



Web Services Reliable Messaging (WS-ReliableMessaging)

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See the Acknowledgments (Appendix E).

Abstract:

This specification (WS-ReliableMessaging) describes a protocol that allows messages to be transferred reliably between nodes implementing this protocol in the presence of software component, system, or network failures. The protocol is described in this specification in a transport-independent manner allowing it to be implemented using different network technologies. To support interoperable Web services, a SOAP binding is defined within this specification.

The protocol defined in this specification depends upon other Web services specifications for the identification of service endpoint addresses and policies. How these are identified and retrieved are detailed within those specifications and are out of scope for this document.

By using the XML [XML], SOAP [SOAP 1.1], [SOAP 1.2] and WSDL [WSDL 1.1] extensibility model, SOAP-based and WSDL-based specifications are designed to be composed with each other to define a rich Web services environment. As such, WS-ReliableMessaging by itself does not define all the features required for a complete messaging solution. WS-ReliableMessaging is a building block that is used in conjunction with other specifications and application-specific protocols to accommodate a wide variety of requirements and scenarios related to the operation of distributed Web services.

Status:

This document was last revised or approved by the WS-RX on the above date. The level of approval is also listed above. Check the current location noted above for possible later revisions of this document. This document is updated periodically on no particular schedule. Technical Committee members should send comments on this specification to the Technical Committee's email list. Others should send comments to the Technical Committee by using the "Send A Comment" button on the Technical Committee's web page at <http://www.oasis-open.org/committees/ws-rx>. For information on whether any patents have been disclosed that may be essential to implementing this specification, and any offers of patent licensing terms, please refer to the Intellectual Property Rights section of the Technical Committee web page (<http://www.oasis-open.org/committees/ws-rx/ipr.php>). The non-normative errata page for this specification is located at <http://www.oasis-open.org/committees/ws-rx>.

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1 Introduction

It is often a requirement for two Web services that wish to communicate to do so reliably in the presence of software component, system, or network failures. The primary goal of this specification is to create a modular mechanism for reliable transfer of messages. It defines a messaging protocol to identify, track, and manage the reliable transfer of messages between a source and a destination. It also defines a SOAP binding that is required for interoperability. Additional bindings can be defined.

This mechanism is extensible allowing additional functionality, such as security, to be tightly integrated. This specification integrates with and complements the WS-Security [WS-Security], WS-Policy [WS-Policy], and other Web services specifications. Combined, these allow for a broad range of reliable, secure messaging options.

1.1 Notational Conventions

The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [KEYWORDS].

This specification uses the following syntax to define normative outlines for messages:

- The syntax appears as an XML instance, but values in italics indicate data types instead of values.
- Characters are appended to elements and attributes to indicate cardinality:
 - "?" (0 or 1)
 - "*" (0 or more)
 - "+" (1 or more)
- The character "|" is used to indicate a choice between alternatives.
- The characters "[" and "]" are used to indicate that contained items are to be treated as a group with respect to cardinality or choice.
- An ellipsis (i.e. "...") indicates a point of extensibility that allows other child or attribute content specified in this document. Additional children elements and/or attributes MAY be added at the indicated extension points but they MUST NOT contradict the semantics of the parent and/or owner, respectively. If an extension is not recognized it SHOULD be ignored.
- XML namespace prefixes (See Section 1.2) are used to indicate the namespace of the element being defined.

Elements and Attributes defined by this specification are referred to in the text of this document using XPath 1.0 [XPATH 1.0] expressions. Extensibility points are referred to using an extended version of this syntax:

- An element extensibility point is referred to using {any} in place of the element name. This indicates that any element name can be used, from any namespace other than the wsrn: namespace.
- An attribute extensibility point is referred to using @{any} in place of the attribute name. This indicates that any attribute name can be used, from any namespace other than the wsrn: namespace.

1.2 Namespace

The XML namespace [XML-ns] URI that MUST be used by implementations of this specification is:

<http://docs.oasis-open.org/ws-rx/wsrn/200702>

Dereferencing the above URI will produce the Resource Directory Description Language [RDDL 2.0] document that describes this namespace.

Table 1 lists the XML namespaces that are used in this specification. The choice of any namespace prefix is arbitrary and not semantically significant.

Table 1

Prefix	Namespace
S	(Either SOAP 1.1 or 1.2)
S11	http://schemas.xmlsoap.org/soap/envelope/
S12	http://www.w3.org/2003/05/soap-envelope
wsrm	http://docs.oasis-open.org/ws-rx/wsrn/200702
wsa	http://www.w3.org/2005/08/addressing
wsam	http://www.w3.org/2007/02/addressing/metadata
wsse	http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd
xs	http://www.w3.org/2001/XMLSchema

The normative schema for WS-ReliableMessaging can be found linked from the namespace document that is located at the namespace URI specified above.

All sections explicitly noted as examples are informational and are not to be considered normative.

1.3 Conformance

An implementation is not conformant with this specification if it fails to satisfy one or more of the MUST or REQUIRED level requirements defined herein. A SOAP Node MUST NOT use the XML namespace identifier for this specification (listed in Section 1.2) within SOAP Envelopes unless it is conformant with this specification.

Normative text within this specification takes precedence over normative outlines, which in turn take precedence over the XML Schema [XML Schema Part 1, Part 2] descriptions.

2 Reliable Messaging Model

Many errors can interrupt a conversation. Messages can be lost, duplicated or reordered. Further the host systems can experience failures and lose volatile state.

The WS-ReliableMessaging specification defines an interoperable protocol that enables a Reliable Messaging (RM) Source to accurately determine the disposition of each message it Transmits as perceived by the RM Destination, so as to allow it to resolve any in-doubt status regarding receipt of the message Transmitted. The protocol also enables an RM Destination to efficiently determine which of those messages it Receives have been previously Received, enabling it to filter out duplicate message transmissions caused by the retransmission, by the RM Source, of an unacknowledged message. It also enables an RM Destination to Deliver the messages it Receives to the Application Destination in the order in which they were sent by an Application Source, in the event that they are Received out of order. Note that this specification places no restriction on the scope of the RM Source or RM Destination entities. For example, either can span multiple WSDL Ports or Endpoints.

The protocol enables the implementation of a broad range of reliability features which include ordered Delivery, duplicate elimination, and guaranteed receipt. The protocol can also be implemented with a range of robustness characteristics ranging from in-memory persistence that is scoped to a single process lifetime, to replicated durable storage that is recoverable in all but the most extreme circumstances. It is expected that the Endpoints will implement as many or as few of these reliability characteristics as necessary for the correct operation of the application using the protocol. Regardless of which of the reliability features is enabled, the wire protocol does not change.

Figure 1 below illustrates the entities and events in a simple reliable exchange of messages. First, the Application Source Sends a message for reliable transfer. The Reliable Messaging Source accepts the message and Transmits it one or more times. After accepting the message, the RM Destination Acknowledges it. Finally, the RM Destination Delivers the message to the Application Destination. The exact roles the entities play and the complete meaning of the events will be defined throughout this specification.

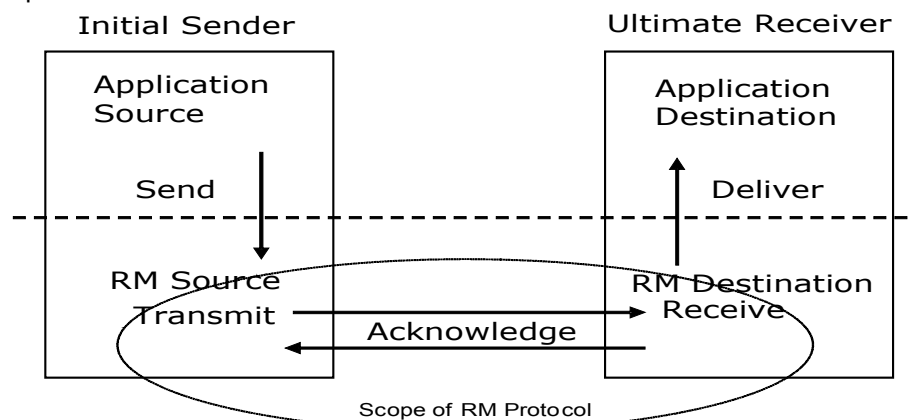


Figure 1: Reliable Messaging Model

2.1 Glossary

The following definitions are used throughout this specification:

Accept: The act of qualifying a message by the RM Destination such that it becomes eligible for Delivery and acknowledgement.

180 **Acknowledgement:** The communication from the RM Destination to the RM Source indicating the
181 successful receipt of a message.

182 **Acknowledgement Message:** A message containing a `SequenceAcknowledgement` header block.
183 Acknowledgement Messages may or may not contain a SOAP body.

184 **Acknowledgement Request:** A message containing an `AckRequested` header. Acknowledgement
185 Requests may or may not contain a SOAP body.

186 **Application Destination:** The Endpoint to which a message is Delivered.

187 **Application Source:** The Endpoint that Sends a message.

188 **Back-channel:** When the underlying transport provides a mechanism to return a transport-protocol
189 specific response, capable of carrying a SOAP message, without initiating a new connection, this
190 specification refers to this mechanism as a back-channel.

191 **Deliver:** The act of transferring responsibility for a message from the RM Destination to the Application
192 Destination.

193 **Endpoint:** As defined in the WS-Addressing specification [[WS-Addressing](#)]; a Web service Endpoint is a
194 (referenceable) entity, processor, or resource to which Web service messages can be addressed.
195 Endpoint references (EPRs) convey the information needed to address a Web service Endpoint.

196 **Receive:** The act of reading a message from a network connection and accepting it.

197 **RM Destination:** The Endpoint that Receives messages Transmitted reliably from an RM Source.

198 **RM Protocol Header Block:** One of `Sequence`, `SequenceAcknowledgement`, or `AckRequested`.

199 **RM Source:** The Endpoint that Transmits messages reliably to an RM Destination.

200 **Send:** The act of transferring a message from the Application Source to the RM Source for reliable
201 transfer.

202 **Sequence Lifecycle Message:** A message that contains one of: `CreateSequence`,
203 `CreateSequenceResponse`, `CloseSequence`, `CloseSequenceResponse`, `TerminateSequence`,
204 `TerminateSequenceResponse` as the child element of the SOAP body element.

205 **Sequence Traffic Message:** A message containing a `Sequence` header block.

206 **Transmit:** The act of writing a message to a network connection.

207 2.2 Protocol Preconditions

208 The correct operation of the protocol requires that a number of preconditions MUST be established prior
209 to the processing of the initial sequenced message:

- 210 • For any single message exchange the RM Source MUST have an endpoint reference that uniquely
211 identifies the RM Destination Endpoint.
- 212 • The RM Source MUST have successfully created a Sequence with the RM Destination.
- 213 • The RM Source MUST be capable of formulating messages that adhere to the RM Destination's
214 policies.
- 215 • If a secure exchange of messages is REQUIRED, then the RM Source and RM Destination MUST
216 have a security context.

2.3 Protocol Invariants

During the lifetime of a Sequence, the following invariants are REQUIRED for correctness:

- The RM Source MUST assign each message within a Sequence a message number (defined below) beginning at 1 and increasing by exactly 1 for each subsequent message. These numbers MUST be assigned in the same order in which messages are sent by the Application Source.
- Within every Acknowledgement Message it issues, the RM Destination MUST include one or more `AcknowledgementRange` child elements that contain, in their collective ranges, the message number of every message accepted by the RM Destination. The RM Destination MUST exclude, in the `AcknowledgementRange` elements, the message numbers of any messages it has not accepted. If no messages have been received the RM Destination MUST return `None` instead of an `AcknowledgementRange(s)`. The RM Destination MAY transmit a `Nack` for a specific message or messages instead of an `AcknowledgementRange(s)`.
- While the Sequence is not closed or terminated, the RM Source SHOULD retransmit unacknowledged messages.

2.4 Delivery Assurances

This section defines a number of Delivery Assurance assertions, which can be supported by RM Sources and RM Destinations. These assertions can be specified as policy assertions using the WS-Policy framework `[[WS-Policy]]`. For details on this see the WSRM Policy specification `[WS-RM Policy]`.

AtLeastOnce

Each message is to be delivered at least once, or else an error MUST be raised by the RM Source and/or RM Destination. The requirement on an RM Source is that it SHOULD retry transmission of every message sent by the Application Source until it receives an acknowledgement from the RM Destination. The requirement on the RM Destination is that it SHOULD retry the transfer to the Application Destination of any message that it accepts from the RM Source, until that message has been successfully delivered. There is no requirement for the RM Destination to apply duplicate message filtering.

AtMostOnce

Each message is to be delivered at most once. The RM Source MAY retry transmission of unacknowledged messages, but is NOT REQUIRED to do so. The requirement on the RM Destination is that it MUST filter out duplicate messages, i.e. that it MUST NOT deliver a duplicate of a message that has already been delivered.

ExactlyOnce

Each message is to be delivered exactly once; if a message cannot be delivered then an error MUST be raised by the RM Source and/or RM Destination. The requirement on an RM Source is that it SHOULD retry transmission of every message sent by the Application Source until it receives an acknowledgement from the RM Destination. The requirement on the RM Destination is that it SHOULD retry the transfer to the Application Destination of any message that it accepts from the RM Source until that message has been successfully delivered, and that it MUST NOT deliver a duplicate of a message that has already been delivered.

InOrder

Messages from each individual sequence are to be delivered in the same order they have been sent by the Application Source. The requirement on an RM Source is that it MUST ensure that the ordinal position of each message in the sequence (as indicated by a message sequence number) is consistent with the

order in which the messages have been sent from the Application Source. The requirement on the RM Destination is that it MUST deliver received messages for each sequence in the order indicated by the message numbering. This DeliveryAssurance can be used in combination with any of the AtLeastOnce, AtMostOnce or ExactlyOnce assertions, and the requirements of those assertions MUST also be met. In particular if the AtLeastOnce or ExactlyOnce assertion applies and the RM Destination detects a gap in the sequence then the RM Destination MUST NOT deliver any subsequent messages from that sequence until the missing messages are received or until the sequence is closed.

2.5 Example Message Exchange

Figure 2 illustrates a possible message exchange between two reliable messaging Endpoints A and B.



Figure 2: The WS-ReliableMessaging Protocol

1. The protocol preconditions are established. These include policy exchange, endpoint resolution, and establishing trust.
2. The RM Source requests creation of a new Sequence.
3. The RM Destination creates a new Sequence and returns its unique identifier.
4. The RM Source begins Transmitting messages in the Sequence beginning with MessageNumber 1. In the figure above, the RM Source sends 3 messages in the Sequence.
5. The 2nd message in the Sequence is lost in transit.

275 6. The 3rd message is the last in this Sequence and the RM Source includes an `AckRequested`
276 header to ensure that it gets a timely `SequenceAcknowledgement` for the Sequence.

277 7. The RM Destination acknowledges receipt of message numbers 1 and 3 as a result of receiving the
278 RM Source's `AckRequested` header.

279 8. The RM Source retransmits the unacknowledged message with `MessageNumber` 2. This is a new
280 message from the perspective of the underlying transport, but it has the same `Sequence Identifier`
281 and `MessageNumber` so the RM Destination can recognize it as a duplicate of the earlier message,
282 in case the original and retransmitted messages are both Received. The RM Source includes an
283 `AckRequested` header in the retransmitted message so the RM Destination will expedite an
284 acknowledgement.

285 9. The RM Destination Receives the second transmission of the message with `MessageNumber` 2
286 and acknowledges receipt of message numbers 1, 2, and 3.

287 10. The RM Source Receives this Acknowledgement and sends a `TerminateSequence` message to the
288 RM Destination indicating that the Sequence is completed. The `TerminateSequence` message
289 indicates that message number 3 was the last message in the Sequence. The RM Destination then
290 reclaims any resources associated with the Sequence.

291 11. The RM Destination Receives the `TerminateSequence` message indicating that the RM Source will
292 not be sending any more messages. The RM Destination sends a `TerminateSequenceResponse`
293 message to the RM Source and reclaims any resources associated with the Sequence.

294 The RM Source will expect to Receive Acknowledgements from the RM Destination during the course of a
295 message exchange at occasions described in Section 3 below. Should an Acknowledgement not be
296 Received in a timely fashion, the RM Source MUST re-transmit the message since either the message or
297 the associated Acknowledgement might have been lost. Since the nature and dynamic characteristics of
298 the underlying transport and potential intermediaries are unknown in the general case, the timing of re-
299 transmissions cannot be specified. Additionally, over-aggressive re-transmissions have been
300 demonstrated to cause transport or intermediary flooding which are counterproductive to the intention of
301 providing a reliable exchange of messages. Consequently, implementers are encouraged to utilize
302 adaptive mechanisms that dynamically adjust re-transmission time and the back-off intervals that are
303 appropriate to the nature of the transports and intermediaries envisioned. For the case of TCP/IP
304 transports, a mechanism similar to that described as RTTM in RFC 1323 [RTTM] SHOULD be
305 considered.

306 Now that the basic model has been outlined, the details of the elements used in this protocol are now
307 provided in Section 3.

3 RM Protocol Elements

The following sub-sections define the various RM protocol elements, and prescribe their usage by a conformant implementations.

3.1 Considerations on the Use of Extensibility Points

The following protocol elements define extensibility points at various places. Implementations MAY add child elements and/or attributes at the indicated extension points but MUST NOT contradict the semantics of the parent and/or owner, respectively. If a receiver does not recognize an extension, the receiver SHOULD ignore the extension.

3.2 Considerations on the Use of "Piggy-Backing"

Some RM Protocol Header Blocks may be added to messages that are targeted to the same Endpoint to which those headers are to be sent (a concept often referred to as "piggy-backing"), thus saving the overhead of an additional message exchange. Reference parameters MUST be considered when determining whether two EPRs are targeted to the same Endpoint. The determination of if and when a Header Block will be piggy-backed onto another message is made by the entity (RM Source or RM Destination) that is sending the header. In order to ensure optimal and successful processing of RM Sequences, endpoints that receive RM-related messages SHOULD be prepared to process RM Protocol Header Blocks that are included in any message it receives. See the sections that define each RM Protocol Header Block to know which ones may be considered for piggy-backing.

3.3 Composition with WS-Addressing

When the RM protocol, defined in this specification, is composed with the WS-Addressing specification, the following rules prescribe the constraints on the value of the `wsa:Action` header:

1. When an Endpoint generates a message that carries an RM protocol element, that is defined in the following sections, in the body of a SOAP envelope that Endpoint MUST include in that envelope a `wsa:Action` SOAP header block whose value is an IRI that is a concatenation of the WS-RM namespace URI, followed by a "/", followed by the value of the local name of the child element of the SOAP body. For example, for a Sequence creation request message as described in section 3.4 below, the value of the `wsa:Action` IRI would be:

```
http://docs.oasis-open.org/ws-rx/wsrn/200702/CreateSequence
```

2. When an Endpoint generates an Acknowledgement Message that has no element content in the SOAP body, then the value of the `wsa:Action` IRI MUST be:

```
http://docs.oasis-open.org/ws-rx/wsrn/200702/SequenceAcknowledgement
```

3. When an Endpoint generates an Acknowledgement Request that has no element content in the SOAP body, then the value of the `wsa:Action` IRI MUST be:

```
http://docs.oasis-open.org/ws-rx/wsrn/200702/AckRequested
```

4. When an Endpoint generates an RM fault as defined in section 4 below, the value of the `wsa:Action` IRI MUST be as defined in section 4 below.

3.4 Sequence Creation

The RM Source MUST request creation of an outbound Sequence by sending a `CreateSequence` element in the body of a message to the RM Destination which in turn responds either with a message containing `CreateSequenceResponse` or a `CreateSequenceRefused` fault. The RM Source MAY include an offer to create an inbound Sequence within the `CreateSequence` message. This offer is either accepted or rejected by the RM Destination in the `CreateSequenceResponse` message.

The SOAP version used for the `CreateSequence` message SHOULD be used for all subsequent messages in or for that Sequence, sent by either the RM Source or the RM Destination.

The following exemplar defines the `CreateSequence` syntax:

```
<wsrm:CreateSequence ...>
  <wsrm:AcksTo> wsa:EndpointReferenceType </wsrm:AcksTo>
  <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
  <wsrm:Offer ...>
    <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
    <wsrm:Endpoint> wsa:EndpointReferenceType </wsrm:Endpoint>
    <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
    <wsrm:IncompleteSequenceBehavior>
      wsrml:IncompleteSequenceBehaviorType
    </wsrm:IncompleteSequenceBehavior> ?
    ...
  </wsrm:Offer> ?
  ...
</wsrm:CreateSequence>
```

The following describes the content model of the `CreateSequence` element.

`/wsrm:CreateSequence`

This element requests creation of a new Sequence between the RM Source that sends it, and the RM Destination to which it is sent. The RM Source MUST NOT send this element as a header block. The RM Destination MUST respond either with a `CreateSequenceResponse` response message or a `CreateSequenceRefused` fault.

`/wsrm:CreateSequence/wsrm:AcksTo`

The RM Source MUST include this element in any `CreateSequence` message it sends. This element is of type `wsa:EndpointReferenceType` (as specified by WS-Addressing). It specifies the endpoint reference to which messages containing `SequenceAcknowledgement` header blocks and faults related to the created Sequence are to be sent, unless otherwise noted in this specification (for example, see Section 3.5).

Implementations MUST NOT use an endpoint reference in the `AcksTo` element that would prevent the sending of Sequence Acknowledgements back to the RM Source. For example, using the WS-Addressing "http://www.w3.org/2005/08/addressing/none" IRI would make it impossible for the RM Destination to ever send Sequence Acknowledgements.

`/wsrm:CreateSequence/wsrm:Expires`

This element, if present, of type `xs:duration` specifies the RM Source's requested duration for the Sequence. The RM Destination MAY either accept the requested duration or assign a lesser value of its choosing. A value of "PT0S" indicates that the Sequence will never expire. Absence of the element indicates an implied value of "PT0S".

`/wsrm:CreateSequence/wsrm:Expires/@{any}`

389 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
390 element.

391 /wsrm:CreateSequence/wsrm:Offer

392 This element, if present, enables an RM Source to offer a corresponding Sequence for the reliable
393 exchange of messages Transmitted from RM Destination to RM Source.

394 /wsrm:CreateSequence/wsrm:Offer/wsrm:Identifier

395 The RM Source MUST set the value of this element to an absolute URI (conformant with RFC3986 [URI])
396 that uniquely identifies the offered Sequence.

397 /wsrm:CreateSequence/wsrm:Offer/wsrm:Identifier/@{any}

398 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
399 element.

400 /wsrm:CreateSequence/wsrm:Offer/wsrm:Endpoint

401 An RM Source MUST include this element, of type `wsa:EndpointReferenceType` (as specified by
402 WS-Addressing). This element specifies the endpoint reference to which Sequence Lifecycle Messages,
403 Acknowledgement Requests, and fault messages related to the offered Sequence are to be sent.

404 Implementations MUST NOT use an endpoint reference in the Endpoint element that would prevent the
405 sending of Sequence Lifecycle Message, etc. For example, using the WS-Addressing
406 "http://www.w3.org/2005/08/addressing/none" IRI would make it impossible for the RM Destination to ever
407 send Sequence Lifecycle Messages (e.g. `TerminateSequence`) to the RM Source for the Offered
408 Sequence.

409 The Offer of an Endpoint containing the "http://www.w3.org/2005/08/addressing/anonymous" IRI as its
410 address is problematic due to the inability of a source to connect to this address and retry
411 unacknowledged messages (as described in Section 2.3). Note that this specification does not define any
412 mechanisms for providing this assurance. In the absence of an extension that addresses this issue, an
413 RM Destination MUST NOT accept (via the `/wsrm:CreateSequenceResponse/wsrm:Accept`
414 element described below) an Offer that contains the "http://www.w3.org/2005/08/addressing/anonymous"
415 IRI as its address.

416 /wsrm:CreateSequence/wsrm:Offer/wsrm:Expires

417 This element, if present, of type `xs:duration` specifies the duration for the offered Sequence. A value of
418 "PT0S" indicates that the offered Sequence will never expire. Absence of the element indicates an implied
419 value of "PT0S".

420 /wsrm:CreateSequence/wsrm:Offer/wsrm:Expires/@{any}

421 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
422 element.

423 /wsrm:CreateSequence/wsrm:Offer/wsrm:IncompleteSequenceBehavior

424 This element, if present, specifies the behavior that the destination will exhibit upon the closure or
425 termination of an incomplete Sequence. For the purposes of defining the values used, the term "discard"
426 refers to behavior equivalent to the Application Destination never processing a particular message.

427 A value of "DiscardEntireSequence" indicates that the entire Sequence MUST be discarded if the
428 Sequence is closed, or terminated, when there are one or more gaps in the final
429 `SequenceAcknowledgement`.

430 A value of “DiscardFollowingFirstGap” indicates that messages in the Sequence beyond the first gap
431 MUST be discarded when there are one or more gaps in the final `SequenceAcknowledgement`.

432 The default value of “NoDiscard” indicates that no acknowledged messages in the Sequence will be
433 discarded.

434 `/wsrm:CreateSequence/wsrm:Offer/{any}`

435 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
436 to be passed.

437 `/wsrm:CreateSequence/wsrm:Offer/@{any}`

438 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
439 element.

440 `/wsrm:CreateSequence/{any}`

441 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
442 to be passed.

443 `/wsrm:CreateSequence/@{any}`

444 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
445 element.

446 A `CreateSequenceResponse` is sent in the body of a response message by an RM Destination in
447 response to receipt of a `CreateSequence` request message. It carries the `Identifier` of the created
448 Sequence and indicates that the RM Source can begin sending messages in the context of the identified
449 Sequence.

450 The following exemplar defines the `CreateSequenceResponse` syntax:

```
451 <wsrm:CreateSequenceResponse ...>
452   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
453   <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
454   <wsrm:IncompleteSequenceBehavior>
455     wsrm:IncompleteSequenceBehaviorType
456   </wsrm:IncompleteSequenceBehavior> ?
457   <wsrm:Accept ...>
458     <wsrm:AcksTo wsa:EndpointReferenceType </wsrm:AcksTo>
459     ...
460   </wsrm:Accept> ?
461   ...
462 </wsrm:CreateSequenceResponse>
```

463 The following describes the content model of the `CreateSequenceResponse` element.

464 `/wsrm:CreateSequenceResponse`

465 This element is sent in the body of the response message in response to a `CreateSequence` request
466 message. It indicates that the RM Destination has created a new Sequence at the request of the RM
467 Source. The RM Destination MUST NOT send this element as a header block.

468 `/wsrm:CreateSequenceResponse/wsrm:Identifier`

469 The RM Destination MUST include this element within any `CreateSequenceResponse` message it sends.
470 The RM Destination MUST set the value of this element to the absolute URI (conformant with RFC3986)
471 that uniquely identifies the Sequence that has been created by the RM Destination.

472 `/wsrm:CreateSequenceResponse/wsrm:Identifier/@{any}`

473 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
474 element.

475 /wsrm:CreateSequenceResponse/wsrm:Expires

476 This element, if present, of type `xs:duration` accepts or refines the RM Source's requested duration for
477 the Sequence. It specifies the amount of time after which any resources associated with the Sequence
478 SHOULD be reclaimed thus causing the Sequence to be silently terminated. At the RM Destination this
479 duration is measured from a point proximate to Sequence creation and at the RM Source this duration is
480 measured from a point approximate to the successful processing of the `CreateSequenceResponse`. A
481 value of "PT0S" indicates that the Sequence will never expire. Absence of the element indicates an
482 implied value of "PT0S". The RM Destination MUST set the value of this element to be equal to or less
483 than the value requested by the RM Source in the corresponding `CreateSequence` message.

484 /wsrm:CreateSequenceResponse/wsrm:Expires/@{any}

485 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
486 element.

487 /wsrm:CreateSequenceResponse/wsrm:IncompleteSequenceBehavior

488 This element, if present, specifies the behavior that the destination will exhibit upon the closure or
489 termination of an incomplete Sequence. For the purposes of defining the values used, the term "discard"
490 refers to behavior equivalent to the Application Destination never processing a particular message.

491 A value of "DiscardEntireSequence" indicates that the entire Sequence MUST be discarded if the
492 Sequence is closed, or terminated, when there are one or more gaps in the final
493 `SequenceAcknowledgement`.

494 A value of "DiscardFollowingFirstGap" indicates that messages in the Sequence beyond the first gap
495 MUST be discarded when there are one or more gaps in the final `SequenceAcknowledgement`.

496 The default value of "NoDiscard" indicates that no acknowledged messages in the Sequence will be
497 discarded.

498 /wsrm:CreateSequenceResponse/wsrm:Accept

499 This element, if present, enables an RM Destination to accept the offer of a corresponding Sequence for
500 the reliable exchange of messages Transmitted from RM Destination to RM Source.

501 **Note:** If a `CreateSequenceResponse` is returned without a child `Accept` in response to a
502 `CreateSequence` that did contain a child `Offer`, then the RM Source MAY immediately reclaim any
503 resources associated with the unused offered Sequence.

504 /wsrm:CreateSequenceResponse/wsrm:Accept/wsrm:AcksTo

505 The RM Destination MUST include this element, of type `wsa:EndpointReferenceType` (as specified
506 by WS-Addressing). It specifies the endpoint reference to which messages containing
507 `SequenceAcknowledgement` header blocks and faults related to the created Sequence are to be sent,
508 unless otherwise noted in this specification (for example, see Section 3.5).

509 Implementations MUST NOT use an endpoint reference in the `AcksTo` element that would prevent the
510 sending of Sequence Acknowledgements back to the RM Source. For example, using the WS-Addressing
511 "http://www.w3.org/2005/08/addressing/none" IRI would make it impossible for the RM Destination to ever
512 send Sequence Acknowledgements.

513 /wsrm:CreateSequenceResponse/wsrm:Accept/{any}

514 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
515 to be passed.

516 /wsrm:CreateSequenceResponse/wsrm:Accept/@{any}

517 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
518 element.

519 /wsrm:CreateSequenceResponse/{any}

520 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
521 to be passed.

522 /wsrm:CreateSequenceResponse/@{any}

523 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
524 element.

525 **3.5 Closing A Sequence**

526 There are times during the use of an RM Sequence that the RM Source or RM Destination will wish to
527 discontinue using a Sequence. Simply terminating the Sequence discards the state managed by the RM
528 Destination, leaving the RM Source unaware of the final ranges of messages that were successfully
529 transferred to the RM Destination. To ensure that the Sequence ends with a known final state either the
530 RM Source or RM Destination MAY choose to close the Sequence before terminating it.

531 If the RM Source wishes to close the Sequence, then it sends a `CloseSequence` element, in the body of
532 a message, to the RM Destination. This message indicates that the RM Destination MUST NOT accept
533 any new messages for the specified Sequence, other than those already accepted at the time the
534 `CloseSequence` element is interpreted by the RM Destination. Upon receipt of this message, or
535 subsequent to the RM Destination closing the Sequence of its own volition, the RM Destination MUST
536 include a final `SequenceAcknowledgement` (within which the RM Destination MUST include the `Final`
537 element) header block on any messages associated with the Sequence destined to the RM Source,
538 including the `CloseSequenceResponse` message or on any Sequence fault Transmitted to the RM
539 Source.

540 To allow the RM Destination to determine if it has received all of the messages in a Sequence, the RM
541 Source SHOULD include the `LastMsgNumber` element in any `CloseSequence` messages it sends. The
542 RM Destination can use this information, for example, to implement the behavior indicated by
543 `/wsrm:CreateSequenceResponse/wsrm:IncompleteSequenceBehavior`. The value of the
544 `LastMsgNumber` element MUST be the same in all the `CloseSequence` messages for the closing
545 Sequence.

546 If the RM Destination decides to close a Sequence of its own volition, it MAY inform the RM Source of this
547 event by sending a `CloseSequence` element, in the body of a message, to the `AcksTo` EPR of that
548 Sequence. The RM Destination MUST include a final `SequenceAcknowledgement` (within which the RM
549 Destination MUST include the `Final` element) header block in this message and any subsequent
550 messages associated with the Sequence destined to the RM Source.

551 While the RM Destination MUST NOT accept any new messages for the specified Sequence it MUST still
552 process Sequence Lifecycle Messages and Acknowledgement Requests. For example, it MUST respond to
553 `AckRequested`, `TerminateSequence` as well as `CloseSequence` messages. Note, subsequent
554 `CloseSequence` messages have no effect on the state of the Sequence.

555 In the case where the RM Destination wishes to discontinue use of a Sequence it is RECOMMENDED
556 that it close the Sequence. Please see `Final` and the `SequenceClosed` fault. Whenever possible the
557 `SequenceClosed` fault SHOULD be used in place of the `SequenceTerminated` fault to allow the RM
558 Source to still Receive Acknowledgements.

559 The following exemplar defines the `CloseSequence` syntax:

```
560 <wsrm:CloseSequence ...>  
561   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
562   <wsrm:LastMsgNumber> wsrm:MessageNumberType </wsrm:LastMsgNumber> ?  
563   ...  
564 </wsrm:CloseSequence>
```

565 The following describes the content model of the `CloseSequence` element.

566 `/wsrm:CloseSequence`

567 This element MAY be sent by an RM Source to indicate that the RM Destination MUST NOT accept any
568 new messages for this Sequence This element MAY also be sent by an RM Destination to indicate that it
569 will not accept any new messages for this Sequence.

570 `/wsrm:CloseSequence/wsrm:Identifier`

571 The RM Source or RM Destination MUST include this element in any `CloseSequence` messages it sends.
572 The RM Source or RM Destination MUST set the value of this element to the absolute URI (conformant
573 with RFC3986) of the closing Sequence.

574 `/wsrm:CloseSequence/wsrm:LastMessageNumber`

575 The RM Source SHOULD include this element in any `CloseSequence` message it sends. The
576 `LastMsgNumber` element specifies the highest assigned message number of all the Sequence Traffic
577 Messages for the closing Sequence.

578 `/wsrm:CloseSequence/wsrm:Identifier/@{any}`

579 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
580 element.

581 `/wsrm:CloseSequence/{any}`

582 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
583 to be passed.

584 `/wsrm:CloseSequence@{any}`

585 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
586 element.

587 A `CloseSequenceResponse` is sent in the body of a message in response to receipt of a
588 `CloseSequence` request message. It indicates that the responder has closed the Sequence.

589 The following exemplar defines the `CloseSequenceResponse` syntax:

```
590 <wsrm:CloseSequenceResponse ...>  
591   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
592   ...  
593 </wsrm:CloseSequenceResponse>
```

594 The following describes the content model of the `CloseSequenceResponse` element.

595 `/wsrm:CloseSequenceResponse`

596 This element is sent in the body of a message in response to receipt of a `CloseSequence` request
597 message. It indicates that the responder has closed the Sequence.

598 `/wsrm:CloseSequenceResponse/wsrm:Identifier`

599 The responder (RM Source or RM Destination) MUST include this element in any
600 `CloseSequenceResponse` message it sends. The responder MUST set the value of this element to the
601 absolute URI (conformant with RFC3986) of the closing Sequence.

602 `/wsrm:CloseSequenceResponse/wsrm:Identifier/@{any}`

603 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
604 element.

605 `/wsrm:CloseSequenceResponse/{any}`

606 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
607 to be passed.

608 `/wsrm:CloseSequenceResponse@{any}`

609 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
610 element.

611 3.6 Sequence Termination

612 When the RM Source has completed its use of the Sequence it sends a `TerminateSequence` element,
613 in the body of a message, to the RM Destination to indicate that the Sequence is complete and that it will
614 not be sending any further messages related to the Sequence. The RM Destination can safely reclaim any
615 resources associated with the Sequence upon receipt of the `TerminateSequence` message. Under
616 normal usage the RM Source will complete its use of the Sequence when all of the messages in the
617 Sequence have been acknowledged. However, the RM Source is free to Terminate or Close a Sequence
618 at any time regardless of the acknowledgement state of the messages.

619 To allow the RM Destination to determine if it has received all of the messages in a Sequence, the RM
620 Source SHOULD include the `LastMsgNumber` element in any `TerminateSequence` messages it sends.
621 The RM Destination can use this information, for example, to implement the behavior indicated by
622 `/wsrm:CreateSequenceResponse/wsrm:IncompleteSequenceBehavior`. The value of the
623 `LastMsgNumber` element in the `TerminateSequence` message MUST be equal to the value of the
624 `LastMsgNumber` element in any `CloseSequence` message(s) sent by the RM Source for the same
625 Sequence.

626 If the RM Destination decides to terminate a Sequence of its own volition, it MAY inform the RM Source of
627 this event by sending a `TerminateSequence` element, in the body of a message, to the AcksTo EPR for
628 that Sequence. The RM Destination MUST include a final `SequenceAcknowledgement` (within which
629 the RM Destination MUST include the `Final` element) header block in this message.

630 The following exemplar defines the `TerminateSequence` syntax:

```
631 <wsrm:TerminateSequence ...>  
632   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
633   <wsrm>LastMsgNumber> wsrm:MessageNumberType </wsrm>LastMsgNumber> ?  
634   ...  
635 </wsrm:TerminateSequence>
```

636 The following describes the content model of the `TerminateSequence` element.

637 `/wsrm:TerminateSequence`

638 This element MAY be sent by an RM Source to indicate it has completed its use of the Sequence. It
639 indicates that the RM Destination can safely reclaim any resources related to the identified Sequence. The
640 RM Source MUST NOT send this element as a header block. The RM Source MAY retransmit this
641 element. Once this element is sent, other than this element, the RM Source MUST NOT send any
642 additional message to the RM Destination referencing this Sequence.

643 This element MAY also be sent by the RM Destination to indicate that it has unilaterally terminated the
644 Sequence. Upon sending this message the RM Destination MUST NOT accept any additional messages
645 (with the exception of the corresponding `TerminateSequenceResponse`) for this Sequence. Upon
646 receipt of a `TerminateSequence` the RM Source MUST NOT send any additional messages (with the
647 exception of the corresponding `TerminateSequenceResponse`) for this Sequence.

648 `/wsrm:TerminateSequence/wsrm:Identifier`

649 The RM Source or RM Destination MUST include this element in any `TerminateSequence` message it
650 sends. The RM Source or RM Destination MUST set the value of this element to the absolute URI
651 (conformant with RFC3986) of the terminating Sequence.

652 `/wsrm:TerminateSequence/wsrm:LastMsgNumber`

653 The RM Source SHOULD include this element in any `TerminateSequence` message it sends. The
654 `LastMsgNumber` element specifies the highest assigned message number of all the Sequence Traffic
655 Messages for the closing Sequence.

656 `/wsrm:TerminateSequence/wsrm:Identifier/@{any}`

657 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
658 element.

659 `/wsrm:TerminateSequence/{any}`

660 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
661 to be passed.

662 `/wsrm:TerminateSequence/@{any}`

663 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
664 element.

665 A `TerminateSequenceResponse` is sent in the body of a message in response to receipt of a
666 `TerminateSequence` request message. It indicates that responder has terminated the Sequence.

667 The following exemplar defines the `TerminateSequenceResponse` syntax:

```
668 <wsrm:TerminateSequenceResponse ...>  
669   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
670   ...  
671 </wsrm:TerminateSequenceResponse>
```

672 The following describes the content model of the `TerminateSequence` element.

673 `/wsrm:TerminateSequenceResponse`

674 This element is sent in the body of a message in response to receipt of a `TerminateSequence` request
675 message. It indicates that the responder has terminated the Sequence. The responder MUST NOT send
676 this element as a header block.

677 `/wsrm:TerminateSequenceResponse/wsrm:Identifier`

678 The responder (RM Source or RM Destination) MUST include this element in any
679 `TerminateSequenceResponse` message it sends. The responder MUST set the value of this element
680 to the absolute URI (conformant with RFC3986) of the terminating Sequence.

681 `/wsrm:TerminateSequenceResponse/wsrm:Identifier/@{any}`

682 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
683 element.

684 `/wsrm:TerminateSequenceResponse/{any}`

685 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
686 to be passed.

687 `/wsrm:TerminateSequenceResponse/@{any}`

688 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
689 element.

690 On receipt of a `TerminateSequence` message the receiver (RM Source or RM Destination) MUST
691 respond with a corresponding `TerminateSequenceResponse` message or generate a fault
692 `UnknownSequenceFault` if the Sequence is not known.

693 3.7 Sequences

694 The RM protocol uses a Sequence header block to track and manage the reliable transfer of messages.
695 The RM Source MUST include a `Sequence` header block in all messages for which reliable transfer is
696 REQUIRED. The RM Source MUST identify Sequences with unique Identifier elements and the RM
697 Source MUST assign each message within a Sequence a `MessageNumber` element that increments by 1
698 from an initial value of 1. These values are contained within a `Sequence` header block accompanying
699 each message being transferred in the context of a Sequence.

700 The RM Source MUST NOT include more than one `Sequence` header block in any message.

701 A following exemplar defines its syntax:

```
702 <wsrm:Sequence ...>  
703   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
704   <wsrm:MessageNumber> wsrm:MessageNumberType </wsrm:MessageNumber>  
705   ...  
706 </wsrm:Sequence>
```

707 The following describes the content model of the `Sequence` header block.

708 `/wsrm:Sequence`

709 This protocol element associates the message in which it is contained with a previously established RM
710 Sequence. It contains the Sequence's unique identifier and the containing message's ordinal position
711 within that Sequence. The RM Destination MUST understand the `Sequence` header block. The RM
712 Source MUST assign a `mustUnderstand` attribute with a value 1/true (from the namespace
713 corresponding to the version of SOAP to which the `Sequence` SOAP header block is bound) to the
714 `Sequence` header block element.

715 `/wsrm:Sequence/wsrm:Identifier`

716 An RM Source that includes a `Sequence` header block in a SOAP envelope MUST include this element in
717 that header block. The RM Source MUST set the value of this element to the absolute URI (conformant
718 with RFC3986) that uniquely identifies the Sequence.

719 /wsrm:Sequence/wsrm:Identifier/@{any}

720 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
721 element.

722 /wsrm:Sequence/wsrm:MessageNumber

723 The RM Source **MUST** include this element within any Sequence headers it creates. This element is of
724 type `MessageNumberType`. It represents the ordinal position of the message within a Sequence.
725 Sequence message numbers start at 1 and monotonically increase by 1 throughout the Sequence. See
726 Section 4.5 for Message Number Rollover fault.

727 /wsrm:Sequence/{any}

728 This is an extensibility mechanism to allow different types of information, based on a schema, to be
729 passed.

730 /wsrm:Sequence/@{any}

731 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
732 element.

733 The following example illustrates a Sequence header block.

```
734 <wsrm:Sequence>  
735   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
736   <wsrm:MessageNumber>10</wsrm:MessageNumber>  
737 </wsrm:Sequence>
```

738 3.8 Request Acknowledgement

739 The purpose of the `AckRequested` header block is to signal to the RM Destination that the RM Source is
740 requesting that a `SequenceAcknowledgement` be sent.

741 The RM Source **MAY** request an Acknowledgement Message from the RM Destination at any time by
742 independently transmitting an `AckRequested` header block (i.e. as a header of a SOAP envelope with an
743 empty body). Alternatively the RM Source **MAY** include an `AckRequested` header block in any message
744 targeted to the RM Destination. The RM Destination **SHOULD** process `AckRequested` header blocks
745 that are included in any message it receives. If a non-mustUnderstand fault occurs when processing an
746 `AckRequested` header block that was piggy-backed, a fault **MUST** be generated, but the processing of
747 the original message **MUST NOT** be affected.

748 An RM Destination that **Receives** a message that contains an `AckRequested` header block **MUST** send
749 a message containing a `SequenceAcknowledgement` header block to the `AcksTo` endpoint reference
750 (see Section 3.4) for a known Sequence or else generate an `UnknownSequence` fault. It is
751 **RECOMMENDED** that the RM Destination return a `AcknowledgementRange` or `None` element instead
752 of a `Nack` element (see Section 3.9).

753 The following exemplar defines its syntax:

```
754 <wsrm:AckRequested ...>  
755   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
756   ...  
757 </wsrm:AckRequested>
```

758 The following describes the content model of the `AckRequested` header block.

759 /wsrm:AckRequested

760 This element requests an Acknowledgement for the identified Sequence.

761 /wsrm:AckRequested/wsrm:Identifier

762 An RM Source that includes an `AckRequested` header block in a SOAP envelope MUST include this
763 element in that header block. The RM Source MUST set the value of this element to the absolute URI,
764 (conformant with RFC3986), that uniquely identifies the Sequence to which the request applies.

765 /wsrm:AckRequested/wsrm:Identifier/@{any}

766 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
767 element.

768 /wsrm:AckRequested/{any}

769 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
770 to be passed.

771 /wsrm:AckRequested/@{any}

772 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
773 element.

774 3.9 Sequence Acknowledgement

775 The RM Destination informs the RM Source of successful message receipt using a
776 `SequenceAcknowledgement` header block. Acknowledgements can be explicitly requested using the
777 `AckRequested` directive (see Section 3.8).

778 The RM Destination MAY Transmit the `SequenceAcknowledgement` header block independently (i.e.
779 As a header of a SOAP envelope with an empty body). Alternatively, an RM Destination MAY include a
780 `SequenceAcknowledgement` header block on any SOAP envelope targeted to the endpoint referenced
781 by the `AcksTo` EPR. The RM Source SHOULD process `SequenceAcknowledgement` header blocks
782 that are included in any message it receives. If a non-mustUnderstand fault occurs when processing a
783 `SequenceAcknowledgement` header that was piggy-backed, a fault MUST be generated, but the
784 processing of the original message MUST NOT be affected.

785 During creation of a Sequence the RM Source MAY specify the WS-Addressing anonymous IRI as the
786 address of the `AcksTo` EPR for that Sequence. When the RM Source specifies the WS-Addressing
787 anonymous IRI as the address of the `AcksTo` EPR, the RM Destination MUST Transmit any
788 `SequenceAcknowledgement` headers for the created Sequence in a SOAP envelope to be Transmitted
789 on the protocol binding-specific back-channel. Such a channel is provided by the context of a Received
790 message containing a SOAP envelope that contains a `Sequence` header block and/or an `AckRequested`
791 header block for that same Sequence identifier. When the RM Destination receives an `AckRequested`
792 header, and the `AckTo` EPR for that sequence is the WS-Addressing anonymous IRI, the RM Destination
793 SHOULD respond on the protocol binding-specific back-channel provided by the Received message
794 containing the `AckRequested` header block.

795 The following exemplar defines its syntax:

```
796 <wsrm:SequenceAcknowledgement ...>
797   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
798   [ [ [ <wsrm:AcknowledgementRange ...
799         Upper="wsrm:MessageNumberType"
800         Lower="wsrm:MessageNumberType" /> +
801         | <wsrm:None/> ]
802         <wsrm:Final/> ? ]
803         | <wsrm:Nack> wsrm:MessageNumberType </wsrm:Nack> + ]
804
805   ...
```

806

`</wsrm:SequenceAcknowledgement>`

807 The following describes the content model of the `SequenceAcknowledgement` header block.

808 `/wsrm:SequenceAcknowledgement`

809 This element contains the Sequence Acknowledgement information.

810 `/wsrm:SequenceAcknowledgement/wsrm:Identifier`

811 An RM Destination that includes a `SequenceAcknowledgement` header block in a SOAP envelope
812 MUST include this element in that header block. The RM Destination MUST set the value of this element
813 to the absolute URI (conformant with RFC3986) that uniquely identifies the Sequence. The RM
814 Destination MUST NOT include multiple `SequenceAcknowledgement` header blocks that share the
815 same value for `Identifier` within the same SOAP envelope.

816 `/wsrm:SequenceAcknowledgement/wsrm:Identifier/@{any}`

817 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
818 element.

819 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange`

820 The RM Destination MAY include one or more instances of this element within a
821 `SequenceAcknowledgement` header block. It contains a range of Sequence message numbers
822 successfully accepted by the RM Destination. The ranges MUST NOT overlap. The RM Destination
823 MUST NOT include this element if a sibling `Nack` or `None` element is also present as a child of
824 `SequenceAcknowledgement`.

825 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange/@Upper`

826 The RM Destination MUST set the value of this attribute equal to the message number of the highest
827 contiguous message in a Sequence range accepted by the RM Destination.

828 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange/@Lower`

829 The RM Destination MUST set the value of this attribute equal to the message number of the lowest
830 contiguous message in a Sequence range accepted by the RM Destination.

831 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange/@{any}`

832 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
833 element.

834 `/wsrm:SequenceAcknowledgement/wsrm:None`

835 The RM Destination MUST include this element within a `SequenceAcknowledgement` header block if
836 the RM Destination has not accepted any messages for the specified Sequence. The RM Destination
837 MUST NOT include this element if a sibling `AcknowledgementRange` or `Nack` element is also present
838 as a child of the `SequenceAcknowledgement`.

839 `/wsrm:SequenceAcknowledgement/wsrm:Final`

840 The RM Destination MAY include this element within a `SequenceAcknowledgement` header block. This
841 element indicates that the RM Destination is not receiving new messages for the specified Sequence. The
842 RM Source can be assured that the ranges of messages acknowledged by this
843 `SequenceAcknowledgement` header block will not change in the future. The RM Destination MUST
844 include this element when the Sequence is closed. The RM Destination MUST NOT include this element
845 when sending a `Nack`; it can only be used when sending `AcknowledgementRange` elements or a `None`.

846 /wsrm:SequenceAcknowledgement/wsrm:Nack

847 The RM Destination MAY include this element within a SequenceAcknowledgement header block. If
848 used, the RM Destination MUST set the value of this element to a MessageNumberType representing
849 the MessageNumber of an unreceived message in a Sequence. The RM Destination MUST NOT include
850 a Nack element if a sibling AcknowledgementRange or None element is also present as a child of
851 SequenceAcknowledgement. Upon the receipt of a Nack, an RM Source SHOULD retransmit the
852 message identified by the Nack. The RM Destination MUST NOT issue a SequenceAcknowledgement
853 containing a Nack for a message that it has previously acknowledged within an
854 AcknowledgementRange. The RM Source SHOULD ignore a SequenceAcknowledgement containing
855 a Nack for a message that has previously been acknowledged within an AcknowledgementRange.

856 /wsrm:SequenceAcknowledgement/{any}

857 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
858 to be passed.

859 /wsrm:SequenceAcknowledgement/@{any}

860 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
861 element.

862 The following examples illustrate SequenceAcknowledgement elements:

- 863 • Message numbers 1..10 inclusive in a Sequence have been accepted by the RM Destination.

```
864 <wsrm:SequenceAcknowledgement>  
865   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
866   <wsrm:AcknowledgementRange Upper="10" Lower="1"/>  
867 </wsrm:SequenceAcknowledgement>
```

- 868 • Message numbers 1..2, 4..6, and 8..10 inclusive in a Sequence have been accepted by the RM
869 Destination, messages 3 and 7 have not been accepted.

```
870 <wsrm:SequenceAcknowledgement>  
871   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
872   <wsrm:AcknowledgementRange Upper="2" Lower="1"/>  
873   <wsrm:AcknowledgementRange Upper="6" Lower="4"/>  
874   <wsrm:AcknowledgementRange Upper="10" Lower="8"/>  
875 </wsrm:SequenceAcknowledgement>
```

- 876 • Message number 3 in a Sequence has not been accepted by the RM Destination.

```
877 <wsrm:SequenceAcknowledgement>  
878   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
879   <wsrm:Nack>3</wsrm:Nack>  
880 </wsrm:SequenceAcknowledgement>
```


4 Faults

Faults for the `CreateSequence` message exchange are treated as defined in WS-Addressing. Create Sequence Refused is a possible fault reply for this operation. Unknown Sequence is a fault generated by Endpoints when messages carrying RM header blocks targeted at unrecognized or terminated Sequences are detected. `WSRMRequired` is a fault generated an RM Destination that requires the use of WS-RM on a Received message that did not use the protocol. All other faults in this section relate to known Sequences. Destinations that generate faults related to known sequences SHOULD transmit those faults. If transmitted, such faults MUST be transmitted to the same [destination] as Acknowledgement messages.

Entities that generate WS-ReliableMessaging faults MUST include as the [action] property the default fault action IRI defined below. The value from the W3C Recommendation is below for informational purposes:

```
http://docs.oasis-open.org/ws-rx/wsrn/200702/fault
```

The faults defined in this section are generated if the condition stated in the preamble is met. Fault handling rules are defined in section 6 of WS-Addressing SOAP Binding.

The definitions of faults use the following properties:

[Code] The fault code.

[Subcode] The fault subcode.

[Reason] The English language reason element.

[Detail] The detail element(s). If absent, no detail element is defined for the fault. If more than one detail element is defined for a fault, implementations MUST include the elements in the order that they are specified.

Entities that generate WS-ReliableMessaging faults MUST set the [Code] property to either "Sender" or "Receiver". These properties are serialized into text XML as follows:

SOAP Version	Sender	Receiver
SOAP 1.1	S11:Client	S11:Server
SOAP 1.2	S:Sender	S:Receiver

The properties above bind to a SOAP 1.2 fault as follows:

```
<S:Envelope>
  <S:Header>
    <wsa:Action>
      http://docs.oasis-open.org/ws-rx/wsrn/200702/fault
    </wsa:Action>
    <!-- Headers elided for brevity. -->
  </S:Header>
  <S:Body>
    <S:Fault>
      <S:Code>
        <S:Value> [Code] </S:Value>
        <S:Subcode>
          <S:Value> [Subcode] </S:Value>
        </S:Subcode>
      </S:Code>
      <S:Reason>
        <S:Text xml:lang="en"> [Reason] </S:Text>
      </S:Reason>
    </S:Fault>
  </S:Body>
</S:Envelope>
```

```

924     [Detail]
925     ...
926   </S:Detail>
927 </S:Fault>
928 </S:Body>
929 </S:Envelope>

```

930 The properties above bind to a SOAP 1.1 fault as follows when the fault is triggered by processing an RM
 931 header block:

```

932 <S11:Envelope>
933   <S11:Header>
934     <wsrm:SequenceFault>
935       <wsrm:FaultCode> wsrm:FaultCodes </wsrm:FaultCode>
936       <wsrm:Detail> [Detail] </wsrm:Detail>
937       ...
938     </wsrm:SequenceFault>
939     <!-- Headers elided for brevity. -->
940   </S11:Header>
941   <S11:Body>
942     <S11:Fault>
943       <faultcode> [Code] </faultcode>
944       <faultstring> [Reason] </faultstring>
945     </S11:Fault>
946   </S11:Body>
947 </S11:Envelope>

```

948 The properties bind to a SOAP 1.1 fault as follows when the fault is generated as a result of processing a
 949 `CreateSequence` request message:

```

950 <S11:Envelope>
951   <S11:Body>
952     <S11:Fault>
953       <faultcode> [Subcode] </faultcode>
954       <faultstring> [Reason] </faultstring>
955     </S11:Fault>
956   </S11:Body>
957 </S11:Envelope>

```

958 4.1 SequenceFault Element

959 The purpose of the `SequenceFault` element is to carry the specific details of a fault generated during
 960 the reliable messaging specific processing of a message belonging to a Sequence. WS-
 961 ReliableMessaging nodes MUST use the `SequenceFault` container only in conjunction with the SOAP
 962 1.1 fault mechanism. WS-ReliableMessaging nodes MUST NOT use the `SequenceFault` container in
 963 conjunction with the SOAP 1.2 binding.

964 The following exemplar defines its syntax:

```

965 <wsrm:SequenceFault ...>
966   <wsrm:FaultCode> wsrm:FaultCodes </wsrm:FaultCode>
967   <wsrm:Detail> ... </wsrm:Detail> ?
968   ...
969 </wsrm:SequenceFault>

```

970 The following describes the content model of the `SequenceFault` element.

971 `/wsrm:SequenceFault`

972 This is the element containing Sequence information for WS-ReliableMessaging

973 /wsrm:SequenceFault/wsrm:FaultCode

974 WS-ReliableMessaging nodes that generate a `SequenceFault` MUST set the value of this element to a
975 qualified name from the set of fault [Subcodes] defined below.

976 /wsrm:SequenceFault/wsrm:Detail

977 This element, if present, carries application specific error information related to the fault being described.

978 /wsrm:SequenceFault/wsrm:Detail/{any}

979 The application specific error information related to the fault being described.

980 /wsrm:SequenceFault/wsrm:Detail/@{any}

981 The application specific error information related to the fault being described.

982 /wsrm:SequenceFault/{any}

983 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,
984 to be passed.

985 /wsrm:SequenceFault/@{any}

986 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the
987 element.

988 4.2 Sequence Terminated

989 The Endpoint that generates this fault SHOULD make every reasonable effort to notify the corresponding
990 Endpoint of this decision.

991 Properties:

992 [Code] Sender or Receiver

993 [Subcode] wsrm:SequenceTerminated

994 [Reason] The Sequence has been terminated due to an unrecoverable error.

995 [Detail]

996 `<wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source or RM Destination.	Encountering an unrecoverable condition or detection of violation of the protocol.	Sequence termination.	MUST terminate the Sequence if not otherwise terminated.

997 4.3 Unknown Sequence

998 Properties:

999 [Code] Sender

1000 [Subcode] wsrm:UnknownSequence

1001 [Reason] The value of wsrn:Identifier is not a known Sequence identifier.

1002 [Detail]

1003 `<wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source or RM Destination.	In response to a message containing an unknown or terminated Sequence identifier.	None.	MUST terminate the Sequence if not otherwise terminated.

1004 4.4 Invalid Acknowledgement

1005 An example of when this fault is generated is when a message is Received by the RM Source containing
1006 a SequenceAcknowledgement covering messages that have not been sent.

1007 [Code] Sender

1008 [Subcode] wsrn:InvalidAcknowledgement

1009 [Reason] The SequenceAcknowledgement violates the cumulative Acknowledgement invariant.

1010 [Detail]

1011 `<wsrm:SequenceAcknowledgement ...> ... </wsrm:SequenceAcknowledgement>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source.	In response to a SequenceAcknowledgement element that violate the invariants stated in 2.3 or any of the requirements in 3.9 about valid combinations of AckRange, Nack and None in a single SequenceAcknowledgement element or with respect to already Received such elements.	Unspecified.	Unspecified.

1012 4.5 Message Number Rollover

1013 If the condition listed below is reached, the RM Destination MUST generate this fault.

1014 Properties:

1015 [Code] Sender

1016 [Subcode] wsrn:MessageNumberRollover

1017 [Reason] The maximum value for wsrn:MessageNumber has been exceeded.

1018 [Detail]

```
1019 <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
1020 <wsrm:MaxMessageNumber> wsrm:MessageNumberType </wsrm:MaxMessageNumber>
```

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Destination.	Message number in /wsrm:Sequence/wsrm:MessageNumber of a Received message exceeds the internal limitations of an RM Destination or reaches the maximum value of 9,223,372,036,854,775,807.	RM Destination SHOULD continue to accept undelivered messages until the Sequence is closed or terminated.	RM Source SHOULD continue to retransmit undelivered messages until the Sequence is closed or terminated.

1021 4.6 Create Sequence Refused

1022 Properties:

1023 [Code] Sender or Receiver

1024 [Subcode] wsrm:CreateSequenceRefused

1025 [Reason] The Create Sequence request has been refused by the RM Destination.

1026 [Detail]

```
1027 xs:any
```

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Destination.	In response to a CreateSequence message when the RM Destination does not wish to create a new Sequence.	Unspecified.	Sequence terminated.

1028 4.7 Sequence Closed

1029 This fault is generated by an RM Destination to indicate that the specified Sequence has been closed.

1030 This fault MUST be generated when an RM Destination is asked to accept a message for a Sequence that
1031 is closed.

1032 Properties:

1033 [Code] Sender

1034 [Subcode] wsrm:SequenceClosed

1035 [Reason] The Sequence is closed and cannot accept new messages.

1036 [Detail]

1037 `<wsrm:Identifier...> xs:anyURI </wsrm:Identifier>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Destination.	In response to a message that belongs to a Sequence that is already closed.	Unspecified.	Sequence closed.

1038 4.8 WSRM Required

1039 If an RM Destination requires the use of WS-RM, this fault is generated when it Receives an incoming
1040 message that did not use this protocol.

1041 Properties:

1042 [Code] Sender

1043 [Subcode] wsrm:WSRMRequired

1044 [Reason] The RM Destination requires the use of WSRM.

1045 [Detail]

1046 `xs:any`

5 Security Threats and Countermeasures

This specification considers two sets of security requirements, those of the applications that use the WS-RM protocol and those of the protocol itself.

This specification makes no assumptions about the security requirements of the applications that use WS-RM. However, once those requirements have been satisfied within a given operational context, the addition of WS-RM to this operational context should not undermine the fulfillment of those requirements; the use of WS-RM should not create additional attack vectors within an otherwise secure system.

There are many other security concerns that one may need to consider when implementing or using this protocol. The material below should not be considered as a "check list". Implementers and users of this protocol are urged to perform a security analysis to determine their particular threat profile and the appropriate responses to those threats.

Implementers are also advised that there is a core tension between security and reliable messaging that can be problematic if not addressed by implementations; one aspect of security is to prevent message replay but one of the invariants of this protocol is to resend messages until they are acknowledged. Consequently, if the security sub-system processes a message but a failure occurs before the reliable messaging sub-system Receives that message, then it is possible (and likely) that the security sub-system will treat subsequent copies as replays and discard them. At the same time, the reliable messaging sub-system will likely continue to expect and even solicit the missing message(s). Care should be taken to avoid and prevent this condition.

5.1 Threats and Countermeasures

The primary security requirement of this protocol is to protect the specified semantics and protocol invariants against various threats. The following sections describe several threats to the integrity and operation of this protocol and provide some general outlines of countermeasures to those threats. Implementers and users of this protocol should keep in mind that all threats are not necessarily applicable to all operational contexts.

5.1.1 Integrity Threats

In general, any mechanism which allows an attacker to alter the information in a Sequence Traffic Message, Sequence Lifecycle Message, Acknowledgement Messages, Acknowledgement Request, or Sequence-related fault, or which allows an attacker to alter the correlation of a RM Protocol Header Block to its intended message represents a threat to the WS-RM protocol.

For example, if an attacker is able to swap *Sequence* headers on messages in transit between the RM Source and RM Destination then they have undermined the implementation's ability to guarantee the first invariant described in Section 2.3. The result is that there is no way of guaranteeing that messages will be Delivered to the Application Destination in the same order that they were sent by the Application Source.

5.1.1.1 Countermeasures

Integrity threats are generally countered via the use of digital signatures some level of the communication protocol stack. Note that, in order to counter header swapping attacks, the signature SHOULD include both the SOAP body and any relevant SOAP headers (e.g. *Sequence* header). Because some headers (*AckRequested*, *SequenceAcknowledgement*) are independent of the body of the SOAP message in which they occur, implementations MUST allow for signatures that cover only these headers.

5.1.2 Resource Consumption Threats

The creation of a Sequence with an RM Destination consumes various resources on the systems used to implement that RM Destination. These resources can include network connections, database tables, message queues, etc. This behavior can be exploited to conduct denial of service attacks against an RM Destination. For example, a simple attack is to repeatedly send `CreateSequence` messages to an RM Destination. Another attack is to create a Sequence for a service that is known to require in-order message Delivery and use this Sequence to send a stream of very large messages to that service, making sure to omit message number “1” from that stream.

5.1.2.1 Countermeasures

There are a number of countermeasures against the described resource consumption threats. The technique advocated by this specification is for the RM Destination to restrict the ability to create a Sequence to a specific set of entities/principals. This reduces the number of potential attackers and, in some cases, allows the identity of any attackers to be determined.

The ability to restrict Sequence creation depends, in turn, upon the RM Destination's ability identify and authenticate the RM Source that issued the `CreateSequence` message.

5.1.3 Sequence Spoofing Threats

Sequence spoofing is a class of threats in which the attacker uses knowledge of the `Identifier` for a particular Sequence to forge Sequence Lifecycle or Traffic Messages. For example the attacker creates a fake `TerminateSequence` message that references the target Sequence and sends this message to the appropriate RM Destination. Some sequence spoofing attacks also require up-to-date knowledge of the current `MessageNumber` for their target Sequence.

In general any Sequence Lifecycle Message, RM Protocol Header Block, or sequence-correlated SOAP fault (e.g. `InvalidAcknowledgement`) can be used by someone with knowledge of the Sequence identifier to attack the Sequence. These attacks are “two-way” in that an attacker may choose to target the RM Source by, for example, inserting a fake `SequenceAcknowledgement` header into a message that it sends to the `AcksTo` EPR of an RM Source.

5.1.3.1 Sequence Hijacking

Sequence hijacking is a specific case of a sequence spoofing attack. The attacker attempts to inject Sequence Traffic Messages into an existing Sequence by inserting fake `Sequence` headers into those messages.

Note that “sequence hijacking” should not be equated with “security session hijacking”. Although a Sequence may be bound to some form of a security session in order to counter the threats described in this section, applications MUST NOT rely on WS-RM-related information to make determinations about the identity of the entity that created a message; applications SHOULD rely only upon information that is established by the security infrastructure to make such determinations. Failure to observe this rule creates, among other problems, a situation in which the absence of WS-RM may deprive an application of the ability to authenticate its peers even though the necessary security processing has taken place.

5.1.3.2 Countermeasures

There are a number of countermeasures against sequence spoofing threats. The technique advocated by this specification is to consider the Sequence to be a shared resource that is jointly owned by the RM

1127 Source that initiated its creation (i.e. that sent the `CreateSequence` message) and the RM Destination that
1128 serves as its terminus (i.e. that sent the `CreateSequenceResponse` message). To counter sequence
1129 spoofing attempts the RM Destination SHOULD ensure that every message or fault that it Receives that
1130 refers to a particular Sequence originated from the RM Source that jointly owns the referenced Sequence.
1131 For its part the RM Source SHOULD ensure that every message or fault that it Receives that refers to a
1132 particular Sequence originated from the RM Destination that jointly owns the referenced Sequence.

1133 For the RM Destination to be able to identify its sequence peer it MUST be able to identify and
1134 authenticate the entity that sent the `CreateSequence` message. Similarly for the RM Source to identify its
1135 sequence peer it MUST be able to identify and authenticate the entity that sent the
1136 `CreateSequenceResponse` message. For either the RM Destination or the RM Source to determine if a
1137 message was sent by its sequence peer it MUST be able to identify and authenticate the initiator of that
1138 message and, if necessary, correlate this identity with the sequence peer identity established at sequence
1139 creation time.

1140 5.2 Security Solutions and Technologies

1141 The security threats described in the previous sections are neither new nor unique. The solutions that
1142 have been developed to secure other SOAP-based protocols can be used to secure WS-RM as well. This
1143 section maps the facilities provided by common web services security solutions against countermeasures
1144 described in the previous sections.

1145 Before continuing this discussion, however, some examination of the underlying requirements of the
1146 previously described countermeasures is necessary. Specifically it should be noted that the technique
1147 described in Section 5.1.2.1 has two components. Firstly, the RM Destination identifies and authenticates
1148 the issuer of a `CreateSequence` message. Secondly, the RM Destination performs an authorization check
1149 against this authenticated identity and determines if the RM Source is permitted to create Sequences with
1150 the RM Destination. Since the facilities for performing this authorization check (runtime infrastructure,
1151 policy frameworks, etc.) lie completely within the domain of individual implementations, any discussion of
1152 such facilities is considered to be beyond the scope of this specification.

1153 5.2.1 Transport Layer Security

1154 This section describes how the facilities provided by SSL/TLS [RFC 4346] can be used to implement the
1155 countermeasures described in the previous sections. The use of SSL/TLS is subject to the constraints
1156 defined in Section 4 of the Basic Security Profile 1.0 [BSP 1.0].

1157 The description provided here is general in nature and is not intended to serve as a complete definition on
1158 the use of SSL/TLS to protect WS-RM. In order to interoperate implementations need to agree on the
1159 choice of features as well as the manner in which they will be used. The mechanisms described in the
1160 Web Services Security Policy Language [SecurityPolicy] MAY be used by services to describe the
1161 requirements and constraints of the use of SSL/TLS.

1162 5.2.1.1 Model

1163 The basic model for using SSL/TLS is as follows:

- 1164 1. The RM Source establishes an SSL/TLS session with the RM Destination.
- 1165 2. The RM Source uses this SSL/TLS session to send a `CreateSequence` message to the RM
1166 Destination.

- 1167 3. The RM Destination establishes an SSL/TLS session with the RM Source and sends an
1168 asynchronous `CreateSequenceResponse` using this session. Alternately it may respond with a
1169 synchronous `CreateSequenceResponse` using the session established in (1).
- 1170 4. For the lifetime of the Sequence the RM Source uses the SSL/TLS session from (1) to Transmit
1171 any and all messages or faults that refer to that Sequence.
- 1172 5. For the lifetime of the Sequence the RM Destination either uses the SSL/TLS session established
1173 in (3) to Transmit any and all messages or faults that refer to that Sequence or, for synchronous
1174 exchanges, the RM Destination uses the SSL/TLS session established in (1).

1175 5.2.1.2 Countermeasure Implementation

1176 Used in its simplest fashion (without relying upon any authentication mechanisms), SSL/TLS provides the
1177 necessary integrity qualities to counter the threats described in Section 5.1.1. Note, however, that the
1178 nature of SSL/TLS limits the scope of this integrity protection to a single transport level session. If
1179 SSL/TLS is the only mechanism used to provide integrity, any intermediaries between the RM Source and
1180 the RM Destination MUST be trusted to preserve the integrity of the messages that flow through them.

1181 As noted, the technique described in Sections 5.1.2.1 involves the use of authentication. This specification
1182 advocates either of two mechanisms for authenticating entities using SSL/TLS. In both of these methods
1183 the SSL/TLS server (the party accepting the SSL/TLS connection) authenticates itself to the SSL/TLS
1184 client using an X.509 certificate that is exchanged during the SSL/TLS handshake.

- 1185 • **HTTP Basic Authentication:** This method of authentication presupposes that a SOAP/HTTP
1186 binding is being used as part of the protocol stack beneath WS-RM. Subsequent to the
1187 establishment of the SSL/TLS session, the sending party authenticates itself to the receiving party
1188 using HTTP Basic Authentication [RFC 2617]. For example, a RM Source might authenticate itself
1189 to a RM Destination (e.g. when transmitting a Sequence Traffic Message) using BasicAuth.
1190 Similarly the RM Destination might authenticate itself to the RM Source (e.g. when sending an
1191 Acknowledgement) using BasicAuth.
- 1192 • **SSL/TLS Client Authentication:** In this method of authentication, the party initiating the
1193 connection authenticates itself to the party accepting the connection using an X.509 certificate
1194 that is exchanged during the SSL/TLS handshake.

1195 To implement the countermeasures described in section 5.1.2.1 the RM Source must authenticate itself
1196 using one the above mechanisms. The authenticated identity can then be used to determine if the RM
1197 Source is authorized to create a Sequence with the RM Destination.

1198 This specification advocates implementing the countermeasures described in section 5.1.3.2 by requiring
1199 an RM node's Sequence peer to be equivalent to their SSL/TLS session peer. This allows the
1200 authorization decisions described in section 5.1.3.2 to be based on SSL/TLS session identity rather than
1201 on authentication information. For example, an RM Destination can determine that a Sequence Traffic
1202 Message rightfully belongs to its referenced Sequence if that message arrived over the same SSL/TLS
1203 session that was used to carry the `CreateSequence` message for that Sequence. Note that requiring a
1204 one-to-one relationship between SSL/TLS session peer and Sequence peer constrains the lifetime of a
1205 SSL/TLS-protected Sequence to be less than or equal to the lifetime of the SSL/TLS session that is used
1206 to protect that Sequence.

1207 This specification does not preclude the use of other methods of using SSL/TLS to implement the
1208 countermeasures (such as associating specific authentication information with a Sequence) although such
1209 methods are not covered by this document.

1210 Issues specific to the life-cycle management of SSL/TLS sessions (such as the resumption of a SSL/TLS
1211 session) are outside the scope of this specification.

1212 **5.2.2 SOAP Message Security**

1213 The mechanisms described in WS-Security may be used in various ways to implement the
1214 countermeasures described in the previous sections. This specification advocates using the protocol
1215 described by WS-SecureConversation [SecureConversation] (optionally in conjunction with WS-Trust
1216 [Trust]) as a mechanism for protecting Sequences. The use of WS-Security (as an underlying component
1217 of WS-SecureConversation) is subject to the constraints defined in the Basic Security Profile 1.0.

1218 The description provided here is general in nature and is not intended to serve as a complete definition on
1219 the use of WS-SecureConversation/WS-Trust to protect WS-RM. In order to interoperate implementations
1220 need to agree on the choice of features as well as the manner in which they will be used. The
1221 mechanisms described in the Web Services Security Policy Language MAY be used by services to
1222 describe the requirements and constraints of the use of WS-SecureConversation.

1223 **5.2.2.1 Model**

1224 The basic model for using WS-SecureConversation is as follows:

- 1225 1. The RM Source and the RM Destination create a WS-SecureConversation security context. This
1226 may involve the participation of third parties such as a security token service. The tokens
1227 exchanged may contain authentication claims (e.g. X.509 certificates or Kerberos service tickets).
- 1228 2. During the `CreateSequence` exchange, the RM Source SHOULD explicitly identify the security
1229 context that will be used to protect the Sequence. This is done so that, in cases where the
1230 `CreateSequence` message is signed by more than one security context, the RM Source can
1231 indicate which security context should be used to protect the newly created Sequence.
- 1232 3. For the lifetime of the Sequence the RM Source and the RM Destination use the session key(s)
1233 associated with the security context to sign (as defined by WS-Security) at least the body and any
1234 relevant WS-RM-defined headers of any and all messages or faults that refer to that Sequence.

1235 **5.2.2.2 Countermeasure Implementation**

1236 Without relying upon any authentication information, the per-message signatures provide the necessary
1237 integrity qualities to counter the threats described in Section 5.1.1.

1238 To implement the countermeasures described in section 5.1.2.1 some mutually agreed upon form of
1239 authentication claims must be provided by the RM Source to the RM Destination during the establishment
1240 of the Security Context. These claims can then be used to determine if the RM Source is authorized to
1241 create a Sequence with the RM Destination.

1242 This specification advocates implementing the countermeasures described in section 5.1.3.2 by requiring
1243 an RM node's Sequence peer to be equivalent to their security context session peer. This allows the
1244 authorization decisions described in section 5.1.3.2 to be based on the identity of the message's security
1245 context rather than on any authentication claims that may have been established during security context
1246 initiation. Note that other methods of using WS-SecureConversation to implement the countermeasures
1247 (such as associating specific authentication claims to a Sequence) are possible but not covered by this
1248 document.

1249 As with transport security, the requisite equivalence of a security context peer and with a Sequence peer
1250 limits the lifetime of a Sequence to the lifetime of the protecting security context. Unlike transport security,

1251 the association between a Sequence and its protecting security context cannot always be established
1252 implicitly at Sequence creation time. This is due to the fact that the `CreateSequence` and
1253 `CreateSequenceResponse` messages may be signed by more than one security context.

1254 Issues specific to the life-cycle management of WS-SecureConversation security contexts (such as
1255 amending or renewing contexts) are outside the scope of this specification.

6 Securing Sequences

As noted in Section 5, the RM Source and RM Destination should be able to protect their shared Sequences against the threat of Sequence Spoofing attacks. There are a number of OPTIONAL means of achieving this objective depending upon the underlying security infrastructure.

6.1 Securing Sequences Using WS-Security

One mechanism for protecting a Sequence is to include a security token using a `wsse:SecurityTokenReference` element from WS-Security (see section 9 in WS-SecureConversation) in the `CreateSequence` element. This establishes an association between the created (and, if present, offered) Sequence(s) and the referenced security token, such that the RM Source and Destination MUST use the security token as the basis for authorization of all subsequent interactions related to the Sequence(s). The `wsse:SecurityTokenReference` explicitly identifies the token as there may be more than one token on a `CreateSequence` message or inferred from the communication context (e.g. transport protection).

It is RECOMMENDED that a message independent referencing mechanism be used to identify the token, if the token being referenced supports such mechanism.

The following exemplar defines the `CreateSequence` syntax when extended to include a `wsse:SecurityTokenReference`:

```
<wsrm:CreateSequence ...>
  <wsrm:AcksTo> wsa:EndpointReferenceType </wsrm:AcksTo>
  <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
  <wsrm:Offer ...>
    <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
    <wsrm:Endpoint> wsa:EndpointReferenceType </wsrm:Endpoint>
    <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
    <wsrm:IncompleteSequenceBehavior>
      wsrml:IncompleteSequenceBehaviorType
    </wsrm:IncompleteSequenceBehavior> ?
    ...
  </wsrm:Offer> ?
  ...
  <wsse:SecurityTokenReference>
    ...
  </wsse:SecurityTokenReference> ?
  ...
</wsrm:CreateSequence>
```

The following describes the content model of the additional `CreateSequence` elements.

`/wsrm:CreateSequence/wsse:SecurityTokenReference`

This element uses the extensibility mechanism defined for the `CreateSequence` element (defined in section 3.4) to communicate an explicit reference to the security token, using a `wsse:SecurityTokenReference` as documented in WS-Security, that the RM Source and Destination MUST use to authorize messages for the created (and, if present, the offered) Sequence(s). All subsequent messages related to the created (and, if present, the offered) Sequence(s) MUST demonstrate proof-of-possession of the secret associated with the token (e.g., by using or deriving from a private or secret key).

When a RM Source transmits a `CreateSequence` that has been extended to include a `wsse:SecurityTokenReference` it SHOULD ensure that the RM Destination both understands and will conform to the requirements listed above. In order to achieve this, the RM Source SHOULD include

1303 the `UsesSequenceSTR` element as a SOAP header block within the `CreateSequence` message. This
1304 element MUST include a `soap:mustUnderstand` attribute with a value of 'true'. Thus the RM Source
1305 can be assured that a RM Destination that responds with a `CreateSequenceResponse` understands
1306 and conforms with the requirements listed above. Note that an RM Destination understanding this header
1307 does not mean that it has processed and understood any WS-Security headers, the fault behavior defined
1308 in WS-Security still applies.

1309 The following exemplar defines the `UsesSequenceSTR` syntax:

```
1310 <wsrm:UsesSequenceSTR ... />
```

1311 The following describes the content model of the `UsesSequenceSTR` header block.

1312 `/wsrm:UsesSequenceSTR`

1313 This element SHOULD be included as a SOAP header block in `CreateSequence` messages that use the
1314 extensibility mechanism described above in this section. The `soap:mustUnderstand` attribute value
1315 MUST be 'true'. The receiving RM Destination MUST understand and correctly implement the extension
1316 described above or else generate a `soap:MustUnderstand` fault, thus aborting the requested
1317 Sequence creation.

1318 The following is an example of a `CreateSequence` message using the
1319 `wsse:SecurityTokenReference` extension and the `UsesSequenceSTR` header block:

```
1320 <soap:Envelope ...>  
1321   <soap:Header>  
1322     ...  
1323     <wsrm:UsesSequenceSTR soap:mustUnderstand='true' />  
1324     ...  
1325   </soap:Header>  
1326   <soap:Body>  
1327     <wsrm:CreateSequence>  
1328       <wsrm:AcksTo>  
1329         <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>  
1330       </wsrm:AcksTo>  
1331       <wsse:SecurityTokenReference>  
1332         ...  
1333       </wsse:SecurityTokenReference>  
1334     </wsrm:CreateSequence>  
1335   </soap:Body>  
1336 </soap:Envelope>
```

1337 6.2 Securing Sequences Using SSL/TLS

1338 One mechanism for protecting a Sequence is to bind the Sequence to the underlying SSL/TLS session(s).
1339 The RM Source indicates to the RM Destination that a Sequence is to be bound to the underlying
1340 SSL/TLS session(s) via the `UsesSequenceSSL` header block. If the RM Source wishes to bind a
1341 Sequence to the underlying SSL/TLS sessions(s) it MUST include the `UsesSequenceSSL` element as a
1342 SOAP header block within the `CreateSequence` message.

1343 The following exemplar defines the `UsesSequenceSSL` syntax:

```
1344 <wsrm:UsesSequenceSSL soap:mustUnderstand="true" ... />
```

1345 The following describes the content model of the `UsesSequenceSSL` header block.

1346 `/wsrm:UsesSequenceSSL`

1347 The RM Source MAY include this element as a SOAP header block of a `CreateSequence` message to
1348 indicate to the RM Destination that the resulting Sequence is to be bound to the SSL/TLS session that was

1349 used to carry the `CreateSequence` message. If included, the RM Source MUST mark this header with a
1350 `soap:mustUnderstand` attribute with a value of 'true'. The receiving RM Destination MUST understand
1351 and correctly implement the functionality described in Section 5.2.1 or else generate a
1352 `soap:MustUnderstand` fault, thus aborting the requested Sequence creation.

1353 Note that the use inclusion of the above header by the RM Source implies that all Sequence-related
1354 information (Sequence Lifecycle or Acknowledgment messages or Sequence-related faults) flowing from
1355 the RM Destination to the RM Source will be bound to the SSL/TLS session that is used to carry the
1356 `CreateSequenceResponse` message.

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Appendix A. Schema

The normative schema that is defined for WS-ReliableMessaging using [XML-Schema Part1] and [XML-Schema Part2] is located at:

<http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-schema-200702.xsd>

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```
<?xml version="1.0" encoding="UTF-8"?>
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FOR A PARTICULAR PURPOSE.
-->
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:wsa="http://www.w3.org/2005/08/addressing"
xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
targetNamespace="http://docs.oasis-open.org/ws-rx/wsrn/200702"
elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:import namespace="http://www.w3.org/2005/08/addressing"
schemaLocation="http://www.w3.org/2006/03/addressing/ws-addr.xsd"/>
  <!-- Protocol Elements -->
  <xs:complexType name="SequenceType">
    <xs:sequence>
      <xs:element ref="wsrm:Identifier"/>
      <xs:element name="MessageNumber" type="wsrm:MessageNumberType"/>
      <xs:any namespace="##other" processContents="lax" minOccurs="0"
maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

```

1502     <xs:anyAttribute namespace="##other" processContents="lax"/>
1503 </xs:complexType>
1504 <xs:element name="Sequence" type="wsrm:SequenceType"/>
1505 <xs:element name="SequenceAcknowledgement">
1506   <xs:complexType>
1507     <xs:sequence>
1508       <xs:element ref="wsrm:Identifier"/>
1509       <xs:choice>
1510         <xs:sequence>
1511           <xs:choice>
1512             <xs:element name="AcknowledgementRange" maxOccurs="unbounded">
1513               <xs:complexType>
1514                 <xs:sequence/>
1515                 <xs:attribute name="Upper" type="xs:unsignedLong"
1516 use="required"/>
1517                 <xs:attribute name="Lower" type="xs:unsignedLong"
1518 use="required"/>
1519               <xs:anyAttribute namespace="##other" processContents="lax"/>
1520             </xs:complexType>
1521           </xs:element>
1522           <xs:element name="None">
1523             <xs:complexType>
1524               <xs:sequence/>
1525             </xs:complexType>
1526           </xs:element>
1527         </xs:choice>
1528         <xs:element name="Final" minOccurs="0">
1529           <xs:complexType>
1530             <xs:sequence/>
1531           </xs:complexType>
1532         </xs:element>
1533       </xs:sequence>
1534       <xs:element name="Nack" type="xs:unsignedLong"
1535 maxOccurs="unbounded"/>
1536     </xs:choice>
1537     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1538 maxOccurs="unbounded"/>
1539   </xs:sequence>
1540   <xs:anyAttribute namespace="##other" processContents="lax"/>
1541 </xs:complexType>
1542 </xs:element>
1543 <xs:complexType name="AckRequestedType">
1544   <xs:sequence>
1545     <xs:element ref="wsrm:Identifier"/>
1546     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1547 maxOccurs="unbounded"/>
1548   </xs:sequence>
1549   <xs:anyAttribute namespace="##other" processContents="lax"/>
1550 </xs:complexType>
1551 <xs:element name="AckRequested" type="wsrm:AckRequestedType"/>
1552 <xs:element name="Identifier">
1553   <xs:complexType>
1554     <xs:annotation>
1555       <xs:documentation>
1556         This type is for elements whose [children] is an anyURI and can have
1557 arbitrary attributes.
1558       </xs:documentation>
1559     </xs:annotation>
1560     <xs:simpleContent>
1561       <xs:extension base="xs:anyURI">
1562         <xs:anyAttribute namespace="##other" processContents="lax"/>
1563       </xs:extension>
1564     </xs:simpleContent>

```

```

1565     </xs:complexType>
1566 </xs:element>
1567 <xs:element name="Address">
1568   <xs:complexType>
1569     <xs:simpleContent>
1570       <xs:extension base="xs:anyURI">
1571         <xs:anyAttribute namespace="##other" processContents="lax"/>
1572       </xs:extension>
1573     </xs:simpleContent>
1574   </xs:complexType>
1575 </xs:element>
1576 <xs:simpleType name="MessageNumberType">
1577   <xs:restriction base="xs:unsignedLong">
1578     <xs:minInclusive value="1"/>
1579     <xs:maxInclusive value="9223372036854775807"/>
1580   </xs:restriction>
1581 </xs:simpleType>
1582 <!-- Fault Container and Codes -->
1583 <xs:simpleType name="FaultCodes">
1584   <xs:restriction base="xs:QName">
1585     <xs:enumeration value="wsrm:SequenceTerminated"/>
1586     <xs:enumeration value="wsrm:UnknownSequence"/>
1587     <xs:enumeration value="wsrm:InvalidAcknowledgement"/>
1588     <xs:enumeration value="wsrm:MessageNumberRollover"/>
1589     <xs:enumeration value="wsrm:CreateSequenceRefused"/>
1590     <xs:enumeration value="wsrm:SequenceClosed"/>
1591     <xs:enumeration value="wsrm:WSRMRequired"/>
1592     <xs:enumeration value="wsrm:UnsupportedSelection"/>
1593   </xs:restriction>
1594 </xs:simpleType>
1595 <xs:complexType name="SequenceFaultType">
1596   <xs:sequence>
1597     <xs:element name="FaultCode" type="wsrm:FaultCodes"/>
1598     <xs:element name="Detail" type="wsrm:DetailType" minOccurs="0"/>
1599     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1600 maxOccurs="unbounded"/>
1601   </xs:sequence>
1602   <xs:anyAttribute namespace="##other" processContents="lax"/>
1603 </xs:complexType>
1604 <xs:complexType name="DetailType">
1605   <xs:sequence>
1606     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1607 maxOccurs="unbounded"/>
1608   </xs:sequence>
1609   <xs:anyAttribute namespace="##other" processContents="lax"/>
1610 </xs:complexType>
1611 <xs:element name="SequenceFault" type="wsrm:SequenceFaultType"/>
1612 <xs:element name="CreateSequence" type="wsrm:CreateSequenceType"/>
1613 <xs:element name="CreateSequenceResponse"
1614 type="wsrm:CreateSequenceResponseType"/>
1615 <xs:element name="CloseSequence" type="wsrm:CloseSequenceType"/>
1616 <xs:element name="CloseSequenceResponse"
1617 type="wsrm:CloseSequenceResponseType"/>
1618 <xs:element name="TerminateSequence" type="wsrm:TerminateSequenceType"/>
1619 <xs:element name="TerminateSequenceResponse"
1620 type="wsrm:TerminateSequenceResponseType"/>
1621 <xs:complexType name="CreateSequenceType">
1622   <xs:sequence>
1623     <xs:element ref="wsrm:AcksTo"/>
1624     <xs:element ref="wsrm:Expires" minOccurs="0"/>
1625     <xs:element name="Offer" type="wsrm:OfferType" minOccurs="0"/>
1626     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1627 maxOccurs="unbounded"/>

```

```

1628     <xs:annotation>
1629         <xs:documentation>
1630             It is the authors intent that this extensibility be used to
1631 transfer a Security Token Reference as defined in WS-Security.
1632         </xs:documentation>
1633     </xs:annotation>
1634 </xs:any>
1635 </xs:sequence>
1636 <xs:anyAttribute namespace="##other" processContents="lax"/>
1637 </xs:complexType>
1638 <xs:complexType name="CreateSequenceResponseType">
1639     <xs:sequence>
1640         <xs:element ref="wsrm:Identifier"/>
1641         <xs:element ref="wsrm:Expires" minOccurs="0"/>
1642         <xs:element name="IncompleteSequenceBehavior"
1643 type="wsrm:IncompleteSequenceBehaviorType" minOccurs="0"/>
1644         <xs:element name="Accept" type="wsrm:AcceptType" minOccurs="0"/>
1645         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1646 maxOccurs="unbounded"/>
1647     </xs:sequence>
1648     <xs:anyAttribute namespace="##other" processContents="lax"/>
1649 </xs:complexType>
1650 <xs:complexType name="CloseSequenceType">
1651     <xs:sequence>
1652         <xs:element ref="wsrm:Identifier"/>
1653         <xs:element name="LastMsgNumber" type="wsrm:MessageNumberType"
1654 minOccurs="0" ref="wsrm:MessageNumberType"/>
1655         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1656 maxOccurs="unbounded"/>
1657     </xs:sequence>
1658     <xs:anyAttribute namespace="##other" processContents="lax"/>
1659 </xs:complexType>
1660 <xs:complexType name="CloseSequenceResponseType">
1661     <xs:sequence>
1662         <xs:element ref="wsrm:Identifier"/>
1663         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1664 maxOccurs="unbounded"/>
1665     </xs:sequence>
1666     <xs:anyAttribute namespace="##other" processContents="lax"/>
1667 </xs:complexType>
1668 <xs:complexType name="TerminateSequenceType">
1669     <xs:sequence>
1670         <xs:element ref="wsrm:Identifier"/>
1671         <xs:element name="LastMsgNumber" type="wsrm:MessageNumberType"
1672 minOccurs="0"/>
1673         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1674 maxOccurs="unbounded"/>
1675     </xs:sequence>
1676     <xs:anyAttribute namespace="##other" processContents="lax"/>
1677 </xs:complexType>
1678 <xs:complexType name="TerminateSequenceResponseType">
1679     <xs:sequence>
1680         <xs:element ref="wsrm:Identifier"/>
1681         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1682 maxOccurs="unbounded"/>
1683     </xs:sequence>
1684     <xs:anyAttribute namespace="##other" processContents="lax"/>
1685 </xs:complexType>
1686 <xs:element name="AcksTo" type="wsa:EndpointReferenceType"/>
1687 <xs:complexType name="OfferType">
1688     <xs:sequence>
1689         <xs:element ref="wsrm:Identifier"/>
1690         <xs:element name="Endpoint" type="wsa:EndpointReferenceType"/>

```

```

1691     <xs:element ref="wsrm:Expires" minOccurs="0"/>
1692     <xs:element name="IncompleteSequenceBehavior"
1693 type="wsrm:IncompleteSequenceBehaviorType" minOccurs="0"/>
1694     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1695 maxOccurs="unbounded"/>
1696   </xs:sequence>
1697   <xs:anyAttribute namespace="##other" processContents="lax"/>
1698 </xs:complexType>
1699 <xs:complexType name="AcceptType">
1700   <xs:sequence>
1701     <xs:element ref="wsrm:AcksTo"/>
1702     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1703 maxOccurs="unbounded"/>
1704   </xs:sequence>
1705   <xs:anyAttribute namespace="##other" processContents="lax"/>
1706 </xs:complexType>
1707 <xs:element name="Expires">
1708   <xs:complexType>
1709     <xs:simpleContent>
1710       <xs:extension base="xs:duration">
1711         <xs:anyAttribute namespace="##other" processContents="lax"/>
1712       </xs:extension>
1713     </xs:simpleContent>
1714   </xs:complexType>
1715 </xs:element>
1716 <xs:simpleType name="IncompleteSequenceBehaviorType">
1717   <xs:restriction base="xs:string">
1718     <xs:enumeration value="DiscardEntireSequence"/>
1719     <xs:enumeration value="DiscardFollowingFirstGap"/>
1720     <xs:enumeration value="NoDiscard"/>
1721   </xs:restriction>
1722 </xs:simpleType>
1723 <xs:element name="UsesSequenceSTR">
1724   <xs:complexType>
1725     <xs:sequence/>
1726     <xs:anyAttribute namespace="##other" processContents="lax"/>
1727   </xs:complexType>
1728 </xs:element>
1729 <xs:element name="UsesSequenceSSL">
1730   <xs:complexType>
1731     <xs:sequence/>
1732     <xs:anyAttribute namespace="##other" processContents="lax"/>
1733   </xs:complexType>
1734 </xs:element>
1735 <xs:element name="UnsupportedElement">
1736   <xs:simpleType>
1737     <xs:restriction base="xs:QName"/>
1738   </xs:simpleType>
1739 </xs:element>
1740 </xs:schema>

```

Appendix B. WSDL

This WSDL describes the WS-RM protocol from the point of view of an RM Destination. In the case where an endpoint acts both as an RM Destination and an RM Source, note that additional messages may be present in exchanges with that endpoint.

Also note that this WSDL is intended to describe the internal structure of the WS-RM protocol, and will not generally appear in a description of a WS-RM-capable Web service. See WS-RM Policy [WS-RM Policy] for a higher-level mechanism to indicate that WS-RM is engaged.

The normative WSDL 1.1 definition for WS-ReliableMessaging is located at:

<http://docs.oasis-open.org/ws-rx/wsrn/200702/wsd/wsrn-1.1-wsd-200702.wsd>

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-->
<wsdl:definitions xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:wsa="http://www.w3.org/2005/08/addressing"
xmlns:wsam="http://www.w3.org/2007/02/addressing/metadata"
xmlns:rm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
xmlns:tns="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsd"
targetNamespace="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsd">
```



```

1794 <wsdl:types>
1795 <xs:schema>
1796 <xs:import namespace="http://docs.oasis-open.org/ws-rx/wsrn/200702"
1797 schemaLocation="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-schema-
1798 200702.xsd"/>
1799 </xs:schema>
1800 </wsdl:types>

1801 <wsdl:message name="CreateSequence">
1802 <wsdl:part name="create" element="rm:CreateSequence"/>
1803 </wsdl:message>
1804 <wsdl:message name="CreateSequenceResponse">
1805 <wsdl:part name="createResponse" element="rm:CreateSequenceResponse"/>
1806 </wsdl:message>
1807 <wsdl:message name="CloseSequence">
1808 <wsdl:part name="close" element="rm:CloseSequence"/>
1809 </wsdl:message>
1810 <wsdl:message name="CloseSequenceResponse">
1811 <wsdl:part name="closeResponse" element="rm:CloseSequenceResponse"/>
1812 </wsdl:message>
1813 <wsdl:message name="TerminateSequence">
1814 <wsdl:part name="terminate" element="rm:TerminateSequence"/>
1815 </wsdl:message>
1816 <wsdl:message name="TerminateSequenceResponse">
1817 <wsdl:part name="terminateResponse"
1818 element="rm:TerminateSequenceResponse"/>
1819 </wsdl:message>

1820 <wsdl:portType name="SequenceAbstractPortType">
1821 <wsdl:operation name="CreateSequence">
1822 <wsdl:input message="tns:CreateSequence" wsam:Action="http://docs.oasis-
1823 open.org/ws-rx/wsrn/200702/CreateSequence"/>
1824 <wsdl:output message="tns:CreateSequenceResponse"
1825 wsam:Action="http://docs.oasis-open.org/ws-
1826 rx/wsrn/200702/CreateSequenceResponse"/>
1827 </wsdl:operation>
1828 <wsdl:operation name="CloseSequence">
1829 <wsdl:input message="tns:CloseSequence" wsam:Action="http://docs.oasis-
1830 open.org/ws-rx/wsrn/200702/CloseSequence"/>
1831 <wsdl:output message="tns:CloseSequenceResponse"
1832 wsam:Action="http://docs.oasis-open.org/ws-
1833 rx/wsrn/200702/CloseSequenceResponse"/>
1834 </wsdl:operation>
1835 <wsdl:operation name="TerminateSequence">
1836 <wsdl:input message="tns:TerminateSequence"
1837 wsam:Action="http://docs.oasis-open.org/ws-rx/wsrn/200702/TerminateSequence"/>
1838 <wsdl:output message="tns:TerminateSequenceResponse"
1839 wsamrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"-
1840 xmlns:tns="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsdl"-
1841 targetNamespace="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsdl">

1842 <wsdl:types>
1843 <xs:schema>
1844 <xs:import namespace="http://docs.oasis-open.org/ws-rx/wsrn/200702"-
1845 schemaLocation="http://docs.oasis-open.org/ws-rx/wsrn/200702/wsrn-1.1-schema-
1846 200702.xsd"/>
1847 </xs:schema>
1848 </wsdl:types>

1849 <wsdl:message name="CreateSequence">
1850 <wsdl:part name="create" element="rm:CreateSequence"/>
1851 </wsdl:message>
1852 <wsdl:message name="CreateSequenceResponse">

```

```

1853 <wsdl:part name="createResponse" element="rm:CreateSequenceResponse"/>
1854 </wsdl:message>
1855 <wsdl:message name="CloseSequence">
1856 <wsdl:part name="close" element="rm:CloseSequence"/>
1857 </wsdl:message>
1858 <wsdl:message name="CloseSequenceResponse">
1859 <wsdl:part name="closeResponse" element="rm:CloseSequenceResponse"/>
1860 </wsdl:message>
1861 <wsdl:message name="TerminateSequence">
1862 <wsdl:part name="terminate" element="rm:TerminateSequence"/>
1863 </wsdl:message>
1864 <wsdl:message name="TerminateSequenceResponse">
1865 <wsdl:part name="terminateResponse"
1866 element="rm:TerminateSequenceResponse"/>
1867 </wsdl:message>
1868 <wsdl:portType name="SequenceAbstractPortType">
1869 <wsdl:operation name="CreateSequence">
1870 <wsdl:input message="tns:CreateSequence" wsaw:Action="http://docs.oasis-
1871 open.org/ws-rx/wsrn/200702/CreateSequence"/>
1872 <wsdl:output message="tns:CreateSequenceResponse"
1873 wsaw:Action="http://docs.oasis-open.org/ws-
1874 rx/wsrn/200702/CreateSequenceResponse"/>
1875 </wsdl:operation>
1876 <wsdl:operation name="CloseSequence">
1877 <wsdl:input message="tns:CloseSequence" wsaw:Action="http://docs.oasis-
1878 open.org/ws-rx/wsrn/200702/CloseSequence"/>
1879 <wsdl:output message="tns:CloseSequenceResponse"
1880 wsaw:Action="http://docs.oasis-open.org/ws-
1881 rx/wsrn/200702/CloseSequenceResponse"/>
1882 </wsdl:operation>
1883 <wsdl:operation name="TerminateSequence">
1884 <wsdl:input message="tns:TerminateSequence"
1885 wsaw:Action="http://docs.oasis-open.org/ws-rx/wsrn/200702/TerminateSequence"/>
1886 <wsdl:output message="tns:TerminateSequenceResponse"
1887 wsaw:Action="http://docs.oasis-open.org/ws-
1888 rx/wsrn/200702/TerminateSequenceResponse"/>
1889 </wsdl:operation>
1890 </wsdl:portType>
1891 </wsdl:definitions>

```

Appendix C. Message Examples

Appendix C.1 Create Sequence

Create Sequence

```
<?xml version="1.0" encoding="UTF-8"?>
<S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
  xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
  xmlns:wsa="http://www.w3.org/2005/08/addressing">
  <S:Header>
    <wsa:MessageID>
      http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546817
    </wsa:MessageID>
    <wsa:To>http://example.com/serviceB/123</wsa:To>
    <wsa:Action>http://docs.oasis-open.org/ws-
rx/wsmr/200702/CreateSequence</wsa:Action>
    <wsa:ReplyTo>
      <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
    </wsa:ReplyTo>
  </S:Header>
  <S:Body>
    <wsmr:CreateSequence>
      <wsmr:AcksTo>
        <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
      </wsmr:AcksTo>
    </wsmr:CreateSequence>
  </S:Body>
</S:Envelope>
```

Create Sequence Response

```
<?xml version="1.0" encoding="UTF-8"?>
<S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
  xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200702"
  xmlns:wsa="http://www.w3.org/2005/08/addressing">
  <S:Header>
    <wsa:To>http://Business456.com/serviceA/789</wsa:To>
    <wsa:RelatesTo>
      http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8a7c2eb546817
    </wsa:RelatesTo>
    <wsa:Action>
      http://docs.oasis-open.org/ws-rx/wsmr/200702/CreateSequenceResponse
    </wsa:Action>
  </S:Header>
  <S:Body>
    <wsmr:CreateSequenceResponse>
      <wsmr:Identifier>http://Business456.com/RM/ABC</wsmr:Identifier>
    </wsmr:CreateSequenceResponse>
  </S:Body>
</S:Envelope>
```

Appendix C.2 Initial Transmission

The following example WS-ReliableMessaging headers illustrate the message exchange in the above figure. The three messages have the following headers; the third message is identified as the last message in the Sequence:

1942 Message 1

```
1943 <?xml version="1.0" encoding="UTF-8"?>
1944 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1945 xmlns:wsm="http://docs.oasis-open.org/ws-rx/wsm/200702"
1946 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1947   <S:Header>
1948     <wsa:MessageID>
1949       http://Business456.com/guid/71e0654e-5ce8-477b-bb9d-34f05cfc9e
1950     </wsa:MessageID>
1951     <wsa:To>http://example.com/serviceB/123</wsa:To>
1952     <wsa:From>
1953       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1954     </wsa:From>
1955     <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1956     <wsm:Sequence>
1957       <wsm:Identifier>http://Business456.com/RM/ABC</wsm:Identifier>
1958       <wsm:MessageNumber>1</wsm:MessageNumber>
1959     </wsm:Sequence>
1960   </S:Header>
1961   <S:Body>
1962     <!-- Some Application Data -->
1963   </S:Body>
1964 </S:Envelope>
```

1965 Message 2

```
1966 <?xml version="1.0" encoding="UTF-8"?>
1967 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1968 xmlns:wsm="http://docs.oasis-open.org/ws-rx/wsm/200702"
1969 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1970   <S:Header>
1971     <wsa:MessageID>
1972       http://Business456.com/guid/daa7d0b2-c8e0-476e-a9a4-d164154e38de
1973     </wsa:MessageID>
1974     <wsa:To>http://example.com/serviceB/123</wsa:To>
1975     <wsa:From>
1976       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1977     </wsa:From>
1978     <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1979     <wsm:Sequence>
1980       <wsm:Identifier>http://Business456.com/RM/ABC</wsm:Identifier>
1981       <wsm:MessageNumber>2</wsm:MessageNumber>
1982     </wsm:Sequence>
1983   </S:Header>
1984   <S:Body>
1985     <!-- Some Application Data -->
1986   </S:Body>
1987 </S:Envelope>
```

1988 Message 3

```
1989 <?xml version="1.0" encoding="UTF-8"?>
1990 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1991 xmlns:wsm="http://docs.oasis-open.org/ws-rx/wsm/200702"
1992 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1993   <S:Header>
1994     <wsa:MessageID>
1995       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546819
1996     </wsa:MessageID>
1997     <wsa:To>http://example.com/serviceB/123</wsa:To>
1998     <wsa:From>
1999       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
```

```

2000 </wsa:From>
2001 <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
2002 <wsrm:Sequence>
2003 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2004 <wsrm:MessageNumber>3</wsrm:MessageNumber>
2005 </wsrm:Sequence>
2006 <wsrm:AckRequested>
2007 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2008 </wsrm:AckRequested>
2009 </S:Header>
2010 <S:Body>
2011 <!-- Some Application Data -->
2012 </S:Body>
2013 </S:Envelope>

```

2014 **Appendix C.3 First Acknowledgement**

2015 Message number 2 has not been accepted by the RM Destination due to some transmission error so it
2016 responds with an Acknowledgement for messages 1 and 3:

```

2017 <?xml version="1.0" encoding="UTF-8"?>
2018 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2019 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
2020 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2021 <S:Header>
2022 <wsa:MessageID>
2023 http://example.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546810
2024 </wsa:MessageID>
2025 <wsa:To>http://Business456.com/serviceA/789</wsa:To>
2026 <wsa:From>
2027 <wsa:Address>http://example.com/serviceB/123</wsa:Address>
2028 </wsa:From>
2029 <wsa:Action>
2030 http://docs.oasis-open.org/ws-rx/wsrn/200702/SequenceAcknowledgement
2031 </wsa:Action>
2032 <wsrm:SequenceAcknowledgement>
2033 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2034 <wsrm:AcknowledgementRange Upper="1" Lower="1"/>
2035 <wsrm:AcknowledgementRange Upper="3" Lower="3"/>
2036 </wsrm:SequenceAcknowledgement>
2037 </S:Header>
2038 <S:Body/>
2039 </S:Envelope>

```

2040 **Appendix C.4 Retransmission**

2041 The RM Sourcediscovers that message number 2 was not accepted so it resends the message and
2042 requests an Acknowledgement:

```

2043 <?xml version="1.0" encoding="UTF-8"?>
2044 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2045 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
2046 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2047 <S:Header>
2048 <wsa:MessageID>
2049 http://Business456.com/guid/daa7d0b2-c8e0-476e-a9a4-d164154e38de
2050 </wsa:MessageID>
2051 <wsa:To>http://example.com/serviceB/123</wsa:To>
2052 <wsa:From>
2053 <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2054 </wsa:From>

```

```

2055 <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
2056 <wsrm:Sequence>
2057 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2058 <wsrm:MessageNumber>2</wsrm:MessageNumber>
2059 </wsrm:Sequence>
2060 <wsrm:AckRequested>
2061 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2062 </wsrm:AckRequested>
2063 </S:Header>
2064 <S:Body>
2065 <!-- Some Application Data -->
2066 </S:Body>
2067 </S:Envelope>

```

2068 Appendix C.5 Termination

2069 The RM Destination now responds with an Acknowledgement for the complete Sequence which can then
 2070 be terminated:

```

2071 <?xml version="1.0" encoding="UTF-8"?>
2072 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2073 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
2074 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2075 <S:Header>
2076 <wsa:MessageID>
2077 http://example.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546811
2078 </wsa:MessageID>
2079 <wsa:To>http://Business456.com/serviceA/789</wsa:To>
2080 <wsa:From>
2081 <wsa:Address>http://example.com/serviceB/123</wsa:Address>
2082 </wsa:From>
2083 <wsa:Action>
2084 http://docs.oasis-open.org/ws-rx/wsrn/200702/SequenceAcknowledgement
2085 </wsa:Action>
2086 <wsrm:SequenceAcknowledgement>
2087 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2088 <wsrm:AcknowledgementRange Upper="3" Lower="1"/>
2089 </wsrm:SequenceAcknowledgement>
2090 </S:Header>
2091 <S:Body/>
2092 </S:Envelope>

```

2093 Terminate Sequence

```

2094 <?xml version="1.0" encoding="UTF-8"?>
2095 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2096 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
2097 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2098 <S:Header>
2099 <wsa:MessageID>
2100 http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546812
2101 </wsa:MessageID>
2102 <wsa:To>http://example.com/serviceB/123</wsa:To>
2103 <wsa:Action>
2104 http://docs.oasis-open.org/ws-rx/wsrn/200702/TerminateSequence
2105 </wsa:Action>
2106 <wsa:From>
2107 <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2108 </wsa:From>
2109 </S:Header>
2110 <S:Body>
2111 <wsrm:TerminateSequence>

```

```

2112     <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2113     <wsrm:LastMsgNumber> 3 </wsrm:LastMsgNumber>
2114     </wsrm:TerminateSequence>
2115 </S:Body>
2116 </S:Envelope>

```

2117 Terminate Sequence Response

```

2118 <?xml version="1.0" encoding="UTF-8"?>
2119 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2120 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200702"
2121 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2122   <S:Header>
2123     <wsa:MessageID>
2124       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546813
2125     </wsa:MessageID>
2126     <wsa:To>http://example.com/serviceA/789</wsa:To>
2127     <wsa:Action>
2128       http://docs.oasis-open.org/ws-rx/wsrn/200702/TerminateSequenceResponse
2129     </wsa:Action>
2130     <wsa:RelatesTo>
2131       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546812
2132     </wsa:RelatesTo>
2133     <wsa:From>
2134       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2135     </wsa:From>
2136   </S:Header>
2137   <S:Body>
2138     <wsrm:TerminateSequenceResponse>
2139       <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2140     </wsrm:TerminateSequenceResponse>
2141   </S:Body>
2142 </S:Envelope>

```

2143 **Appendix D. State Tables**

2144 This appendix specifies the non-normative state transition tables for RM Source and RM Destination.

2145 The state tables describe the lifetime of a sequence in both the RM Source and the RM Destination

2146 Legend:

2147 The first column of these tables contains the motivating event and has the following format:

Event
<i>Event name</i> [source] {ref}

2148 Where:

- 2149 ● Event Name: indicates the name of the event. Event Names surrounded by "<>" are optional as
2150 described by the specification.
- 2151 ● [source]: indicates the source of the event; one of:
 - 2152 ● [msg] a Received message
 - 2153 ● [int]: an internal event such as the firing of a timer
 - 2154 ● [app]: the application
 - 2155 ● [unspec]: the source is unspecified

2156 Each event / state combination cell in the tables in this appendix has the following format:

State Name
<i>Action to take</i> [next state] {ref}

2157 Where:

- 2158 ● action to take: indicates that the state machine performs the following action. Actions surrounded
2159 by "<>" are optional as described by the specification. "Xmit" is used as a short form for the word
2160 "Transmit"
- 2161 ● [next state]: indicates the state to which the state machine will advance upon the performance of
2162 the action. For ease of reading the next state "same" indicates that the state does not change.
- 2163 ● {ref} is a reference to the document section describing the behavior in this cell

2164 "N/A" in a cell indicates a state / event combination self-inconsistent with the state machine; should these
2165 conditions occur, it would indicate an implementation error. A blank cell indicates that the behavior is not
2166 described in this specification and does not indicate normal protocol operation. Implementations MAY
2167 generate a Sequence Terminated fault (see section 4.2) in these circumstances. Robust implementations
2168 MUST be able to operate in a stable manner despite the occurrence of unspecified event / state
2169 combinations.

2170 Table 1 RM Source Sequence State Transition Table

Events	Sequence States					
	None	Creating	Created	Closing	Closed	Terminating
Create Sequence [unspec] {3.4}	Xmit Create Sequence [Creating] {3.4}	N/A	N/A	N/A	N/A	N/A
Create Sequence Response [msg] {3.4}		Process Create Sequence Response [Created] {3.4}				
Create Sequence Refused Fault [msg] {3.4}		No action [None] {4.6}				
Send message [app] {2.1}	N/A	N/A	Xmit message [Same] {2}	No action [Same] {2}	N/A	N/A
Retransmit of un-ack'd message [int] {2.3}	N/A	N/A	Xmit message [Same] {2.3}	Xmit message [Same] {2.3}	N/A	N/A
SeqAck (non-final) [msg] {3.9}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Process Ack ranges [Same] {3.9}	Process Ack ranges [Same] {3.9}	Process Ack ranges [Same] {3.9}	Process Ack ranges [Same] {3.9}
Nack [msg] {3.9}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	<Xmit message(s)> [Same] {3.9}	<Xmit message(s)> [Same] {3.9}	No action [Same]	No action [Same]
Message Number Rollover Fault [msg] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	No action [Rollover]	No action [Same]	No action [Same]	No action [Same]
CloseSequence [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit CloseSequence Response [Closed] {3.5}	Xmit CloseSequence Response [Closed] {3.5}	Xmit CloseSequence Response [Closed] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}
<Close Sequence> [int] {3.5}	N/A		Xmit Close Sequence [Closing] {3.5}	N/A	N/A	N/A
Close Sequence Response [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}		No action [Closed] {3.5}	No action [Same] {3.5}	No action [Same] {3.5}

Events	Sequence States					
	None	Creating	Created	Closing	Closed	Terminating
SeqAck (final) [msg] {3.9}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Process Ack ranges [Closed] {3.9}	Process Ack ranges [Closed] {3.9}	Process Ack ranges [Same]	Process Ack ranges [Same]
Sequence Closed Fault [msg] {4.7}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	No action [Closed] {4.7}	No action [Closed] {4.7}	No action [Same]	No action [Same]
Unknown Sequence Fault [msg] {4.3}			Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}
Sequence Terminated Fault [msg] {4.2}	N/A		Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.2}
TerminateSequence [msg] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}
Terminate Sequence [int]	N/A	No action [None] {unspec}	Xmit Terminate Sequence [Terminating]	Xmit Terminate Sequence [Terminating]	Xmit Terminate Sequence [Terminating]	N/A
Terminate Sequence Response [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}				Terminate Sequence [None] {3.6}
Expires exceeded [int]	N/A	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}	Terminate Sequence [None] {3.7}
Invalid Acknowledgement [msg] {4.4}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Invalid Acknowledgement Fault [Same] {4.4}	Generate Invalid Acknowledgement Fault [Same] {4.4}	Generate Invalid Acknowledgement Fault [Same] {4.4}	Generate Invalid Acknowledgement Fault [Same] {4.4}

2171 Table 2 RM Destination Sequence State Transition Table

Events	Sequence States			
	None	Created	Closed	Terminating
CreateSequence (successful) [msg/int] {3.4}	Xmit Create Sequence Response [Created] {3.4}	N/A	N/A	

Events	Sequence States			
	None	Created	Closed	Terminating
CreateSequence (unsuccessful) [msg/int] {3.4}	Generate Create Sequence Refused Fault [None] {3.4}	N/A	N/A	
Message (with message number within range) [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Accept Message; <Xmit SeqAck> [Same]	Generate Sequence Closed Fault (with SeqAck+Final) [Same] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
Message (with message number outside of range) [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Message Number Rollover Fault [Same] {3.7}{4.5}	Generate Sequence Closed Fault (with SeqAck+Final) [Same] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
<AckRequested> [msg] {3.8}	Generate Unknown Seq Fault [Same] {4.3}	Xmit SeqAck [Same] {3.8}	Xmit SeqAck+Final [Same] {3.9}	Generate Sequence Terminated Fault [Same] {4.2}
CloseSequence [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit CloseSequence Response with SeqAck+Final [Closed] {3.5}	Xmit CloseSequence Response with SeqAck+Final [Closed] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
<CloseSequence autonomously> [int]		Xmit CloseSequence with SeqAck+Final [Closed] {3.5}	Xmit CloseSequence with SeqAck+Final [Same] {3.5}	
CloseSequenceResponse [msg] {3.5}	Generate Unknown Sequence Fault [Same] {4.3}		No Action [Closed] {3.5}	Generate Sequence Terminated Fault [Same] {4.2}
TerminateSequence [msg] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}	Xmit Terminate Sequence Response [None] {3.6}
<TerminateSequence autonomously> [int]		Xmit TerminateSequence with SeqAck+Final [Terminating] {3.6}	Xmit TerminateSequence with SeqAck+Final [Terminating] {3.6}	Xmit TerminateSequence with SeqAck+Final [Terminating] {3.6}
TerminateSequenceResponse [msg]	Generate Unknown Sequence Fault [Same] {4.3}			Terminate Sequence [None]
UnknownSequence Fault [msg] {4.3}		Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}
SequenceTerminated Fault [msg] {4.2}		Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.3}
Invalid Acknowledgement Fault [msg] {4.4}	N/A			
Expires exceeded	N/A	Terminate Sequence	Terminate Sequence	

Events	Sequence States			
	None	Created	Closed	Terminating
[int]		[None] {3.4}	[None] {3.4}	
<Seq Acknowledgement autonomously> [int] {3.9}	N/A	Xmit SeqAck [Same] {3.9}	Xmit SeqAck+Final [Same] {3.9}	
Non WSRM message when WSRM required [msg] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	

Appendix E. Acknowledgments

This document is based on initial contribution to OASIS WS-RX Technical Committee by the following authors:

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Appendix F. Revision History

Rev	Date	By Whom	What
wd-01	2005-07-07	Christopher Ferris	Initial version created based on submission by the authors.
ws-02	2005-07-21	Doug Davis	i011 (PT0S) added
wd-02	2005-08-16	Anish Karmarkar	Trivial editorial changes
ws-03	2005-09-15	Doug Davis	i019 and i028 (CloseSeq) added
wd-05	2005-09-26	Gilbert Pilz	i005 (Source resend of nacks messages when ack already received) added.
wd-05	2005-09-27	Doug Davis	i027 (InOrder delivery assurance spanning multiple sequences) added
wd-05	2005-09-27	Doug Davis	i020 (Semantics of "At most once" Delivery Assurance) added
wd-05	2005-09-27	Doug Davis	i034 (Fault while processing a piggy-backed RM header) added
wd-05	2005-09-27	Doug Davis	i033 (Processing model of NACKs) added
wd-05	2005-09-27	Doug Davis	i031 (AckRequested schema inconsistency) added
wd-05	2005-09-27	Doug Davis	i025 (SeqAck/None) added
wd-05	2005-09-27	Doug Davis	i029 (Remove dependency on WS-Security) added
wd-05	2005-09-27	Doug Davis	i039 (What does 'have a mU attribute' mean) added
wd-05	2005-09-27	Doug Davis	i040 (Change 'optiona'/'required' to 'OPTIONAL'/'REQUIRED') added
wd-05	2005-09-30	Anish Karmarkar	i017 (Change NS to http://docs.oasis-open.org/wsrn/200510/)
wd-05	2005-09-30	Anish Karmarkar	i045 (Include SecureConversation as a reference and move it to non-normative citation)
wd-05	2005-09-30	Anish Karmarkar	i046 (change the type of wsrn:FaultCode element)
wd-06	2005-11-02	Gilbert Pilz	Start wd-06 by changing title page from cd-01.
wd-06	2005-11-03	Gilbert Pilz	i047 (Reorder spec sections)
wd-07	2005-11-17	Gilbert Pilz	Start wd-07
wd-07	2005-11-28	Doug Davis	i071 – except for period in Appendix headings
wd-07	2005-11-28	Doug Davis	i10
wd-07	2005-11-28	Doug Davis	i030
wd-07	2005-11-28	Doug Davis	i037
wd-07	2005-11-28	Doug Davis	i038
wd-07	2005-11-28	Doug Davis	i041
wd-07	2005-11-28	Doug Davis	i043
wd-07	2005-11-28	Doug Davis	i044

Rev	Date	By Whom	What
wd-07	2005-11-28	Doug Davis	i048
wd-07	2005-11-28	Doug Davis	i051
wd-07	2005-11-28	Doug Davis	i053
wd-07	2005-11-28	Doug Davis	i059
wd-07	2005-11-28	Doug Davis	i062
wd-07	2005-11-28	Doug Davis	i063
wd-07	2005-11-28	Doug Davis	i065
wd-07	2005-11-28	Doug Davis	i067
wd-07	2005-11-28	Doug Davis	i068
wd-07	2005-11-28	Doug Davis	i069
wd-07	2005-11-28	Doug Davis	Fix bulleted list (#2) in section 2.3
wd-07	2005-11-29	Gilbert Pilz	i074 (Use of [tcShortName] in artifact locations namespaces, etc)
wd-07	2005-11-29	Gilbert Pilz	i071 – Fixed styles and formatting for TOC. Fixed styles of the appendix headings.
wd-07	2005-11-30	Doug Davis	Removed dup definition of "Receive"
wd-07	2005-11-30	Gilbert Pilz	Fixed lost formatting from heading for Namespace section. Fixed style of text body elements to match OASIS example documents. Fixed tables to match OASIS example documents.
wd-07	2005-12-01	Gilbert Pilz	Updated fix for i074 to eliminate trailing '/'. Added corresponding text around action IRI composition.
wd-07	2005-12-01	Gilbert Pilz	Use non-fixed fields for date values on both title page and body footers.
wd-07	2005-12-01	Doug Davis	Alphabetize the glossary
wd-07	2005-12-02	Doug Davis	i064
wd-07	2005-12-02	Doug Davis	i066
wd-08	2005-12-15	Doug Davis	Add back in RM Source to glossary
wd-08	2005-12-15	Steve Winkler	Doug added Steve's editorial nits
wd-08	2005-12-21	Doug Davis	i050
wd-08	2005-12-21	Doug Davis	i081
wd-08	2005-12-21	Doug Davis	i080 – but i050 negates the need for any changes
wd-08	2005-12-21	Doug Davis	i079
wd-08	2005-12-21	Doug Davis	i076 – didn't add text about "replies" since the RMD to RMS sequence could be used for any message not just replies
wd-08	2005-12-21	Umit Yalcinalp	Action Su03: removed wsse from Table 1
wd-08	2005-12-21	Umit Yalcinalp	i057 per Sunnyvale F2F 2005, Cleaned up some formatting errors in contributors
wd-08	2005-12-27	Doug Davis	i060
wd-08	2005-12-27	Gilbert Pilz	Moved schema and WSDL files to their own artifacts. Converted source document to

Rev	Date	By Whom	What
			OpenDocument Text format. Changed line numbers to be a single style.
wd-08	2005-12-28	Anish Karmarkar	Included a section link to c:\temp\wsrm-1.1-schema-200510.xsd and to c:\temp\wsrm-1.1-wsdl-200510.wsdl
wd-08	2006-01-04	Gilbert Pilz	Fixed formatting for included sections.
wd-08	2006-01-05	Gilbert Pilz	Created links for unused references. Fixed exemplars for CloseSequence and CloseSequenceResponse.
wd-09	2006-01-11	Doug Davis	Minor tweaks to text/typos.
wd-10	2006-01-23	Doug Davis	Accept all changes from wd-09 Make some minor editorial tweaks from Marc's comments.
wd-10	2006-02-14	Doug Davis	Issue 082 resolution
wd-10	2006-02-14	Doug Davis	Issue 083 resolution
wd-10	2006-02-14	Doug Davis	Issue 085 resolution
wd-10	2006-02-14	Doug Davis	Issues 086, 087 resolutions Defined MessageNumberType
wd-10	2006-02-15	Doug Davis	Issue 078 resolution
wd-10	2006-02-15	Doug Davis	Issue 094 resolution
wd-10	2006-02-15	Doug Davis	Issue 095 resolution
wd-10	2006-02-15	Gilbert Pilz	Issue 088 – added namespace URI link to namespace URI; added text explaining that this URI could be dereferenced to produce the RDDDL doc; added non-normative reference to RDDDL 2.0
wd-10	2006-02-17	Anish Karmarkar	Namespace changed to 200602 for both WSDL and XSD docs.
wd-10	2006-02-17	Anish Karmarkar	Issue i087 as it applies to WSRM spec.
wd-10	2006-02-17	Anish Karmarkar	Added titles and minor text for state table (issue i058).
wd-11	2006-02-22	Doug Davis	Accept all changes for new WD Minor typos fixed
wd-11	2006-02-23	Doug Davis	s/'close'/close/g – per Marc Goodner Added first ref to [URI] – per Marc G again
wd-11	2006-02-27	Doug Davis	Issue i061 applied
wd-11	2006-02-28	Doug Davis	Fixed typo around the use of "above" and "below"
wd-11	2006-03-01	Doug Davis	Minor typos found by Marc Goodner
wd-11	2006-03-02	Doug Davis	Minor typos found by Matt Lovett
wd-11	2006-03-08	Doug Davis	Issue 091 applied
wd-11	2006-03-08	Doug Davis	Issue 092 applied
wd-11	2006-03-08	Doug Davis	Issue 100 applied

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wd-12	2006-03-20	Doug Davis	Added space in "SOAP1.x" – PaulCotton
wd-12	2006-04-11	Doug Davis	Issue 007 applied
wd-12	2006-04-11	Doug Davis	Issue 090 applied
wd-12	2006-04-11	Doug Davis	Issue 098 applied
wd-12	2006-04-11	Doug Davis	Issue 099 applied
wd-12	2006-04-11	Doug Davis	Issue 101 applied
wd-12	2006-04-11	Doug Davis	Issue 103 applied
wd-12	2006-04-11	Doug Davis	Issue 104 applied
wd-12	2006-04-11	Doug Davis	Issue 105 applied
wd-12	2006-04-11	Doug Davis	Issue 107 applied
wd-12	2006-04-11	Doug Davis	Issue 109 applied
wd-12	2006-04-11	Doug Davis	Issue 110 applied
wd-12	2006-04-12	Doug Davis	Used "generated" instead of "issue" or "send" when talking about faults.
wd-12	2006-04-24	Gilbert Pilz	Update references to WS-Addressing to the Proposed Recommendations; update WS-RM namespace to "200604".
wd-13	2006-05-08	Gilbert Pilz	i093 part 1; more work needed
wd-13	2006-05-10	Doug Davis	Issue 096 applied
wd-13	2006-05-26	Gilbert Pilz	i093 part 2; reflects decisions from 2006-05-25 meeting
wd-13	2006-05-28	Gilbert Pilz	Issue 106 applied
wd-13	2006-05-29	Gilbert Pilz	Issue 118 applied
wd-13	2006-05-29	Gilbert Pilz	Issue 120 applied
wd-13	2006-05-30	Gilbert Pilz	Issue 114 applied
wd-13	2006-05-30	Gilbert Pilz	Issue 116 applied
wd-14	2006-06-05	Gilbert Pilz	Accept all changes; bump WD number
wd-14	2006-06-07	Doug Davis	Applied lots of minor edits from Marc Goodner
wd-14	2006-06-07	Doug Davis	Change a couple of period/sp/sp to period/sp
wd-14	2006-06-07	Doug Davis	Added a space in "URI]of" – per Marc Goodner
wd-14	2006-06-07	Doug Davis	Issue 131 applied
wd-14	2006-06-07	Doug Davis	Issue 132 applied
wd-14	2006-06-07	Doug Davis	Issue 119 applied
wd-14	2006-06-07	Doug Davis	Applied lots of minor edits from Doug Davis
wd-14	2006-06-07	Doug Davis	s/"none"/"full-uri"/ - per Marc Goodner
wd-14	2006-06-12	Doug Davis	Complete i106
wd-14	2006-06-12	Doug Davis	Issues 089 applied
wd-14	2006-06-12	Doug Davis	Fix for several RFC2119 keywords – per Anish
wd-15	2006-06-12	Doug Davis	Accept all changed, dump WD number
wd-15	2006-06-12	Doug Davis	Move WSDL after Schema
wd-15	2006-06-12	Doug Davis	Nits – remove tabs, extra [yyy]'s ...
wd-15	2006-06-14	Doug Davis	Remove extra "OPTIONAL"s – Matt Lovett

Rev	Date	By Whom	What
wd-15	2006-06-14	Doug Davis	Remove blank rows/columns from state table. Fix italics in state table
wd-15	2006-06-15	Doug Davis	Typo – section D was empty
wd-15	2006-06-16	Doug Davis	Issue 125 applied
wd-15	2006-06-16	Doug Davis	Issue 126 applied
wd-15	2006-06-16	Doug Davis	Issue 127 applied
wd-15	2006-06-16	Doug Davis	Issue 133 applied
wd-15	2006-06-16	Doug Davis	Issue 136 applied
wd-15	2006-06-16	Doug Davis	Issue 138 applied
wd-15	2006-06-16	Doug Davis	Issue 135 applied
wd-15	2006-06-20	Doug Davis	Added all TC members to the ack list
wd-15	2006-06-22	Doug Davis	Issue 129 applied
wd-15	2006-06-22	Doug Davis	Issue 130 applied
wd-15	2006-06-22	Doug Davis	Issue 137 applied
wd-15	2006-06-26	Doug Davis	Issue 111 applied
wd-15	2006-06-26	Doug Davis	Missed a part of issue 129
wd-15	2006-06-30	Doug Davis	Fixed a typo in schema
wd-15	2006-06-30	Doug Davis	Issue 141 applied
wd-15	2006-06-30	Doug Davis	Issue 142 applied
wd-15	2006-06-30	Doug Davis	Issue 148 applied
wd-15	2006-06-30	Doug Davis	Issue 149 applied
wd-15	2006-06-30	Doug Davis	Issue 150 applied
wd-15	2006-07-06	Doug Davis	Issue 121 applied
wd-15	2006-07-21	Doug Davis	Issue 139 applied
wd-15	2006-07-21	Doug Davis	Issue 144 applied
wd-15	2006-07-21	Doug Davis	Issue 147 applied
wd-15	2006-07-21	Doug Davis	Issues 122-124 applied
wd-15	2006-07-27	Doug Davis	Updated list of oasis TC members (i134)
wd-15	2006-07-27	Doug Davis	Issue 140 applied
wd-15	2006-07-27	Doug Davis	Issue 145 applied
wd-15	2006-07-27	Doug Davis	Issue 143 applied
wd-15	2006-07-28	Doug Davis	Lots of minor typos found by Matt L.
wd-15	2006-07-28	Doug Davis	Issue 113 applied
wd-15	2006-08-04	Doug Davis	Update old namespaces – found by PaulC
wd-15	2006-08-04	Doug Davis	Issue 150 applied
wd-15	2006-08-04	Doug Davis	Minor typos – found by PeterN
wd-15	2006-08-04	Doug Davis	Verify all [refs]
wd-15	2006-08-04	Doug Davis	Change namespace to 2006/08
wd-15	2006-08-04	Doug Davis	Issue 148 applied
wd-15	2006-08-07	Doug Davis	Add some new glossary terms – per GilP
cd-04	2006-08-10	Gilbert Pilz	Formatting changes for better HTML rendering.

Rev	Date	By Whom	What
cd-04	2006-08-11	Doug Davis	Issue 158 applied
cd-04	2006-08-11	Doug Davis	Issue 153 applied
cd-04	2006-08-11	Doug Davis	Issue 156 applied
cd-04	2006-08-15	Gilbert Pilz	More formatting changes for better HTML rendering.
wd-16	2006-10-25	Doug Davis	Accept all changes, update to wd16
wd-16	2006-10-26	Doug Davis	PR002 applied
wd-16	2006-10-26	Doug Davis	PR003 applied
wd-16	2006-10-26	Doug Davis	PR004 applied
wd-16	2006-10-27	Doug Davis	PR005 applied
wd-16	2006-10-27	Doug Davis	PR006 applied
wd-16	2006-10-27	Doug Davis	PR024 applied
wd-16	2006-11-13	Doug Davis	PR010 applied
wd-16	2006-11-13	Doug Davis	PR011 applied (technically as part of PR004)
wd-16	2006-11-13	Doug Davis	PR016 applied
wd-16	2006-11-13	Doug Davis	PR032 applied
wd-16	2006-11-20	Doug Davis	PR025 applied
wd-16	2006-11-20	Doug Davis	PR023 applied
wd-16	2006-12-03	Doug Davis	PR036 applied
wd-16	2006-12-03	Doug Davis	PR017 applied
wd-16	2006-12-11	Doug Davis	PR012 applied (and PR013)
wd-16	2006-12-14	Doug Davis	PR033 applied – changed a 'return' to 'generate' when talking about a fault
wd-16	2007-01-04	Doug Davis	PR018 applied
wd-16	2007-01-05	Doug Davis	Moved MakeConnection to new spec
wd-16	2007-01-17	Doug Davis	PR026 applied
wd-16	2007-01-18	Doug Davis	PR021 applied
wd-16	2007-01-18	Doug Davis	PR022 applied
wd-16	2007-01-18	Doug Davis	Fixed a few typos (Doug,Gil)
wd-16	2007-01-18	Gilbert Pilz	PR007 applied
wd-16	2007-01-25	Doug Davis	PR039 applied
wd-17	2007-01-31	Doug Davis	Lots of typos from MarcG Updated WD number and date
wd-17	2007-02-01	Doug Davis	PR038 applied
wd-17	2007-02-01	Doug Davis	PR035 (009,020 dups) applied Fixed typo in state table

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