Qpid Dispatch Router Book

REVISION HISTORY			
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Chapter 1

Introduction

1.1 Overview

The Dispatch router is an AMQP message router that provides advanced interconnect capabilities. It allows flexible routing of messages between any AMQP-enabled endpoints, whether they be clients, servers, brokers or any other entity that can send or receive standard AMQP messages.

A messaging client can make a single AMQP connection into a messaging bus built of Dispatch routers and, over that connection, exchange messages with one or more message brokers, and at the same time exchange messages directly with other endpoints without involving a broker at all.

The router is an intermediary for messages but it is *not* a broker. It does not *take responsibility for* messages. It will, however, propagate settlement and disposition across a network such that delivery guarantees are met. In other words: the router network will deliver the message, possibly via several intermediate routers, *and* it will route the acknowledgement of that message by the ultimate receiver back across the same path. This means that *responsibility* for the message is transfered from the original sender to the ultimate receiver *as if they were directly connected.* However this is done via a flexible network that allows highly configurable routing of the message transparent to both sender and receiver.

There are some patterns where this enables "brokerless messaging" approaches that are preferable to brokered approaches. In other cases a broker is essential (in particular where you need the separation of responsibility and/or the buffering provided by store-and-forward) but a dispatch network can still be useful to tie brokers and clients together into patterns that are difficult with a single broker.

For a "brokerless" example, consider the common brokered implementation of the request-response pattern, a client puts a request on a queue and then waits for a reply on another queue. In this case the broker can be a hindrance - the client may want to know immediatly if there is nobody to serve the request, but typically it can only wait for a timeout to discover this. With a dispatch network, the client can be informed immediately if its message cannot be delivered because nobody is listening. When the client receives acknowledgement of the request it knows not just that it is sitting on a queue, but that it has actually been received by the server.

For an exampe of using dispatch to enhance the use of brokers, consider using an array of brokers to implement a scalable distributed work queue. A dispatch network can make this appear as a single queue, with senders publishing to a single address and receivers subscribing to a single address. The dispatch network can distribute work to any broker in the array and collect work from any broker for any receiver. Brokers can be shut down or added without affecting clients. This elegantly solves the common difficulty of "stuck messages" when implementing this pattern with brokers alone. If a receiver is connected to a broker that has no messages, but there are messages on another broker, you have to somehow transfer them or leave them "stuck". With a dispatch network, *all* the receivers are connected to *all* the brokers. If there is a message anywhere it can be delivered to any receiver.

The router is meant to be deployed in topologies of multiple routers, preferably with redundant paths. It uses link-state routing protocols and algorithms (similar to OSPF or IS-IS from the networking world) to calculate the best path from every point to every other point and to recover quickly from failures. It does not need to use clustering for high availability; rather, it relies on redundant paths to provide continued connectivity in the face of system or network failure. Because it never takes responsibility for messages it is effectively stateless. Messages not delivered to their final destination will not be acknowledged to the sender and therefore the sender can re-send such messages if it is disconnected from the network.

1.2 Benefits

Simplifies connectivity

- An endpoint can do all of its messaging through a single transport connection
- Avoid opening holes in firewalls for incoming connections

Provides messaging connectivity where there is no TCP/IP connectivity

- A server or broker can be in a private IP network (behind a NAT firewall) and be accessible by messaging endpoints in other networks (learn more).

Simplifies reliability

- Reliability and availability are provided using redundant topology, not server clustering
- Reliable end-to-end messaging without persistent stores
- Use a message broker only when you need store-and-forward semantics

1.3 Features

- Can be deployed stand-alone or in a network of routers
  - Supports arbitrary network topology - no restrictions on redundancy
    - Automatic route computation - adjusts quickly to changes in topology
- Provides remote access to brokers or other AMQP servers
- Security

Chapter 2

Theory of Operation

This section introduces some key concepts about the router.

2.1 Overview

The router is an *application layer* program running as a normal user program or as a daemon.

The router accepts AMQP connections from clients and creates AMQP connections to brokers or AMQP-based services. The router classifies incoming AMQP messages and routes the messages between message producers and message consumers.

The router is meant to be deployed in topologies of multiple routers, preferably with redundant paths. It uses link-state routing protocols and algorithms similar to OSPF or IS-IS from the networking world to calculate the best path from every message source to every message destination and to recover quickly from failures. The router relies on redundant network paths to provide continued connectivity in the face of system or network failure.

A messaging client can make a single AMQP connection into a messaging bus built with routers and, over that connection, exchange messages with one or more message brokers connected to any router in the network. At the same time the client can exchange messages directly with other endpoints without involving a broker at all.

2.2 Connections

The router connects clients, servers, AMQP services, and other routers through network connections.

2.2.1 Listener

The router provides *listeners* that accept client connections. A client connecting to a router listener uses the same methods that it would use to connect to a broker. From the client's perspective the router connection and link establishment are identical to broker connection and link establishment.

Several types of listeners are defined by their role.

Role	Description
normal	The connection is used for AMQP clients using normal message delivery.
inter-router	The connection is assumed to be to another router in the network. Inter-router discovery and routing protocols can only be used over inter-router connections.
route-container	The connection is a broker or other resource that holds known addresses. The router will use this connection to create links as necessary. The addresses are available for routing only after the remote resource has created a connection.

2.2.2 Connector

The router can also be configured to create outbound connections to messaging brokers or other AMQP entities using *connectors*. A connector is defined with the network address of the broker and the name or names of the resources that are available in that broker. When a router connects to a broker through a connector it uses the same methods a normal messaging client would use when connecting to the broker.

Several types of connectors are defined by their role.

Role	Description
normal	The connection is used for AMQP clients using normal message delivery. On this connector the router will initiate the connection but it will never create any links. Links are to be created by the peer that accepts the connection.
inter-router	The connection is assumed to be to another router in the network. Inter-router discovery and routing protocols can only be used over inter-router connections.
route-container	The connection is to a broker or other resource that holds known addresses. The router will use this connection to create links as necessary. The addresses are available for routing only after the router has created a connection to the remote resource.

2.3 Addresses

AMQP addresses are used to control the flow of messages across a network of routers. Addresses are used in a number of different places in the AMQP 1.0 protocol. They can be used in a specific message in the *to* and *reply-to* fields of a message's properties. They are also used during the creation of links in the *address* field of a *source* or a *target*.

Note
Addresses in this discussion refer to AMQP protocol addresses and not to TCP/IP network addresses. TCP/IP network addresses are used by messaging clients, brokers, and routers to create AMQP connections. AMQP protocol addresses are the names of source and destination endpoints for messages within the messaging network.

Addresses designate various kinds of entities in a messaging network:

- Endpoint processes that consume data or offer a service
- Topics that match multiple consumers to multiple producers
- Entities within a messaging broker:
  - Queues
  - Durable Topics
  - Exchanges

The syntax of an AMQP address is opaque as far as the router network is concerned. A syntactical structure may be used by the administrator who creates addresses but the router treats them as opaque strings.

The router maintains several classes of address based on how the address is configured or discovered.

Address Type	Description
mobile	The address is a rendezvous point between senders and receivers. The router aggregates and serializes messages from senders and distributes messages to receivers.
link route	The address defines a private messaging path between a sender and a receiver. The router simply passes messages between the end points.

2.3.1 Mobile Addresses

Routers consider addresses to be mobile such that any users of an address may be directly connected to any router in a network and may move around the topology. In cases where messages are broadcast to or balanced across multiple consumers, the address users may be connected to multiple routers in the network.

Mobile addresses are rendezvous points for senders and receivers. Messages arrive at the mobile address and are dispatched to their destinations according to the routing defined for the mobile address. The details of these routing patterns are discussed later.

Mobile addresses may be discovered during normal router operation or configured through management settings.

2.3.1.1 Discovered Mobile Addresses

Mobile addresses are created when a client creates a link to a source or destination address that is unknown to the router network.

Suppose a service provider wants to offer *my-service* that clients may use. The service provider must open a receiver link with source address *my-service*. The router creates a mobile address *my-service* and propagates the address so that it is known to every router in the network.

Later a client wants to use the service and creates a sending link with target address *my-service*. The router matches the service provider's receiver having source address *my-service* to the client's sender having target address *my-service* and routes messages between the two.

Any number of other clients can create links to the service as well. The clients do not have to know where in the router network the service provider is physically located nor are the clients required to connect to a specific router to use the service. Regardless of how many clients are using the service the service provider needs only a single connection and link into the router network.

Another view of this same scenario is when a client tries to use the service before service provider has connected to the network. In this case the router network creates the mobile address *my-service* as before. However, since the mobile address has only client sender links and no receiver links the router stalls the clients and prevents them from sending any messages. Later, after the service provider connects and creates the receiver link, the router will issue credits to the clients and the messages will begin to flow between the clients and the service.

The service provider can connect, disconnect, and reconnect from a different location without having to change any of the clients or their connections. Imagine having the service running on a laptop. One day the connection is from corporate headquarters and the next day the connection is from some remote location. In this case the service provider's computer will typically have different host IP addresses for each connection. Using the router network the service provider connects to the router network and offers the named service and the clients connect to the router network and consume from the named service. The router network routes messages between the mobile addresses effectively masking host IP addresses of the service provider and the client systems.

2.3.1.2 Configured Mobile Addresses

Mobile addresses may be configured using the router *autoLink* object. An address created via an *autoLink* represents a queue, topic, or other service in an external broker. Logically the *autoLink* addresses are treated by the router network as if the broker had connected to the router and offered the services itself.

For each configured mobile address the router will create a single link to the external resource. Messages flow between sender links and receiver links the same regardless if the mobile address was discovered or configured.

Multiple *autoLink* objects may define the same address on multiple brokers. In this case the router network creates a sharded resource split between the brokers. Any client can seamlessly send and receive messages from either broker.

Note that the brokers do not need to be clustered or federated to receive this treatment. The brokers may even be from different vendors or be different versions of the same broker yet still work together to provide a larger service platform.

2.3.2 Link Route Addresses

Link route addresses may be configured using the router *linkRoute* object. An link route address represents a queue, topic, or other service in an external broker similar to addresses configured by *autoLink* objects. For link route addresses the router

propagates a separate link attachment to the broker resource for each incoming client link. The router does not automatically create any links to the broker resource.

Using link route addresses the router network does not participate in aggregated message distribution. The router simply passes message delivery and settlement between the two end points.

2.4 Message Routing

Addresses have semantics associated with them that are assigned when the address is provisioned or discovered. The semantics of an address control how routers behave when they see the address being used. Address semantics include the following considerations:

- Routing pattern - balanced, closest, multicast
- Routing mechanism - message routed, link routed

2.4.1 Routing Patterns

Routing patterns define the paths that a message with a mobile address can take across a network. These routing patterns can be used for both direct routing, in which the router distributes messages between clients without a broker, and indirect routing, in which the router enables clients to exchange messages through a broker.

Pattern	Description
Balanced	An anycast method which allows multiple receivers to use the same address. In this case, messages (or links) are routed to exactly one of the receivers and the network attempts to balance the traffic load across the set of receivers using the same address. This routing delivers messages to receivers based on how quickly they settle the deliveries. Faster receivers get more messages.
Closest	An anycast method in which even if there are more receivers for the same address, every message is sent along the shortest path to reach the destination. This means that only one receiver will get the message. Each message is delivered to the closest receivers in terms of topology cost. If there are multiple receivers with the same lowest cost, deliveries will be spread evenly among those receivers.
Multicast	Having multiple consumers on the same address at the same time, messages are routed such that each consumer receives one copy of the message.

2.4.2 Routing Mechanisms

The fact that addresses can be used in different ways suggests that message routing can be accomplished in different ways. Before going into the specifics of the different routing mechanisms, it would be good to first define what is meant by the term *routing*:

```
In a network built of multiple, interconnected routers 'routing'
determines which connection to use to send a message directly
to its destination or one step closer to its destination.
```

Each router serves as the terminus of a collection of incoming and outgoing links. Some of the links are designated for message routing, and others are designated for link routing. In both cases, the links either connect directly to endpoints that produce and consume messages, or they connect to other routers in the network along previously established connections.

2.4.2.1 Message Routed

Message routing occurs upon delivery of a message and is done based on the address in the message's *to* field.

When a delivery arrives on an incoming message-routing link, the router extracts the address from the delivered message's *to* field and looks the address up in its routing table. The lookup results in zero or more outgoing links onto which the message shall be resent.

Message routing can also occur without an address in the message's *to* field if the incoming link has a target address. In fact, if the sender uses a link with a target address, the *to* field shall be ignored even if used.

2.4.2.2 Link Routed

Link routing occurs when a new link is attached to the router across one of its AMQP connections. It is done based on the *target.address* field of an inbound link and the *source.address* field of an outbound link.

Link routing uses the same routing table that message routing uses. The difference is that the routing occurs during the link-attach operation, and link attaches are propagated along the appropriate path to the destination. What results is a chain of links, connected end-to-end, from source to destination. It is similar to a virtual circuit in a telecom system.

Each router in the chain holds pairs of link termini that are tied together. The router then simply exchanges all deliveries, delivery state changes, and link state changes between the two termini.

The endpoints that use the link chain do not see any difference in behavior between a link chain and a single point-to-point link. All of the features available in the link protocol (flow control, transactional delivery, etc.) are available over a routed link-chain.

2.4.3 Message Settlement

Messages may be delivered with varying degrees of reliability.

- At most once
- At least once
- Exactly once

The reliability is negotiated between the client and server during link establishment. The router handles all levels of reliability by treating messages as either *pre-settled* or *unsettled*.

Delivery	Handling
pre-settled	If the arriving delivery is pre-settled (i.e., fire and forget), the incoming delivery shall be settled by the router, and the outgoing deliveries shall also be pre-settled. In other words, the pre-settled nature of the message delivery is propagated across the network to the message's destination.
unsettled	Unsettled delivery is also propagated across the network. Because unsettled delivery records cannot be discarded, the router tracks the incoming deliveries and keeps the association of the incoming deliveries to the resulting outgoing deliveries. This kept association allows the router to continue to propagate changes in delivery state (settlement and disposition) back and forth along the path which the message traveled.

2.5 Security

The router uses the SSL protocol and related certificates and SASL protocol mechanisms to encrypt and authenticate remote peers. Router listeners act as network servers and router connectors act as network clients. Both connection types may be configured securely with SSL and SASL.

The router Policy module is an optional authorization mechanism enforcing user connection restrictions and AMQP resource access control.

Chapter 3

Using Qpid Dispatch

3.1 Configuration

The default configuration file is installed in */usr/etc/qpid-dispatch/qdrouterd.conf*. This configuration file will cause the router to run in standalone mode, listening on the standard AMQP port (5672). Dispatch Router looks for the configuration file in the installed location by default. If you wish to use a different path, the "-c" command line option will instruct Dispatch Router as to which configuration to load.

To run the router, invoke the executable: `qdrouterd [-c my-config-file]`

For more details of the configuration file see the *qdrouterd.conf(5)* man page.

3.2 Tools

3.2.1 qdstat

qdstat is a command line tool that lets you view the status of a Dispatch Router. The following options are useful for seeing what the router is doing:

Option	***Description***
-l	Print a list of AMQP links attached to the router. Links are unidirectional. Outgoing links are usually associated with a subscription address. The tool distinguishes between *endpoint* links and *router* links. Endpoint links are attached to clients using the router. Router links are attached to other routers in a network of routbers.
-a	Print a list of addresses known to the router.
-n	Print a list of known routers in the network.
-c	Print a list of connections to the router.
--autolinks	Print a list of configured auto-links.
--linkroutes	Print a list of configures link-routes.

For complete details see the *qdstat(8)* man page and the output of `qdstat --help`.

3.2.2 qdmanage

qdmanage is a general-purpose AMQP management client that allows you to not only view but modify the configuration of a running dispatch router.

For example you can query all the connection entities in the router:

```
$ qdmanage query --type connection
```

To enable logging debug and higher level messages by default:

```
$ qdmanage update log/DEFAULT enable=debug+
```

In fact, everything that can be configured in the configuration file can also be created in a running router via management. For example to create a new listener in a running router:

```
$ qdmanage create type=listener port=5555
```

Now you can connect to port 5555, for exampple:

```
$ qdmanage query -b localhost:5555 --type listener
```

For complete details see the *qdmanage(8)* man page and the output of `qdmanage --help`. Also for details of what can be configured see the *qdrouterd.conf(5)* man page.

3.3 Basic Usage and Examples

3.3.1 Standalone and Interior Modes

The router can operate stand-alone or as a node in a network of routers. The mode is configured in the *router* section of the configuration file. In stand-alone mode, the router does not attempt to collaborate with any other routers and only routes messages among directly connected endpoints.

If your router is running in stand-alone mode, *qdstat -a* will look like the following:

```
$ qdstat -a
Router Addresses
  class   addr                  phs  distrib  in-proc  local  remote  cntnr  in  out  thru ↩
      to-proc  from-proc
  ================================================================================================

  local   $_management_internal       closest  1        0      0       0      0   0    0  ↩
          0        0
  local   $displayname                closest  1        0      0       0      0   0    0  ↩
          0        0
  mobile  $management           0     closest  1        0      0       0      1   0    0  ↩
          1        0
  local   $management                 closest  1        0      0       0      0   0    0  ↩
          0        0
  local   temp.1GThUllfR7N+BDP        closest  0        1      0       0      0   0    0  ↩
          0        0
```

Note that there are a number of known addresses. *$management* is the address of the router's embedded management agent. *temp.1GThUllfR7N+BDP* is the temporary reply-to address of the *qdstat* client making requests to the agent.

If you change the mode to interior and restart the processs, the same command will yield additional addresses which are used for inter-router communication:

```
$ qdstat -a
Router Addresses
  class   addr                  phs  distrib    in-proc  local  remote  cntnr  in  out   ↩
      thru  to-proc  from-proc
  ================================================================================================

  local   $_management_internal       closest    1        0      0       0      0   0    0  ↩
          0        0
```

```
  local   $displayname                closest    1        0      0       0      0   0    0  ↩
          0        0
  mobile  $management            0    closest    1        0      0       0      1   0    0  ↩
          1        0
  local   $management                 closest    1        0      0       0      0   0    0  ↩
          0        0
  local   qdhello                     flood      1        0      0       0      0   0    0  ↩
          0        10
  local   qdrouter                    flood      1        0      0       0      0   0    0  ↩
          0        0
  topo    qdrouter                    flood      1        0      0       0      0   0    0  ↩
          0        1
  local   qdrouter.ma                 multicast  1        0      0       0      0   0    0  ↩
          0        0
  topo    qdrouter.ma                 multicast  1        0      0       0      0   0    0  ↩
          0        0
  local   temp.wfx54+zf+YWQF3T        closest    0        1      0       0      0   0    0  ↩
          0        0
```

3.3.2 Mobile Subscribers

The term "mobile subscriber" simply refers to the fact that a client may connect to the router and subscribe to an address to receive messages sent to that address. No matter where in the network the subscriber attaches, the messages will be routed to the appropriate destination.

To illustrate a subscription on a stand-alone router, you can use the examples that are provided with Qpid Proton. Using the *simple_recv.py* example receiver:

```
$ python ./simple_recv.py -a 127.0.0.1/my-address
```

This command creates a receiving link subscribed to the specified address. To verify the subscription:

```
$ qdstat -a
Router Addresses
  class   addr                  phs  distrib  in-proc  local  remote  cntnr  in  out  thru ↩
       to-proc  from-proc
  ================================================================================================

  local   $_management_internal       closest  1        0      0       0      0   0    0  ↩
          0        0
  local   $displayname                closest  1        0      0       0      0   0    0  ↩
          0        0
  mobile  $management            0    closest  1        0      0       0      2   0    0  ↩
          2        0
  local   $management                 closest  1        0      0       0      0   0    0  ↩
          0        0
  mobile  my-address             0    closest  0        1      0       0      0   0    0  ↩
          0        0
  local   temp.75_d2X23x_KOT51        closest  0        1      0       0      0   0    0  ↩
          0        0
```

You can then, in a separate command window, run a sender to produce messages to that address:

```
$ python ./simple_send.py -a 127.0.0.1/my-address
```

3.3.3 Dynamic Reply-To

Dynamic reply-to can be used to obtain a reply-to address that routes back to a client's receiving link regardless of how many hops it has to take to get there. To illustrate this feature, see below a simple program (written in C++ against the qpid::messaging API) that queries the management agent of the attached router for a list of other known routers' management addresses.

```
#include <qpid/messaging/Address.h>
#include <qpid/messaging/Connection.h>
#include <qpid/messaging/Message.h>
#include <qpid/messaging/Receiver.h>
#include <qpid/messaging/Sender.h>
#include <qpid/messaging/Session.h>

using namespace qpid::messaging;
using namespace qpid::types;

using std::stringstream;
using std::string;

int main() {
    const char* url = "amqp:tcp:127.0.0.1:5672";
    std::string connectionOptions = "{protocol:amqp1.0}";

    Connection connection(url, connectionOptions);
    connection.open();
    Session session = connection.createSession();
    Sender sender = session.createSender("mgmt");

    // create reply receiver and get the reply-to address
    Receiver receiver = session.createReceiver("#");
    Address responseAddress = receiver.getAddress();

    Message request;
    request.setReplyTo(responseAddress);
    request.setProperty("x-amqp-to", "amqp:/_local/$management");
    request.setProperty("operation", "DISCOVER-MGMT-NODES");
    request.setProperty("type", "org.amqp.management");
    request.setProperty("name, "self");

    sender.send(request);
    Message response = receiver.fetch();
    Variant content(response.getContentObject());
    std::cout << "Response: " << content << std::endl << std::endl;

    connection.close();
}
```

The equivalent program written in Python against the Proton Messenger API:

```
from proton import Messenger, Message

def main():
    host = "0.0.0.0:5672"

    messenger = Messenger()
    messenger.start()
    messenger.route("amqp:/*", "amqp://%s/$1" % host)
    reply_subscription = messenger.subscribe("amqp:/#")
    reply_address = reply_subscription.address

    request  = Message()
    response = Message()

    request.address = "amqp:/_local/$management"
    request.reply_to = reply_address
    request.properties = {u'operation' : u'DISCOVER-MGMT-NODES',
                          u'type'      : u'org.amqp.management',
```

```
                          u'name'      : u'self'}

    messenger.put(request)
    messenger.send()
    messenger.recv()
    messenger.get(response)

    print "Response: %r" % response.body

    messenger.stop()

main()
```

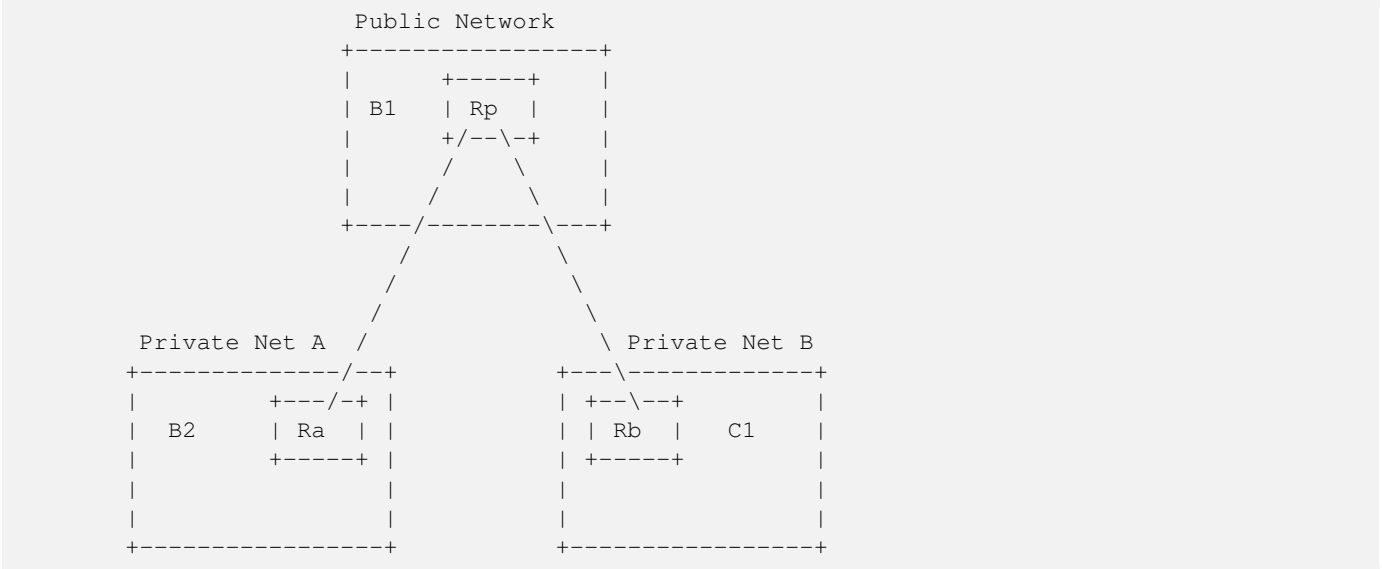
3.4 Link Routing

This feature was introduced in Qpid Dispatch 0.4. This feature was significantly updated in Qpid Dispatch 0.6.

Link-routing is an alternative strategy for routing messages across a network of routers. With the existing message-routing strategy, each router makes a routing decision on a per-message basis when the message is delivered. Link-routing is different because it makes routing decisions when link-attach frames arrive. A link is effectively chained across the network of routers from the establishing node to the destination node. Once the link is established, the transfer of message deliveries, flow frames, and dispositions is performed across the routed link.

The main benefit to link-routing is that endpoints can use the full link protocol to interact with other endpoints in far-flung parts of the network. For example, a client can establish a receiver across the network to a queue on a remote broker and use link credit to control the flow of messages from the broker. Similarly, a receiver can establish a link to a topic on a remote broker using a server-side filter.

Why would one want to do this? One reason is to provide client isolation. A network like the following can be deployed:



The clients in Private Net B can be constrained (by firewall policy) to only connect to the Router in their own network. Using link-routing, these clients can access queues, topics, and other AMQP services that are in the Public Network or even in Private Net A.

For example, The router Ra can be configured to expose queues in broker B2 to the network. Client C1 can then establish a connection to Rb, the local router, open a subscribing link to "b2.event-queue", and receive messages stored on that queue in broker B2.

C1 is unable to create a TCP/IP connection to B1 because of its isolation (and because B2 is itself in a private network). However, with link routing, C1 can interact with B2 using the AMQP link protocol.

Note that in this case, neither C1 nor B2 have been modified in any way and neither need be aware of the fact that there is a message-router network between them.

3.4.1 Configuration

Starting with the configured topology shown above, how is link-routing configured to support the example described above?

First, router Ra needs to be told how to make a connection to the broker B2:

```
connector {
    name: broker
    role: route-container
    host: <B2-url>
    port: <B2-port>
    saslMechanisms: ANONYMOUS
}
```

This *route-container* connector tells the router how to connect to an external AMQP container when it is needed. The name "broker" will be used later to refer to this connection.

Now, the router must be configured to route certain addresses to B2:

```
linkRoute {
    prefix: b2
    dir: in
    connection: broker
}

linkRoute {
    prefix: b2
    dir: out
    connection: broker
}
```

The linkRoute tells router Ra that any sender or receiver that is attached with a target or source (respectively) whos address begins with "b2", should be routed to the broker B2 (via the route-container connector).

Note that receiving and sending links are configured and routed separately. This allows configuration of link routes for listeners only or senders only. A direction of "in" matches client senders (i.e. links that carry messages inbound to the router network). Direction "out" matches client receivers.

Examples of addresses that "begin with *b2*" include:

- b2
- b2.queues
- b2.queues.app1

When the route-container connector is configured, router Ra establishes a connection to the broker. Once the connection is open, Ra tells the other routers (Rp and Rb) that it is a valid destination for link-routes to the "b2" prefix. This means that sender or receiver links attached to Rb or Rp will be routed via the shortest path to Ra where they are then routed outbound to the broker B2.

On Rp and Rb, it is advisable to add the identical configuration. It is permissible for a linkRoute configuration to reference a connection that does not exist.

This configuration tells the routers that link-routing is intended to be available for targets and sources starting with "b2". This is important because it is possible that B2 might be unavailable or shut off. If B2 is unreachable, Ra will not advertize itself as a destination for "b2" and the other routers might never know that "b2" was intended for link-routing.

The above configuration allows Rb and Rp to reject attaches that should be routed to B2 with an error message that indicates that there is no route available to the destination.

3.5 Indirect Waypoints and Auto-Links

This feature was introduced in Qpid Dispatch 0.6. It is a significant improvement on an earlier somewhat experimental feature called Waypoints.

Auto-link is a feature of Qpid Dispatch Router that enables a router to actively attach a link to a node on an external AMQP container. The obvious application for this feature is to route messages through a queue on a broker, but other applications are possible as well.

An auto-link manages the lifecycle of one AMQP link. If messages are to be routed to and from a queue on a broker, then two auto-links are needed: one for sending messages to the queue and another for receiving messages from the queue. The container to which an auto-link attempts to attach may be identified in one of two ways:

- The name of the connector/listener that resulted in the connection of the container, or
- The AMQP container-id of the remote container.

3.5.1 Queue Waypoint Example

Here is an example configuration for routing messages deliveries through a pair of queues on a broker:

```
connector {
    name: broker
    role: route-container
    host: <hostname>
    port: <port>
    saslMechanisms: ANONYMOUS
}

address {
    prefix: queue
    waypoint: yes
}

autoLink {
    addr: queue.first
    dir: in
    connection: broker
}

autoLink {
    addr: queue.first
    dir: out
    connection: broker
}

autoLink {
    addr: queue.second
    dir: in
    connection: broker
}

autoLink {
    addr: queue.second
    dir: out
    connection: broker
}
```

The `address` entity identifies a namespace *queue.* that will be used for routing messages through queues via autolinks. The four `autoLink` entities identify the head and tail of two queues on the broker that will be connected via auto-links.

If there is no broker connected, the auto-links shall remain *inactive*. This can be observed by using the `qdstat` tool:

```
$ qdstat --autolinks
AutoLinks
  addr          dir  phs  extAddr  link  status    lastErr
  ================================================================
  queue.first   in   1                  inactive
  queue.first   out  0                  inactive
  queue.second  in   1                  inactive
  queue.second  out  0                  inactive
```

If a broker comes online with a queue called *queue.first*, the auto-links will attempt to activate:

```
$ qdstat --autolinks
AutoLinks
  addr          dir  phs  extAddr  link  status  lastErr
  ================================================================================
  queue.first   in   1             6     active
  queue.first   out  0             7     active
  queue.second  in   1                   failed  Node not found: queue.second
  queue.second  out  0                   failed  Node not found: queue.second
```

Note that two of the auto-links are in *failed* state because the queue does not exist on the broker.

If we now use the Qpid Proton example application `simple_send.py` to send three messages to *queue.first* via the router:

```
$ python simple_send.py -a 127.0.0.1/queue.first -m3
all messages confirmed
```

and then look at the address statistics on the router:

```
$ qdstat -a
Router Addresses
  class   addr           phs  distrib   in-proc  local  remote  cntnr  in  out  thru  to- ↩
      proc  from-proc
  ================================================================================================================

  mobile  queue.first    1    balanced  0        0      0       0      0   0    0     0  ↩
             0
  mobile  queue.first    0    balanced  0        1      0       0      3   3    0     0  ↩
             0
```

we see that *queue.first* appears twice in the list of addresses. The `phs`, or phase column shows that there are two phases for the address. Phase *0* is for routing message deliveries from producers to the tail of the queue (the `out` auto-link associated with the queue). Phase 1 is for routing deliveries from the head of the queue to subscribed consumers.

Note that three deliveries have been counted in the "in" and "out" columns for phase *0*. The "in" column represents the three messages that arrived from `simple_send.py` and the `out` column represents the three deliveries to the queue on the broker.

If we now use `simple_recv.py` to receive three messages from this address:

```
$ python simple_recv.py -a 127.0.0.1:5672/queue.first -m3
{u'sequence': int32(1)}
{u'sequence': int32(2)}
{u'sequence': int32(3)}
```

We receive the three queued messages. Looking at the addresses again, we see that phase 1 was used to deliver those messages from the queue to the consumer.

```
$ qdstat -a
Router Addresses
  class   addr           phs  distrib   in-proc  local  remote  cntnr  in  out  thru  to- ↩
      proc  from-proc
```

```
  ================================================================================================================

  mobile  queue.first    1    balanced  0        0      0       0      3   3    0     0  ↩
            0
  mobile  queue.first    0    balanced  0        1      0       0      3   3    0     0  ↩
            0
```

Note that even in a multi-router network, and with multiple producers and consumers for *queue.first*, all deliveries will be routed through the queue on the connected broker.

3.5.2 Sharded Queue Example

Here is an extension of the above example to illustrate how Qpid Dispatch Router can be used to create a distributed queue in which multiple brokers share the message-queueing load.

```
connector {
    name: broker1
    role: route-container
    host: <hostname>
    port: <port>
    saslMechanisms: ANONYMOUS
}

connector {
    name: broker2
    role: route-container
    host: <hostname>
    port: <port>
    saslMechanisms: ANONYMOUS
}

address {
    prefix: queue
    waypoint: yes
}

autoLink {
    addr: queue.first
    dir: in
    connection: broker1
}

autoLink {
    addr: queue.first
    dir: out
    connection: broker1
}

autoLink {
    addr: queue.first
    dir: in
    connection: broker2
}

autoLink {
    addr: queue.first
    dir: out
    connection: broker2
}
```

In the above configuration, there are two instances of *queue.first* on brokers 1 and 2. Message traffic from producers to address *queue.first* shall be balanced between the two instance and messages from the queues shall be balanced across the collection of subscribers to the same address.

3.5.3 Dynamically Adding Shards

Since configurable entities in the router can also be accessed via the management protocol, we can remotely add a shard to the above example using `qdmanage`:

```
qdmanage create --type org.apache.qpid.dispatch.connector host=<host> port=<port> name= ↩
    broker3
qdmanage create --type org.apache.qpid.dispatch.router.config.autoLink addr=queue.first dir ↩
    =in connection=broker3
qdmanage create --type org.apache.qpid.dispatch.router.config.autoLink addr=queue.first dir ↩
    =out connection=broker3
```

3.5.4 Using a Different External Address on an Auto-Link

Sometimes, greater flexibility is needed with regard to the addressing of a waypoint. For example, the above sharded-queue example requires that the two instances of the queue have the same name/address. Auto-links can be configured with an independent `externalAddr` that allows the waypoint to have a different address than that which is used by the senders and receivers.

Here's an example:

```
connector {
    name: broker
    role: route-container
    host: <hostname>
    port: <port>
    saslMechanisms: ANONYMOUS
}

address {
    prefix: queue
    waypoint: yes
}

autoLink {
    addr: queue.first
    externalAddr: broker_queue
    dir: in
    connection: broker
}

autoLink {
    addr: queue.first
    externalAddr: broker_queue
    dir: out
    connection: broker
}
```

In the above configuration, the router network provides waypoint routing for the address *queue.first*, where senders and receivers use that address to send and receive messages. However, the queue on the broker is named "broker_queue". The address is translated through the auto-link that is established to the broker.

In this example, the endpoints (senders and receivers) are unaware of the *broker_queue* address and simply interact with *queue.first*. Likewise, the broker is unaware of the *queue.first* address and behaves as though a sender and a receiver is attached each using the address *broker_queue*.

The `qdstat` tool shows the external address for auto-links.

```
$ qdstat --autolinks
AutoLinks
  addr          dir  phs  extAddr       link  status  lastErr
  ============================================================
  queue.first   in   1    broker_queue  6     active
  queue.first   out  0    broker_queue  7     active
```

3.6 Policy

The Policy module is an optional authorization mechanism enforcing user connection restrictions and AMQP resource access control.

Policy is assigned when a connection is created. The connection properties **AMQP virtual host**, **authenticated user name**, and **connection remote host** are passed to the policy engine for a connection allow/deny decision. If the connection is allowed then the user is assigned to a group that names a set of AMQP resource limits that are enforced for the lifetime of the connection.

Note
Policy limits are applied only to incoming user network connections. Policy limits are not applied to interrouter connections nor are they applied to router connections outbound to waypoints.

3.6.1 Definitions

3.6.1.1 vhost

A *vhost* is typically the name of the host to which the client AMQP connection is directed. For example, suppose a client application opens connection URL:

```
amqp://bigbroker.example.com:5672/favorite_subject
```

The client will signal virtual host name *bigbroker.example.com* to the router during AMQP connection startup. Router Policy intercepts the virtual host *bigbroker.example.com* and applies a vhost policy with that name to the connection.

3.6.2 Policy Features

3.6.2.1 Total Connection Limit

A router may be configured with a total connection limit. This limit controls the maximum number of simultaneous incoming user connections that are allowed at any time. It protects the router from file descriptor resource exhaustion in the face of many incoming client connections. This limit is specified and enforced independently of any other Policy settings.

3.6.2.2 Vhost Policy

Vhost policy defines users and assigns them to user groups. Each user group defines the remote hosts from which the members may connect to the router network, and what resources in the router network the group members are allowed to access.

Vhost policy also defines connection count limits to control the number of users that may be simultaneously connected to the vhost.

Note
A vhost user may be assigned to one user group only.

3.6.2.3 Default Vhost

A default vhost may be defined. The default vhost policy is used for connections whose vhost is otherwise not defined in the policy database.

Example 2 Section 3.6.5.2 illustrates how the default vhost feature can be used to apply a single vhost policy set of restrictions to any number of vhost connections.

3.6.3 Policy Schema

Policy configuration is specified in two schema objects.

```
policy = {
    <global settings>
}

vhost = {
    id: vhost-name
    <connection limits>
    groups: {
        group-name: {
            <user group settings>
        }
    }
}
```

The *policy* object is a singleton. Multiple *vhost* objects may be created as needed.

3.6.3.1 Global Policy

attribute	default	description
maxConnections	65535	Global maximum number of concurrent client connections allowed. This limit is always enforced even if no other policy settings have been defined. This limit is applied to all incoming connections regardless of remote host, authenticated user, or targeted vhost.
enableVhostPolicy	false	Enable vhost policy connection denial, and resource limit enforcement.
policyDir	""	Absolute path to a directory that holds vhost definition .json files. All vhost definitions in all .json files in this directory are processed.
defaultVhost	"$default"	Vhost rule set name to use for connections with a vhost that is otherwise not defined. Default vhost processing may be disabled either by erasing the definition of *defaultVhost* or by not defining a *vhost* object named *$default*.

3.6.3.2 Vhost Policy

attribute	default	description
id		Vhost name must be unique.
maxConnections	65535	Maximum number of concurrent client connections allowed.
maxConnectionsPerUser	65535	Maximum number of concurrent client connections allowed for any user.

attribute	default	description
maxConnectionsPerRemoteHost	65535	Maximum number of concurrent client connections allowed for any remote host.
allowUnknownUser	false	Allow unknown users who are not members of a defined user group. Unknown users are assigned to the *$default* user group and receive *$default* settings.
groups		A map where each key is a user group name and the value is a Vhost User Group Settings map.

3.6.3.3 Vhost User Group Settings Map

This object is the data value contained in entries in the policy/groups map.

Section/Attribute	default	description
Group Membership		
users	""	Comma separated list of authenticated users in this group.
Connection Restrictions		
remoteHosts	""	List of remote hosts from which the users may connect. List values may be host names, numeric IP addresses, numeric IP address ranges, or the wildcard *. An empty list denies all access.
AMQP Connection Open Limits		
maxFrameSize	2^31-1	Largest frame that may be sent on this connection. (AMQP Open, max-frame-size)
maxSessions	65535	Maximum number of sessions that may be created on this connection. (AMQP Open, channel-max)
AMQP Session Begin Limits		
maxSessionWindow	2^31-1	Incoming capacity for new sessions. (AMQP Begin, incoming-window)
AMQP Link Attach		
maxMessageSize	0	Largest message size supported by links created on this connection. If this field is zero there is no maximum size imposed by the link endpoint. (AMQP Attach, max-message-size)
maxSenders	2^31-1	Maximum number of sending links that may be created on this connection.
maxReceivers	2^31-1	Maximum number of receiving links that may be created on this connection.
allowDynamicSource	false	This connection is allowed to create receiving links using the Dynamic Link Source feature.
allowAnonymousSender	false	This connection is allowed to create sending links using the Anonymous Sender feature.
allowUserIdProxy	false	This connection is allowed to send messages with a user_id property that differs from the connection's authenticated user id.
sources	""	List of Source addresses allowed when creating receiving links. This list may be expressed as a CSV string or as a list of strings. An empty list denies all access.
targets	""	List of Target addresses allowed when creating sending links. This list may be expressed as a CSV string or as a list of strings. An empty list denies all access.

3.6.4 Policy Wildcard and User Name Substitution

Policy provides several conventions to make writing rules easier.

3.6.4.1 Remote Host Wildcard

Remote host rules may consist of a single asterisk character to specify all hosts.

```
    remoteHosts: *
```

The asterisk must stand alone and cannot be appended to a host name or to an IP address fragment.

3.6.4.2 AMQP Source and Target Wildcard and Name Substitution

The rule definitions for `sources` and `targets` may include the username substitution token

```
    {user}
```

or a trailing asterisk.

The username substitution token is replaced with the authenticated user name for the connection. Using this token, an administrator may allow access to some resources specific to each user without having to name each user individually. This token is substituted once for the leftmost occurrence in the link name.

The asterisk is recognized only if it is the last character in the link name.

```
    sources: tmp_{user}, temp*, {user}-home-*
```

3.6.5 Composing Policies

This section shows policy examples designed to illustrate some common use cases.

3.6.5.1 Example 1. User Policy Disabled

Policy is disabled when no policy configuation objects are defined. Any number of connections are allowed and all users have access to all AMQP resources in the network.

3.6.5.2 Example 2. All Users Have Simple Connection Limits

This example shows how to keep users from overwhelming the router with connections. Any user can create up to ten connections and the router will limit the aggregated user connection count to 100 connections total. No other restrictions apply.

This example also shows how to use a default vhost policy effectively. Only one vhost policy is defined and all user connections regardless of the requested vhost use that policy.

```
policy {
    maxConnections: 100            ❶
}

vhost {
    name: $default                 ❷
    maxConnectionsPerUser: 10      ❸
    allowUnknownUser: true         ❹
    groups: {
        $default: {
            remoteHosts: *         ❺
            sources: *             ❻
            targets: *             ❼
        }
    }
}
```

1. The global maxConnections limit of 100 is enforced.
2. No normal vhost names are defined; user is assigned to default vhost *$default*.
3. The vhost maxConnectionsPerUser limit of 10 is enforced.
4. No groups are defined to have any users but allowUnknownUser is true so all users are assigned to group $default.
5. The user is allowed to connect from any remote host.
6, 7. The user is allowed to connect to any source or target in the AMQP network. Router system-wide values are used for the other AMQP settings that are unspecified in the vhost rules.

3.6.5.3 Example 3. Admins Must Connect From Localhost

This example shows how an admin group may be created and restricted to accessing a vhost only from localhost. The admin users are allowed to connect to any AMQP resources while normal users are restricted.

In this example a user connects to vhost *example.com*.

```
vhost {
    name: example.com                          (1)
    allowUnknownUser: true                     (2)
    groups: {
        admin: {
            users: alice, bob                  (3)
            remoteHosts: 127.0.0.1, ::1        (4)
            sources: *                         (5)
            targets: *                         (6)
        },
        $default: {
            remoteHosts: *                     (7)
            sources: news*, sports*, chat*     (8)
            targets: chat*                     (9)
        }
    }
}
```

1. A connection to vhost *example.com* locates this vhost rule set.
3. If one of users *alice* or *bob* is connecting then she or he is assigned to the *admin* user group.
2. Any other user is not defined by a user group. However, since the *allowUnknownUser* setting is true then this user is assigned to the *$default* user group.
4. Users in the *admin* user group must connect from localhost. Connections for an *admin* user from other hosts on the network are denied.
5, 6. Users in the *admin* user group are allowed to access any resource offered by the vhost service.
7. Other users are allowed to connect from any host.
8, 9. Other users have source and target name lists that restrict the resources they are allowed to access.

3.6.5.4 Example 4. Limiting Possible Memory Consumption

Policy provides a mechanism to control how much system buffer memory a user connection can potentially consume. The formula for computing buffer memory consumption for each session is

```
  potential buffer usage = maxFrameSize * maxSessionWindow
```

By adjusting *maxFrameSize*, *maxSessions*, and *maxSessionWindow* an administrator can prevent a user from consuming too much memory by buffering messages in flight.

Note

The settings passed into the AMQP protocol connection and session negotiations. Normal AMQP session flow control limits buffer consumption in due course with no processing cycles required by the router.

In this example normal users, the traders, are given smaller buffer allocations while high-capacity, automated data feeds are given a higher buffer allocation. This example skips the details of settings unrelated to buffer allocation.

```
vhost {
    name: traders.com                          (1)
    groups: {
        traders: {
            users: trader-1, trader-2, ...     (2)
            maxFrameSize: 10000                (3)
            maxSessionWindow: 500              (4)
            maxSessions: 1                     (5)
            ...
        },
        feeds: {
            users: nyse-feed, nasdaq-feed      (6)
            maxFrameSize: 60000                (7)
            maxSessionWindow: 20000            (8)
            maxSessions: 3                     (9)
            ...
        }
    }
}
```

(1) These rules are for vhost traders.com.

(2) The *traders* group includes trader-1, trader-2, and any other user defined in the list.

(3), (4) *maxFrameSize* and *maxSessionWindow* allow for at most 5,000,000 bytes of data to be in flight on each session.

(5) Only one session per connection is allowed.

(6) In the *feeds* group two users are defined.

(7), (8) *maxFrameSize* and *maxSessionWindow* allow for at most 1,200,000,000 bytes of data to be in flight on each session.

(9) Up to three sessions per connection are allowed.

Chapter 4

Technical Details and Specifications

4.1 Client Compatibility

Dispatch Router should, in theory, work with any client that is compatible with AMQP 1.0. The following clients have been tested:

Client	*Notes*
qpid::messaging	The Qpid messaging clients work with Dispatch Router as long as they are configured to use the 1.0 version of the protocol. To enable AMQP 1.0 in the C++ client, use the {protocol:amqp1.0} connection option.
Proton Reactor	The Proton Reactor API is compatible with Dispatch Router.
Proton Messenger	Messenger works with Dispatch Router.

4.2 Addressing

AMQP addresses are used to control the flow of messages across a network of routers. Addresses are used in a number of different places in the AMQP 1.0 protocol. They can be used in a specific message in the `to` and `reply-to` fields of a message's properties. They are also used during the creation of links in the `address` field of a `source` or a `target`.

Addresses designate various kinds of entities in a messaging network:

- Endpoint processes that consume data or offer a service
- Topics that match multiple consumers to multiple producers
- Entities within a messaging broker:
  - Queues
  - Durable Topics
  - Exchanges

The syntax of an AMQP address is opaque as far as the router network is concerned. A syntactical structure may be used by the administrator that creates addresses, but the router treats them as opaque strings. Routers consider addresses to be mobile such that any address may be directly connected to any router in a network and may move around the topology. In cases where messages are broadcast to or balanced across multiple consumers, an address may be connected to multiple routers in the network.

Addresses have semantics associated with them. When an address is created in the network, it is assigned a set of semantics (and access rules) during a process called provisioning. The semantics of an address control how routers behave when they see the address being used.

Address semantics include the following considerations:

- *Routing pattern* - direct, multicast, balanced
- *Undeliverable action* - drop, hold and retry, redirect
- *Reliability* - N destinations, etc.

4.2.1 Routing patterns

Routing patterns constrain the paths that a message can take across a network.

Pattern	***Description***
Direct	Direct routing allows for only one consumer to use an address at a time. Messages (or links) follow the lowest cost path across the network from the sender to the one receiver.
Multicast	Multicast routing allows multiple consumers to use the same address at the same time. Messages are routed such that each consumer receives a copy of the message.
Balanced	Balanced routing also allows multiple consumers to use the same address. In this case, messages are routed to exactly one of the consumers, and the network attempts to balance the traffic load across the set of consumers using the same address.

4.2.2 Routing mechanisms

The fact that addresses can be used in different ways suggests that message routing can be accomplished in different ways. Before going into the specifics of the different routing mechanisms, it would be good to first define what is meant by the term *routing*:

> In a network built of multiple routers connected by connections (i.e., nodes and edges in a graph), *routing* determines which connection to use to send a message directly to its destination or one step closer to its destination.

Each router serves as the terminus of a collection of incoming and outgoing links. The links either connect directly to endpoints that produce and consume messages, or they connect to other routers in the network along previously established connections.

4.2.2.1 Message routing

Message routing occurs upon delivery of a message and is done based on the address in the message's `to` field.

When a delivery arrives on an incoming link, the router extracts the address from the delivered message's `to` field and looks the address up in its routing table. The lookup results in zero or more outgoing links onto which the message shall be resent.

Delivery	***Handling***
pre-settled	If the arriving delivery is pre-settled (i.e., fire and forget), the incoming delivery shall be settled by the router, and the outgoing deliveries shall also be pre-settled. In other words, the pre-settled nature of the message delivery is propagated across the network to the message's destination.
unsettled	Unsettled delivery is also propagated across the network. Because unsettled delivery records cannot be discarded, the router tracks the incoming deliveries and keeps the association of the incoming deliveries to the resulting outgoing deliveries. This kept association allows the router to continue to propagate changes in delivery state (settlement and disposition) back and forth along the path which the message traveled.

4.3 AMQP Mapping

Dispatch Router is an AMQP router and as such, it provides extensions, code-points, and semantics for routing over AMQP. This page documents the details of Dispatch Router's use of AMQP.

4.3.1 Message Annotations

The following Message Annotation fields are defined by Dispatch Router:

Field	*Type*	*Description*
x-opt-qd.ingress	string	The identity of the ingress router for a message-routed message. The ingress router is the first router encountered by a transiting message. The router will, if this field is present, leave it unaltered. If the field is not present, the router shall insert the field with its own identity.
x-opt-qd.trace	list of string	The list of routers through which this message-routed message has transited. If this field is not present, the router shall do nothing. If the field is present, the router shall append its own identity to the end of the list.
x-opt-qd.to	string	To-Override for message-routed messages. If this field is present, the address in this field shall be used for routing in lieu of the *to* field in the message properties. A router may append, remove, or modify this annotation field depending on the policy in place for routing the message.
x-opt-qd.phase	integer	The address-phase, if not zero, for messages flowing between routers.

4.3.2 Source/Target Capabilities

The following Capability values are used in Sources and Targets.

Capability	*Description*
qd.router	This capability is added to sources and targets that are used for inter-router message exchange. This capability denotes a link used for router-control messages flowing between routers.
qd.router-data	This capability is added to sources and targets that are used for inter-router message exchange. This capability denotes a link used for user messages being message-routed across an inter-router connection.

4.3.3 Dynamic-Node-Properties

The following dynamic-node-properties are used by Dispatch in Sources.

Property	*Description*
x-opt-qd.address	The node address describing the destination desired for a dynamic source. If this is absent, the router will terminate any dynamic receivers. If this address is present, the router will use the address to route the dynamic link attach to the proper destination container.

4.3.4 Addresses and Address Formats

The following AMQP addresses and address patterns are used within Dispatch Router.

4.3.4.1 Address Patterns

Pattern	*Description*
`_local/<addr>`	An address that references a locally attached endpoint. Messages using this address pattern shall not be routed over more than one link.

Pattern	*Description*
`_topo/0/<router>/<addr>`	An address that references an endpoint attached to a specific router node in the network topology. Messages with addresses that follow this pattern shall be routed along the shortest path to the specified router. Note that addresses of this form are a-priori routable in that the address itself contains enough information to route the message to its destination. The *0* component immediately preceding the router-id is a placeholder for an *area* which may be used in the future if area routing is implemented.
`<addr>`	A mobile address. An address of this format represents an endpoint or a set of distinct endpoints that are attached to the network in arbitrary locations. It is the responsibility of the router network to determine which router nodes are valid destinations for mobile addresses.

4.3.4.2 Supported Addresses

Address	*Description*
`$management`	The management agent on the attached router/container. This address would be used by an endpoint that is a management client/console/tool wishing to access management data from the attached container.
`_topo/0/Router.E/$management`	The management agent at Router.E in area 0. This address would be used by a management client wishing to access management data from a specific container that is reachable within the network.
`_local/qdhello`	The router entity in each of the connected routers. This address is used to communicate with neighbor routers and is exclusively for the HELLO discovery protocol.
`_local/qdrouter`	The router entity in each of the connected routers. This address is used by a router to communicate with other routers in the network.
`_topo/0/Router.E/qdrouter`	The router entity at the specifically indicated router. This address form is used by a router to communicate with a specific router that may or may not be a neighbor.

4.3.5 Implementation of the AMQP Management Specification

Qpid Dispatch is manageable remotely via AMQP. It is compliant with the emerging AMQP Management specification (draft 9).

Differences from the specification:

- The `name` attribute is not required when an entity is created. If not supplied it will be set to the same value as the system-generated "identity" attribute. Otherwise it is treated as per the standard.
- The `REGISTER` and `DEREGISTER` operations are not implemented. The router automatically discovers peer routers via the router network and makes their management addresses available via the standard `GET-MGMT-NODES` operation. = Management Schema

This chapter documents the set of **management entity types** that define configuration and management of a Dispatch Router. A management entity type has a set of **attributes** that can be read, some attributes can also be updated. Some entity types also support **operations** that can be called.

All management entity types have the following standard attributes:

type
: The fully qualified type of the entity, e.g. `org.apache.qpid.dispatch.router`. This document uses the short name without the `org.apache.qpid.dispatch` prefix e.g. `router`. The dispatch tools will accept the short or long name.

name
: A user-generated identity for the entity. This can be used in other entities that need to refer to the named entity.

identity
A system-generated identity of the entity. It includes the short type name and some identifying information. E.g. `log/AGENT` or `listener/localhost:amqp`

There are two main categories of management entity type.

Configuration Entities
Parameters that can be set in the configuration file (see `qdrouterd.conf(5)` man page) or set at run-time with the `qdmanage(8)` tool.

Operational Entities
Run-time status values that can be queried using `qdstat(8)` or `qdmanage(8)` tools.

4.4 Configuration Entities

Configuration entities define the attributes allowed in the configuration file (see `qdrouterd.conf(5)`) but you can also create entities once the router is running using the `qdrouterd(8)` tool's `create` operation. Some entities can also be modified using the `update` operation, see the entity descriptions below.

4.4.1 router

Tracks peer routers and computes routes to destinations. This entity is mandatory. The router will not start without this entity.

Operations allowed: `READ`

id **(string, `CREATE`)**
Router's unique identity. One of id or routerId is required. The router will fail to start without id or routerId

mode **(One of [*standalone*, *interior*], default=*standalone*, `CREATE`)**
In standalone mode, the router operates as a single component. It does not participate in the routing protocol and therefore will not cooperate with other routers. In interior mode, the router operates in cooperation with other interior routers in an interconnected network.

area **(string)**
Unused placeholder.

version **(string)**
Software Version

helloInterval **(integer, default=1, `CREATE`)**
Interval in seconds between HELLO messages sent to neighbor routers.

helloMaxAge **(integer, default=3, `CREATE`)**
Time in seconds after which a neighbor is declared lost if no HELLO is received.

raInterval **(integer, default=30, `CREATE`)**
Interval in seconds between Router-Advertisements sent to all routers in a stable network.

raIntervalFlux **(integer, default=4, `CREATE`)**
Interval in seconds between Router-Advertisements sent to all routers during topology fluctuations.

remoteLsMaxAge **(integer, default=60, `CREATE`)**
Time in seconds after which link state is declared stale if no RA is received.

addrCount **(integer)**
Number of addresses known to the router.

linkCount **(integer)**
Number of links attached to the router node.

nodeCount **(integer)**
Number of known peer router nodes.

linkRouteCount **(integer)**
Number of link routes attached to the router node.

autoLinkCount **(integer)**
Number of auto links attached to the router node.

connectionCount **(integer)**
Number of open connections to the router node.

workerThreads **(integer, default=4, `CREATE`)**
The number of threads that will be created to process message traffic and other application work (timers, non-amqp file descriptors, etc.) .

debugDump **(path, `CREATE`)**
A file to dump debugging information that can't be logged normally.

saslConfigPath **(path, `CREATE`)**
Absolute path to the SASL configuration file.

saslConfigName **(string, default=*qdrouterd*, `CREATE`)**
Name of the SASL configuration. This string + *.conf* is the name of the configuration file.

routerId **(string, `CREATE`)**
(DEPRECATED) Router's unique identity. This attribute has been deprecated. Use id instead

mobileAddrMaxAge **(integer, default=60, `CREATE`)**
(DEPRECATED) This value is no longer used in the router.

4.4.2 sslProfile

Attributes for setting TLS/SSL configuration for connections.

Operations allowed: `CREATE`, `DELETE`, `READ`

certDb **(path, `CREATE`)**
The absolute path to the database that contains the public certificates of trusted certificate authorities (CA).

certFile **(path, `CREATE`)**
The absolute path to the file containing the PEM-formatted public certificate to be used on the local end of any connections using this profile.

keyFile **(path, `CREATE`)**
The absolute path to the file containing the PEM-formatted private key for the above certificate.

passwordFile **(path, `CREATE`)**
If the above private key is password protected, this is the absolute path to a file containing the password that unlocks the certificate key.

password **(string, `CREATE`)**
An alternative to storing the password in a file referenced by passwordFile is to supply the password right here in the configuration file. This takes precedence over the passwordFile if both are specified.

uidFormat **(string, `CREATE`)**
A list of x509 client certificate fields that will be used to build a string that will uniquely identify the client certificate owner. For e.g. a value of *cou* indicates that the uid will consist of c - common name concatenated with o - organization-company name concatenated with u - organization unit; or a value of *o2* indicates that the uid will consist of o (organization name) concatenated with 2 (the sha256 fingerprint of the entire certificate) . Allowed values can be any combination of *c*(ISO3166 two character country code), *s*(state or province), *l*(Locality; generally - city), *o*(Organization - Company Name),

u(Organization Unit - typically certificate type or brand), *n*(CommonName - typically a user name for client certificates) and *1*(sha1 certificate fingerprint, as displayed in the fingerprints section when looking at a certificate with say a web browser is the hash of the entire certificate) and 2 (sha256 certificate fingerprint) and 5 (sha512 certificate fingerprint). The user identifier (uid) that is generated based on the uidFormat is a string which has a semi-colon as a separator between the components

displayNameFile **(string, `CREATE`)**
The absolute path to the file containing the unique id to display name mapping

4.4.3 listener

Listens for incoming connections to the router.

Operations allowed: `CREATE`, `DELETE`, `READ`

host **(string, default=*127.0.0.1*, `CREATE`)**
IP address: ipv4 or ipv6 literal or a host name

port **(string, default=*amqp*, `CREATE`)**
Port number or symbolic service name.

protocolFamily **(One of [*IPv4*, *IPv6*], `CREATE`)**
[*IPv4*, *IPv6*] IPv4: Internet Protocol version 4; IPv6: Internet Protocol version 6. If not specified, the protocol family will be automatically determined from the address.

role **(One of [*normal*, *inter-router*, *route-container*, *on-demand*], default=*normal*, `CREATE`)**
The role of an established connection. In the normal role, the connection is assumed to be used for AMQP clients that are doing normal message delivery over the connection. In the inter-router role, the connection is assumed to be to another router in the network. Inter-router discovery and routing protocols can only be used over inter-router connections. route-container role can be used for router-container connections, for example, a router-broker connection. on-demand role has been deprecated.

cost **(integer, default=*1*, `CREATE`)**
For the *inter-router* role only. This value assigns a cost metric to the inter-router connection. The default (and minimum) value is one. Higher values represent higher costs. The cost is used to influence the routing algorithm as it attempts to use the path with the lowest total cost from ingress to egress.

sslProfile **(string, `CREATE`)**
Name of the sslProfile.

saslMechanisms **(string, `CREATE`)**
Space separated list of accepted SASL authentication mechanisms.

authenticatePeer **(boolean, `CREATE`)**
yes: Require the peer's identity to be authenticated; no: Do not require any authentication.

requireEncryption **(boolean, `CREATE`)**
yes: Require the connection to the peer to be encrypted; no: Permit non-encrypted communication with the peer

requireSsl **(boolean, `CREATE`)**
yes: Require the use of SSL or TLS on the connection; no: Allow clients to connect without SSL or TLS.

trustedCerts **(path, `CREATE`)**
This optional setting can be used to reduce the set of available CAs for client authentication. If used, this setting must provide the absolute path to a PEM file that contains the trusted certificates.

maxFrameSize **(integer, default=16384, `CREATE`)**
The maximum frame size in octets that will be used in the connection-open negotiation with a connected peer. The frame size is the largest contiguous set of uninterrupted data that can be sent for a message delivery over the connection. Interleaving of messages on different links is done at frame granularity. Policy settings, if specified, will overwrite this value. Defaults to 16384.

maxSessions **(integer, default=32768, `CREATE`)**
The maximum number of sessions that can be simultaneously active on the connection. Setting this value to zero selects the default number of sessions. Policy settings, if specified, will overwrite this value. Defaults to 32768.

maxSessionFrames **(integer, `CREATE`)**
Session incoming window measured in transfer frames for sessions created on this connection. This is the number of transfer frames that may simultaneously be in flight for all links in the session. Setting this value to zero selects the default session window size. Policy settings, if specified, will overwrite this value. The numerical product of maxFrameSize and maxSessionFrames may not exceed 2^{31}-1. If (maxFrameSize x maxSessionFrames) exceeds 2^{31}-1 then maxSessionFrames is reduced to (2^31-1 / maxFrameSize). maxSessionFrames has a minimum value of 1. Defaults to 0 (unlimited window).

idleTimeoutSeconds **(integer, default=16, `CREATE`)**
The idle timeout, in seconds, for connections through this listener. If no frames are received on the connection for this time interval, the connection shall be closed.

stripAnnotations **(One of [*in*, *out*, *both*, *no*], default=*both*, `CREATE`)**
[*in*, *out*, *both*, *no*] in: Strip the dispatch router specific annotations only on ingress; out: Strip the dispatch router specific annotations only on egress; both: Strip the dispatch router specific annotations on both ingress and egress; no - do not strip dispatch router specific annotations

linkCapacity **(integer, `CREATE`)**
The capacity of links within this connection, in terms of message deliveries. The capacity is the number of messages that can be in-flight concurrently for each link.

multiTenant **(boolean, `CREATE`)**
If true, apply multi-tenancy to endpoints connected at this listener. The address space is defined by the virtual host (hostname field in the Open).

failoverList **(string, `CREATE`)**
A comma-separated list of failover urls to be supplied to connected clients. Form: [(amqp|amqps|ws|wss)://]host_or_ip[:port]

addr **(string, default=*127.0.0.1*, `CREATE`)**
(DEPRECATED)IP address: ipv4 or ipv6 literal or a host name. This attribute has been deprecated. Use host instead

allowNoSasl **(boolean, `CREATE`)**
(DEPRECATED) This attribute is now controlled by the authenticatePeer attribute.

requirePeerAuth **(boolean, `CREATE`)**
(DEPRECATED) This attribute is now controlled by the authenticatePeer attribute.

allowUnsecured **(boolean, `CREATE`)**
(DEPRECATED) This attribute is now controlled by the requireEncryption attribute.

http **(boolean, `CREATE`)**
Accept HTTP connections that can upgrade to AMQP over WebSocket

httpRoot **(path, `CREATE`)**
Serve HTTP files from this directory, defaults to the installed stand-alone console directory

logMessage **(string, default=*none*, `CREATE`)**
A comma separated list that indicates which components of the message should be logged. Defaults to *none* (log nothing). If you want all properties and application properties of the message logged use *all*. Specific components of the message can be logged by indicating the components via a comma separated list. The components are message-id, user-id, to, subject, reply-to, correlation-id, content-type, content-encoding, absolute-expiry-time, creation-time, group-id, group-sequence, reply-to-group-id, app-properties. The application-data part of the bare message will not be logged. No spaces are allowed

4.4.4 connector

Establishes an outgoing connection from the router.

Operations allowed: `CREATE`, `DELETE`, `READ`

host **(string, default=*127.0.0.1*, `CREATE`)**
IP address: ipv4 or ipv6 literal or a host name

port **(string, default=*amqp*, `CREATE`)**
Port number or symbolic service name.

protocolFamily **(One of [*IPv4*, *IPv6*], `CREATE`)**
[*IPv4*, *IPv6*] IPv4: Internet Protocol version 4; IPv6: Internet Protocol version 6. If not specified, the protocol family will be automatically determined from the address.

role **(One of [*normal*, *inter-router*, *route-container*, *on-demand*], default=*normal*, `CREATE`)**
The role of an established connection. In the normal role, the connection is assumed to be used for AMQP clients that are doing normal message delivery over the connection. In the inter-router role, the connection is assumed to be to another router in the network. Inter-router discovery and routing protocols can only be used over inter-router connections. route-container role can be used for router-container connections, for example, a router-broker connection. on-demand role has been deprecated.

cost **(integer, default=*1*, `CREATE`)**
For the *inter-router* role only. This value assigns a cost metric to the inter-router connection. The default (and minimum) value is one. Higher values represent higher costs. The cost is used to influence the routing algorithm as it attempts to use the path with the lowest total cost from ingress to egress.

sslProfile **(string, `CREATE`)**
Name of the sslProfile.

saslMechanisms **(string, `CREATE`)**
Space separated list of accepted SASL authentication mechanisms.

allowRedirect **(boolean, default=True, `CREATE`)**
Allow the peer to redirect this connection to another address.

maxFrameSize **(integer, default=16384, `CREATE`)**
The maximum frame size in octets that will be used in the connection-open negotiation with a connected peer. The frame size is the largest contiguous set of uninterrupted data that can be sent for a message delivery over the connection. Interleaving of messages on different links is done at frame granularity. Policy settings will not overwrite this value. Defaults to 16384.

maxSessions **(integer, default=32768, `CREATE`)**
The maximum number of sessions that can be simultaneously active on the connection. Setting this value to zero selects the default number of sessions. Policy settings will not overwrite this value. Defaults to 32768.

maxSessionFrames **(integer, `CREATE`)**
Session incoming window measured in transfer frames for sessions created on this connection. This is the number of transfer frames that may simultaneously be in flight for all links in the session. Setting this value to zero selects the default session window size. Policy settings will not overwrite this value. The numerical product of maxFrameSize and maxSessionFrames may not exceed 2^{31}-1. If (maxFrameSize x maxSessionFrames) exceeds 2^{31}-1 then maxSessionFrames is reduced to (2^31-1 / maxFrameSize). maxSessionFrames has a minimum value of 1. Defaults to 0 (unlimited window).

idleTimeoutSeconds **(integer, default=16, `CREATE`)**
The idle timeout, in seconds, for connections through this connector. If no frames are received on the connection for this time interval, the connection shall be closed.

stripAnnotations **(One of [*in*, *out*, *both*, *no*], default=*both*, `CREATE`)**
[*in*, *out*, *both*, *no*] in: Strip the dispatch router specific annotations only on ingress; out: Strip the dispatch router specific annotations only on egress; both: Strip the dispatch router specific annotations on both ingress and egress; no - do not strip dispatch router specific annotations

linkCapacity **(integer, `CREATE`)**
The capacity of links within this connection, in terms of message deliveries. The capacity is the number of messages that can be in-flight concurrently for each link.

verifyHostName **(boolean, default=True, CREATE)**
yes: Ensures that when initiating a connection (as a client) the host name in the URL to which this connector connects to matches the host name in the digital certificate that the peer sends back as part of the SSL connection; no: Does not perform host name verification

saslUsername **(string, CREATE)**
The user name that the connector is using to connect to a peer.

saslPassword **(string, CREATE)**
The password that the connector is using to connect to a peer.

addr **(string, default=*127.0.0.1*, CREATE)**
(DEPRECATED)IP address: ipv4 or ipv6 literal or a host name. This attribute has been deprecated. Use host instead

logMessage **(string, default=*none*, CREATE)**
A comma separated list that indicates which components of the message should be logged. Defaults to *none* (log nothing). If you want all properties and application properties of the message logged use *all*. Specific components of the message can be logged by indicating the components via a comma separated list. The components are message-id, user-id, to, subject, reply-to, correlation-id, content-type, content-encoding, absolute-expiry-time, creation-time, group-id, group-sequence, reply-to-group-id, app-properties. The application-data part of the bare message will not be logged. No spaces are allowed

4.4.5 log

Configure logging for a particular module. You can use the `UPDATE` operation to change log settings while the router is running.

Operations allowed: `UPDATE`, `READ`

module **(One of [*ROUTER*, *ROUTER_CORE*, *ROUTER_HELLO*, *ROUTER_LS*, *ROUTER_MA*, *MESSAGE*, *SERVER*, *AGENT*,**

Module to configure. The special module *DEFAULT* specifies defaults for all modules.

enable **(string, UPDATE)**
Levels are: trace, debug, info, notice, warning, error, critical. The enable string is a comma-separated list of levels. A level may have a trailing + to enable that level and above. For example *trace,debug,warning+* means enable trace, debug, warning, error and critical. The value *none* means disable logging for the module.

timestamp **(boolean, UPDATE)**
Include timestamp in log messages.

source **(boolean, UPDATE)**
Include source file and line number in log messages.

output **(string, UPDATE)**
Where to send log messages. Can be *stderr*, *stdout*, *syslog* or a file name.

4.4.6 address

Entity type for address configuration. This is used to configure the treatment of message-routed deliveries within a particular address-space. The configuration controls distribution and address phasing.

Operations allowed: `CREATE`, `DELETE`, `READ`

prefix **(string, required, CREATE)**
The address prefix for the configured settings

distribution **(One of [*multicast*, *closest*, *balanced*], default=*balanced*, CREATE)**
Treatment of traffic associated with the address

waypoint **(boolean, CREATE)**
Designates this address space as being used for waypoints. This will cause the proper address-phasing to be used.

ingressPhase **(integer, CREATE)**
Advanced - Override the ingress phase for this address

egressPhase **(integer, CREATE)**
Advanced - Override the egress phase for this address

4.4.7 linkRoute

Entity type for link-route configuration. This is used to identify remote containers that shall be destinations for routed link-attaches. The link-routing configuration applies to an addressing space defined by a prefix.

Operations allowed: CREATE, DELETE, READ

prefix **(string, required, CREATE)**
The address prefix for the configured settings

containerId **(string, CREATE)**
ContainerID for the target container. Only one of containerId or connection should be specified for a linkRoute. Specifying both will result in the linkRoute not being created.

connection **(string, CREATE)**
The name from a connector or listener. Only one of containerId or connection should be specified for a linkRoute. Specifying both will result in the linkRoute not being created.

distribution **(One of [*linkBalanced*], default=*linkBalanced*, CREATE)**
Treatment of traffic associated with the address

dir **(One of [*in*, *out*], required, CREATE)**
The permitted direction of links: *in* means client senders; *out* means client receivers

operStatus **(One of [*inactive*, *active*])**
The operational status of this linkRoute: inactive - The remote container is not connected; active - the remote container is connected and ready to accept link routed attachments.

4.4.8 autoLink

Entity type for configuring auto-links. Auto-links are links whose lifecycle is managed by the router. These are typically used to attach to waypoints on remote containers (brokers, etc.).

Operations allowed: CREATE, DELETE, READ

addr **(string, required, CREATE)**
The address of the provisioned object

dir **(One of [*in*, *out*], required, CREATE)**
The direction of the link to be created. In means into the router, out means out of the router.

phase **(integer, CREATE)**
The address phase for this link. Defaults to *0* for *out* links and *1* for *in* links.

containerId **(string, CREATE)**
ContainerID for the target container. Only one of containerId or connection should be specified for an autoLink. Specifying both will result in the autoLink not being created

connection **(string, CREATE)**
The name from a connector or listener. Only one of containerId or connection should be specified for an autoLink. Specifying both will result in the autoLink not being created

externalAddr **(string, CREATE)**
If present, an alternate address of the node on the remote container. This is used if the node has a different address than the address used internally by the router to route deliveries.

linkRef **(string)**
Reference to the org.apache.qpid.dispatch.router.link if the link exists

operStatus **(One of [*inactive*, *attaching*, *failed*, *active*, *quiescing*, *idle*])**
The operational status of this autoLink: inactive - The remote container is not connected; attaching - the link is attaching to the remote node; failed - the link attach failed; active - the link is attached and operational; quiescing - the link is transitioning to idle state; idle - the link is attached but there are no deliveries flowing and no unsettled deliveries.

lastError **(string)**
The error description from the last attach failure

4.4.9 console

Start a websocket/tcp proxy and http file server to serve the web console

Operations allowed: `READ`

listener **(string)**
The name of the listener to send the proxied tcp traffic to.

wsport **(integer, default=5673)**
port on which to listen for websocket traffic

proxy **(string)**
The full path to the proxy program to run.

home **(string)**
The full path to the html/css/js files for the console.

args **(string)**
Optional args to pass the proxy program for logging, authentication, etc.

4.4.10 policy

Defines global connection limit

Operations allowed: `READ`

maxConnections **(integer, default=65535, `CREATE`)**
Global maximum number of concurrent client connections allowed. This limit is always enforced even if no other policy settings have been defined.

enableVhostPolicy **(boolean, `CREATE`)**
Enable vhost policy user groups, connection denial, and resource limit enforcement

policyDir **(path, `CREATE`)**
Absolute path to a directory that holds vhost definition .json files. All vhost definitions in all .json files in this directory are processed.

defaultVhost **(string, `CREATE`)**
Vhost rule set name to use for connections with a vhost that is otherwise not defined. Default vhost processing may be disabled either by erasing the definition of defaultVhost or by not defining a vhost object named *$default*.

connectionsProcessed **(integer) , *connectionsDenied*** **(integer) , *connectionsCurrent*** **(integer)**
=== vhost

AMQP virtual host policy definition of users, user groups, allowed remote hosts, and AMQP restrictions.

Operations allowed: `CREATE`, `UPDATE`, `DELETE`, `READ`

id **(string, required, `CREATE`)**
The vhost name.

maxConnections **(integer, default=65535, `CREATE`, `UPDATE`)**
Maximum number of concurrent client connections allowed.

maxConnectionsPerUser **(integer, default=65535, `CREATE`, `UPDATE`)**
Maximum number of concurrent client connections allowed for any single user.

maxConnectionsPerHost **(integer, default=65535, `CREATE`, `UPDATE`)**
Maximum number of concurrent client connections allowed for any remote host.

allowUnknownUser **(boolean, `CREATE`, `UPDATE`)**
Unrestricted users, those who are not members of a defined user group, are allowed to connect to this application. Unrestricted users are assigned to the *default* user group and receive *default* settings.

groups **(map, `CREATE`, `UPDATE`)**
A map where each key is a user group name and the value is a map of the corresponding settings for that group.

4.4.11 container

(DEPRECATED)Attributes related to the AMQP container. This entity has been deprecated. Use the router entity instead.

Operations allowed: `READ`

containerName **(string, `CREATE`)**
The name of the AMQP container. If not specified, the container name will be set to a value of the container's choosing. The automatically assigned container name is not guaranteed to be persistent across restarts of the container.

workerThreads **(integer, default=4, `CREATE`)**
The number of threads that will be created to process message traffic and other application work (timers, non-amqp file descriptors, etc.) .

debugDump **(path, `CREATE`)**
A file to dump debugging information that can't be logged normally.

saslConfigPath **(path, `CREATE`)**
Absolute path to the SASL configuration file.

saslConfigName **(string, `CREATE`)**
Name of the SASL configuration. This string + *.conf* is the name of the configuration file.

4.4.12 waypoint

(DEPRECATED) A remote node that messages for an address pass through. This entity has been deprecated. Use autoLink instead

Operations allowed: `CREATE`, `DELETE`, `READ`

address **(string, required, `CREATE`)**
The AMQP address of the waypoint.

connector **(string, required, `CREATE`)**
The name of the on-demand connector used to reach the waypoint's container.

inPhase **(integer, default=-1, `CREATE`)**
The phase of the address as it is routed *to* the waypoint.

outPhase **(integer, default=-1, `CREATE`)**
The phase of the address as it is routed *from* the waypoint.

4.4.13 fixedAddress

(DEPRECATED) Establishes treatment for addresses starting with a prefix. This entity has been deprecated. Use address instead

Operations allowed: `CREATE`, `READ`

prefix **(string, required, `CREATE`)**
The address prefix (always starting with /).

phase **(integer, `CREATE`)**
The phase of a multi-hop address passing through one or more waypoints.

fanout **(One of [*multiple*, *single*], default=*multiple*, `CREATE`)**
One of *multiple* or *single*. Multiple fanout is a non-competing pattern. If there are multiple consumers using the same address, each consumer will receive its own copy of every message sent to the address. Single fanout is a competing pattern where each message is sent to only one consumer.

bias **(One of [*closest*, *spread*], default=*closest*, `CREATE`)**
Only if fanout is single. One of *closest* or *spread*. Closest bias means that messages to an address will always be delivered to the closest (lowest cost) subscribed consumer. Spread bias will distribute the messages across subscribers in an approximately even manner.

4.4.14 linkRoutePattern

(DEPRECATED) An address pattern to match against link sources and targets to cause the router to link-route the attach across the network to a remote node. This entity has been deprecated. Use linkRoute instead

Operations allowed: `CREATE`, `READ`

prefix **(string, required, `CREATE`)**
An address prefix to match against target and source addresses. This pattern must be of the form <*text*>.<*text1*>.<*textN*> or <*text*> or <*text*>. and matches any address that contains that prefix. For example, if the prefix is set to org.apache (or org.apache.), any address that has the prefix *org.apache* (like org.apache.dev) will match. Note that a prefix must not start with a (.), can end in a (.) and can contain zero or more dots (.). Any characters between the dots are simply treated as part of the address

dir **(One of [*in*, *out*, *both*], default=*both*, `CREATE`)**
Link direction for match: *in* matches only links inbound to the client; *out* matches only links outbound from the client; *both* matches any link.

connector **(string, `CREATE`)**
The name of the on-demand connector used to reach the target node's container. If this value is not provided, it means that the target container is expected to be connected to a different router in the network. This prevents links to a link-routable address from being misinterpreted as message-routing links when there is no route to a valid destination available.

4.5 Operational Entities

Operational entities provide statistics and other run-time attributes of the router. The `qdstat(8)` tool provides a convenient way to query run-time statistics. You can also use the general-purpose management tool `qdmanage(8)` to query operational attributes.

4.5.1 org.amqp.management

The standard AMQP management node interface.

Operations allowed: `QUERY`, `GET-TYPES`, `GET-ANNOTATIONS`, `GET-OPERATIONS`, `GET-ATTRIBUTES`, `GET-MGMT-NODES`, `READ`

4.5.1.1 Operation GET-TYPES

Get the set of entity types and their inheritance relationships

REQUEST PROPERTIES

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

***identity* (string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is the list of the entity types (strings) that it extends.

4.5.1.2 Operation GET-ATTRIBUTES

Get the set of entity types

REQUEST PROPERTIES

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

***identity* (string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is a list (of strings) of attributes on that entity type.

4.5.1.3 Operation GET-OPERATIONS

Get the set of entity types and the operations they support

REQUEST PROPERTIES

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

***identity* (string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is the list of operation names (strings) that it supports.

4.5.1.4 Operation GET-ANNOTATIONS

REQUEST PROPERTIES

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

***identity* (string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is the list of annotations (strings) that it implements.

4.5.1.5 Operation QUERY

Query for attribute values of multiple entities.

Request body (map) A map containing the key `attributeNames` with value a list of (string) attribute names to return. If the list or the map is empty or the body is missing all attributes are returned.

REQUEST PROPERTIES

count **(integer)**
If set, specifies the number of entries from the result set to return. If not set return all from `offset`

entityType **(string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

identity **(string)**
Set to the value `self`

offset **(integer)**
If set, specifies the number of the first element of the result set to be returned.

Response body (map) A map with two entries. `attributeNames` is a list of the attribute names returned. `results` is a list of lists each containing the attribute values for a single entity in the same order as the names in the `attributeNames` entry. If an attribute name is not applicable for an entity then the corresponding value is `null`

RESPONSE PROPERTIES

count **(integer)**
Number of results returned

identity **(string)**
Set to the value `self`

4.5.1.6 Operation GET-MGMT-NODES

Get the addresses of all management nodes known to this router

REQUEST PROPERTIES

identity **(string)**
Set to the value `self`

Response body (list) A list of addresses (strings) of management nodes known to this management node.

4.5.2 management

Qpid dispatch router extensions to the standard org.amqp.management interface.

Operations allowed: `GET-SCHEMA`, `GET-JSON-SCHEMA`, `GET-LOG`, `PROFILE`, `QUERY`, `GET-TYPES`, `GET-ANNOTATIONS`, `GET-OPERATIONS`, `GET-ATTRIBUTES`, `GET-MGMT-NODES`, `READ`

4.5.2.1 Operation GET-SCHEMA-JSON

Get the qdrouterd schema for this router in JSON format

REQUEST PROPERTIES

indent **(integer)**
Number of spaces to indent the formatted result. If not specified, the result is in minimal format, no unnecessary spaces or newlines.

***identity* (string)**
Set to the value `self`

Response body (string) The qdrouter schema as a JSON string.

4.5.2.2 Operation GET-LOG

Get recent log entries from the router.

REQUEST PROPERTIES

***limit* (integer)**
Maximum number of log entries to get.

***identity* (string)**
Set to the value `self`

Response body (string) A list of log entries where each entry is a list of: module name(string), level name(string), message text(string), file name(string or None), line number(integer or None) , timestamp(integer)

4.5.2.3 Operation GET-SCHEMA

Get the qdrouterd schema for this router in AMQP map format

REQUEST PROPERTIES

***identity* (string)**
Set to the value `self`

Response body (map) The qdrouter schema as a map.

4.5.3 logStats

histogram of the different severity-levels of events on the given log.

Operations allowed: `READ`

***traceCount* (integer)**
How many trace-level events have happened on this log.

***debugCount* (integer)**
How many debug-level events have happened on this log.

***infoCount* (integer)**
How many info-level events have happened on this log.

***noticeCount* (integer)**
How many notice-level events have happened on this log.

***warningCount* (integer)**
How many warning-level events have happened on this log.

***errorCount* (integer)**
How many error-level events have happened on this log.

***criticalCount* (integer)**
How many critical-level events have happened on this log.

4.5.4 router.link

Link to another AMQP endpoint: router node, client or other AMQP process.

Operations allowed: `UPDATE`, `READ`

adminStatus **(One of [*enabled*, *disabled*], default=*enabled*, `UPDATE`)** , ***operStatus*** **(One of [*up*, *down*, *quiescing*, *idle*])** , ***linkName*** **(**

Name assigned to the link in the Attach.

linkType **(One of [*endpoint*, *router-control*, *inter-router*])**
Type of link: endpoint: a link to a normally connected endpoint; inter-router: a link to another router in the network.

linkDir **(One of [*in*, *out*])**
Direction of delivery flow over the link, inbound or outbound to or from the router.

owningAddr **(string)**
Address assigned to this link during attach: The target for inbound links or the source for outbound links.

capacity **(integer)**
The capacity, in deliveries, for the link. The number of undelivered plus unsettled deliveries shall not exceed the capacity. This is enforced by link flow control.

peer **(string)**
Identifier of the paired link if this is an attach-routed link.

undeliveredCount **(integer)**
The number of undelivered messages pending for the link.

unsettledCount **(integer)**
The number of unsettled deliveries awaiting settlement on the link

deliveryCount **(integer)**
The total number of deliveries that have traversed this link.

presettledCount **(integer)**
The total number of pre-settled deliveries.

acceptedCount **(integer)**
The total number of accepted deliveries.

rejectedCount **(integer)**
The total number of rejected deliveries.

releasedCount **(integer)**
The total number of released deliveries.

modifiedCount **(integer)**
The total number of modified deliveries.

4.5.5 router.address

AMQP address managed by the router.

Operations allowed: `READ`

distribution **(One of [*flood*, *multicast*, *closest*, *balanced*, *linkBalanced*])**
Forwarding treatment for the address: flood - messages delivered to all subscribers along all available paths (this will cause duplicate deliveries if there are redundant paths); multi - one copy of each message delivered to all subscribers; anyClosest - messages delivered to only the closest subscriber; anyBalanced - messages delivered to one subscriber with load balanced across subscribers; linkBalanced - for link-routing, link attaches balanced across destinations.

inProcess **(integer)**
The number of in-process subscribers for this address

subscriberCount **(integer)**
The number of local subscribers for this address (i.e. attached to this router)

remoteCount **(integer)**
The number of remote routers that have at least one subscriber to this address

containerCount **(integer)**
The number of attached containers that serve this route address

deliveriesIngress **(integer)**
The number of deliveries to this address that entered the router network on this router

deliveriesEgress **(integer)**
The number of deliveries to this address that exited the router network on this router

deliveriesTransit **(integer)**
The number of deliveries to this address that transited this router to another router

deliveriesToContainer **(integer)**
The number of deliveries to this address that were given to an in-process subscriber

deliveriesFromContainer **(integer)**
The number of deliveries to this address that were originated from an in-process entity

key **(string)**
Internal unique (to this router) key to identify the address

remoteHostRouters **(list)**
List of remote routers on which there is a destination for this address.

transitOutstanding **(list)**
List of numbers of outstanding deliveries across a transit (inter-router) link for this address. This is for balanced distribution only.

trackedDeliveries **(integer)**
Number of transit deliveries being tracked for this address (for balanced distribution).

4.5.6 router.node

Remote router node connected to this router.

Operations allowed: `READ`

id **(string)**
Remote node identifier.

protocolVersion **(integer)**
Router-protocol version supported by the node.

instance **(integer)**
Remote node boot number.

linkState **(list)**
List of remote node's neighbours.

nextHop **(string)**
Neighbour ID of next hop to remote node from here.

validOrigins **(list)**
List of valid origin nodes for messages arriving via the re mote node, used for duplicate elimination in redundant networks.

address **(string)**
Address of the remote node

routerLink **(entityId)**
Local link to remote node

cost **(integer)**
Reachability cost

lastTopoChange **(integer)**
Timestamp showing the most recent change to this node's neighborhood.

4.5.7 connection

Connections to the router's container.

Operations allowed: `READ`

container **(string)**
The container for this connection

opened **(boolean)**
The connection has been opened (i.e. AMQP OPEN)

host **(string)**
IP address and port number in the form addr:port.

dir **(One of [*in*, *out*])**
Direction of connection establishment in or out of the router.

role **(string) ,** ***isAuthenticated*** **(boolean)**
Indicates whether the identity of the connection's user is authentic.

isEncrypted **(boolean)**
Indicates whether the connection content is encrypted.

sasl **(string)**
SASL mechanism in effect for authentication.

user **(string)**
Identity of the authenticated user.

ssl **(boolean)**
True iff SSL/TLS is in effect for this connection.

sslProto **(string)**
SSL protocol name

sslCipher **(string)**
SSL cipher name

sslSsf **(integer)**
SSL strength factor in effect

tenant **(string)**
If multi-tenancy is on for this connection, the tenant space in effect

properties **(map)**
Connection properties supplied by the peer.

4.5.8 allocator

Memory allocation pool.

Operations allowed: READ

typeName* (string) , *typeSize* (integer) , *transferBatchSize* (integer) , *localFreeListMax* (integer) , *globalFreeListMax* (integer) , *tot

=== vhostStats

Virtual host connection and access statistics.

Operations allowed: READ

***id* (string)**
The vhost name.

***connectionsApproved* (integer) , *connectionsDenied* (integer) , *connectionsCurrent* (integer) , *perUserState* (map)**
A map where the key is the authenticated user name and the value is a list of the user's connections.

***perHostState* (map)**
A map where the key is the host name and the value is a list of the host's connections.

***sessionDenied* (integer) , *senderDenied* (integer) , *receiverDenied* (integer)**
== Management Operations

The *qdstat(8)* and *qdmanage(8)* tools allow you to view or modify management entity attributes. They work by invoking **management operations**. You can invoke these operations from any AMQP client by sending a message with the appropriate properties and body to the *$management* address. The message should have a *reply-to* address indicating where the response should be sent.

4.5.9 Operations for all entity types

4.5.9.1 Operation READ

Read attributes of a single entity

REQUEST PROPERTIES

***type* (string)**
Type of desired entity.

***name* (string)**
Name of desired entity. Must supply name or identity.

***identity* (string)**
Identity of desired entity. Must supply name or identity.

Response body (map) Attributes of the entity

4.5.9.2 Operation CREATE

Create a new entity.

Request body (map, required) Attributes for the new entity. Can include name and/or type.

REQUEST PROPERTIES

***type* (string, required)**
Type of new entity.

***name* (string)**
Name of new entity. Optional, defaults to identity.

Response body (map) Attributes of the entity

4.5.9.3 Operation UPDATE

Update attributes of an entity

Request body (map) Attributes to update for the entity. Can include name or identity.

REQUEST PROPERTIES

type **(string)**
Type of desired entity.

name **(string)**
Name of desired entity. Must supply name or identity.

identity **(string)**
Identity of desired entity. Must supply name or identity.

Response body (map) Updated attributes of the entity

4.5.9.4 Operation DELETE

Delete an entity

REQUEST PROPERTIES

type **(string)**
Type of desired entity.

name **(string)**
Name of desired entity. Must supply name or identity.

identity **(string)**
Identity of desired entity. Must supply name or identity.

4.5.10 Operations for *org.amqp.management* entity type

4.5.10.1 Operation GET-TYPES

Get the set of entity types and their inheritance relationships

REQUEST PROPERTIES

entityType **(string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

identity **(string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is the list of the entity types (strings) that it extends.

4.5.10.2 Operation GET-ATTRIBUTES

Get the set of entity types

REQUEST PROPERTIES

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

***identity* (string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is a list (of strings) of attributes on that entity type.

4.5.10.3 Operation GET-OPERATIONS

Get the set of entity types and the operations they support

REQUEST PROPERTIES

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

***identity* (string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is the list of operation names (strings) that it supports.

4.5.10.4 Operation GET-ANNOTATIONS

REQUEST PROPERTIES

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

***identity* (string)**
Set to the value `self`

Response body (map) A map where each key is an entity type name (string) and the corresponding value is the list of annotations (strings) that it implements.

4.5.10.5 Operation QUERY

Query for attribute values of multiple entities.

Request body (map) A map containing the key `attributeNames` with value a list of (string) attribute names to return. If the list or the map is empty or the body is missing all attributes are returned.

REQUEST PROPERTIES

***count* (integer)**
If set, specifies the number of entries from the result set to return. If not set return all from `offset`

***entityType* (string)**
If set, restrict query results to entities that extend (directly or indirectly) this type

identity **(string)**
Set to the value `self`

offset **(integer)**
If set, specifies the number of the first element of the result set to be returned.

Response body (map) A map with two entries. `attributeNames` is a list of the attribute names returned. `results` is a list of lists each containing the attribute values for a single entity in the same order as the names in the `attributeNames` entry. If an attribute name is not applicable for an entity then the corresponding value is `null`

RESPONSE PROPERTIES

count **(integer)**
Number of results returned

identity **(string)**
Set to the value `self`

4.5.10.6 Operation GET-MGMT-NODES

Get the addresses of all management nodes known to this router

REQUEST PROPERTIES

identity **(string)**
Set to the value `self`

Response body (list) A list of addresses (strings) of management nodes known to this management node.

4.5.11 Operations for *management* entity type

4.5.11.1 Operation GET-SCHEMA-JSON

Get the qdrouterd schema for this router in JSON format

REQUEST PROPERTIES

indent **(integer)**
Number of spaces to indent the formatted result. If not specified, the result is in minimal format, no unnecessary spaces or newlines.

identity **(string)**
Set to the value `self`

Response body (string) The qdrouter schema as a JSON string.

4.5.11.2 Operation GET-LOG

Get recent log entries from the router.

REQUEST PROPERTIES

limit **(integer)**
Maximum number of log entries to get.

identity **(string)**
Set to the value `self`

Response body (string) A list of log entries where each entry is a list of: module name(string), level name(string), message text(string), file name(string or None), line number(integer or None) , timestamp(integer)

4.5.11.3 Operation GET-SCHEMA

Get the qdrouterd schema for this router in AMQP map format

REQUEST PROPERTIES

***identity* (string)**
Set to the value `self`

Response body (map) The qdrouter schema as a map.

Chapter 5

Console

5.1 Console overview

The console is an HTML based web site that displays information about a qpid dispatch router network.

The console requires an HTML web server that can serve static html, javascript, style sheets, and images.

The console only provides limited information about the clients that are attached to the router network and is therfore more appropriate for administrators needing to know the layout and health of the router network.

5.2 Console installation

5.2.1 Prerequisites

The following need to be installed before running a console:

- One or more dispatch routers. See the documentation for the dispatch router for help in starting a router network.
- A websockets to tcp proxy.
- A web server. This can be any server capable of serving static html/js/css/image files.

To install a websockets to tcp proxy:

```
sudo dnf install python-websockify
websockify localhost:5673 localhost:5672
```

This will start the proxy listening to ws traffic on port 5673 and translating it to tcp on port 5672. One of the routers in the network needs to have a listener configured on port 5672. That listener's role should be *normal*. For example:

```
listener {
   host: 0.0.0.0
   role: normal
   port: amqp
   saslMechanisms: ANONYMOUS
}
```

5.2.2 The console files

The files for the console are located under the console/stand-alone directory in the source tree * *index.html* * *plugin/*

Copy these files to a directory under the the html or webapps directory of your web server. For example, for apache tomcat the files should be under webapps/dispatch. Then the console is available as *http://localhost:8080/dispatch*

5.3 Console operation

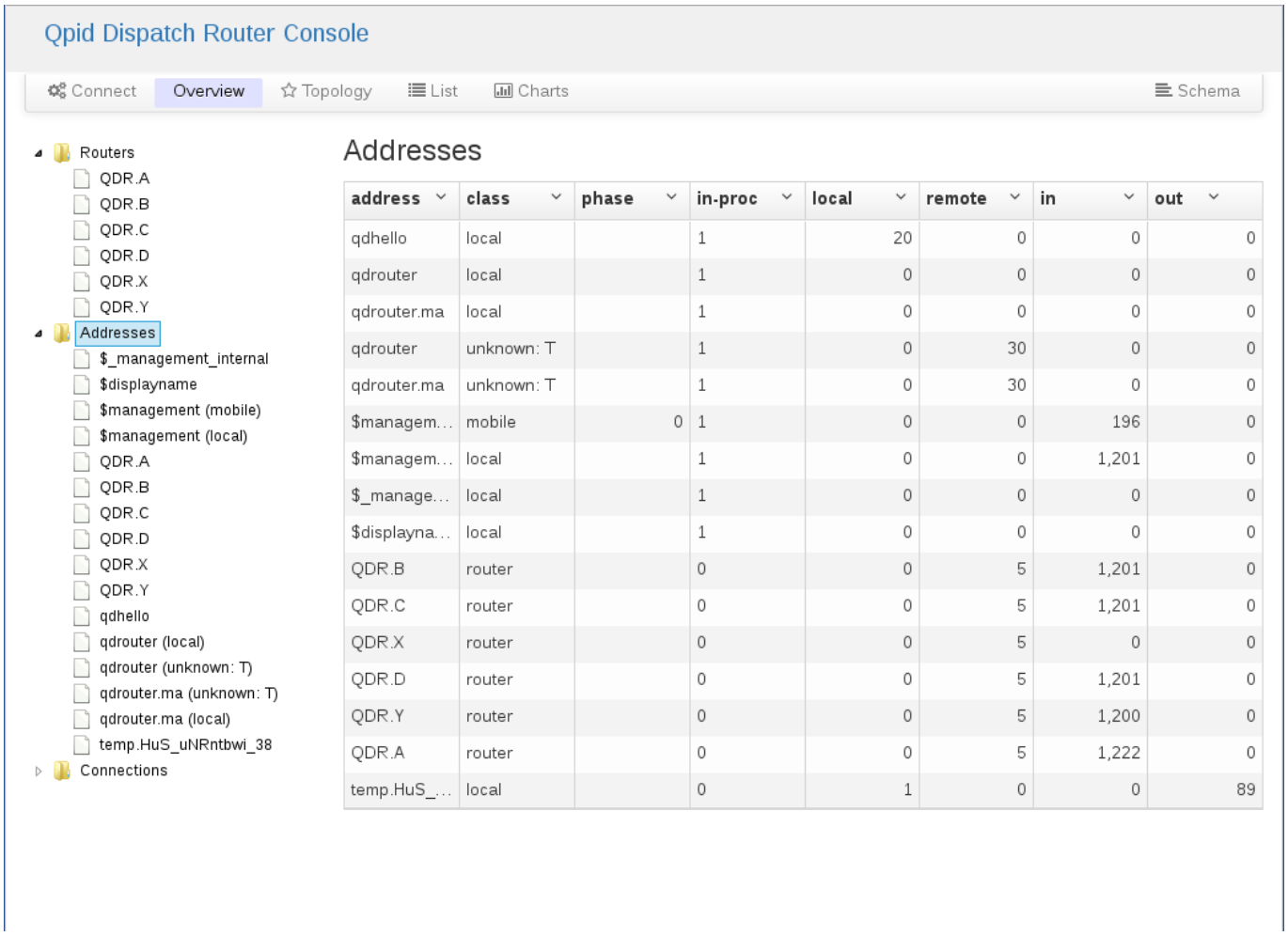
5.3.1 Logging in to a router network

image

Enter the address of the websockets to tcp proxy that is connected to a router in the network.

The Autostart checkbox, when checked, will automatically log in with the previous host:port the next time you start the console.

5.3.2 Overview page



On the overview page, aggregate information about routers, addresses, and connections is displayed.

5.3.3 Topology page

image

This page displays the router network in a graphical form showing how the routers are connected and information about the individual routers and links.

5.3.4 List page

image

Displays detailed information about entities such as routers, links, addresses, memory.

5.3.5 Charts page

image

This page displays graphs of numeric values that are on the list page.

5.3.6 Schema page

image

This page displays the json schema that is used to manage the router network.