Red Hat JBoss A-MQ 6.2

Using Networks of Brokers

Networking multiple brokers for better performance

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Abstract

Message brokers can be connected together to form a robust cluster. Once connected the brokers can more easily distribute load and provide more robust fault tolerance.

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CHAPTER 1. INTRODUCTION

Abstract

Distributing your brokers can provide a number of benefits including fault tolerance, load balancing, and network segmentation. Red Hat JBoss A-MQ allows you to federate your brokers into a network of brokers so that distributed brokers can share information and route messages as needed.

OVERVIEW

For many applications, using a single message broker is sufficient. However, there are many cases where using multiple interconnected brokers is more appropriate. For example, if you need to ensure that your application is continuously available, if your application needs to process large volumes of messages, or if your integration solution calls for message processing across distributed location a network of brokers will work better than a single message broker.

Red Hat JBoss A-MQ facilitates these use cases by making it possible to build up a network of brokers. A network of brokers is a set of two or more brokers connected together by network connectors. All of the brokers in the network share information about the clients and destinations each broker hosts. The connected brokers use this information to route messages through the network.

NETWORK OF BROKERS

A network of brokers is created when one broker establishes a network connector to another broker. Once the network connector is established the broker that established the connection discovers information about the destinations being hosted on the other broker and which consumers are actively listening for messages on the destinations. Using this information, the first broker can route messages from its producers to consumers on the connected broker. A simple network of brokers, such as this, spreads load between the two brokers, allows each broker to be configured for specific needs, and partitions the producers and consumers.

A network of brokers can be expanded by introducing more brokers to the network. This allows you to build up sophisticated network topologies. You can also create bidirectional connections between brokers to allow for more sophisticated message routing.

DYNAMIC NETWORKS

To create a robust network, it is important to be able to deploy brokers dynamically through out your infrastructure. It is also important to be able to add and remove brokers as needed. JBoss A-MQ facilitates this with a number of discovery protocols. These protocols allow brokers and clients to determine a list of active brokers. Brokers can automatically add new brokers to a network of brokers and removes inactive brokers. Clients always have a list of brokers that are available if they need to failover to a new broker.

CHAPTER 2. NETWORK CONNECTORS

Abstract

The network connector is the glue that binds a network of brokers. They are define the pathways between the brokers and are responsible for controlling how messages propagate throughout the network.

OVERVIEW

Network connectors define the broker-to-broker links that are the basis of a broker network. This section defines the basic options for configuring network connectors and explains the concepts that underlie them.

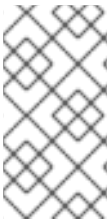
ACTIVE CONSUMERS

An *active consumer* is a consumer that is connected to one of the brokers in the network, has indicated to the broker which topics and queues it wants to receive messages on, and is ready to receive messages. The broker network has the ability to keep track of active consumers, receiving notifications whenever a consumer connects to or disconnects from the network.

SUBSCRIPTIONS

In the context of a broker network, a *subscription* is a block of data that represents an active consumer's interest in receiving messages on a particular queue or on a particular topic. Brokers use the subscription data to decide what messages to send where. Subscriptions, therefore, encapsulate all of the information that a broker might need to route messages to a consumer, including JMS selectors and which route to take through the broker network.

Subscriptions are inherently dynamic. If a given consumer disconnects from the broker network (thus becoming inactive), its associated subscriptions are automatically cancelled throughout the network.



NOTE

This usage of the term, *subscription*, deviates from standard JMS terminology, where there can be topic subscriptions but there is no such thing as a queue subscription. In the context of broker networks, however, we speak of both *topic subscriptions* and *queue subscriptions*.

PROPAGATION OF SUBSCRIPTIONS

Both topic subscriptions and queue subscriptions propagate automatically through a broker network. That is, when a consumer connects to a broker, it passes its subscriptions to the local broker and the local broker then forwards the subscriptions to neighbouring brokers. This process continues until the subscriptions are propagated throughout the broker network.

Under the hood, Red Hat JBoss A-MQ implements subscription propagation using *advisory messages*, where an advisory message is a message sent through one of the special channels known as an *advisory topic*. An advisory topic is essentially a reserved JMS topic used for transmitting administrative messages. All advisory topics have names that start with the prefix, **`ActiveMQ.Advisory`**.

WARNING

In order for dynamic broker networks to function correctly, it is essential that advisory messages are enabled (which they are by default). Make sure that you do *not* disable advisory messages on any broker in the network. For example, if you are configuring your brokers using XML, make sure that the **`advisorySupport`** attribute on the **`broker`** element is *not* set to **`false`**.

In principle, it *is* possible to configure a static broker network when advisory messages are disabled. See Chapter 3, *Dynamic and Static Propagation* for details.

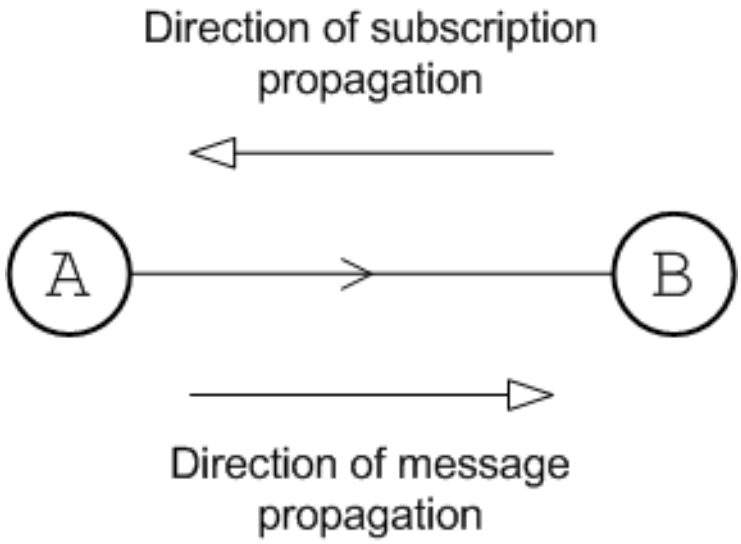
NETWORK CONNECTOR

A broker network is built up by defining directed connections from one broker to another, using *network connectors*. The broker that establishes the connection *passes messages* to the broker it is connected to. In XML, a network connector is defined using the **`networkConnector`** element, which is a child of the **`networkConnectors`** element.

SINGLE CONNECTOR

Figure 2.1, “Single Connector” shows a single network connector from broker A to broker B. The arrow on the connector indicates the direction of message propagation (from A to B). Subscriptions propagate in the *opposite* direction (from B to A). Because of the restriction on the direction of message flow in this network, it is advisable to connect producers only to broker A and consumers only to broker B. Otherwise, some messages might not be able to reach the intended consumers.

Figure 2.1. Single Connector



When the connector arrow points from A to B, this implies that the network connector is actually defined on broker A. For example, the following fragment from broker A's configuration file shows the network connector that connects to broker B:

Example 2.1. Single connector configuration

```
<beans ...>
    <broker xmlns="http://activemq.apache.org/schema/core"
            brokerName="brokerA" brokerId="A" ... >
        ...
        <networkConnectors>
            <networkConnector name="linkToBrokerB"
                uri="static:(tcp://localhost:61002)"
                networkTTL="3"
            />
        </networkConnectors>
        ...
        <transportConnectors>
            <transportConnector name="openwire"
uri="tcp://0.0.0.0:61001"/>
        </transportConnectors>
    </broker>
</beans>
```

The **networkConnector** element in the preceding example sets the following basic attributes:

name

Identifies this network connector instance uniquely (for example, when monitoring the broker through JMX). If you define more than one **networkConnector** element on a broker, you must set the name in order to ensure that the connector name is unique within the scope of the broker.

uri

The discovery agent URI that returns which brokers to connect to. In other words, broker A connects to *every* transport URI returned by the discovery agent.

In the preceding example, the static discovery agent URI returns a single transport URI, **tcp://localhost:61002**, which refers to a port opened by one of the transport connectors on broker B.

networkTTL

The network time-to-live (**networkTTL**) attribute specifies the maximum number of hops that a message can make through the broker network. It is almost always necessary to set this attribute because the default value (**1**) enables a message to make just one hop to a neighboring broker.

Each time a message is forwarded across a network bridge, the receiving broker's ID is appended to an internal BrokerId array, **BrokerPath**. Comparison of the **networkTTL**'s setting with the size of **BrokerPath** enforces the configured number of hops.

When messages fail to propagate as expected, you can use **BrokerPath**, which is exposed as a string property, to check the brokers that specific messages have traversed. Two methods are available, and both return a comma-separated list of broker IDs:

- Browsing a message via JConsole, hawtio, or a JMS browser to check its **BrokerPath** property
- Programmatically via **getStringProperty("JMSActiveMQBrokerPath")**; for example:

```
((ActiveMQMessage)message1).getStringProperty(ActiveMQMessage.BROK
```

```
ER_PATH_PROPERTY).

contains(localBroker.getBroker().getBrokerId().toString())
```

A list of returned broker IDs looks something like this:

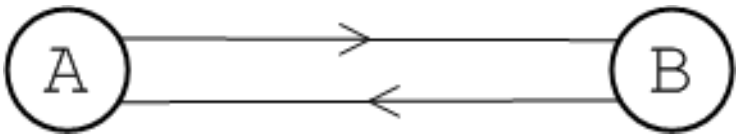
```
[ID:jdoe-ThinkPad-T222s-35488-1985672254433-0:2,
                            id_broker3, id_broker2]
```

In this example, the first ID, **`jdoe-ThinkPad-T222s-35488-1985672254433-0:2`**, is an embedded broker that has an automatically generated ID based on machine-name, and the second and third brokers were manually created with configured IDs.

CONNECTORS IN EACH DIRECTION

Figure 2.1, “Single Connector” shows a pair of network connectors in each direction: one from broker A to broker B, and one from broker B to broker A. In this network, there is no restriction on the direction of message flow and messages can propagate freely in either direction. It follows that producers and consumers can arbitrarily connect to either broker in this network.

Figure 2.2. Connectors in Each Direction



In order to create a connector in the reverse direction, from B to A, define a network connector on broker B, as follows:

Example 2.2. Two way connector

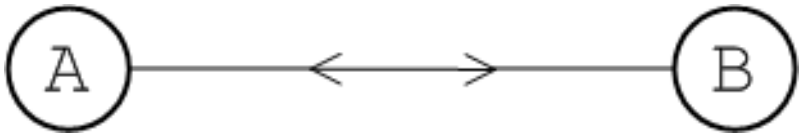
```
<beans ...>
    <broker xmlns="http://activemq.apache.org/schema/core"
            brokerName="brokerB" brokerId="B"... >
        ...
        <networkConnectors>
            <networkConnector name="linkToBrokerA"
                uri="static:(tcp://localhost:61001)"
                networkTTL="3" />
        </networkConnectors>
        ...
        <transportConnectors>
            <transportConnector name="openwire"
uri="tcp://0.0.0.0:61002" />
        </transportConnectors>
    </broker>
</beans>
```

DUPLEX CONNECTOR

An easier way to enable message propagation in both directions is by enabling duplex mode on an

existing connector. Figure 2.3, “Duplex Connector” shows a duplex network connector defined on broker A (where the dot indicates which broker defines the network connector in the figure). The duplex connector allows messages to propagate in both directions, but only one network connector needs to be defined and only *one* network connection is created.

Figure 2.3. Duplex Connector



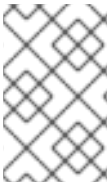
To enable duplex mode on a network connector, simple set the **`duplex`** attibute to **`true`**. For example, to make the network connector on broker A a duplex connector, you can configure it as follows:

Example 2.3. Duplex connector configuration

```
<networkConnectors>
   <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3"
       duplex="true" />
</networkConnectors>
```

NOTE

Duplex mode is particularly useful for cases where a network connection must be established across a firewall, because only one port need be opened on the firewall to enable bi-directional traffic.



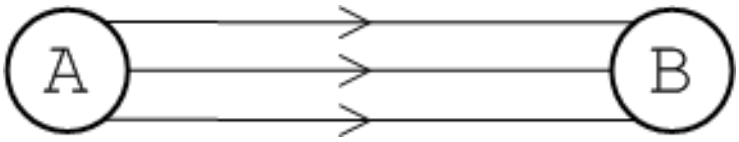
NOTE

Duplex mode works particularly well in a hub and spoke network. The spokes only need to know about one hub port and the hub does not need to know any of the spoke addresses (each spoke opens a duplex network connector to the hub).

MULTIPLE CONNECTORS

It is also possible to establish multiple connectors between brokers, as long as you observe the rule that each connector has a unique name. Figure 2.4, “Multiple Connectors” shows an example where three network connectors are established from broker A to broker B.

Figure 2.4. Multiple Connectors



To configure multiple connectors from broker A, use a separate **`networkConnector`** element for each connector and specify a unique name for each connector, as follows:

```
<networkConnectors>
   <networkConnector name="link01ToBrokerB"
```

```
        uri="static:(tcp://localhost:61002)"
        networkTTL="3"
    />
    <networkConnector name="link02ToBrokerB"
        uri="static:(tcp://localhost:61002)"
        networkTTL="3"
    />
    <networkConnector name="link03ToBrokerB"
        uri="static:(tcp://localhost:61002)"
        networkTTL="3"
    />
</networkConnectors>
```

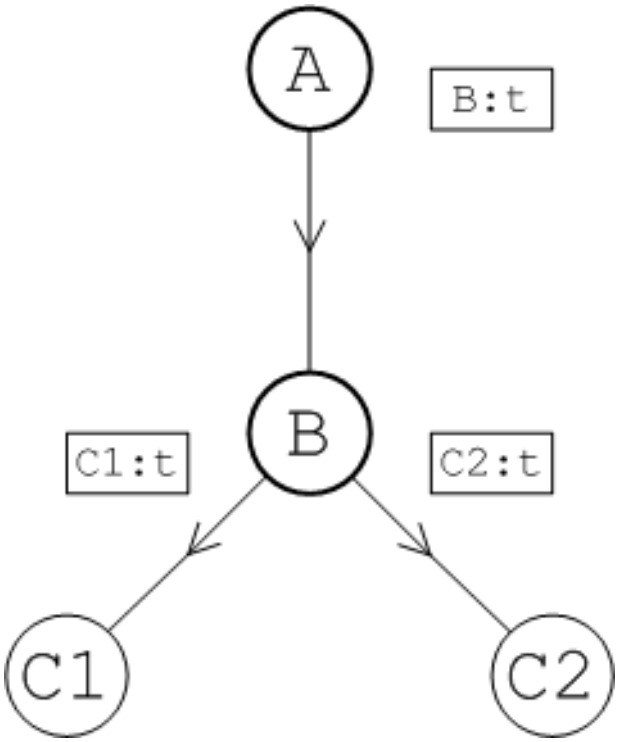
Here are some potential uses for creating multiple connectors between brokers:

- Spreading the load amongst multiple connections.
- Defining separate configuration for topics and queues. That is, you can configure one network connector to transmit queue subscriptions only and another network connector to transmit topic subscriptions only.

CONDUIT SUBSCRIPTIONS

By default, after passing through a network connector, subscriptions to the same queue or subscriptions to the same topic are automatically consolidated into a *single* subscription known as a *conduit subscription*. Figure 2.5, “Conduit Subscriptions” shows an overview of how the topic subscriptions from two consumers, C1 and C2, are consolidated into a single conduit subscription after propagating from broker B to broker A.

Figure 2.5. Conduit Subscriptions



In this example, each consumer subscribes to the identical topic, **`t`**, which gives rise to the subscriptions, **`C1:t`** and **`C2:t`** in broker B. Both of these subscriptions propagate automatically from broker B to broker A. Because broker A has conduit subscriptions enabled, its network connector consolidates the duplicate

subscriptions, **`C1:t`** and **`C2:t`**, into a single subscription, **`B:t`**. Now, if a message on topic **`t`** is sent to broker A, broker A sends a *single* copy of the message to broker B, to honor the conduit subscription, **`B:t`**. Broker B then sends a copy of the message to *each* consumer, to honor the topic subscriptions, **`C1:t`** and **`C2:t`**.

It is essential to enable conduit subscription in order to avoid duplication of topic messages. Consider what would happen in Figure 2.5, “Conduit Subscriptions” if conduit subscription was disabled. In this scenario, two subscriptions, **`B:C1:t`** and **`B:C2:t`**, would be registered in broker A. Now, if a message on topic **`t`** is sent to broker A, broker A would send *two* copies of the message to broker B, to honor the topic subscriptions, **`B:C1:t`** and **`B:C2:t`**. Broker B would then send *two* copies of the message to *each* consumer, to honor the topic subscriptions, **`C1:t`** and **`C2:t`**. In other words, each consumer would receive the topic message twice.

Conduit subscriptions can optionally be disabled by setting the **`conduitSubscriptions`** attribute to **`false`** on the **`networkConnector`** element. See Section 9.1, “Balancing Consumer Load” for more details.

CHAPTER 3. DYNAMIC AND STATIC PROPAGATION

Abstract

Because of the special nature of routing in a messaging system, the propagation of messages must be inherently dynamic. That is, the broker network must keep track of the active consumers attached to the network and the routing of messages is governed by the real-time transmission of advisory messages (subscriptions). However, there are cases in which messages need to be propagated in the absence of subscriptions.

OVERVIEW

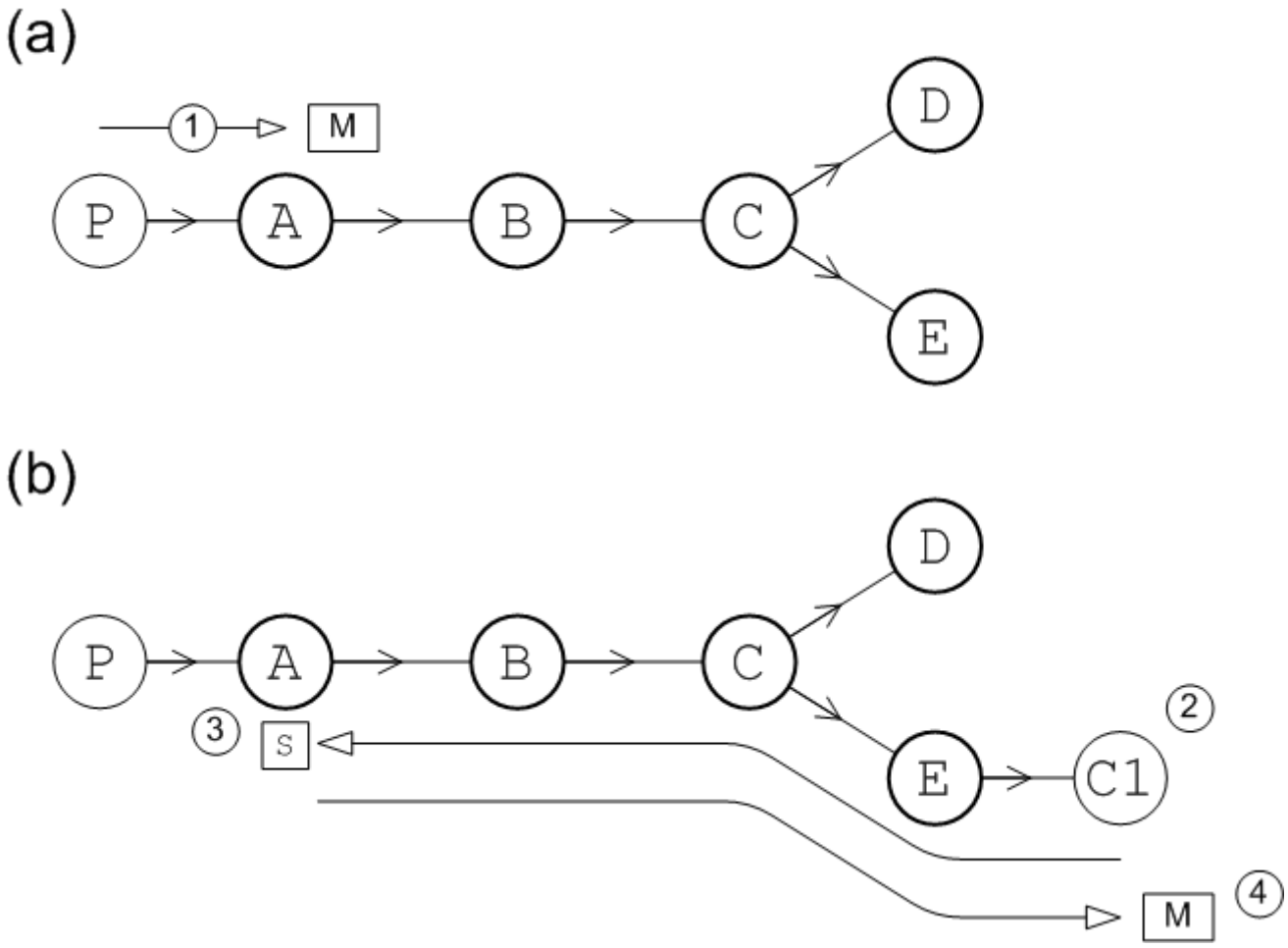
The fundamental purpose of a broker network is to route messages to their intended recipients, which are consumers that could be attached at any point in the network. The peculiar difficulty in devising routing rules for a messaging network is that messages are sent to an *abstract* destination rather than a *physical* destination. In other words, a message might be sent to a specific queue, but that gives you no clue as to which broker or which consumer that message should ultimately be sent to. Contrast this with the Internet Protocol (IP), where each message packet includes a header with an IP address that references the physical location of the destination host.

Because of the special nature of routing in a messaging system, the propagation of messages must be inherently dynamic. That is, the broker network must keep track of the active consumers attached to the network and the routing of messages is governed by the real-time transmission of advisory messages (subscriptions).

DYNAMIC PROPAGATION

Figure 3.1, “Dynamic Propagation of Queue Messages” illustrates how dynamic propagation works for messages sent to a queue. The broker connectors in this network are simple (non-duplex).

Figure 3.1. Dynamic Propagation of Queue Messages



The dynamic message propagation in this example proceeds as follows:

1. As shown in part (a), initially, there are *no* consumers attached to the network. A producer, **P**, connects to broker A and starts sending messages to a particular queue, **TEST.FOO**. Because there are no consumers attached to the network, all of the messages accumulate in broker A. The messages do *not* propagate any further at this time.

2. As shown in part (b), a consumer, C, now connects to the network at broker E and subscribes to the same queue, **TEST.FOO**, to which the producer is sending messages.

3. The consumer's subscription, **s**, propagates through the broker network, following the reverse arrow direction, until it reaches broker A.

4. After broker A receives the subscription, **s**, it knows that it can send the messages accumulated in the queue, **TEST.FOO**, to the consumer, C. Based on the information in the subscription, **s**, broker A sends messages along the path ABCE to reach consumer C.

STATIC PROPAGATION

Static propagation refers to message propagation that occurs in the *absence* of subscription information. Sometimes, because of the way a broker network is set up, it can make sense to move messages between brokers, even when there is no relevant subscription information.

Static propagation is configured by specifying the queue (or queues) that you want to statically propagate. Into the relevant **`networkConnector`** element, insert **`staticallyIncludedDestinations`** as a child element and then list the queues and topics you want

to propagate using the **queue** and **topic** child elements. For example, to specify that messages in the queue, **TEST.FOO**, are statically propagated from A to B, you would define the network connector in broker A's configuration as follows:

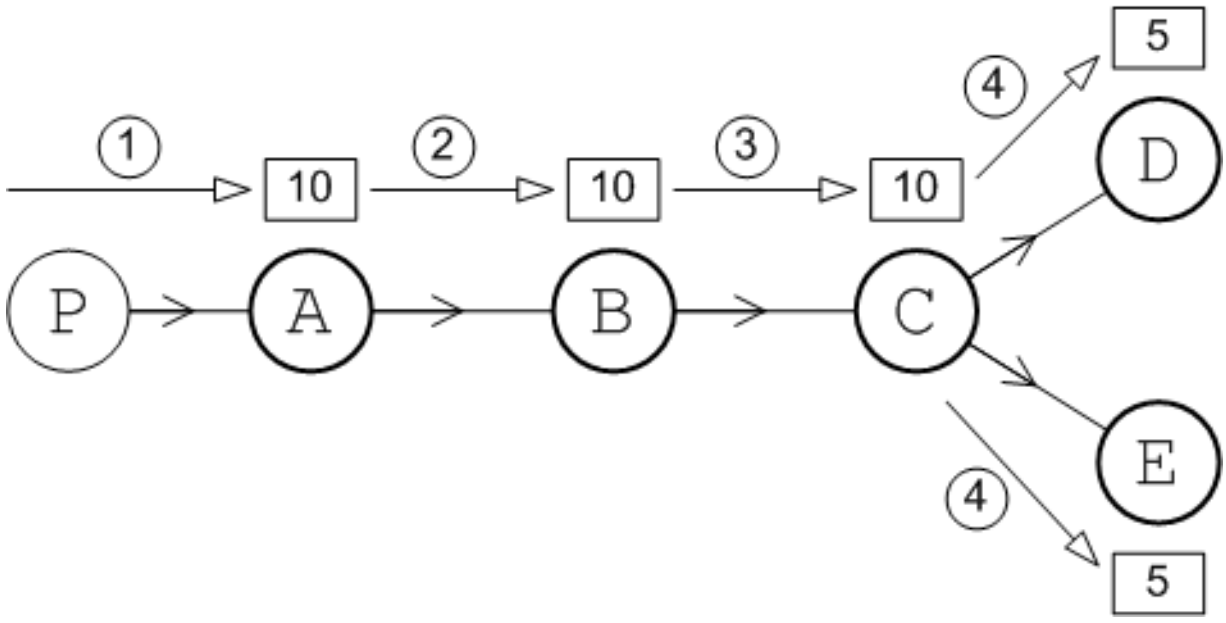
```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3">
        <staticallyIncludedDestinations>
            <queue physicalName="TEST.FOO"/>
        </staticallyIncludedDestinations>
    </networkConnector>
</networkConnectors>
```

NOTE

You can use wildcards when specifying statically included queue names or topic names—for example, the **physicalName** attribute in the preceding example could be set to **TEST.***. See Chapter 4, *Destination Filtering*.

Consider the network shown in Figure 3.2, “Static Propagation of Queue Messages”. This network is set up so that consumers only attach to broker D or to broker E Messages sent to the queue, **TEST.FOO**, are configured to propagate statically on all on all of the network connectors, **(A,B)**, **(B,C)**, **(C,D)**, and **(C,E)**.

Figure 3.2. Static Propagation of Queue Messages



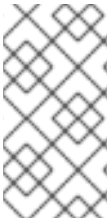
The static message propagation in this example proceeds as follows:

1. Initially, there are *no* consumers attached to the network. A producer, **P**, connects to broker A and sends 10 messages to the queue, **TEST.FOO**.

2. Because the network connector, **(A,B)**, has enabled static propagation for the queue, **TEST.FOO**, the 10 messages on broker A are forwarded to broker B.

3. Likewise, because the network connector, **(B,C)**, has enabled static propagation for the queue, **TEST.FOO**, the 10 messages on broker B are forwarded to broker C.

4. Finally, because the network connectors, **(C,D)** and **(C,E)**, have enabled static propagation for the queue, **TEST.FOO**, the 10 messages on broker C are alternately sent to broker D and broker E. In other words, the brokers, D and E, receive every second message. Hence, at the end of the static propagation, there are 5 messages on broker D and 5 messages on broker E.



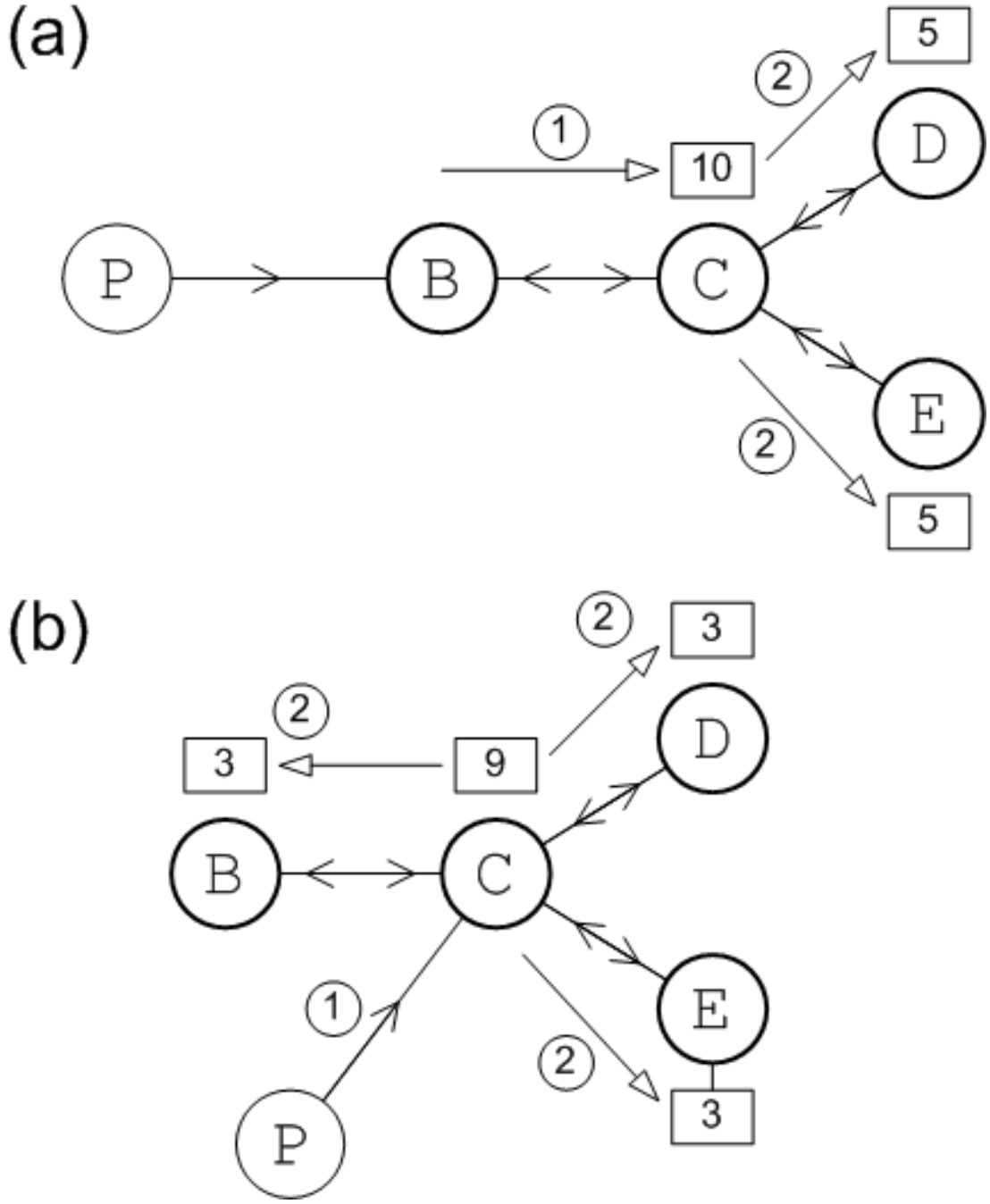
NOTE

Using the preceding static configuration, it is possible for messages to get stuck in a particular broker. For example, if a consumer now connects to broker E, it will receive the 5 messages stored on broker E, but it will *not* receive the 5 messages stored on broker D. The messages remain stuck on broker D until a consumer connects directly to it.

DUPLEX MODE AND STATIC PROPAGATION

It is also possible to use static propagation in combination with duplex connectors. In this case, messages can propagate statically in *either* direction through the duplex connector. For example, Figure 3.3, “Duplex Mode and Static Propagation” shows a network of four brokers, B, C, D, and E, linked by duplex connectors. All of the connectors have enabled static propagation for the queue, **TEST.FOO**.

Figure 3.3. Duplex Mode and Static Propagation



In part (a), the producer, P, connects to broker B and sends 10 messages to the queue, **TEST.FOO**. The static message propagation then proceeds as follows:

1. Because the duplex connector, **{B,C}**, has enabled static propagation for the queue, **TEST.FOO**, the 10 messages on broker B are forwarded to broker C.

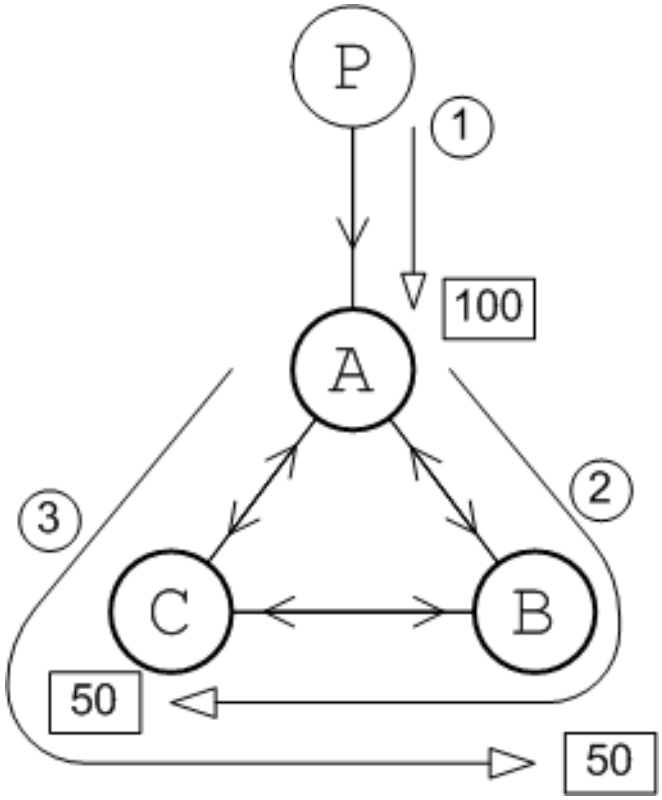
2. Because the duplex connectors, **{C,D}** and **{C,E}**, have enabled static propagation for the queue, **TEST.FOO**, the 10 messages on broker C are alternately sent to broker D and broker E. At the end of the static propagation, there are 5 messages on broker D and 5 messages on broker E.

In part (b), the producer, P, connects to broker C and sends 9 messages to the queue, **TEST.FOO**. Because static propagation is enabled on all of the connectors, broker C sends messages alternately to B, D, and E. At the end of the static propagation, there are 3 messages on broker B, 3 messages on broker D, and 3 messages on broker E.

SELF-AVOIDING PATHS

Brokers implement a strategy of *self-avoiding paths* in order to prevent pathalogical routes from occurring in a statically configured broker network. For example, consider what could happen, if a closed loop occurs in a network with statically configured duplex connectors. If the brokers followed a strategy of simply forwarding messages to a neighbouring broker (or brokers), messages could end up circulating around the closed loop for ever. This does *not* happen, however, because the broker network applies a strategy of self-avoiding paths to static propagation. For example, Figure 3.4, “Self-Avoiding Paths” shows a network consisting of three brokers, A, B, and C, linked by statically configured duplex connectors. The path ABCA forms a closed loop in this network.

Figure 3.4. Self-Avoiding Paths



The static message propagation in this example proceeds as follows:

1. The producer, P, connects to broker A and sends 100 messages to the queue, **`TEST.FOO`**.

2. The 100 messages on broker A are alternately sent to broker B and broker C. The 50 messages sent to broker B are immediately forwarded to broker C, but at this point the messages stop moving and remain on broker C. The self-avoiding path strategy dictates that messages can *not* return to a broker they have already visited.

3. Similarly, the 50 messages sent from broker A to broker C are immediately forwarded to broker B, but do not travel any further than that.

BROKERID AND SELF-AVOIDING PATHS

Red Hat JBoss A-MQ uses broker ID values (set by the **`broker`** element's **`brokerId`** attribute) to figure out self-avoiding paths. By default, the broker ID value is generated dynamically and assigned a new value each time a broker starts up. If your network topology relies on self-avoiding paths, however, this default behavior is *not* appropriate. If a broker is stopped and restarted, it would rejoin the network with a different broker ID, which confuses the self-avoiding path algorithm and can lead to stuck messages.

In the context of a broker network, therefore, it is recommended that you set the broker ID explicitly on the **broker** element, as shown in the following example:

```
<broker xmlns="http://activemq.apache.org/schema/core"
        brokerName="brokerA" brokerId="A"... >
    ...
</broker>
```

NOTE

Make sure you always specify a broker ID that is unique within the current broker network.

CHAPTER 4. DESTINATION FILTERING

Abstract

One reason to create a network of brokers is to partition message destinations to sub-domains of the network. Red Hat JBoss A-MQ can apply filters to destination names to prevent messages for a destination from passing through a network connector.

OVERVIEW

Typically, one of the basic tasks of managing a broker network is to partition the network so that certain queues and topics are restricted to a sub-domain, while messages on other queues and topics are allowed to cross domains. This kind of domain management can be achieved by applying filters at certain points in the network. Red Hat JBoss A-MQ lets you define filters on network connectors in order to control the flow of messages throughout the network.

JBoss A-MQ allows you to control the flow of messages in two ways:

- specifying which destinations' messages can pass through a connector
- excluding messages for specific destinations from passing through a connector

DESTINATION WILDCARDS

Destination names are often segmented to denote how they are related. For example, an application may use the prefix **`PRICE.STOCK`** to denote all of the destinations that handle stock quotes. The application may then further segment the destination names such that all stock quotes from the New York Stock Exchange were prefixed with **`PRICE.STOCK.NYSE`** and stock quotes from NASDAQ used the prefix **`PRICE.STOCK.NASDAQ`**. Using wildcards would be a natural way to create filters for specific types of destinations.

Table 4.1, “Destination Name Wildcards” describes the characters can be used to define wildcard matches for destination names.

Table 4.1. Destination Name Wildcards

Wildcard	Description
.	Separates segments in a path name.
*****	Matches any single segment in a path name.
>	Matches any number of segments in a path name.

Table 4.2, “Example Destination Wildcards” shows some examples of destination wildcards and the names they would match.

Table 4.2. Example Destination Wildcards

Destination wildcard	What it matches
PRICE.>	Any price for any product on any exchange.
PRICE.STOCK.>	Any price for a stock on any exchange.
PRICE.STOCK.NASDAQ.*	Any stock price on NASDAQ.
PRICE.STOCK.*.IBM	Any IBM stock price on any exchange.

FILTERING DESTINATIONS BY INCLUSION

The default behavior of a network connector is to allow messages for all destinations to pass. You can, however, configure a network connector to only allow messages for specific destinations to pass. If you use segmented destination names, you can use wildcards to filter groups of destinations.

You do this by adding a **dynamicallyIncludedDestinations** child to the network connector's **networkConnector** element. The included destinations are specified using **queue** and **topic** children. Example 4.1, “Network Connector Using Inclusive Filtering” shows configuration for a network connector that only passes messages destined for queues with names that match **TRADE.STOCK.>** and topics with names that match **PRICE.STOCK.>**.

Example 4.1. Network Connector Using Inclusive Filtering

```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3">
        <dynamicallyIncludedDestinations>
            <queue physicalName="TRADE.STOCK.>"/>
            <topic physicalName="PRICE.STOCK.>"/>
        </dynamicallyIncludedDestinations>
    </networkConnector>
</networkConnectors>
```

IMPORTANT

Once you add the **dynamicallyIncludedDestinations** to a network connector's configuration, the network connector will *only* pass messages for the specified destinations.

FILTERING DESTINATIONS BY EXCLUSION

Another way of partitioning a network and create filters is to explicitly specify a list destinations whose messages are not allowed to pass through a network connector. If you use segmented destination names, you can use wildcards to filter groups of destinations.

You do this by adding a **excludedDestinations** child to the network connector's **networkConnector** element. The excluded destinations are specified using **queue** and **topic**

children. Example 4.2, “Network Connector Using Exclusive Filtering” shows configuration for a network connector that blocks messages destined for queues with names that match **`TRADE.STOCK.NYSE.*`** and topics with names that match **`PRICE.STOCK.NYSE.*`**.

Example 4.2. Network Connector Using Exclusive Filtering

```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3">
        <excludedDestinations>
            <queue physicalName="TRADE.STOCK.NYSE.*"/>
            <topic physicalName="PRICE.STOCK.NYSE.*"/>
        </excludedDestinations>
    </networkConnector>
</networkConnectors>
```

COMBINING INCLUSIVE AND EXCLUSIVE FILTERS

You can combine inclusive and exclusive filtering to create complex network partitions. Example 4.3, “Combining Exclusive and Inclusive Filters” shows a network connector that is configured to transmit stock prices from any exchange except the NYSE and transmits orders to trade stocks for any exchange except the NYSE.

Example 4.3. Combining Exclusive and Inclusive Filters

```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3">
        <dynamicallyIncludedDestinations>
            <queue physicalName="TRADE.STOCK.>"/>
            <topic physicalName="PRICE.STOCK.>"/>
        </dynamicallyIncludedDestinations>
        <excludedDestinations>
            <queue physicalName="TRADE.STOCK.NYSE.*"/>
            <topic physicalName="PRICE.STOCK.NYSE.*"/>
        </excludedDestinations>
    </networkConnector>
</networkConnectors>
```

CHAPTER 5. USING JMS MESSAGE SELECTORS

Abstract

Red Hat JBoss A-MQ supports using JMS message selectors to filter messages. When using JMS message selectors with a network of brokers, you need to be aware of how the message selectors interact with conduit subscriptions. The interaction can lead to some undesirable outcomes if not properly managed.

OVERVIEW

JMS message selectors allow consumers to filter messages by testing the contents of a message's JMS header. The selectors are specified when the consumer connects to a broker and starts listing to messages on a particular destination. The broker then filters the messages that delivered to the consumer.

Brokers in a network also use JMS message selectors to determine how messages are routed. A consumer's message selectors are included in the subscription information propagated throughout the network. All of the brokers can then use this information to filter messages before forwarding messages through a network connector.

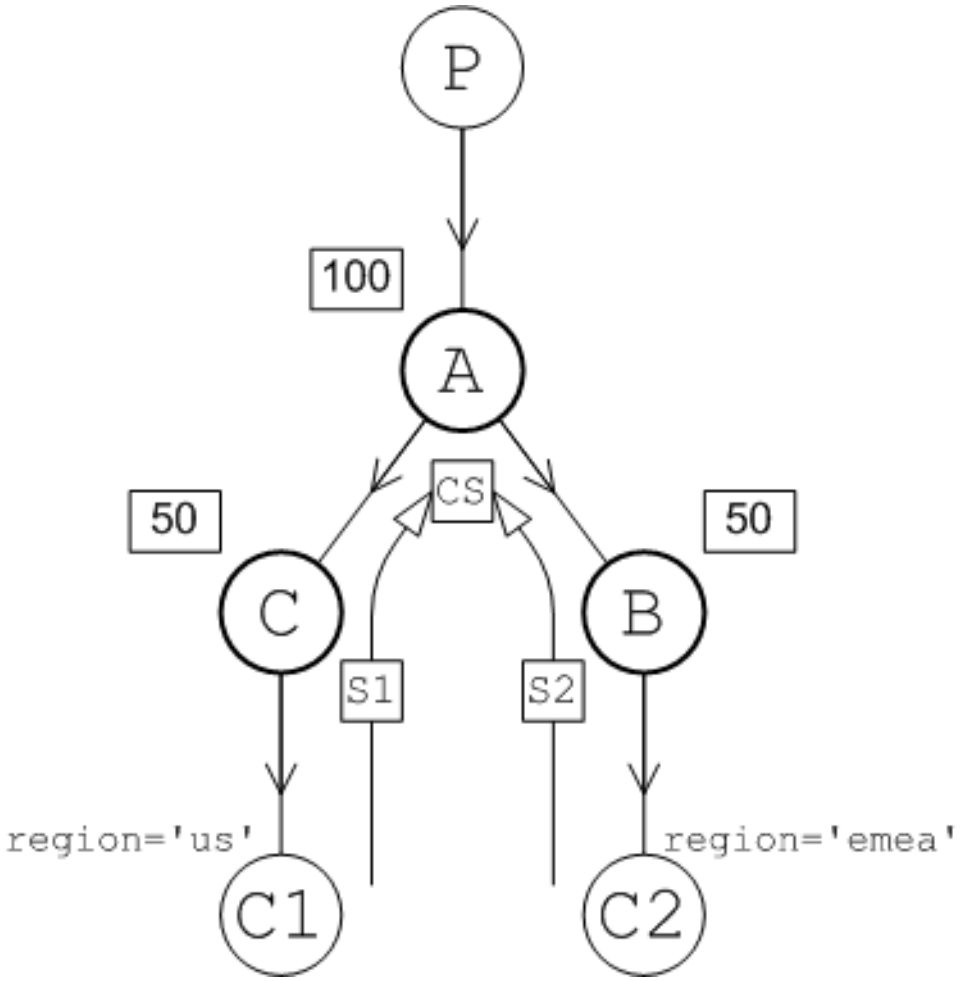
The one instance where message selectors are not used is when one or more consumer subscriptions are combined into a conduit subscription. This means that the broker receiving the conduit subscription cannot use the message selectors when determining what messages to forward.

SCENARIOS THAT DO NOT WORK

Trouble arises when message selectors are combined with conduit subscriptions for consumers that are listening on the same queue.

Consider the broker network shown in Figure 5.1, “JMS Message Selectors and Conduit Subscriptions”. Consumers C1 and C2 subscribe to the same queue and they also define JMS message selectors. C1 selects messages for which the **`region`** header is equal to **`us`**. C2 selects messages for which the **`region`** header is equal to **`emea`**.

Figure 5.1. JMS Message Selectors and Conduit Subscriptions



The consumer subscriptions, **s1** and **s2**, automatically propagate to broker A. Because these subscriptions are both on the same queue broker A combines the subscriptions into a single conduit subscription, **cs**, which does *not* include any selector details. When the producer P starts sending messages to the queue, broker A forwards the messages alternately to broker B and broker C *without* checking whether the messages satisfy the relevant selectors.

The best case scenario is that, by luck, the messages are forwarded to the broker with a selector that matches the message. The worst case scenario is that all of the messages for region **emea** end up on broker B and all of the messages for region **us** end up on broker C. Chances are that the result would be somewhere in the middle. However, that means that at least some messages will sit at a broker where they will never be consumed.

If the consumers were both listening to a topic instead of a queue broker A would send a copy of every message to both networked brokers. All of the messages would get processed because C1 would consume the messages for the US region and C2 would consumer the messages for the EMEA region. However, any messages for the EMEA region would sit unconsumed in broker C and any messages for the US region would sit unconsumed in broker B.

RESOLVING THE PROBLEM

When you are faced with a network of brokers suffering from the effects of combining conduit subscriptions and message selectors and the consumers are listening to a queue, the easiest solution is to disable conduit subscriptions at the network connector where the problem arises.

You disable conduit subscriptions by setting the **`networkConnector`** element's **`conduitSubscriptions`** to **`false`**. Example 5.1, “Disabling Conduit Subscriptions” shows configuration for a network connector with conduit subscriptions disabled.

Example 5.1. Disabling Conduit Subscriptions

```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3"
       conduitSubscriptions="false" />
</networkConnectors>
```

If the problem arises using topics, the solution is more difficult. Disabling conduit subscriptions will cause more problems. In this case, you will need to rethink the requirements of your application. If you *must* use message selectors with topics in a network of brokers, you have two options:

- ensure that your network topology is such that messages won't be sent to brokers without appropriate consumers
- ensure that the orphaned messages will not create issues in your application

CHAPTER 6. NETWORK TOPOLOGIES

Abstract

The topology of your network describes the pattern created by the pathways through your network. Different topologies are appropriate for particular use cases.

OVERVIEW

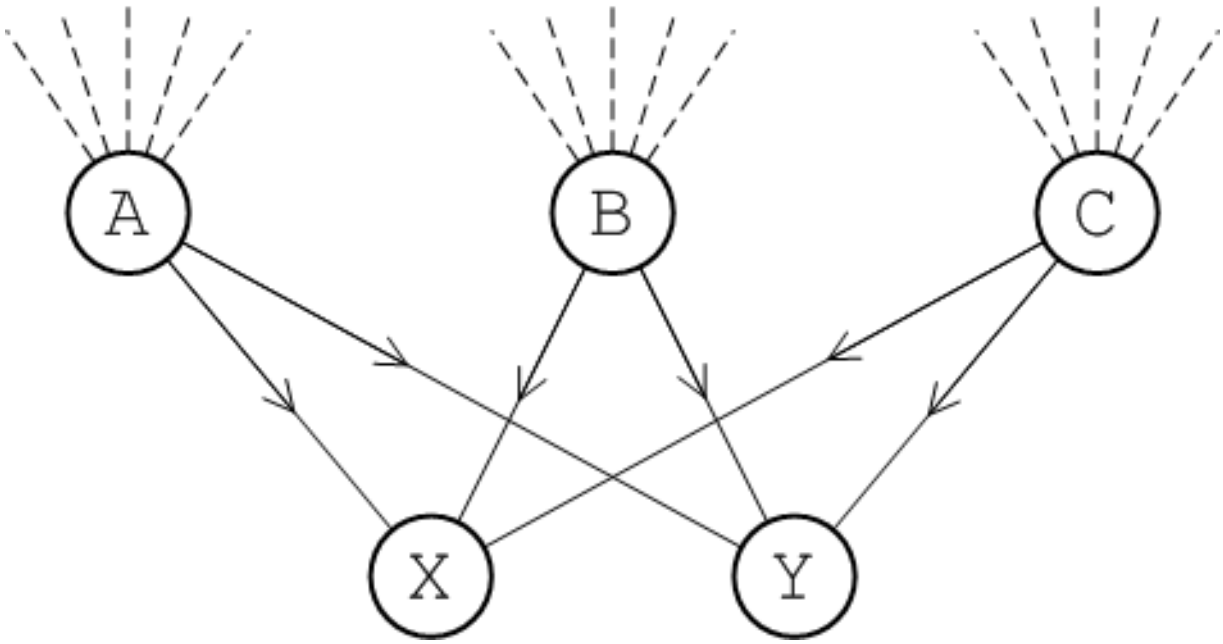
The following examples illustrate some of the common topologies encountered real-world networks:

- the section called “Concentrator topology”.
- the section called “Hub and spokes topology”.
- the section called “Tree topology”.
- the section called “Mesh topology”.
- the section called “Complete graph”.

CONCENTRATOR TOPOLOGY

If you anticipate that your system will have a large number of incoming connections that would overwhelm a single broker, you can deploy a concentrator topology to deal with this scenario, as shown in Figure 6.1, “Concentrator Topology”.

Figure 6.1. Concentrator Topology

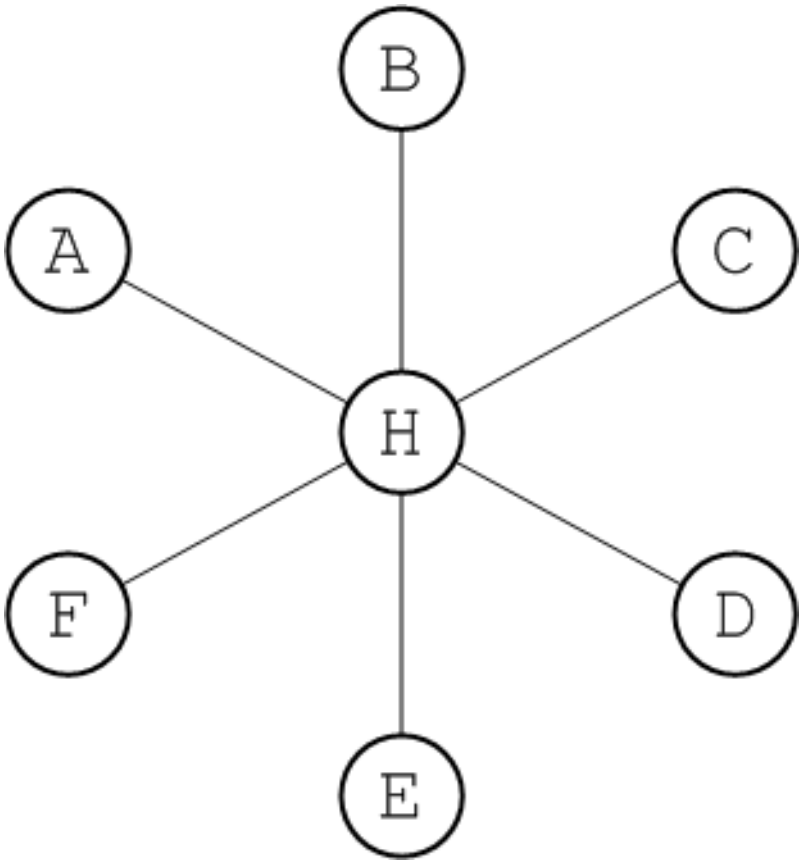


The idea of the concentrator topology is that you deploy brokers in two (or more) layers in order to funnel incoming connections into a smaller collection of services. The first layer consists of a relatively large number of brokers, with each broker servicing a large number of incoming connections (from producers **P1** to **Pn**). The next layer consists of a smaller number of brokers, where each broker in the first layer connects to all of the brokers in the second layer. With this topology, each broker in the second layer can receive messages from *any* of the producers.

HUB AND SPOKES TOPOLOGY

The hub and spokes, as shown in Figure 6.2, “Hub and Spoke Topology”, is a topology that is relatively easy to set up and maintain. The edges in this graph are all assumed to represent duplex network connectors.

Figure 6.2. Hub and Spoke Topology

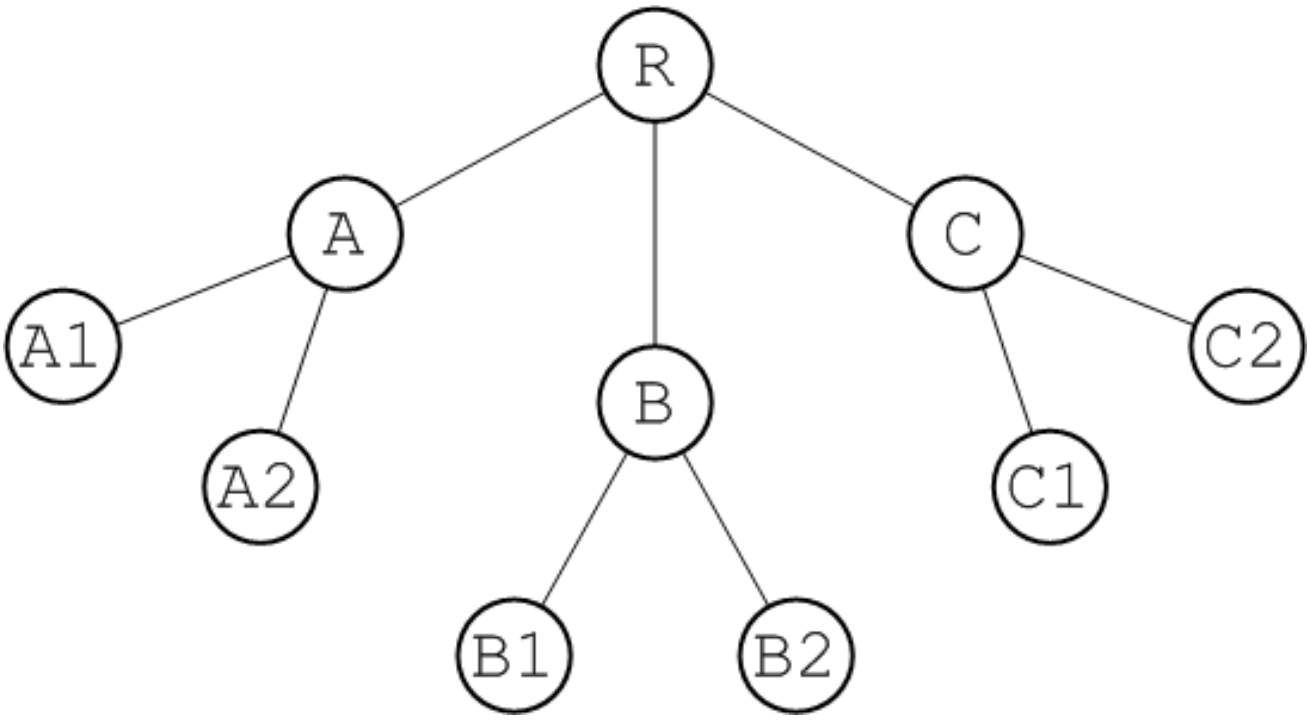


This topology is relatively robust. The only critical element is the hub node, so you would need to focus your maintenance efforts on keeping the hub up and running. Routes are determinate and the diameter of the network is always 2, no matter how many nodes are added.

TREE TOPOLOGY

The tree, as shown in Figure 6.3, “Tree Topology”, is a topology that arises naturally when a physical network grows in an informal manner.

Figure 6.3. Tree Topology

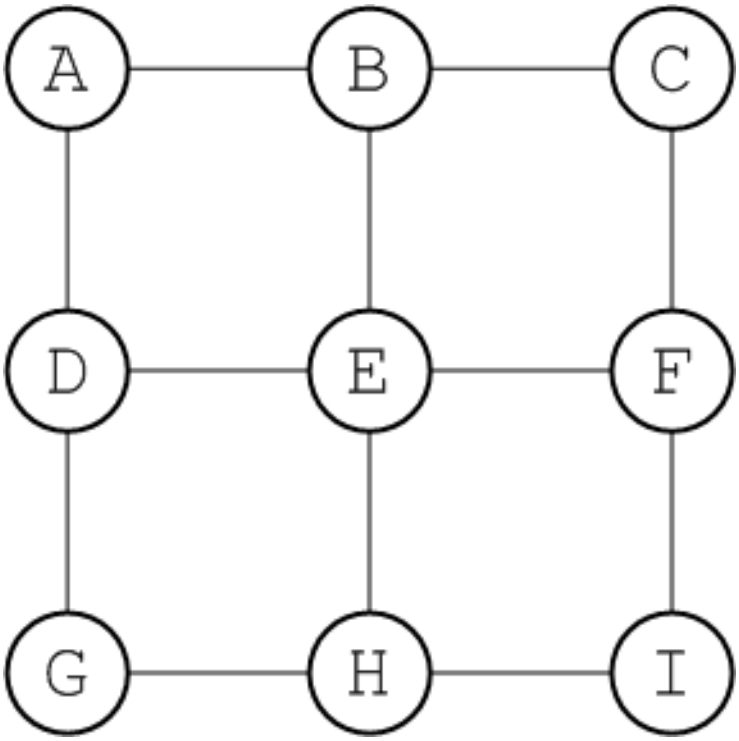


For example, if the network under consideration is an ethernet LAN, **R** could represent the hub in the basement of the IT department's building and **A** could represent a router in the ground floor of another building. If you want to extend the LAN to the first and second floor of building **A**, you are unlikely to run dedicated cables back to the IT hub for each of these floors. It is more likely that you will simply plug a second tier of routers, **A1** and **A2**, into the existing router, **A**, on the ground floor. In this way, you effectively add another layer to the tree topology.

MESH TOPOLOGY

The mesh, as shown in Figure 6.4, “Mesh Topology”, is a topology that arises naturally in a geographic network, when you decide to link together neighbouring hubs.

Figure 6.4. Mesh Topology

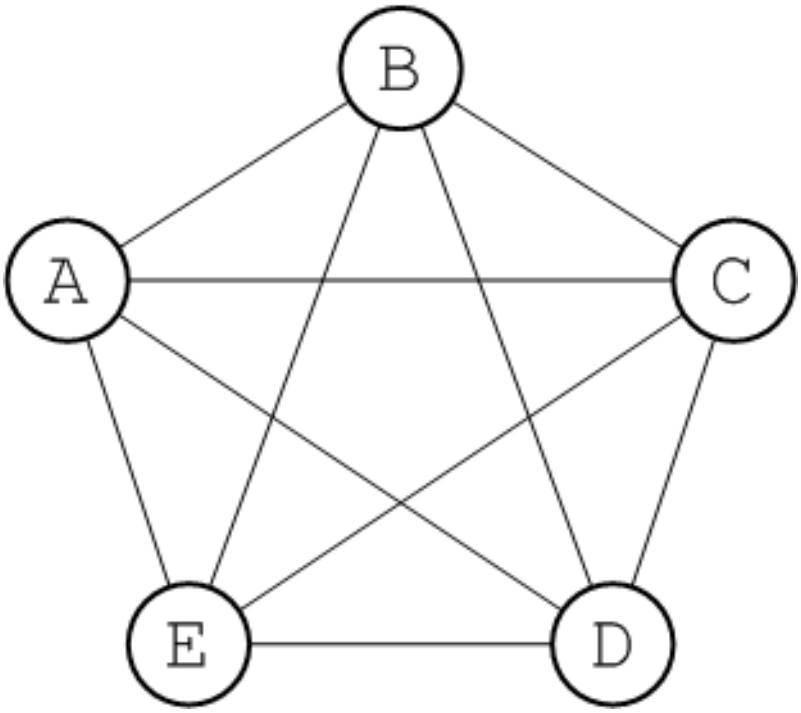


The diameter of a mesh increases whenever you add a node to its periphery. You must, therefore, be careful to set the network TTL sufficiently high that your network can cope with expansion. Alternatively, you could set up some mechanism for the central management of broker configurations. This would enable you to increase the network TTL for all of the brokers simultaneously.

COMPLETE GRAPH

In graph theory, the *complete graph on **n** vertices* is the graph with **n** vertices that has edges joining every pair of vertices. This graph is denoted by the symbol, $\mathbf{K_n}$. For example, Figure 6.5, “The Complete Graph, K_5” shows the graph, $\mathbf{K_5}$.

Figure 6.5. The Complete Graph, K_5



Every complete graph has a diameter of 1. Potentially, a network that is a complete graph could be difficult to manage, because there are many connections between broker nodes. In practice, though, it is relatively easy to set up a broker network as a complete graph, if you define all of the network connectors to use a multicast discovery agent (see Section 8.1.4, “Multicast Discovery Agent”).

NOTE

In the complete graph topology, it is mandatory to set **`networkTTL=1`** in the network connector elements, in order for the broker network to function correctly.

CHAPTER 7. OPTIMIZING ROUTES

Abstract

It is possible, depending on your network's topology, that a message will multiple routes through the network. Red Hat JBoss A-MQ allows you to configure the network to reduce the number of alternate routes and choose the optimum route.

7.1. INTRODUCTION TO OPTIMIZING ROUTES

Overview

In network topologies such as a hub-and-spoke or a tree there exists a unique route between any two brokers. For topologies, such as a mesh or a complete graph, it is possible to have multiple routes between any two brokers. In such cases, you may need simplify the routing behavior, so that an optimum route is preferred by the network.

Configuring routing behaviour

Red Hat JBoss A-MQ provides two configuration settings that work in conjunction to refine routing behavior:

- **`decreaseNetworkConsumerPriority`**—deprecates the priority of a network connector based on the number of hops from the message's origin so that messages are routed along the shortest route
- **`suppressDuplicateQueueSubscriptions`**—suppresses duplicate subscriptions from intermediary brokers so that alternative paths are reduced

IMPORTANT

To be most effective these properties should be set on *all* of the network connectors in the network of brokers.

7.2. CHOOSING THE SHORTEST ROUTE

Overview

In indeterminate networks, it is typically preferable for messages to take the *shortest* route. This reduces the time for the message to reach its destination, reduces the chances of the message being caught in a broker failure, and reduces the load on the network. In general, sending messages along to the nearest possible consumer maximizes the effectiveness of the broker network.

This is accomplished by configuring all of the connectors in your network to generate route priorities that automatically lowers the route's priority for each network connector it must traverse In this way the broker's can determine the shortest route between a message's producer and its consumer. In most cases, the broker will use the shortest route. However, if the shortest route is under heavy load, the broker will divert it to the next shortest route.

Connector configuration

To ensure that the shortest route is preferred, you need to configure *all* of the network connectors in the network to create priority profiles for each of the possible routes through the network. This is done by setting the **networkConnetor** element's **decreaseNetworkConsumerPriority** attribute to **true**.

Example 7.1, “Network Connector for Choosing the Shortest Route” shows a network connector configured to determine the shortest route.

Example 7.1. Network Connector for Choosing the Shortest Route

```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3"
       decreaseNetworkConsumerPriority="true" />
</networkConnectors>
```

When **decreaseNetworkConsumerPriority** is set to **true**, the route priority is determined as follows:

- Local consumers (attached directly to the broker) have a priority of **0**.
- Network subscriptions have an initial priority of **-5**.
- The priority of a network subscription is reduced by **1** for every network hop that it traverses.

IMPORTANT

If you choose not to enable **decreaseNetworkConsumerPriority** on all of the connectors in your network, the brokers will not be able to accurately determine the shortest route. Some network connectors will not have the proper starting priority and will not reduce their priority as required.

Route priority and broker load

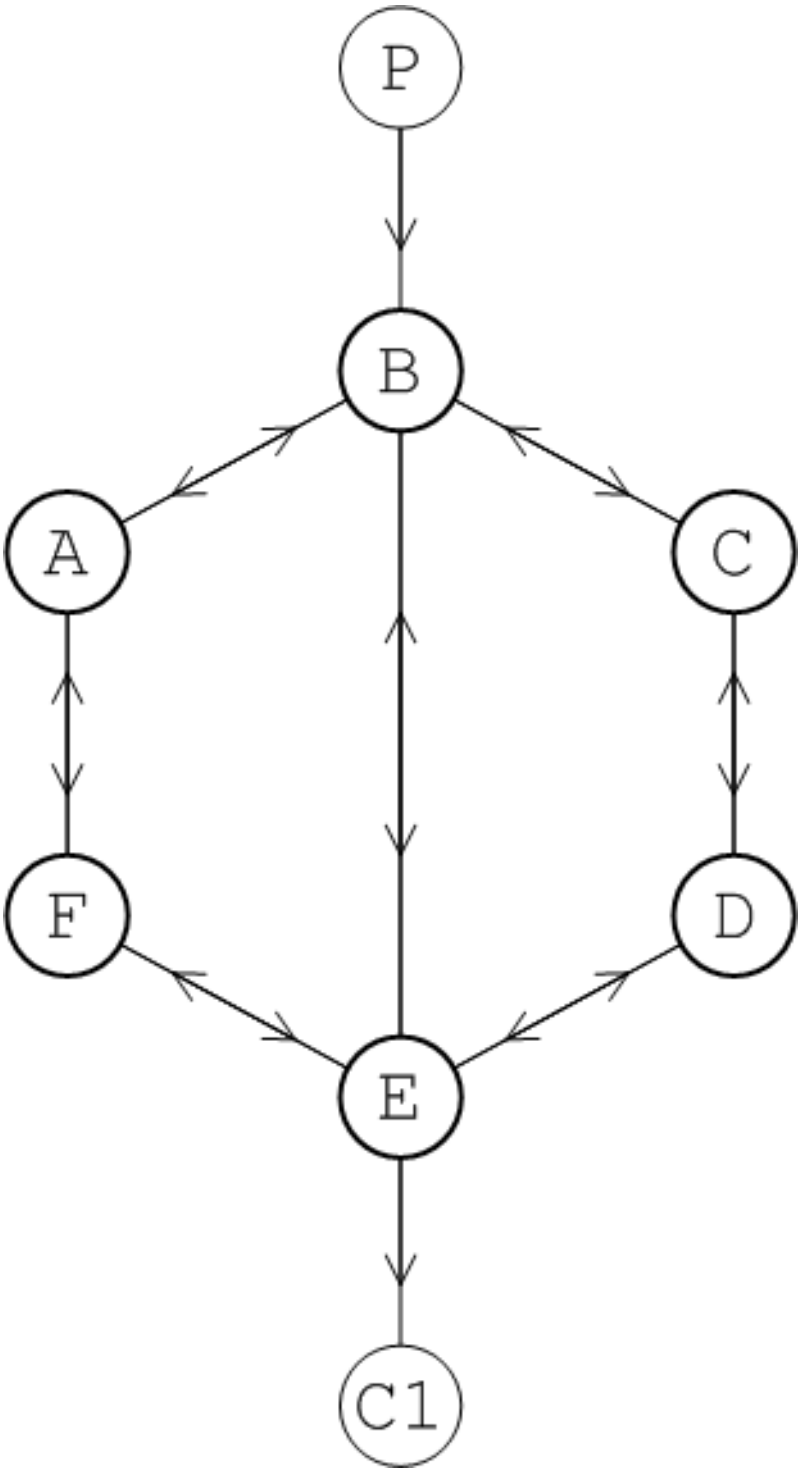
A broker prefers to send messages to the subscription with the highest priority. However, if the prefetch buffer for that subscription is full, the broker will divert messages to the subscription with the next highest priority.

If multiple subscriptions have the same priority, the broker distributes messages equally between those subscriptions.

Example

Figure 7.1, “Shortest Route in a Mesh Network” illustrates the effect of activating **decreaseNetworkConsumerPriority** in a broker network.

Figure 7.1. Shortest Route in a Mesh Network



In this network, there are three alternative routes connecting producer P to consumer C1: **PBAFEC1** (three broker hops), **PBEC1** (one broker hop), and **PBCDEC1** (three broker hops). When **decreaseNetworkConsumerPriority** is enabled, the route **PBEC1** has highest priority, so messages from P to C1 are sent along this route unless connector **BE**'s prefetch buffer is full. In the case where connector **BE**'s prefetch buffer is full messages will be sent to route **PBAFEC1** and route **PBCDEC1** on an alternating basis.

7.3. SUPPRESSING DUPLICATE ROUTES

Abstract

Configuring your network to always prefer the shortest route does not ensure deterministic routing. The alternate routes are still available under heavy load conditions. This can result in dead routes if a consumer fails or migrates to a new broker. Red Hat JBoss A-MQ allows you to suppress the duplicate subscriptions that create alternate routes.

Overview

Configuring your broker network to prefer the shortest route does not ensure that routing is deterministic. Under heavy load, the brokers will use the alternate routes to optimize performance. The danger of this is that if the message is routed along the longer alternate route and the consumer dies, the route becomes a dead-end and the message becomes stuck.

Red Hat JBoss A-MQ allows you to configure your network connectors to suppress duplicate subscriptions that arise from intermediary brokers. This has the effect of eliminating alternate paths between the networked brokers because only direct connections are recognized.

Connector configuration

To suppress duplicate subscriptions you set the **`networkConnector`** element's **`suppressDuplicateQueueSubscriptions`** attribute to **`true`** on all of the network connectors in you network. Example 7.2, “Network Connector that Suppresses Duplicate Routes” shows a network connector that is configured to suppress duplicate routes.

Example 7.2. Network Connector that Suppresses Duplicate Routes

```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
       suppressDuplicateQueueSubscriptions="true"/>
</networkConnectors>
```

Broker ID and duplicate routes

JBoss A-MQ uses the brokers' IDs to figure out duplicate routes. In order for the suppression of duplicate routes to work reliably, you must give each broker a unique ID by explicitly setting the **`broker`** element's **`brokerId`** for each broker in the network. Example 7.3, “Setting a Broker's ID” shows configuration setting a broker's ID.

Example 7.3. Setting a Broker's ID

```
<broker xmlns="http://activemq.apache.org/schema/core"
        brokerName="brokerA" brokerId="A"... >
    ...
</broker>
```

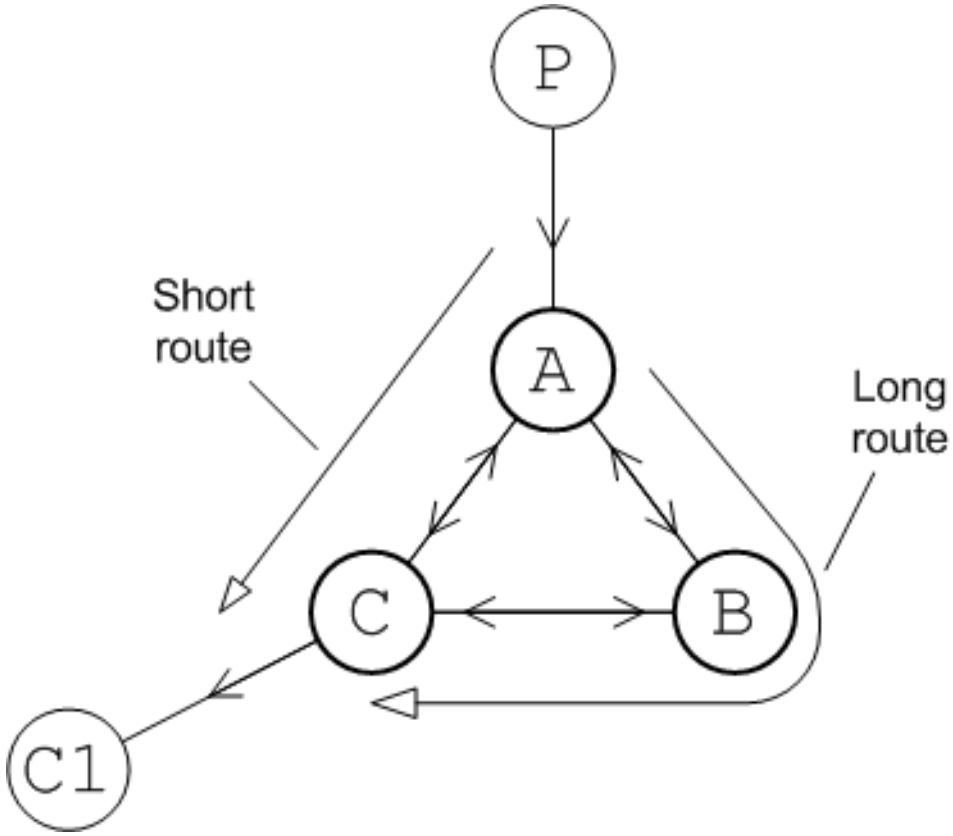
Example

Consider the network of brokers, A, B, and C, shown in Figure 7.2, “Duplicate Subscriptions in a Network”. In this scenario, a producer, P, connects to broker A and a consumer, C1 that subscribes to

messages from P connects to broker B. The network TTL is equal to **2**, so two alternative routes are possible:

- the short route: **PABC1**
- long route: **PACBC1**

Figure 7.2. Duplicate Subscriptions in a Network



If you set **decreaseNetworkConsumerPriority** to **true**, the short route is preferred. and messages are propagated along the route **PABC1**. However, under heavy load conditions, the short route,**PABC1**, can become overloaded and in this case the broker, A, will fall back to the long route, **PACBC1**. The problem with this scenario is that when the consumer, C1, shuts down, it can lead to messages getting stuck on broker C.

Setting **suppressDuplicateQueueSubscriptions** attribute to **true** will suppress the intermediary subscriptions that are generated between A and B. Because this subscription is suppressed the only route left is **PACC1**. Routing becomes fully deterministic.

NOTE

In the example shown in Figure 7.2, “Duplicate Subscriptions in a Network”, you could have suppressed the long route by reducing the network TTL to 1. Normally, however, in a large network you do not have the option of reducing the network TTL arbitrarily. The network TTL has to be large enough for messages to reach the most distant brokers in the network.

CHAPTER 8. DISCOVERING BROKERS

Abstract

One of the main strengths of Red Hat JBoss A-MQ is that brokers can be located dynamically through out your infrastructure. In order for clients and other brokers to be able to interact with a broker, they need some way of discovering that the broker exists. JBoss A-MQ does this using a combination of discovery agents and special URI schemes. In order for location transparency to work, the members of a messaging application need a way for discovering each other. In Red Hat JBoss A-MQ this is accomplished using two pieces: *discovery agents*, components that advertise the brokers available to other members of a messaging application; and *discovery URI*, a URI that looks up all of the discoverable brokers and presents them as a list of actual URIs for use by the client or network connector.

8.1. DISCOVERY AGENTS

Abstract

A discovery agent is a mechanism that advertises available brokers to clients and other brokers.

8.1.1. Introduction to Discovery Agents

What is a discovery agent?

A discovery agent is a mechanism that advertises available brokers to clients and other brokers. When a client, or broker, using a discovery URI starts up it will look for any brokers that are available using the specified discovery agent. The clients will update their lists periodically using the same mechanism.

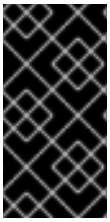
Discovery mechanisms

How a discovery agent learns about the available brokers varies between agents. Some agents use a static list, some use a third party registry, and some rely on the brokers to provide the information. For discovery agents that rely on the brokers for information, it is necessary to enable the discovery agent in the message broker configuration. For example, to enable the multicast discovery agent on an Openwire endpoint, you edit the relevant **`transportConnector`** element as shown in Example 8.1, “Enabling a Discovery Agent on a Broker”.

Example 8.1. Enabling a Discovery Agent on a Broker

```
<transportConnectors>
  <transportConnector name="openwire"
    uri="tcp://localhost:61716"
    discoveryUri="multicast://default" />
</transportConnectors>
```

Where the **`discoveryUri`** attribute on the **`transportConnector`** element is initialized to **`multicast://default`**.



IMPORTANT

If a broker uses multiple transport connectors, you need to configure each transport connector to use a discovery agent individually. This means that different connectors can use different discovery mechanisms or that one or more of the connectors can be undiscoverable.

Discovery agent types

Red Hat JBoss A-MQ currently supports the following discovery agents:

- Fuse Fabric Discovery Agent
- Static Discovery Agent
- Multicast Discovery Agent
- Zeroconf Discovery Agent

8.1.2. Fuse Fabric Discovery Agent

Abstract

The Fuse Fabric discovery agent uses Fuse Fabric to discovery brokers that are deployed into a fabric.

Overview

The *Fuse Fabric discovery agent* uses Fuse Fabric to discover the brokers in a specified group. The discovery agent requires that all of the discoverable brokers be deployed into a single fabric. When the client attempts to connect to a broker the agent looks up all of the available brokers in the fabric's registry and returns the ones in the specified group.

URI

The Fuse Fabric discovery agent URI conforms to the syntax in Example 8.2, “Fuse Fabric Discovery Agent URI Format”.

Example 8.2. Fuse Fabric Discovery Agent URI Format

```
fabric://GID
```

Where *GID* is the ID of the broker group from which the client discovers the available brokers.

Configuring a broker

The Fuse Fabric discovery agent requires that the discoverable brokers are deployed into a single fabric.

The best way to deploy brokers into a fabric is using the management console. For information on using the management console see "Management Console User Guide".

You can also use the console to deploy brokers into a fabric. See chapter "Fabric Console Commands" in "Console Reference".

Configuring a client

To use the agent a client must be configured to connect to a broker using a discovery protocol that uses a Fuse Fabric agent URI as shown in Example 8.3, “Client Connection URL using Fuse Fabric Discovery”.

Example 8.3. Client Connection URL using Fuse Fabric Discovery

```
discovery:(fabric://nwBrokers)
```

A client using the URL in Example 8.3, “Client Connection URL using Fuse Fabric Discovery” will discover all the brokers in the **`nwBrokers`** broker group and generate a list of brokers to which it can connect.

8.1.3. Static Discovery Agent

Abstract

The static discovery agent uses an explicit list of broker URLs to specify the available brokers.

Overview

The *static discovery agent* does not truly discover the available brokers. It uses an explicit list of broker URLs to specify the available brokers. Brokers are not involved with the static discovery agent. The client only knows about the brokers that are hard coded into the agent's URI.

Using the agent

The static discovery agent is a client-side only agent. It does not require any configuration on the brokers that will be discovered.

To use the agent, you simply configure the client to connect to a broker using a discovery protocol that uses a static agent URI.

The static discovery agent URI conforms to the syntax in Example 8.4, “Static Discovery Agent URI Format”.

Example 8.4. Static Discovery Agent URI Format

```
static://(URI1,URI2,URI3,...)
```

Example

Example 8.5, “Discovery URI using the Static Discovery Agent” shows a discovery URI that configures a client to use the static discovery agent to connect to one member of a broker pair.

Example 8.5. Discovery URI using the Static Discovery Agent

```
discovery:(static://(tcp://localhost:61716,tcp://localhost:61816))
```

8.1.4. Multicast Discovery Agent

Abstract

The multicast discovery agent uses the IP multicast protocol to find any message brokers currently active on the local network.

Overview

The *multicast discovery agent* uses the IP multicast protocol to find any message brokers currently active on the local network. The agent requires that *each* broker you want to advertise is configured to use the multicast agent to publish its details to a multicast group. Clients using the multicast agent as part of the discovery URI they use for connecting to a broker will use the agent to receive the list of available brokers advertising in the specified multicast group.

IMPORTANT

Your local network (LAN) must be configured appropriately for the IP/multicast protocol to work.

URI

The multicast discovery agent URI conforms to the syntax in Example 8.6, “Multicast Discovery Agent URI Format”.

Example 8.6. Multicast Discovery Agent URI Format

```
multicast://GroupID
```

Where *GroupID* is an alphanumeric identifier. All participants in the same discovery group must use the same *GroupID*.

Configuring a broker

For a broker to be discoverable using the multicast discovery agent, you must enable the discovery agent in the broker's configuration. To enable the multicast discovery agent you set the **`transportConnector`** element's **`discoveryUri`** attribute to a mulitcast discovery agent URI as shown in Example 8.7, “Enabling a Multicast Discovery Agent on a Broker”.

Example 8.7. Enabling a Multicast Discovery Agent on a Broker

```
<transportConnectors>
  <transportConnector name="openwire"
    uri="tcp://localhost:61716"
    discoveryUri="multicast://default" />
</transportConnectors>
```

The broker configured in Example 8.7, “Enabling a Multicast Discovery Agent on a Broker” is discoverable as part of the multicast group **`default`**.

Configuring a client

To use the multicast agent a client must be configured to connect to a broker using a discovery URI that uses a multicast agent URI as shown in Example 8.8, “Client Connection URL using Multicast Discovery”.

Example 8.8. Client Connection URL using Multicast Discovery

```
discovery:(multicast://default)
```

A client using the URI in Example 8.8, “Client Connection URL using Multicast Discovery” will discover all the brokers advertised in the **`default`** multicast group and generate a list of brokers to which it can connect.

8.1.5. Zeroconf Discovery Agent

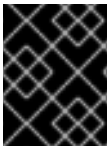
Abstract

The zeroconf discovery agent uses an open source implementation of Apple's Bonjour networking technology to find any brokers currently active on the local network.

Overview

The *zeroconf discovery agent* is derived from Apple’s Bonjour Networking technology, which defines the zeroconf protocol as a mechanism for discovering services on a network. Red Hat JBoss A-MQ bases its implementation of the zeroconf discovery agent on JmDSN, which is a service discovery protocol that is layered over IP/multicast and is compatible with Apple Bonjour.

The agent requires that *each* broker you want to advertise is configured to use a multicast discovery agent to publish its details to a multicast group. Clients using the zeroconf agent as part of the discovery URI they use for connecting to a broker will use the agent to receive the list of available brokers advertising in the specified multicast group.



IMPORTANT

Your local network (LAN) must be configured to use IP/multicast for the zeroconf agent to work.

URI

The zeroconf discovery agent URI conforms to the syntax in Example 8.9, “Zeroconf Discovery Agent URI Format”.

Example 8.9. Zeroconf Discovery Agent URI Format

```
zeroconf://GroupID
```

Where the *GroupID* is an alphanumeric identifier. All participants in the same discovery group must use the same *GroupID*.

Configuring a broker

For a broker to be discoverable using the zeroconf discovery agent, you must enable a multicast discovery agent in the broker's configuration. To enable the multicast discovery agent you set the **`transportConnector`** element's **`discoveryUri`** attribute to a mulitcast discovery agent URI as shown in Example 8.10, “Enabling a Multicast Discovery Agent on a Broker”.

Example 8.10. Enabling a Multicast Discovery Agent on a Broker

```
<transportConnectors>
  <transportConnector name="openwire"
    uri="tcp://localhost:61716"
    discoveryUri="multicast://NEGroup" />
</transportConnectors>
```

The broker configured in Example 8.10, “Enabling a Multicast Discovery Agent on a Broker” is discoverable as part of the multicast group **`NEGroup`**.

Configuring a client

To use the agent a client must be configured to connect to a broker using a discovery protocol that uses a zeroconf agent URI as shown in Example 8.11, “Client Connection URL using Zeroconf Discovery”.

Example 8.11. Client Connection URL using Zeroconf Discovery

```
discovery:(zeroconf://NEGroup)
```

A client using the URL in Example 8.11, “Client Connection URL using Zeroconf Discovery” will discover all the brokers advertised in the **`NEGroup`** multicast group and generate a list of brokers to which it can connect.

8.2. DYNAMIC DISCOVERY PROTOCOL

Abstract

The dynamic discovery protocol combines reconnect logic with a discovery agent to dynamically create a list of brokers to which the client can connect.

Overview

The *dynamic discovery protocol* combines reconnect logic with a discovery agent to dynamically create a list of brokers to which the client can connect. The discovery protocol invokes a discovery agent in order to build up a list of broker URIs. The protocol then randomly chooses a URI from the list and attempts to establish a connection to it. If it does not succeed, or if the connection subsequently fails, a new connection is established to one of the other URIs in the list.

URI syntax

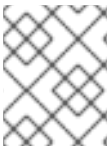
Example 8.12, “Dynamic Discovery URI” shows the syntax for a discovery URI.

Example 8.12. Dynamic Discovery URI

```
discovery:(DiscoveryAgentUri)?Options
```

DiscoveryAgentUri is URI for the discovery agent used to build up the list of available brokers. Discovery agents are described in Section 8.1, “Discovery Agents”.

The options, ***?Options***, are specified in the form of a query list. The discovery options are described in Table 8.1, “Dynamic Discovery Protocol Options”. You can also inject transport options as described in the section called “Setting options on the discovered transports”.



NOTE

If no options are required, you can drop the parentheses from the URI. The resulting URI would take the form discovery:*DiscoveryAgentUri*

Transport options

The discovery protocol supports the options described in Table 8.1, “Dynamic Discovery Protocol Options”.

Table 8.1. Dynamic Discovery Protocol Options

Option	Default	Description
initialReconnectDelay	**10**	Specifies, in milliseconds, how long to wait before the first reconnect attempt.
maxReconnectDelay	**30000**	Specifies, in milliseconds, the maximum amount of time to wait between reconnect attempts.
useExponentialBackOff	**true**	Specifies if an exponential back-off is used between reconnect attempts.
backOffMultiplier	**2**	Specifies the exponent used in the exponential back-off algorithm.
maxReconnectAttempts	**0**	Specifies the maximum number of reconnect attempts before an error is sent back to the client. **0** specifies unlimited attempts.

Sample URI

Example 8.13, “Discovery Protocol URI” shows a discovery URI that uses a multicast discovery agent.

Example 8.13. Discovery Protocol URI

```
discovery:(multicast://default)?initialReconnectDelay=100
```

Setting options on the discovered transports

The list of transport options, *Options*, in the discovery URI can also be used to set options on the *discovered* transports. If you set an option *not* listed in the section called “Setting options on the discovered transports”, the URI parser attempts to inject the option setting into every one of the discovered endpoints.

Example 8.14, “Injecting Transport Options into a Discovered Transport” shows a discovery URI that sets the TCP **`connectionTimeout`** option to 10 seconds.

Example 8.14. Injecting Transport Options into a Discovered Transport

```
discovery:(multicast://default)?connectionTimeout=10000
```

The 10 second timeout setting is injected into every discovered TCP endpoint.

8.3. FANOUT PROTOCOL

Abstract

The fanout protocol allows clients to connect to multiple brokers at once and broadcast messages to consumers connected to all of the brokers at once.

Overview

The *fanout protocol* enables a producer to auto-discover broker endpoints and broadcast topic messages to *all* of the discovered brokers. The fanout protocol gives producers a convenient mechanism for broadcasting messages to multiple brokers that are not part of a network of brokers.

The fanout protocol relies on a discovery agent to build up the list of broker URIs to which it connects.

URI syntax

Example 8.15, “Fanout URI Syntax” shows the syntax for a fanout URI.

Example 8.15. Fanout URI Syntax

```
fanout://(DiscoveryAgentUri)?Options
```

DiscoveryAgentUri is URI for the discovery agent used to build up the list of available brokers. Discovery agents are described in Section 8.1, “Discovery Agents”.

The options, ***?Options***, are specified in the form of a query list. The discovery options are described in Table 8.2, “Fanout Protocol Options”. You can also inject transport options as described in the section called “Setting options on the discovered transports”.

NOTE

If no options are required, you can drop the parentheses from the URI. The resulting URI would take the form fanout://*DiscoveryAgentUri*

Transport options

The fanout protocol supports the transport options described in Table 8.2, “Fanout Protocol Options”.

Table 8.2. Fanout Protocol Options

Option Name	Default	Description
initialReconnectDelay	**10**	Specifies, in milliseconds, how long the transport will wait before the first reconnect attempt.
maxReconnectDelay	**30000**	Specifies, in milliseconds, the maximum amount of time to wait between reconnect attempts.
useExponentialBackOff	**true**	Specifies if an exponential back-off is used between reconnect attempts.
backOffMultiplier	**2**	Specifies the exponent used in the exponential back-off algorithm.
maxReconnectAttempts	**0**	Specifies the maximum number of reconnect attempts before an error is sent back to the client. **0** specifies unlimited attempts.
fanOutQueues	**false**	Specifies whether queue messages are replicated to every connected broker. For more information see the section called “Applying fanout to queue messages”.
minAckCount	**2**	Specifies the minimum number of brokers to which the client must connect before it sends out messages. For more informaiton see the section called “Minimum number of brokers”.

Sample URI

Example 8.16, “Fanout Protocol URI” shows a discovery URI that uses a multicast discovery agent.

Example 8.16. Fanout Protocol URI

```
fanout://(multicast://default)?initialReconnectDelay=100
```

Applying fanout to queue messages

The fanout protocol replicates topic messages by sending each topic message to all of the connected brokers. By default, however, the fanout protocol does *not* replicate queue messages.

For queue messages, the fanout protocol picks one of the brokers at random and sends all of the queue messages to that broker. This is a sensible default, because under normal circumstances, you would not want to create more than one copy of a queue message.

It is possible to change the default behavior by setting the **`fanOutQueues`** option to **`true`**. This configures the protocol so that it also replicates queue messages.

Minimum number of brokers

By default, the fanout protocol does not start sending messages until the producer has connected to a *minimum of two brokers*. You can customize this minimum value using the **`minAckCount`** option.

Setting minimum number of brokers equal to the expected number of discovered brokers ensures that all of the available brokers start receiving messages at the same time. This ensures that no messages are missed if a broker starts up after the producer has started sending messages.

Using fanout with a broker network

You have to be careful when using the fanout protocol with brokers that are joined in a network of brokers.

The combination of the fanout protocol's broadcasting behavior and the nature of how messages are propagated through a network of brokers makes it likely that consumers will receive duplicate messages. If, for example, you joined four brokers into a network of brokers and connected a consumer listening for messages on topic **`hello.jason`** to broker A and connected a producer to broker B to send messages to topic **`hello.jason`**, the consumer would get one copy of the messages. If, on the other hand, the producer connects to the network using the fanout protocol, the producer will connect to every broker in the network simultaneously and start sending messages. Each of the four brokers will receive a copy of every message and deliver its copy to the consumer. So, for each message, the consumer will get four copies.

CHAPTER 9. LOAD BALANCING

Abstract

Broker networks can address the problem of load balancing in a messaging system. Consumer load is managed by changing how network connectors recognize subscriptions. Producer load is managed using different broker topologies.

9.1. BALANCING CONSUMER LOAD

Abstract

When using queues it is easy to balance load over a group of consumers. The messages are evenly distributed among all of the consumers attached to a queue. In a network of brokers, however, conduit subscriptions can adversely effect the ability of brokers to evenly distribute messages to all of the queue subscribers. This can be mitigated by disabling conduit subscriptions.

Overview

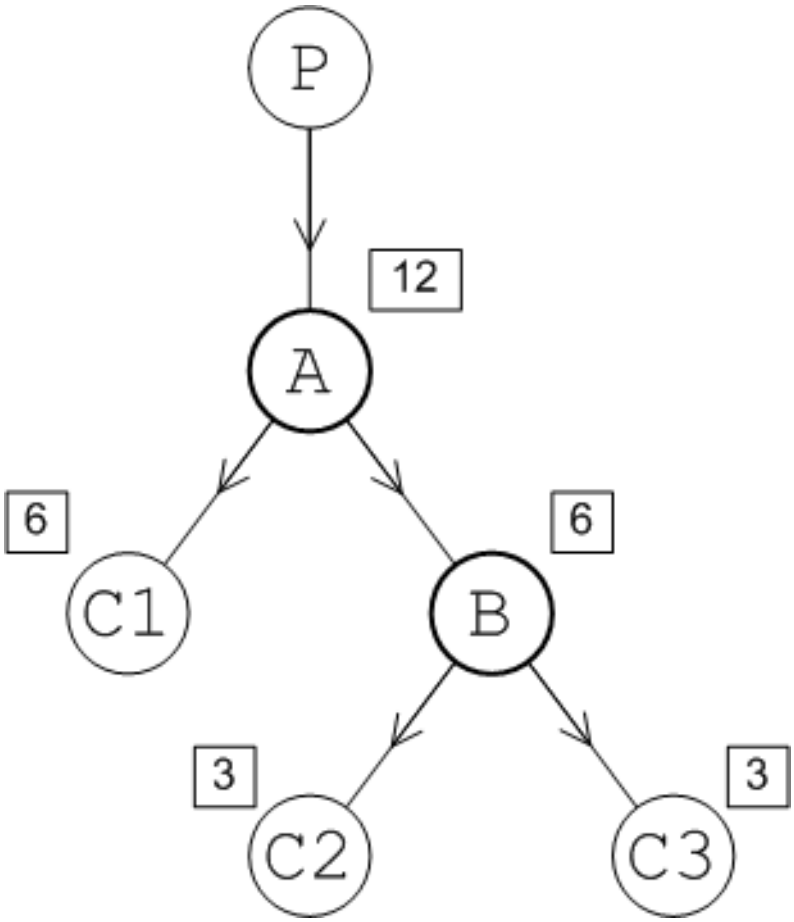
Multiple consumers attached to a JMS queue automatically obey *competing consumer* semantics. That is, each message transmitted by the queue is consumed by *one consumer only*. Hence, if you want to scale up load balancing on the consumer side, all that you need to do is attach extra consumers to the queue. The competing consumer semantics of the JMS queue then automatically ensures that the queue's messages are evenly distributed amongst the attached consumers.

The default behavior of Red Hat JBoss A-MQ's conduit subscriptions, however, can sometimes be detrimental to load balancing on the consumer side. As described in the section called “Conduit subscriptions”, conduit subscriptions concentrate all of the subscriptions from a networked broker into a single subscription. For topics this behavior optimizes traffic and has no effect on consumer load. For queues, however, it results in uneven message distribution which can impede consumer load balancing.

Default load behavior

Figure 9.1, “Message Flow when Conduit Subscriptions Enabled” illustrates how conduit subscriptions can result in uneven message distribution to the consumers of a queue.

Figure 9.1. Message Flow when Conduit Subscriptions Enabled



Assume that the consumers, C1, C2, and C3, all subscribe to the **TEST.FOO** queue. Producer, P, connects to Broker A and sends 12 messages to the **TEST.FOO** queue. By default conduit subscriptions are enabled and Broker A sees only a single subscription from Broker B and a single subscription from consumer C1. So, Broker A sends messages alternately to C1 and B. Assuming that C1 and B process messages at the same speed, A sends a total of 6 messages to C1 and 6 messages to B.

Broker B sees two subscriptions, from C2 and C3 respectively. So, Broker B will send messages alternately to C2 and C3. Assuming that both consumers process messages at equal speed, each consumer receives a total of 3 messages.

In the end, the distribution of messages amongst the consumers is 6, 3, 3, which is not optimally load balanced. C1 processes twice as many messages as either C2 or C3.

Disabling conduit subscriptions

If you want to improve the load balancing behavior for queues, you can disable conduit subscriptions by setting the **networkConnector** element's **conduitSubscriptions** to **false**. Example 9.1, "Disabling Conduit Subscriptions" shows configuration for a network connector with conduit subscriptions disabled.

Example 9.1. Disabling Conduit Subscriptions

```
<networkConnectors>
    <networkConnector name="linkToBrokerB"
       uri="static:(tcp://localhost:61002)"
```

```
        networkTTL="3"
        conduitSubscriptions="false" />
</networkConnectors>
```

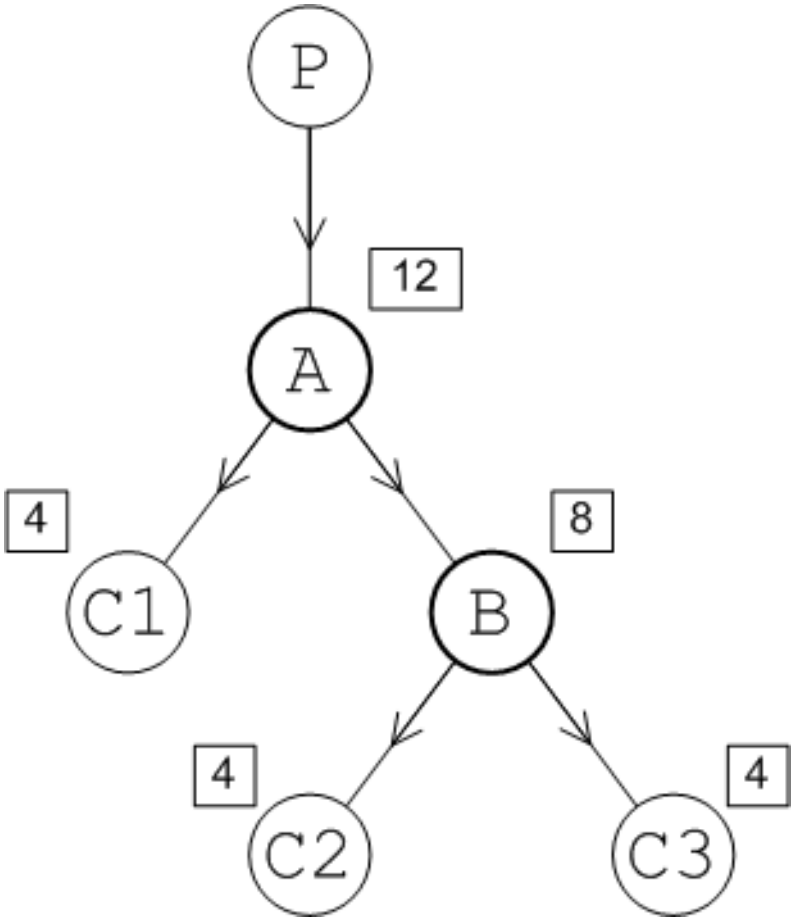
WARNING

As described in the section called “Conduit subscriptions”, conduit subscriptions protect against duplicate topic messages. If you are using both queues and topics consider using separate network connectors for queues and topics. See the section called “Separate connectors for topics and queues”.

Balanced load behavior

Figure 9.2, “Message Flow when Conduit Subscriptions Disabled” illustrates the message flow through a queue with distributed consumers when conduit subscriptions are disabled.

Figure 9.2. Message Flow when Conduit Subscriptions Disabled



Assume that the consumers, C1, C2, and C3, all subscribe to the **TEST.FOO** queue. Producer, P, connects to Broker A and sends 12 messages to the **TEST.FOO** queue. With conduit subscriptions disabled, Broker A sees both of the subscriptions on Broker B and a single subscription from consumer

C1. Broker A sends messages alternately to each of the subscriptions. Assuming that all of the consumers process messages at equal speeds, C1 receives 4 messages and Broker B receives 8 messages.

Broker B sees two subscriptions, from C2 and C3 respectively. So, Broker B will send messages alternately to C2 and C3. Assuming that both consumers process messages at equal speed, each consumer receives a total of 4 messages.

In the end, the distribution of messages amongst the consumers is 4, 4, 4, which is optimally balanced.

Separate connectors for topics and queues

If your brokers need to handle both queues and topics, you might need to *disable* conduit subscriptions for queues to optimize load balancing, but also *enable* conduit subscriptions for topics to avoid duplicate topic messages.

Because the **`conduitSubscriptions`** attribute applies simultaneously to queues and topics, you cannot configure this using a single network connector. It is possible to configure topics and queues differently by using multiple network connectors: one for queues and another for topics.

Example 9.2, “Separate Configuration of Topics and Queues” shows how to configure separate network connectors for topics and queues. The **`queuesOnly`** network connector, which has conduit subscriptions disabled, is equipped with a filter that transmits only queue messages. The **`topicsOnly`** network connector, which has conduit subscriptions enabled, is equipped with a filter that transmits only topic messages.

Example 9.2. Separate Configuration of Topics and Queues

```
<networkConnectors>
  <networkConnector name="queuesOnly"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3"
       conduitSubscriptions="false">
        <dynamicallyIncludedDestinations>
            <queue physicalName=">"/>
        </dynamicallyIncludedDestinations>
    </networkConnector>
    <networkConnector name="topicsOnly"
       uri="static:(tcp://localhost:61002)"
       networkTTL="3">
        <dynamicallyIncludedDestinations>
            <topic physicalName=">"/>
        </dynamicallyIncludedDestinations>
    </networkConnector>
</networkConnectors>
```

9.2. MANAGING PRODUCER LOAD

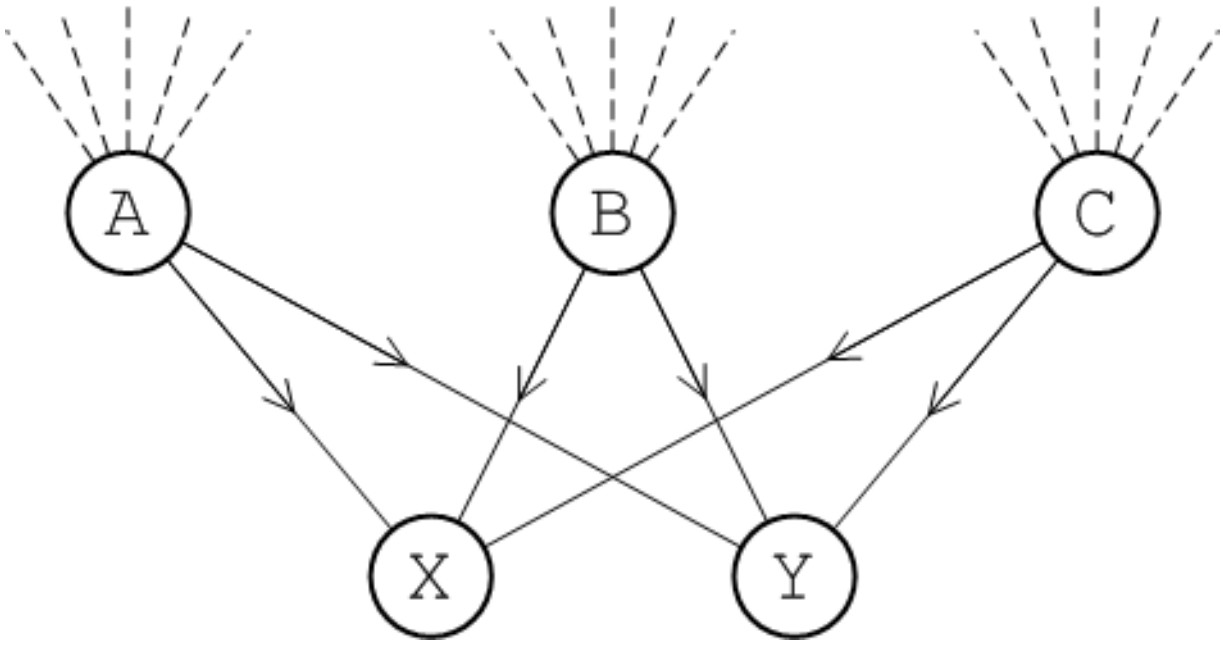
Overview

For greater scalability on the producer side, you might want to spread the message load across multiple brokers. For the purpose of spreading the load across brokers, one of the most useful topologies is the concentrator topology.

Concentrator topology

Figure 9.3, “Load Balancing with the Concentrator Topology” illustrates a two layer network arranged in a concentrator topology.

Figure 9.3. Load Balancing with the Concentrator Topology



The two layers of brokers manage the producer load as follows:

- The first layer of brokers, A, B, and C, accepts connections from message producers and specializes in receiving incoming messages.
- The second layer of brokers, X and Y, accepts connections from message consumers and specializes in sending messages to the consumers.

With this topology, the first layer of brokers, A, B, and C, can focus on managing a large number of incoming producer connections. The received messages are consolidated within the brokers before being passed through a relatively small number of network connectors to the second layer, X and Y. Assuming the number of consumers is small, the brokers, X and Y, only need to deal with a relatively small number of connections. If the number of consumers is large, you could add a third layer of brokers to fan out and handle the consumer connections.

Client configuration

When connecting to a broker network laid out in a concentrator topology, producers and consumers must be configured to connect to the brokers in the appropriate layer. In the case of a producer connecting to the concentrator topology shown in Figure 9.3, “Load Balancing with the Concentrator Topology”, producers should connect to the brokers in the first layer: A, B, and C. Consumers should connect to the brokers in the second layer: X and Y.

CHAPTER 10. JMS-TO-JMS BRIDGE

Abstract

There are two alternative implementations available for implementing a JMS-to-JMS bridge: the Apache Camel JMS-to-JMS bridge (which can be built using Camel route definitions and the JMS and ActiveMQ components for connectivity); or the native ActiveMQ JMS-to-JMS bridge (which can be used only to route JMS messages). In most cases, Apache Camel is the preferred way to build a messaging bridge.

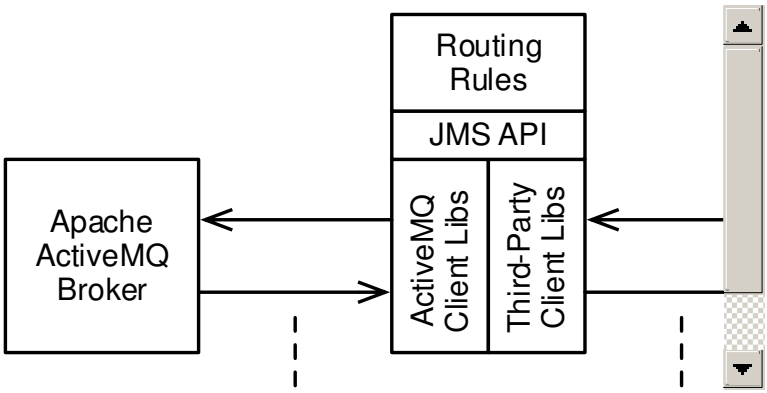
10.1. BRIDGE ARCHITECTURE

Overview

The purpose of a JMS-to-JMS bridge is to enable two different JMS providers that speak a different wire protocol to communicate with each other. A bridge consists essentially of two different client libraries strapped together: one client library facilitates communication with the first JMS provider; and the other client library facilitates communication with the second JMS provider.

The basic architecture is illustrated in Figure 10.1, “Architecture of the JMS-to-JMS Bridge”.

Figure 10.1. Architecture of the JMS-to-JMS Bridge



Wire protocols

JMS defines the interfaces for a messaging service and describes how a client interacts with the messaging service. But JMS does *not* define the details of a messaging implementation and, in particular, JMS does not specify how to implement an on-the-wire protocol for transmitting messages. Because of this, different JMS providers use different wire protocols.

For Java clients, the ActiveMQ broker normally uses the Openwire/TCP protocol, which is not compatible with a third-party JMS provider. Hence, you cannot simply connect an ActiveMQ broker directly to a third-party JMS provider. It is generally necessary to interpose a JMS-to-JMS bridge between the ActiveMQ broker and the third-party JMS provider.

ActiveMQ client libraries

To enable the JMS-to-JMS bridge to talk to the ActiveMQ broker, it is necessary for the ActiveMQ client libraries to be installed in the bridge. These ActiveMQ client libraries are normally installed by default in JBoss A-MQ, so no action is required to make them available.

Third-party client libraries

To enable the JMS-to-JMS bridge to talk to the third-party JMS provider, it is necessary for the third-party client libraries to be installed in the bridge. These third-party client libraries are *not* available by default in the JBoss A-MQ container. Third-party JMS providers are licensed separately from JBoss A-MQ. After purchasing the relevant licence from a third-party vendor, you can install the relevant client libraries into the JBoss A-MQ container (see Section 10.3.7, “Sample Bridge Configuration”).

JMS API

The JMS API is layered between the JMS-to-JMS bridge and the client libraries. The JMS API enables the bridge to invoke both of the client libraries (ActiveMQ and third-party) using standard method calls.

Router rules

There are two different approaches to defining router rules, depending on which bridge implementation you choose:

- *Apache Camel JMS-to-JMS bridge*—a general-purpose routing engine, which includes support for processing messages using enterprise integration patterns, and over 100 integration components (including FTP, HTTP, and Web services).
- *Native ActiveMQ JMS-to-JMS bridge (deprecated)*—special-purpose routing engine, which is capable of routing JMS messages between arbitrary JMS providers. This implementation includes automatic proxy support for ReplyTo messages.

10.2. APACHE CAMEL JMS-TO-JMS BRIDGE

10.2.1. Configuring the Broker

Overview

You need to modify the broker configuration in order to add a VM transport connector.

NOTE

This is the only modification you should make to the broker configuration file. The Apache Camel JMS-to-JMS bridge *must not* be embedded inside the broker configuration file. The broker configuration file is not a regular Spring XML file: it is used by a specialized sevice factory, which controls the broker life cycle.

Broker configuration file

In a standalone container, the broker is configured by the following file:

```
InstallDir/etc/activemq.xml
```

Adding a VM transport connector

To ensure efficient communication between the Apache Camel JMS-to-JMS bridge and the broker, create a Virtual Machine (VM) transport connector on the broker. Th VM protocol provide a high performace connection between processes that are running inside the *same* Java Virtual Machine. Example 10.1, “Embedded Apache Camel JMS-to-JMS Bridge” shows how to add a VM connector to the broker configuration in the **`etc/activemq.xml`** file.

Example 10.1. Embedded Apache Camel JMS-to-JMS Bridge

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans" ... >
  ...
  <broker xmlns="http://activemq.apache.org/schema/core"
          brokerName="${broker-name}"
          dataDirectory="${data}"
          start="false">
    ...
    <transportConnectors>
      <transportConnector name="openwire" uri="tcp://0.0.0.0:0?
maximumConnections=1000"/>
      <!-- Create a VM endpoint to enable embedded connections -->
      <transportConnector uri="vm://local" />
    </transportConnectors>

  </broker>
  ...
</beans>
```

10.2.2. Configuring ActiveMQ JMS Connections

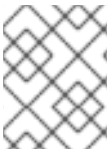
The Camel ActiveMQ component

The Camel ActiveMQ component (hosted in the Apache ActiveMQ project) is a Camel component that is used to integrate the Apache ActiveMQ Java client with Camel. Using the Camel ActiveMQ component, it is possible to define JMS consumer endpoints (at the start of a Camel route) and JMS producer endpoints (at the end of a Camel route).

Apache Camel bridge configuration file

The simplest way to configure the Apache Camel JMS-to-JMS file is to create a Spring XML file and copy it into the hot deploy directory. For the current example, we assume that the bridge configuration is stored in the following file:

```
InstallDir/deploy/jms-bridge.xml
```



NOTE

Subsequently, if you need to undeploy the Spring XML file, you can do so by deleting the **jms-bridge.xml** file from the **deploy/** directory *while the Karaf container is running*.

Spring XML example

The following code example shows how to define and configure a Camel ActiveMQ endpoint by adding Spring XML code to the bridge configuration file, ***InstallDir*/deploy/jms-bridge.xml**.

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans" ... >
  ...
```

```
  <!--
    -- Configure the ActiveMQ broker connection
    -->
  <bean id="amqConnectionFactory"
        class="org.apache.activemq.ActiveMQConnectionFactory">
    <property name="brokerURL" value="vm://local?create=false"/>
  </bean>

  <bean id="jmsConfig"
        class="org.apache.camel.component.jms.JmsConfiguration">
    <property name="connectionFactory" ref="amqConnectionFactory"/>
    <property name="concurrentConsumers" value="10"/>
  </bean>

  <bean id="activemq"
        class="org.apache.activemq.camel.component.ActiveMQComponent">
    <property name="configuration" ref="jmsConfig"/>
  </bean>
  ...
</beans>
```

Note the following points about this example:

- The bean with ID, **activemq**, and of type, **ActiveMQComponent**, defines the Camel ActiveMQ component instance. This bean overrides the default ActiveMQ component instance and implicitly associates the bean ID value, **activemq**, with the URI scheme of the same name. The **activemq** URI scheme can then be used to define endpoints of this component in a Camel route.
- The bean with ID, **jmsConfig**, is used to configure the ActiveMQ component (and supports many additional options).
- The bean with ID, **amqConnectionFactory**, is a JMS connection factory that is used to create connections to the ActiveMQ broker. Note the following attribute settings:
  - The **brokerURL** attribute specifies the transport protocol for connecting to the broker. In this case, the protocol is **vm://local**, which uses the Java Virtual Machine to route messages directly to and from the embedded broker.

Defining an endpoint with the activemq scheme

The bean ID of the ActiveMQ component (in this example, **activemq**) is implicitly adopted as the URI scheme for defining ActiveMQ endpoints in Camel routes. For example, to define an endpoint that connects to the QueueA queue in the ActiveMQ broker, use the following URI:

```
activemq:queue:QueueA
```

To define an endpoint that connects to the **TopicA** topic in the ActiveMQ broker, use the following URI:

```
activemq:topic:TopicA
```

Other types of ActiveMQ connection factory

ActiveMQ provides a variety of different types of JMS connection factory, as follows:

`ActiveMQConnectionFactory`

For ordinary JMS connections (includes support for JMS authentication).

`ActiveMQSslConnectionFactory`

For configuring JMS connections over SSL/TLS (encrypted transport).

`ActiveMQXAConnectionFactory`

For integrating the ActiveMQ client with an XA transaction manager.

References

For more details about the Camel ActiveMQ component, see the following references:

- The ActiveMQ component chapter from the *EIP Component Reference*.
- The community documentation for the ActiveMQ Component.

10.2.3. Configuring Third-Party JMS Connections

The Camel JMS component

The Camel JMS component is a general purpose JMS integration point that can be used to integrate Apache Camel with *any* JMS client library. Using the Camel JMS component, it is possible to define JMS consumer endpoints (at the start of a Camel route) and JMS producer endpoints (at the end of a Camel route).

Alternative approaches

You can connect to a third-party JMS broker using either of the following approaches:

- the section called “Reference a connection factory bean”.
- the section called “Look up a connection factory in JNDI”.

Reference a connection factory bean

You can configure connections to a third-party JMS provider by instantiating a **`javax.jms.ConnectionFactory`** instance directly as a Spring bean. You can then inject this third-party connection factory bean into the configuration of the Camel JMS component.

For example, you can instantiate and reference a WebSphere MQ queue connection factory by adding the following XML code to the bridge configuration, **`deploy/jms-bridge.xml`**:

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans" ... >
  ...
  <!-- Configure IBM WebSphere MQ connection factory -->
  <bean id="webSphereConnectionFactory"
        class="com.ibm.mq.jms.MQConnectionFactory">
    <property name="transportType" value="1"/>
    <property name="hostName" value="localhost"/>
    <property name="port" value="1414"/>
```

```
    <property name="queueManager" value="QM_TEST"/>
  </bean>

  <bean id="websphereConfig"
        class="org.apache.camel.component.jms.JmsConfiguration">
    <property name="connectionFactory" ref="websphereConnectionFactory"/>
    <property name="concurrentConsumers" value="10"/>
  </bean>

  <bean id="websphere"
        class="org.apache.camel.component.jms.JmsComponent">
    <property name="configuration" ref="websphereConfig"/>
  </bean>
  ...
</beans>
```

Look up a connection factory in JNDI

You can use JNDI to configure connections to a third-party JMS provider by configuring the **destinationResolver** attribute of Camel's **JmsComponent** class to reference a Spring **JndiDestinationResolver** instance.

For example, to look up a WebSphere MQ connection factory in an LDAP based JNDI server, you could add the following XML code to the bridge configuration file, **deploy/jms-bridge.xml**, as follows:

```
<beans ... >
  ...
  <!-- Configure a Spring JNDI template instance -->
  <bean id="jmsJndiTemplate"
        class="org.springframework.jndi.JndiTemplate">
    <property name="environment">
      <props>
        <prop
key="java.naming.factory.initial">com.sun.jndi.ldap.LdapCtxFactory</prop>
        <prop
key="java.naming.provider.url">ldap://server.company.com/o=company_us,c=us
</prop>
      </props>
    </property>
  </bean>

  <bean id="jmsConnectionFactory"
        class="org.springframework.jndi.JndiObjectFactoryBean">
    <property name="jndiTemplate" ref="jmsJndiTemplate"/>
    <property name="jndiName" value="jms/websphere-test"/>
  </bean>

  <bean id="jndiDestinationResolver"

class="org.springframework.jms.support.destination.JndiDestinationResolver
">
    <property name="jndiTemplate" ref="jmsJndiTemplate"/>
  </bean>

  <bean id="websphereConfig"
```

```
        class="org.apache.camel.component.jms.JmsConfiguration">
    <property name="connectionFactory" ref="jmsConnectionFactory"/>
    <property name="destinationResolver" ref="jndiDestinationResolver"/>
    <property name="concurrentConsumers" value="10"/>
  </bean>

  <bean id="websphere"
        class="org.apache.camel.component.jms.JmsComponent">
    <property name="configuration" ref="websphereConfig"/>
  </bean>
  ...
</beans>
```

References

For more details about the Camel JMS component, see the following references:

- The JMS component chapter from the *EIP Component Reference*.
- The community documentation for the JMS Component.

10.2.4. Defining Apache Camel Routes

Overview

Apache Camel is a sophisticated and flexible routing engine. At the simplest level, you can use it move JMS messages back and forth between an ActiveMQ broker and a third-party JMS provider. But Camel can do much more. You can insert processors into a route to process the message contents and Camel also has built in processors that implement a wide variety of Enterprise Integration Patterns.

The description in this section—which shows you how to define simple pass-through routes—only scratches the surface of Camel's capabilities. It is recommended that you take a look at some of the references at the end of this section to get a better idea of Camel's capabilities.

JMS endpoint syntax

To create a JMS endpoint in an Apache Camel route, specify an endpoint URI according to the following queue syntax:

```
JmsUriScheme:queue:QueueName[?Options]
```

Or according to the following topic syntax:

```
JmsUriScheme:topic:TopicName[?Options]
```

Where the URI scheme, *JmsUriScheme*, is equal to the bean ID of the corresponding JMS component (or ActiveMQ component) defined in Spring XML—for example, **`activemq`** or **`websphere`**.

Route syntax

In the XML language, Camel routes are defined inside a **`camelContext`** element. Each route definition appears inside a **`route`** element, starting with a **`from`** element (which defines a *consumer endpoint* for receiving messages) and ending with a **`to`** element (which defines a *producer endpoint* for sending

messages).

For example, to perform simple, straight-through routing, consuming messages from the **TEST.FOO** queue on the ActiveMQ broker and passing them straight on to the **TEST.FOO** queue on the WebSphere messaging system, you can use the following route definition:

```
<camelContext xmlns="http://camel.apache.org/schema/spring">
  <route>
    <from uri="activemq:queue:TEST.FOO"/>
    <to uri="websphere:queue:TEST.FOO"/>
  </route>
</camelContext>
```

Sample routes

The following sample Camel routes give examples of how to route queues and topics into and out of the ActiveMQ broker. To define these routes, you would add them to the bridge configuration file, ***InstallDir*/deploy/jms-bridge.xml**.

```
<beans ... >
  ...
  <camelContext xmlns="http://camel.apache.org/schema/spring">
    <!-- Route outgoing QueueA queue -->
    <route>
      <from uri="activemq:queue:QueueA?mapJmsMessage=false"/>
      <to uri="websphere:queue:QueueA"/>
    </route>

    <!-- Route outgoing TopicA topic -->
    <route>
      <from uri="activemq:topic:TopicA?mapJmsMessage=false"/>
      <to uri="websphere:topic:TopicA"/>
    </route>

    <!-- Route incoming QueueX queue -->
    <route>
      <from uri="websphere:queue:QueueX?mapJmsMessage=false"/>
      <to uri="activemq:queue:QueueX"/>
    </route>

    <!-- Route incoming TopicX topic -->
    <route>
      <from uri="websphere:topic:TopicX?mapJmsMessage=false"/>
      <to uri="activemq:topic:TopicX"/>
    </route>

  </camelContext>
</beans>
```

mapJmsMessage option

In the preceding example, the consumer endpoints are configured with the **mapJmsMessage** set to **false**. This prevents the JMS message from being parsed into the standard Java data format, thus ensuring that the message is passed straight through without processing, which gives optimum

performance for a pass-through route.

On the other hand, if you want to perform any processing on the message content or the message headers, you should remove this option (or set it to **`true`**).

Camel schema location

If you want to take advantage of the content completion feature of your XML editor, you can configure your editor to fetch the Camel schema from the following location:

```
http://camel.apache.org/schema/spring/camel-spring.xsd
```

The preceding location always holds the latest version of the Camel schema. If you want to specify a particular version of the schema, you can use the version-specific location:

```
http://camel.apache.org/schema/spring/camel-spring-Version.xsd
```

References

Apache Camel is a sophisticated routing and integration tool. To get a better idea of the capabilities of this tool, please consult the following guides from the JBoss Fuse library:

- *Implementing Enterprise Integration Patterns*
- *Routing Expression and Predicate Languages*
- *EIP Component Reference*

10.3. NATIVE ACTIVEMQ JMS-TO-JMS BRIDGE (DEPRECATED)

10.3.1. Embedded Native Configuration

Overview

The normal way to configure a native ActiveMQ JMS-to-JMS bridge is to embed it in an ActiveMQ broker instance. This makes sense, because the JMS-to-JMS bridge requires an ActiveMQ broker to be running in any case. This deployment approach means that you start and stop the ActiveMQ broker and the JMS-to-JMS bridge simultaneously, which is convenient from a systems management perspective.

Spring configuration

Example 10.2, “Embedded native JMS-to-JMS Bridge” shows the outline configuration of a native JMS-to-JMS bridge embedded in a broker configuration. The native JMS-to-JMS bridge configuration is introduced by the **`jmsBridgeConnectors`** element, which can contain any number of **`jmsQueueConnector`** elements and **`jmsTopicConnector`** elements. The detailed configuration of the bridge is described in the following sections.

Example 10.2. Embedded native JMS-to-JMS Bridge

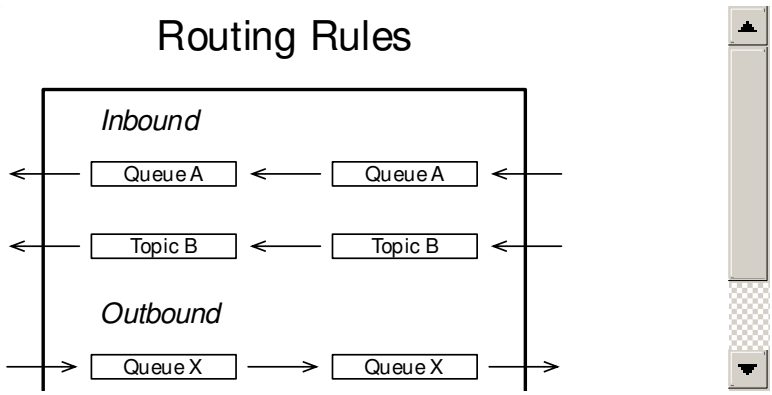
```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans" ... >
  ...
```

```
  <broker xmlns="http://activemq.apache.org/schema/core"
      id="localbroker"
      brokerName="localBroker"
      persistent="false">

    <jmsBridgeConnectors>
      <jmsQueueConnector> ... </jmsQueueConnector>
      ...
      <jmsTopicConnector> ... </jmsTopicConnector>
      ...
    </jmsBridgeConnectors>

    <transportConnectors>
      <transportConnector uri="tcp://localhost:61234" />
    </transportConnectors>

  </broker>
  ...
</beans>
```

Router rules

The heart of the JMS-to-JMS bridge is a simple set of routing rules, where each rule describe how to pull messages off a particular queue or topic, and how to push the messages to the corresponding queue or topic in the other JMS provider. Figure 10.2, “Routing Rules in the JMS-to-JMS Bridge” shows an overview of the kinds of routing rule you can define in the JMS-to-JMS bridge.

Figure 10.2. Routing Rules in the JMS-to-JMS Bridge



Rule types

The JMS-to-JMS bridge enables you to define the following types of routing rule:

- *Inbound queue-to-queue mapping*—defines a rule for pulling messages off a queue in the third-party JMS provider and forwarding the messages to a queue (possibly with a different name) in the ActiveMQ broker.
- *Outbound queue-to-queue mapping*—defines a rule for pulling messages off a queue in the ActiveMQ broker and forwarding the messages to a queue (possibly with a different name) in the third-party JMS provider.

- *Inbound topic-to-topic mapping*—defines a rule for receiving messages from a topic in the third-party JMS provider and forwarding the messages to a topic (possibly with a different name) in the ActiveMQ broker.
- *Outbound topic-to-topic mapping*—defines a rule for receiving messages from a topic in the ActiveMQ broker and forwarding the messages to a topic (possibly with a different name) in the third-party JMS provider.

10.3.2. Connecting to the ActiveMQ Broker

Bootstrapping an embedded bridge

In the case of an embedded JMS-to-JMS bridge (as shown in Example 10.2, “Embedded native JMS-to-JMS Bridge”), connecting to the ActiveMQ broker is trivial. The bridge automatically connects to the broker in which it is embedded, using the ActiveMQ VM (virtual machine) protocol.

In other words, *no configuration is required* to connect to the ActiveMQ broker in the embedded case.

Non-embedded deployments

It is also possible to deploy a native JMS-to-JMS bridge separately from an ActiveMQ broker (non-embedded case). For this type of deployment, the **`jmsQueueConnector`** supports various attributes (**`localQueueConnection`**, **`localQueueConnectionFactory`**, and so on), which you can use to configure the ActiveMQ broker connection explicitly. Likewise, the **`jmsTopicConnector`** element supports attributes for configuring an ActiveMQ broker connection explicitly. This type of deployment lies beyond the scope of the current guide. We recommend that you use an embedded deployment of the native JMS-to-JMS bridge.

10.3.3. Connecting to the Third-Party JMS Provider

Overview

You can connect to a third-party JMS provider using either of the following approaches:

- the section called “Reference a connection factory bean”.
- the section called “Look up a connection factory in JNDI”.

Reference a connection factory bean

You can configure connections to a third-party JMS provider by instantiating a **`javax.jms.QueueConnectionFactory`** instance directly as a Spring bean. You can then reference this bean from the native JMS-to-JMS bridge by setting the **`outboundQueueConnectionFactory`** attribute of the **`jmsQueueConnector`** element.

For example, you can instantiate and reference a WebSphere MQ queue connection factory as follows:

```
<beans ... >
  ...
  <broker xmlns="http://activemq.apache.org/schema/core" ... >

    <jmsBridgeConnectors>
      <jmsQueueConnector outboundQueueConnectionFactory="#remoteFactory">
        ...
```

```
      </jmsQueueConnector>
    </jmsBridgeConnectors>
    ...
  </broker>
  ...
  <!-- Configure IBM WebSphere MQ queue connection factory -->
  <bean id="remoteFactory"
class="com.ibm.mq.jms.MQQueueConnectionFactory">
    <property name="transportType" value="1"/>
    <property name="hostName" value="localhost"/>
    <property name="port" value="1414"/>
    <property name="queueManager" value="QM_TEST"/>
  </bean>
  ...
</beans>
```

Similarly, you can configure the **jmsTopicConnector** element by setting the **outboundTopicConnectionFactory** attribute to reference a **javax.jms.TopicConnectionFactory** instance.

Look up a connection factory in JNDI

You can configure connections to a third-party JMS provider by looking up a **javax.jms.QueueConnectionFactory** instance in a JNDI directory (assuming that some administrative tool has already instantiated and registered the connection factory in JNDI).

For example, to look up a WebSphere MQ connection factory in an LDAP based JNDI server, you could use a configuration like the following:

```
<beans ... >
  ...
  <broker xmlns="http://activemq.apache.org/schema/core" ... >

    <jmsBridgeConnectors>
      <jmsQueueConnector
          jndiOutboundTemplate="#remoteJndi"
          outboundQueueConnectionFactoryName="cn=MQQueueCF">
        ...
      </jmsQueueConnector>
    </jmsBridgeConnectors>
    ...
  </broker>
  ...
  <!-- Configure a Spring JNDI template instance -->
  <bean id="remoteJndi" class="org.springframework.jndi.JndiTemplate">
    <property name="environment">
      <props>
        <prop key="java.naming.factory.initial">
            com.sun.jndi.ldap.LdapCtxFactory
        </prop>
        <prop key="java.naming.provider.url">
            ldap://server.company.com/o=company_us,c=us
        </prop>
      </props>
    </property>
```

```
  </bean>
  ...
</beans>
```

Where the **jndiOutboundTemplate** attribute references an **org.springframework.jndi.JndiTemplate** bean instance, which is a Spring wrapper class that configures a JNDI directory. In this example, the JNDI directory is LDAP based, so the **JndiTemplate** bean is configured with the URL for connecting to the LDAP server. The **outboundQueueConnectionFactoryName** attribute specifies a query on the LDAP server, which should return a **javax.jms.QueueConnectionFactory** instance.

10.3.4. Configuring Queue Bridges

Overview

The routing of queue messages within the native JMS-to-JMS bridge is configured using the **inboundQueueBridges** element and the **outboundQueueBridges** element. Using these elements, you can specify which queues to bridge between the third-party JMS provider and the ActiveMQ broker.

Inbound queue bridges

The **inboundQueueBridges** element and the **inboundQueueBridge** child elements are used to route queue messages *from* the third-party JMS provider *to* the ActiveMQ broker. In this case, *inbound* means heading into the ActiveMQ broker.

For example, consider the following inbound queue bridge configuration in Spring XML:

```
<inboundQueueBridges>
  <inboundQueueBridge inboundQueueName="QueueA" />
</inboundQueueBridges>
```

The preceding configuration creates a JMS consumer client, which is connected to the third-party JMS provider, and a JMS producer client, which is connected to the ActiveMQ broker. The bridge pulls messages off the **QueueA** queue on the third-party JMS provider and pushes the messages on to the **QueueA** queue on the ActiveMQ broker.

If the names of the corresponding queues in each provider are *different*, you can map between the queues using the following configuration:

```
<inboundQueueBridges>
  <inboundQueueBridge
      inboundQueueName="QueueA"
      localQueueName="org.activemq.example.QueueA" />
</inboundQueueBridges>
```

Where **inboundQueueName** specifies the name of the queue on the third-party JMS provider and **localQueueName** specifies the name of the queue on the ActiveMQ broker.

Outbound queue bridges

The **outboundQueueBridges** element and the **outboundQueueBridge** child elements are used to route queue messages *from* the ActiveMQ broker *to* the third-party JMS provider. In this case, *outbound* means heading away from the ActiveMQ broker.

For example, consider the following outbound queue bridge configuration in Spring XML:

```
<outboundQueueBridges>
  <outboundQueueBridge outboundQueueName="QueueX" />
</inboundQueueBridges>
```

The preceding configuration creates a JMS consumer client, which is connected to the ActiveMQ broker, and a JMS producer client, which is connected to the third-party JMS provider. The bridge pulls messages off the **QueueX** queue on the ActiveMQ broker and pushes the messages on to the **QueueX** queue on the third-party JMS provider.

If the names of the corresponding queues in each provider are *different*, you can map between the queues using the following configuration:

```
<outboundQueueBridges>
  <outboundQueueBridge
      outboundQueueName="QueueX"
      localQueueName="org.activemq.example.QueueX" />
</inboundQueueBridges>
```

Where **outboundQueueName** specifies the name of the queue on the third-party JMS provider and **localQueueName** specifies the name of the queue on the ActiveMQ broker.

Sample queue bridges

Example 10.3, “Sample Queue Bridges” shows a sample configuration of a native JMS-to-JMS bridge, which routes three inbound queues, **QueueA**, **QueueB**, and **QueueC**, and three outbound queues, **QueueX**, **QueueY**, and **QueueZ**.

Example 10.3. Sample Queue Bridges

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans" ... >
  ...
  <broker xmlns="http://activemq.apache.org/schema/core" ... >

    <jmsBridgeConnectors>
      <jmsQueueConnector
        outboundQueueConnectionFactory="#remoteFactory">

        <inboundQueueBridges>
          <inboundQueueBridge inboundQueueName="QueueA" />
          <inboundQueueBridge inboundQueueName="QueueB" />
          <inboundQueueBridge inboundQueueName="QueueC" />
        </inboundQueueBridges>

        <outboundQueueBridges>
          <outboundQueueBridge outboundQueueName="QueueX" />
          <outboundQueueBridge outboundQueueName="QueueY" />
          <outboundQueueBridge outboundQueueName="QueueZ" />
        </outboundQueueBridges>
      </jmsQueueConnector>
    </jmsBridgeConnectors>
```

```
    <transportConnectors>
      <transportConnector uri="tcp://localhost:61234" />
    </transportConnectors>

  </broker>
  ...
</beans>
```

10.3.5. Configuring Topic Bridges

Overview

The routing of topic messages within the native JMS-to-JMS bridge is configured using the **inboundTopicBridges** element and the **outboundTopicBridges** element. Using these elements, you can specify which topics to bridge between the third-party JMS provider and the ActiveMQ broker.

Inbound topic bridges

The **inboundTopicBridges** element and the **inboundTopicBridge** child elements are used to route topic messages *from* the third-party JMS provider *to* the ActiveMQ broker. In this case, *inbound* means heading into the ActiveMQ broker.

For example, consider the following inbound topic bridge configuration in Spring XML:

```
<inboundTopicBridges>
  <inboundTopicBridge inboundTopicName="TopicA" />
</inboundTopicBridges>
```

The preceding configuration creates a JMS consumer client, which is connected to the third-party JMS provider, and a JMS producer client, which is connected to the ActiveMQ broker. The bridge pulls messages off the **TopicA** topic on the third-party JMS provider and pushes the messages on to the **TopicA** topic on the ActiveMQ broker.

If the names of the corresponding topics in each provider are *different*, you can map between the topics using the following configuration:

```
<inboundTopicBridges>
  <inboundTopicBridge
      inboundTopicName="TopicA"
      localTopicName="org.activemq.example.TopicA" />
</inboundTopicBridges>
```

Where **inboundTopicName** specifies the name of the topic on the third-party JMS provider and **localTopicName** specifies the name of the topic on the ActiveMQ broker.

Outbound topic bridges

The **outboundTopicBridges** element and the **outboundTopicBridge** child elements are used to route topic messages *from* the ActiveMQ broker *to* the third-party JMS provider. In this case, *outbound* means heading away from the ActiveMQ broker.

For example, consider the following outbound topic bridge configuration in Spring XML:

```
<outboundTopicBridges>
  <outboundTopicBridge outboundTopicName="TopicX" />
</inboundTopicBridges>
```

The preceding configuration creates a JMS consumer client, which is connected to the ActiveMQ broker, and a JMS producer client, which is connected to the third-party JMS provider. The bridge pulls messages off the **`TopicX`** topic on the ActiveMQ broker and pushes the messages on to the**`TopicX`** topic on the third-party JMS provider.

If the names of the corresponding topics in each provider are *different*, you can map between the topics using the following configuration:

```
<outboundTopicBridges>
  <outboundTopicBridge
      outboundTopicName="TopicX"
      localTopicName="org.activemq.example.TopicX" />
</inboundTopicBridges>
```

Where **`outboundTopicName`** specifies the name of the topic on the third-party JMS provider and **`localTopicName`** specifies the name of the topic on the ActiveMQ broker.

Sample topic bridges

Example 10.4, “Sample Topic Bridges” shows a sample configuration of a native JMS-to-JMS bridge, which routes three inbound topics, **`TopicA`**, **`TopicB`**, and **`TopicC`**, and three outbound topics, **`TopicX`**, **`TopicY`**, and **`TopicZ`**.

Example 10.4. Sample Topic Bridges

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans" ... >
  ...
  <broker xmlns="http://activemq.apache.org/schema/core" ... >

    <jmsBridgeConnectors>
      <jmsTopicConnector
        outboundTopicConnectionFactory="#remoteFactory">

        <inboundTopicBridges>
          <inboundTopicBridge inboundTopicName="TopicA" />
          <inboundTopicBridge inboundTopicName="TopicB" />
          <inboundTopicBridge inboundTopicName="TopicC" />
        </inboundTopicBridges>

        <outboundTopicBridges>
          <outboundTopicBridge outboundTopicName="TopicX" />
          <outboundTopicBridge outboundTopicName="TopicY" />
          <outboundTopicBridge outboundTopicName="TopicZ" />
        </outboundTopicBridges>
      </jmsTopicConnector>
    </jmsBridgeConnectors>

    <transportConnectors>
      <transportConnector uri="tcp://localhost:61234" />
```

```
    </transportConnectors>

  </broker>
  ...
</beans>
```

10.3.6. Deploying a Bridge

Overview

To deploy a native JMS-to-JMS bridge in the JBoss A-MQ broker, perform the following steps:

- the section called “Deploy the Third-Party Client Libraries”.
- the section called “Deploy the Bridge”.

Deploy the Third-Party Client Libraries

A basic prerequisite for using the third-party JMS provider is that the third-party JMS client libraries are installed in the JBoss A-MQ OSGi container. Before they are deployed into the OSGi container, however, the third-party client JARs must also be packaged as *OSGi bundles*. A quick and easy way to convert a JAR into an OSGi bundle is to prefix it with the **`wrap:`** URL prefix.

For example, given the client JAR file **`foo-jms-client.jar`** located in the **`/tmp`** directory, you could deploy it into the OSGi container as follows:

```
JBossA-MQ:karaf@root> osgi:install -s wrap:file:///tmp/foo-jms-client.jar
```

If the third-party client libraries are already packaged as OSGi bundles, you can leave out the **`wrap:`** prefix.

Deploy the Bridge

To deploy the native JMS-to-JMS bridge in embedded mode, edit the ***`InstallDir`*`/etc/activemq.xml`** file, and insert the **`jmsBridgeConnectors`** element as a child of the **`broker`** element, as follows:

```
<beans ... >

    <!-- Allows us to use system properties and fabric as variables in
this configuration file -->
    <bean
class="org.springframework.beans.factory.config.PropertyPlaceholderConfigu
rer">
        <property name="properties">
            <bean class="io.fabric8.mq.fabric.ConfigurationProperties"/>
        </property>
    </bean>

    <broker xmlns="http://activemq.apache.org/schema/core"
            brokerName="${broker-name}"
            dataDirectory="${data}"
```

```
            start="false">
        ...
        <jmsBridgeConnectors>
            <jmsQueueConnector> ... </jmsQueueConnector>
            ...
            <jmsTopicConnector> ... </jmsTopicConnector>
            ...
        </jmsBridgeConnectors>
        ...
    </broker>

</beans>
```

The native JMS-to-JMS bridge will be enabled when you restart the A-MQ broker.

10.3.7. Sample Bridge Configuration

Overview

This section describes a sample configuration for native JMS-to-JMS bridge between a JBoss A-MQ broker and a WebSphere MQ server. This example assumes you are using the Java client libraries from WebSphere MQ version 7.0.1.3.

ActiveMQ-to-WebSphere MQ bridge

Example 10.5, “ActiveMQ-to-WebSphere MQ Configuration” shows a sample configuration for an ActiveMQ-to-WebSphere MQ bridge, which you could add to the broker configuration in the ***InstallDir*/etc/activemq.xml** file.

Example 10.5. ActiveMQ-to-WebSphere MQ Configuration

```
<beans ... >

    <!-- Allows us to use system properties and fabric as variables in
this configuration file -->
    <bean
class="org.springframework.beans.factory.config.PropertyPlaceholderConfi
gurer">
        <property name="properties">
            <bean
class="io.fabric8.mq.fabric.ConfigurationProperties"/>
        </property>
    </bean>

    <broker xmlns="http://activemq.apache.org/schema/core"
            brokerName="${broker-name}"
            dataDirectory="${data}"
            start="false">
        ...
        <jmsBridgeConnectors>
            <jmsQueueConnector
outboundQueueConnectionFactory="#remoteFactory">
                <inboundQueueBridges>
                    <inboundQueueBridge inboundQueueName="QueueA" />
```

```
                </inboundQueueBridges>

                <outboundQueueBridges>
                    <outboundQueueBridge outboundQueueName="QueueX" />
                </outboundQueueBridges>
            </jmsQueueConnector>
        </jmsBridgeConnectors>
        ...
    </broker>
    ...
    <!-- Configure IBM WebSphere MQ queue connection factory -->
    <bean id="remoteFactory"
class="com.ibm.mq.jms.MQQueueConnectionFactory">
        <property name="transportType" value="1"/>
        <property name="hostName" value="localhost"/>
        <property name="port" value="1414"/>
        <property name="queueManager" value="QM_TEST"/>
    </bean>
    ...
</beans>
```

This example assumes that you have already created a `QueueA` queue and a `QueueX` queue on the WebSphere MQ server. ActiveMQ will create the corresponding queues dynamically—there is no need to create them in advance.

Deploying the WebSphere MQ client libraries

Conveniently, WebSphere MQ 7.0 provides OSGi bundle versions of the client libraries in the following directory:

```
$MQ_INSTALL_DIR/java/lib/OSGI
```

For the WebSphere MQ Java client, you need to install the following JARs (OSGi bundles):

```
com.ibm.mq.osgi.directip_7.0.1.3.jar
com.ibm.msg.client.osgi.commonservices.j2se_7.0.1.3.jar
com.ibm.msg.client.osgi.jms.prereq_7.0.1.3.jar
com.ibm.msg.client.osgi.jms_7.0.1.3.jar
com.ibm.msg.client.osgi.nls_7.0.1.3.jar
com.ibm.msg.client.osgi.wmq.nls_7.0.1.3.jar
com.ibm.msg.client.osgi.wmq.prereq_7.0.1.3.jar
com.ibm.msg.client.osgi.wmq_7.0.1.3.jar
```

You can deploy these client libraries into JBoss A-MQ OSGi container using the following series of `install` commands:

```
JBossA-MQ:karaf@root> osgi:install -s
file:/tmp/mqclient/com.ibm.mq.osgi.directip_7.0.1.3.jar
JBossA-MQ:karaf@root> osgi:install -s
file:/tmp/mqclient/com.ibm.msg.client.osgi.commonservices.j2se_7.0.1.3.jar
JBossA-MQ:karaf@root> osgi:install -s
file:/tmp/mqclient/com.ibm.msg.client.osgi.jms.prereq_7.0.1.3.jar
JBossA-MQ:karaf@root> osgi:install -s
```

```
file:/tmp/mqclient/com.ibm.msg.client.osgi.jms_7.0.1.3.jar
JBossA-MQ:karaf@root> osgi:install -s
file:/tmp/mqclient/com.ibm.msg.client.osgi.nls_7.0.1.3.jar
JBossA-MQ:karaf@root> osgi:install -s
file:/tmp/mqclient/com.ibm.msg.client.osgi.wmq.nls_7.0.1.3.jar
JBossA-MQ:karaf@root> osgi:install -s
file:/tmp/mqclient/com.ibm.msg.client.osgi.wmq.prereq_7.0.1.3.jar
JBossA-MQ:karaf@root> osgi:install -s
file:/tmp/mqclient/com.ibm.msg.client.osgi.wmq_7.0.1.3.jar
```

10.3.8. Handling ReplyTo Destinations

Overview

One of the features of the native ActiveMQ JMS-to-JMS bridge is its ability to handle ReplyTo destinations automatically. No special configuration is necessary—this feature is enabled by default.

ReplyTo destinations

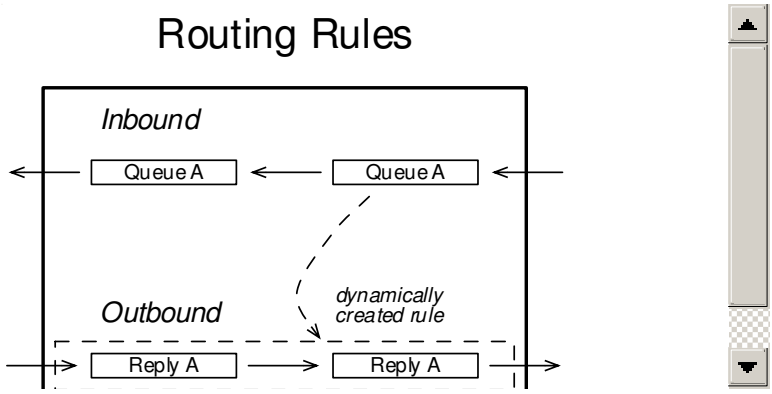
ReplyTo destinations are a feature of the JMS specification. An individual JMS message can be created with a `JMSReplyTo` header, which specifies the Destination (Queue or Topic) on which the sender expects to receive a reply.

Automatic proxification

To support ReplyTo destinations effectively, the native JMS-to-JMS bridge implements support for *automatic proxification*. The problem is that whenever a message defines a `JMSReplyTo` header, a corresponding rule must be put in place to ensure that the reply message is propagated back through the bridge. In general, the most effective approach is for the bridge to create the required rule *dynamically*, whenever a `JMSReployTo` header is encountered.

For example, Figure 10.3, “Automatic Proxification in the native JMS-to-JMS Bridge” shows how the native JMS-to-JMS bridge automatically creates a return route for the reply to message `M1`, where the ReplyTo destination is a queue named `ReplyA`.

Figure 10.3. Automatic Proxification in the native JMS-to-JMS Bridge



10.3.9. Implementing Message Convertors

Overview

Sometimes, in addition to forwarding messages, it is also necessary to reformat the messages that pass through the bridge. The native JMS-to-JMS bridge provides interception points for converting queue messages and topic messages.

You can implement two different kinds of message convertor, as follows:

- *Inbound message convertor*—converts third-party JMS messages to ActiveMQ messages.
- *Outbound message convertor*—converts ActiveMQ messages to third-party JMS messages.

JmsMessageConvertor interface

Example 10.6, "JmsMessageConvertor interface" shows the definition of the `JmsMessageConvertor` interface, which can be used as the basis for implementing either an inbound message convertor or an outbound message convertor.

Example 10.6. JmsMessageConvertor interface

```
package org.apache.activemq.network.jms;

import javax.jms.Connection;
import javax.jms.Destination;
import javax.jms.JMSException;
import javax.jms.Message;

/**
 * Converts Message from one JMS to another
 */
public interface JmsMesageConvertor {

    Message convert(Message message) throws JMSException;

    Message convert(Message message, Destination replyTo) throws
JMSException;

    void setConnection(Connection connection);

}
```

Message converter methods

The `JmsMesageConvertor` interface exposes the following methods:

`Message convert(Message message)`

This variant of the `convert` method is called, if the `doHandleReplyTo` option is set to `false` or if the `ReplyTo` destination on the message is `null`. In this case, the `convert` method should simply reformat the message content as required.

`Message convert(Message message, Destination replyTo)`

This variant of the `convert` method is called, if the `ReplyTo` destination on the message is

non-null. In this case, in addition to reformatting the message, you have the ability to change the `replyTo` destination, so that the reply to this message is redirected to a different destination.

The `replyTo` argument contains the original destination of the message. If you want to change the ReplyTo destination, you can do so by calling the `message.setJMSReplyTo()` method, passing in the changed destination.

The reason you might want to change the ReplyTo destination is in order to take control of proxification (see Section 10.3.8, "Handling ReplyTo Destinations"). Proxification is necessary, because the ActiveMQ broker is not able to make a direct connection back to the third-party JMS provider.

`void setConnection(Connection connection)`

Provides a reference to the `javax.jms.Connection` object *to which messages will be forwarded*. In other words, if this message convertor is used as an inbound message convertor, this connection is the connection to the ActiveMQ broker. If this message convertor is used as an outbound message convertor, this connection is the connection to the third-party JMS provider.

Sample implementation

Example 10.7, "Sample Message Convertor" shows a trivial implementation of a message convertor, which passes messages through without performing any conversion.

Example 10.7. Sample Message Convertor

```
package org.apache.activemq.network.jms;

import javax.jms.Connection;
import javax.jms.Destination;
import javax.jms.JMSException;
import javax.jms.Message;

/**
 * Converts Message from one JMS to another
 *
 * @org.apache.xbean.XBean
 */
public class SimpleJmsMessageConvertor implements JmsMesageConvertor {

    public Message convert(Message message) throws JMSException {
        return message;
    }

    public Message convert(Message message, Destination replyTo) throws
JMSException {
        Message msg = convert(message);
        if (replyTo != null) {
            msg.setJMSReplyTo(replyTo);
        } else {
            msg.setJMSReplyTo(null);
        }
        return msg;
```

```
        }

        public void setConnection(Connection connection) {
            // do nothing
        }
    }
```

Configuring the message convertor

Message convertors can be attached to the native JMS-to-JMS bridge using the `inboundMessageConvertor` and `outboundMessageConvertor` attributes.

For example, to use the `SimpleJmsMessageConvertor` implementation both as an inbound message convertor and as an outbound message convertor, you could configure a JMS queue connector as follows:

```
<jmsBridgeConnectors>
  <jmsQueueConnector
      outboundQueueConnectionFactory="#remoteFactory"

inboundMessageConvertor="org.apache.activemq.network.jms.SimpleJmsMessageC
onvertor"

outboundMessageConvertor="org.apache.activemq.network.jms.SimpleJmsMessage
Convertor">

    <inboundQueueBridges>
      <inboundQueueBridge inboundQueueName="QueueA" />
    </inboundQueueBridges>

    <outboundQueueBridges>
      <outboundQueueBridge outboundQueueName="QueueX" />
    </outboundQueueBridges>
  </jmsQueueConnector>
</jmsBridgeConnectors>
```

10.3.10. Configuration Reference

Overview

jmsQueueConnector attributes

The following attributes can be used to configure the `jmsQueueConnector` element:

`id`

Optional beran ID of `xs:ID` type, which could be used to reference this bean.

`inboundMessageConvertor`

References a bean instance of `org.apache.activemq.network.jms.JmsMesageConvertor` type, which transforms inbound messages from the third-party JMS provider into a format that is suitable for the ActiveMQ broker.

`jndiLocalTemplate`

References a bean instance of `org.springframework.jndi.JndiTemplate` type, which provides access to a JNDI directory instance. Used in combination with the `localConnectionFactoryName` attribute to locate a JMS `QueueConnectionFactory` instance in a JNDI directory, where this connection factory instance is then used to connect to the local JMS provider (that is, the ActiveMQ broker).

`jndiOutboundTemplate`

References a bean instance of `org.springframework.jndi.JndiTemplate` type, which provides access to a JNDI directory instance. Used in combination with the `outboundQueueConnectionFactoryName` attribute to locate a JMS `QueueConnectionFactory` instance in a JNDI directory, where this connection factory instance is then used to connect to the third-party JMS provider.

`localClientId`

Sets the ID of the local connection (useful for logging and JMX monitoring).

`localConnectionFactoryName`

Specifies the JNDI name of a `QueueConnectionFactory` instance. Used in combination with the `jndiLocalTemplate` attribute to connect to the local JMS provider (that is, the ActiveMQ broker).

`localPassword`

Specifies the password part of the credentials used to log on to the local JMS provider (ActiveMQ broker). Used in combination with the `localUsername` attribute.

`localQueueConnection`

References a bean of `javax.jms.QueueConnection` type, which is used to connect to the local JMS provider (ActiveMQ broker).

`localQueueConnectionFactory`

References a bean of `javax.jms.QueueConnectionFactory` type, which is used to connect to the local JMS provider (ActiveMQ broker).

`localUsername`

Specifies the username part of the credentials used to log on to the local JMS provider (ActiveMQ broker). Used in combination with the `localPassword` attribute.

`name`

Assigns a name to this `jmsQueueConnector` element (useful for logging and JMX monitoring).

`outboundClientId`

Sets the ID of the third-party connection (useful for logging and JMX monitoring).

`outboundMessageConvertor`

References a bean instance of `org.apache.activemq.network.jms.JmsMesageConvertor` type, which transforms outbound messages from the ActiveMQ broker into a format that is suitable for the third-party JMS provider.

`outboundPassword`

Specifies the password part of the credentials used to log on to the third-party JMS provider. Used in combination with the `outboundUsername` attribute.

`outboundQueueConnection`

References a bean of `javax.jms.QueueConnection` type, which is used to connect to the third-party JMS provider.

`outboundQueueConnectionFactory`

References a bean of `javax.jms.QueueConnectionFactory` type, which is used to connect to the third-party JMS provider.

`outboundQueueConnectionFactoryName`

Specifies the JNDI name of a `QueueConnectionFactory` instance. Used in combination with the `jndiOutboundTemplate` attribute to connect to the third-party JMS provider.

`outboundUsername`

Specifies the username part of the credentials used to log on to the third-party JMS provider. Used in combination with the `outboundPassword` attribute.

`preferJndiDestinationLookup`

Specifies whether the connector should first try to find a destination in JNDI before using JMS semantics to create a `Destination`. By default, the connector will first use JMS semantics and then fall back to JNDI look-up. Setting this attribute to `true` reverses that order.

jmsTopicConnector attributes

The following attributes can be used to configure the `jmsTopicConnector` element:

`id`

Optional bean ID of `xs:ID` type, which could be used to reference this bean.

`inboundMessageConvertor`

References a bean instance of `org.apache.activemq.network.jms.JmsMesageConvertor` type, which transforms inbound messages from the third-party JMS provider into a format that is suitable for the ActiveMQ broker.

`jndiLocalTemplate`

References a bean instance of `org.springframework.jndi.JndiTemplate` type, which provides access to a JNDI directory instance. Used in combination with the `localConnectionFactoryName` attribute to locate a JMS `TopicConnectionFactory` instance in a JNDI directory, where this connection factory instance is then used to connect to the local JMS provider (that is, the ActiveMQ broker).

`jndiOutboundTemplate`

References a bean instance of `org.springframework.jndi.JndiTemplate` type, which provides access to a JNDI directory instance. Used in combination with the `outboundTopicConnectionFactoryName` attribute to locate a JMS `TopicConnectionFactory` instance in a JNDI directory, where this connection factory instance is then used to connect to the third-party JMS provider.

`localClientId`

Sets the ID of the local connection (useful for logging and JMX monitoring).

`localConnectionFactoryName`

Specifies the JNDI name of a `TopicConnectionFactory` instance. Used in combination with the `jndiLocalTemplate` attribute to connect to the local JMS provider (that is, the ActiveMQ broker).

`localPassword`

Specifies the password part of the credentials used to log on to the local JMS provider (ActiveMQ broker). Used in combination with the `localUsername` attribute.

`localTopicConnection`

References a bean of `javax.jms.TopicConnection` type, which is used to connect to the local JMS provider (ActiveMQ broker).

`localTopicConnectionFactory`

References a bean of `javax.jms.TopicConnectionFactory` type, which is used to connect to the local JMS provider (ActiveMQ broker).

`localUsername`

Specifies the username part of the credentials used to log on to the local JMS provider (ActiveMQ broker). Used in combination with the `localPassword` attribute.

`name`

Assigns a name to this `jmsTopicConnector` element (useful for logging and JMX monitoring).

`outboundClientId`

Sets the ID of the third-party connection (useful for logging and JMX monitoring).

`outboundMessageConvertor`

References a bean instance of `org.apache.activemq.network.jms.JmsMesageConvertor` type, which transforms outbound messages from the ActiveMQ broker into a format that is suitable for the third-party JMS provider.

`outboundPassword`

Specifies the password part of the credentials used to log on to the third-party JMS provider. Used in combination with the `outboundUsername` attribute.

outboundTopicConnection

References a bean of `javax.jms.TopicConnection` type, which is used to connect to the third-party JMS provider.

outboundTopicConnectionFactory

References a bean of `javax.jms.TopicConnectionFactory` type, which is used to connect to the third-party JMS provider.

outboundTopicConnectionFactoryName

Specifies the JNDI name of a `TopicConnectionFactory` instance. Used in combination with the `jndiOutboundTemplate` attribute to connect to the third-party JMS provider.

outboundUsername

Specifies the username part of the credentials used to log on to the third-party JMS provider. Used in combination with the `outboundPassword` attribute.

preferJndiDestinationLookup

Specifies whether the connector should first try to find a destination in JNDI before using JMS semantics to create a `Destination`. By default, the connector will first use JMS semantics and then fall back to JNDI look-up. Setting this attribute to `true` reverses that order.

inboundQueueBridge attributes

The following attributes can be used to configure the `inboundQueueBridge` element:

doHandleReplyTo

A boolean attribute that specifies whether ReplyTo messages should be handled or not. Default is `true`.

id

Optional bean ID of `xs:ID` type, which could be used to reference this bean.

inboundQueueName

Specifies the name of the queue in the third-party JMS provider, from which messages are consumed.

localQueueName

Specifies the local queue name (in the ActiveMQ broker), into which messages are pushed. If not specified, defaults to the same value as `inboundQueueName`.

selector

Optionally, specifies a JMS selector string.

outboundQueueBridge attributes

The following attributes can be used to configure the `outboundQueueBridge` element:

`doHandleReplyTo`

A boolean attribute that specifies whether ReplyTo messages should be handled or not. Default is `true`.

`id`

Optional bean ID of `xs:ID` type, which could be used to reference this bean.

`outboundQueueName`

Specifies the name of the queue in the third-party JMS provider, into which messages are pushed.

`localQueueName`

Specifies the local queue name (in the ActiveMQ broker), from which messages are consumed. If not specified, defaults to the same value as `outboundQueueName`.

`selector`

Optionally, specifies a JMS selector string.

inboundTopicBridge attributes

The following attributes can be used to configure the `inboundTopicBridge` element:

`consumerName`

If this attribute is set, the bridge creates a durable consumer for this topic.

`doHandleReplyTo`

A boolean attribute that specifies whether ReplyTo messages should be handled or not. Default is `true`.

`id`

Optional bean ID of `xs:ID` type, which could be used to reference this bean.

`inboundTopicName`

Specifies the name of the topic in the third-party JMS provider, from which messages are consumed.

`localTopicName`

Specifies the local topic name (in the ActiveMQ broker), into which messages are pushed. If not specified, defaults to the same value as `inboundTopicName`.

`selector`

Optionally, specifies a JMS selector string.

outboundTopicBridge attributes

The following attributes can be used to configure the `outboundTopicBridge` element:

`consumerName`

If this attribute is set, the bridge creates a durable consumer for this topic.

`doHandleReplyTo`

A boolean attribute that specifies whether ReplyTo messages should be handled or not. Default is `true`.

`id`

Optional bean ID of `xs:ID` type, which could be used to reference this bean.

`outboundTopicName`

Specifies the name of the topic in the third-party JMS provider, into which messages are pushed.

`localTopicName`

Specifies the local topic name (in the ActiveMQ broker), from which messages are consumed. If not specified, defaults to the same value as `outboundTopicName`.

`selector`

Optionally, specifies a JMS selector string.

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