Keeping Your MQ Service Up and Running Queue Manager Clustering

[z/OS & distributed]

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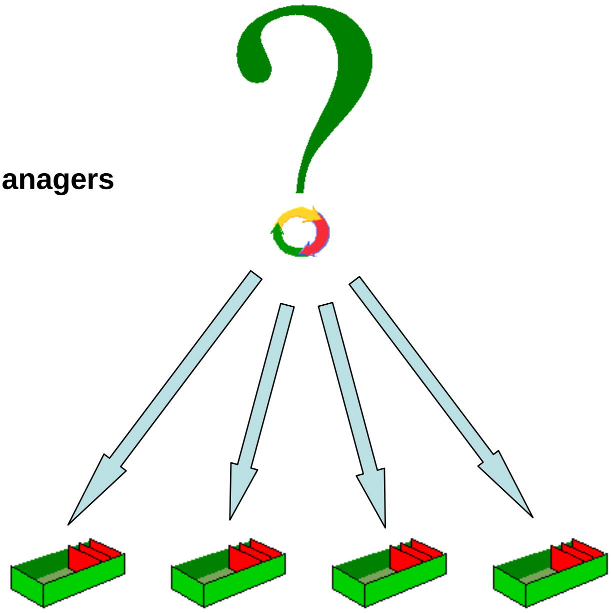
(Session # 9516)

Agenda

- The purpose of clustering
- Defining a cluster
  - Clustering concepts
  - Defining and checking cluster queue managers
- Lifting the Lid on Clustering
  - Initial Definitions
  - First MQOPEN
- Workload Balancing
  - The WLM algorithm in depth
- Pub/Sub Clusters
- Further Considerations
  - RESET, REFRESH
- Recommendations



What are clusters?

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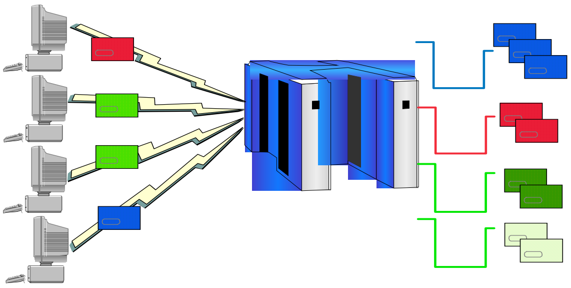
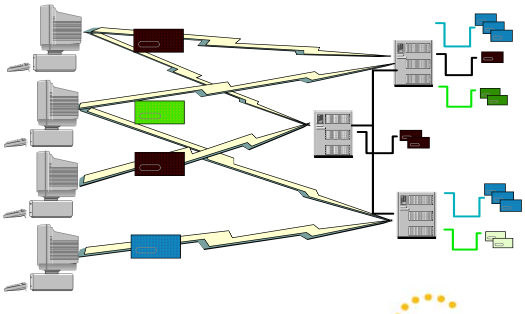
- The term clusters means has different meaning for different people as there are a large number of technologies that use the term and a large number of products that offer “clustering”.
- Clustering is usually associated with parallel processing or high availability technologies.
- There exist many different types of parallel processing architectures. The amount of symmetry between the processing nodes varies between architectures.
- Although WMQ clustering does provide a level of high availability, its raison d’etre is as a WMQ parallel processing feature.
- The most symmetric systems are similar to SP2. These are essentially a set of identical processors (RS/6000) connected together using a high speed switch which allows fast communication between the individual nodes.
- Systems like z/OS Parallel Sysplex consist of complexes of processors, each complex comprising numerous, but same type processors. The complex is connected together using a coupling facility, which, as well as allowing high speed communication, also allows efficient data sharing. Most parallel architectures do not have this type of data sharing capability.
- The most generalized parallel architectures involve processors of different types, running different operating systems connected together using different network protocols. This necessarily includes symmetric systems like SP2 and Parallel Sysplex.
- A WebSphere MQ cluster is most similar to the most generalized parallel architecture. This is because WebSphere MQ exploits a wide variety of platforms and network protocols. This allows WebSphere MQ applications to naturally benefit from clustering.
- WebSphere MQ clusters are solve a requirement to group queue managers together (i.e. to increase processing power of the WMQ network) whilst minimising the administration costs associated with WMQ queue manager intercommunication.

How can we process more messages?



- Single queue manager
  - Increase power of the machine
    - A machine to which processors, etc can be added to respond to increases in workload
    - Not realistic – Cost, locking, availability, etc



- Multiple queue managers
  - Add more queue managers
    - Add to what?
    - How are they grouped?
    - Intercommunication admin costs
    - Application development costs

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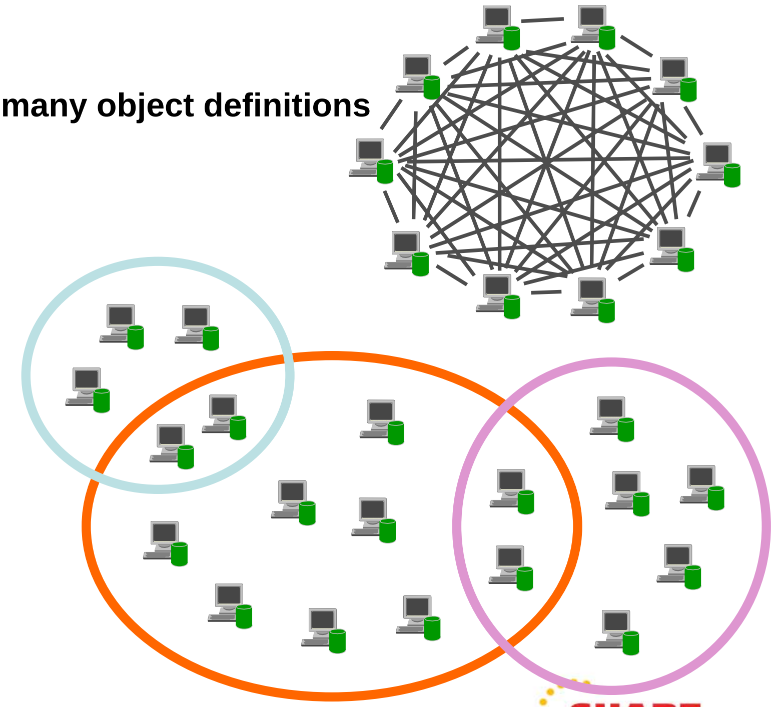
How can we process more messages?

NOTES

- It would be nice if we could place all the queues in one place. We could then add processing capacity around this single Queue manager as required and start multiple servers on each of the processors. We would incrementally add processing capacity to satisfy increased demand. We could manage the system as a single entity. A client application would consider itself to be talking to a single Queue manager entity.
- Even though this is highly desirable, in practice it is almost impossible to achieve. Single machines cannot just have extra processors added indefinitely. Invalidation of processor caches becomes a limiting factor. Most systems do not have an architecture that allows data to be efficiently shared between an arbitrary number of processors. Very soon, locking becomes an issue that inhibits scalability of the number of processors on a single machine. These systems are known as "tightly coupled" because operations on one processor may have a large effect on other processors in the machine cluster.
- By contrast, "loosely coupled" clusters (e.g. the Internet) have processors that are more or less independent of each other. Data transferred to one processor is owned by it and is not affected by other processors. Such systems do not suffer from processor locking issues.

The purpose of clustering

- Simplified administration
  - Large WMQ networks require many object definitions
    - Channels
    - Transmit queues
    - Remote queues
- Workload balancing
  - Spread the load
  - Route around failures
- Flexible connectivity
  - Overlapping clusters
  - Gateway Queue managers
- Pub/sub Clusters



How can we process more messages?

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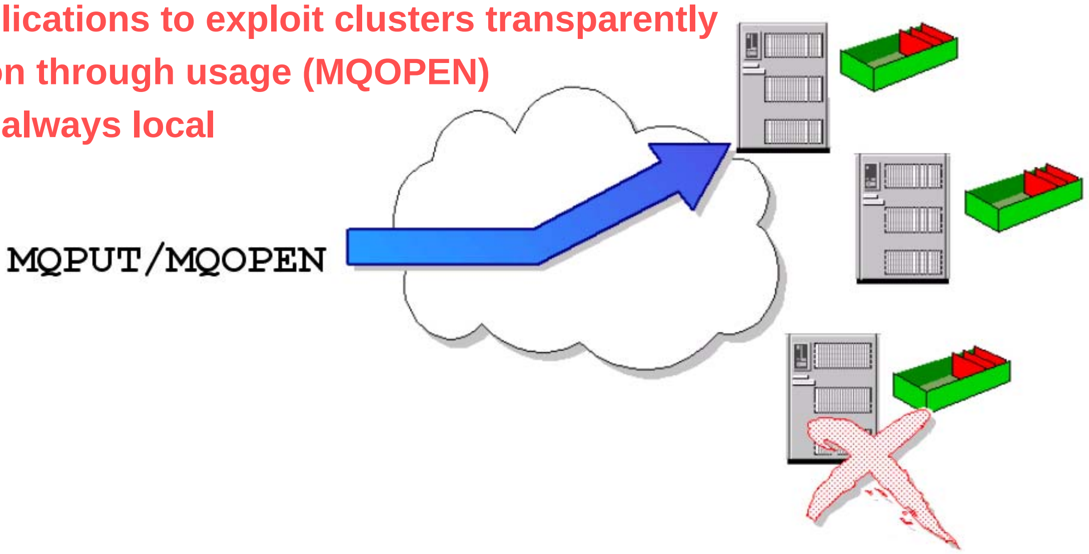
- In a cluster solution, there are multiple consumers of queues (client queue managers) and multiple providers of queues (server queue managers). In this model, for example, the black queue is available on multiple servers. Some clients use the black queue on both servers, other clients use the black queue on just one server.
- A cluster is a loosely coupled system. Messages flow from clients to servers and are processed and responses messages sent back to the client. Servers are selected by the client and are independent of each other. It is a good representation of how, in an organization, some servers provide many services, and how clients use services provided by multiple servers.
- The objective of WebSphere MQ clustering is to make this system as easy to administer and scale as the Single Queue Manager solution.

Goals of Clustering

- Multiple Queues with single image
- Failure isolation
- Scalable throughput
- MQI applications to exploit clusters transparently
- Definition through usage (MQOPEN)
- MQGET always local



Goals of Clustering

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- Consider a client using the black queue that is available in the cluster on three server queue managers. A message is MQPUT by the client and is delivered to *one* of the servers. It is processed there and a response message sent to a ReplyToQueue on the client queue manager.
- In this system, if a server becomes unavailable, then it is not sent any further messages. If messages are not being processed quickly enough, then another server can be added to improve the processing rate.
- It is important that both these behaviors are achieved by existing MQI applications, i.e. without change. It is also important that the administration of clients and servers is easy. It must be straight forward to add new servers and new clients to the server.
- We see how a cluster can provide a highly available and scalable message processing system. The administration point in processing is MQOPEN as this is when a queue or queue manager is identified as being required by an application.
- Note that only one message is sent to a server; it is not replicated three times, rather a specific server is chosen and the message sent there. Also note that MQGET processing is still local, we are not extending MQGET into the network.

WMQ Cluster Architecture

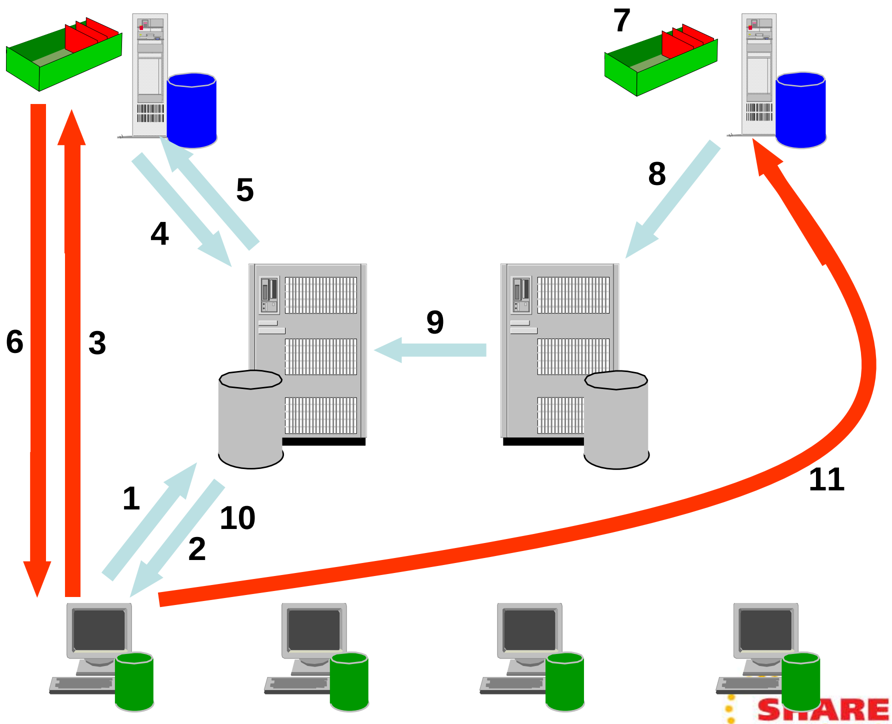
Partial Repository QMs

+ Reply applications

Full Repository QMs

Partial Repository QMs

+ Request applications



WMQ Cluster Architecture

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- Reply queue manager hosts applications that send request and receive reply.
- Request queue manager hosts applications that receive request and send reply.
- Let us walk through the flow of a message from a request queue manager to a reply queue manager and the response message that is returned. We assume that the request app has never used the queue providing the service previously, and that the request app has not communicated with the request app previously.
- Clustering introduces a new architectural layer, the Full Repository and Partial Repository queue managers, purely for the sake of explanation. Full Repository queue managers are not separate queue managers (contrast to DNS servers), and their role is to serve as a global directory of queues and queue managers in the cluster. There are a small number of these Full Repositories. Each request and reply queue manager have a Partial Repository. In practice, Full Repository queue managers often host applications too.

WMQ Cluster Architecture

N O T E S

- At MQOPEN, the queue manager to which the application is connected detects that this queue has not been used by this queue manager previously. The queue manager sends an internal message (1) requesting the location of the servers for the green queue and channel definitions to get to these servers. The returned definitions (2) are installed on the request queue manager, a channel is automatically defined to the reply queue manager (3).
- Similar processing occurs at the request side, to locate the requestor's ReplyToQueue manager.
- The most frequent method used by a reply app to send a response message to a requestor is to use the routing information in the message descriptor, namely the ReplyToQ and ReplyToQMgr. The reply app's requirement is slightly different to the original request, since the originating application's ReplyToQ is normally private to its Queue manager, i.e. it is not visible to the whole cluster. In this case the server needs to be able to locate the ReplyToQMgr rather than the ReplyToQ.

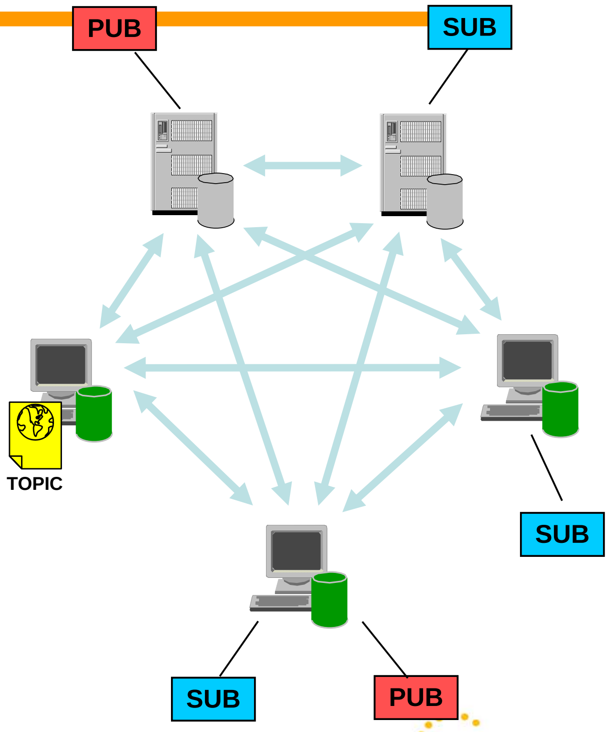
WMQ Cluster Architecture

N O T E S

- This happens as follows. When an MQPUT1 or MQOPEN request is made to send a message to a ReplyToQMgr for the first time, the queue manager sends an internal message (4) to the repository requesting the channel definition required to reach the client. The returned definition (5) is used to automatically define a channel to the request queue manager (6) to get the message back to the request queue manager where local queue resolution puts the message on the ReplyToQ.
- Finally, we see what happens when some attributes of a cluster queue or cluster Queue manager change. One interesting case is the creation of a new instance of a cluster queue manager holding a cluster queue being used by a request (7). This information is propagated from the reply queue manager (8). The Full Repository propagates the definition to the other Full Repository (9) and the Full Repository propagates it to any interested request QMs through the repository network (10), allowing this new instance to be used during an MQOPEN, MQPUT or MQPUT1 call (11).
- Note that channels are only automatically defined once on the first MQOPEN that resolves to a queue on the remote queue manager, not for every MQOPEN or MQPUT.

New in V7 - Pub/sub Clusters

- For distributed pub/sub
- Based on clustered topic objects
  - Hosted on one or more queue managers in the cluster
- Based on clustering for object auto-definition
  - All to all queue manager connectivity
  - Channel auto-definition on first cluster topic definition
- How large?
  - 100 queue managers



New in V7 - Pub/sub Clusters

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- WebSphere MQ V7 introduces Pub/sub Clusters which are used for distributed pub/sub, allowing publishers to send publications to remote subscribers.
- Pub/Sub clusters use the underlying clustering features to provide automatic connectivity between queue managers.
- The point of control for Pub/sub clusters is the topic object which can be administratively shared in the cluster, just as queues can be shared in a cluster.
- We will look at this in more detail a little later.

Resource definition for a Partial Repository

```
DEFINE CHANNEL(TO.QM1) CHLTYPE(CLUSRCVR) TRPTYPE(TCP)
CONNAME(MACHINE1.IBM.COM) CLUSTER(DEMO)
```

- CLUSRCVR definition provides the information to the cluster that allows other queue managers to automatically define sender channels

```
DEFINE CHANNEL(TO.QM2) CHLTYPE(CLUSSDR) TRPTYPE(TCP)
CONNAME(MACHINE2.IBM.COM) CLUSTER(DEMO)
```

- CLUSSDR definition must direct the queue manager to a Full Repository where it can find out information about the cluster

```
DEFINE QLOCAL(PAYROLLQ) CLUSTER(DEMO)
```

- Queues can be advertised to the cluster using the CLUSTER() keyword

```
DEFINE TOPIC(SPORTS) TOPICSTR(/global/sports) CLUSTER(DEMO)
```

- …and so can Topics

Resource definition for Partial Repository QM1

NOTES

- The cluster channels are the backbone of the cluster, and it is worth taking a little time to understand what they are used for. The use varies slightly depending on whether the queue manager is going to be used as a Full Repository or a Partial Repository.

Partial Repository

- To get a Partial Repository queue manager running in the cluster, you will need to define a cluster sender channel and a cluster receiver channel.
- The cluster receiver channel is the most important of the two as it has 2 roles. (1) It is used as a standard receiver channel on the queue manager on which it is defined. (2) The information it contains is used by other queue managers within the cluster to generate automatically defined cluster sender channels to talk to the queue manager on which the cluster receiver is defined. It is for this reason that the cluster receiver channel definition contains a number of attributes usually associated with sender channels such as the conname.
- The cluster sender channel is used to point the Partial Repository at a Full Repository queue manager from which it can then find out about other Full Repository queue managers and resources in the cluster. The cluster sender channel on a Partial Repository queue manager could be considered to be a boot-strap. Once the Partial Repository has exchanged some initial information with the Full Repository, the manually defined cluster sender channel is no longer required, but can be used to preferentially choose a Full Repository to publish and subscribe for cluster resources as mentioned previously.

Resource definition for a full repository

```
ALTER QMGR REPOS(DEMO)
```

- A queue manager is made into a full repository for a cluster by using the REPOS keyword on the QMGR object

```
DEFINE CHANNEL(TO.QM2) CHLTYPE(CLUSRCVR) TRPTYPE(TCP)
CONNAME(MACHINE2.IBM.COM)  CLUSTER(DEMO)
```

- CLUSRCVR definition provides the information to the cluster that allows other queue managers to automatically define sender channels.

```
DEFINE CHANNEL(TO.QM3) CHLTYPE(CLUSSDR) TRPTYPE(TCP)
CONNAME(MACHINE3.IBM.COM) CLUSTER(DEMO)
```

- CLUSSDR definition must direct the queue manager to another full repository for the cluster. When a full repository learns some information about the cluster it only forwards it to other full repositories for which it has a manually defined CLUSSDR channel

Resource definition for Full Repositories

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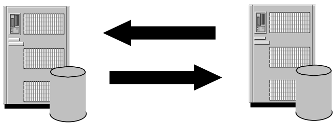
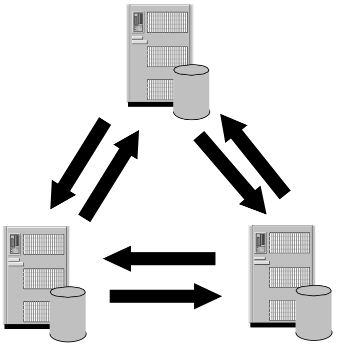
Full Repository

- A full repository is created by issuing alter qmgr(CLUSNAME)
- On a Full Repository, the role of the cluster receiver channel is the same :- it provides the information required by other queue managers in the cluster to talk to the Full Repository. The difference is in the use of the cluster sender channels. Manually defined cluster sender channels must be used to link all of the Full Repositories within the cluster. For the Full Repositories to communicate correctly, these channels need to connect the Full Repositories into a fully connected set. In a typical scenario with 2 Full Repositories, this means each Full Repository must have a cluster sender channel to the other Full Repository. These manual definitions mean that the flow of information between the Full Repositories can be controlled, rather than each one always sending information to every other Full Repository.
- The 2 key points to remember are:
- The Full Repositories must form a fully connected set using manually defined cluster sender channels.
- The information in the cluster receiver will be propagated around the cluster and used by other queue managers to create auto defined cluster sender channels. Therefore it is worth double checking that the information is correct.
- Note: If you alter a cluster receiver channel, the changes are not immediately reflected in the corresponding automatically defined cluster sender channels. If the sender channels are running, they will not pick up the changes until the next time they restart. If the sender channels are in retry, the next time they hit a retry interval, they will pick up the changes.

Considerations for Full Repositories (FRs)



- **FRs should be highly available**
  - **Avoid single point of failure - have at least 2**
  - **Recommended to have exactly 2 unless you find a very good reason to have more**
  - **Put them on highly available machines**
- **FRs must be fully inter-connected**
  - **Using manually defined cluster sender channels**
- **If at least one FR is not available or they are not fully connected**
  - **Cluster definition changes via FRs will not flow**
  - **User messages between Partial Repositories over existing channels will flow**



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Considerations for Full Repositories (FRs)

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- Full Repositories must be fully connected with each other using manually defined cluster sender channels.
- You should always have at least 2 Full Repositories in the cluster so that in the event of a failure of a Full Repository, the cluster can still operate. If you only have one Full Repository and it loses its information about the cluster, then manual intervention on all queue managers within the cluster will be required in order to get the cluster working again. If there are two or more Full Repositories, then because information is always published to and subscribed for from 2 Full Repositories, the failed Full Repository can be recovered with the minimum of effort.
- Full Repositories should be held on machines that are reliable and highly available. This said, if no Full Repositories are available in the cluster for a short period of time, this does not effect application messages which are being sent using the clustered queues and channels, however it does mean that the clustered queue managers will not find out about administrative changes in the cluster until the Full Repositories are active again.
- For most clusters, 2 Full Repositories is the best number to have. If this is the case, we know that each Partial Repository manager in the cluster will make its publications and subscriptions to both the Full Repositories.
- It is possible to have more than 2 Full Repositories.

Considerations for Full Repositories (FRs)

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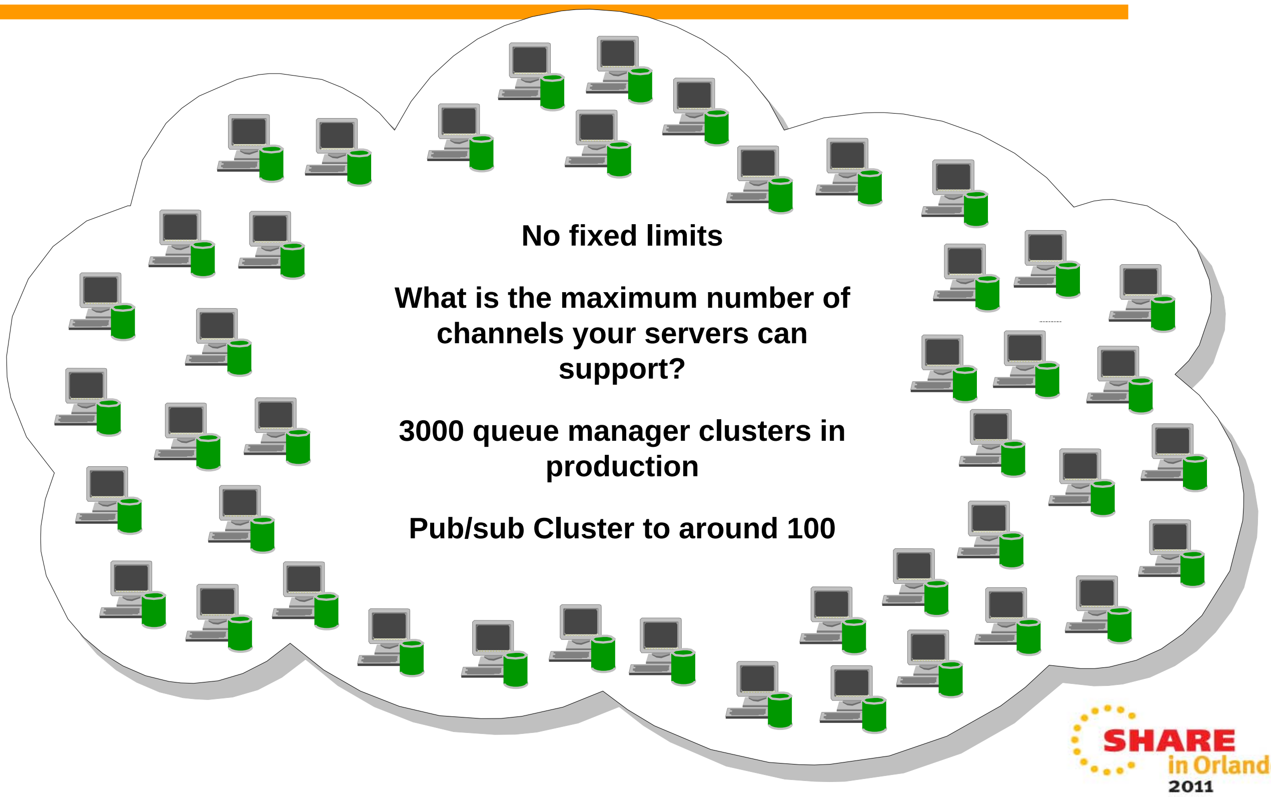
- The thing to bear in mind when using more than 2 Full Repositories is that queue managers within the cluster still only publish and subscribe to 2. This means that if the 2 Full Repositories to which a queue manager subscribed for a queue are both off-line, then that queue manager will not find out about administrative changes to the queue, even if there are other Full Repositories available. If the Full Repositories are taken off-line as part of scheduled maintenance, then this can be overcome by altering the Full Repositories to be Partial Repositories before taking them off-line, which will cause the queue managers within the cluster to remake their subscriptions elsewhere.
- If you want a Partial Repository to subscribe to a particular Full Repository queue manager, then manually defining a cluster sender channel to that queue manager will make the Partial Repository attempt to use it first, but if that Full Repository is unavailable, it will then use any other Full Repositories that it knows about.
- Once a cluster has been setup, the amount of messages that are sent to the Full Repositories from the Partial Repositories in the cluster is very small. Partial Repositories will re-subscribe for cluster queue and cluster queue manager information every 30 days at which point messages are sent. Other than this, messages are not sent between the Full and Partial Repositories unless a change occurs to a resource within the cluster, in which case the Full Repositories will notify the Partial Repositories that have subscribed for the information on the resource that is changing.
- As this workload is very low, there is usually no problem with hosting the Full Repositories on the server queue managers. This of course is based on the assumption that the server queue managers will be highly available within the cluster.
- This said, it may be that you prefer to keep the application workload separate from the administrative side of the cluster. This is a business decision.

How big can a cluster be?



No fixed limits

What is the maximum number of channels your servers can support?

3000 queue manager clusters in production

Pub/sub Cluster to around 100

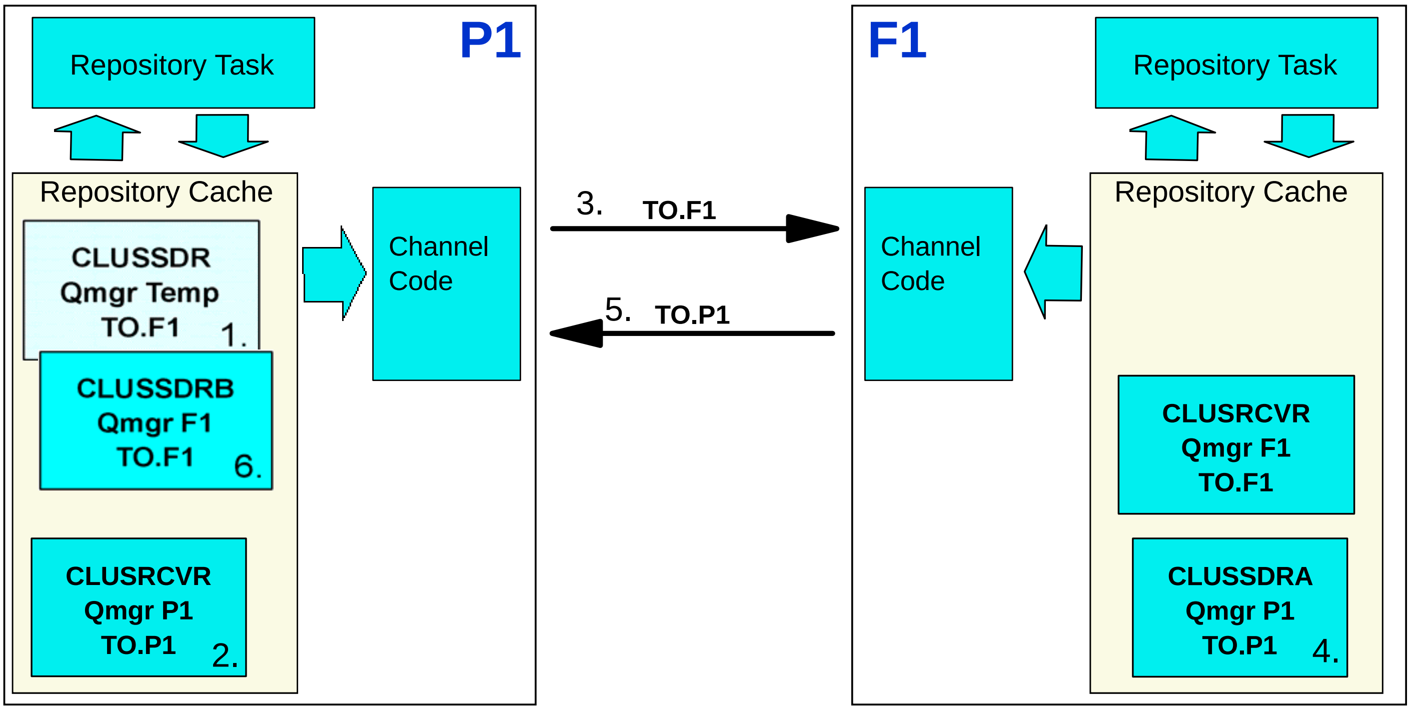
How big can a cluster be?

NOTES

- There are no predefined limits to the size of a cluster. The main thing to consider is the maximum number of channels that will need to connect to your server queue managers (and also to the Full Repositories). If for instance, you are hosting cluster queues on a WMQ z/OS queue manager, then the maximum number of channels is about 9000. This would give a maximum theoretical cluster size of 4500 queue managers, if each queue manager in the cluster had one channel going to the server queue manager and one channel back from the server queue manager.
- If you require more queue managers than this, there are ways that this can be achieved. For example you could have more than one backend server and a customized workload balancing exit could be written to partition the work across the different servers. The internal workload algorithm will always round robin across all the servers so they would each need to cope with channels from all the clients. We will look closer at workload balancing later in the presentation.
- One question we are regularly asked is whether it is better to have one large cluster or multiple smaller clusters. This should usually be a business decision only. It may be for example that you wish to separate secure requests coming from branches of the business over channels using SSL from un-secure requests coming from the internet. Multiple clusters would allow you to achieve this whilst still using the same backend servers to handle both request types.

- Pub/subs clusters scale into the 100s of queue managers, not the 1000s due to the all to all connectivity and overhead of proxy-subscriptions.

Initial definitions



Initial definitions

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- The previous diagram shows the communications that occur between a Partial Repository and a Full Repository queue manager when the Partial Repository is added to the cluster.

- A cluster sender channel is defined on the Partial Repository. The queue manager name seen on a DISPLAY CLUSQMGR command, shows a name that starts SYSTEM.TEMPQMGR. This name will be changed when the Partial Repository has communicated with the Full Repository and found out the real name of the Full Repository.
- A cluster receiver channel is defined on the Partial Repository.
- Once both a cluster sender channel and a cluster receiver channel for the same cluster are defined, the repository task starts the cluster sender channel to the Full Repository.
- The information from the cluster receiver channel on the Partial Repository is sent to the Full Repository which uses it to construct an auto defined cluster sender channel back to the Partial Repository.
- The repository task on the Full Repository starts the channel back to the Partial Repository and sends back the information from its cluster receiver channel.
- The Partial Repository merges the information from the Full Repositories cluster receiver channel with that from its manually defined cluster sender channel. The information from the Full Repositories cluster receiver channel takes precedence.

Checking initial definitions

- On the Full Repository display the new Partial Repository queue manager

```
DISPLAY CLUSQMGR(<partial repos qmgr name>)
```

- If the Partial Repository queue manager is not shown, the Full Repository has not heard from the Partial Repository
  - Check channel status from the Partial to the Full
  - Check CLUSRCVR and CLUSSDR channels CLUSTER name
  - Check for error messages
- On the Partial Repository display all cluster queue managers

```
DISPLAY CLUSQMGR(*)
```

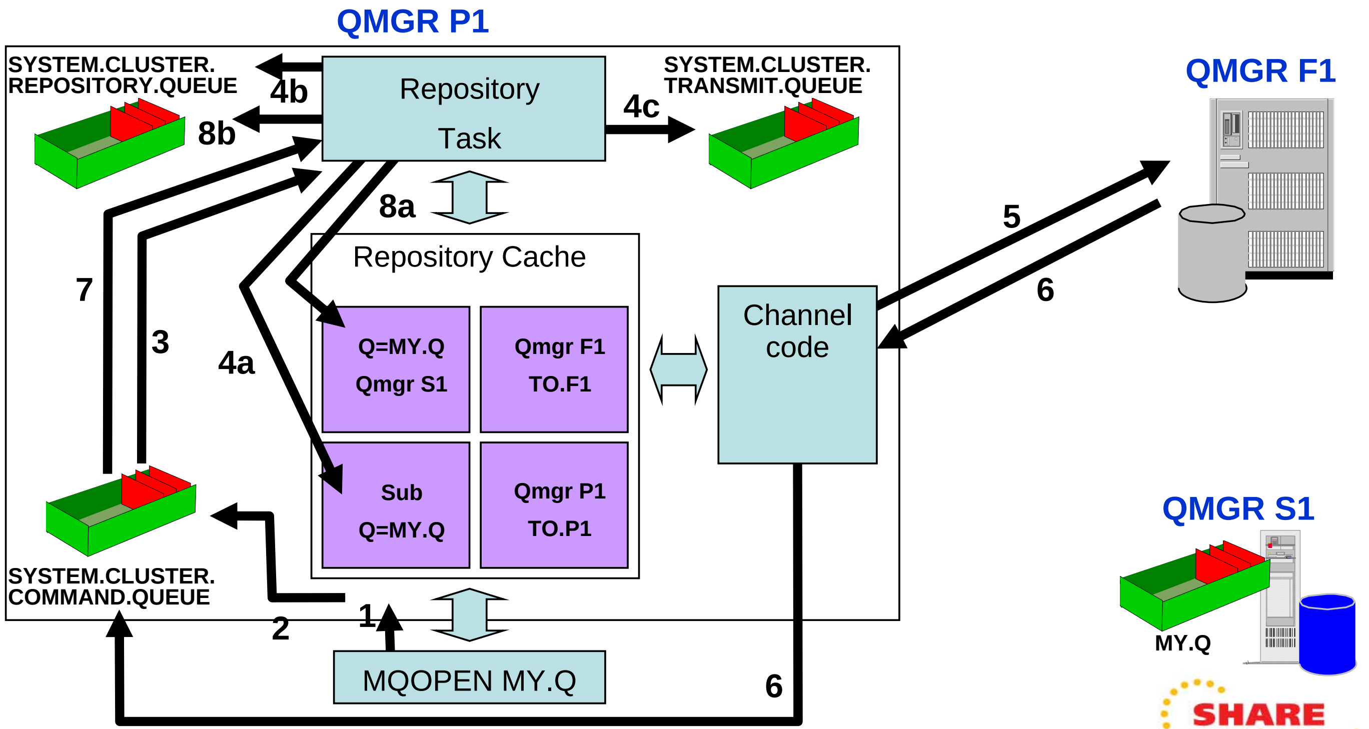
- If the channel to the Full Repository has a queue manager name starting SYSTEM.TEMPQMGR, the Partial Repository has not heard back from the Full Repository
  - Check channel status from the Full to the Partial
  - Check for error messages

Checking initial definitions

N O T E S

- On the Partial Repository, issue DISPLAY CLUSQMGR(*) to display all the cluster queue managers that the Partial Repository is aware of. What we want to check is that the manually defined cluster-sender channel to the Full Repository no longer has a CLUSQMGR name starting SYSTEM.TEMPQMGR. If it does, then we know that the initial communications between the Partial Repository and the Full Repository have not completed. The checklist below should help to track down the problem:
- Check the CLUSTER name defined on the CLUSRCVR and CLUSSDR channels
  - The Partial Repository will not attempt to talk to the Full Repository unless both the CLUSRCVR and the CLUSSDR channels are defined with the same cluster name in the CLUSTER keyword.
- Check the status of the channel to the Full Repository.
  - The CLUSSDR channel to the Full Repository should be RUNNING. If it is in status RETRYING, check the CONNAME is correct, the network is ok and that the listener on the Full Repository is running.
- On Full Repository, issue DISPLAY CLUSQMGR(<partial repos name>)
  - If the Partial Repository has established a connection with the Full Repository, it will have sent the information from its CLUSRCVR channel to the Full Repository which will have used it to create an auto-defined CLUSSDR channel back to the Partial Repository. We can check if this has occurred by issuing the DISPLAY CLUSQMGR command on the Full Repository. Check channel status of the channel back from Full Repository.
  - The Full Repository should send the information from its CLUSRCVR channel back to the Partial Repository, thus the channel back to the Partial Repository should be RUNNING. If the channel is RETRYING, check the CONNAME on the Partial Repository's CLUSRCVR is correct (remember this is where the Full Repository got the CONNAME from) and check that the listener on the Partial Repository is running.
- Check for error messages
  - If an error occurs in the repository task on either the Partial Repository queue manager or the Full Repository queue manager, error messages are produced. If the checklist above does not provide the answer to the problem, it is worth examining the error logs from the queue managers as this may aid the problem diagnosis.

First MQOPEN of a Queue

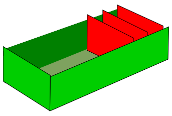


First MQOPEN of a Queue

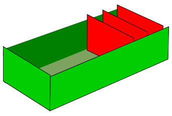
N O T E S

- The previous diagram shows what happens when a cluster queue is opened for the first time on a queue manager.
- The MQOPEN request is issued and as part of the MQOPEN, the repository cache is examined to see if the queue is known about. No information is available in the cache as this is the first MQOPEN of the queue on this qmgr.
- A message is put to the SYSTEM.CLUSTER.COMMAND.QUEUE requesting the repository task to subscribe for the queue.
- When the repository task is running, it has the SYSTEM.CLUSTER.COMMAND.QUEUE open for input and is waiting for messages to arrive. It reads the request from the queue.
- The repository task creates a subscription request. It places a record in the repository cache indicating that a subscription has been made and this record is also hardened to the SYSTEM.CLUSTER.REPOSITORY.QUEUE. This queue is where the hardened version of the cache is kept and is used when the repository task starts, to repopulate the cache. The subscription request is sent to 2 Full Repositories. It is put to the SYSTEM.CLUSTER.TRANSMIT.QUEUE awaiting delivery to the SYSTEM.CLUSTER.COMMAND.QUEUE on the Full Repository queue managers.
- The channel to the Full Repository queue manager is started automatically and the message is delivered to the Full Repository. The Full Repository processes the message and stores the subscription request.
- The Full Repository queue manager sends back the information about the queue being opened to the SYSTEM.CLUSTER.COMMAND.QUEUE on the Partial Repository queue manager.
- The message is read from the SYSTEM.CLUSTER.COMMAND.QUEUE by the repository task.
- The information about the queue is stored in the repository cache and hardened to the SYSTEM.CLUSTER.REPOSITORY.QUEUE
- At this point the Partial Repository knows which queue managers host the queue. What it would then need to find out is information on the channels that the hosts of the queue have advertised to the cluster, so that it can create auto-defined cluster sender channels too them. To do this, more subscriptions would be made (if necessary) to the Full Repositories.

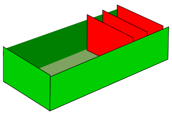
The SYSTEM.CLUSTER queues



- SYSTEM.CLUSTER.COMMAND.QUEUE
  - Holds inbound administrative messages
  - IPPROCS should always be 1
  - CURDEPTH should be zero or decrementing
  - If not, check repository task and error messages



- SYSTEM.CLUSTER.REPOSITORY.QUEUE
  - Holds hardened view of repository cache
  - CURDEPTH should be greater than zero
  - CURDEPTH varies depending on checkpoints. This is not a problem.



- SYSTEM.CLUSTER.TRANSMIT.QUEUE
  - Holds outbound administrative messages
  - Holds outbound user messages
  - CorrelId in MQMD added on transmission queue will contain the name of the channel that the message should be sent down

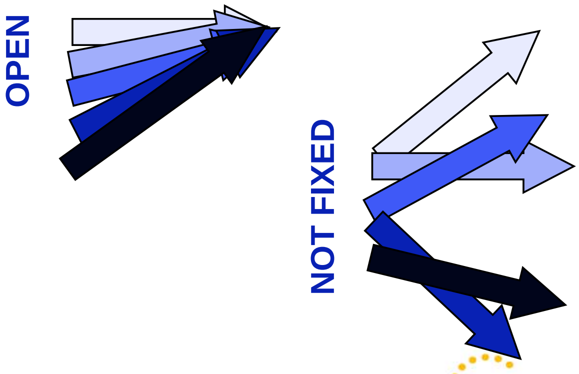
The SYSTEM.CLUSTER queues

NOTES

- These queues are for internal use only. It is important that applications do not put or get messages from the SYSTEM.CLUSTER queues.

Workload balancing - Bind Options

- Bind on open
  - Messages are bound to a destination chosen at MQOPEN
  - All messages put using open handle are bound to same destination
- Bind not fixed
  - Each message is bound to a destination at MQPUT
  - Workload balancing done on every message
  - Recommended - No affinities are created (SCTQ build up)
- Application options
  - MQOO_BIND_ON_OPEN
  - MQOO_BIND_NOT_FIXED
  - MQOO_BIND_AS_Q_DEF (Default)
- DEFBIND Queue attribute
  - OPEN (Default)
  - NOTFIXED

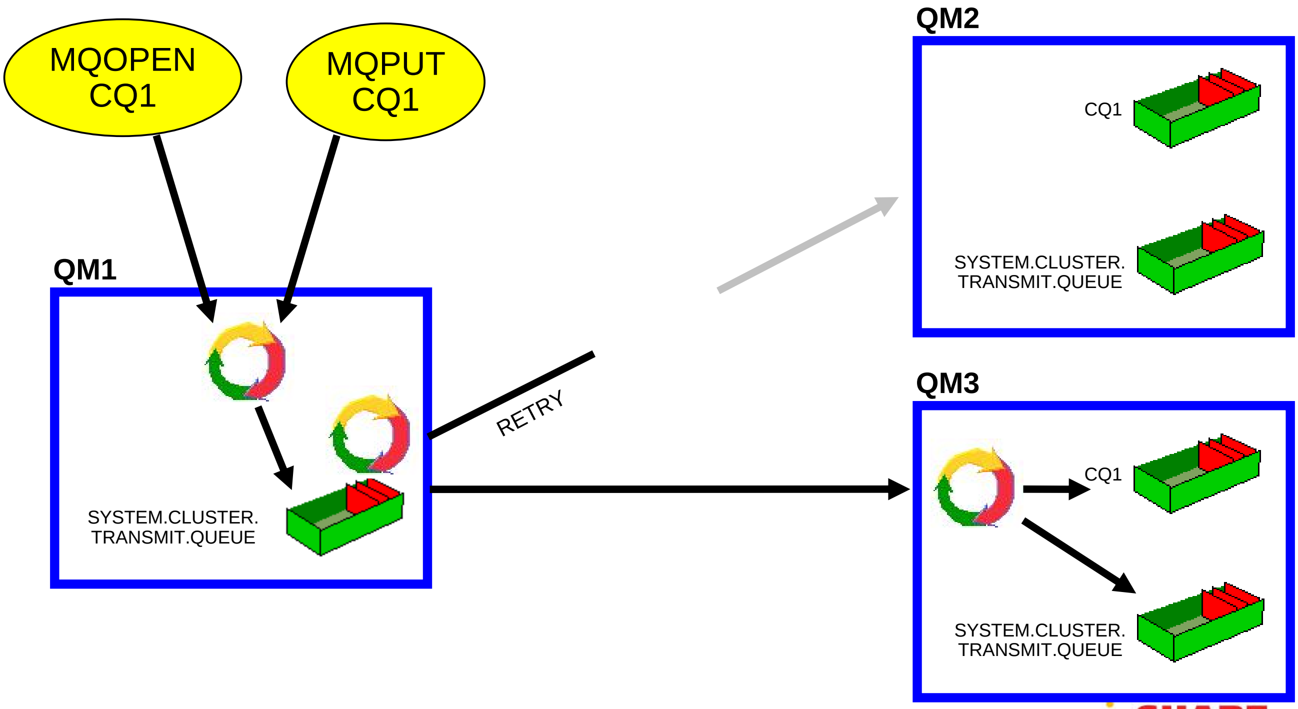


Workload balancing - Bind Options - Notes

N O T E S

- Affinity is the need to continue using the same instance of a service, with multiple messages being sent to the same application process. This is often also known as conversational style applications. Affinity is bad news for parallel applications since it means there is a single point of failure. It can also inhibit scalability (no longer shared nothing, long locks needed). Historically, affinities have caused many problems.
- When writing new applications, one of your design goals should be for no affinities.
- If you cannot get around the need for an affinity in your application, however, MQ will help you.
- If you require all the messages in a conversation to be targeted to the same queue manager, you can request that using the bind options, specifically the “Bind on open” option. Using this option, a destination is chosen at MQOPEN time and all messages put using that open handle are bound to same destination. To choose a new destination, perhaps for the next set of messages, close and reopen the destination in order to re-drive the workload balancing algorithm to choose a new queue manager.
- If you do not have any affinities in your applications, you can use the opposite option, the “Bind not fixed” option.
- This behaviour can either be coded explicitly in your application using the MQOO_BIND_* options or through the default attribute DEFBIND on a queue definition. This attribute defaults to “Bind on open” to ensure applications not written with parallelism in mind still work correctly in a cluster.

When does workload balancing occur?



MQOPEN CQ1
MQPUT CQ1
QM1
SYSTEM.CLUSTER.TRANSMIT.QUEUE
RETRY
QM2
CQ1
SYSTEM.CLUSTER.TRANSMIT.QUEUE
QM3
CQ1
SYSTEM.CLUSTER.TRANSMIT.QUEUE

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When does workload balancing occur?

N O T E S

- In a typical setup, where a message is put to a queue manager in the cluster, destined for a backend server queue manager also in the cluster, there are three places at which workload balancing may occur.
- The first of these is at either MQOPEN or MQPUT time depending on the bind options associated with message affinity. If bind_on_open is specified, then this means all messages will go to the same destination, so once the destination is chosen at MQOPEN time, no more workload balancing will occur on the message. If bind_not_fixed is specified, the messages can be sent to any of the available destinations. The decision where to send the message is made at MQPUT time, however this may change whilst the message is in transit.
- If a channel from a queue manager to a backend server goes into retry, then any bind_not_fixed messages waiting to be sent down that channel will go through workload balancing again to see if there is a different destination that is available.
- Once a message is sent down a channel, at the far end the channel code issues an MQPUT to put the message to the target queue and the workload algorithm will be called.

Workload management features

QUEUES

- Put allowed
  - PUT(ENABLED/DISABLED)
- Utilising remote destinations
  - CLWLUSEQ
- Queue rank
  - CLWLRANK
- Queue priority
  - CLWLPRTY

QUEUE MANAGER

- Utilising remote destinations
  - CLWLUSEQ
- Availability status
  - SUSPEND/RESUME
- Most recently used
  - CLWLMRUC

CHANNELS

- Channel status
  - INACTIVE, RUNNING
  - BINDING, INITIALIZING, STARTING, STOPPING
  - RETRYING
  - REQUESTING, PAUSED STOPPED
- Channel network priority
  - NETPRTY
- Channel rank
  - CLWLRANK
- Channel priority
  - CLWLPRTY
- Channel weighting
  - CLWLWGHT

EXIT

- A cluster workload exit can be used

Workload management features

NOTES

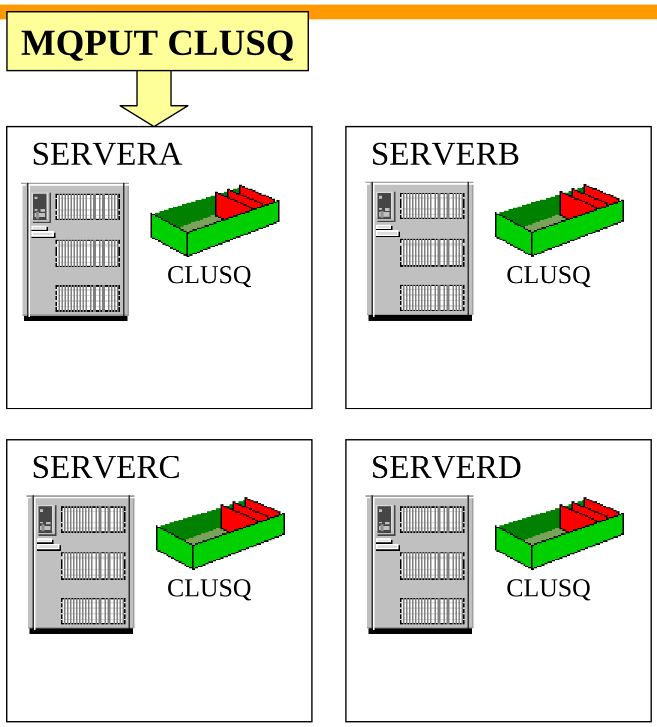
- There are a number of features in WebSphere MQ which affect the way the default workload balancing algorithm works. With all these attributes set to their default values, the workload balancing algorithm could be described as “round robin, excluding failed servers”. More control is required in some scenarios to allow more flexible interconnected cluster, or to allow greater scalability, and some of these attributes will then need to be altered to achieve the behaviour required.
- Only some attributes on a clustered queue or channel have an impact on the workload balancing algorithm. In other words, not all attributes are propagated around the cluster. Those that have an impact are shown on this page.
- If a queue is altered to be disabled for put, this change is propagated around the cluster and is used by other queue managers in the cluster when choosing which queues to send their messages to. A queue that is disabled for put is not a good choice!
- A queue manager may be suspended from the cluster. This is another way of removing queues on that queue manager from being chosen by the workload balancing algorithm. Note, that if all queue managers in a cluster are suspended, then they are all equally ‘good’ choices and the effects will be nullified.

Workload management features

N O T E S

- Channel status plays a part in the workload balancing algorithm, by indicating when a server has failed. ‘Bad’ channel status suggests a problem and makes that queue manager a worse choice. If the entire network is having a problem and all channels are in RETRY state, then all queue managers are equally ‘good’ choices and the effects again will be nullified – where-ever the messages are targeted, they will have to wait on the transmission queue for the network to come back up.
- Network priority provides a way of choosing between two routes to the same queue manager. For example, a TCP route and a SNA route, or an SSL route and a non-SSL route. The higher network priority route is always used when it’s channel is in a good state.
- All of the choices made by the queue manager using it’s default workload balancing algorithm can be over-ridden by the use of a cluster workload exit. This exit is provided with all the same information that the queue manager uses to make its choices, and is also told which choice the default algorithm made, and can then change that choice if it wishes. It can make decisions based on message content, or other information that the queue manager is not aware, such as business routing decisions.

Utilising remote destinations



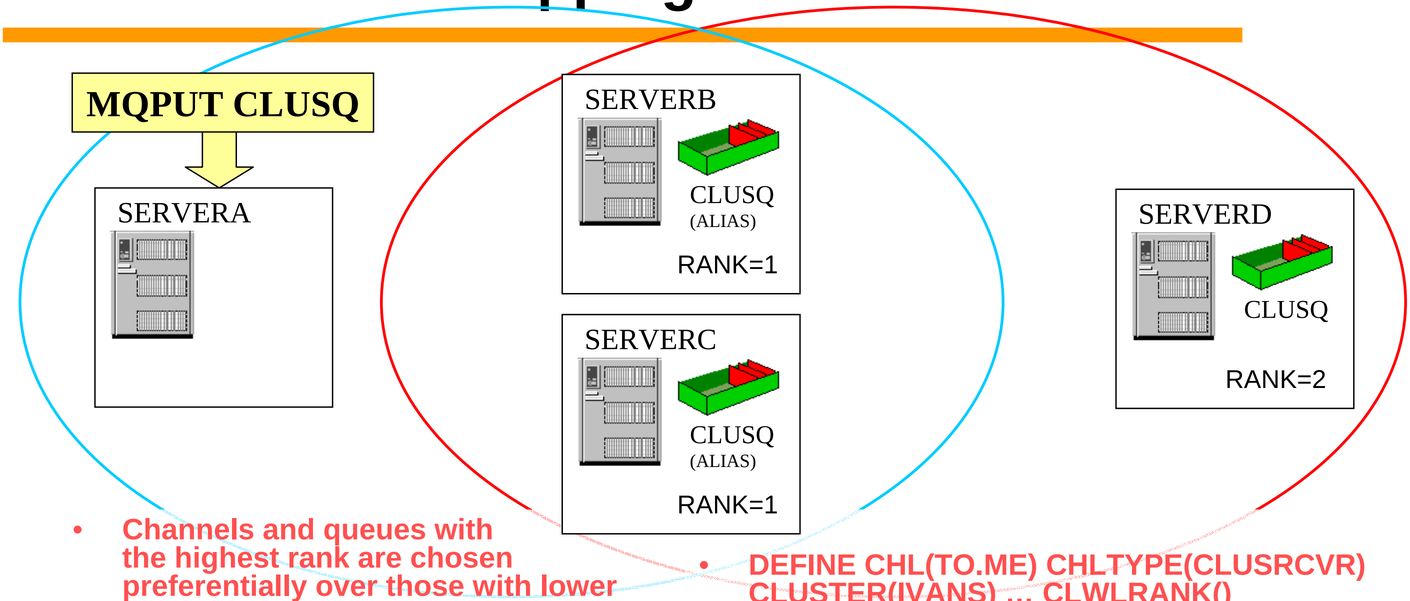
- Allows remote queues to be chosen, when a local queue exists
- DEFINE QL(CLUSQ) CLUSTER(IVANS) CLWLUSEQ( )
  - LOCAL = If a local queue exists, choose it.
  - ANY = Choose either local or remote queues.
  - QMGR = Use the queue manager's use-queue value.
- ALTER QMGR CLWLUSEQ( )
  - LOCAL = If the queue specifies CLWLUSEQ(QMGR) and a local queue exists, choose it.
  - ANY = If the queue specifies CLWLUSEQ(QMGR) choose either local or remote queues.
- Messages received by a cluster channel are always put to a local queue if one exists

Utilising remote destinations

N O T E S

- Prior to WebSphere MQ V6, if a local instance of the named cluster queue existed, it was always utilised in favour of any remote instances. This behaviour can be over-ridden at V6 by means of the CLWLUSEQ attribute, which allows remote queues to be chosen, when a local queue exists.
- The CLWLUSEQ attribute is available on queue definitions, to allow only specific named queues to utilise this over-ride, or on the queue manager to over-ride this behaviour for all cluster queues.
- DEFINE QL(CLUSQ) CLUSTER(IVANS) CLWLUSEQ( )
  - LOCAL If a local queue exists, choose it.
  - ANY Choose either local or remote queues.
  - QMGR Use the queue manager's use-queue value.
- ALTER QMGR CLWLUSEQ( )
  - LOCAL If the queue specifies CLWLUSEQ(QMGR) and a local queue exists, choose it.
  - ANY If the queue specifies CLWLUSEQ(QMGR) choose either local or remote queues.
- Any messages received by a cluster channel will be put to a local queue if one exists in order to avoid looping round the cluster.

Rank and Overlapping Clusters



- Channels and queues with the highest rank are chosen preferentially over those with lower ranks.
- Channel rank checked before queue rank
- Alternative to put disabling queues
  - MQRC_NONE Vs MQRC_PUT_INHIBITED

- DEFINE CHL(TO.ME) CHLTYPE(CLUSRCVR) CLUSTER(IVANS) … CLWLRANK()
  - Range 0 – 9
  - Default 0
- DEFINE QL(CLUSQ) CLUSTER(IVANS) CLWLRANK( )
  - Range 0 – 9
  - Default 0

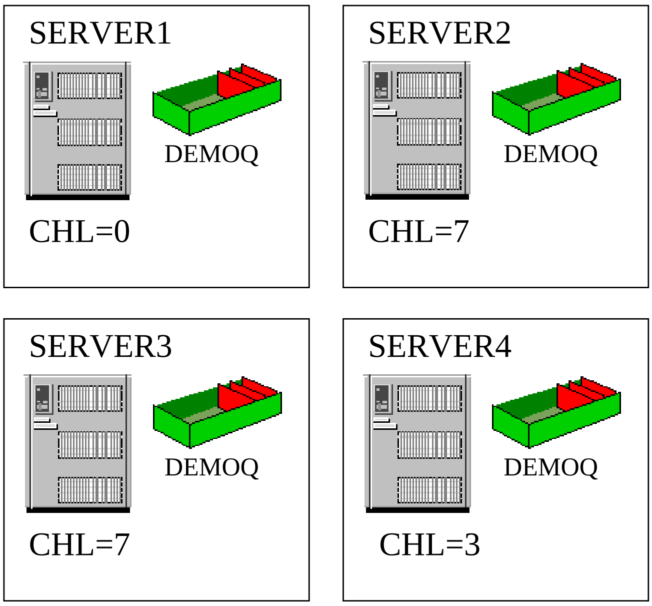
Rank and Overlapping Clusters

NOTES

- Rank allows greater control of the routing of messages through overlapping clusters.

- Without using rank, messages put to CLUSQ by applications connected to SERVERA could bounce between the alias queues on SERVERB and SERVERC. Using rank solves this “bouncing” problem because once messages arrive on SERVERB or SERVERC, the CLUSQ instance on SERVERD is available to the cluster workload management algorithm. As CLUSQ on SERVERD is ranked higher it will be chosen.

Channel Rank example



SERVER1 DEMOQ CHL=0

SERVER2 DEMOQ CHL=7

SERVER3 DEMOQ CHL=7

SERVER4 DEMOQ CHL=3

SERVER2

```
ALTER CHL(TO.SERVER2)
CHLTYPE(CLUSRCVR) CLWLRANK(7)
```

SERVER3

```
ALTER CHL(TO.SERVER3)
CHLTYPE(CLUSRCVR)
CLWLRANK(7)
```

SERVER4

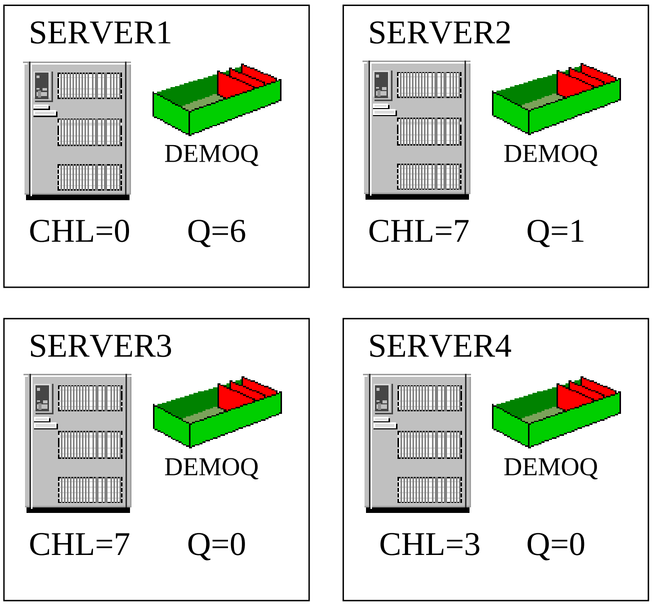
```
ALTER CHL(TO.SERVER4)
CHLTYPE(CLUSRCVR)
CLWLRANK(3)
```

Channel Rank example

NOTES

- The channel rank for SERVER2 and SERVER3 are set higher than SERVER4. As the default channel rank is zero, SERVER1 has the lowest rank.
- Once the ranks for channels on SERVER2, SERVER3 and SERVER4 have been altered the messages are distributed equally between the highest ranked destinations (SERVER2 and SERVER3).

Queue Rank example



SERVER1

ALTER QL(DEMOQ) CLWLRANK(6)

SERVER2

ALTER QL(DEMOQ) CLWLRANK(1)

Queue Rank example

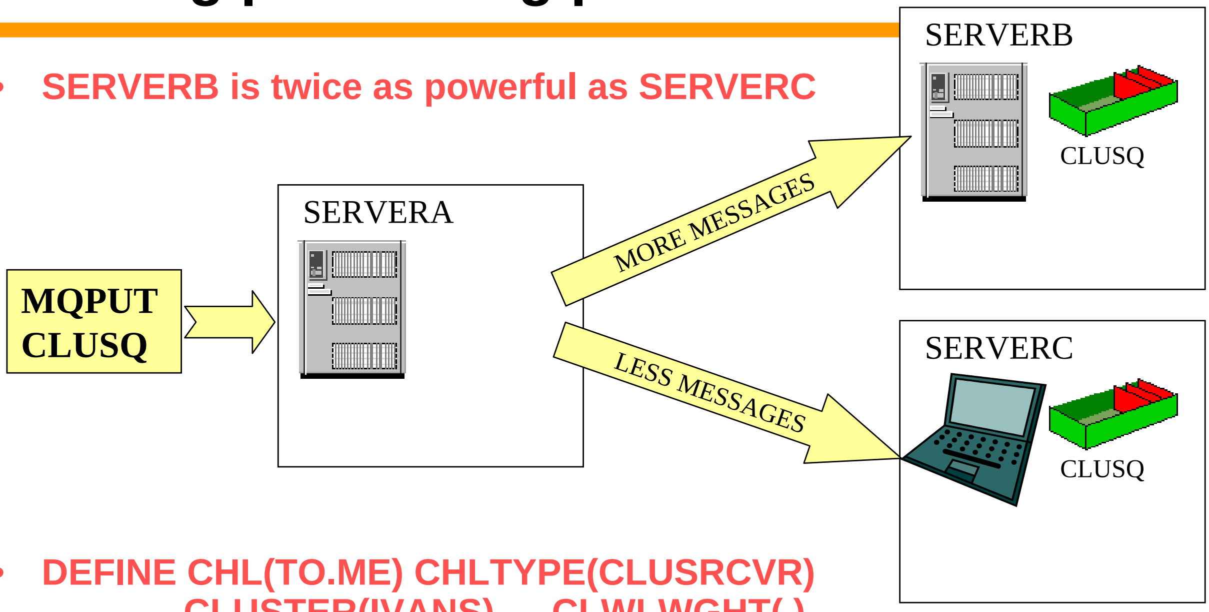
NOTES

- Once the ranks for queues on SERVER1 and SERVER2 have been changed the all messages are delivered to SERVER2. This is because the cluster workload management algorithm checks channel ranks before queue rank. The channel rank check leaves SERVER2 and SERVER3 as valid destinations and because the queue rank for DEMOQ on SERVER2 is higher than that on SERVER3 the messages are delivered to SERVER2. Note that as channel rank is more powerful than queue rank, the highest ranked queue (on SERVER1) is not chosen.

- It is important to note that destinations with the highest rank will be chosen regardless of the channel status to that destination. This could lead to messages building up on the SYSTEM.CLUSTER.TRANSMIT.QUEUE.

Utilising processing power

- SERVERB is twice as powerful as SERVERC



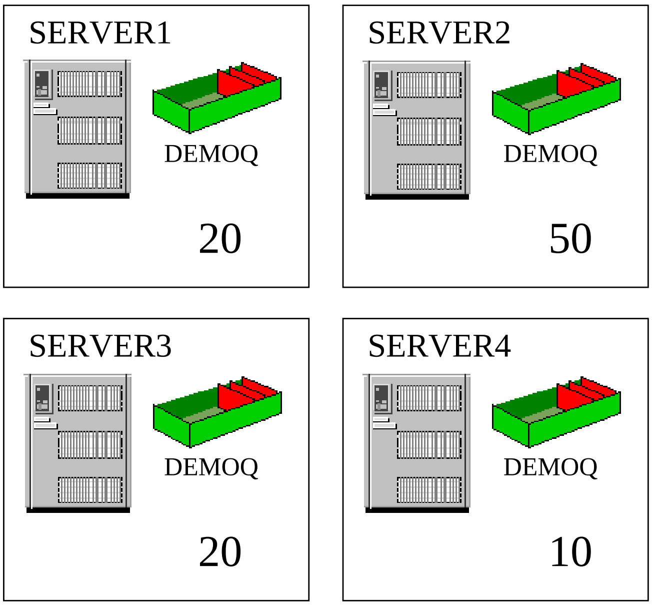
- DEFINE CHL(TO.ME) CHLTYPE(CLUSRCVR) CLUSTER(IVANS) … CLWLWGHT( )
  - Range 1 – 99
  - Default 50

Utilising processing power - Notes

N O T E S

- When SERVERB is twice as powerful as SERVERC. How can I send SERVERB twice as many messages as SERVERC?
- To do this you can make use of the CLWLWGHT attribute to indicate the weighting to be applied to each destination. If more than one destination is valid, the round robin algorithm sends messages in numbers proportional to channel weights.

Channel Weight example



SERVER1

```
ALTER CHL(TO.SERVER2)
CHLTYPE(CLUSRCVR)
CLWLWGHT(20)
```

SERVER3

```
ALTER CHL(TO.SERVER3)
CHLTYPE(CLUSRCVR)
CLWLWGHT(20)
```

SERVER4

```
ALTER CHL(TO.SERVER4)
CHLTYPE(CLUSRCVR)
CLWLWGHT(10)
```

Channel Weight example

NOTES

- In this example, the approximate percentage of messages distributed to each queue manager are as follows…

- SERVER1 20%
- SERVER2 50%
- SERVER3 20%
- SERVER4 10%

- Weight enables the cluster workload management algorithm to favour more powerful machines.

Cluster Workload Algorithm

- Queue PUT(ENABLED/DISABLED)
- Local instance (CLWLUSEQ)
- Channel rank (CLWLRANK)
- Queue rank (CLWLRANK)
- Channel Status
  - INACTIVE, RUNNING
  - BINDING, INITIALIZING, STARTING, STOPPING
  - RETRYING
  - REQUESTING, PAUSED, STOPPED
- Channel net priority (NETPRTY)
- Channel priority (CLWLPRTY)
- Queue priority (CLWLPRTY)
- Most recently used (CLWLMRUC)
- Least recently used with channel weighting (CLWLWGHT)

Cluster Workload Algorithm

NOTES

- The full algorithm (taken from the Queue Manager Clusters manual) is as follows…
- 1. If a queue name is specified, queues that are not PUT enabled are eliminated as possible destinations. Remote instances of queues that do not share a cluster with the local queue manager are then eliminated. Next, remote CLUSRCVR channels that are not in the same cluster as the queue are eliminated.
- 2. If a queue manager name is specified, queue manager aliases that are not PUT enabled are eliminated. Remote CLUSRCVR channels that are not in the same cluster as the local queue manager are then eliminated.
- 3. If the result above contains the local instance of the queue, and the use-queue attribute of the queue is set to local (CLWLUSEQ(LOCAL)), or the use-queue attribute of the queue is set to queue manager (CLWLUSEQ(QMGR)) and the use-queue attribute of the queue manager is set to local (CLWLUSEQ(LOCAL)), the queue is chosen; otherwise a local queue is chosen if the message was not put locally (that is, the message was received over a cluster channel). User exits are able to detect this using the MQWXP.Flags flag MQWXP_PUT_BY_CLUSTER_CHL and MQWQR.QFlags flag MQQF_CLWL_USEQ_ANY not set.
- 4. If the message is a cluster PCF message, any queue manager to which a publication or subscription has already been sent is eliminated.
- 4a. All channels to queue managers or queue manager alias with a rank (CLWLRANK) less than the maximum rank of all remaining channels or queue manager aliases are eliminated.
- 4b. All queues (not queue manager aliases) with a rank (CLWLRANK) less than the maximum rank of all remaining queues are eliminated.

Cluster Workload Algorithm (cont)

N O T E S

- 5. If only remote instances of a queue remain, resumed queue managers are chosen in preference to suspended ones.
- 6. If more than one remote instance of a queue remains, all channels that are inactive (MQCHS_INACTIVE) or running (MQCHS_RUNNING) are included.
- 7. If no remote instance of a queue remains, all channels that are in binding, initializing, starting or stopping state (MQCHS_BINDING, MQCHS_INITIALIZING, MQCHS_STARTING, or MQCHS_STOPPING) are included.
- 8. If no remote instance of a queue remains, all channels in retrying state (MQCHS_RETRYING) are included.
- 9. If no remote instance of a queue remains, all channels in requesting, paused or stopped state (MQCHS_REQUESTING, MQCHS_PAUSED and MQCHS_STOPPED) are included.
- 10. If more than one remote instance of a queue remains and the message is a cluster PCF message, locally defined CLUSSDR channels are chosen.
- 11. If more than one remote instance of a queue remains to any queue manager, channels with the highest NETPRTY value for each queue manager are chosen.
- 11a. If a queue manager is being chosen: all remaining channels and queue manager aliases other than those with the highest priority (CLWLPRTY) are eliminated. If any queue manager aliases remain, channels to the queue manager are kept.
- 11b. If a queue is being chosen: all queues other than those with the highest priority (CLWLPRTY) are eliminated, and channels are kept.

Cluster Workload Algorithm (cont)

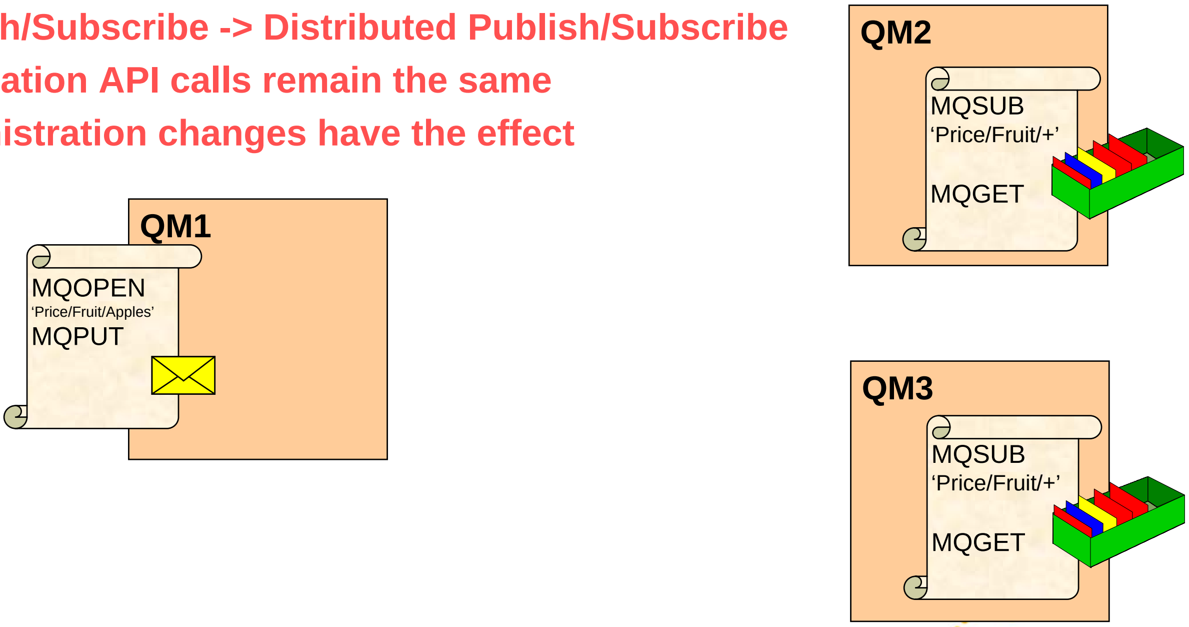
N O T E S

- 11c. All channels except a number of channels with the highest values in MQWDR.DestSeqNumber are eliminated. If this number is greater than the maximum allowed number of most-recently-used channels (CLWLMRUC), the least recently used channels are eliminated until the number of remaining channels is no greater than CLWLMRUC.
- 12. If more than one remote instance of a queue remains, the least recently used channel is chosen (that is, the one with the lowest value in MQWDR.DestSeqFactor). If there is more than one with the lowest value, one of those with the lowest value in MQWDR.DestSeqNumber is chosen. The destination sequence factor of the choice is increased by the queue manager, by approximately 1000/(Channel weight) (CLWLWGHT). The destination sequence factors of all destinations are reset to zero if the cluster workload attributes of available destinations are altered, or if new cluster destinations become available. Also, the destination sequence number of the choice is set to the destination sequence number of the previous choice plus one, by the queue manager.

- Note that the distribution of user messages is not always exact, because administration and maintenance of the cluster causes messages to flow across channels. This can result in an apparent uneven distribution of user messages which can take some time to stabilize. Because of this, no reliance should be made on the exact distribution of messages during workload balancing.

Publish/Subscribe Topologies

- Local Queuing -> Distributed Queuing
- Publish/Subscribe -> Distributed Publish/Subscribe
- Application API calls remain the same
- Administration changes have the effect



QM1

MQOPEN
'Price/Fruit/Apples'
MQPUT

QM2

MQSUB
'Price/Fruit/+'
MQGET

QM3

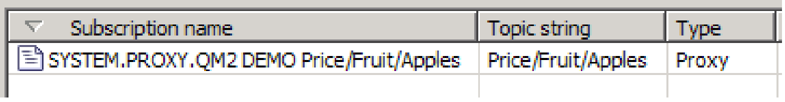
MQSUB
'Price/Fruit/+'
MQGET

Publish/Subscribe Topologies - Notes

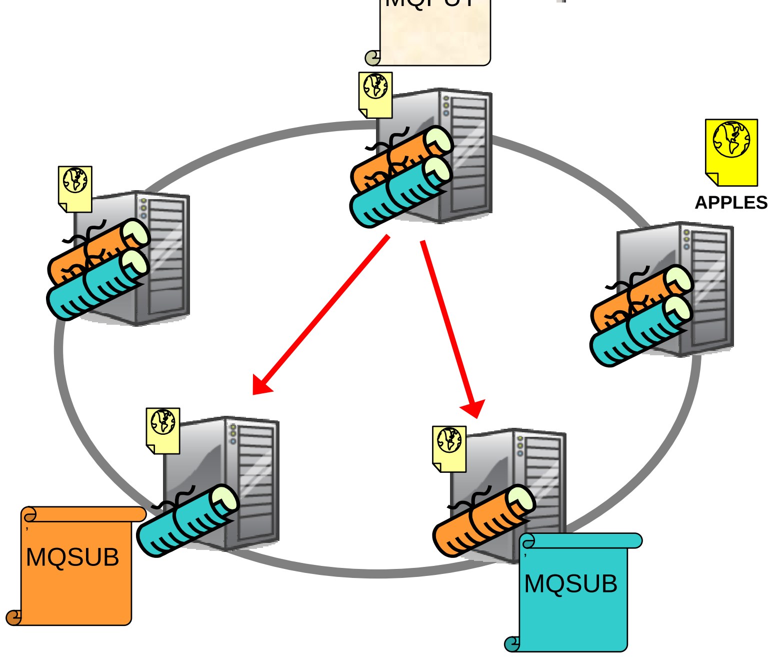
NOTES

- Just as queuing can be done on a single queue manager or can be done by moving messages between multiple queue managers – known as distributed queuing – so can publish/subscribe. We call this distributed publish/subscribe.
- This is the concept (and the features to implement it) where an application may be publishing to a topic on QM1 and other applications may be subscribing on that topic on others queue managers, here QM2 and QM3, and the publication message needs to flow to those other queue managers to satisfy those subscribers.
- The application code stays the same, you still call MQSUB or MQOPEN and MQPUT, the difference, as with distributed queuing is in the administrative set-up of your queue managers.
- We are going to introduce the way clustering can be used to set up your queue managers to publish messages to another queue manager.

Pub/Sub Clusters

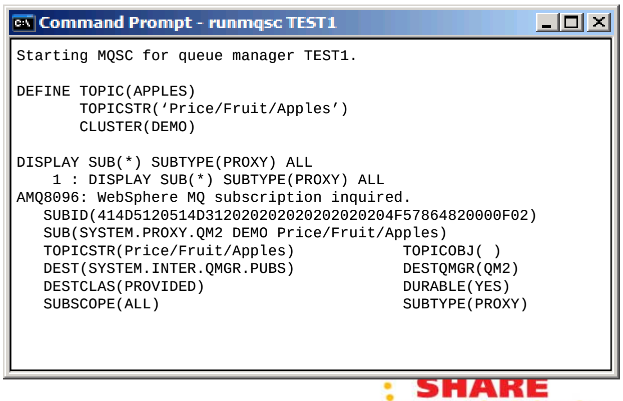


Subscription name	Topic string	Type
SYSTEM.PROXY.QM2 DEMO Price/Fruit/Apples	Price/Fruit/Apples	Proxy



TOPIC attributes

CLUSTER
SUBSCOPE
PUBSCOPE
PROXYSUB



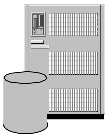
```
Starting MQSC for queue manager TEST1.

DEFINE TOPIC(APPLES)
       TOPICSTR(‘Price/Fruit/Apples’)
       CLUSTER(DEMO)

DISPLAY SUB(*) SUBTYPE(PROXY) ALL
    1 : DISPLAY SUB(*) SUBTYPE(PROXY) ALL
AMQ8096: WebSphere MQ subscription inquired.
   SUBID(414D5120514D312020202020202020204F57864820000F02)
   SUB(SYSTEM.PROXY.QM2 DEMO Price/Fruit/Apples)
   TOPICSTR(Price/Fruit/Apples)            TOPICOBJ( )
   DEST(SYSTEM.INTER.QMGR.PUBS)            DESTQMGR(QM2)
   DESTCLAS(PROVIDED)                      DURABLE(YES)
   SUBSCOPE(ALL)                           SUBTYPE(PROXY)
```

Pub/Sub Clusters - Notes

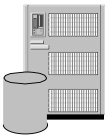
NOTES

- A pub/sub cluster is a cluster of queue managers, with the usual CLUSRCVR and CLUSSDR definitions, but that also contains a TOPIC object that has been defined in the cluster.
- With a cluster you have “any-to-any” connectivity. There are direct links between all queue managers in the cluster. This provides good availability for the delivery of messages, if one route is unavailable, there may well be another route to deliver the messages to the target subscription.
- With a TOPIC object defined in the cluster, an application connected to one queue manager in the cluster can subscribe to that topic or any node in the topic tree below that topic and receive publications on that topic from other queue managers in the cluster.
- This is achieved by the creation of proxy subscriptions on the queue managers in the cluster, so that when a publication to the topic in question happens on their queue manager, they know to forward it to the appropriate other members of the cluster.
- You can view these proxy subscriptions through the same commands we saw earlier. By default proxy subscriptions are not shown to you because the default value for SUBTYPE is USER. If you use SUBTYPE(ALL) or SUBTYPE(PROXY) you will see these subscriptions.
- There are a few attributes that are specifically related to Distributed Publish/Subscribe. PUBSCOPE and SUBSCOPE determine whether this queue manager propagates publications to queue managers in the topology (pub/sub cluster or hierarchy) or restricts the scope to just its local queue manager. You can do the equivalent job programmatically using MQPMO_SCOPE_QMGR / MQSO_SCOPE_QMGR.
- PROXYSUB is an attribute that controls when proxy subscriptions are made. By default it has value FIRSTUSE and thus proxy subscriptions are only created when a user subscription is made to the topic. Alternatively you can have the value FORCE which means proxy subscriptions are made even when no local user subscriptions exist.

Cluster Topic Hosts



- Cluster Topics can be defined on any queue manager in the cluster
  - Full or Partial Repositories
- Cluster topics can be defined on more than one queue manager
  - Recommended to chose two hosts
    - QM1 - DEF TOPIC(APPLES) TOPICSTR(Price/Fruit/Apples) CLUSTER(DEMO)
    - QM2 - DEF TOPIC(APPLES) TOPICSTR(Price/Fruit/Apples) CLUSTER(DEMO)
  - Multiple definitions ok
    - But not necessarily concurrent
      - If topic host is lost, cluster topic will remain usable for up to 30 days
      - RESET CLUSTER the lost queue manager
  - … but definitions should be identical
    - Behaviour is undefined where attributes conflict
    - Conflict reported
      - AMQ9465 / AMQ9466
      - CSQX465I / CSQX466I



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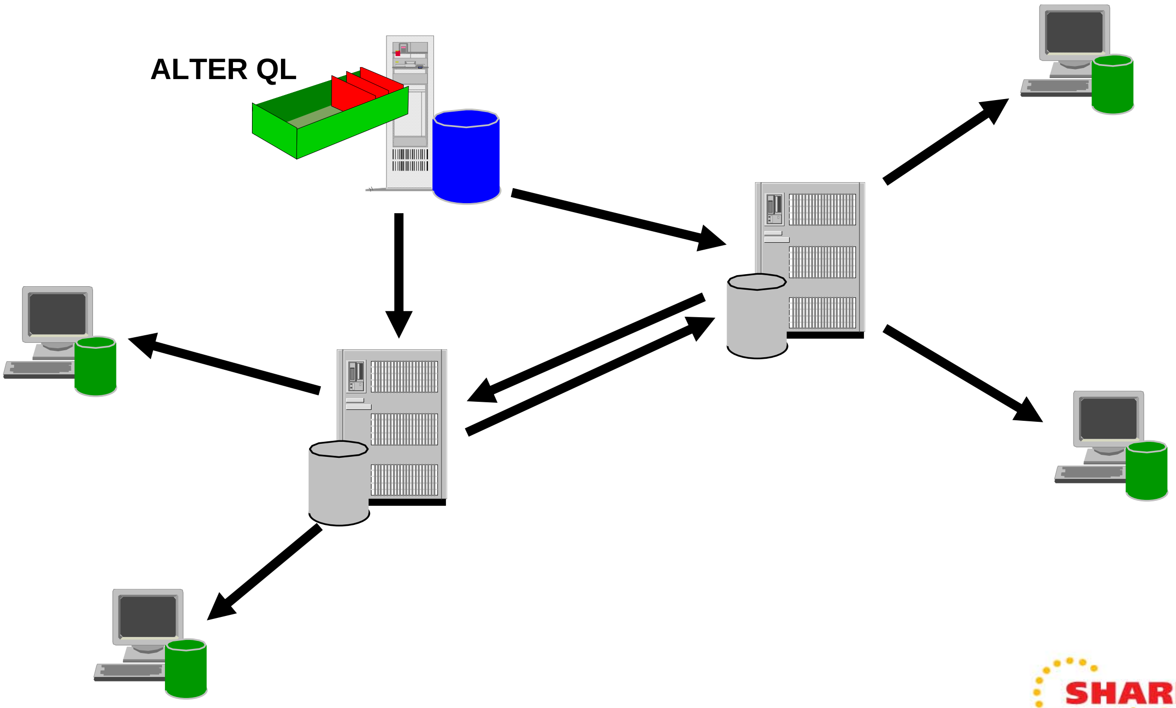
Cluster Topic Hosts

N O T E S

- Cluster TOPICS are regular TOPIC objects that are advertised to the cluster. When a cluster TOPIC is defined, the cluster in which it is defined becomes a Pub/sub Cluster.
- Like traditional clusters, Pub/sub clusters are designed for many-many queue manager connectivity. In traditional clusters, cluster objects are automatically defined based on usage (e.g. put to a queue). The usage model is based on a putter using a set of cluster queues (not necessarily defined on all queue managers in the cluster). Therefore in traditional clusters it is unlikely that all queue managers will actually be connected to all other queue managers by auto-defined channels.
- In Pub/sub clusters, cluster objects are automatically defined before usage, at the time the first cluster TOPIC is defined in the cluster. This is because the usage model is different to that of traditional clusters. Channels are required from any queue manager to which a subscriber (for a cluster topic) is connected to all other queue managers so that a proxy-subscription can be fanned out to all the queue managers. Channels are also required back from any queue manager where a publisher (for a cluster topic) is connected to those queue managers which have a connected subscriber. Therefore in Pub/sub Clusters it is much more likely that all queue managers will actually be connected to all other queue managers by auto-defined channels. It is for this reason that, in Pub/sub clusters, cluster objects are automatically defined before usage.
- A cluster topic host is a queue manager where a clustered TOPIC object is defined. Clustered TOPIC objects can be defined on any queue manager in the pub/sub cluster. When at least one clustered topic exists within a cluster the cluster is a pub/sub cluster. It is recommended that all clustered TOPIC objects be identically defined on two queue managers and that these machines be highly available. If a single host of a clustered TOPIC object is lost (e.g. due to disk failure), any cluster topic cache records based on the clustered topic object that already exist in the cluster cache on other queue managers, will be usable within the cluster for a period of up to 30 days (or until the cache is refreshed). The clustered TOPIC object can be redefined on a healthy queue manager. If a new object is not defined, up to 27 days after the host queue manager failure, all members of the cluster will report that an expected object update has not been received (AMQ9465 / AMQ9466 or CSQX465I / CSQX466I).
- There is no requirement that full repositories and topic hosts overlap, or indeed that they are separated. In pub/sub clusters that have just two highly available machines amongst many machines, it would be recommended to define both the highly available machines as full repositories and cluster topic hosts. In pub/sub clusters with many highly available machines it would be recommended to define full repositories, and cluster topic hosts on separate highly available machines, so that the operation and maintenance of one function can be managed without affecting the operation of other functions.
- Although there is nothing wrong with having multiple identical definitions for a topic within a cluster, it adds administration overhead when changing, so is probably a bad idea. Definitions must be kept consistent or it could result in unpredictable behavior (as indicated by warning messages in logs).

Change Propagation

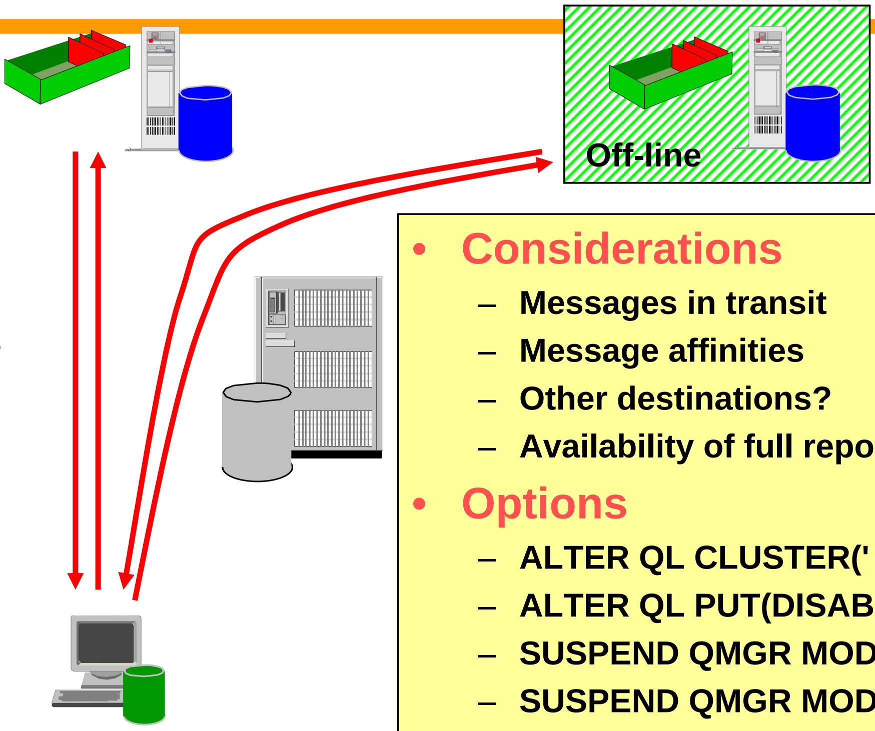


Change Propagation

N O T E S

- The important thing to note about change propagation is that notification of a change always starts at the queue manager where the change occurs. In a cluster, resources are defined, altered and deleted by the owner of the resource. This is because the owner of the resource is best placed to change the resource. When a resource changes, such as a queue, for example, that change is firstly reflected in the local queue manager. This queue manager then publishes the change to two full repositories to increase the likelihood of it reaching the network quickly. Full repositories publish the change to any other full repositories for which they have manually defined cluster sender channels and they also publish the change to any partial repositories which have subscribed for the resource that has been modified.
- In this way a change applied to a locally owned resource is propagated to all repositories for that cluster and all client and server queue managers that have applications that have expressed interest in the resource at MQOPEN time.
- Change propagation also needs to take place if a queue manager is being removed from the cluster.
- The resources that the queue manager owns in the cluster (any queues and its clusrcvr channels) should be deleted and these deletes will then get published around the cluster so that all the queue managers are aware of the changes.
- Quite often what we have seen occurring is that a queue manager is removed without first deleting its cluster resources. This leaves a situation where the rest of the cluster thinks the queue manager still exists. If you find this has occurred, you will need to use the RESET CLUSTER command to force the removed queue managers definitions out of the cluster. This is discussed later in the presentation.

Taking a queue manager off-line for maintenance



Server QMs

Partial repositories

Full repository QMs

Client QMs

Partial repositories

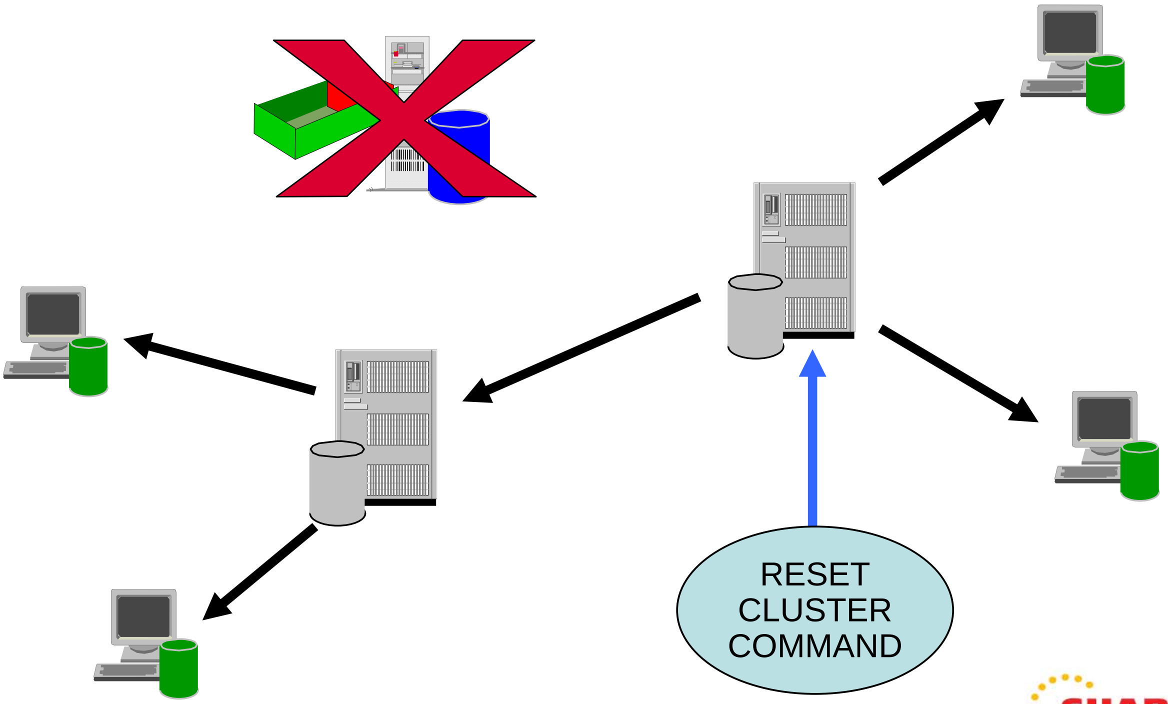
- **Considerations**
  - – Messages in transit
  - – Message affinities
  - – Other destinations?
  - – Availability of full repositories?
- **Options**
  - – ALTER QL CLUSTER(' ')
  - – ALTER QL PUT(DISABLED)
  - – SUSPEND QMGR MODE(QUIESCE)
  - – SUSPEND QMGR MODE(FORCE)
  - – STOP CLUSRCVR MODE(FORCE)

Taking a queue manager off-line for maintenance

NOTES

- There are several different options available for stopping the workload to a cluster queue manager whilst maintenance is performed. These have differing characteristics explained below:
- **ALTER QL PUT(DISABLED)**
- This will stop any new work being put to the queue. Any messages in transit that are bind_on_open cannot be sent elsewhere so they will go to the dead letter queue. Any messages in transit that are bind_not_fixed will be sent elsewhere if another destination is available, otherwise they will also go to the dead letter queue. The information about whether a queue is inhibited for puts or not is flowed around the cluster. Therefore as long as the full repositories are available, the queue managers in the cluster will see that the queues are put inhibited and will not send them any more work. Until the queue managers find out this information they will continue to send messages to the queue.
- **SUSPEND QMGR MODE(QUIESCE)**
- This is a gentle way of stopping the flow of work to a queue manager. The work will be sent elsewhere if possible, but if not then it will still be sent to the queue manager which is suspended. The information that a qmgr has suspended itself from the cluster is flowed around the cluster so that all the queue managers in the cluster are aware of this. Those queue managers will then take this into consideration when deciding which destination to send messages too. If there are other destinations available that are not suspended from the cluster then these will be picked instead of the suspended qmgr. In transit messages will still flow to the suspended qmgr and be processed. Similarly, any messages being sent bind_on_open will still be sent to the suspended qmgr. If there are no other destinations available, then work will still be sent to the suspended qmgr.
- **SUSPEND QMGR MODE(FORCE)**
- The mode force attribute on the suspend command means that as well as telling the queue managers in the cluster that the queue manager is suspended, all inbound channels will be forced to stop, i.e. the clusrcvr channels are stopped mode force. This ensures that no more work can be sent to the queue manager. The channels from the other queue managers will retry and messages sent bind_not_fixed will be sent to other destinations if these are available. Stopping the channels in this way can occasionally lead to indoubt messages which cannot be sent elsewhere for processing.
- **STOP CLUSRCVR MODE(FORCE)**
- This has a similar effect to SUSPEND QMGR MODE(FORCE). The only difference is that other queue managers in the cluster will not see that the qmgr is suspended, only that the channels are in retry state. Again there is the possiblity of indoubt messages.

Incorrectly deleted queue managers

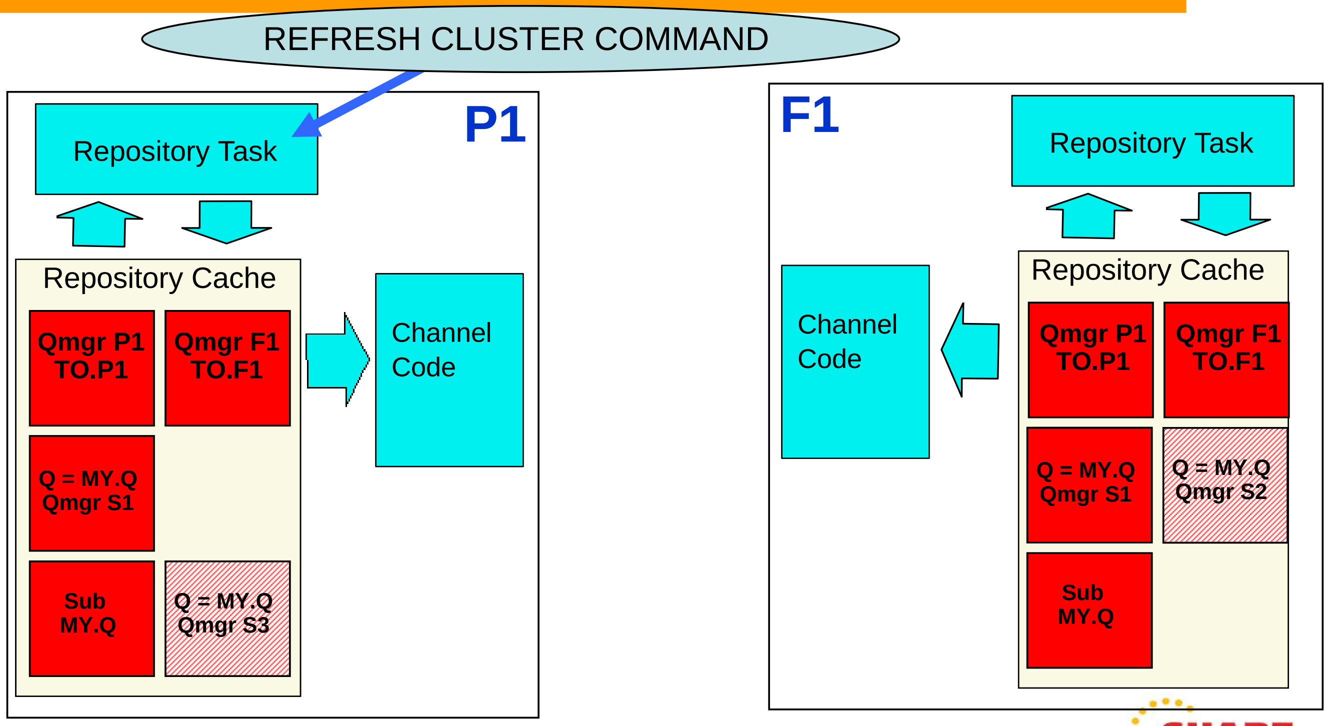


Incorrectly deleted queue managers

NOTES

- If a queue manager is deleted without first removing it from the cluster, then the rest of the queue managers in the cluster will still believe that the queue manager exists and will retain this information for up to 90 days.
- Another way is required to tell the cluster to remove the information about the deleted queue manager. The RESET CLUSTER command can be used to force a queue managers definitions to be deleted from the cluster. It has to be run on a Full Repository, as the Full Repositories know about all the cluster resources owned by the queue manager being removed and can then inform the other queue managers in the cluster to delete them.
- Quite often we see a situation where the deleted queue manager is recreated using a script, however the cluster treats this as a different queue manager, as each queue manager is assigned a unique queue manager identifier when it is created. This can lead to duplicate queue managers in the cluster. Once again the RESET CLUSTER command can be used to remove the old instance of the queue manager by deleting it by its queue manager identifier (QMID). The ability to force remove a queue manager by QMID was introduced in V5.3.

Refreshing repository information



REFRESH CLUSTER COMMAND

P1

Repository Task

Repository Cache

Qmgr P1 TO.P1

Qmgr F1 TO.F1

Q = MY.Q Qmgr S1

Sub MY.Q

Q = MY.Q Qmgr S3

Channel Code

F1

Repository Task

Repository Cache

Qmgr P1 TO.P1

Qmgr F1 TO.F1

Q = MY.Q Qmgr S1

Q = MY.Q Qmgr S2

Sub MY.Q

Channel Code

Refreshing repository information

NOTES

- The diagram on the previous page shows a situation where the information held in the Partial Repositories cluster cache has become out of sync with the information held on the Full Repository. In this example, the Partial Repository believes that a queue called MY.Q is hosted by queue managers S1 and S3, but the Full Repository knows it is actually hosted by S1 and S2.
- This discrepancy can be fixed by issuing the REFRESH CLUSTER command on the Partial Repository. The command tells the Partial Repository to delete the information it has built up about the cluster. This information will then be rebuilt over time, by requesting it from the Full Repositories.
- It is not normally necessary to issue a REFRESH CLUSTER command except in one of the following circumstances:
  - Messages have been removed from either the SYSTEM.CLUSTER.COMMAND.QUEUE, or from another queue manager's SYSTEM.CLUSTER.TRANSMIT.QUEUE, where the destination queue is SYSTEM.CLUSTER.COMMAND.QUEUE on the queue manager in question.
  - Issuing a REFRESH CLUSTER command has been recommended by IBM® Service.
  - The CLUSRCVR channels were removed from a cluster, or their CONNAMEs were altered on two or more Full Repository queue managers while they could not communicate.
  - The same name has been used for a CLUSRCVR channel on more than one queue manager in a cluster, and as a result, messages destined for one of the queue managers have been delivered to another. In this case, the duplicates should be removed, and then a REFRESH CLUSTER command should be issued on the single remaining queue manager that has the CLUSRCVR definition.
  - RESET CLUSTER ACTION(FORCEREMOVE) was issued in error.
  - The queue manager has been restarted from an earlier point in time than it last finished, (for example, by restoring backed up data.)

Securing a cluster with SSL

- External CAs, Internal CAs or self-signed?
- Alter existing channels or define new channels?
  - NETPRTY
  - Must delete non-SSL channels
- SSLCAUTH
- DEFINE/ALTER CHANNEL
  - Ensure full repositories and cluster channels are healthy
  - Recommended order
    - Cluster receivers on all full repositories
    - Cluster senders on all full repositories
    - Cluster receivers on all partial repositories
    - Cluster senders on all partial repositories
  - Channels must be restarted to pick up changes

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Securing a cluster with SSL

NOTES

- Self-Signed
  - Not very scalable – Every certificate must be copied to all queue manager's key repositories
- Internal CA
  - Scaleable – Only CA certificate is copied to all queue manager's key repositories
  - Ideal for cluster queue managers in same company/department
- External CA
  - Scaleable – Only CA certificate is copied to all queue manager's key repositories
  - Ideal for cluster queue managers spanning companies/departments
- If creating a cluster from scratch you can define SSL channels by setting SSLCIPH on the DEFINE CHANNEL command.
- If altering an existing non-SSL cluster to use SSL, you can alter the existing channel definitions to set the SSLCIPH attributes or define a second set of channels, with the second set having the SSLCIPH attribute set. This will mean having two sets of channels in the cluster; one SSL set and one non-SSL set. You can use NETPRTY to prioritise message traffic over one set. Note that the cluster will only be truly secure when the non-SSL channels have been deleted. If the NETPRTY on the SSL channels is higher, message traffic will flow over it unless the channel is in a less favourable state that the non-SSL channel. This means traffic can still flow over the non-SSL channel, and therefore the cluster is not secure.
- All queue managers in a cluster should have a certificate, so even if SSLCAUTH is set to OPTIONAL, the check of the sending queue manager's certificate will always take place since a certificate will always be presented.
- When changing any cluster definitions is important that the full repositories and cluster channels are healthy, so that the changes can automatically propagate around the cluster.
- The cluster receivers should be altered before cluster senders so that definitions can be propagated and channel errors are avoided. Cluster sender channels must be restarted after the changes before they are secure.

Implementation recommendations

- Be clear about your requirements
  - Reduced system administration?
  - Workload balancing?
- Read the Queue Manager Clusters manual
  - The tasks sections are useful – Especially how to remove a queue manager from a cluster
- Helps to experiment in a development/test environment
  - Before using commands (especially REFRESH CLUSTER) read the whole section for that command in the MQSC manual
- Usage notes contain important info
- Naming conventions
  - No one recommended convention - consistency is the key
- Document processes for production system changes
  - Add/remove queue manager to/from cluster
  - Take queue manager offline for maintenance
- Start small
- Have two Full Repositories
  - Be careful about connecting them
  - Consider where you should host them

Implementation recommendations (continued)

- Be careful defining cluster topics in existing clusters
- Monitor the SYSTEM.CLUSTER.TRANSMIT.QUEUE
  - Per channel CURDEPTH (V6) – DIS CHSTATUS XQMSGSA
- When debugging check that channels are healthy
  - Definition propagation: Path from one QM to another via FRs
  - Application: Path from application to queue manager hosting queue.
- Consider how you will administrate and debug
  - Monitor CSQX4.../AMQ94.. messages
  - MQRC_UNKNOWN_OBJECT_NAME
  - “Where’s my message?” (when there are now n cluster queues)
- Bind-not-fixed gives better availability
  - By default, bind-on-open is used
- Further Information in the Infocenter
  - Queue Manager Clusters
  - Script (MQSC) Command Reference
  - Publish/Subscribe User’s Guide

Summary

- The purpose of clustering
- Architecture
  - Channels, Full Repositories, cluster sizes
  - Defining and checking cluster queue managers
  - How Clustering works (System queues, queue discovery)
- New in V7
  - Pub/sub Clusters
- Using Clusters
  - Workload balancing
  - Message routing
- Further Considerations
  - RESET, REFRESH
- Recommendations