



Advanced Message Queuing Protocol (AMQP) JMS Mapping Version 1.0

Working Draft 9

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Abstract:

The Java Message Service (JMS) API is a Java API for utilising messaging systems from Java applications. It provides a common way to create, send, receive, and read messages with a particular messaging system without becoming tied to its specific implementation. Whilst JMS defines a vendor-neutral client API, it does not define a wire level protocol, and so JMS client implementations often only interoperate with specific servers and clients from the same vendor. AMQP defines an open internet protocol for messaging, and so a JMS client implementation using AMQP as its wire level protocol would be able to interoperate with server and client implementations from different vendors similarly using AMQP. This document defines a JMS mapping for AMQP such that client implementations may interoperate with each other, and servers may offer specific functionality necessary to support particular JMS 2.0 features.

Status:

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1 References

TODO (presentation): move refs to wherever they are meant to go, ensure they are structured correctly, etc.

[AMQPMSGFORMAT]

AMQP Message Format <http://docs.oasis-open.org/amqp/core/v1.0/os/amqp-core-messaging-v1.0-os.html#section-message-format>

[UNICODE63]

The Unicode Consortium. The Unicode Standard, Version 6.3.0, (Mountain View, CA: The Unicode Consortium, 2013. ISBN 978-1-936213-08-5)

<http://www.unicode.org/versions/Unicode6.3.0/>

2 Connections

2.1 Client Identifier

JMS defines the concept of a *Client Identifier*, often shortened as *ClientID*, which is used to associate a Connection and its objects with state maintained on their behalf. In JMS 1.1, each connection must have a unique identifier, with only a single Connection at a time making use of a particular value. The identifier may be configured administratively on a ConnectionFactory instance that will then apply it to the Connection objects it creates, or it may alternatively be set explicitly on the Connection immediately after creation by the application. Some client implementations generate an identifier if not set via either of these means.

AMQP connections are established between *containers*, each of which MUST have an ID transmitted in the `container-id` field of `open`, so this will be utilised to convey the JMS identifier. JMS clients MUST set the `container-id` field of `open` to the value of the *Client Identifier*.

AMQP permits multiple connections between given containers, whereas JMS only allows a single connection to use a given identifier at a time. As such, an additional mechanism is required to facilitate use of the *container-id* to carry the identifier and also satisfy the JMS requirements. To this end, a connection capability is used to request the peer provide sole use of the `container-id` being used by the client. If the peer is able to do so, it will supply the capability in return. If it is unable to satisfy the request because the `container-id` is already in use on another connection, it will close the connection with “invalid-field” error. Because closing the connection requires first opening it, the open frame SHOULD carry a connection property of “amqp:connection-establishment-failed” to hint that the close frame will follow immediately afterwards. If the peer is unable to provide sole use because it does not support the mechanism, this will be visible by it opening the connection without supplying the capability, and it is then the decision of the client whether to proceed or fail immediately.

TODO (content): Update to reflect JMS 2.0 semantics rather than mentioned 1.1

TODO (content): Move 'connection failed' property outwith JMS mapping? The sole-use mechanism too?

3 Messages

3.1 Message Structure

Both JMS and AMQP define Message structure in terms of “Header”, “Properties” and the message “Body”. Unfortunately the definitions of these terms are not consistent. For JMS the Headers refer to a defined set of attributes which are a mix of “immutable” and “mutable” (i.e. some which are invariant over the lifetime of the message, and some which are updated as the message travels from sender to eventual receiver). In contrast JMS Properties are (mostly) application defined message attributes set by the sender and invariant over the message lifetime from sender to receiver. A number of JMS-defined ‘JMSX’ Properties also exist which live in the same namespace as the application properties.

The AMQP Message is defined as a sequence of “Sections” [AMQPMSGFORMAT].

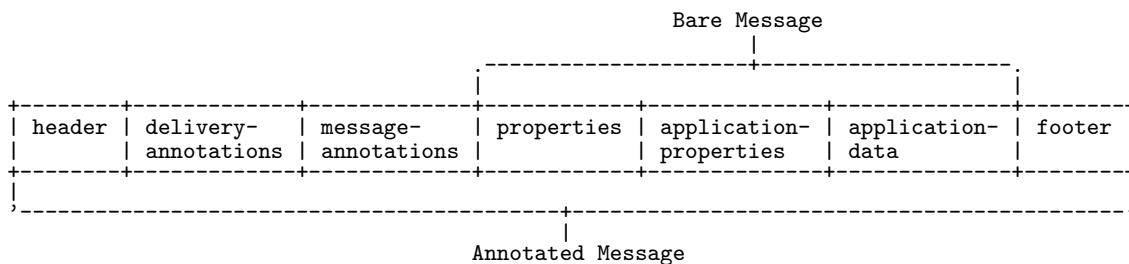


Figure 3.1: AMQP Message Structure

The AMQP header section defines a set of attributes which apply to the message (or rather this particular transfer of the message). These attributes are “mutable” throughout the passage of the message through the AMQP network. The properties section defines “immutable” properties of the message.

3.2 Mapping JMS Messages To AMQP

In overview we can say that a JMS Message has the following logical layout:

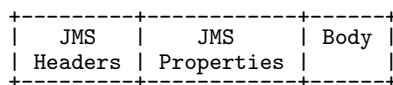


Figure 3.2: JMS Message

In overview we can say that a JMS Message maps to an AMQP message as follows: The JMS Headers and some JMS-defined ‘JMSX’ Properties will be stored within the header and properties sections, with occasional aid of additional message-annotations. JMS Properties set by applications will be stored in the application-properties section, including some JMS-defined ‘JMSX’ Properties. If no such properties are set, the application-properties section MAY be omitted. The Message body will be stored in application-data section(s) with type dependent on the particular JMS Message type in use.

TODO (content): do we enable setting (and thus describe here) delivery-annotations or footer details?

3.2.1 JMS Headers

The following section describes how each of the defined JMS Headers can be mapped to an AMQP Message.

Header Name	Description
JMSMessageID	<p>The JMSMessageID is defined as a Java String identifier for the Message which is set by the implementation during publication. AMQP uses the <code>message-id</code> field of properties for the same purpose, which is defined as being of type providing <i>message-id</i>, that is <code>message-id-ulong</code>, <code>message-id-uuid</code>, <code>message-id-binary</code> Or <code>message-id-string</code>.</p> <p>Sending JMS clients SHOULD use the <code>message-id-string</code> type for the <code>message-id</code> field of properties by default.</p> <p>JMSMessageID String values are REQUIRED to have a prefix of <code>"ID:"</code>. This prefix SHOULD be included in the value of the <code>message-id</code> field of properties set by producing JMS clients when of type <code>message-id-string</code></p> <p>See 3.2.1.1 JMSMessageID And JMSCorrelationID Handling for REQUIRED additional detail relating to supporting usage of the various AMQP types possible for the <code>message-id</code> field of properties.</p>
JMSTimestamp	<p>The JMSTimestamp header is defined as a Java long representing the time at which the message was handed off to the provider to send, in milliseconds since the Unix Epoch. That is, the value is set at the originating client and not changed thereafter. AMQP uses the <code>creation-time</code> field of properties for the same purpose.</p>
JMSCorrelationID	<p>The JMSCorrelationID header is defined as a Java String or <code>byte []</code> used to link one message with another.</p> <p>AMQP uses the <code>correlation-id</code> field of properties for the same purpose, which is defined as being of type providing <i>message-id</i>, that is <code>message-id-ulong</code>, <code>message-id-uuid</code>, <code>message-id-binary</code> Or <code>message-id-string</code>.</p> <p>In the case of a String this may represent either a JMSMessageID value, which begins with <code>"ID:"</code>, or an application-specific value which does not.</p> <p>See 3.2.1.1 JMSMessageID And JMSCorrelationID Handling for REQUIRED additional detail relating to supporting usage of the various AMQP types possible for the <code>correlation-id</code> field of properties.</p> <p>Application-specific JMSCorrelationID values MUST be sent using the <code>message-id-string</code> type.</p>

JMSReplyTo	<p>The JMSReplyTo header is equivalent to the reply-to field of properties.</p> <p>JMSReplyTo is defined as being of the JMS Destination type, while the reply-to field of properties requires an address-string. See 5. Destinations for REQUIRED detail as to how conversion between these types is achieved.</p>
JMSDestination	<p>The JMSDestination header is equivalent to the to field of properties.</p> <p>Note that producers MUST set the to field of properties explicitly (intermediaries can't derive it from the target address of the link on which the message was sent).</p> <p>JMSDestination is defined as being of the JMS Destination type, while the to field of properties requires an address-string. See 5. Destinations for REQUIRED detail as to how conversion between these types is achieved.</p>
JMSDeliveryMode	<p>The JMSDeliveryMode header is defined as a Java int with two possible values: NON_PERSISTENT and PERSISTENT.</p> <p>The JMSDeliveryMode header relates to two different aspects of sending a JMS Message as an AMQP message. Firstly, its value is equivalent to the durable field of header. For PERSISTENT messages, the durable field of header MUST be set to <i>true</i>. For NON_PERSISTENT messages, the durable field of header MUST be either set to false or omitted.</p> <p>Additionally, the JMSDeliveryMode value relates to the reliability guarantees of the AMQP message transfer, specifically the point at which sent messages are considered settled. For PERSISTENT messages the sender MUST NOT consider the message settled until the point that the sender has received notification of the disposition at the receiver. For NON_PERSISTENT messages on a non-transacted session an implementer MAY choose to send messages considering them settled as soon as they are sent (i.e. with the settled flag set to true on their original transfer).</p>
JMSRedelivered	<p>This header is set by the client provider on receipt of the message, based on handling of the delivery-count field of header.</p> <p>See delivery-count-handling for more details on handling of the <i>delivery-count</i> value.</p>
JMSType	<p>The JMSType header is mapped to the subject field of properties.</p>

JMSExpiration	<p>The JMSExpiration header is defined as a Java long representing the time at which the message expires, in milliseconds since the Unix Epoch. A value for JMSExpiration is set by the provider when sending the message. That is, the value is set at the originating client and not changed thereafter.</p> <p>If a non-zero <i>time-to-live</i> value is specified when sending the message, JMSExpiration contains the computed expiry time. If no <i>time-to-live</i> value (or a value of zero) is supplied when sending the message, then JMSExpiration has the value zero.</p> <p>AMQP uses the <code>absolute-expiry-time</code> field of <code>properties</code> for the purpose of setting an expiration time. When a non-zero value <i>time-to-live</i> is supplied, the computed expiration time MUST be set in the <code>absolute-expiry-time</code> field of <code>properties</code>. When no <i>time-to-live</i> value (or a value of zero) is supplied and JMSExpiration thus has the value zero, the <code>absolute-expiry-time</code> field of <code>properties</code> MUST be omitted rather than set to zero.</p> <p>See 6.1 Sending Messages for additional REQUIRED detail relating to message expiration.</p>
JMSPriority	<p>The JMSPriority is equivalent to the <code>priority</code> field of header. JMSPriority is specified as being a Java int despite the valid values only being 0-9. AMQP allows the priority to be any valid ubyte value.</p> <p>When messages are being sent with a priority of <code>DEFAULT_PRIORITY</code>, the <code>priority</code> field of header SHOULD be omitted.</p>
JMSDeliveryTime	<p>The JMSDeliveryTime header has no direct equivalent field in the AMQP message, however information to convey or synthesize the value can be carried.</p> <p>See 8. Delivery Delay for additional REQUIRED detail relating to JMSDeliveryTime and requesting/verifying server support for delayed delivery.</p>

3.2.1.1 JMSMessageID And JMSCorrelationID Handling

As indicated in 3.2.1 JMS Headers and 3.3.2 Properties Section, AMQP allows for messages to use a variety of types for the *message-id* and *correlation-id* fields of the `properties` section, specifically `message-id-ulong`, `message-id-uuid`, `message-id-binary` or `message-id-string`. JMS utilises the String type for JMSMessageID and also primarily for JMSCorrelationID, plus optionally `byte[]` for the latter to facilitate support of native correlation id values with certain providers. Due to this difference in possible types, it is necessary to support controlling and preserving the type information for the underlying fields of the AMQP message when setting and accessing the JMSMessageID and JMSCorrelationID headers of the JMS Message, both for basic interoperability and because it is common for an application to retrieve the JMSMessageID or JMSCorrelationID value from one message and then use it to set the JMSCorrelationID value of another message.

To that end, implementing JMS clients MUST support the behaviour described herein for encoding/decoding all `JMSMessageID` values, and any `JMSCorrelationID` values which represent a `JMSMessageID` rather than an application-specific value, in order to influence values sent and received using the underlying `message-id` and `correlation-id` fields of the AMQP `properties` section.

The following mapping is defined between a String representing a `JMSMessageID` value (used as a `JMSMessageID` or a `JMSCorrelationID` as appropriate) and the associated AMQP types, facilitating use of the different `message-id` and `correlation-id` types and maintaining fidelity of the AMQP type during round-trip through the JMS application layer in String form:

JMSMessageID representation	Description
"ID:AMQP_BINARY:<hex representation of bytes>"	JMSMessageID or JMSCorrelationID representation of a <code>message-id-binary</code> value.
"ID:AMQP_UUID:<string representation of uuid>"	JMSMessageID or JMSCorrelationID representation of a <code>message-id-uuid</code> value.
"ID:AMQP_ULONG:<string representation of ulong>"	JMSMessageID or JMSCorrelationID representation of a <code>message-id-ulong</code> value.
"ID:AMQP_NO_PREFIX:<original-string>"	JMSMessageID representation of a received AMQP <code>message-id</code> of type <code>message-id-string</code> which did not start with the "ID:" prefix. May be used to set the <code>JMSCorrelationID</code> .
"ID:AMQP_STRING:<original-string>"	JMSMessageID or JMSCorrelationID representation of a received <code>message-id-string</code> value which starts with one of the "ID:AMQP_<type>" escape prefixes used in this table.

The "ID:AMQP_STRING:" prefix exists only to escape `message-id-string` values that represent a `JMSMessageID` (for use as either a `JMSMessageID` or `JMSCorrelationID`) and happen to begin with one of the "ID:AMQP_<type>" prefixes detailed above (including `AMQP_STRING` itself). It MUST NOT be used otherwise by the client library.

For the "ID:AMQP_BINARY:" prefix, the client MUST return upper-case hex characters when the `getJMSMessageID` and `getJMSCorrelationID` methods of `Message` are used, but MUST accept both upper-case and lower-case values via the `setJMSMessageID(String id)` and `setJMSCorrelationID(String id)` methods.

When `JMSCorrelationID` is set using the `setJMSCorrelationID(String id)` method, any value that begins with the "ID:" prefix of a `JMSMessageID` value and attempts to identify itself as representing a `message-id-binary`, `message-id-uuid`, or `message-id-ulong` but which can't be converted into the indicated underlying format MUST cause an appropriate exception to be thrown. For example, "ID:AMQP_ULONG:foo" can't be converted to a `message-id-ulong` and so MUST cause an exception. Providing a value beginning "ID:AMQP_ULONG:" in which the remainder contained a leading zero would be similarly be invalid, as would a value with an odd number of characters following the "ID:AMQP_BINARY:" prefix.

If implemented, the `getJMSCorrelationIDAsBytes()` method of the `Message` MUST throw an exception if the type of the `correlation-id` field of `properties` is not `message-id-binary`.

The following table provides examples of various `JMSMessageID` values derived from the `message-id` field of `properties` of a received message:

AMQP message-id	AMQP type	JMSMessageID
"ID:my-string-id"	<code>message-id-string</code>	"ID:my-string-id"
"non-prefixed-string-id"	<code>message-id-string</code>	"ID:AMQP_NO_PREFIX:non-prefixed-string-id"
<UUID>	<code>message-id-uuid</code>	"ID:AMQP_UUID:<UUID toString>"
42	<code>message-id-ulong</code>	"ID:AMQP_ULONG:42"

0xABCDEF	message-id-binary	"ID:AMQP_BINARY:ABCDEF"
"ID:AMQP_ULONG:string-id"	message-id-string	"ID:AMQP_STRING:ID:AMQP_ULONG:string-id"

A message sent after one of the above `JMSMessageID` values has been used to set its `JMSCorrelationID` value, would give the reverse mapping such that the `correlation-id` field of `properties` contains the same value as found in the `message-id` field of `properties` of the originally received message.

The following table provides examples of the effect of setting various additional application-specific `JMSCorrelationID` values (i.e a string not beginning with "ID:") on a message to be sent:

JMSCorrelationID	AMQP type	AMQP correlation-id
"application-specific"	message-id-string	"application-specific"
"AMQP_ULONG:42"	message-id-string	"AMQP_ULONG:42"
"AMQP_ULONG:foo"	message-id-string	"AMQP_ULONG:foo"

The following table provides examples of various `JMSCorrelationID` values derived from the `correlation-id` field of `properties` of a received message:

AMQP correlation-id	AMQP type	JMSCorrelationID
"ID:my-string-id"	message-id-string	"ID:my-string-id"
"non-prefixed-string-id"	message-id-string	"non-prefixed-string-id"
<UUID>	message-id-uuid	"ID:AMQP_UUID:<UUID toString>"
42	message-id-ulong	"ID:AMQP_ULONG:42"
0xABCDEF	message-id-binary	"ID:AMQP_BINARY:ABCDEF"
"ID:AMQP_ULONG:string-id"	message-id-string	"ID:AMQP_STRING:ID:AMQP_ULONG:string-id"
"AMQP_ULONG:foo"	message-id-string	"AMQP_ULONG:foo"

3.2.2 JMS-defined 'JMSX' Properties

The following section describes how each of the JMS-defined 'JMSX' Properties can be mapped to an AMQP Message.

Property Name	Description
JMSXUserID	<p>The <code>JMSXUserID</code> property is equivalent to the <code>user-id</code> field of <code>properties</code>. The <code>JMSXUserID</code> is specified as <code>String</code>, while the <code>user-id</code> field of <code>properties</code> is specified as type <code>binary</code>.</p> <p>To maintain end-to-end fidelity for this property, implementations SHOULD convert between AMQP <code>binary</code> and Java <code>String</code> by using the UTF-8 Unicode [UNICODE63] character encoding.</p>

JMSXAppID	The JMSXAppID property is defined as a Java String representing the identity of the application sending the message. If this property is supported by the client library, it MUST be stored in the application-properties section of the AMQP message.
JMSXDeliveryCount	This property is set by the client provider on receipt of the message, based on handling of the delivery-count field of header. See delivery-count-handling for more details on handling of the <i>delivery-count</i> value.
JMSXGroupID	The JMSXGroupID property is equivalent to the group-id field of properties.
JMSXGroupSeq	The JMSXGroupSeq property is used for the equivalent purpose of the group-sequence field of properties. As JMSXGroupSeq is an int and the group-sequence field of properties is an uint, JMSXGroupSeq values in the range -2^{31} to -1 inclusive MUST be mapped to values in the range 2^{31} to $2^{32}-1$ inclusive for the group-sequence field of properties.
JMSXProducerTXID	No standard mapping is provided for JMSXProducerTXID nor is a relation of its semantics to AMQP provided.
JMSXConsumerTXID	No standard mapping is provided for JMSXConsumerTXID nor is a relation of its semantics to AMQP provided. Should the semantics of this property be defined with respect to AMQP it would not affect the on-the-wire encoding as this property is defined to be set by the JMS provider on receipt of the message at the client.
JMSXRcvTimestamp	This value is (if supported) set by the client provider on receipt of the message, it is not transported on the wire and therefore does not need to be mapped to AMQP.
JMSXState	There is no direct mapping of the JMSXState property to AMQP. It is advised that implementers do not attempt to provide any sort of implementation of this property.

3.2.3 JMS Properties

JMS properties set by applications will typically be stored in the application-properties section, including some JMS-defined 'JMSX' Properties. If no such properties are set, the application-properties section MAY be omitted.

3.2.4 Message Body Types

JMS defines a number of standard Message body types. These different forms of body each need to be encoded into AMQP message in a defined manner such that JMS Messages which are communicated from one provider to another may be reassembled into the correct message type with full fidelity. Moreover this definition then allows for non-JMS producers to create messages of a form where their handling by a JMS client can be predicted.

The different Message body formats are expressed through the use of different types of *application-data* sections within the AMQP message, different values within those sections, use of fields in the message *properties* section to indicate the nature of the content, and finally through use of entries in the *message-annotations* section.

3.2.4.1 Message Type Annotation

In order that it be possible to identify messages as being compatible with the structure defined to be produced by JMS clients implementing this mapping, a message annotation with *symbol* key of “*x-opt-jms-msg-type*” is defined to carry the necessary message type information in an interoperable way. The following values have been assigned for each of the existing JMS Message types:

Message Type	Annotation value (type)
Message	0 (byte)
ObjectMessage	1 (byte)
MapMessage	2 (byte)
BytesMessage	3 (byte)
StreamMessage	4 (byte)
TextMessage	5 (byte)

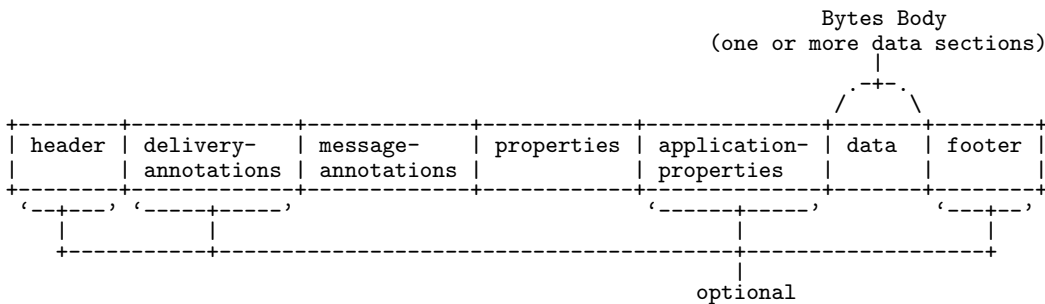
These annotation values may be used by JMS clients implementing this mapping to allow distinguishing their messages from arbitrary AMQP messages of similar structure sent by other AMQP containers, but can similarly be used by those other AMQP containers to produce equivalent messages for consumption by JMS clients.

Note that while byte values **MUST** be used by sending JMS clients, implementations **MUST** cope with receiving any integral type for the annotation value.

3.2.4.2 BytesMessage

A *BytesMessage* is encoded using one or more body sections of type *data*. The client **SHOULD** set the *content-type* field of *properties* to contain the *symbol* value “*application/octet-stream*”. The message annotation with *symbol* key of “*x-opt-jms-msg-type*” **MUST** be set to a byte value of 3.

The *getBodyLength()* method on *BytesMessage* **MUST** return the combined length of the data sections.



- message-annotation with symbol key "x-opt-jms-msg-type" **MUST** be set to byte value of 3.
- content-type field of properties section **SHOULD** contain symbol "application/octet-stream".

Figure 3.3: AMQP Message Structure of a BytesMessage

3.2.4.3 TextMessage

A TextMessage is encoded as an amqp-value section containing a single encoded string or null. The client SHOULD NOT set the content-type field of properties. The message annotation with symbol key of “x-opt-jms-msg-type” MAY be set to a byte value of 5.

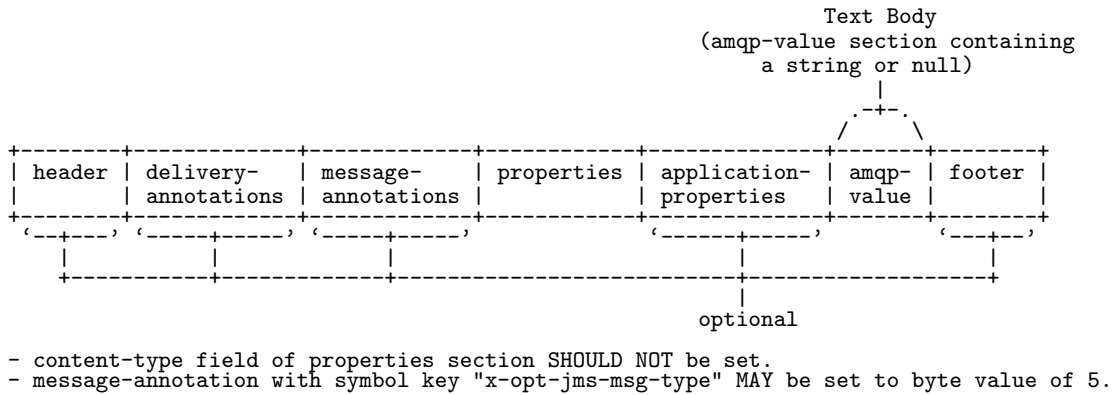


Figure 3.4: AMQP Message Structure of a TextMessage

3.2.4.4 MapMessage

A MapMessage body is encoded as a single amqp-value section containing a single map value. The client SHOULD NOT set the content-type field of properties. Any *byte[]* entries in the MapMessage body MUST be encoded as binary entries in the AMQP map. The message annotation with symbol key of “x-opt-jms-msg-type” MUST be set to a byte value of 2.

Note that this restricts the MapMessage to having at most $2^{31} - 1$ entries, and at most $2^{32} - 1$ octets of encoded map content. Attempting to send a MapMessage which exceeds these limits MUST result in an appropriate JMSEException being thrown.

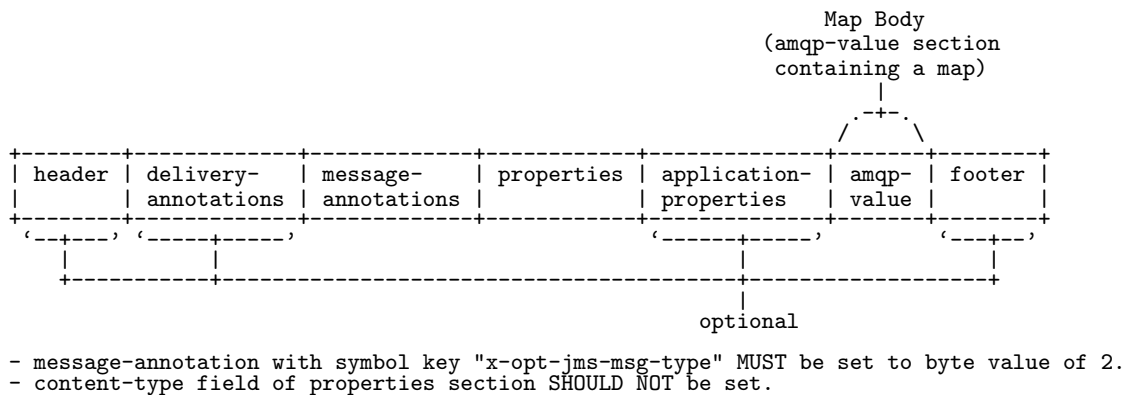


Figure 3.5: AMQP Message Structure of a MapMessage

3.2.4.5 StreamMessage

A StreamMessage body is encoded as one or more amqp-sequence sections. The client SHOULD NOT set the content-type field of properties. The message annotation with symbol key of “x-opt-jms-msg-type” MUST be set to a byte value of 4.

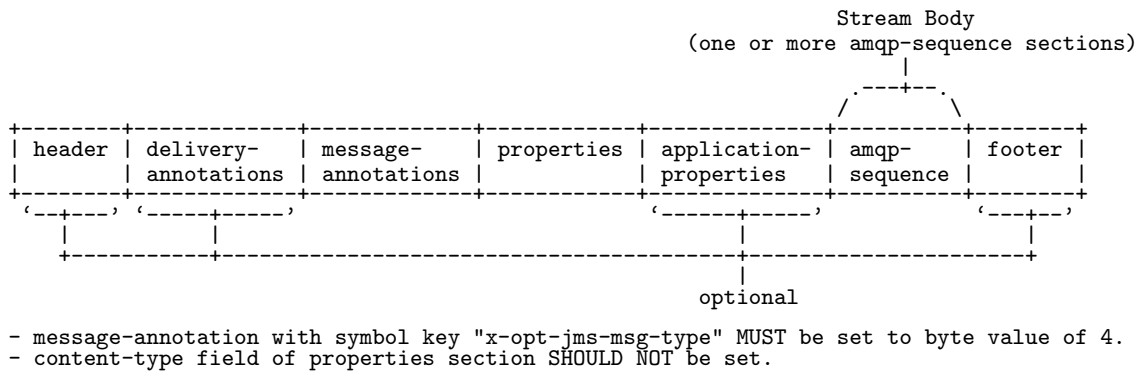


Figure 3.6: AMQP Message Structure of a StreamMessage

3.2.4.6 ObjectMessage

This mapping defines two ways in which an `ObjectMessage` may be encoded, by default as a series of data sections containing a serialised Java object and alternatively by representing the body components using the AMQP type system directly. This enables composition of AMQP messages with arbitrary body content for increased interoperability with other AMQP containers. JMS clients supporting this mapping MUST support both encoding processes.

To encode an `ObjectMessage` as serialised Java object data, one or more data body sections are used, where the content contains part or all of the serialised object data. If multiple data sections are used, e.g. because the serialised object data exceeds the limits of a single section, each subsequent data section MUST contain a continuation of the serialised object content in the previous section. When the object is either not set or explicitly set null, a data section containing the serialised *null* MUST be sent. In all cases, the `content-type` field of properties MUST contain the symbol value "*application/x-java-serialized-object*". The message annotation with symbol key of "*x-opt-jms-msg-type*" MUST be set to a byte value of 1.

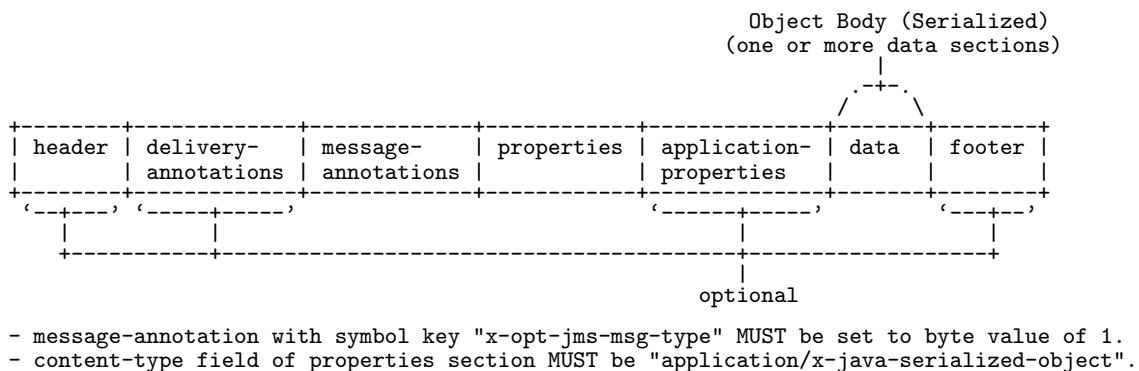


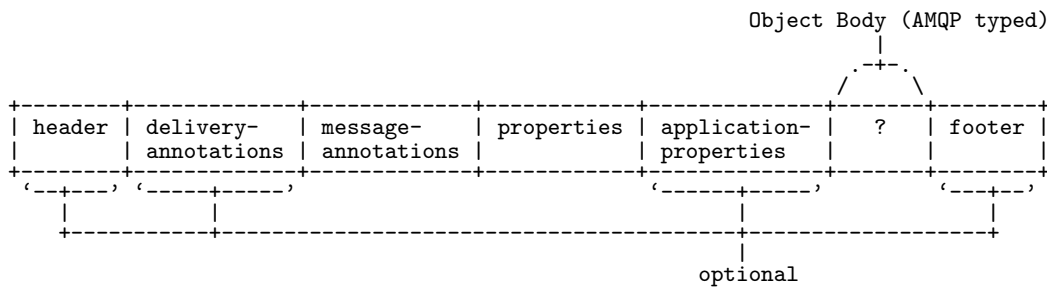
Figure 3.7: AMQP Message Structure of a Java serialized ObjectMessage

TODO (intent): Describe a way of selecting the method of encoding used for a particular ObjectMessage

TODO (intent): Describe how to encode bodies using AMQP type system, how to handle being able to add components that dont align to the JMS types (e.g ubyte, uint etc), etc.

If using a non-data section, the `content-type` field of properties SHOULD NOT be set. The client MUST NOT set the `content-type` field of properties to contain the symbol value "*application/x-java-serialized-object*". When

the object is either not set or explicitly set null, an `amqp-value` section containing `null` MUST be sent. The message annotation with `symbol` key of `"x-opt-jms-msg-type"` MUST be set to a byte value of 1.

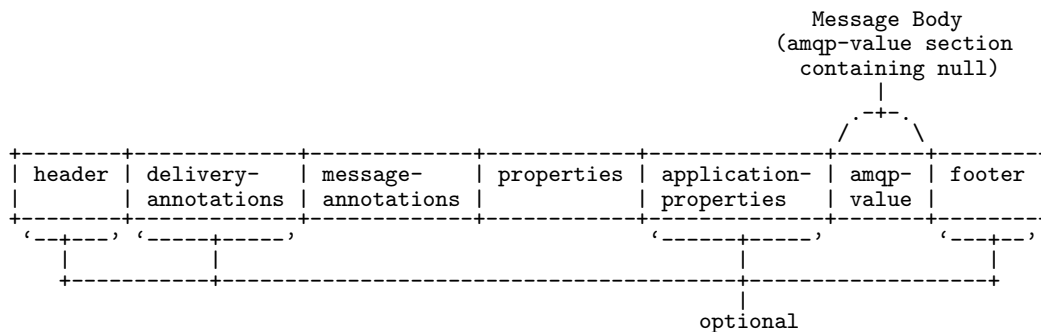


- body section(s) used dependent on composition of object being sent.
- message-annotation with symbol key "x-opt-jms-msg-type" MUST be set to byte value of 1.
- content-type field of properties section SHOULD NOT be set if using a non-data section.
- content-type field of properties section MUST NOT be "application/x-java-serialized-object".

Figure 3.8: AMQP Message Structure of an ObjectMessage using the AMQP type system

3.2.4.7 Message

A Message is encoded as a single `amqp-value` section containing `null`. The client SHOULD NOT set the `content-type` field of properties. The message annotation with `symbol` key of `"x-opt-jms-msg-type"` MUST be set to a byte value of 0.



- message-annotation with symbol key "x-opt-jms-msg-type" MUST be set to byte value of 0.
- content-type field of properties section SHOULD NOT be set.

Figure 3.9: AMQP Message Structure of a Message

3.3 Mapping AMQP Messages To JMS

The previous section defined how a Message as defined by the JMS specification is mapped into AMQP in order to achieve interoperability. In this section the mapping of both these and other arbitrary messages from an AMQP to JMS will be defined.

3.3.1 Header Section

Field Name	Description
------------	-------------

<p> durable</p>	<p>When receiving a message, the durable field of header MUST be mapped to the JMSDeliveryMode header of the Message. If the durable field of header is set to <i>false</i> or isn't set then the JMSDeliveryMode MUST be taken to be NON_PERSISTENT. When the durable field of header is set to <i>true</i> the JMSDeliveryMode of the Message MUST be taken to be PERSISTENT.</p>
<p> priority</p>	<p>This field is mapped to the JMSPriority header of the Message. JMSPriority is specified as being of type int despite the valid values only being 0-9. AMQP allows for the priority field of header to be any valid ubyte value. When receiving a message with the priority field of header greater than 9, the JMSPriority MUST be set to 9. If the priority field of header is unset then the JMSPriority MUST be taken to be DEFAULT_PRIORITY (i.e. the value 4).</p>
<p> ttl</p>	<p>This field defines the number of milliseconds for which a given message is considered "live". There is no direct equivalent for the ttl field of header in the JMS specification.</p> <p>If and only if the absolute-expiry-time field of properties is not set, JMSExpiration SHOULD be based on the ttl field of header if set, by summing it with the current time in milliseconds since the Unix Epoch.</p>
<p> first-acquirer</p>	<p>This field does not have a direct equivalent within the JMS specification, although JMSRedelivered is related, and so vendor property <i>JMS_AMQP_FIRST_ACQUIRER</i> SHOULD be used. For further details, see 4. JMS Vendor Properties .</p>

delivery-count	<p>This field is mapped to the JMS-defined <code>JMSXDeliveryCount</code> property and <code>JMSRedelivered</code> header of the Message as follows.</p> <p>AMQP uses the <code>delivery-count</code> field of header to track previously failed delivery attempts for a message, with the first delivery attempt having a value of zero, and so on.</p> <p><code>JMSXDeliveryCount</code> is defined as a Java <code>int</code> count of delivery attempts, set by the provider on receive, where the first delivery attempt has value 1, the second has value 2 and so on.</p> <p>The value of <code>JMSXDeliveryCount</code> property is thus equal to <i>delivery-count + 1</i>.</p> <p>The <code>JMSRedelivered</code> header MUST be considered to be true if and only if the <code>delivery-count</code> field of header has a value greater than 0.</p> <p>See <code>delivery-count-handling</code> for more details on handling of this field.</p>
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3.3.2 Properties Section

Field Name	Description
message-id	<p>This field is mapped to the <code>JMSMessageID</code> header of the Message.</p> <p>The <code>JMSMessageID</code> value is a Java <code>String</code> whereas the <code>message-id</code> field of properties is defined as being of type providing <i>message-id</i>, that is <code>message-id-ulong</code>, <code>message-id-uuid</code>, <code>message-id-binary</code> or <code>message-id-string</code>.</p> <p>See 3.2.1.1 <code>JMSMessageID</code> And <code>JMSCorrelationID</code> Handling for REQUIRED additional detail relating to supporting usage of the various AMQP types possible for the <code>message-id</code> field of properties.</p>
user-id	<p>This field is mapped to the JMS-defined <code>JMSXUserID</code> property of the Message.</p> <p><code>JMSXUserID</code> is specified as being of type <code>String</code>, while the <code>user-id</code> field of properties field is specified as type <code>binary</code>. To maintain end-to-end fidelity for this property implementations SHOULD convert between AMQP <code>binary</code> and Java <code>String</code> by using the UTF-8 Unicode [UNICODE63] character encoding.</p>

to	<p>This field is mapped to the <code>JMSDestination</code> header of the Message.</p> <p><code>JMSDestination</code> is defined as being of the <code>JMS Destination</code> type, while the <code>to</code> field of properties requires an <code>address-string</code>. See 5. Destinations for REQUIRED detail regarding how conversion between these types is achieved if the <code>to</code> field of properties was set.</p> <p>If the <code>to</code> field of properties was not set on a received message, the <code>JMSDestination</code> header value SHOULD be derived from the <code>Destination</code> to which the receiving consumer was established.</p>
subject	<p>This field is mapped to the <code>JMSType</code> header of the Message.</p>
reply-to	<p>This field is mapped to the <code>JMSReplyTo</code> header of the Message.</p> <p><code>JMSReplyTo</code> is defined as being of the <code>JMS Destination</code> type, while the <code>reply-to</code> field of properties requires an <code>address-string</code>. See 5. Destinations for REQUIRED detail regarding how conversion between these types is achieved if the <code>reply-to</code> field of properties was set.</p>
correlation-id	<p>This field is mapped to the <code>JMSCorrelationID</code> header of the Message.</p> <p>The <code>JMSCorrelationID</code> value is a Java String whereas the <code>correlation-id</code> field of properties is defined as being of type providing <code>message-id</code>, that is <code>message-id-ulong</code>, <code>message-id-uuid</code>, <code>message-id-binary</code> Or <code>message-id-string</code>.</p> <p>See 3.2.1.1 <code>JMSMessageID</code> And <code>JMSCorrelationID</code> Handling for REQUIRED additional detail relating to supporting usage of the various AMQP types possible for the <code>correlation-id</code> field of properties.</p>
content-type	<p>This field does not have an equivalent within the JMS specification, and so the vendor property <code>JMS_AMQP_CONTENT_TYPE</code> SHOULD be used. For further details, see 4. JMS Vendor Properties .</p>
content-encoding	<p>This field does not have an equivalent within the JMS specification, and so the vendor property <code>JMS_AMQP_CONTENT_ENCODING</code> SHOULD be used. For further details, see 4. JMS Vendor Properties .</p>

absolute-expiry-time	<p>This field is mapped to the <code>JMSExpiration</code> head of the Message</p> <p>If the <code>absolute-expiry-time</code> field of <code>properties</code> is set, then <code>JMSExpiration</code> MUST have the equivalent Java <code>long</code> value, representing the time at which the message expires, in milliseconds since the Unix Epoch.</p> <p>If the <code>absolute-expiry-time</code> field of <code>properties</code> is not set then <code>JMSExpiration</code> SHOULD be based on the <code>ttl</code> field of header instead if set, see 3.3.1 Header Section for more details.</p>
creation-time	<p>This field is mapped to the <code>JMSTimestamp</code> header of the Message.</p> <p>If the <code>creation-time</code> field of <code>properties</code> is not set, then <code>JMSTimestamp</code> MUST have the value zero. If the <code>creation-time</code> field of <code>properties</code> field is set, then <code>JMSTimestamp</code> MUST have the equivalent Java <code>long</code> value, representing the time at which the message was sent/created, in milliseconds since the Unix Epoch.</p>
group-id	<p>This field is mapped to the JMS-defined <code>JMSXGroupID</code> property of the Message.</p>
group-sequence	<p>This field is mapped to the JMS-defined <code>JMSXGroupSeq</code> property of the Message.</p> <p>As the <code>group-sequence</code> field of <code>properties</code> is an <code>uint</code> and <code>JMSXGroupSeq</code> is an <code>int</code>, <i>group-sequence</i> values in the range 2^{31} to $2^{32}-1$ inclusive MUST be mapped to <code>JMSXGroupSeq</code> values in the range -2^{31} to -1 inclusive.</p>
reply-to-group-id	<p>This field does not have an equivalent within the JMS specification, and so the vendor property <code>JMS_AMQP_REPLY_TO_GROUP_ID</code> MUST be used. For further details, see 4. JMS Vendor Properties .</p>

3.3.3 Application Properties Section

The `application-properties` section contents are roughly equivalent to the JMS Message *Properties*, however they differ in the supported types of their contents.

TODO (intent): how to handle receiving the following:

- String property names which do not conform with the JMS restrictions on naming
- property values with types not defined in the JMS specification

3.3.4 Delivery Annotations Section

TODO (content):

3.3.5 Message Annotations Section

TODO (content):

3.3.6 Footer Section

TODO (content):

3.3.7 Body Sections

The following sections detail how to determine which type of JMS Message should be used to represent a received AMQP message, based on first identifying whether it is appropriately annotated as corresponding to those produced by JMS clients implementing this mapping, or subsequently by analysing the message structure.

3.3.7.1 Messages With 'x-opt-jms-msg-type' Annotation

If the the “*x-opt-jms-msg-type*” message annotation is present on the received message, its value MUST be used to determine the type of JMS message used to represent the AMQP message, according to the mapping detailed in 3.2.4.1 Message Type Annotation. If the annotation is not present, the sections which follow should be used to identify the appropriate JMS Message type.

TODO (presentation): Some of these section numbers should be nested but arent. Investigate.

3.3.7.2 Messages Without 'x-opt-jms-msg-type' Annotation

3.3.7.3 Data

Where the “*x-opt-jms-msg-type*” message annotation is not set and one or more data body sections are received, the following should be used to identify the JMS Message type:

If the `content-type` field of `properties` is either not set, is set to the `symbol` value “*application/octet-stream*”, or is set to a value not determined to represent another message type, then the message MUST be interpreted as a `BytesMessage`.

If the `content-type` field of `properties` is set to the `symbol` value “*application/x-java-serialized-object*” the message MUST be interpreted as an `ObjectMessage`.

When the `content-type` field of `properties` contains a value representing common textual media types as detailed below, the message MUST be interpreted as a `TextMessage`. Where the total length of content in the data section(s) is 0, then the return value from the `getText()` method MUST be a Java `String` of length 0.

Top level type	Sub-type
“text”	*
“application”	“xml”
“application”	“xml-dtd”
“application”	Ends with “+xml”
“application”	“json”
“application”	Ends with “+json”

"application"	"javascript"
"application"	"ecmascript"

3.3.7.4 Amqp-value

Where the message type annotation is not set and an `amqp-value` body section is received, the following should be used to identify the JMS Message type:

If the received body section contains a `string` or `null` value, the message **MUST** be interpreted as a `TextMessage`.

If the received body section contains a `binary` value, the message **MUST** be interpreted as a `BytesMessage`.

For all other `amqp-value` body section contents, the message **MUST** be interpreted as an `ObjectMessage`.

3.3.7.5 Amqp-sequence

Where the message type annotation is not set and one or more `amqp-sequence` body sections are received, the message **MUST** be interpreted as an `ObjectMessage`.

3.3.7.6 Todo

TODO (intent): Discuss how arbitrary AMQP messages will be handled when being represented as an `ObjectMessage`

4 JMS Vendor Properties

This document defines the following JMS Vendor Properties.

Property Name	Set By	Description
JMS_AMQP_TTL	Application	<p>Optionally used for controlling the value of the <code>ttl</code> field of <code>header</code> for the outgoing AMQP message independently from the value normally used due to the JMS <i>Time To Live</i> value applied when sending the message. If set, it MUST be a <code>long</code> property with a value in the range zero to $2^{32} - 1$. If the property value is zero then the <code>ttl</code> field of <code>header</code> MUST be omitted rather than set to zero.</p> <p>When setting the <code>ttl</code> field of <code>header</code> by using the JMS_AMQP_TTL property, an entry with this key MUST NOT be included in the application-properties section of the transmitted AMQP message.</p>
JMS_AMQP_FIRST_ACQUIRER	Provider on Receive	Optionally used for accessing the <code>first-acquirer</code> field of <code>header</code> . If set, it MUST be of type <code>boolean</code> .
JMS_AMQP_CONTENT_TYPE	Application/ Provider on Receive	Optionally used for setting and/or accessing the <code>content-type</code> field of <code>properties</code> to distinguish the content type within the message body where necessary. If set, it MUST be of type <code>String</code> .
JMS_AMQP_CONTENT_ENCODING	Application/ Provider on Receive	Optionally used for setting and/or accessing the <code>content-encoding</code> field of <code>properties</code> to distinguish the content encoding within the message body where necessary. If set, it MUST be of type <code>String</code> .
JMS_AMQP_REPLY_TO_GROUP_ID	Application/ Provider on Receive	Optionally used for setting and/or accessing the <code>reply-to-group-id</code> field of <code>properties</code> . If set, it MUST be of type <code>String</code> .

Each implementation MAY, in addition, define its own extension properties but these MUST NOT use AMQP as the “vendor” name, i.e. the additional extension property names MUST NOT begin with “JMS_AMQP”.

TODO (presentation): Decide where this goes, it isn't necessarily a section.

5 Destinations

5.1 Destinations On Messages

In order to faithfully re-construct the `Destination` objects used in the `JMSDestination` and `JMSReplyTo` headers of a `Message` following its transmission via AMQP, information regarding the particular type of `Destination` object also has to be transmitted in an interoperable fashion.

This type information is transferred via message annotations with `symbol` keys of “*x-opt-jms-dest*” and “*x-opt-jms-reply-to*” and containing one of the following `byte` values:

Destination Type	Annotation value (type)
Queue	0 (byte)
Topic	1 (byte)
TemporaryQueue	2 (byte)
TemporaryTopic	3 (byte)

Producing JMS clients SHOULD set the “*x-opt-jms-dest*” message annotation on each message sent, and SHOULD set the “*x-opt-jms-reply-to*” message annotation on each message sent that has a `JMSReplyTo` header value.

When receiving an AMQP message which lacks the “*x-opt-jms-dest*” and/or “*x-opt-jms-reply-to*” message annotations, the `JMSDestination` and/or `JMSReplyTo` values respectively SHOULD be constructed using the same `Destination` type derivative as that used when creating the consumer which received the message.

When receiving an AMQP message that lacks the `to` field of `properties`, receiving JMS clients SHOULD synthesize this by returning the `Destination` value supplied when creating the consumer which received the message.

Note that while byte values MUST be used by sending JMS clients, implementations MUST cope with receiving any integral type for the annotation value.

TODO (presentation): Decide where this goes, it isn't necessarily a section.

5.2 Destinations And Producers/Consumers

When creating producing or consuming entities, links will be established to the remote peer with an appropriate `Source` or `Target` address. Some peers may support automatically creating nodes with the appropriate address if they do not exist, while some clients may wish to assert that they have attached to the expected type of node at the given address.

In order to facilitate these actions for the various `Destination` types that JMS supports, type information SHOULD be conveyed when creating producer or consumer links for the application by supplying a terminus capability for the particular `Destination` type to which the client expects to attach. The following capabilities are defined:

Destination Type	Terminus capability (type)
Queue	queue (symbol)
Topic	topic (symbol)
TemporaryQueue	temporary-queue (symbol)

TemporaryTopic	temporary-topic (symbol)
----------------	--------------------------

TODO (presentation): Decide where this goes, it isn't necessarily a section.

5.3 Temporary Destinations

JMS allows for creation of `TemporaryQueue` and `TemporaryTopic` entities for the lifetime of the parent `Connection`. Unlike creation of `Queue` and `Topic` objects, JMS does not define that creation of these objects at the client result in creation of the node at the peer.

AMQP allows for dynamic creation of peer-named nodes via use of the *dynamic* field on the *source* and *target* types. To create a node with the required lifecycle properties, establish a uniquely named sending link with the *dynamic* field of *target* set *true*, the *expiry-policy* field of *target* set to symbol *"link-detach"*, and the *dynamic-node-properties* field of *target* containing the *"lifetime-policy"* symbol key mapped to *delete-on-close*. The appropriate capability from 5.2 Destinations And Producers/Consumers MUST be included in the *capabilities* field of *target*.

The creating link will then be kept open until the `Connection` is closed, or the *delete()* method is called on the destination object, at which point detaching the link will result in destruction of the dynamic node.

As the destination is tied to the life of the `Connection`, the creating link is established on a separate AMQP session not managed by the JMS application.

TODO (presentation): Decide where this goes, it isn't necessarily a section.

6 Message Producers

6.1 Sending Messages

JMS producers (e.g `MessageProducer`) are required to set various headers on a message during the sending operation.

For the `JMSExpiration` header, specific handling was discussed in 3.2.1 JMS Headers. However, beyond setting the `JMSExpiration` header with the computed expiration, producing JMS clients need additionally ensure an appropriate value for the `ttl` field of `header` on outgoing messages.

If the `JMS_AMQP_TTL` vendor property outlined in 4. JMS Vendor Properties has been set on the `Message`, its value SHOULD be used to populate the `ttl` field of `header`.

If the `JMS_AMQP_TTL` vendor property has not been set and a *Time To Live* value of 0 is applicable when sending a `Message`, then producing JMS clients MUST NOT set the `ttl` field of `header`, that is it MUST be omitted rather than set to zero.

If the `JMS_AMQP_TTL` vendor property has not been set, and a non-zero *Time To Live* value of $2^{32}-1$ or less is applicable when sending a `Message`, the `ttl` field of `header` MUST be set accordingly by the provider on the AMQP message. If the applicable *Time To Live* value exceeds $2^{32} - 1$ then the `ttl` field of `header` MUST be omitted instead rather than populated with a value less than specified by the application.

6.2 Anonymous Producers

JMS producers (e.g `MessageProducer`) can be created with an explicit `Destination`, in which case applications MUST use one of their *send* methods that do not take a destination argument. Alternatively, producers can be created without a particular `Destination`, in which case they MUST be used with their *send* methods that take a destination argument for each message, and are typically described as anonymous producers.

To support the anonymous producer case the concept of an Anonymous Relay node is defined, such that messages sent to the relay node will be relayed to a node at the address given in the `to` field of `properties` of the message. Messages arriving at the relay node that don't contain a valid value for the `to` field of `properties` or are otherwise unable to be relayed successfully will be rejected by the peer. To establish a sending link to the Anonymous Relay node, a link attach is attempted with the `address` field of `target` set to null. Peers supporting the Anonymous Relay functionality advertise this by offering the `ANONYMOUS-RELAY` capability in their Open frame, and clients SHOULD use this ability when offered.

When the `ANONYMOUS-RELAY` capability is not offered by the peer, clients MAY support the anonymous producer use case through fallback means of establishing sending links to each distinct destination address used by the application, with potential use of link caching mechanisms to improve efficiency.

TODO (content): Pull out references to Addressing spec definition around `ANONYMOUS-RELAY` behaviour, once it actually exists.

7 Durable Subscriptions

7.1 Subscribe

Applications may create a durable `TopicSubscriber` to receive messages sent to a `Topic` while the subscriber is inactive. Each subscription is given a name, unique within the required `clientid` of the `Connection`, and only 1 subscriber may be active on the subscription at a time. The act of creating the `TopicSubscriber` is used both to create a subscription if it does not exist, and resume consumption of messages for an existing inactive subscription.

To represent the durable subscription, a consuming link is attached using the subscription name as the link name. The `Source terminus-durability` is set as either `configuration / 1` or `unsettled-state / 2` to indicate the terminus is durable, and a `terminus-expiry-policy` of `never` is used to indicate the terminus does not expire based on a timer.

7.2 Close

Closing a `TopicSubscriber` object does not end the subscription, but rather leaves the subscription in place, accumulating messages sent to the `Topic` while the subscriber is inactive.

To achieve this, the consuming link for the subscriber is detached without indicating the link should be closed.

7.3 Unsubscribe

An inactive subscription may be removed by calling the `Session unsubscribe` method with the name of the subscription.

A subscription is ended by closing the durable consuming link. To achieve this, a receiving link is attached using the subscription name as the link name, and providing a null `Source` in the initial attach request. This is necessary because only the subscription name is given at the point of unsubscribe. The broker peer will reattach the named link and respond with an attach containing the actual `Source` details of the subscription link. The client can then send a closing detach to end the subscription. In the event the named subscription does not exist, the initial attach request will be refused, and the client will treat this as an invalid subscription name.

TODO (content): Flesh out a bit more, update for JMS 2.0 shared subs.

8 Delivery Delay

JMS 2.0 introduced support for delivery delay, through which producers may be configured with a delay value so that messages sent by them only become permitted for delivery to consumers at a future point in time.

Support for the the delivery delay mechanism is established through use of a connection capability or a link capability value of *DELAYED_DELIVERY*. Where support for the mechanism can not be established, any attempt to send messages with a non-zero delivery delay **MUST** fail and result in an exception alerting the application that delayed delivery could not be assured.

JMS clients **MUST** include *DELAYED_DELIVERY* in the *desired-capabilities* field of *open* in order to request support by the server for the delayed delivery mechanism for any address. If the capability is not present in the *offered-capabilities* field of *open* sent by the server, then the client **MUST** assume the server does not support delayed delivery unless otherwise established on an individual sending link basis.

If support for the delayed delivery mechanism could not be established for all addresses at a connection level, then the client **MUST** include *DELAYED_DELIVERY* in the *desired-capabilities* field of *attach* sent for sending links in order to request server support for the delayed delivery mechanism for that specific link. If the capability is not present in the *offered-capabilities* field of *attach* sent by the server, then the client **MUST** assume the server does not support delayed delivery.

The *JMSDeliveryTime* header is used to convey the earliest point in time at which a message may be delivered to a consumer, represented as the number of milliseconds since the Unix Epoch. The value is set by the producing client during the send operation by adding any configured *delivery delay* value to the time at which the message is sent.

When a message is sent with a delivery delay configured, in order to carry the delivery time information on the AMQP message in an interoperable way, a message annotation with *symbol* key of “*x-opt-delivery-time*” and *long* value **MUST** be included. If no delivery delay is specified (i.e the value is zero) then the annotation **SHOULD** be omitted.

When a message is received by a JMS client with the “*x-opt-delivery-time*” annotation, the value **MUST** be used to populate *JMSDeliveryTime*. If a message is received without the annotation, the client **MUST** then synthesize the *JMSDeliveryTime* header value from the *JMSTimestamp* header value.

9 Supplementary Definitions

Annotation Name	Reference
x-opt-delivery-time	For further details, see 3.2.1 JMS Headers and 8. Delivery Delay .
x-opt-jms-dest	For further details, see 5. Destinations
x-opt-jms-reply-to	For further details, see 5. Destinations
x-opt-jms-msg-type	For further details, see 3.2.4.1 Message Type Annotation, 3.2.4 Message Body Types and 3.3.7 Body Sections.

TODO (content): add annotations to registry, back-reference these definitions.

TODO (presentation): Decide where this goes, it isn't necessarily a section.