Building Scalable Enterprise Messaging Systems using AMQP

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Bio

- Actively involved in several open source projects
- Karma on Apache Qpid, Axis2, Tuscany
- Contributed to Apache Synapse, Geronimo
- Involved in AMQP spec group

Agenda

- Introduction
- Look at user level problems in messaging
- And see how AMQP solves them
- Questions

User Level Problems

- Interoperability – Vendor Lock in
- Message Routing
- Broker Management
- Reliability
- Queue Browsing *vs* Consume
- Performance
- Scalability
- Transactions
- Hardware Monitoring

Introduction

- Advanced Message Queuing Protocol
- Open standard with royalty free use
- Strong focus on financial services industry
- AMQP Spec group (www.amqp.org)

Demo

- Simple demo to show interoperability
  - A client talking different broker implementations
  - A broker talking to different client implementations
- Involves a C++ & Java Broker
- Clients Java(JMS), C++, Python and Ruby

Interoperability

- What does it take to achieve this?
- All brokers need to behave the same way
- All clients need to behave the same way
- Use a standard for commands on the wire
- Use a language neutral type system

Interoperability

- AMQP solves this by defining
  - A network wire-level protocol
  - A defined set of messaging capabilities (AMQP model)
  - A type system

AMQP

- Broker semantics are defined explicitly
- Defines an explicit set of commands
- Grouped by class of functionality
- Commands modify state in a peer

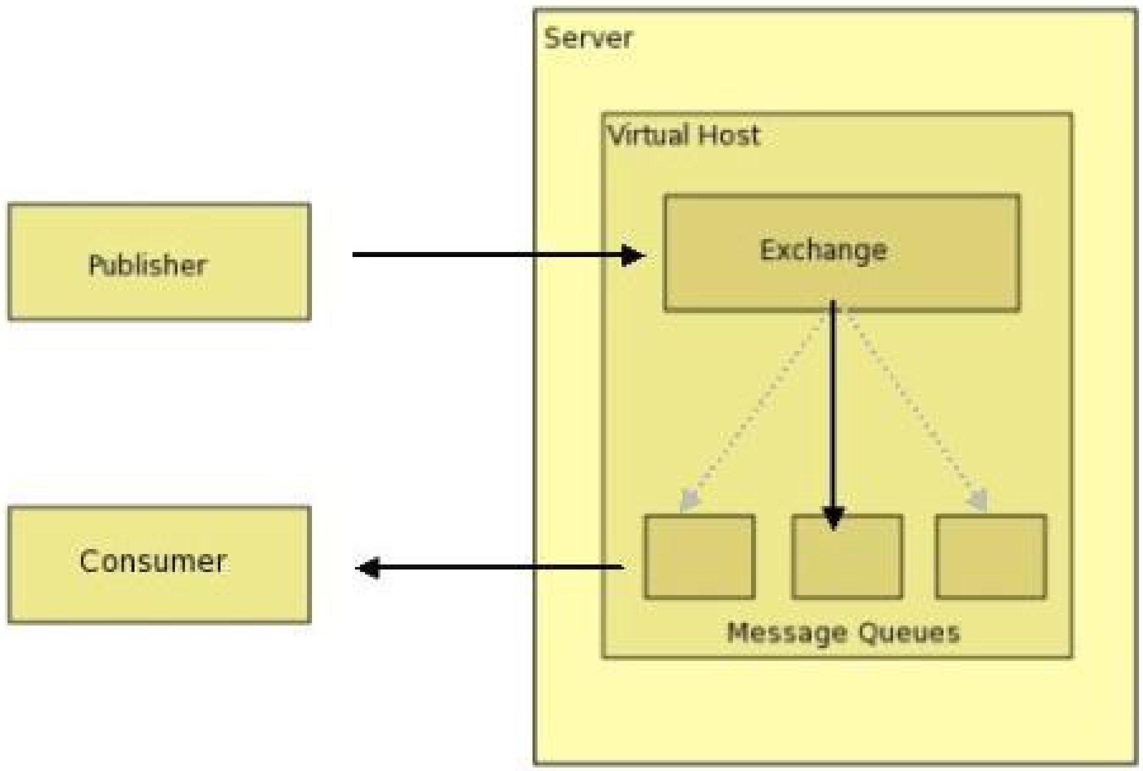
Message Routing

- Pre AMQP models had several issues
  - Opaque routing models – not explicitly defined
  - Rigid monolithic routing engines
  - Cannot manipulate the RM using the protocol

AMQP Routing Model

- RM is explicitly defined, and that permits
- Management commands to manipulate RM
- Exchange, Queue and Binding
- Composed to define processing chains
- Similar to how Email works

AMQP Routing Model



Exchange

- Accepts messages from producers
- Routes based on bindings to
- Queues or other exchanges
- Analogues to a Mail Transfer Agent

Message Queue

- Stores messages in memory or disk
- And delivers to consumers
- Can have the following properties
  - Durable/Temporary, Private/Shared, Auto-Delete
- Analogues to a Mailbox

Routing Key

- Special Field (Header) present in
- Message Delivery Properties
- It's a virtual address
- Analogues to 'To' or 'CC' in Email
- The exchange may use this to route

Binding

- Relationship btw Queue & Exchange
- Defines routing criteria
- Simple case, criteria == Routing Key
- Same queue can have multiple bindings
- Analogues to Routing Tables

Exchange Types

- Defines a set of standard exchanges
  - Direct
  - Topic
  - Fanout
  - Headers

Direct Exchange

- R == routing_key supplied in publish
- K == routing_key supplied in binding
- If k == R, the message is sent to that queue
- Can match more than one queue
- Common case, queue_name = k

Topic Exchange

- R == routing_key supplied in publish
- K == routing_key supplied in binding
- If routing pattern k matches R, (wild card)
- The message is sent to that queue
- Ex routing_key == stocks.us.RHT

Fanout Exchange

- Queues are bound with no criteria
- All messages are routed to every queue

Headers Exchange

- Routes based on headers
- Queues bind with arguments for matching
- The routing_key may not be used

Common Messaging Cases

- Point-to-point,
  - routing_key == queue name
- Pub-Sub
  - routing_key == topic hierarchy value

Extending the Routing Model

- Can create your own exchange type OR
- Routing criteria ..*etc*
- Within the general rules of the protocol

Broker Management

- Explicit commands to manipulate
  - Queues, Exchanges, Bindings
  - Ex. create, bind, delete queue/exchange
- Language neutral management API for free
- The ability to manipulate runtime

Reliability

- Most applications require messages to be
  - Delivered Exactly Once (no duplicates)
  - Guaranteed Delivery
- Let's look at the reliability use cases

Reliability Use Cases

- When a producer sends a message to broker
  - Needs confirmation that is accepts responsibility
  - Needs confirmation it's on the queue
- When a broker sends a message to client
  - Needs confirmation that is accepts responsibility
  - Needs confirmation it's consumed

Let's understand the problem

- Needs to understand the different between
- Transfer of data *vs* Transfer of responsibility
- And message processed *vs* seen.
- Understanding this is key for reliability
- AMQP makes this distinction very clearly

Transfer of Responsibility

- Before/After actions permitted and required
- From a sender/recipient is very different
- After responsibility is transfered
- AMQP defines two modes
  - no-acquire
  - pre-acquire

no-acquire mode

- Only data is transfered, not responsibility
- No exclusive access to process the message
- Another client may see, acquire and consume
- Need to explicitly acquire before processing

pre-acquire mode

- Both data and responsibility is transfered
- Exclusive access to process the message
- No other client can see the message
- Can release to relinquish responsibility

Processed *vs* Seen

- Peer may see the message, BUT it could
- Crash before processing the message.
- So Semantic acknowledgment is required.
- The Broker should only dequeue messages
- On receipt of the semantic Ack

Disabling the Semantic Ack

- The broker may want to dequeue
- Immediately upon sending the message
- It may not care if the client gets it or not
- The delivery of message cannot be undone
- *i.e.* Client cannot reject or release message
- Ex StockTickers

Confirm Mode

- Defines a confirm mode to disable
- Semantic Akcs to optimize for certain Apps
- On – requires semantic ack for dequeue
- Off – dequeue immediately upon acquisition

Summary

- no-acquire, confirm-mode = on
  - Dequeue message only upon semantic ack
  - After message is explicitly acquired
- pre-acquire, confirm-mode = on
  - Dequeue message only upon semantic ack

Summary *(Continued)*

- no-acquire, confirm-mode = off
  - Dequeue message immediately
  - Upon explicit acquisition
- pre-acquire, confirm-mode = off
  - Dequeue message immediately upon sending

Queue Browsing *vs* Consume

- Applications may need to look at
- Messages in a non destructive way, *i.e.*
- Only to examine the messages on the queue
- Not to process them
- Ex Queue Browsing, Client Side Selectors

Queue Browsing *vs* Consume

- Only transfer of data is required.
- Transfer of responsibility is required
- Only if it decides to process the message.
- Can implement this with no-acquire mode
- And explicitly acquire if need to process

Performance Requirements

- Need to prefetch messages
- Need to throttle message flow
- Need for Asynchronous Processing
- Control the window of unacked commands

Message Prefetch Problem

- To improve performance, Clients may need
- To optimistically fetch messages.
- If the client stops message processing
- The client will end up having valid
- Messages that it cannot/will not process

Message Prefetch Solution

- If we subscribe in no-acquire mode, we
- Don't need to release explicitly.
- We will only acquire them message
- If the client wants to process it

Message Prefetch Solution

- If we subscribe in pre-acquire mode, we
- Simply release the message.

Release *vs* Reject Message

- Release
  - Relinquish responsibility for processing message
  - Message can be safely delivered to other clients
- Reject
  - Indicates a problem with processing a message
  - Will result in a DLQ of the message

Throttling Message Flow

- A peer may need to control the flow of
- Messages it receives from its partner.
- This prevents from the partner pushing more
- Messages than the peer actually needs.

Throttling Message Flow

- A Peer may also need to control the flow of
- Messages it sends to its partner.
- This prevents from sending more messages
- Than the the partner actually needs and may
- Control the window of unacked messages

Credit Based Solution

- Sender maintains credit balance with recipient
- Credit Balance consist of a
  - Message Count
  - Byte Count
- When a Message is sent
- Both counts are decremented

Credit Based *(Continued)*

- When either value is zero,
- No more messages are sent until,
- Further credit is received from peer.
- If byte count is insufficient,
- No partial messages can be sent.

Window Based Solution

- Identical to credit based, except
- Message acknowledgment implicitly grants
  - A single unit of message credit
  - And size of message in byte credits
- Controls the window of unacked messages.

Asynchronous Processing

- Application may need to create 50 queues
- Without waiting for confirmation, But
- Eventually would like to know the outcome.
- So we have a requirement for correlating
- Acks sent by the broker asynchronously.

Execution Layer

- The execution layer provides correlation of
- Semantic Acknowledgments by exchanging
- An execution mark (EM) between peers.
- An abnormal termination of a command M,
- Should be notified explicitly before EM>=M.

Unacked Command Window

- For performance (and other reasons) a peer
- May want to control the unacked window by,
- Synchronization of state
  - Peer needs to block on completion of a command
- Requesting the partners current execution mark
  - So it can discard unwanted state

Synchronization of State

- If I create 50 queues, eventually I want to
- Know the outcome, so I can release resources
- that maybe locked until desired state is reached.
- Client may also hold state related to unacked
- Commands which might create memory issues if
- It continues to grow and affect performance.

Solution based on Sync bit

- AMQP allows a peer to force its partner to
- Synchronize by sending its Execution Mark
- When the given command is executed.
- Ex. You can sync on the 50th Queue create.

Managing Unacked Window

- Assume that in a high volume pub/sub system
- The broker acks every 1000 messages unless
- Explicitly requested to do so.
- A particular publisher can only hold 250
- Unacked messages due to memory constraints.
- How would you get around this problem?

Possible Solutions

- Explicitly synchronizing state with the broker is
- Inefficient as you would block until the broker
- Process All 250 messages.
- This may result in a slow publishing rate.
- How about if you if you request a snapshot of
- Brokers current state (execution mark) ?

Solution based on Flush bit

- If you know partners current execution mark,
- Can calculate the no of messages processed.
- You can then release state relating to those
- Messages and send more messages until you
- Reach 250 unacked messages again.
- AMQP provides a way to ask the current EM.

Scalability

- Transparent Failover *via* Session resume
- Failover Exchange provides updates about
- Cluster membership state.

Transactions

- Applications need to Enqueue and Dequeue,
- Messages within transaction boundaries.
- Supports local and distributed transactions.
- Only enqueue and dequeue are covered.
- Any other state change is not covered.

Transactions *(Continued)*

- If you create an exchange or bind a queue
- Inside a transaction, it will NOT be undone,
- If a rollback occurs.

Hardware Monitoring

- Hardware devices need to statelessly index
- Themselves into interesting points inside an
- AMQP payload at wire speeds to provide
- AMQP-aware hardware monitoring and QoS

Frame, Segment, Frameset

- AMQP defines the above concepts to
- Facilitate hardware monitoring and QoS.
- Frame is the smallest unit on the wire
- Segment is a collection of frames
- Frameset consists of one or more segments

Frame

- Consists of a header which is 12 bytes
- And a variable payload size
- Peers negotiate a max frame size
- Bits to indicate boundaries
- Space reserved for future extensions

Segment

- Smallest logical unit parsed by a peer
- Has a type, Ex Method, Header ..*etc*
- Bits identify first/last frame in segment
- And first/last segment in Frameset
- These bits are packed in to frame headers

Frameset

- Forms a logical unit for the model
- Marked independent of the model
- Intermediaries can do generic parsing
- Without explicit knowledge of the model
- Facilitates stateless parsing at wire speeds

Links