788 messages SAW001-SYS4 → SAW001QMGR3 - 785 messages SAW001-SYS4 → SAW001QMGR4 - 459 messages Total messages processed: 2198	Pass
Overall Test Status The test verified the high availability provided by redundant execution groups. Although two in-flight transactions were not processed, any subsequent transactions were routed to available execution groups. When the execution groups were restarted, DataPower detected that the execution groups were available again and began to route messages to these execution groups.		Pass

Test case 2: Outage of a broker

Table 7-9 describes the test case for the loss of a broker.

Table 7-9 Test case 2

Component	**WebSphere Message Broker broker**
Test Case	Outage of a WebSphere Message Broker brokers
Description	In our test scenario we have four WebSphere Message Broker brokers. In this test case we verify that an outage of two of these brokers has no impact on availability. We expect that DataPower detects that the broker is down or not responding and blacklists the endpoints corresponding to the brokers that are down during the outage period, and that all new messages are routed to the available endpoints during the outage.

Table 7-10 describes the steps executed in the test case and the results.

Table 7-10 Test case 2 steps and results

Step	**Description**	**Pass/ Fail**
1	Make sure that all four output queues are cleared and that all of the brokers/execution groups are running. Apply a load of 200 messages. After processing approximately 100 messages, cleanly shutdown broker SAW001BKR2 on server saw001-sys3. Verify that the messages are no longer being written to the queue corresponding to broker SAW001BKR2. Results: SAW001-SYS3 → SAW001QMGR1 - 57 messages SAW001-SYS3 → SAW001QMGR2 - 28 messages SAW001-SYS4 → SAW001QMGR3 - 57 messages SAW001-SYS4 → SAW001QMGR4 - 58 messages Total messages processed: 200	Pass

Step	Description	Pass/ Fail
2	Apply a load of 200 messages. After processing approximately 100 messages, perform an immediate shutdown of broker SAW001BKR3 on server saw001-sys4. Verify that the messages are no longer being written to the queue corresponding to broker SAW001BKR3. Results: SAW001-SYS3 → SAW001QMGR1 - 137 messages SAW001-SYS3 → SAW001QMGR2 - 28 messages SAW001-SYS4 → SAW001QMGR3 - 97 messages SAW001-SYS4 → SAW001QMGR4 - 138 messages Total messages processed: 400	Pass
3	Apply a load of 1000 messages. After processing approximately 100 messages, re-tart the stopped brokers. Verify that the brokers are back online and processing requests. (That is, messages are being written to the message queue corresponding to these brokers.) Note: It depends upon the DataPower configuration as to how long it takes to detect the execution groups are back online. If the all of the messages have been processed and the queue depth of the queues associated with the previously stopped execution groups remains static you might need to use more than 600 messages for this step. Results: SAW001-SYS3 → SAW001QMGR1 - 486 messages SAW001-SYS3 → SAW001QMGR2 - 180 messages SAW001-SYS4 → SAW001QMGR3 - 248 messages SAW001-SYS4 → SAW001QMGR4 - 486 messages Total messages processed: 1400	Pass
Overall Test Status The test verified the high availability provided by redundant brokers. As the two brokers were shutdown DataPower routed all new messages to the remaining online brokers. When the brokers were restarted, DataPower detected that the brokers were available again and began to route messages to these execution groups. There was a delay in which approximately 500 messages were processed before DataPower detected that the brokers had been restarted and automatically began to route messages to these brokers again. No in-flight messages were lost during the test and all 1400 messages were processed.		Pass

Test case 3: Outage of a broker server

Table 7-11 describes the test case for the loss of a broker server.

Table 7-11 Test case 3

Component	Server
Test Case	Outage of a WebSphere Message Broker application server
Description	In our test scenario we have two WebSphere Message Broker application servers, saw001-sys3 and saw001-sys4. In this test case we verify that an outage one of these servers has no impact on availability. We expect that DataPower detects that the server is down or not responding and blacklists the endpoints corresponding to that server during the outage period and that all new messages are routed to the available endpoints during the outage.

Table 7-12 describes the steps executed in the test case and the results.

Table 7-12 Test case 3 steps and results

Step	Description	Pass/ Fail
1	Make sure that all four output queues are cleared and that all of the brokers and execution groups are running. Apply a load to the application for a period of 300 seconds. After processing for approximately 60 seconds, unplug saw001-sys3 from the network.	Pass
2	120 seconds into the processing, plug server saw001-sys3 back into the network. Verify that the brokers are now back online and processing requests. (That is, messages are being written to the message queue corresponding to these brokers.)	Pass
7	Once the test is complete verify that all messages have been processed. Results: Messages sent in the 300 second period: 799 SAW001-SYS3 → SAW001QMGR1 - 132 messages SAW001-SYS3 → SAW001QMGR2 - 103 messages SAW001-SYS4 → SAW001QMGR3 - 280 messages SAW001-SYS4 → SAW001QMGR4 - 280 messages Total messages processed: 795 Failed Messages: 4 (this equates to one in-flight message per execution group)	Pass

Step	Description	Pass/ Fail
Overall Test Status The test verified the high availability provided by redundant servers. When one server was taken offline DataPower routed all new messages to the remaining server. When the server was brought back online DataPower detected that the server was available again and began to route messages to the server. There was a delay before DataPower detected that the server was online again and began to route messages to it. Four in-flight messages (one per execution group) were lost during the test.		Pass

8

Duplexing WebSphere MQ structures

WebSphere MQ on z/OS provides a greater degree of availability for messages than any other platform through the implementation of queue sharing groups (QSGs). QSGs make use of the z/OS Coupling Facility (CF), which is a hardware and software tool unique to z/OS providing and managing shared resources to any z/OS system defined in the Parallel Sysplex. A Sysplex is a logical and physical group of z/OS images or LPARs that are connected to the CF using special links.

The availability advantages provided by shared queues has been well documented, in particular in IBM Redbooks publication *Parallel Sysplex Application Considerations*, SG24-6523 and IBM Redpaper™ *High Availability z/OS Solutions for WebSphere Business Integration Message Broker V5*, REDP-3894.

There have been a number of improvements to shared queues, including removing the message size limitation (63 K had been the limit) that prevented applications from taking advantage of the capability. As of WebSphere MQ V6, shared queues can hold message up to 100 Mb, like any other WebSphere MQ queue. In addition, there have been improvements made to the coupling facility code and the underlying hardware that have enhanced the use of shared queues.

It is not the intention of this Redbooks publication to re-invent the material from prior IBM Redbooks publications, but to extend the available information with additional examples.

This chapter presents a scenario that illustrates the use of queue sharing groups and duplexed structures in a z/OS environment to achieve high availability.

8.1 Scenario overview

The coupling facility supports three types of structures:

- Cache
- Lock
- List

MQ shared queues are implemented on list structures, and require a minimum of two structures, although most environments have more. The first list structure is the required administration structure. It has a fixed name xxxxCSQ_ADMIN, where the xxxx is the queue-sharing group name. This structure holds information about the QSG and its members. With WebSphere MQ V7.0.1, a second structure, that we think of as administrative, has been added to support group units of recovery. It is optional, and has a fixed name of xxxxCSQSYSAPPL.

The application structure or structures are where the queues are defined. In most environments there are at least two application list structures, and often there are more to support varying application needs. The application structures are much like the pagesets and buffer pools used for private queues, in that they supply the storage for the messages.

There are many reasons to define multiple application structures:

- Historical reasons
- Application requirements (for example only this application needs large message support)
- Application isolation requirements

This scenario demonstrates the message availability provided by system-managed duplexing WebSphere MQ structures. The coupling facility, especially when configured externally to the application LPARs and with a separate power supply, is extremely robust. If a failure occurs, the WebSphere MQ structures, and the persistent messages, are recovered from the WebSphere MQ logs.

Recovering an application structure from the logs is much like recovering persistent messages after a queue manager outage. The logs are read from the last point of consistency and persistent messages are restored to the queues from those logs. Unlike a single queue manager recovery operation, when an application structure is recovered, the logs from each queue manager in the QSG might need to be read to recover the persistent messages. The length of time it takes to recover a structure varies based on how long it has been since a point of consistency, usually from where the BACKUP CFSTRUCT command was issued and completed. The number of log files and records that have to be read is also a factor.

For applications with strict service level agreements, the potential of even a slight delay while a structure is recovered is not acceptable. For those applications, using system-managed duplexing provides a greater level of availability. System-managed duplexing essentially makes two copies of the structure and all updates to the structure so that if one fails, the other image continues to process. In addition, the CF code automatically rebuilds the structure that failed from the good copy as soon as the structure is capable.

All WebSphere MQ structures, including the administration structure, might be duplexed. There can be a mix of duplexed and non-duplexed structures in a QSG. It is often recommended that if the coupling facilities are internal (meaning they are defined on the same physical machines as the application queue managers and workload), the structures be duplexed. This is particularly important for the administration structure and any structures that have queues used by applications with stringent service level agreements and persistent messages.

When using duplexed structures, all changes (like putting a message to a queue) are made to both copies. In the event of a structure failure the working copy is used while the other is being rebuilt. As with any mirrored solution, this causes throughput degradation as there must be a response from both structures before control returns to WebSphere MQ and then to the application. There is a greater CPU, coupling facility storage and CF CPU cost for duplexed requests.

In this scenario, two WebSphere MQ application structures are used.

- PERSISTENT

  This is defined as a recoverable structure, meaning that it can hold both persistent and nonpersistent messages. This structure can experience an outage, but no persistent messages are lost.

- DUPLEXED

  This is both recoverable and duplexed. This structure should not experience an outage. An outage only happens if both coupling facilities were lost.

The scenario is artificial, as the testing is batch driven and the need for continuous message availability is usually driven by services and real time processing. This method of testing, while artificial, was chosen because it highlights the functional differences between the structure types.

The scenario uses an active-active topology, as shown in Figure 8-1 on page 187.

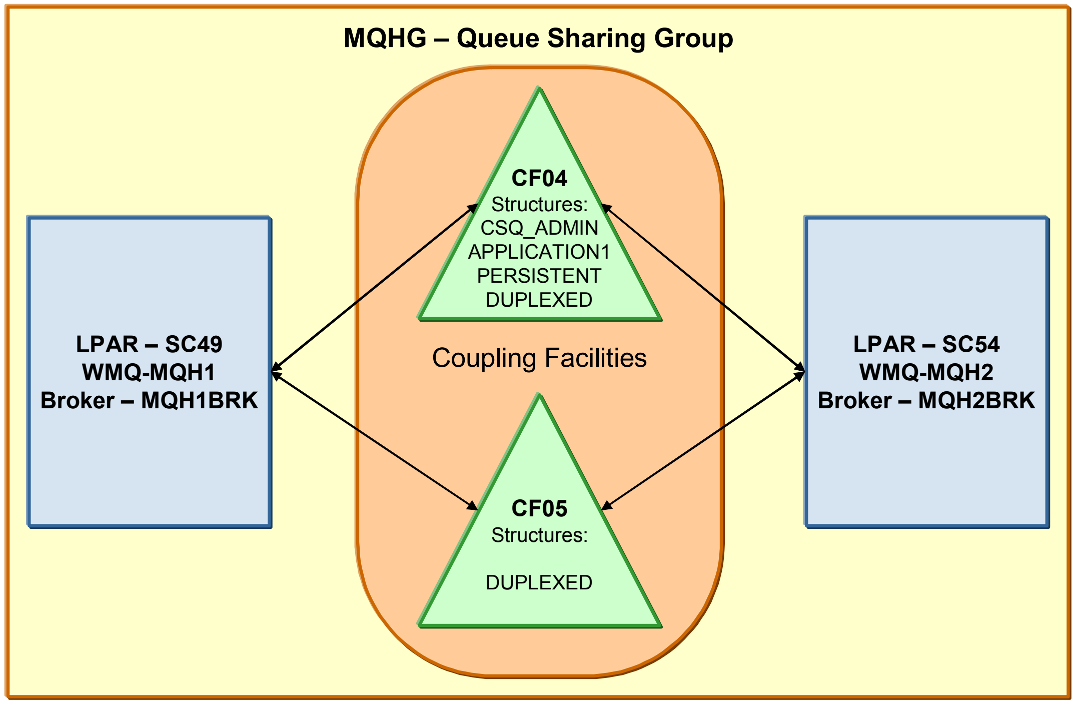


Figure 8-1 WebSphere MQ queue sharing group

8.1.1 Topology

For this scenario the topology includes two queue managers in the queue sharing group, MQHG. The two queue managers use queues defined on the PERSISTENT and DUPLEXED structures.

8.1.2 High availability characteristics and actions

In this scenario two availability options are compared: non-duplexed and duplexed application structures.

Queues defined on the PERSISTENT structure are highly available, by the nature of being on the coupling facility. In addition to the availability provided by the coupling facility itself, all persistent messages are logged and can be recovered from the logs in the event of a CF outage or structure failure. Nonpersistent messages are not logged, and cannot be recovered if there is a structure or CF outage for any reason.

Queues defined on the DUPLEXED structure are considered to be continuously available. The only outage is if both coupling facilities hosting the structure were unavailable at the same time. If one structure or CF experiences an outage, the second copy is used and all messages both persistent and nonpersistent continue to be available. In the event that both CFs experience an outage, all persistent messages can be recovered from the queue manager logs.

8.1.3 Recovery

Recovery for the non-duplexed structure is done with the WebSphere MQ `RECOVER CFSTRUCT` command. The duplexed structure recovery is handled by the CF itself.

8.2 Coupling facility configuration

The coupling facility structures are normally built by the z/OS system administrator. The samples are those used in the ITSO environment, and were input in the coupling facility resource manager (CFRM) administrative utility called IXCMIAPU. For additional information about the set-up required, see *MVS Setting Up a Sysplex*, SA22-7625.

The hardware configuration for the WebSphere MQ for z/OS environment is shown in Figure 8-2 on page 189.

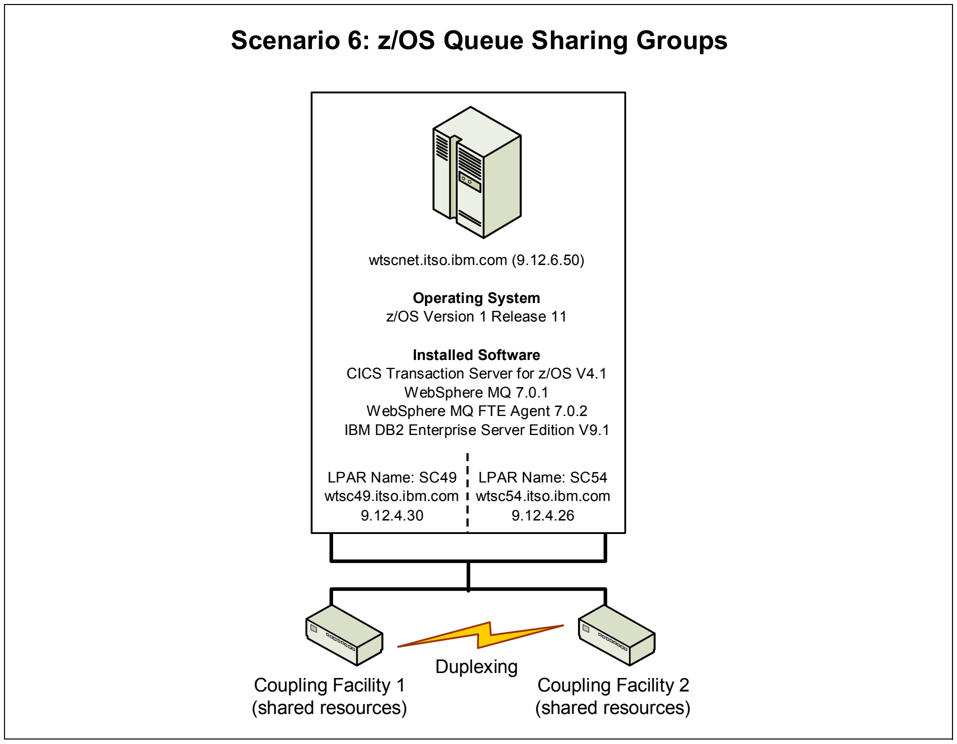


Figure 8-2 MQ for z/OS hardware configuration

The coupling facilities contain four WebSphere MQ structures. All are prefaced with the QSG name MQHG. These are:

- CSQ_ADMIN

  This is the administration structure used by the QSG.

- APPLICATION1

  This structure can be used for non-persistent messages only, because the structure is defined to WebSphere MQ with the RECOVER(NO) option.

- PERSISTENT

  This structure can be used for both persistent and non-persistent messages. The structure is defined to WebSphere MQ with the RECOVER(YES) option. The coupling facility definition looks like that of APPLICATION1.

- DUPLEXED

  This structure can be used for both persistent and non-persistent messages. The CF definition include the DUPLEX(ENABLED) option.

Example 8-1 shows the MQHG structure definitions used as input to the CFRM utility IXCMIAPU.MQHG structure definitions.

Example 8-1 MQHG structure definitions

```
/*-----------------------------------------------------*/
/* MQHG STRUCTURES SC49/SC54                           */
/*-----------------------------------------------------*/

 STRUCTURE NAME(MQHGCSQ_ADMIN)
       INITSIZE(20480)
       SIZE(50000)
       PREFLIST(CF04,CF05)
       REBUILDPERCENT(5)
       FULLTHRESHOLD(85)

 STRUCTURE NAME(MQHGPERSISTENT)
       INITSIZE(20480)
       SIZE(50000)
       PREFLIST(CF04,CF05)
       REBUILDPERCENT(5)
       FULLTHRESHOLD(85)

 STRUCTURE NAME(MQHGDUPLEXED)
         INITSIZE(20480)
         SIZE(50000)
         PREFLIST(CF04,CF05)
         REBUILDPERCENT(5)
         FULLTHRESHOLD(85)
         DUPLEX(ENABLED)

  STRUCTURE NAME(MQHGAPPLICATION1)
        INITSIZE(20480)
        SIZE(50000)
        PREFLIST(CF04,CF05)
        REBUILDPERCENT(5)
        FULLTHRESHOLD(85)
```

All the structures are defined with a preference list (PREFLIST), showing CF04 and CF05. This list provides flexibility to the system when the structure is defined. For example, if the first structure in the list does not have enough storage, the system tries the next one in the list (the list is not limited to two structures, but our environment is). For our duplexed structure, storage must exist on both CFs at allocation time because a copy of the structure is allocated on each.

These structures have not been allocated using the ALLOWAUTOALT(YES) parameter, which is normally used in production environments. The ALLOWAUTOALT parameter controls whether the coupling facility can alter the size of the structure and the storage usage within the structure.

In this Redbooks publication, only two the DUPLEX options are discussed:

- DUPLEX(DISABLED)
- DUPLEX(ENABLED)

There is a third option, DUPLEX(ALLOWED), which allows duplex enabling to be controlled by operations, starting duplexing by using a **`SETXCF START,REBUILD,DUPLEX`** command.

Defining the structures with DUPLEX(ALLOWED), even if there is no anticipation of needing to duplex a structure, provides additional resiliency and flexibility to the environment. As an example, even though duplexing is not needed most of the time, prior to a major service or application upgrade it might be advisable to turn duplexing on to prevent unanticipated issues with the WebSphere MQ structures.

To verify the structure definitions, the RMF Monitor III ISPF panels were used. A defined CF structure does not show up on the RMF reports until it has been used.

For additional information about structure definitions, see the MVS manual *Setting Up a Sysplex*, SA22-7625. For additional information about RMF reporting see *RMF Report Analysis*, SC33-7991.

8.3 WebSphere Message Broker configuration

On each LPAR there is an instance of the message broker, MQH1BRK on SC49 and MQH2BRK on SC54. Each broker is running two instances of the SimpleReply message flow, as shown in Figure 8-3. This flow reflects the original message back to the requestor.

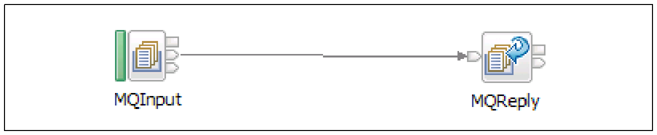


Figure 8-3 SimpleReply message flow

The input for the first instance is a queue defined on the PERSISTENT structure, the second has an input queue defined on the DUPLEXED structure. The reply queues are defined in a similar manner. Figure 8-4 shows how the SimpleReply message flow is deployed across the two brokers.

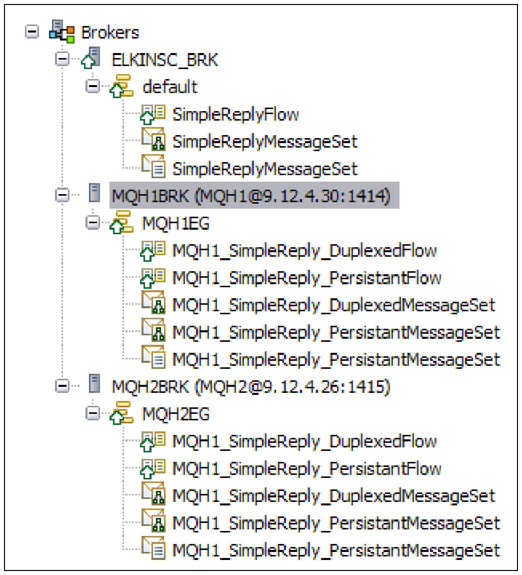

Brokers
ELKINSC_BRK
default
SimpleReplyFlow
SimpleReplyMessageSet
SimpleReplyMessageSet
MQH1BRK (MQH1@9.12.4.30:1414)
MQH1EG
MQH1_SimpleReply_DuplexedFlow
MQH1_SimpleReply_PersistantFlow
MQH1_SimpleReply_DuplexedMessageSet
MQH1_SimpleReply_PersistantMessageSet
MQH1_SimpleReply_PersistantMessageSet
MQH2BRK (MQH2@9.12.4.26:1415)
MQH2EG
MQH1_SimpleReply_DuplexedFlow
MQH1_SimpleReply_PersistantFlow
MQH1_SimpleReply_DuplexedMessageSet
MQH1_SimpleReply_PersistantMessageSet
MQH1_SimpleReply_PersistantMessageSet

Figure 8-4 SimpleReply deployed on the z/OS brokers

8.4 WebSphere MQ configuration

The WebSphere MQ configuration is illustrated in figure Figure 8-1 on page 187.

8.4.1 Defining the coupling facility structures to WebSphere MQ

In addition to defining the structures to the coupling facilities, they must also be defined to the queue sharing group. For our scenario, the WebSphere MQ Explorer was used to create the definitions.

1. From the WebSphere MQ Explorer Navigator pane, expand the MQHG queue sharing group.
2. Right-click **Coupling Facility Structures** and select **New**, as shown in Figure 8-5 on page 193.

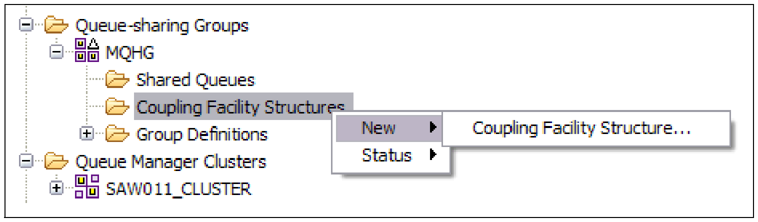
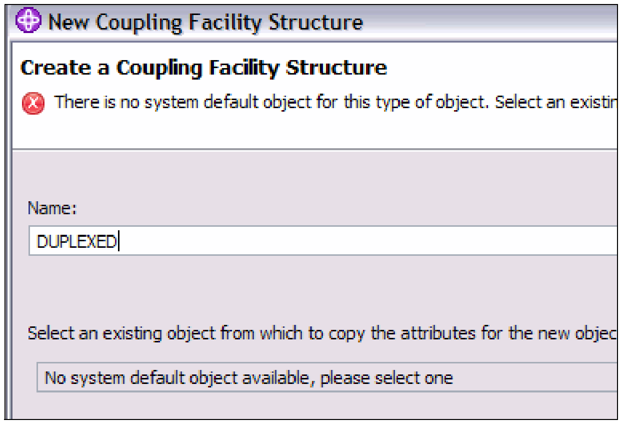


Figure 8-5 WebSphere MQ new coupling facility structure definition

3. In the New Coupling Facility Structure pane (Figure 8-6), enter the name of the structure. This version of the WebSphere MQ Explorer does not have a default structure to copy from. To proceed you have to click **Select** (not shown due to size limitations) and pick an already defined structure to go forward.



New Coupling Facility Structure

Create a Coupling Facility Structure

There is no system default object for this type of object. Select an existin

Name:

DUPLEXED

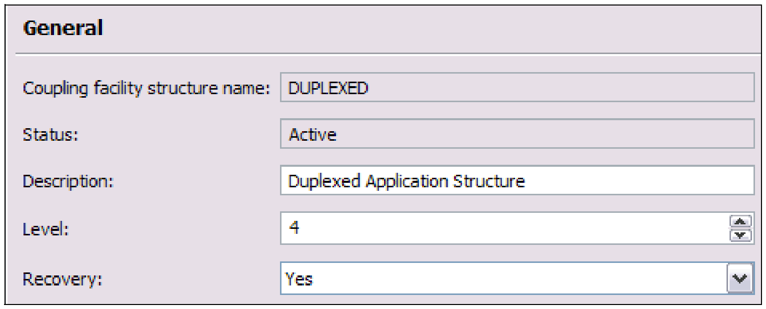
Select an existing object from which to copy the attributes for the new objec

No system default object available, please select one

Figure 8-6 Naming the new structure

4. Because there is no default object available, select one. Click **Select** (not shown), and select an existing structure. At the time of writing, you cannot create the first WebSphere MQ structure definition through Explorer.

   As shown in Figure 8-7, the Level was set to 4 to allow messages larger than 63 K to be put to the structure. Recovery was set to **Yes** so that the queues can hold both persistent and non-persistent messages.



General

Coupling facility structure name:	DUPLEXED
Status:	Active
Description:	Duplexed Application Structure
Level:	4
Recovery:	Yes

Figure 8-7 New structure properties

5. Click **Finish** (not shown) to complete the definition.

8.4.2 Defining the shared queues

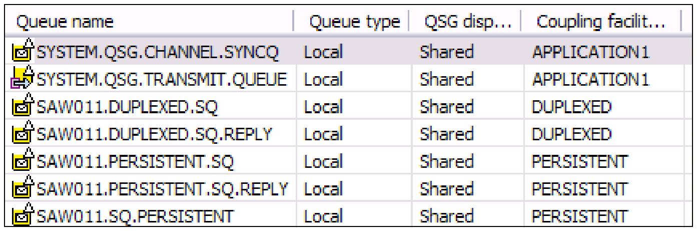
For this scenario four shared queues were defined, as shown in Table 8-1.

Table 8-1 Shared queues used

Queue Name	Structure
SAW011.DUPLEXED.SQ	DUPLEXED
SAW011.DUPLEXED.SQ.REPLY	DUPLEXED
SAW011.PERSISTENT.SQ	PERSISTENT
SAW011.PERSISTENT.SQ.REPLY	PERSISTENT

In addition to the shared queues, a private queue is defined on each queue manager to act as a backout queue for the input queue to the message flows. This is standard practice to prevent a poisoned message from causing a backup on the inbound queues. Backout queues, like dead letter queues, are not normally shared queues because of the potential for significant queue depth build-up.

The WebSphere MQ Explorer was used to define the queues. The list of the shared queues is shown in Figure 8-8 on page 195.



Queue name	Queue type	QSG disp...	Coupling facilit...
SYSTEM.QSG.CHANNEL.SYNCQ	Local	Shared	APPLICATION1
SYSTEM.QSG.TRANSMIT.QUEUE	Local	Shared	APPLICATION1
SAW011.DUPLEXED.SQ	Local	Shared	DUPLEXED
SAW011.DUPLEXED.SQ.REPLY	Local	Shared	DUPLEXED
SAW011.PERSISTENT.SQ	Local	Shared	PERSISTENT
SAW011.PERSISTENT.SQ.REPLY	Local	Shared	PERSISTENT
SAW011.SQ.PERSISTENT	Local	Shared	PERSISTENT

Figure 8-8 Shared queues

Note: Queues had to be defined as both sharable for input (meaning that more than one application can open the queue for input at a time) and the default open for input set to shared because each queue was opened by flows running on each broker instance.

8.5 Operational considerations

This section discusses a few operational considerations for this type of topology.

8.5.1 Backing up WebSphere MQ structures

WebSphere MQ includes a command, **BACKUP CFSTRUCT**, that copies the persistent messages from a structure to the log of the queue manager where the command is issued. It puts a record in DB2 to indicate when the back up took place and which queue manager issued the command.

This command should be issued periodically and the results monitored. The current recommendation is to issue the **CFSTRUCT BACKUP** command at least once per hour for a busy structure.

For highly active queue sharing groups, it is a good idea to add an administrative queue manager to the QSG. An administrative queue manager is defined as a queue manager where there is no (or little) application workload. It is also often used as a full repository for a queue manager cluster. This allows the **CFSTRUCT BACKUP** command to be issued and not to impact the WebSphere MQ logs on application-focused queue managers.

8.5.2 Recovering a WebSphere MQ structure

Following a structure failure, the WebSphere MQ structures should be rebuilt from the WebSphere MQ logs by using the **RECOVER CFSTRUCT** command. There are two recovery options:

- TYPE(NORMAL)

  This option can rebuild the structure and repopulate it with persistent messages.

- TYPE(PURGE)

  This option rebuilds the structure and leaves it empty.

The recovery with repopulation of the messages looks for the DB2 record that is generated by the **BACKUP CFSTRUCT** command and uses that as a starting point. It reads the log files from every queue manager in the queue sharing group and applies the changes to bring the structure back to the point of the failure.

As with the **BACKUP CFSTRUCT**, the **RECOVER CFSTRUCT** command is often issued on an administrative queue manager to avoid impact on application queue managers.

8.5.3 DB2 impact for large messages

WebSphere MQ shared queues define large messages as any message over 63 K (64512 bytes) including the MQMD and any other message headers. WebSphere MQ supports messages over 63 K by storing the message header in the application structure defined for the queue and the message body in DB2.

This increases the CPU cost for the messages, but reduces the storage footprint of the messages in the coupling facility.

From the perspective of an application program, large messages in shared queues are like any other message; The WebSphere MQ API calls to put and get the messages does not change because of the message storage mechanism.

8.6 Testing the topology

This section discusses the tools and methods used to test the topology. The goal is to ensure that the topology works as designed and to understand how the recovery works.

8.6.1 Testing tools

The tools used to test the topology are as follows:

- SupportPac IP13,

  This is the OEMPUTX program from the SupportPac is used to drive messages through the message flows. This SupportPac can be found at the following Web page:

  `http://www-01.ibm.com/support/docview.wss?rs=171&uid=swg24006892&loc=en_US&cs=utf-8&lang=en`

- INJERROR

  This tool is used to inject errors into coupling facility structures, which can be found at the following Web page:

  `http://www-03.ibm.com/systems/services/platformtest/servers/injerror.html`

8.6.2 Testing approach

The testing approach we used was to simulate failure of the application structures through the use of the INJERROR tool. For the PERSISTENT structure we expect to have to manually recover using the **`RECOVER CFSTRUCT`** command.

For the DUPLEXED structure we expect the system to recover the structure, and for work to continue without disruption.

The following components are under test:

- WebSphere MQ on z/OS - a queue sharing group
- Two instances of the message broker, one on each LPAR
- Two coupling facility structures

Note: We are not doing performance testing, but this scenario demonstrates the continuous message availability provided by the duplexed structures. Also the throughput and CPU costs reported by OEMPUTX in these tests are not intended to indicate true costs in a production environment.

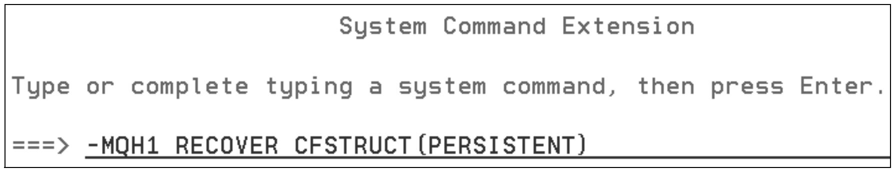
8.6.3 Test cases and results

The testing consisted of two separate test cases.

Queue behaviour when a structure problem occurs

This test case demonstrates the difference between the behavior and content of queues defined to the duplexed and non-duplexed structures. This test emphasizes which messages are restored to the structures and queues following a structure problem.

1. The **BACKUP CFSTRUCT** command is issued for the PERSISTENT structure. The backup is done to create a point of consistency for the structure, and to demonstrate that the structure is currently empty. The command is issued from the SDSF command extension panel shown in Figure 8-9.



```
                      System Command Extension

Type or complete typing a system command, then press Enter.

===> -MQH1 RECOVER CFSTRUCT(PERSISTENT)
```

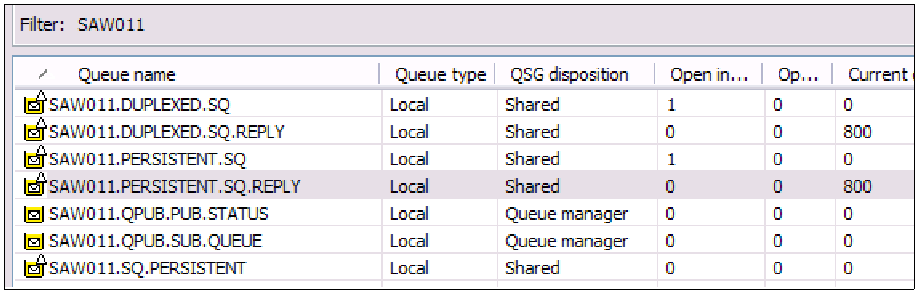
Figure 8-9 CFSTRUCT BACKUP Command

The results of the back-up command are shown in Example 8-2.

Example 8-2 CFSTRUCT Backup results

```
16.13.09 STC26707  CSQE105I -MQH1 CSQELRBK BACKUP task initiated for
structure PERSISTENT
 16.13.09 STC26707  CSQ9022I -MQH1 CSQELRBK ' BACKUP CFSTRUCT' NORMAL
COMPLETION
 16.13.09 STC26707  CSQE120I -MQH1 Backup of structure PERSISTENT
started  539
    539             at RBA=0000005BA82B
 16.13.10 STC26707  CSQE121I -MQH1 CSQELBK1 Backup of structure  540
    540             PERSISTENT completed at RBA=0000005F3B51, size 0 MB
```

2. Each reply queue is populated with 400 persistent and 400 nonpersistent messages. You can see the queue message depth from the MQ Explorer queues display shown in Figure 8-10.



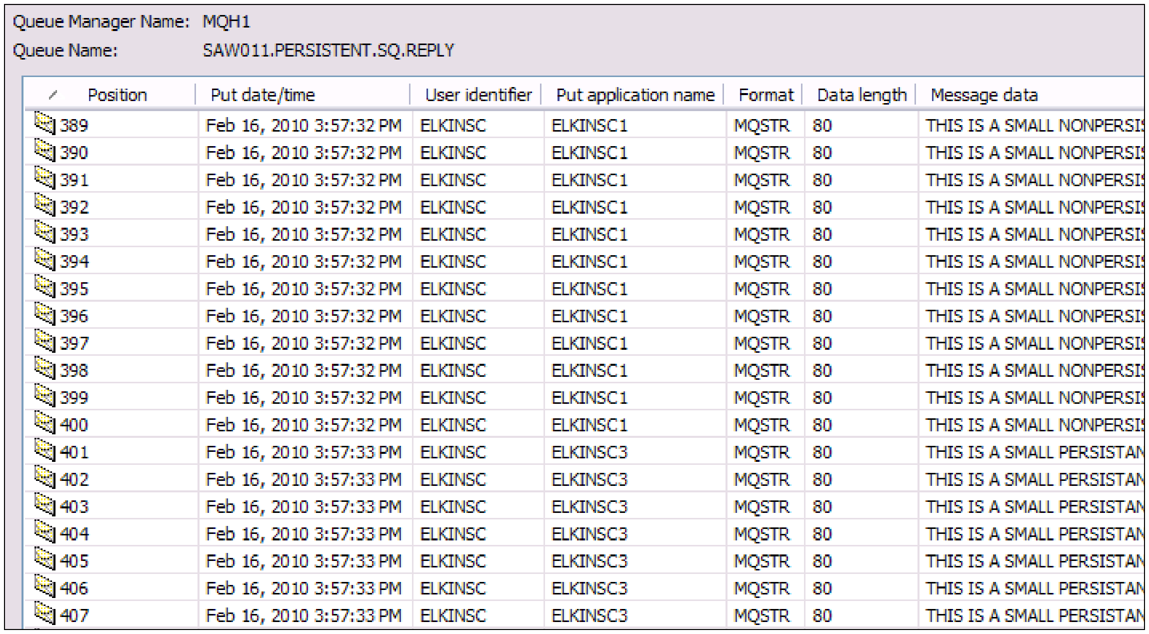
Filter: SAW011

Queue name	Queue type	QSG disposition	Open in...	Op...	Current
SAW011.DUPLEXED.SQ	Local	Shared	1	0	0
SAW011.DUPLEXED.SQ.REPLY	Local	Shared	0	0	800
SAW011.PERSISTENT.SQ	Local	Shared	1	0	0
SAW011.PERSISTENT.SQ.REPLY	Local	Shared	0	0	800
SAW011.QPUB.PUB.STATUS	Local	Queue manager	0	0	0
SAW011.QPUB.SUB.QUEUE	Local	Queue manager	0	0	0
SAW011.SQ.PERSISTENT	Local	Shared	0	0	0

Figure 8-10   Messages on shared queues

3. The messages on each queue are browsed to make sure there is a mixture of persistent and nonpersistent messages.

   Figure 8-11 shows the messages on the persistent structure.

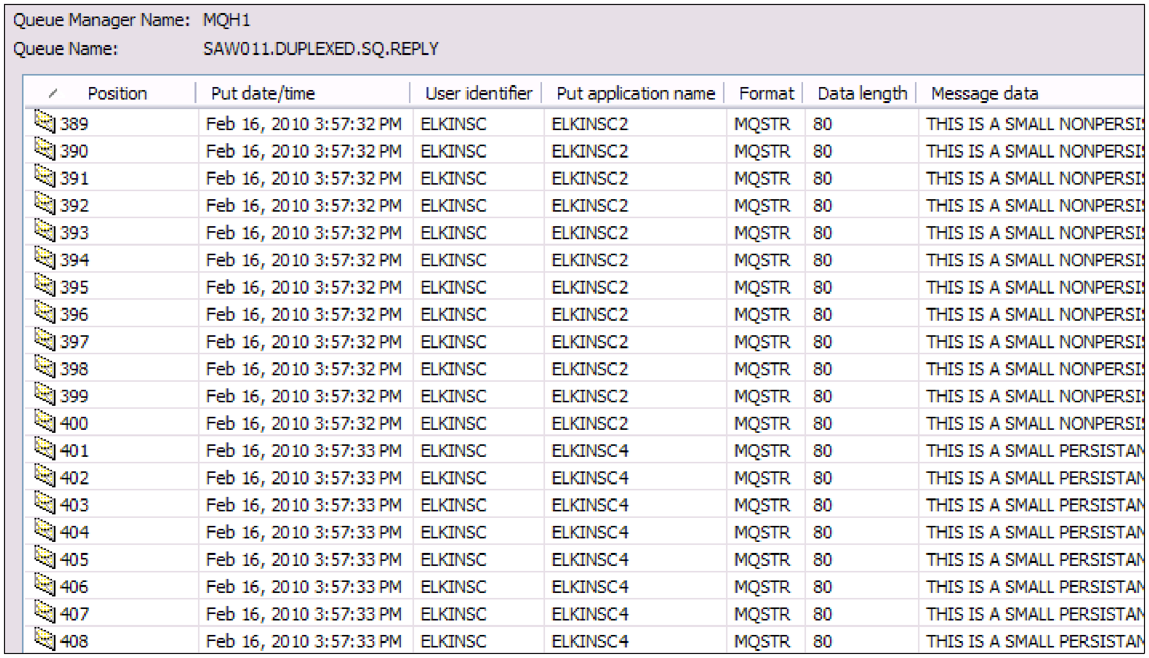


Queue Manager Name: MQH1
Queue Name: SAW011.PERSISTENT.SQ.REPLY

Position	Put date/time	User identifier	Put application name	Format	Data length	Message data
389	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
390	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
391	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
392	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
393	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
394	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
395	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
396	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
397	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
398	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
399	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
400	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC1	MQSTR	80	THIS IS A SMALL NONPERSIS
401	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
402	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
403	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
404	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
405	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
406	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
407	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN

Figure 8-11   Messages on the persistent structure

Figure 8-12 shows the messages on the duplexed structure.



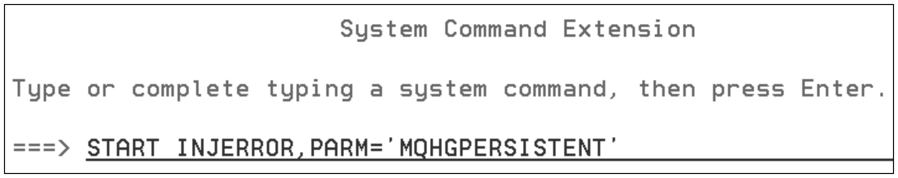
Queue Manager Name: MQH1
Queue Name: SAW011.DUPLEXED.SQ.REPLY

Position	Put date/time	User identifier	Put application name	Format	Data length	Message data
389	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
390	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
391	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
392	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
393	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
394	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
395	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
396	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
397	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
398	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
399	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
400	Feb 16, 2010 3:57:32 PM	ELKINSC	ELKINSC2	MQSTR	80	THIS IS A SMALL NONPERSIS
401	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN
402	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN
403	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN
404	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN
405	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN
406	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN
407	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN
408	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC4	MQSTR	80	THIS IS A SMALL PERSISTAN

Figure 8-12 Messages on duplexed structure

4. A structure error is introduced with the INJERROR tool in both the PERSISTENT and DUPLEXED structures.

   Figure 8-13 shows the command for the persistent structure.



```
                 System Command Extension

Type or complete typing a system command, then press Enter.

===> START INJERROR,PARM='MQHGPERSISTENT'
```

Figure 8-13 INJERROR command for PERSISTENT structure

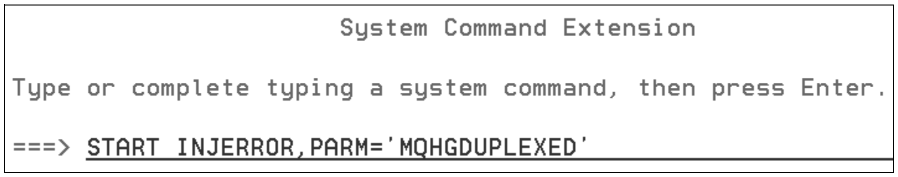
Example 8-3 on page 201 shows the system log following this INJERROR command.

Note: Note that the damaged structure shows up as disconnected. The queue managers (both MQH1 and MQH2) give the informative message `CSQE006I`.

Example 8-3 System log following INJERROR command

```
SDSF  OPERLOG  PRINT      DATE 02/16/2010                    PAGE
1
IXC579I PENDING DEALLOCATION FOR STRUCTURE MQHGPERSISTENT IN 860
          COUPLING FACILITY  002097.IBM.02.00000001DE50
                             PARTITION: 0D    CPCID: 00
                             HAS BEEN COMPLETED.
PHYSICAL STRUCTURE VERSION: C58CE2E3 36393A8A
INFO116: 13572B00 01 6A00 00000025
TRACE THREAD: 00325E85.
CSQE006I -MQH2 Structure PERSISTENT connection name 861
CSQEMQHGMQH202 disconnected
CSQE006I -MQH1 Structure PERSISTENT connection name 570
CSQEMQHGMQH101 disconnected
```

Figure 8-14 shows the command for the duplexed structure.



```
                         System Command Extension

Type or complete typing a system command, then press Enter.

===> START INJERROR,PARM='MQHGDUPLEXED'
```

Figure 8-14 INJERROR command for DUPLEXED structure

Example 8-4 shows the system log following the INJERROR command for the duplexed structure.

Note: For DUPLEXED the structure is never disconnected so the WMQ activities never stop. In the messages shown in Example 8-4, you can see that system-managed duplexing is initially stopped, the structure is switched to CF05, and the CF04 version of the duplexed structure is reallocated, DUPLEXED on CF04 is rebuilt from the in-use copy on CF05, and system-managed duplexing is restarted. This was done without manual intervention.

Example 8-4 Systems log after DUPLEXED INJERROR and structure rebuild

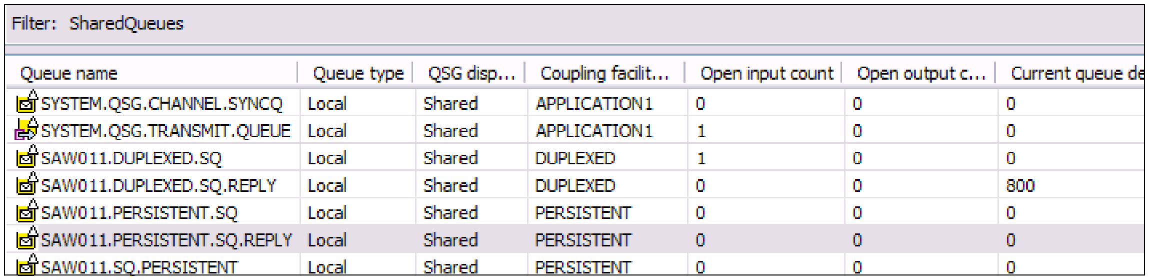
```
$HASP373 INJERROR STARTED
INJERROR: PROCESSING STARTED - VERSION 3.1 - 09/16/02
INJERROR: INPUT RECEIVED - STR=MQHGDUPLEXED    , STRTYPE=N/A
INJERROR: STR FAILURE INITIATED AGAINST STR=MQHGDUPLEXED    ,
STRTYPE=N/A
INJERROR: PROCESSING COMPLETE
```

```
-                                         --TIMINGS (MINS.)--
   ----PAGING COUNTS---
-JOBNAME  STEPNAME PROCSTEP    RC   EXCP    CPU    SRB  CLOCK   SERV
PG   PAGE   SWAP    VIO SWAPS
-INJERROR          INJERROR    00      8    .00    .00     .0    161
 0      0      0      0     0
-INJERROR ENDED.  NAME-                   TOTAL CPU TIME=   .00
TOTAL ELAPSED TIME=    .0
IXC522I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 291
MQHGDUPLEXED IS BEING STOPPED
TO SWITCH TO THE NEW STRUCTURE DUE TO
FAILURE OF THE OLD STRUCTURE
IXC571I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 292
MQHGDUPLEXED HAS COMPLETED THE DUPLEX ESTABLISHED PHASE
AND IS ENTERING THE SWITCH PHASE.
 TIME: 02/16/2010 16:26:59.496703
 AUTO VERSION: C586F91F BE7FC589
IXC571I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 597
MQHGDUPLEXED HAS COMPLETED THE SWITCH PHASE
AND IS ENTERING THE CLEANUP PHASE.
 TIME: 02/16/2010 16:26:59.715080
 AUTO VERSION: C586F91F BE7FC589
IXC577I SYSTEM-MANAGED DUPLEXING REBUILD HAS 598
BEEN COMPLETED FOR STRUCTURE MQHGDUPLEXED
STRUCTURE NOW IN COUPLING FACILITY CF05
 PHYSICAL STRUCTURE VERSION: C586F920 0850A583
LOGICAL STRUCTURE VERSION: C5855AFC 93C6A684
 AUTO VERSION: C586F91F BE7FC589
IXC579I PENDING DEALLOCATION FOR STRUCTURE MQHGDUPLEXED IN 599
        COUPLING FACILITY  002097.IBM.02.00000001DE50
                           PARTITION: 0D    CPCID: 00
HAS BEEN COMPLETED.
PHYSICAL STRUCTURE VERSION: C586AF16 DE8ABA84
INFO116: 13088068 01 6A00 00000029
TRACE THREAD: 0035DE9E.
IXC536I DUPLEXING REBUILD OF STRUCTURE MQHGDUPLEXED 600
INITIATED.
REASON: PREVIOUS REBUILD PROCESS COMPLETED
IXC570I SYSTEM-MANAGED DUPLEXING REBUILD STARTED FOR STRUCTURE 601
MQHGDUPLEXED IN COUPLING FACILITY CF05
 PHYSICAL STRUCTURE VERSION: C586F920 0850A583
 LOGICAL STRUCTURE VERSION: C5855AFC 93C6A684
 START REASON:  POLICY-INITIATED
 AUTO VERSION: C58CEADA 2D10980A
IXC571I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 602
```

```
           PAGE      2
MQHGDUPLEXED HAS COMPLETED THE STARTUP PHASE
AND IS ENTERING THE QUIESCE PHASE.
 TIME: 02/16/2010 16:27:00.320121
 AUTO VERSION: C58CEADA 2D10980A
IXC571I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 603
MQHGDUPLEXED HAS COMPLETED THE QUIESCE PHASE
AND IS ENTERING THE ALLOCATION PHASE.
 TIME: 02/16/2010 16:27:00.433907
 AUTO VERSION: C58CEADA 2D10980A
IXC578I SYSTEM-MANAGED DUPLEXING REBUILD SUCCESSFULLY ALLOCATED 604
STRUCTURE MQHGDUPLEXED.
OLD COUPLING FACILITY: CF05
OLD PHYSICAL STRUCTURE VERSION: C586F920 0850A583
NEW COUPLING FACILITY: CF04
NEW PHYSICAL STRUCTURE VERSION: C58CEADA 7AE3AD80
LOGICAL STRUCTURE VERSION: C5855AFC 93C6A684
AUTO VERSION: C58CEADA 2D10980A
IXC582I STRUCTURE MQHGDUPLEXED ALLOCATED BY COUNTS. 605
  PHYSICAL STRUCTURE VERSION: C58CEADA 7AE3AD80
  STRUCTURE TYPE:             SERIALIZED LIST
  CFNAME:                     CF04
  ALLOCATION SIZE:      21504 K
  POLICY SIZE:          50000 K
  POLICY INITSIZE:      20480 K
  POLICY MINSIZE:           0 K
  IXLCONN STRSIZE:          0 K
  ENTRY COUNT:           3934
  ELEMENT COUNT:        22950
  EMC COUNT:             7882
  LOCKS:                 1024
  ENTRY:ELEMENT RATIO:           1 :      6
  EMC STORAGE PERCENTAGE:     5.00 %
ALLOCATION SIZE EXCEEDS CFRM POLICY DEFINITIONS
IXC574I ALLOCATION INFORMATION FOR SYSTEM-MANAGED DUPLEXING REBUILD
OF STRUCTURE MQHGDUPLEXED
 AUTO VERSION: C58CEADA 2D10980A
 CFNAME     STATUS/FAILURE REASON
 --------   ---------------------
 CF05       RESTRICTED BY REBUILD OTHER
 CF04       STRUCTURE ALLOCATED
                                  INFO110: 00000014 CC000800 00000000
IXC571I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 607
MQHGDUPLEXED HAS COMPLETED THE ALLOCATION PHASE
AND IS ENTERING THE ATTACH PHASE.
```

```
 TIME: 02/16/2010 16:27:00.580301
 AUTO VERSION: C58CEADA 2D10980A
IXC571I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 608
MQHGDUPLEXED HAS COMPLETED THE ATTACH PHASE
AND IS ENTERING THE COPY PHASE.
 TIME: 02/16/2010 16:27:00.645031
 AUTO VERSION: C58CEADA 2D10980A
IXC572I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 870
           PAGE      3
MQHGDUPLEXED HAS COMPLETED THE INITIALIZATION
SUBPHASE OF THE COPY PHASE AND IS ENTERING THE
ATTACH SUBPHASE.
 TIME: 02/16/2010 16:27:00.686837
 AUTO VERSION: C58CEADA 2D10980A
IXC572I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 871
MQHGDUPLEXED HAS COMPLETED THE ATTACH
SUBPHASE OF THE COPY PHASE AND IS ENTERING THE
LIST SUBPHASE.
 TIME: 02/16/2010 16:27:00.688005
 AUTO VERSION: C58CEADA 2D10980A
IXC572I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 258
MQHGDUPLEXED HAS COMPLETED THE LIST
SUBPHASE OF THE COPY PHASE AND IS ENTERING THE
EVENT QUEUE SUBPHASE.
 TIME: 02/16/2010 16:27:00.796617
AUTO VERSION: C58CEADA 2D10980A
IXC572I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 259
MQHGDUPLEXED HAS COMPLETED THE EVENT QUEUE
SUBPHASE OF THE COPY PHASE AND IS ENTERING THE
EXIT SUBPHASE.
 TIME: 02/16/2010 16:27:00.798687
 AUTO VERSION: C58CEADA 2D10980A
IXC571I SYSTEM-MANAGED DUPLEXING REBUILD FOR STRUCTURE 541
MQHGDUPLEXED HAS COMPLETED THE COPY PHASE
AND IS ENTERING THE DUPLEX ESTABLISHED PHASE.
 TIME: 02/16/2010 16:27:01.129676
 AUTO VERSION: C58CEADA 2D10980A
IXC577I SYSTEM-MANAGED DUPLEXING REBUILD HAS 542
REACHED THE DUPLEX ESTABLISHED PHASE FOR STRUCTURE MQHGDUPLEXED
STRUCTURE IS DUPLEXED
 OLD PHYSICAL STRUCTURE VERSION: C586F920 0850A583
 NEW PHYSICAL STRUCTURE VERSION: C58CEADA 7AE3AD80
 LOGICAL STRUCTURE VERSION: C5855AFC 93C6A684
```

5. The queue depths are checked. Only those messages on the DUPLEXED queues are available. See Figure 8-15.

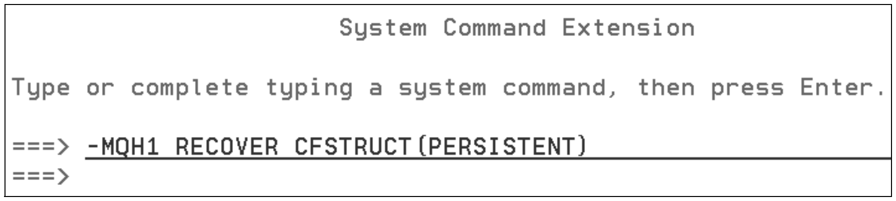


Filter: SharedQueues

Queue name	Queue type	QSG disp...	Coupling facilit...	Open input count	Open output c...	Current queue de
SYSTEM.QSG.CHANNEL.SYNCQ	Local	Shared	APPLICATION1	0	0	0
SYSTEM.QSG.TRANSMIT.QUEUE	Local	Shared	APPLICATION1	1	0	0
SAW011.DUPLEXED.SQ	Local	Shared	DUPLEXED	1	0	0
SAW011.DUPLEXED.SQ.REPLY	Local	Shared	DUPLEXED	0	0	800
SAW011.PERSISTENT.SQ	Local	Shared	PERSISTENT	0	0	0
SAW011.PERSISTENT.SQ.REPLY	Local	Shared	PERSISTENT	0	0	0
SAW011.SQ.PERSISTENT	Local	Shared	PERSISTENT	0	0	0

Figure 8-15 Messages available after INJERROR has completed

6. The **RECOVER CFSTRUCT** command is issued for the PERSISTENT structure, as shown in Figure 8-16.



```
                System Command Extension

Type or complete typing a system command, then press Enter.

===> -MQH1 RECOVER CFSTRUCT(PERSISTENT)
===>
```

Figure 8-16 RECOVER CFSTRUCT command

Example 8-5 shows the queue manager log to show the activity after the RECOVER command.

Note: The important message to look for is CSQE131I. That message indicates that the structure was recovered properly.

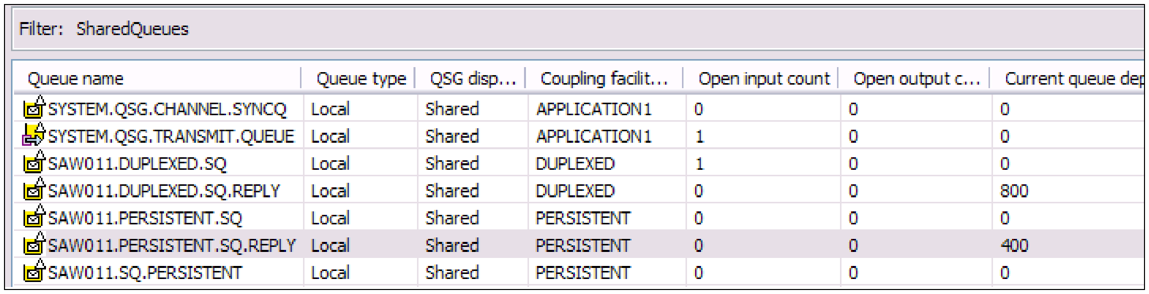
Example 8-5 Queue manager log after RECOVER CFSTRUCT

```
IXL014I IXLCONN REQUEST FOR STRUCTURE MQHGPERSISTENT  773
CSQE005I -MQH1 Structure PERSISTENT connected as  775CSQEMQHGMQH101,
version=C58CF46553BDF609 00010013
WAS SUCCESSFUL.  JOBNAME: MQH1MSTR ASID: 005C
CONNECTOR NAME: CSQEMQHGMQH101 CFNAME: CF04
IXL015I STRUCTURE ALLOCATION INFORMATION FOR  774
  STRUCTURE MQHGPERSISTENT, CONNECTOR NAME CSQEMQHGMQH101
 CFNAME     ALLOCATION STATUS/FAILURE REASON
 --------   ----------------------------------------
 CF04       STRUCTURE ALLOCATED AC001800
 CF05       PREFERRED CF ALREADY SELECTED AC001800
```

```
CSQE104I -MQH1 CSQERCFS RECOVER task initiated for structure PERSISTENT
CSQE132I -MQH1 Structure recovery started, using log  777
CSQ9022I -MQH1 CSQERCFS ' RECOVER CFSTRUCT' NORMAL COMPLETION
range from LRSN=C58CE7A5C157 to LRSN=C58CE9C76F7
CSQE134I -MQH1 Structure recovery reading log completed
CSQE130I -MQH1 Recovery of structure PERSISTENT  780
started, using MQH1 log range from RBA=0000005BA82B to
RBA=0000005F3B51
CSQE131I -MQH1 CSQERCF2 Recovery of structure PERSISTENT completed
CSQE006I -MQH1 Structure PERSISTENT connection name  782
   CSQEMQHGMQH101 disconnected
```

7. The message depths are checked and the messages browsed again. Only the persistent messages from the queue defined in the PERSISTENT structure and all messages on the DUPLEXED queue are available.

   Figure 8-17 shows the queue depths following the **`CFSTRUCT RECOVER`** command.

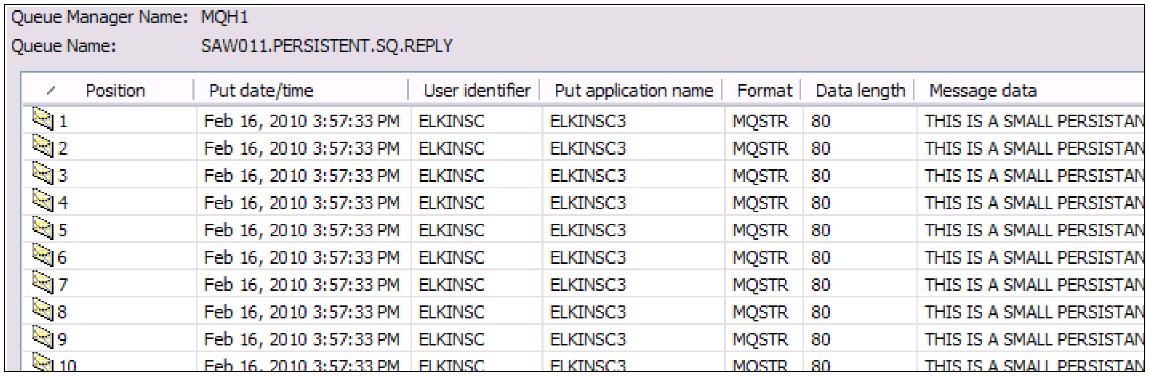


Filter: SharedQueues

Queue name	Queue type	QSG disp...	Coupling facilit...	Open input count	Open output c...	Current queue dep
SYSTEM.QSG.CHANNEL.SYNCQ	Local	Shared	APPLICATION1	0	0	0
SYSTEM.QSG.TRANSMIT.QUEUE	Local	Shared	APPLICATION1	1	0	0
SAW011.DUPLEXED.SQ	Local	Shared	DUPLEXED	1	0	0
SAW011.DUPLEXED.SQ.REPLY	Local	Shared	DUPLEXED	0	0	800
SAW011.PERSISTENT.SQ	Local	Shared	PERSISTENT	0	0	0
SAW011.PERSISTENT.SQ.REPLY	Local	Shared	PERSISTENT	0	0	400
SAW011.SQ.PERSISTENT	Local	Shared	PERSISTENT	0	0	0

Figure 8-17 Queue depths following CFSTRUCT RECOVER

Figure 8-18 on page 207 shows the messages on the recovered persistent queue.



Queue Manager Name: MQH1
Queue Name: SAW011.PERSISTENT.SQ.REPLY

Position	Put date/time	User identifier	Put application name	Format	Data length	Message data
1	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
2	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
3	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
4	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
5	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
6	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
7	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
8	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
9	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN
10	Feb 16, 2010 3:57:33 PM	ELKINSC	ELKINSC3	MQSTR	80	THIS IS A SMALL PERSISTAN

Figure 8-18 Messages on the recovered queue

8. The non-duplexed structure can be recovered from the logs, but it required intervention. The queue managers detected the outage and return errors to an application trying to use a queue defined on that structure, and the nonpersistent messages were lost. In contrast, the duplexed structure continued functioning, all the messages (both persistent and nonpersistent) were available to be processed even during the system-managed recovery process. There was no intervention required.
9. The messages are cleared from the queue for the next test.

Queue behaviour when a structure problem occurs with in-flight messages

This test case demonstrates the difference in behavior when the structure has a failure while messages are in-flight. This test emphasizes the behavior of the two seperate structure types on continuous message availability.

1. The **`BACKUP CFSTRUCT`** command is issued for the PERSISTENT structure.
2. OEMPUTX jobs are started to run for five minutes to send messages to the queues.
3. INJERROR is used to inject an error in both the PERSISTENT and DUPLEXED structures.
4. The OEMPUTX job stream output is examined. The expected result is that the jobs putting messages to the PERSISTENT queues fail when the error is introduced and does not run until the **`RECOVER CFSTRUCT`** is performed. The jobs putting messages to the DUPLEXED queues continue to process.

Example 8-6 shows the results from the persistent structure test.

Note: The job began receiving the 2373 return code, indicating that the underlying structure had failed. A few transactions were completed before the error occurred, and statistics on those transactions are reported in the OEMPUTX output.

Example 8-6 OEMPUTX results from PERSISTENT structure

```
1
 Compiled Sep 13 2006 11:23:57.
 buffer:-qSAW011.PERSISTENT.SQ    * request queue
 buffer:-rSAW011.PERSISTENT.SQ.REPLY    * Reply queue
 buffer:-fileDD:MSGIN
 buffer:-dJTEST4
 parm: -mMQH1 -n&MSGS. -x -p -tm5
 Test will run for 5 minutes
 Message file: DD:MSGIN
 OEMPUTX about to MQCONN to QMgr MQH1.
 OEMPUTX about to MQOPEN request queue: SAW011.PERSISTENT.SQ
 OEMPUTX about to MQOPEN reply queue: SAW011.PERSISTENT.SQ.REPLY
 CPU type 15DE502097
 Date Time 2010/02/22 10:18:26.
 Description JTEST4.
 Entering PUT/GET loops (MQGET_Wait=60 seconds)...
 Preload the queue with 0 messages...
   Message size        : <Determined by Message File data>
   Message persistence : PERSISTENT
   Messages per loop   : 1
   Total messages      : -1
   Syncpoints          : NO-SYNCPOINT
   MQGET replies by    : Any message
 Starting loop at 2010-02-22 10:18:26.938859
 OEMPUTX: MQGET failed cc=2, rc=2373
  Workload manager data
                  Samples %idle %unknown(MQ?) %using CPU %doing I/O
%Wait for CPU
   MQH1BRK .0063      9    0         100        0        0
0
   MQH1BRK .0064      9    0         100        0        0
0
   MQH1CHIN.0052      9   77           0       11        0
0
              CSA paging 11
   MQH1MSTR.006C      11    0          0       54        0
0
             CSA paging 45
 -------------------------------------------------------
 Total Transactions  : 408
 Elapsed Time        :    3.757 seconds
 Application CPU Time:    0.114 seconds  (3.0%)
 Transaction Rate    :  108.600 trans/sec
 -------------------------------------------------------
 Round trip per msg  :     9208 microseconds
 Avg App CPU per msg :      279 microseconds
 -------------------------------------------------------
  Jobname.ASID  TCB(uS)  SRB(uS) Tot(uS) (%)
                /tran    /tran   /tran
 ------------- -------- -------- -------- ----
 MQH1MSTR.006C 00000003 00000758 00000761 8.3
 MQH1CHIN.0052 00000658 00000033 00000691 7.5
 MQH1BRK .0064 00000005 00000000 00000006 0.1
 MQH1BRK .0063 00000762 00000011 00000774 8.4
 MQH1BRK*      00000768 00000011 00000780 8.5
 Total CPUmicrosecs/tran             2233
 -------------------------------------------------------
 Ending loop at 2010-02-22 10:18:30.701071
 OEMPUTX Normal Exit: End of program
 Exiting at 2010-02-22 10:18:30.703484
```

Example 8-7 shows the results from the duplexed structure.

Note: The queues using the DUPLEXED structure did not have an outage, all five minutes of the test run were completed.

Example 8-7 OEMPUTX result for DUPLEXED structure

```
1
 Compiled Sep 13 2006 11:23:57.
 buffer:-qSAW011.DUPLEXED.SQ    * request queue
 buffer:-rSAW011.DUPLEXED.SQ.REPLY    * Reply queue
 buffer:-fileDD:MSGIN
 buffer:-dJTEST4
 parm: -mMQH1 -n&MSGS. -x -p -tm5
 Test will run for 5 minutes
 Message file: DD:MSGIN
 OEMPUTX about to MQCONN to QMgr MQH1.
 OEMPUTX about to MQOPEN request queue: SAW011.DUPLEXED.SQ
 OEMPUTX about to MQOPEN reply queue: SAW011.DUPLEXED.SQ.REPLY
 CPU type 15DE502097
 Date Time 2010/02/22 10:18:26.
 Description JTEST4.
 Entering PUT/GET loops (MQGET_Wait=60 seconds)...
 Preload the queue with 0 messages...
   Message size        : <Determined by Message File data>
   Message persistence : PERSISTENT
   Messages per loop   : 1
   Total messages      : -1
   Syncpoints          : NO-SYNCPOINT
   MQGET replies by    : Any message
 Starting loop at 2010-02-22 10:18:26.939449
  Workload manager data
                   Samples %idle %unknown(MQ?) %using CPU %doing I/O
%Wait for CPU
   MQH1BRK .0063      34    0          88       11         0
0
   MQH1BRK .0064      34    0          97        2         0
0
   MQH1CHIN.0052      36   75           0       11         0
0
              CSA paging 13
   MQH1MSTR.006C      30    3           0       53        23
0
              CSA paging 13
              Enclave private area paging delay 6
```

```
-------------------------------------------------------
Total Transactions  : 24479
Elapsed Time        :  300.019 seconds
Application CPU Time:    3.935 seconds  (1.3%)
Transaction Rate    :   81.592 trans/sec
-------------------------------------------------------
Round trip per msg  :    12256 microseconds
Avg App CPU per msg :      160 microseconds
-------------------------------------------------------
 Jobname.ASID  TCB(uS)  SRB(uS) Tot(uS) (%)
               /tran    /tran   /tran
------------- -------- -------- -------- ----
MQH1MSTR.006C 00000007 00000686 00000693 5.7
MQH1CHIN.0052 00000704 00000038 00000742 6.1
MQH1BRK .0064 00000007 00000000 00000008 0.1
MQH1BRK .0063 00000351 00000008 00000360 2.9
MQH1BRK*      00000359 00000008 00000368 3.0
Total CPUmicrosecs/tran             1804
-------------------------------------------------------
Ending loop at 2010-02-22 10:23:26.968998
OEMPUTX Normal Exit: End of program
Exiting at 2010-02-22 10:23:26.972661
```

8.7 Summary

To summarize, using system-managed duplexing offer the following benefits:

- Increased availability of both persistent and nonpersistent messages
- Increased quality of service, keeping the underlying structures available to the queue sharing group
- Required less intervention

System-managed duplexing does incur additional overhead. However, for applications that require true continuous availability for messages, the use of WebSphere MQ shared queues on z/OS and duplexing the underlying structures is the only option to provide this level of service.

9

WebSphere MQ shared queues and CICS group attach

In many enterprises CICS is a component of most business transactions. In the past 15 years many of these transactions have been initiated by or use WebSphere MQ to fulfill the service requests. The loss of a queue manager can have far reaching effects on availability.

This chapter presents a scenario that demonstrates the WebSphere MQ group attach feature of CICS 4.1. This feature allows a CICS region to attach to any local queue manager (on the same LPAR) in a Queue Sharing Group (QSG).

9.1 Overview

For CICS releases prior to CICS 4.1 the connection from CICS to WebSphere MQ is from a CICS region to a specific queue manager. The queue manager connection is normally defined in the CICS INITPARM. In the event of a queue manager outage, an active CICS region can be switched to connect to another queue manager through the CKQC transaction, but it is a manual operation. This hard connection between a CICS region and a queue manager means that there might be a noticeable lag time between a queue manager being brought down and a connection from a CICS region to another available queue manager. In addition, in the event of an LPAR outage, the CICS regions cannot be started on another LPAR without either changing the INITPARM to point to a local queue manager or bringing the normal queue manager up on the backup LPAR. This is true even when all the WebSphere MQ resources used by the CICS applications are shared.

With CICS 4.1 the connection from CICS regions to WebSphere MQ has been substantially improved. The group attach capability has been implemented by removing the INITPARM and creating a new resource definition, MQCONN. The MQCONN definition allows the CICS regions to connect to a queue sharing group, not an individual queue manager. When the MQCONN specifies a queue sharing group, the CICS region connects to a local (on the same LPAR) queue manager that is part of that group. The topology uses an active-active technique.

The topology used to illustrate this scenario is shown in Figure 9-1 on page 215.

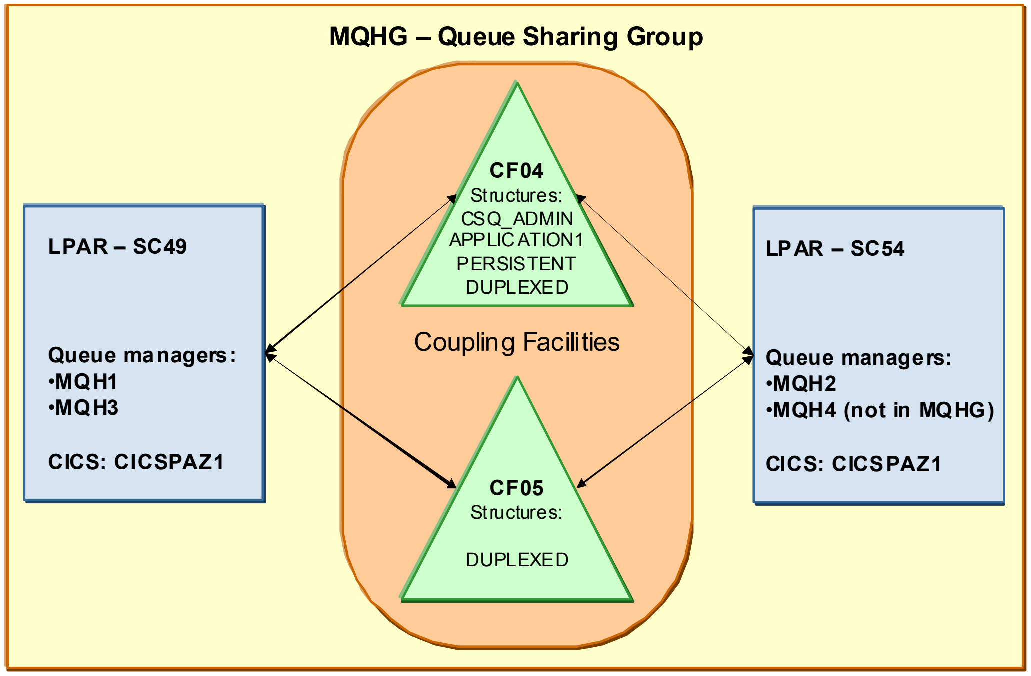


Figure 9-1 WebSphere MQ Queue sharing group and CICS 4.1 topology

9.1.1 Topology

For this scenario, illustrated in Figure 9-1, all the systems used are on z/OS. There is only one CICS region on each LPAR. In a more typical development and production environment there are multiple CICS regions with messages coming into WebSphere MQ and, subsequently, into CICS from an external, application (often on a distributed system).

9.1.2 High availability characteristics and actions

Using group attach allows CICS regions to switch almost seamlessly between queue managers when required.

This does not imply that transactions that are processing continues to process. If a queue manager is gracefully stopped for a planned outage, any active CICS transaction using MQ begins receiving 2161 return codes, indicating that the queue manager is quiescing. This gives those applications an opportunity to cleanly end the current processing, which might be a transaction rollback. If a rollback is done, the transaction can be re-initiated after the switch has taken place. If the queue manager terminates abnormally, the task is purged.

CICS transactions might not function properly if the new queue manager does not have the same MQ resources (queues, topics, and so forth) defined. It is important to examine both the application code and MQ resource definitions to make certain a queue manager switch does not cause unexpected results.

There can be only one MQCONN definition installed in a CICS region at any time. If you attempt to install a second definition you get the error shown in Example 9-1.

Example 9-1 Second MQCONN install error

```
S Install of MQCONN MQH4CONN failed because an MQCONN is already
    installed and is in use.
```

9.1.3 Recovery

Once a queue manager switch has taken place, the CICS region can be manually switched back to the original queue manager when it has returned to an operational state. An alternative is to quiesce the second queue manager, which causes CICS to shift to the next local queue manager in the queue sharing group.

9.2 WebSphere MQ configuration

For this scenario, we have the following WebSphere MQ configuration in place:

- One queue sharing group called MQHG with the following queue managers:
  - MQH1 and MQH3 on one LPAR
  - MQH2 on a second LPAR
- A queue manager, MQH4, that is not part of the QSG (used for demonstration purposes)

Note: In many environments the traditional LPAR format includes multiple, cloned, CICS regions and a single queue manager. To get the fullest benefit of the CICS group attach, there needs to be at least two queue managers in the queue sharing group on an LPAR.

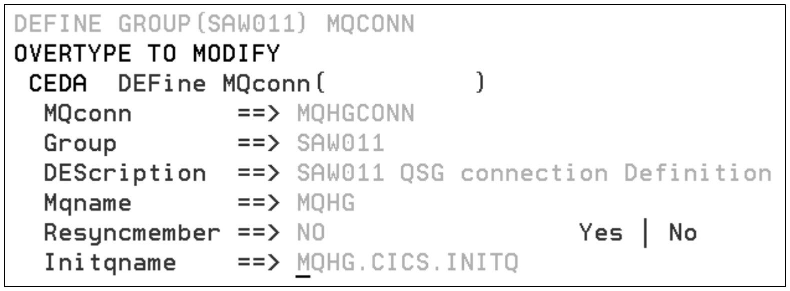
9.3 CICS definitions

For both CICS regions an MQCONN definition to the QSG was created using the standard CEDA transaction.

1. The definition is started by entering the **`CEDA DEFINE GROUP(SAW011) MQCONN`** command.
2. The specific connection information is entered as shown in Figure 9-2.

   For both CICS regions, the QSG name, MQHG, was specified. On LPAR SC49 there are two queue managers that are part of the QSG, MQH1 and MQH3. On LPAR SC54 there are two queue managers, but only one, MQH2, is part of the QSG.

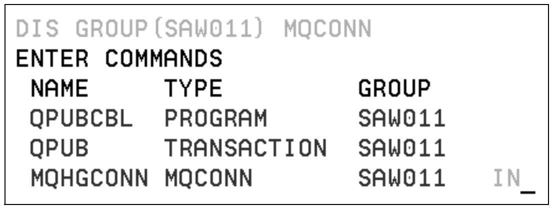
   Figure 9-2 shows the MQCONN definition.



```
DEFINE GROUP(SAW011) MQCONN
OVERTYPE TO MODIFY
 CEDA  DEFine MQconn(           )
  MQconn       ==> MQHGCONN
  Group        ==> SAW011
  DEScription  ==> SAW011 QSG connection Definition
  Mqname       ==> MQHG
  Resyncmember ==> NO                  Yes | No
  Initqname    ==> MQHG.CICS.INITQ
```

Figure 9-2 MQCONN definition

3. The new group, SAW011, is installed, using CEDA. This is shown in Figure 9-3.



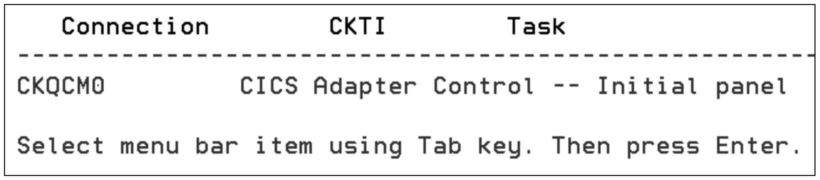
```
DIS GROUP(SAW011) MQCONN
ENTER COMMANDS
 NAME     TYPE          GROUP
 QPUBCBL  PROGRAM       SAW011
 QPUB     TRANSACTION   SAW011
 MQHGCONN MQCONN        SAW011   IN_
```

Figure 9-3 Installing the MQHGCONN MQCONN

4. Once the group is installed, the CICS region shows the connection to the QSG queue manager. Use the CICS MQ connection transaction, CKQC, to verify the queue manager connection.

   a. Enter the `CKQC` command.

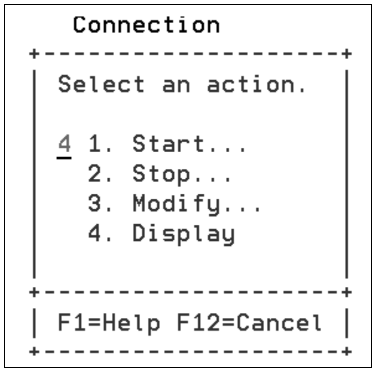
      The first panel displayed looks like Figure 9-4.



```
   Connection        CKTI        Task
----------------------------------------------------
CKQCM0         CICS Adapter Control -- Initial panel

Select menu bar item using Tab key. Then press Enter.
```

Figure 9-4 CICS Connection® panel

   b. Position the cursor in front of the Connection tab and press the Enter key. The drop-down menu that displays has four options (Figure 9-5). To check the connection status enter **4**.

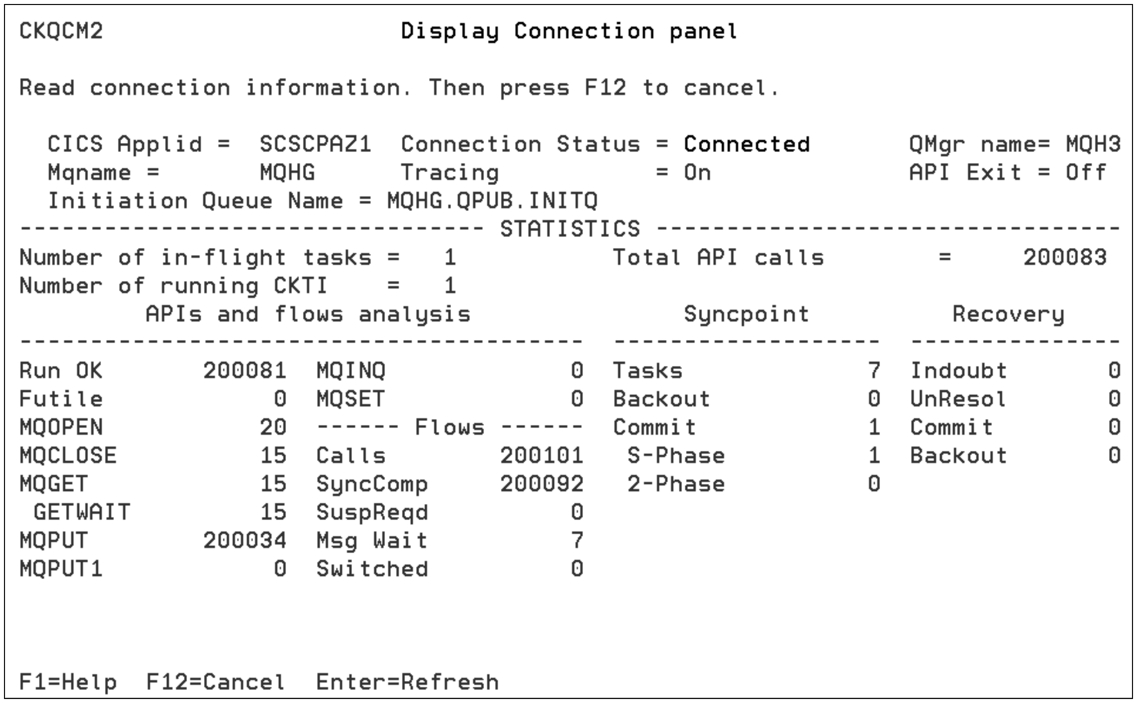


```
    Connection
 +--------------------+
 | Select an action.  |
 |                    |
 | 4 1. Start...      |
 |   2. Stop...       |
 |   3. Modify...     |
 |   4. Display       |
 |                    |
 +--------------------+
 | F1=Help F12=Cancel |
 +--------------------+
```

Figure 9-5 CICS Connection display drop-down menu

   c. The Display Connection panel is presented. Verify the ConnectionStatus and QMgr name fields.

      In this scenario, after the MQCONN definition is installed, the CICS region connect to queue manager MQH3 and the region status is connected, as shown in Figure 9-6 on page 219.



```
CKQCM2                      Display Connection panel

Read connection information. Then press F12 to cancel.

  CICS Applid =  SCSCPAZ1  Connection Status = Connected       QMgr name= MQH3
  Mqname =       MQHG      Tracing           = On              API Exit = Off
  Initiation Queue Name = MQHG.QPUB.INITQ
--------------------------------- STATISTICS ---------------------------------
Number of in-flight tasks =   1          Total API calls        =     200083
Number of running CKTI    =   1
         APIs and flows analysis              Syncpoint         Recovery
----------------------------------------  -------------------  ---------------
Run OK       200081  MQINQ            0  Tasks             7  Indoubt      0
Futile            0  MQSET            0  Backout           0  UnResol      0
MQOPEN           20  ------ Flows ------  Commit            1  Commit       0
MQCLOSE          15  Calls       200101   S-Phase          1  Backout      0
MQGET            15  SyncComp    200092   2-Phase          0
 GETWAIT         15  SuspReqd         0
MQPUT        200034  Msg Wait         7
MQPUT1            0  Switched         0



F1=Help  F12=Cancel  Enter=Refresh
```

Figure 9-6 CICS MQ connection display

9.4 Testing the topology

No special tools were used in this test, just standard CICS and MQ commands and panels.

9.4.1 Test cases and results

There were two test cases. The first shows the connection moving from one queue manager in the queue sharing group to another following a queue manager shutdown. The second demonstrates what happens when there is no second queue manager in the QSG on the LPAR available for connection.

9.4.2 Test case 1: Automatic queue manager switch

The CICS region, CICSPAZ1, is on an LPAR with two queue managers in the QSG, MQH1 and MQH3.

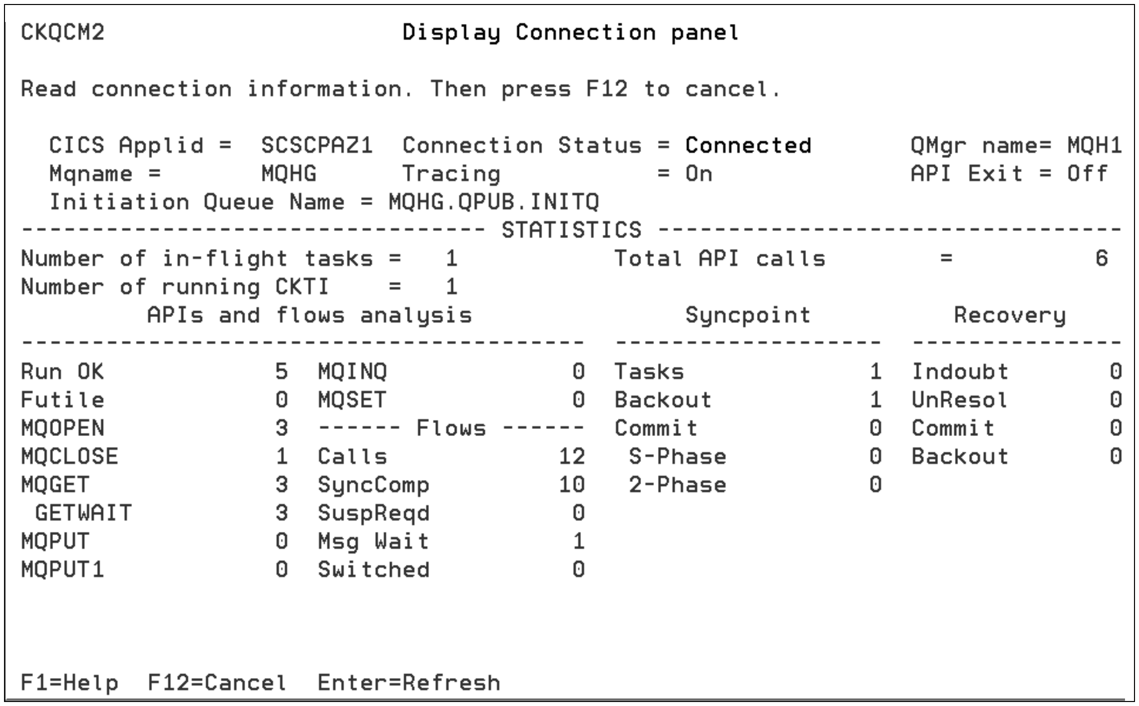
1. Check the CICS/queue manager connection as illustrated in Figure 9-6 on page 219.
2. The queue manager connection is to MQH3, so quiesce that queue manager with the **`-mqh3 stop qmgr`** command.

   When the queue manager stops, there is a normal completion message, as shown in Example 9-2.

   Example 9-2 Normal shutdown message

   ```
   CSQ9022I -MQH3 CSQYASCP 'STOP QMGR' NORMAL COMPLETION
   ```

3. Check the queue manager connection using the CKQC transaction following the shutdown. It shows the connection to queue manager MQH1, as seen in Figure 9-7.



```
CKQCM2                     Display Connection panel

Read connection information. Then press F12 to cancel.

  CICS Applid =  SCSCPAZ1  Connection Status = Connected      QMgr name= MQH1
  Mqname =       MQHG      Tracing           = On             API Exit = Off
  Initiation Queue Name = MQHG.QPUB.INITQ
--------------------------------- STATISTICS ---------------------------------
Number of in-flight tasks =   1        Total API calls        =         6
Number of running CKTI    =   1
         APIs and flows analysis             Syncpoint          Recovery
----------------------------------------  -------------------  ---------------
Run OK            5  MQINQ            0  Tasks            1  Indoubt       0
Futile            0  MQSET            0  Backout          1  UnResol       0
MQOPEN            3  ------ Flows ------  Commit           0  Commit        0
MQCLOSE           1  Calls           12   S-Phase         0  Backout       0
MQGET             3  SyncComp        10   2-Phase         0
 GETWAIT          3  SuspReqd         0
MQPUT             0  Msg Wait         1
MQPUT1            0  Switched         0



F1=Help  F12=Cancel  Enter=Refresh
```

Figure 9-7 CICS automatic reconnection to MQH1

4. During the queue manager quiesce, CICS reports on the status in the MSGUSR file it creates as a part of its normal processing. As shown in Example 9-3, the CICS alert monitor detects the WebSphere MQ stop and issues the connect. That connection request is resolved to MQH1.

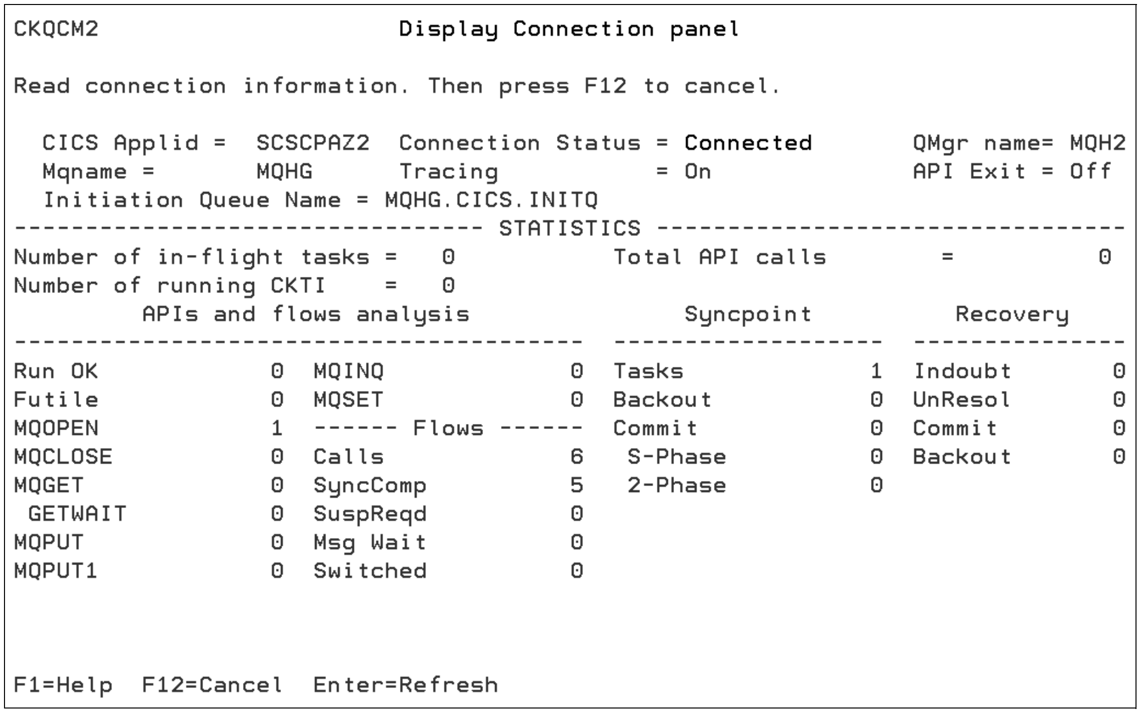
Example 9-3 CICS messages during the queue manager switch

```
STOP requested by alert monitor CKAM.
A request to end CKTI has been received. CKTI ended.
Adapter shutdown successful.
CONNECT received from alert monitor.
Unable to LOAD API exit CSQCAPX. Program is disabled.
Successful connection to queue manager MQH1 release 0701 group MQHG
```

9.4.3 Test case 2: No automatic queue manager switch

The CICS region, CICSPAZ2, is on an LPAR with one queue manager in the Queue Sharing Group, MQH2. A second queue manager, MQH4, is on the LPAR, but it is not part of the QSG.

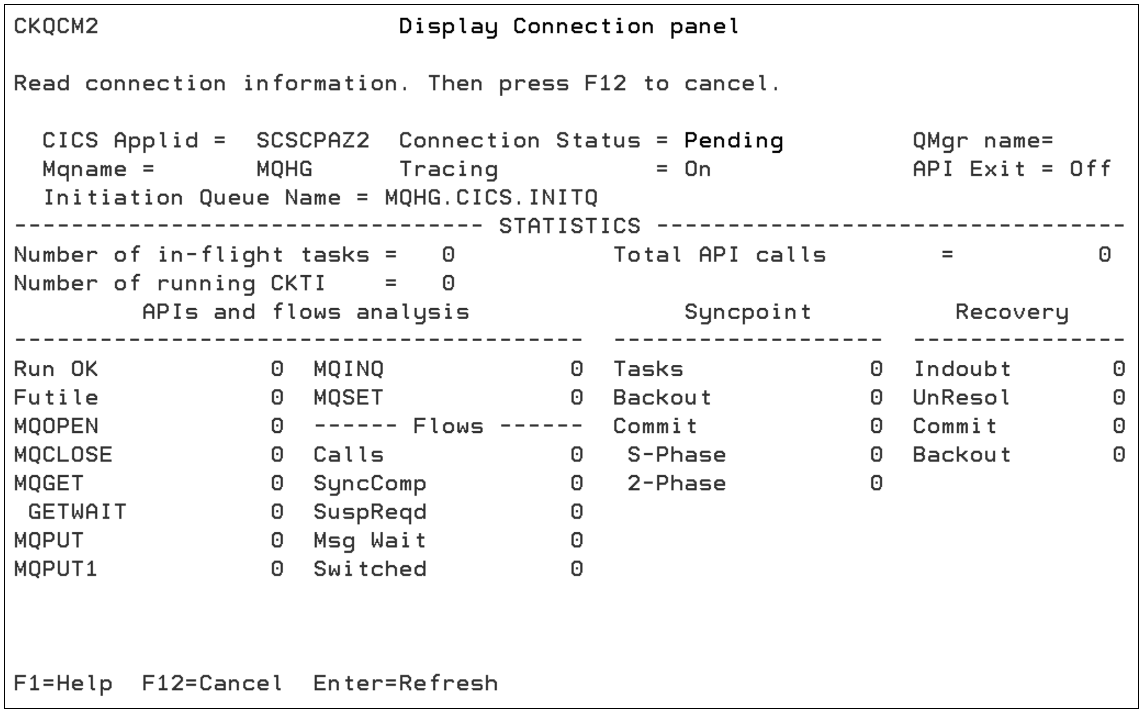
1. Check the CICS/queue manager connection by entering the **CKQC** command. The results are shown in Figure 9-8.



```
CKQCM2                     Display Connection panel

Read connection information. Then press F12 to cancel.

  CICS Applid =  SCSCPAZ2  Connection Status = Connected       QMgr name= MQH2
  Mqname =       MQHG      Tracing           = On              API Exit = Off
  Initiation Queue Name = MQHG.CICS.INITQ
--------------------------------- STATISTICS ---------------------------------
Number of in-flight tasks =   0          Total API calls        =          0
Number of running CKTI    =   0
         APIs and flows analysis              Syncpoint          Recovery
----------------------------------------  -------------------  ---------------
Run OK              0  MQINQ             0  Tasks             1  Indoubt       0
Futile              0  MQSET             0  Backout           0  UnResol       0
MQOPEN              1  ------ Flows ------  Commit            0  Commit        0
MQCLOSE             0  Calls             6   S-Phase          0  Backout       0
MQGET               0  SyncComp          5   2-Phase          0
 GETWAIT            0  SuspReqd          0
MQPUT               0  Msg Wait          0
MQPUT1              0  Switched          0



F1=Help  F12=Cancel  Enter=Refresh
```

Figure 9-8 Second CICS region MQ connection

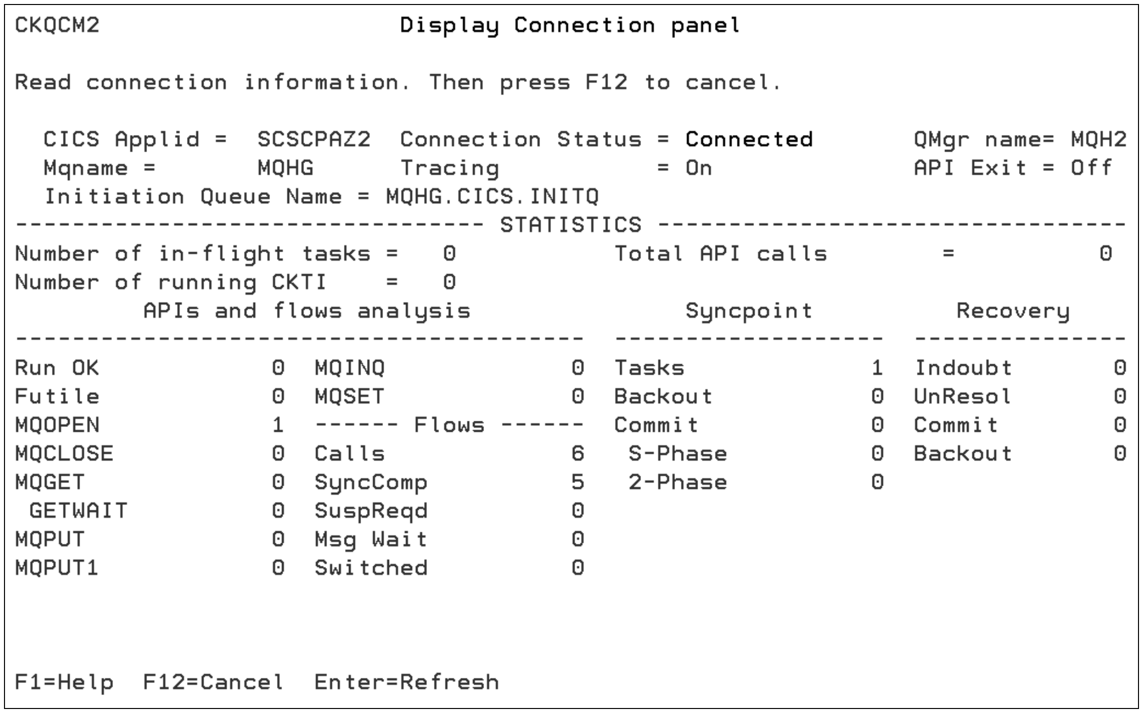
2. Quiesce the queue manager using the **-MQH2 STOP QMGR** stop queue manager command.
3. Check the connection status using the CKQC transaction. The connection status is now pending, as shown in Figure 9-9 on page 223.


```
CKQCM2                     Display Connection panel

Read connection information. Then press F12 to cancel.

  CICS Applid =  SCSCPAZ2  Connection Status = Pending        QMgr name=
  Mqname =       MQHG      Tracing           = On             API Exit = Off
  Initiation Queue Name = MQHG.CICS.INITQ
--------------------------------- STATISTICS ---------------------------------
Number of in-flight tasks =   0          Total API calls        =          0
Number of running CKTI    =   0
         APIs and flows analysis              Syncpoint          Recovery
----------------------------------------  -------------------  ---------------
Run OK             0  MQINQ            0  Tasks             0  Indoubt      0
Futile             0  MQSET            0  Backout           0  UnResol      0
MQOPEN             0  ------ Flows ------  Commit            0  Commit       0
MQCLOSE            0  Calls            0   S-Phase          0  Backout      0
MQGET              0  SyncComp         0   2-Phase          0
 GETWAIT           0  SuspReqd         0
MQPUT              0  Msg Wait         0
MQPUT1             0  Switched         0



F1=Help  F12=Cancel  Enter=Refresh
```
Figure 9-9 CICS region 2 in pending status

4. The queue manager is started with the standard start command, **`-MQH2 START QMGR`**

5. Refresh the CICS connection panel, by hitting the enter key. This shows that CICS has reconnected to the restarted queue manager with no operational effort. This is shown in Figure 9-10.

t



```
CKQCM2                     Display Connection panel

Read connection information. Then press F12 to cancel.

  CICS Applid =   SCSCPAZ2  Connection Status = Connected       QMgr name= MQH2
  Mqname =        MQHG      Tracing           = On              API Exit = Off
  Initiation Queue Name = MQHG.CICS.INITQ
-------------------------------- STATISTICS --------------------------------
Number of in-flight tasks =   0          Total API calls       =         0
Number of running CKTI    =   0
         APIs and flows analysis              Syncpoint         Recovery
---------------------------------------  ------------------  ---------------
Run OK             0  MQINQ            0  Tasks             1  Indoubt      0
Futile             0  MQSET            0  Backout           0  UnResol      0
MQOPEN             1  ------ Flows ------ Commit            0  Commit       0
MQCLOSE            0  Calls            6   S-Phase          0  Backout      0
MQGET              0  SyncComp         5   2-Phase          0
 GETWAIT           0  SuspReqd         0
MQPUT              0  Msg Wait         0
MQPUT1             0  Switched         0



F1=Help  F12=Cancel  Enter=Refresh
```

Figure 9-10   CICS Connection after queue manager restart

Part 3

Appendixes

The appendixes contain supplemental information to explain processes and sample applications used in this book.

A

QPUB Transaction

This appendix describes a sample CICS MQ-enabled transaction, called QPUB, which is used for testing scenarios in this book. The description is broken into sections.

- QPUBCBL

  A description of the COBOL program
- CICS administration

  A description of the CICS definitions needed to enable the program and transaction
- WebSphere MQ administration

  A description of the WebSphere MQ definitions needed
- Test data

  The format of the data used to initiate the transaction

QPUBCBL program

The QPUBCBL program is a simple CICS COBOL application that uses WebSphere MQ to publish a varying number of messages, from 1 to 9,999,999, to a specified topic. It is associated with a CICS transaction, QPUB. The transaction is triggered by WebSphere MQ, and the information about the number of messages to publish and the topic used are expected on the initial, publish control, message.

Trigger message

The trigger message shown in Example A-1 is the standard MQ copybook CMQTV, which can be found in *hlq*.SCSQCOBC in an MQ for z/OS installation.

Example A-1 Trigger message copybook, CMQTV

```
10  MQTM.
      ** Structure identifier
       15  MQTM-STRUCID PIC X(4) VALUE 'TM  '.
      ** Structure version number
       15  MQTM-VERSION PIC S9(9) BINARY VALUE 1.
      ** Name of triggered queue
       15  MQTM-QNAME PIC X(48) VALUE SPACES.
      ** Name of process object
       15  MQTM-PROCESSNAME PIC X(48) VALUE SPACES.
      ** Trigger data
       15  MQTM-TRIGGERDATA PIC X(64) VALUE SPACES.
      ** Application type
       15  MQTM-APPLTYPE PIC S9(9) BINARY VALUE 0.
      ** Application identifier
       15  MQTM-APPLID PIC X(256) VALUE SPACES.
      ** Environment data
       15  MQTM-ENVDATA PIC X(128) VALUE SPACES.
** User data
       15  MQTM-USERDATA PIC X(128) VALUE SPACES.
```

From the trigger message the program uses

- MQTM-QNAME

  This is the queue that holds the publish control message

- MQTM-ENVDATA

  If supplied, the first 48 bytes are used as the status queue name

- MQTM-USERDATA

  If supplied, this is the body for the published messages.

Publish control message

The publish control message is shown in Example A-2.

Example A-2 Publish control message definitions

```
01  PUB-CONTROL-MESSAGE.
    05  NUMBER-OF-PUBS         PIC 9(7) VALUE ZEROS.
    05  TOPIC-OBJECT           PIC X(48) VALUE SPACES.
    05  FILLER PIC X(100) VALUE SPACES.
```

Field usage:

- NUMBER-OF-PUBS

  This is the number of messages to be published ranging from 1 to 9,999,999.
- TOPIC-OBJECT

  This is the defined topic object name.
- The filler area might be used later.

Status message

The status message, shown in Example A-3, provides the topic object used in the publications and the number of messages published.

Example A-3 Status Message

```
01  STATUS-MESSAGE.
    05  FILLER                 PIC X(20)
                 VALUE 'PUBLICATIONS MADE= '.
    05  SM-NUMBER              PIC 9(7) VALUE ZEROS.
    05  FILLER                 PIC X(20)
                 VALUE ' FOR TOPIC = '.
    05  SM-TOPIC               PIC X(48) VALUE SPACES.
```

QPUBCBL flow

The complete COBOL program is provided in “QPUBCBL program code” on page 237. The following process is an outline of the processing.

1. Store trigger information.
2. Open input queue and get the publish control message.
3. Setup publication and control values.
4. Open the topic specified in the control message.
5. Publish the messages.
6. Open the status queue.
7. Format and put the status message.
8. Close the topic.
9. Close the queues.
10. Return control to CICS.

CICS definitions

Two CICS resource definitions were required to support the QPUB sample, one transaction and one program definition. We used QPUB as the transaction name. This can be any four characters.

QPUB transaction definition

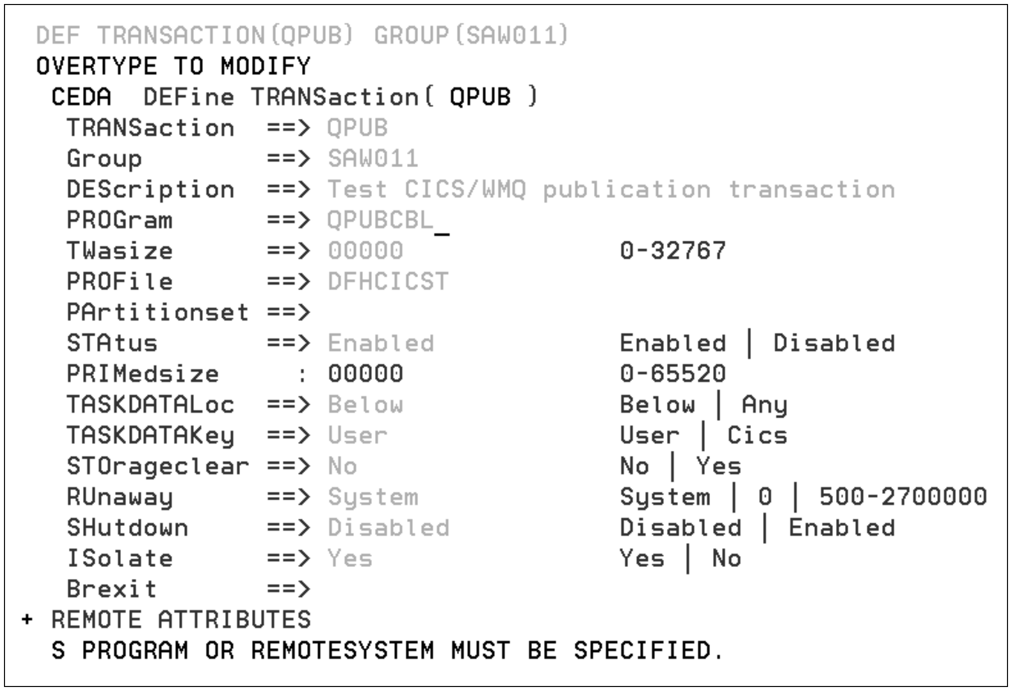
The CICS resource definition transaction CEDA was used to define both the transaction and the program to CICS. As with the other CICS definitions, the group SAW011 was used.

The QPUB definition is shown in Example A-4.

Example A-4 Starting the CICS transaction definition

```
ceda def transaction(QPUB) group(SAW011)
```

The program name is entered, as shown in Figure A-1.



```
 DEF TRANSACTION(QPUB) GROUP(SAW011)
 OVERTYPE TO MODIFY
  CEDA  DEFine TRANSaction( QPUB )
   TRANSaction  ==> QPUB
   Group        ==> SAW011
   DEScription  ==> Test CICS/WMQ publication transaction
   PROGram      ==> QPUBCBL_
   TWasize      ==> 00000             0-32767
   PROFile      ==> DFHCICST
   PArtitionset ==>
   STAtus       ==> Enabled           Enabled | Disabled
   PRIMedsize     : 00000             0-65520
   TASKDATALoc  ==> Below             Below | Any
   TASKDATAKey  ==> User              User | Cics
   STOrageclear ==> No                No | Yes
   RUnaway      ==> System            System | 0 | 500-2700000
   SHutdown     ==> Disabled          Disabled | Enabled
   ISolate      ==> Yes               Yes | No
   Brexit       ==>
+ REMOTE ATTRIBUTES
  S PROGRAM OR REMOTESYSTEM MUST BE SPECIFIED.
```

Figure A-1 Defining the QPUB transaction

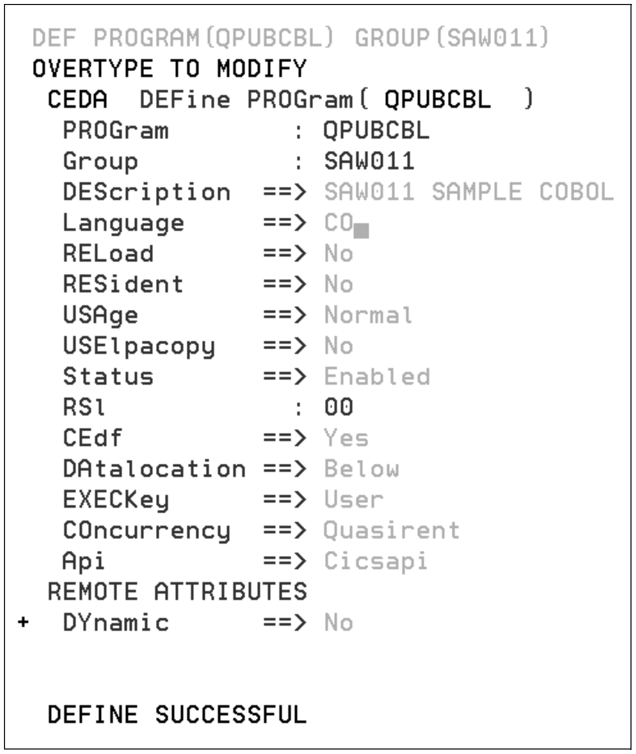
QPUBCBL program definition

CEDA was also used to define the program, as shown in Example A-5.

Example A-5 CICS program definition

```
ceda def program(QPUBCBL) group(SAW011)
```

The only change required is the language specification, as shown in Figure A-2.



```
 DEF PROGRAM(QPUBCBL) GROUP(SAW011)
 OVERTYPE TO MODIFY
  CEDA  DEFine PROGram( QPUBCBL  )
   PROGram        : QPUBCBL
   Group          : SAW011
   DEScription  ==> SAW011 SAMPLE COBOL
   Language     ==> CO
   RELoad       ==> No
   RESident     ==> No
   USAge        ==> Normal
   USElpacopy   ==> No
   Status       ==> Enabled
   RSl            : 00
   CEdf         ==> Yes
   DAtalocation ==> Below
   EXECKey      ==> User
   COncurrency  ==> Quasirent
   Api          ==> Cicsapi
  REMOTE ATTRIBUTES
+  DYnamic      ==> No


  DEFINE SUCCESSFUL
```

Figure A-2 QPUBCBL Program definitions

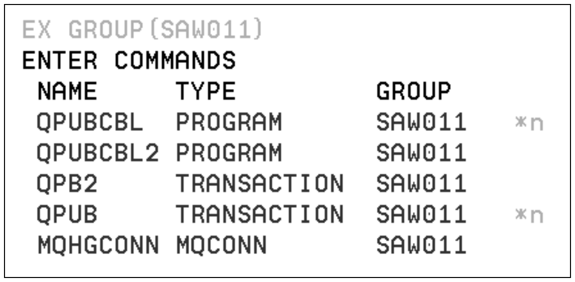
Installing the definitions

Once both definitions have been created, they need to be installed in the CICS region. CEDA is again used, and is initiated as shown in Example A-6.

Example A-6 CEDA expand command

```
CEDA EX GROUP(SAW011)
```

The transaction and program are installed by entering IN by the resources and hitting the Enter key. The successful installation of the program and transaction is shown in Figure A-3.



```
EX GROUP(SAW011)
ENTER COMMANDS
 NAME     TYPE          GROUP
 QPUBCBL  PROGRAM       SAW011    *n
 QPUBCBL2 PROGRAM       SAW011
 QPB2     TRANSACTION   SAW011
 QPUB     TRANSACTION   SAW011    *n
 MQHGCONN MQCONN        SAW011
```

Figure A-3 Successful resource installation

WebSphere MQ definitions

Several WebSphere MQ resources need to be defined to use the sample, These are summarized in Table A-1.

Table A-1 WebSphere MQ resource definition list

Name	Resource Type	Purpose
SAW011.PROCESS	Process	Trigger process for the QPUB transaction
MQHG.QPUB.START.QUEUE	Local Queue	Triggered queue that starts the QPUB transaction
MQHG.QPUB.INITQ	Local Queue	Initiation queue for the trigger process
SAW011.QPUB.PUB.STATUS	Local Queue	Status queue - reports on the results of the transactions
MQHG.TEST.TOPIC	Topic	Publication topic object

Process definition

The WebSphere MQ process definition, shown in Example A-7, tells the queue manager about the transaction to be started and provides operational data used by the transaction. The optional information is in the userdata and the environment data fields. The userdata field defines the content of the published message. The environment data field is used to provide the status queue.

Example A-7 Sample Process definition

```
DEFINE NOREPLACE
 PROCESS('SAW011.PROCESS')
 QSGDISP(COPY)
 DESCR(' ')
 APPLTYPE(CICS)
 APPLICID('QPUB')
 USERDATA('REPORT BACK WHEN IT MAKES SENSE')
 ENVRDATA('SAW011.QPUB.PUB.STATUS')
```

Queue definitions

The first queue defined (Example A-8) is the triggered queue that starts the transaction. The message put to this queue sets the number of publications and the publication topic. This definition sample is for a shared queue, but the queue can be private. All queue properties that are not specified were allowed to default.

Example A-8 Start queue example definition

```
QLOCAL('MQHG.QPUB.START.QUEUE')
QSGDISP(SHARED)
STGCLASS('DEFAULT')
CFSTRUCT('PERSISTENT')
PUT(ENABLED)
PROCESS('SAW011.PROCESS')
TRIGGER
INITQ('MQHG.QPUB.INITQ')
TRIGTYPE(EVERY)
TRIGDPTH(1)
TRIGMPRI(0)
TRIGDATA(' ')
```

The second queue is the initiation queue (Example A-9) used by WebSphere MQ and the CICS trigger monitor. When a message arrives on a triggered queue that meets the triggering criteria, the queue manager automatically puts an initiation message on the initiation queue. The CICS trigger monitor has been set to listen on the initiation queue and accept the transaction identified in the process definition. In many environments the initiation queue for CICS is left as the default CICS01.INITQ.

The initiation queue is defined as a shared queue for this IBM Redbooks publication. This is so that any CICS region to which it is connected can initiate the transactions if needed. All queue information that is not specified has been allowed to default.

Example A-9 Initiation queue definition

```
DEFINE NOREPLACE
 QLOCAL('MQHG.QPUB.INITQ')
 QSGDISP(SHARED)
 STGCLASS('DEFAULT')
 CFSTRUCT('PERSISTENT')
```

The status queue (Example A-10) contains information about the number of publications made and the topic used. For the examples in this book, it as been defined as a private queue. All queue information that is not specified in this example have been allowed to default.

Example A-10 Status queue definition

```
DEFINE NOREPLACE
 QLOCAL('SAW011.QPUB.PUB.STATUS')
 QSGDISP(QMGR)
 STGCLASS('DEFAULT')
```

Topic definitions

The definitions shown in Example A-11 were used in testing the scenario environment. They define the topic string used by the subscribing applications. For the scenario, the topics were defined as in the QSG and as part of the cluster.

Example A-11 Topic definitions

```
DEFINE NOREPLACE
 TOPIC('MQHG.TEST.TOPIC')
 QSGDISP(COPY)
 CLUSTER('SAW011_CLUSTER')
 TOPICSTR(
'QPUB.STRING'
  )
DEFINE NOREPLACE
 TOPIC('NEWS.POLITICS')
 QSGDISP(COPY)
 CLUSTER('SAW011_CLUSTER')
 TOPICSTR(
'NEWS/POLITICS'
  )
```

Sample data

The sample data shows the format of the message used to trigger the transaction and start the message publication. It is defined as the publish control message shown in “Publish control message” on page 229. The sample data shown in Example A-12 causes the publication of 10,000 messages to the MQHG.TEST.TOPIC. The other characters are ignored.

Example A-12 Sample QPUB data

```
0010000MQHG.TEST.TOPIC                                      PUB
```

QPUBCBL program code

The QPUBCBL program is shown in Example A-13.

Example A-13 QPUBCBL program

```
CBL NODYNAM,LIB,OBJECT,RENT,RES,APOST
      * ------------------------------------------------------------- *
       IDENTIFICATION DIVISION.
      * ------------------------------------------------------------- *
       PROGRAM-ID. QPUBCBL.
      *REMARKS
      *****************************************************************
      *****************************************************************
      *                   IBM WEBSPHERE MQ FOR Z/OS                   *
      *                                                               *
      *  MODULE NAME           : QPUBCBL                              *
      *                                                               *
      *  ENVIRONMENT           : CICS; COBOL                          *
      *                                                               *
      *  CICS TRANSACTION NAME : QPUB                                 *
      *                                                               *
      *  DESCRIPTION : SAMPLE PROGRAM TO PUBLISH FROM CICS TO A       *
      *                SPECIFIED TOPIC OBJECT.                        *
      *                                                               *
      *  OPERATIONS  : THIS TRANSACTION SHOULD BE TRIGGERED.  IT      *
      *                EXPECTS THE TRIGGER MESSAGE TO INCLUDE THE     *
      *                NUMBER OF MESSAGES TO BE PUBLISHED.            *
      *                THE ENVIRONMENT DATA ON THE PROCESS SHOULD     *
      *                BE SET TO THE STATUS QUEUE.                    *
      *                                                               *
      *                THE FIRST 100 BYTES OF THE USER DATA WILL BE   *
      *                PRE-PENDED TO THE PUBLISHED MESSAGE.           *
      *                                                               *
      * ************************************************************* *
          EJECT
      * ------------------------------------------------------------- *
       ENVIRONMENT DIVISION.
      * ------------------------------------------------------------- *
      * ------------------------------------------------------------- *
       DATA DIVISION.
      * ------------------------------------------------------------- *
      * ------------------------------------------------------------- *
       WORKING-STORAGE SECTION.
      * ------------------------------------------------------------- *
```

```
*
 01  WSAREA                  PIC X(20) VALUE
          'START OF WS      '.
 01  HCONN                       PIC S9(9) BINARY VALUE ZERO.
 01  HOBJ-PUB-CONTROL            PIC S9(9) BINARY VALUE ZERO.
 01  HOBJ-PUB-MSGS               PIC S9(9) BINARY VALUE ZERO.
 01  HOBJ-PUB-STATUS             PIC S9(9) BINARY VALUE ZERO.
 01  WAIT-INTERVAL               PIC S9(9) BINARY VALUE 30000.
 01  OPENOPTIONS-PC              PIC S9(9) BINARY.
 01  OPENOPTIONS-STATUS          PIC S9(9) BINARY.
 01  OPENOPTIONS-PUBLISH         PIC S9(9) BINARY.
 01  GET-OPTIONS-PC              PIC S9(9) BINARY.
 01  PUT-OPTIONS-STATUS          PIC S9(9) BINARY.
 01  PUB-OPTIONS                 PIC S9(9) BINARY.
 01  COMPCODE                    PIC S9(9) BINARY.
 01  REASON                      PIC S9(9) BINARY.
 01  DATALEN                     PIC S9(9) BINARY.
 01  BUFFLEN                     PIC S9(9) BINARY.
 01  NUMPUBS-HDR                 PIC X(20)
           VALUE 'NUMBER PUBS     =   '.
 01  NUMPUBS                     PIC S9(9) BINARY VALUE 0.
 01  PUB-LOOP-CONTROL-HDR        PIC X(20)
           VALUE 'PUB LOOP CONTROL=   '.
 01  PUB-LOOP-CONTROL            PIC S9(9) BINARY VALUE 0.
 01  ERROR-MESSAGE               PIC X(48) VALUE SPACES.
 01  ABEND-CODE                  PIC X(04) VALUE SPACES.
 01  TOPIC-NAME                  PIC X(48) VALUE SPACES.
 01  TOPIC-STR                   PIC X(100) VALUE SPACES.
 01  PC-MESSAGE                  PIC X(20)
              VALUE 'PUB CNTL MESSAGE = '.
 01  PUB-CONTROL-MESSAGE.
     05  NUMBER-OF-PUBS          PIC 9(7) VALUE ZEROS.
     05  TOPIC-OBJECT            PIC X(48) VALUE SPACES.
     05  TOPIC-STRING            PIC X(100) VALUE SPACES.
 01  PUBLISH-MESSAGE.
     05  PM-USER-DATA            PIC X(100) VALUE SPACES.
     05  PM-NUMBER               PIC 9(7) VALUE ZEROS.
     05  PM-TOPIC                PIC X(48) VALUE SPACES.
 01  STATUS-MESSAGE.
     05  FILLER                  PIC X(20)
              VALUE 'PUBLICATIONS MADE= '.
     05  SM-NUMBER               PIC 9(7) VALUE ZEROS.
     05  FILLER                  PIC X(20)
              VALUE ' FOR TOPIC = '.
     05  SM-TOPIC                PIC X(48) VALUE SPACES.
 01  MQMARKER                PIC X(20)
      VALUE 'START OF MQ STUFF'.
 01  STATUS-QUEUE-NAME             PIC X(48)
      VALUE 'QPUB.PUB.STATUS'.
 01  PUB-START-QUEUE               PIC X(48)
      VALUE 'QPUB.PUB.MESSAGE'.
 01  WORK-ERROR-MSG.
     05  ERR-FILLER1         PIC X(24)
         VALUE 'ERROR IN PROCESSING '.
     05  ERROR-REQUEST       PIC X(5).
     05  ERR-FILLER2         PIC X(24)
         VALUE ', RETURN CODE = '.
     05  ERR-RC              PIC 9(04).
     05  FILLER                  PIC X(55).
*
*    MQ WORK FIELDS
*
 01  FILLER PIC X(30) VALUE
           'TRIGGER MESSAGE = '.
 01  MQM-TRIGGER-MESSAGE.
     COPY CMQTMV.
 01  MQM-OBJECT-DESCRIPTOR.
     COPY CMQODV.
 01  MQM-MESSAGE-DESCRIPTOR.
     COPY CMQMDV.
 01  MQM-PUT-MESSAGE-OPTIONS.
     COPY CMQPMOV.
 01  MQM-GET-MESSAGE-OPTIONS.
     COPY CMQGMOV.
 01  MQM-CONSTANTS.
     COPY CMQV.
*
*    DFHAID CONTAINS THE CONSTANTS USED FOR CHECKING FOR
*    ATTENTION IDENTIFIERS
*
 COPY DFHAID SUPPRESS.
*
* ------------------------------------------------------------- *
 LINKAGE SECTION.
 01  DFHCOMMAREA        PIC X(600).
* ------------------------------------------------------------- *
*
 EJECT
* ------------------------------------------------------------- *
 PROCEDURE DIVISION.
```

```
* -------------------------------------------------------------- *
* -------------------------------------------------------------- *
 A-MAIN SECTION.
* -------------------------------------------------------------- *
*                                                              *
*  THIS SECTION INITIALIZES AND CONTROLS THE PROGRAM FLOW      *
*                                                              *
*  1) OPEN INPUT QUEUE AND RETRIEVE PUB CONTROL MESSAGE        *
*  2) SETUP CONTROL VALUES                                     *
*  3) OPEN OUTPUT STATUS QUEUE                                 *
*  4) OPEN TOPIC SPECIFIED IN CONTROL MESSAGE                  *
*  5) PUBLISH MESSAGES                                         *
*  6) FORMAT AND WRITE STATUS MESSAGE                          *
*  7) CLOSE TOPIC                                              *
*  8) CLOSE QUEUES                                             *
*  9) RETURN TO CICS                                           *
*                                                              *
* ------------------------------------------------------------ *
*
*    READ MESSAGE FROM THE PUBLICATION CONTROL QUEUE
*
* RETRIEVE THE TRIGGER MESSAGE TO GET QUEUE NAME
*
*
     EXEC CICS RETRIEVE
               INTO(MQTM)
     END-EXEC.
*
*    OPEN THE QUEUE
*
     MOVE MQOT-Q         TO  MQOD-OBJECTTYPE.
     MOVE MQTM-QNAME     TO  MQOD-OBJECTNAME.
     IF MQOD-OBJECTNAME IS EQUAL TO SPACES THEN
         MOVE PUB-START-QUEUE TO MQOD-OBJECTNAME.
     IF MQTM-ENVDATA IS EQUAL TO SPACES OR LOW-VALUES
         THEN NEXT SENTENCE
         ELSE MOVE MQTM-ENVDATA TO STATUS-QUEUE-NAME.
     IF MQTM-USERDATA IS EQUAL TO SPACES OR LOW-VALUES
         THEN MOVE 'NO USER DATA PROVIDED' TO PM-USER-DATA
         ELSE MOVE MQTM-USERDATA TO PM-USER-DATA
         END-IF.
*
*    INITIALIZE OPTIONS AND OPEN THE INPUT QUEUE
*
     COMPUTE OPENOPTIONS-PC  = MQOO-INPUT-SHARED +
                MQOO-FAIL-IF-QUIESCING.
*
     CALL 'MQOPEN' USING HCONN
                         MQOD
                         OPENOPTIONS-PC
                         HOBJ-PUB-CONTROL
                         COMPCODE
                         REASON.
*
*    TEST THE OUTPUT FROM THE OPEN, IF
*    NOT OK THEN EXIT PROGRAM
*
     IF COMPCODE NOT = MQCC-OK THEN
         GO TO OPEN-PC-ERROR-EXIT.
*
*  GET THE PUBLISH CONTROL RECORD
*
*
     COMPUTE MQGMO-OPTIONS  =  MQGMO-NO-SYNCPOINT +
                               MQGMO-CONVERT +
                               MQGMO-WAIT    +
                               MQGMO-FAIL-IF-QUIESCING.
     MOVE WAIT-INTERVAL     TO MQGMO-WAITINTERVAL.
*
*    SET CORRELID IN MD TO MESSAGE ID FROM MQPUT
*
     MOVE MQMD-MSGID TO MQMD-CORRELID.
     MOVE MQCI-NONE  TO MQMD-MSGID.
     MOVE LENGTH OF PUB-CONTROL-MESSAGE TO BUFFLEN.
*
     CALL 'MQGET' USING HCONN,
                        HOBJ-PUB-CONTROL,
                        MQMD,
                        MQGMO,
                        BUFFLEN,
                        PUB-CONTROL-MESSAGE,
                        DATALEN,
                        COMPCODE,
                        REASON.
*
     IF (COMPCODE NOT = MQCC-OK) THEN
         MOVE 'MQGET'  TO ERROR-REQUEST
         MOVE REASON  TO ERR-RC
*         MOVE WORK-ERROR-MSG TO OUTPUT-MSG
         GO TO MQGET-PC-ERROR-EXIT
```

```
           END-IF.
      *
           IF NUMBER-OF-PUBS = ZERO
              MOVE +1 TO PUB-LOOP-CONTROL
           ELSE
              MOVE NUMBER-OF-PUBS TO PUB-LOOP-CONTROL
           END-IF.

           MOVE TOPIC-OBJECT TO TOPIC-NAME.
           IF TOPIC-NAME = SPACES
              MOVE 'SYSTEM.DEFAULT.TOPIC' TO TOPIC-NAME
           END-IF.
           MOVE TOPIC-STRING TO TOPIC-STR.
      *
      *    OPEN THE TOPIC
      *
           MOVE MQOT-TOPIC     TO  MQOD-OBJECTTYPE.
      *
      *    FIRST TEST - ONLY TOPIC OBJECT IS SPECIFIED
      *
           MOVE TOPIC-NAME     TO MQOD-OBJECTNAME.
      *
      *    INITIALIZE OPTIONS AND OPEN THE INPUT QUEUE
      *
           COMPUTE OPENOPTIONS-PUBLISH = MQOO-OUTPUT +
                      MQOO-FAIL-IF-QUIESCING.
      *
           CALL 'MQOPEN' USING HCONN
                               MQOD
                               OPENOPTIONS-PUBLISH
                               HOBJ-PUB-MSGS
                               COMPCODE
                               REASON.
      *
      *    TEST THE OUTPUT FROM THE OPEN, IF
      *    NOT OK THEN EXIT PROGRAM
      *
           IF COMPCODE NOT = MQCC-OK THEN
               GO TO OPEN-TOPIC-ERROR-EXIT.

           MOVE MQMI-NONE TO MQMD-MSGID.
           MOVE MQCI-NONE TO MQMD-CORRELID.
           MOVE MQPER-PERSISTENT TO MQMD-PERSISTENCE.
           COMPUTE MQPMO-OPTIONS = MQPMO-NO-SYNCPOINT +
                        MQPMO-NEW-MSG-ID +
                 MQPMO-NEW-CORREL-ID +
                 MQPMO-FAIL-IF-QUIESCING.
      MOVE LENGTH OF PUBLISH-MESSAGE TO BUFFLEN.
      MOVE TOPIC-NAME TO PM-TOPIC.
      PERFORM PUBLISH-LOOP THRU PUBLISH-LOOP-EXIT
           UNTIL NUMPUBS IS EQUAL TO PUB-LOOP-CONTROL.
*
*
*     OPEN THE STATUS QUEUE
*
      MOVE MQOT-Q         TO  MQOD-OBJECTTYPE.
      MOVE STATUS-QUEUE-NAME TO MQOD-OBJECTNAME.
*
      COMPUTE OPENOPTIONS-STATUS = MQOO-OUTPUT +
                 MQOO-FAIL-IF-QUIESCING.
*
      CALL 'MQOPEN' USING HCONN
                          MQOD
                          OPENOPTIONS-STATUS
                          HOBJ-PUB-STATUS
                          COMPCODE
                          REASON.
*
*     TEST THE OUTPUT FROM THE OPEN, IF
*     NOT OK THEN EXIT PROGRAM
*
      IF COMPCODE NOT = MQCC-OK THEN
          GO TO OPEN-STAT-ERROR-EXIT.
      MOVE MQMI-NONE TO MQMD-MSGID.
      MOVE MQCI-NONE TO MQMD-CORRELID.
      COMPUTE MQPMO-OPTIONS = MQPMO-NO-SYNCPOINT +
                 MQPMO-NEW-MSG-ID +
                 MQPMO-NEW-CORREL-ID +
                 MQPMO-FAIL-IF-QUIESCING.
      COMPUTE SM-NUMBER = PUB-LOOP-CONTROL.
      MOVE TOPIC-NAME TO SM-TOPIC.
      MOVE LENGTH OF STATUS-MESSAGE TO BUFFLEN.
      CALL 'MQPUT' USING HCONN
                         HOBJ-PUB-STATUS
                         MQMD
                         MQPMO
                         BUFFLEN
                         STATUS-MESSAGE
                         COMPCODE
                         REASON.
      GO TO  A-CLOSE-QUEUE.
*
 OPEN-PC-ERROR-EXIT.
      MOVE 'QPU1' TO ABEND-CODE.
      GO TO ALL-ABENDS.
 OPEN-TOPIC-ERROR-EXIT.
      MOVE 'QPU2' TO ABEND-CODE.
      GO TO ALL-ABENDS.
 MQGET-PC-ERROR-EXIT.
      MOVE 'QPU3' TO ABEND-CODE.
      GO TO ALL-ABENDS.
 OPEN-STAT-ERROR-EXIT.
      MOVE 'QPU4' TO ABEND-CODE.
      GO TO ALL-ABENDS.
 ALL-ABENDS.
      EXEC CICS ABEND ABCODE(ABEND-CODE) NODUMP END-EXEC.
      GO TO A-MAIN-EXIT.
 A-CLOSE-QUEUE.
      PERFORM CLOSE-QUEUES.
 A-MAIN-EXIT.
*
* RETURN TO CICS
*
     EXEC CICS RETURN
     END-EXEC.
*
     GOBACK.
     EJECT
 PUBLISH-LOOP SECTION.
*
     ADD +1 TO NUMPUBS.
     COMPUTE PM-NUMBER = NUMPUBS.
     CALL 'MQPUT' USING HCONN
                        HOBJ-PUB-MSGS
                        MQMD
                        MQPMO
                        BUFFLEN
                        PUBLISH-MESSAGE
                        COMPCODE
                        REASON.
 PUBLISH-LOOP-EXIT.
     EXIT.
*
*    RETURN TO PERFORMING SECTION
*
```

```
     EJECT
 CLOSE-QUEUES SECTION.
* ------------------------------------------------------------- *
*                                                               *
* THIS SECTION CLOSES THE OUTPUT AND INPUT QUEUES               *
*                                                               *
* ------------------------------------------------------------ *
*
     CALL 'MQCLOSE' USING HCONN
                          HOBJ-PUB-CONTROL
                          MQCO-NONE
                          COMPCODE
                          REASON.
*
     CALL 'MQCLOSE' USING HCONN
                          HOBJ-PUB-MSGS
                          MQCO-NONE
                          COMPCODE
*
     CALL 'MQCLOSE' USING HCONN
                          HOBJ-PUB-STATUS
                          MQCO-NONE
                          COMPCODE
                          REASON.
*
 CLOSE-QUEUES-EXIT.
     EXIT.
*
*    RETURN TO PERFORMING SECTION
*
     EJECT
*
* ------------------------------------------------------------- *
 MQ-ERROR SECTION.
*
 MQ-ERROR-EXIT.
*
*    RETURN TO PERFORMING SECTION
*
     EXIT.
     EJECT
*
* ------------------------------------------------------------- *
*
* ------------------------------------------------------------- *
*                   END OF PROGRAM                              *
* ------------------------------------------------------------- *
```

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks

For information about ordering these publications, see “How to get Redbooks” on page 248. Note that a few of the documents referenced here might be available in softcopy only.

- *Parallel Sysplex Application Considerations*, SG24-6523
- *High Availability z/OS Solutions for WebSphere Business Integration Message Broker V5*, REDP-3894
- *TCP/IP in a Sysplex*, SG24-5235
- *WebSphere Application Server Network Deployment V6: High Availability Solutions*, SG24-6688

Other publications

These publications are also relevant as further information sources:

- *Setting Up a Sysplex*, SA22-7625
- *RMF Report Analysis*, SC33-7991.

Online resources

These Web sites are also relevant as further information sources:

- HACMP library

  http://www.ibm.com/servers/eserver/pseries/library/hacmp_docs.html
- IBM Tivoli System Automation for Multiplatforms Guide and Reference

  http://publib.boulder.ibm.com/tividd/td/ITSAFL/SC33-8210-03/en_US/PDF/halgre11.pdf
- IBM Smart Business: Cloud Computing

  http://www.ibm.com/ibm/cloud/
- SOAP nodes in IBM WebSphere Message Broker V6.1, Part 1: SOAP node basics

  http://www.ibm.com/developerworks/webservices/library/ws-soapnode/

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IBM Redbooks

High Availability in WebSphere Messaging Solutions

(0.2”spine)
0.17”<->0.473”
90<->249 pages

High Availability in WebSphere Messaging Solutions

Design solutions for high availability

Use WebSphere features to increase availability

Use PowerHA clusters to increase availability

This IBM Redbooks publication is for anyone needing to increase WebSphere messaging availability, especially people interested in the new capabilities of WebSphere MQ and WebSphere Message Broker. It discusses and demonstrates solutions to provide high availability for WebSphere Messaging solutions. For the distributed platforms, this ranges from the traditional PowerHA for AIX to the new WebSphere MQ multi-instance queue managers and WebSphere Message Broker multi-instance brokers. For the appliance users, we included solutions for WebSphere DataPower. For enterprises that need continuous availability of WebSphere MQ messages, MQ Queue Sharing Groups and the CICS Group Attach features are demonstrated.

The book includes guidance on HA options, such as when you might need PowerHA (or a similar solution for your platform), when the multi-instance features work for your applications, and when duplexing the coupling facility structures might be appropriate.

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