MQ Clustering 101

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TABLE OF CONTENTS

1 Conventions used

Throughout this document formatting has been used to indicate the following to the reader:

- Important notes are in ***bold italics***
- Definitions and specific new terms are in *italics*
- MQ MQSC commands, objects, and API calls are in **BOLD UPPERCASE**.
- URLs, FTP and email addresses are in blue when displayed from a monitor. For print, http:// always proceeds a URL, ftp:// always proceeds an FTP address, and mailto: always proceeds an email address.

2 Audience

This document will be useful for both MQ developers who are implementing an MQ cluster, as well as system architects and designers.

3 Introduction to MQ Clustering

3.1 What is a cluster?

Clustering is not a new concept. Clustering in its simplest form, means logically grouping 2 or more components and making them appear as one to a consumer of the components. Two forms of clustering exist; shared, and shared-nothing.

A shared cluster generally involves creating redundant, shareable components for the purpose of high availability, fault tolerance, and load balancing. Typically, system resources that can be shared include disk storage and CPU/applications. When disk storage is clustered, the operating system must manage locking conditions across the CPUs to maintain the integrity of the data being accessed. This is no simple task, and is the reason many vendors provide only shared-nothing clustering solutions.

A shared-nothing cluster (such as Microsoft’s Cluster Server) does not share any components, but usually involves replication of data (in a timely manner) that can be used by a hot standby system/application. In this scenario, clustering provides fail-over capabilities, but not load-balancing.

Digital Equipment Corporation (DEC), now a division within COMPAQ has produced shared clustered systems since the mid-1980s. These systems typically provide redundant CPU, disk subsystem, operating system, and applications. The idea is that if any one of these components fail, and alternate path survives to provide a relatively transparent fail over to the users. The two key components to this architecture are a high-speed computer-interconnect bus that allows the processors to communicate very quickly with one another, and hierarchical storage controllers with dual-ported disks to provide the concurrent access to shared storage.

Clustered applications in a shared-nothing environment are a little different than their shared cluster counterparts. Since no common data is shared among the applications, each instance of the application has access to a replicated copy of configuration and/or production data. MQ clustering works on this concept of replicated data. MQ object definitions are stored in a repository queue and replicated, either in a full or partial, to replication partners known as repository queue managers. We’ll discuss the components later.

3.2 Clustering versus Distributed Queuing

Clustering offers several benefits over distributed queuing. By clustering and sharing data, the MQ network becomes more dynamic and more manageable. As your MQ network grows, the risk of errors increases, and the flexibility decreases. With clustering however, the risk of errors can be greatly reduced, while maintaining the flexibility to modify your configuration on the fly.

Clustering also provides a simple way to provide fault-tolerance and high availability. The product provides built-in, customizable logic for routing messages to destination queues. You can use the default method for message distribution, or create customized '*workload exits*' for advanced routing algorithms.

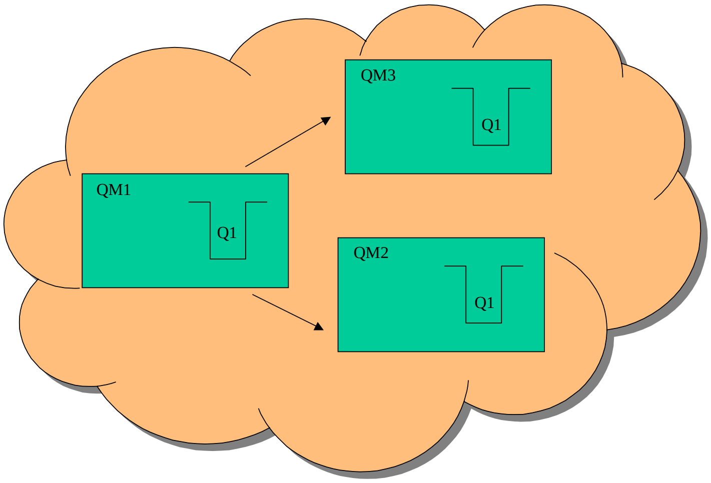
In a distributed queuing architecture, this logic has to be coded into the applications that are sending the messages. In addition, error-handling routines need to be developed to manage the condition where one or more queue managers become unavailable. Furthermore, additional code is needed to recognize when these unavailable queue managers become available once again.

MQ clustering will dynamically create and destroy certain objects as needed, further increasing the ease of management. Specifically, the channel definitions to/from cluster queue managers are created automatically – however, the first channel pair must be defined manually. These are known as Cluster Sender (**CLUSSDR**) and Cluster receiver (**CLUSRCVR**) channels. As with all MQ implementations, all channels are uni-directional and therefore require this pairing.

Perhaps the best feature of MQ clustering is that existing applications do not need to be modified in order to benefit from the features of clustering. The entire cluster configuration is handled at the administration layer – entirely transparent from users and applications.

3.2.1 Load Balancing and Performance

MQ clustering provides essential load-balancing features by providing a default method for identifying target queues. Consider the following diagram:



Cluster Workload Management Algorithm

An application running on QM1 needs to put a message to Q1. But which queue will be the target? In this case, Q1 on QM1 will always be used.

MQ clustering uses a *workload management algorithm*, which operates according to the following rules:

1. If a local queue exists, the message will always be sent to the local queue. That is, a queue managed by the same queue manager that is putting the message;
2. If multiple instances of the queue are available, but only on non-local queue managers, then a round robin approach is used. The state of each sender channel, as well as the priority associated with the channel (**NETPRTY** channel attribute) is used in determining which queue is selected first;
3. If an attempt fails to put the message to the selected target queue, each alternate target is attempted in succession;
4. If all target queues fail, then the message is sent to the deal letter queue.

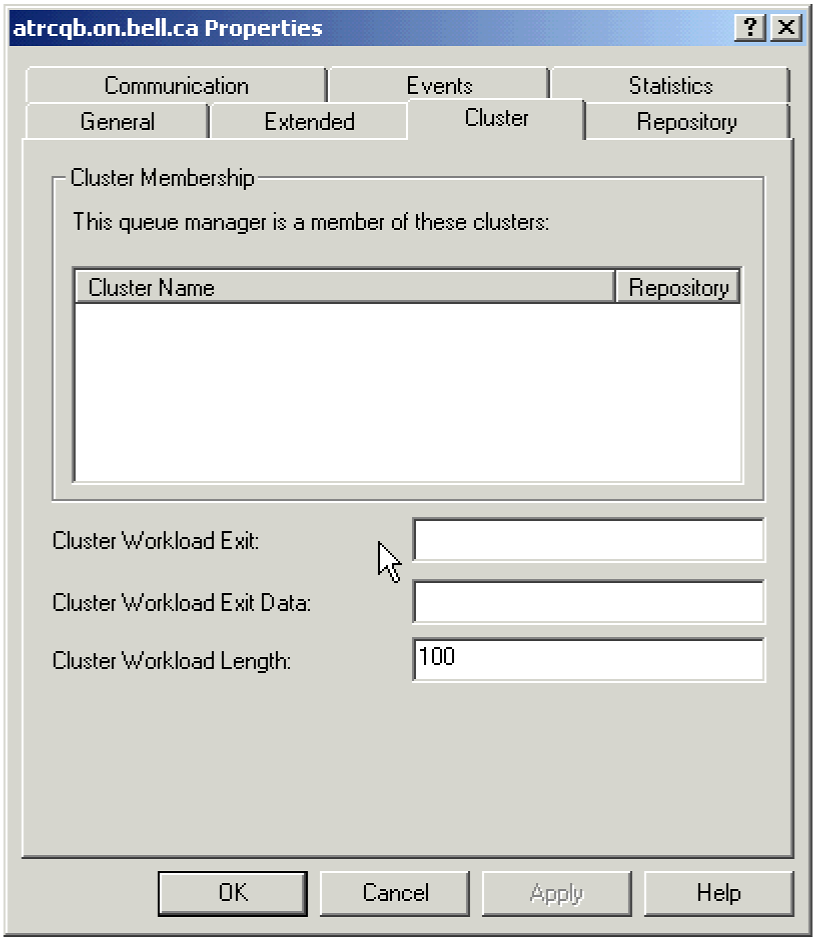
Cluster Workload Exits

In addition to the *workload management algorithm*, you can customize how workload is distributed using *cluster workload exits.* There are many reasons you may need to customize. For example:

- If you need to determine which channels use a high-speed connection in order to favor that channel;
- Perhaps application performance is your primary concern and you want to send messages to the least busy processor;
- What if your data is partitioned? You may have the same application running on QM1 and QM2, but each instance is responsible for a certain range of data, like customer identifier. Your workload exit could examine the message data first, and then route to the application that handles that specific customer;
- Perhaps the previous applications are designated by a quality of service (QOS) and high-value customers requests need to be routed to the system running the more reliable or faster instance of the application.

Cluster workload exits are called at open or put time. That is, when the sending application calls **MQPUT**, **MQPUT1**, or **MQOPEN**. ***Note: Only one cluster workload exist can be defined for a given queue manager.***

To define a workload exit, go to the properties sheet of the queue manager from MQ Explorer as shown in Figure 1. Enter the *cluster workload exist* name, the *cluster workload data* (user data contained in a maximum 32-character field), and the *cluster workload length* (This is the maximum length of the message data passed to the cluster workload exit. The actual length of data passed to the exit is the minimum of: the length of the message, the queue-manager's *MaxMsgLength* attribute, and the *cluster workload length*).



This queue manager is a member of these clusters:

Cluster Workload Exit:

Cluster Workload Exit Data:

Cluster Workload Length: 100

Figure 1

3.2.2 High Availability

By implementing an architecture with multiple instances of a cluster queue, higher availability can be realized. As previously mentioned, the *cluster workload algorithm* contains built-in recovery mechanisms to accommodate situations where messages cannot be routed to a specific target cluster queue. The default mechanism will successively attempt to route the message to any available target queue based on channel priority (NETPRTY channel attribute) and status. Of course, you can write your own cluster workload exits to handle this scenario as well.

In a distribute queuing environment, these types of failures would result in the message being routed to the dead letter queue, where some cleanup application would need to take some form of corrective action. The cluster workload algorithm thus provides high availability by having messages processed by alternate means. It is recommended that the redundant target cluster queues be placed on separate nodes, in order to increase the availability. This will ensure that messages will continue to be processed, even in the event that a destination queue manager fails. Placing all of your target queues on a single node would not provide high availability in the event of a queue manager or system failure, but only that of a queue failure.

Duplication of the cluster repository also provides for high-availability. IBM recommends at least 2 queue managers in the cluster are designated as full cluster repository queue managers. As we'll see in later articles, the management of the cluster repositories is critical in ensuring high availability of your cluster.

3.2.3 Simplified Management

Any MQ administrator will agree that managing the MQ objects in a complex network can be very cumbersome, especially without a 3rd part management tool such as Candle Command Center, or Tivoli's MQ. The fewer the objects, the easier it is to manage both a static MQ network, and a growing one.

Including remote queue definitions, a simple MQ network with 4 Queue Managers with two local queues would require a minimum of 68 objects to be defined, broken down as:

- 3 sender channels per queue manager (12 total);
- 3 receiver channels per queue manager (12 total);
- 3 transmission queues per queue manager (12 total);
- 2 local queue definitions per queue manager (8 total);
- 6 remote queue definitions per queue manager (24 total).

In a clustered environment, the number of objects to be defined is reduced to 16. This is due to the fact that only one cluster sender and cluster receiver channel is needed, and no transmission queues or remote queue definitions are necessary. Therefore the only objects required are:

- 1 cluster sender channel per queue manager (4 total);
- 1 cluster receiver channel per queue manager (4 total);
- 2 local queue definitions per queue manager (8 total).

With this type of configuration, the risk of making errors in defining transmission queues and remote queue definitions is eliminated.

3.2.4 Dynamic Object Creation

MQ clustering will automatically create and destroy certain objects, as they are needed for clustering. The two type of objects created are cluster channels and cluster queues.

Channels

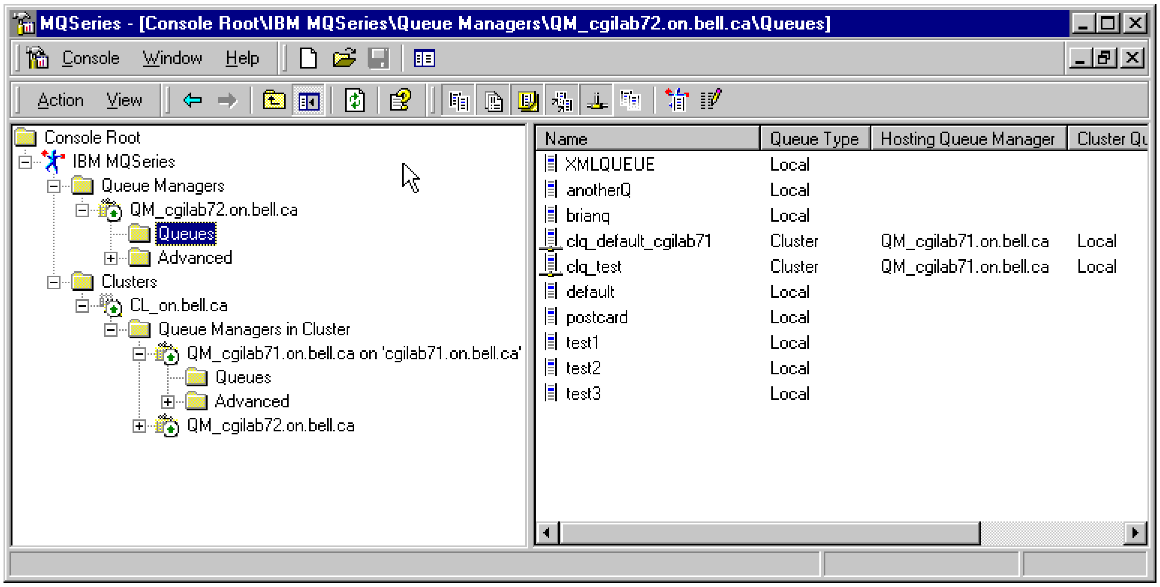
MQ clustering relieves some of the burden of managing channels. In studies performed by IBM, channels were the number 1 cause of administrative frustration. To reduce the level of aggravation and the risk of errors through incorrect channel declaration, clustering requires only 2 channels to be defined on each queue manager:

- 1 cluster receiver channel (CLUSRCVR);
- 1 cluster sender channel (CLUSSDR).

Once these channels are defined, MQ will automatically create any subsequent channels to other queue managers in the cluster. For instance, in our diagram, if QM1 needed to send a message to QM3/Q1, but had only been defined with sender/receiver channels to QM2, the sender/receiver channels to QM3 would automatically be created. The attributes of these channels are taken from the cluster sender/receiver channels on the destination queue manager (QM3 in this case).

Remote Queues

Queues defined as cluster queues are automatically made available to all queue managers in the cluster. What happens locally is that MQ dynamically creates a remote queue definition on the local queue manager. These queues can be displayed using MQ Explorer and will appear as “local cluster queues”. The queue clq_test in Figure 2 is a local cluster queue on QM_cgilab72.on.bell.ca that is hosted by the QM_cgilab71.on.bell.ca queue manager.

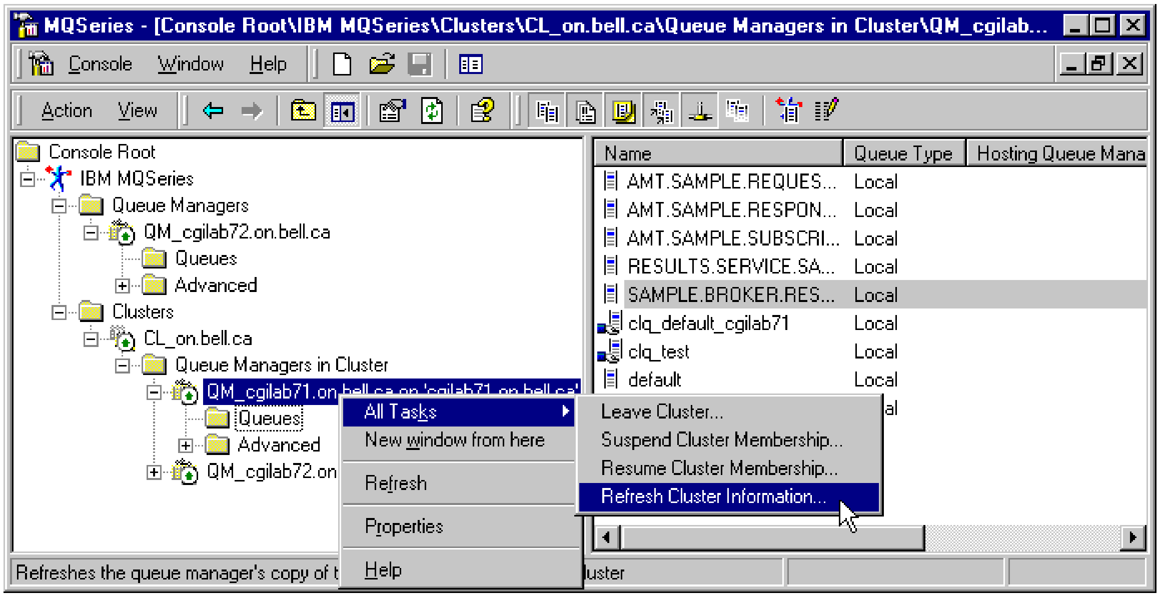


Name	Queue Type	Hosting Queue Manager	Cluster Qu
XMLQUEUE	Local		
anotherQ	Local		
brianq	Local		
clq_default_cgilab71	Cluster	QM_cgilab71.on.bell.ca	Local
clq_test	Cluster	QM_cgilab71.on.bell.ca	Local
default	Local		
postcard	Local		
test1	Local		
test2	Local		
test3	Local		

Figure 2

Removal of Dynamic Objects

These objects will be automatically destroyed after a period of inactivity. However, you can refresh the local queue manager repository information using MQ Explorer as shown in Figure 2. This will destroy and recreate the automatically defined cluster channels and cluster queue definitions on the local machine. You can also see the local shared cluster queues in Figure 2 (clq_test and clq_default_cgilab71) that have been manually created on QM_cgilab71.on.bell.ca.



MQSeries - [Console Root\IBM MQSeries\Clusters\CL_on.bell.ca\Queue Managers in Cluster\QM_cgilab...

Name	Queue Type	Hosting Queue Mana
AMT.SAMPLE.REQUES...	Local	
AMT.SAMPLE.RESPON...	Local	
AMT.SAMPLE.SUBSCRI...	Local	
RESULTS.SERVICE.SA...	Local	
SAMPLE.BROKER.RES...	Local	
clq_default_cgilab71	Local	
clq_test	Local	
default	Local	
	al	

Refreshes the queue manager's copy of t

Figure 3

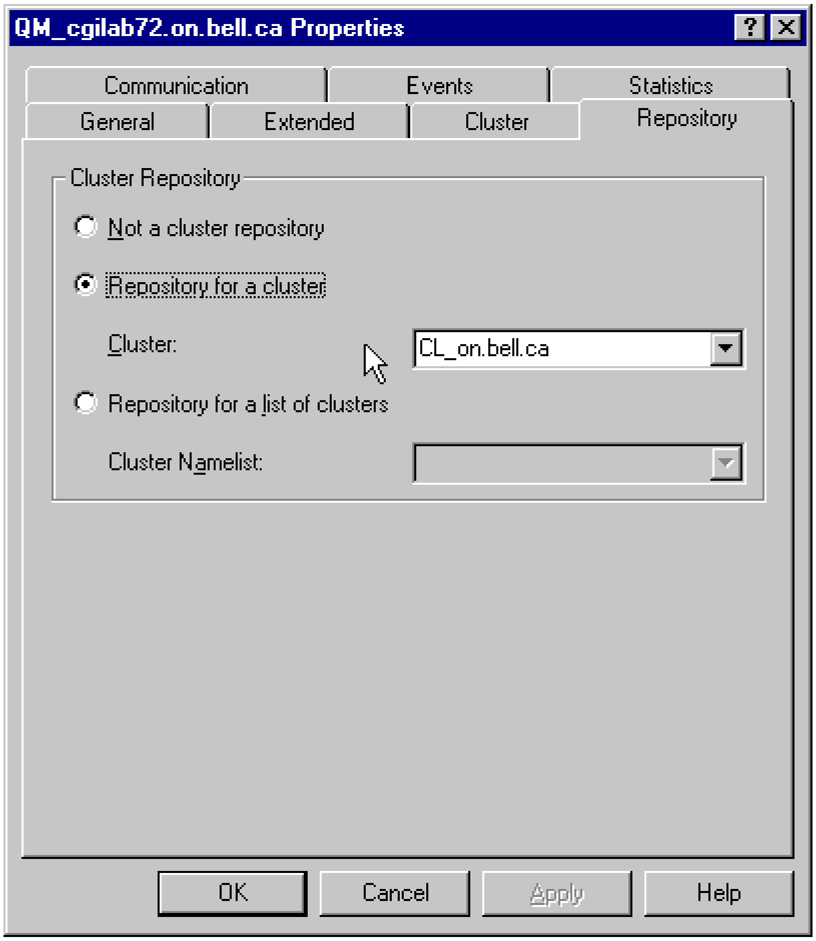
3.3 MQ Clustering Components

3.3.1 Repository Queue Managers

Repository queue managers are the keepers of cluster information. At least 2 repository queue managers should be defined in a cluster for availability purposes. A cluster queue manager can be designated as either a FULL or PARTIAL repository. A FULL repository contains information about all the queue managers in a cluster, including the queue manager names, locations, their channels, what queues they host, etc. A PARTIAL repository is held by all non-FULL repository queue managers in a cluster, and contains only information about queue managers that the local system needs to exchange messages with.

Cluster repository information is retained and managed within a local system queue know as the SYSTEM.CLUSTER.REPOSITORY.QUEUE. The cluster repository information is replicated as it changes. The SYSTEM.CLUSTER.COMMAND.QUEUE is used to send/receive repository updates from repository queue managers. This information can be refreshed, as in Figure 2.

To define a queue manager as a repository queue manager, open MQ Explorer and right click on the queue manager. Then select properties, and choose the Repository tab. Select the radio button ‘Repository for a cluster’ and enter the name of the cluster, as shown in Figure 3.



Cluster Repository

○ Not a cluster repository

● Repository for a cluster

Cluster: CL_on.bell.ca

○ Repository for a list of clusters

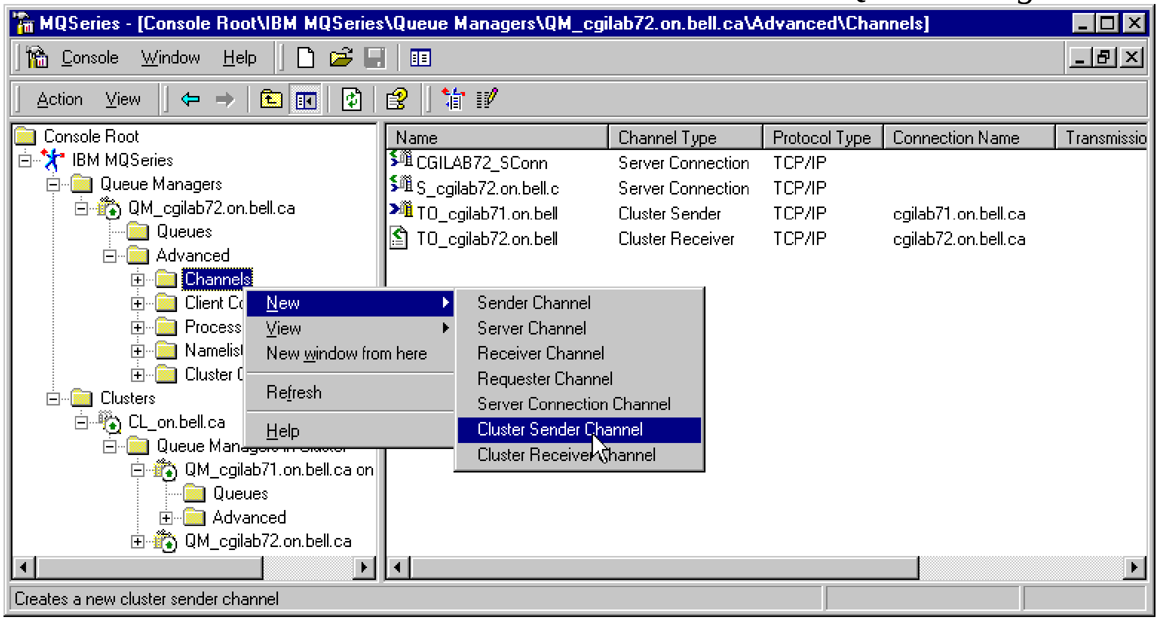
Cluster Namelist:

Figure 4

3.3.2 Cluster Channels (Sender-Receiver)

Cluster channels are used by cluster queue managers to exchange messages between one another. A minimum of 2 channels are needed, a cluster sender (CLUSSDR) and a cluster receiver (CLUSRCVR). It is important to note than the channel pair names must match. That is, the CLUSSDR channel name on QM1 must match the corresponding CLUSRCVR channel name on QM2.

To define a cluster channel, use the MQ Explorer and right click on Channels..New as shown in Figure 5.



Name	Channel Type	Protocol Type	Connection Name	Transmissio
CGILAB72_SConn	Server Connection	TCP/IP		
S_cgilab72.on.bell.c	Server Connection	TCP/IP		
TO_cgilab71.on.bell	Cluster Sender	TCP/IP	cgilab71.on.bell.ca	
TO_cgilab72.on.bell	Cluster Receiver	TCP/IP	cgilab72.on.bell.ca	

Creates a new cluster sender channel

Figure 5

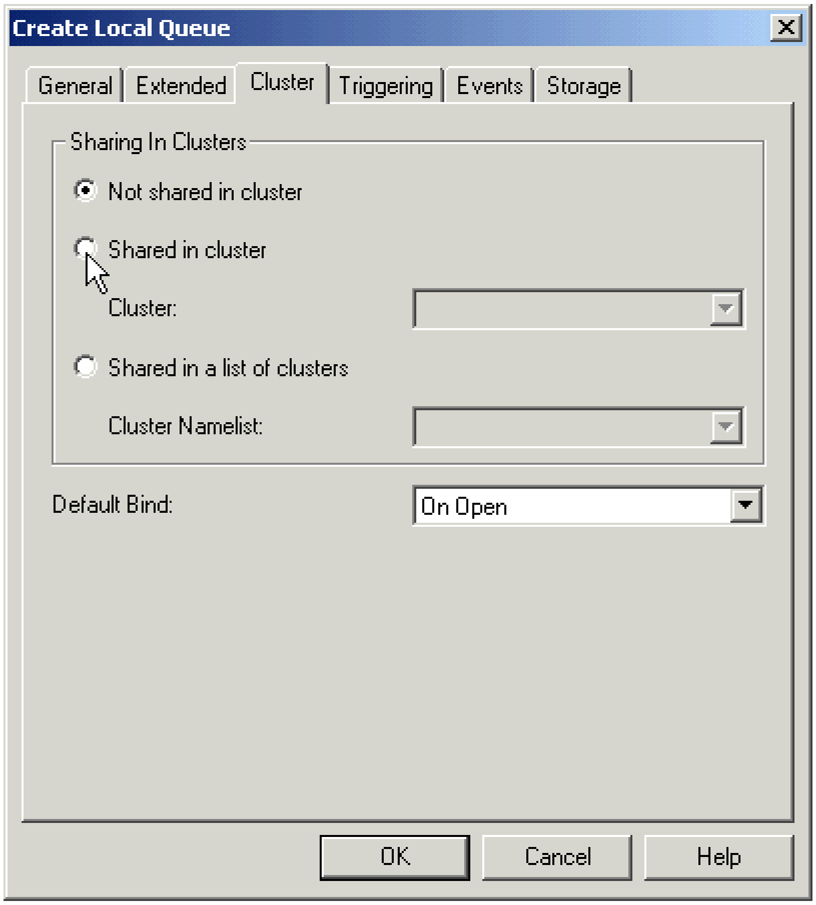
As a minimum, you must supply the channel name, the connection name, and the transport type. Valid transport types for WindowsNT are TCP/IP, NetBIOS, IPX, or LU6.2. On the ‘new cluster sender channel’ properties sheet, select the ‘cluster’ tab to share the channel in the cluster, and to set the priority (NETPRTY).

MQ will automatically define any additional cluster channels needed. This is the default, unlike other channels that MQ can create automatically (i.e. Server Connection channels).

3.3.3 Cluster Queues (Local and Transmission)

Cluster queues are either defined by users, as in the case of local cluster queues, or automatically in the case of cluster transmission queues.

To create a cluster queue, you must first create a local queue on the queue manager that will host the queue. By selecting ‘Share in Cluster’ or ‘Share in a list of clusters’ (and selecting the cluster name – or namelist) as shown in Figure 6, you can share this queue in the cluster(s).



Create Local Queue

Sharing In Clusters

● Not shared in cluster

○ Shared in cluster

Cluster:

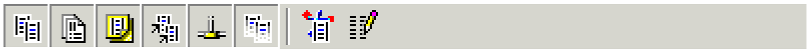
○ Shared in a list of clusters

Cluster Namelist:

Default Bind: On Open

Figure 6

To view cluster queues within MQ Explorer, you must first click the “Show/Hide Cluster Queues” toggle button on the toolbar, shown below as the 5th icon from the left.



In addition, a system default ‘cluster transmission queue’ called **SYSTEM.CLUSTER.TRANSMIT.QUEUE** is automatically created when you create a new queue manager. This queue is similar to the user-defined default transmission queue, but takes precedence over it in cases where the target queue is resolved via the repository.

3.3.4 NameList

A namelist can be used to define a group of clusters. This would typically be used when defining a queue manager that will host repositories for multiple clusters. In order to specify that the queue manager will be a repository queue manager for a list of clusters, use the properties sheet for the queue manager and select the “Repository for a list of Clusters’ radio button as shown in Figure 4. Additionally, queues can be shared in a list of clusters also, as shown in Figure 6.

To create a namelist, right click the Namelist folder in MQ Explorer as shown in Figure 7.

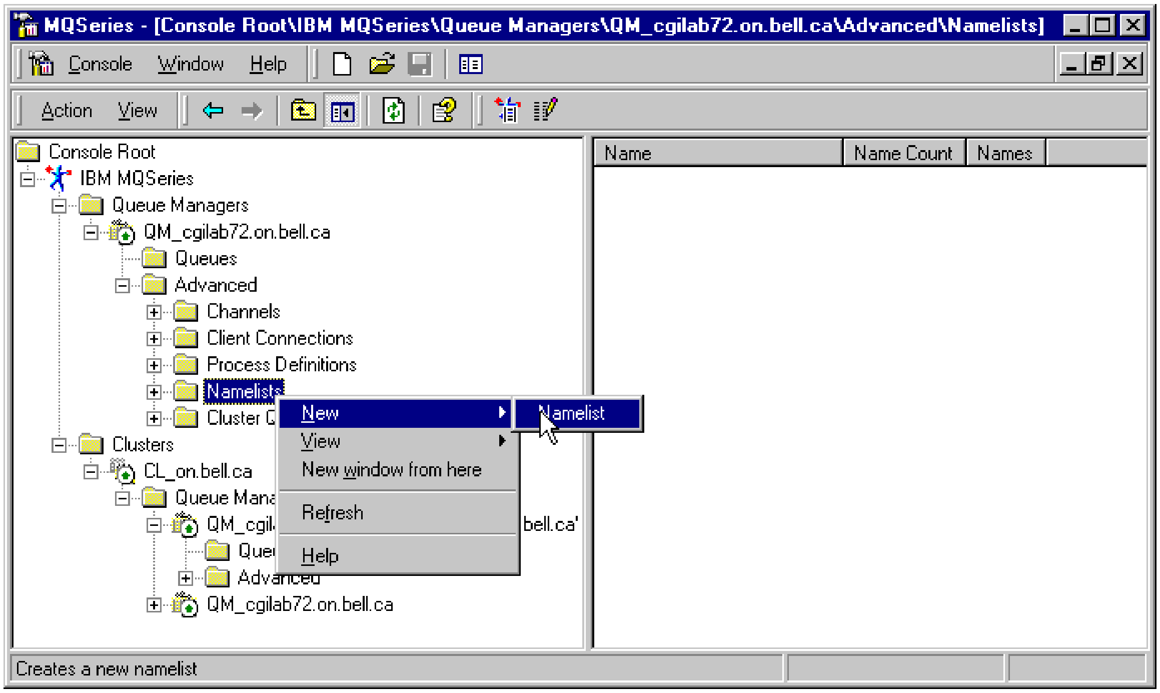


Figure 7

3.3.5 The default cluster objects summary

As with any MQ installation, several default objects are created when you create the queue manager. Most of these have previously been discussed. Here is a synopsis of the system cluster objects:

SYSTEM.CLUSTER.REPOSITORY.QUEUE – the queue that holds repository information;
SYSTEM.CLUSTER.COMMAND.QUEUE – the queue used to send repository update messages;
SYSTEM.CLUSTER.TRANSMIT.QUEUE – the default cluster transmission queue;
SYSTEM.DEF.CLUSSDR – the default definition for a cluster sender channel;
SYSTEM.DEF.CLUSRCVR – the default definition for a cluster receiver channel.

In order to display the system objects within MQ Explorer, you must click on the “Display System Objects” Icon on the toolbar; show below as the second icon from the right.