



# Web Services Reliable Messaging (WS-ReliableMessaging)

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### 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/200608>

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	<a href="http://schemas.xmlsoap.org/soap/envelope/">http://schemas.xmlsoap.org/soap/envelope/</a>
S12	<a href="http://www.w3.org/2003/05/soap-envelope">http://www.w3.org/2003/05/soap-envelope</a>
wsrm	<a href="http://docs.oasis-open.org/ws-rx/wsrn/200608">http://docs.oasis-open.org/ws-rx/wsrn/200608</a>
wsa	<a href="http://www.w3.org/2005/08/addressing">http://www.w3.org/2005/08/addressing</a>
wsaw	<a href="http://www.w3.org/2006/05/addressing/wsdl">http://www.w3.org/2006/05/addressing/wsdl</a>
wsse	<a href="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd">http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd</a>
xs	<a href="http://www.w3.org/2001/XMLSchema">http://www.w3.org/2001/XMLSchema</a>

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 Compliance

An implementation is not compliant 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 compliant 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 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.

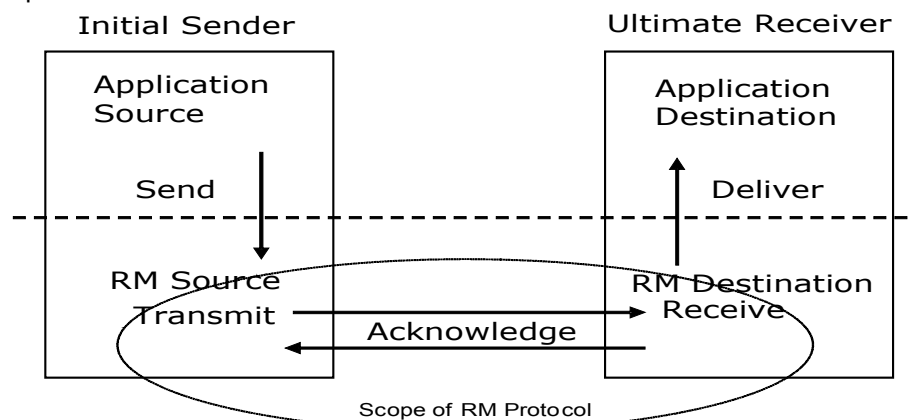


Figure 1: Reliable Messaging Model

### 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.

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

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

200 **Acknowledgement Request:** A message containing a `AckRequested` header. Acknowledgement  
201 Requests may or may not contain a SOAP body.

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

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

204 **Deliver:** The act of transferring a message from the RM Destination to the Application Destination.

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

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

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

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

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

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

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

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

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

## 219 2.2 Protocol Preconditions

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

- 222 • For any single message exchange the RM Source MUST have an endpoint reference that uniquely  
223 identifies the RM Destination Endpoint.
- 224 • The RM Source MUST have successfully created a Sequence with the RM Destination.
- 225 • The RM Source MUST be capable of formulating messages that adhere to the RM Destination's  
226 policies.
- 227 • If a secure exchange of messages is REQUIRED, then the RM Source and RM Destination MUST  
228 have a security context.

## 229 2.3 Protocol Invariants

230 During the lifetime of a Sequence, two 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.

## 2.4 Example Message Exchange

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



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 2<sup>nd</sup> message in the Sequence is lost in transit.



248 6. The 3<sup>rd</sup> message is the last in this Sequence and the RM Source includes an `AckRequested`  
249 header to ensure that it gets a timely `SequenceAcknowledgement` for the Sequence.

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

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

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

260 10. The RM Source Receives this Acknowledgement and sends a `TerminateSequence` message to the  
261 RM Destination indicating that the Sequence is completed. The `TerminateSequence` message  
262 indicates that message number 3 is the last message in the Sequence. The RM Source then-and  
263 reclaims any resources associated with the Sequence.

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

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

279 Now that the basic model has been outlined, the details of the elements used in this protocol are now  
280 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 header blocks may be added to messages that happen to be 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.

### 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 section 3 below, 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 3.1 below, the value of the `wsa:Action` IRI would be:

```
http://docs.oasis-open.org/ws-rx/wsrn/200608/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/200608/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/200608/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.

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

320 The following exemplar defines the CreateSequence syntax:

```
321 <wsrm:CreateSequence ...>
322   <wsrm:AcksTo> wsa:EndpointReferenceType </wsrm:AcksTo>
323   <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
324   <wsrm:Offer ...>
325     <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
326     <wsrm:Endpoint> wsa:EndpointReferenceType </wsrm:Endpoint>
327     <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
328     <wsrm:IncompleteSequenceBehavior>
329       wsrml:IncompleteSequenceBehaviorType
330     </wsrm:IncompleteSequenceBehavior> ?
331     ...
332   </wsrm:Offer> ?
333   ...
334 </wsrm:CreateSequence>
```

335 /wsrm:CreateSequence

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

340 /wsrm:CreateSequence/wsrm:AcksTo

341 The RM Source MUST include this element in any CreateSequence message it sends. This element is of  
342 type wsa:EndpointReferenceType (as specified by WS-Addressing). It specifies the endpoint  
343 reference to which messages containing SequenceAcknowledgement header blocks and faults related  
344 to the created Sequence are to be sent, unless otherwise noted in this specification (for example, see  
345 Section 3.2).

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

350 /wsrm:CreateSequence/wsrm:Expires

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

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

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

358 /wsrm:CreateSequence/wsrm:Offer

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

361 /wsrm:CreateSequence/wsrm:Offer/wsrm:Identifier

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

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

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

367 /wsrm:CreateSequence/wsrm:Offer/wsrm:Endpoint

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

372 Implementations MUST NOT use an endpoint reference in the Endpoint element that would prevent the  
373 sending of Sequence Lifecycle Message, Sequence Traffic Message, etc. For example, using the WS-  
374 Addressing "http://www.w3.org/2005/08/addressing/none" IRI would make it impossible for the RM  
375 Destination to ever send Sequence Lifecycle Messages (e.g. `TerminateSequence`) to the RM Source  
376 for the Offered Sequence. Implementations MAY use the WS-RM anonymous URI template and doing so  
377 implies that messages will be retrieved using a mechanism such as the `MakeConnection` message (see  
378 section 3.7).

379 /wsrm:CreateSequence/wsrm:Offer/wsrm:Expires

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

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

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

386 /wsrm:CreateSequence/wsrm:Offer/wsrm:IncompleteSequenceBehavior

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

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

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

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

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

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

400 /wsrm:CreateSequence/wsrm:Offer/@{any}

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

403 /wsrm:CreateSequence/{any}

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

406 /wsrm:CreateSequence/@{any}

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

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

413 The following exemplar defines the `CreateSequenceResponse` syntax:

```
414 <wsrm:CreateSequenceResponse ...>
415   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
416   <wsrm:Expires ...> xs:duration </wsrm:Expires> ?
417   <wsrm:IncompleteSequenceBehavior>
418     wsrm:IncompleteSequenceBehaviorType
419   </wsrm:IncompleteSequenceBehavior> ?
420   <wsrm:Accept ...>
421     <wsrm:AcksTo> wsa:EndpointReferenceType </wsrm:AcksTo>
422     ...
423   </wsrm:Accept> ?
424   ...
425 </wsrm:CreateSequenceResponse>
```

426 /wsrm:CreateSequenceResponse

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

430 /wsrm:CreateSequenceResponse/wsrm:Identifier

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

434 /wsrm:CreateSequenceResponse/wsrm:Identifier/@{any}

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

437 /wsrm:CreateSequenceResponse/wsrm:Expires

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

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

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

449 `/wsrm:CreateSequenceResponse/wsrm:IncompleteSequenceBehavior`  
 450 This element, if present, specifies the behavior that the destination will exhibit upon the closure or  
 451 termination of an incomplete Sequence. For the purposes of defining the values used, the term "discard"  
 452 refers to behavior equivalent to the Application Destination never processing a particular message.

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

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

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

460 `/wsrm:CreateSequenceResponse/wsrm:Accept`  
 461 This element, if present, enables an RM Destination to accept the offer of a corresponding Sequence for  
 462 the reliable exchange of messages Transmitted from RM Destination to RM Source.

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

466 `/wsrm:CreateSequenceResponse/wsrm:Accept/wsrm:AcksTo`  
 467 The RM Destination MUST include this element, of type `wsa:EndpointReferenceType` (as specified  
 468 by WS-Addressing). It specifies the endpoint reference to which messages containing  
 469 `SequenceAcknowledgement` header blocks and faults related to the created Sequence are to be sent,  
 470 unless otherwise noted in this specification (for example, see Section 3.2).

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

475 `/wsrm:CreateSequenceResponse/wsrm:Accept/{any}`  
 476 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,  
 477 to be passed.

478 `/wsrm:CreateSequenceResponse/wsrm:Accept/@{any}`  
 479 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,  
 480 to be passed.

481 `/wsrm:CreateSequenceResponse/{any}`  
 482 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,  
 483 to be passed.

484 `/wsrm:CreateSequenceResponse/@{any}`  
 485 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the  
 486 element.

## 3.5 Closing A Sequence

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

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

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

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

The following exemplar defines the `CloseSequence` syntax:

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

`/wsrm:CloseSequence`

This element is sent by an RM Source to indicate that the RM Destination MUST NOT accept any new messages for this Sequence. A `SequenceClosed` fault MUST be generated by the RM Destination when it Receives a message for a Sequence that is already closed.

`/wsrm:CloseSequence/wsrm:Identifier`

The RM Source MUST include this element in any `CloseSequence` messages it sends. The RM Source MUST set the value of this element to the absolute URI (conformant with RFC3986) of the Sequence that is being closed.

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

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

`/wsrm:CloseSequence/{any}`

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

`/wsrm:CloseSequence@{any}`

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

532 A `CloseSequenceResponse` is sent in the body of a response message by an RM Destination in  
533 response to receipt of a `CloseSequence` request message. It indicates that the RM Destination has  
534 closed the Sequence.

535 The following exemplar defines the `CloseSequenceResponse` syntax:

```
536 <wsrm:CloseSequenceResponse ...>  
537   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
538   ...  
539 </wsrm:CloseSequenceResponse>
```

540 `/wsrm:CloseSequenceResponse`

541 This element is sent in the body of a response message by an RM Destination in response to receipt of a  
542 `CloseSequence` request message. It indicates that the RM Destination has closed the Sequence.

543 `/wsrm:CloseSequenceResponse/wsrm:Identifier`

544 The RM Destination MUST include this element in any `CloseSequenceResponse` message it sends. The  
545 RM Destination MUST set the value of this element to the absolute URI (conformant with RFC3986) of the  
546 Sequence that is being closed.

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

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

550 `/wsrm:CloseSequenceResponse/{any}`

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

553 `/wsrm:CloseSequenceResponse@{any}`

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

## 556 3.6 Sequence Termination

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

564 In order to allow the RM Destination to determine if it has received all of the messages in a Sequence, the  
565 RM Source includes a `LastMsgNumber` element in the `TerminateSequence` message. The  
566 `LastMsgNumber` element specifies the message number of the last Sequence Traffic Message for a  
567 particular Sequence. The RM Destination can use this information, for example, to implement the  
568 behavior indicated by `/wsrm:CreateSequenceResponse/wsrm:IncompleteSequenceBehavior`.

569 The following exemplar defines the `TerminateSequence` syntax:

```
570 <wsrm:TerminateSequence ...>
```



```

571 <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
572 <wsrm:LastMsgNumber> wsrm:MessageNumberType </wsrm:LastMsgNumber>
573 ...
574 </wsrm:TerminateSequence>

```

575 /wsrm:TerminateSequence

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

581 /wsrm:TerminateSequence/wsrm:Identifier

582 The RM Source MUST include this element in any TerminateSequence message it sends. The RM Source MUST set the value of this element to the absolute URI (conformant with RFC3986) of the Sequence that is being terminated.

585 /wsrm:TerminateSequence/wsrm:Identifier/@{any}

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

588 /wsrm:TerminateSequence/wsrm:LastMsgNumber

589 The RM Source MUST include this element in any TerminateSequence messages it sends. The RM Source MUST set the value of this element to the MessageNumber of the last Sequence Traffic Message for the Sequence identified in this TerminateSequence message.

592 /wsrm:TerminateSequence/{any}

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

595 /wsrm:TerminateSequence/@{any}

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

598 A TerminateSequenceResponse is sent in the body of a response message by an RM Destination in response to receipt of a TerminateSequence request message. It indicates that the RM Destination has terminated the Sequence.

601 The following exemplar defines the TerminateSequenceResponse syntax:

```

602 <wsrm:TerminateSequenceResponse ...>
603   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
604   ...
605 </wsrm:TerminateSequenceResponse>

```

606 /wsrm:TerminateSequenceResponse

607 This element is sent in the body of a response message by an RM Destination in response to receipt of a TerminateSequence request message. It indicates that the RM Destination has terminated the Sequence. The RM Destination MUST NOT send this element as a header block.

610 /wsrm:TerminateSequenceResponse/wsrm:Identifier

611 The RM Destination MUST include this element in any `TerminateSequenceResponse` message it  
612 sends. The RM Destination MUST set the value of this element to the absolute URI (conformant with  
613 RFC3986) of the Sequence that is being terminated.

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

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

617 `/wsrm:TerminateSequenceResponse/{any}`

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

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

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

623 On receipt of a `TerminateSequence` message an RM Destination MUST respond with a corresponding  
624 `TerminateSequenceResponse` message or generate a fault `UnknownSequenceFault` if the  
625 Sequence is not known.

## 626 3.7 Sequences

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

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

634 A following exemplar defines its syntax:

```
635 <wsrm:Sequence ...>  
636   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
637   <wsrm:MessageNumber> wsrm:MessageNumberType </wsrm:MessageNumber>  
638   ...  
639 </wsrm:Sequence>
```

640 The following describes the content model of the Sequence header block.

641 `/wsrm:Sequence`

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

648 `/wsrm:Sequence/wsrm:Identifier`

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

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

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

655 /wsrm:Sequence/wsrm:MessageNumber

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

660 /wsrm:Sequence/{any}

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

663 /wsrm:Sequence/@{any}

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

666 The following example illustrates a Sequence header block.

```
667 <wsrm:Sequence>  
668   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
669   <wsrm:MessageNumber>10</wsrm:MessageNumber>  
670 </wsrm:Sequence>
```

## 671 3.8 Request Acknowledgement

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

674 The RM Source MAY request an Acknowledgement Message from the RM Destination at any time by  
675 including an `AckRequested` header block in any message targeted to the RM Destination. An RM  
676 Destination that Receives a message that contains an `AckRequested` header block MUST send a  
677 message containing a `SequenceAcknowledgement` header block to the `AcksTo` endpoint reference  
678 (see Section 3.1) for a known Sequence or else generate an `UnknownSequence` fault. If a non-  
679 `mustUnderstand` fault occurs when processing an RM header that was piggy-backed on another  
680 message, a fault MUST be generated, but the processing of the original message MUST NOT be  
681 affected. It is RECOMMENDED that the RM Destination return a `AcknowledgementRange` or `None`  
682 element instead of a `Nack` element (see Section 3.6).

683 The following exemplar defines its syntax:

```
684 <wsrm:AckRequested ...>  
685   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>  
686   ...  
687 </wsrm:AckRequested>
```

688 /wsrm:AckRequested

689 This element requests an Acknowledgement for the identified Sequence.

690 /wsrm:AckRequested/wsrm:Identifier

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

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

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

697 /wsrm:AckRequested/{any}

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

700 /wsrm:AckRequested/@{any}

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

### 703 3.9 Sequence Acknowledgement

704 The RM Destination informs the RM Source of successful message receipt using a  
705 `SequenceAcknowledgement` header block. The RM Destination MAY Transmit the  
706 `SequenceAcknowledgement` header block independently or it MAY include the  
707 `SequenceAcknowledgement` header block on any message targeted to the `AcksTo` EPR.  
708 Acknowledgements can be explicitly requested using the `AckRequested` directive (see Section 3.5). If a  
709 non-mustUnderstand fault occurs when processing an RM header that was piggy-backed on another  
710 message, a fault MUST be generated, but the processing of the original message MUST NOT be  
711 affected.

712 A RM Destination MAY include a `SequenceAcknowledgement` header block on any SOAP envelope  
713 targetted to the endpoint referenced by the `AcksTo` EPR.

714 During creation of a Sequence the RM Source MAY specify the WS-Addressing anonymous IRI as the  
715 address of the `AcksTo` EPR for that Sequence. When the RM Source specifies the WS-Addressing  
716 anonymous IRI as the address of the `AcksTo` EPR, the RM Destination MUST Transmit any  
717 `SequenceAcknowledgement` headers for the created Sequence in a SOAP envelope to be Transmitted  
718 on the protocol binding-specific channel. Such a channel is provided by the context of a Received  
719 message containing a SOAP envelope that contains a `Sequence` header block and/or a `AckRequested`  
720 header block for that same Sequence identifier.

721 The following exemplar defines its syntax:

```
722 <wsrm:SequenceAcknowledgement ...>
723   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
724   [ [ [ <wsrm:AcknowledgementRange ...
725         Upper="wsrm:MessageNumberType"
726         Lower="wsrm:MessageNumberType" /> +
727         | <wsrm:None/> ]
728         <wsrm:Final/> ? ]
729     | <wsrm:Nack> wsrm:MessageNumberType </wsrm:Nack> + ]
730
731   ...
732 </wsrm:SequenceAcknowledgement>
```

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

734 /wsrm:SequenceAcknowledgement

735 This element contains the Sequence Acknowledgement information.

736 /wsrm:SequenceAcknowledgement/wsrm:Identifier

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

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

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

745 `/wsrm:SequenceAcknowledgement/wsrm:AcknowledgementRange`

746 The RM Destination MAY include one or more instances of this element within a  
747 `SequenceAcknowledgement` header block. It contains a range of Sequence MessageNumbers  
748 successfully accepted by the RM Destination. The ranges SHOULD NOT overlap. The RM Destination  
749 MUST NOT include this element if a sibling `Nack` or `None` element is also present as a child of  
750 `SequenceAcknowledgement`.

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

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

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

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

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

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

760 `/wsrm:SequenceAcknowledgement/wsrm:None`

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

765 `/wsrm:SequenceAcknowledgement/wsrm:Final`

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

772 `/wsrm:SequenceAcknowledgement/wsrm:Nack`

773 The RM Destination MAY include this element within a `SequenceAcknowledgement` header block. If  
774 used, the RM Destination MUST set the value of this element to a `MessageNumberType` representing  
775 the `MessageNumber` of an unreceived message in a Sequence. The RM Destination MUST NOT include  
776 a `Nack` element if a sibling `AcknowledgementRange` or `None` element is also present as a child of  
777 `SequenceAcknowledgement`. Upon the receipt of a `Nack`, an RM Source SHOULD retransmit the  
778 message identified by the `Nack`. The RM Destination MUST NOT issue a `SequenceAcknowledgement`

779 containing a `Nack` for a message that it has previously acknowledged within a  
780 `AcknowledgementRange`. The RM Source SHOULD ignore a `SequenceAcknowledgement` containing  
781 a `Nack` for a message that has previously been acknowledged within a `AcknowledgementRange`.

782 `/wsrm:SequenceAcknowledgement/{any}`

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

785 `/wsrm:SequenceAcknowledgement/@{any}`

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

788 The following examples illustrate `SequenceAcknowledgement` elements:

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

```
790 <wsrm:SequenceAcknowledgement>  
791   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
792   <wsrm:AcknowledgementRange Upper="10" Lower="1"/>  
793 </wsrm:SequenceAcknowledgement>
```

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

```
796 <wsrm:SequenceAcknowledgement>  
797   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
798   <wsrm:AcknowledgementRange Upper="2" Lower="1"/>  
799   <wsrm:AcknowledgementRange Upper="6" Lower="4"/>  
800   <wsrm:AcknowledgementRange Upper="10" Lower="8"/>  
801 </wsrm:SequenceAcknowledgement>
```

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

```
803 <wsrm:SequenceAcknowledgement>  
804   <wsrm:Identifier>http://example.com/abc</wsrm:Identifier>  
805   <wsrm:Nack>3</wsrm:Nack>  
806 </wsrm:SequenceAcknowledgement>
```

## 807 3.10 MakeConnection

808 When an Endpoint is not directly addressable (e.g. behind a firewall or not able to allow incoming  
809 connections), an anonymous URI in the EPR address property can indicate such an Endpoint. The WS-  
810 Addressing anonymous URI is one such anonymous URI. This specification defines a URI template (the  
811 WS-RM anonymous URI) which may be used to uniquely identify anonymous Endpoints.

```
812 http://docs.oasis-open.org/ws-rx/wsrm/200608/anonymous?id={uuid}
```

813 This URI template in an EPR indicates a protocol-specific back-channel will be established through a  
814 mechanism such as `MakeConnection`, defined below. When using this URI template, "{uuid}" MUST be  
815 replaced by a UUID value as defined by RFC4122[UUID]. This UUID value uniquely distinguishes the  
816 Endpoint. A sending Endpoint SHOULD Transmit messages at Endpoints identified with the URI template  
817 using a protocol-specific back-channel, including but not limited to those established with a  
818 `MakeConnection` message. Note, this URI is semantically similar to the WS-Addressing anonymous  
819 URI if a protocol-specific back-channel is available.

820 The `MakeConnection` is a one-way operation that establishes a contextualized back-channel for the  
821 transmission of messages according to matching criteria (defined below). In the non-faulting case, if no

822 matching message is available then no SOAP envelopes will be returned on the back-channel. A common  
823 usage will be a client RM Destination sending `MakeConnection` to a server RM Source for the purpose  
824 of receiving asynchronous response messages.

825 The following exemplar defines the `MakeConnection` syntax:

```
826 <wsrm:MakeConnection ...>  
827   <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier> ?  
828   <wsrm:Address ...> xs:anyURI </wsrm:Address> ?  
829   ...  
830 </wsrm:MakeConnection>
```

831 `/wsrm:MakeConnection`

832 This element allows the sender to create a transport-specific back-channel that can be used to return a  
833 message that matches the selection criteria. Endpoints MUST NOT send this element as a header block.

834 `/wsrm:MakeConnection/wsrm:Identifier`

835 This element specifies the WS-RM Sequence Identifier that establishes the context for the transport-  
836 specific back-channel. The Sequence Identifier should be compared with the Sequence Identifiers  
837 associated with the messages held by the sending Endpoint, and if there is a matching message it will be  
838 returned. If this element is omitted from the message then the `Address` MUST be included in the  
839 message.

840 `/wsrm:MakeConnection/wsrm:Identifier/@{any}`

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

843 `/wsrm:MakeConnection/wsrm:Address`

844 This element specifies the URI (`wsa:Address`) of the initiating Endpoint. Endpoints MUST NOT return  
845 messages on the transport-specific back-channel unless they have been addressed to this URI. This  
846 `Address` property and a message's WS-Addressing destination property are considered identical when  
847 they are exactly the same character-for-character. Note that URIs which are not identical in this sense  
848 may in fact be functionally equivalent. Examples include URI references which differ only in case, or  
849 which are in external entities which have different effective base URIs. If this element is omitted from the  
850 message then the `Identifier` MUST be included in the message.

851 `/wsrm:MakeConnection/wsrm:Address/@{any}`

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

854 `/wsrm:MakeConnection/{any}`

855 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,  
856 to be passed. This allows fine-tuning of the messages to be returned, additional selection criteria included  
857 here are logically ANDed with the `Address` and/or `Identifier`. If an extension is not supported by the  
858 Endpoint then it should return a `UnsupportedSelection` fault.

859 `/wsrm:MakeConnection/@{any}`

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

862 If both `Identifier` and `Address` are present, then the Endpoint processing the `MakeConnection`  
863 message MUST insure that any SOAP Envelope flowing on the backchannel MUST be associated with  
864 the given Sequence and MUST be addressed to the given URI.

865 The management of messages that are awaiting the establishment of a back-channel to their receiving  
866 Endpoint is an implementation detail that is outside the scope of this specification. Note, however, that  
867 these messages form a class of asynchronous messages that is not dissimilar from "ordinary"  
868 asynchronous messages that are waiting for the establishment of a connection to their destination  
869 Endpoints.

870 This specification places no constraint on the types of messages that can be returned on the transport-  
871 specific back-channel. As in an asynchronous environment, it is up to the recipient of the  
872 `MakeConnection` message to decide which messages are appropriate for transmission to any particular  
873 Endpoint. However, the Endpoint processing the `MakeConnection` message MUST insure that the  
874 messages match the selection criteria as specified by the child elements of the `MakeConnection`  
875 element.

### 876 3.11 MessagePending

877 When `MakeConnection` is used, and a message is returned on the transport-specific back-channel, the  
878 `MessagePending` header SHOULD be included on the returned message as an indicator whether there  
879 are additional messages waiting to be retrieved using the same selection criteria that was specified in the  
880 `MakeConnection` element.

881 The following exemplar defines the `MessagePending` syntax:

```
882 <wsrm:MessagePending pending="xs:boolean" ...>  
883   ...  
884 </wsrm:MessagePending>
```

885 `/wsrm:MessagePending`

886 This element indicates whether additional messages are waiting to be retrieved.

887 `/wsrm:MessagePending@pending`

888 This attribute, when set to "true", indicates that there is at least one message waiting to be retrieved.

889 When this attribute is set to "false" it indicates there are currently no messages waiting to be retrieved.

890 `/wsrm:MessagePending/{any}`

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

893 `/wsrm:MessagePending/@{any}`

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

896 The absence of the `MessagePending` header has no implication as to whether there are additional  
897 messages waiting to be retrieved.



## 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. WSRM Required 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. RM Destinations that generate Sequence faults SHOULD send those faults 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/200608/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/200608/fault
    </wsa:Action>
    <!-- Headers elided for clarity. -->
  </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:Detail>
        [Detail]
```

```

941     ...
942     </S:Detail>
943     </S:Fault>
944     </S:Body>
945     </S:Envelope>

```

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

```

948 <S11:Envelope>
949   <S11:Header>
950     <wsrm:SequenceFault>
951       <wsrm:FaultCode> wsrm:FaultCodes </wsrm:FaultCode>
952       <wsrm:Detail> [Detail] </wsrm:Detail>
953       ...
954     </wsrm:SequenceFault>
955     <!-- Headers elided for clarity. -->
956   </S11:Header>
957   <S11:Body>
958     <S11:Fault>
959       <faultcode> [Code] </faultcode>
960       <faultstring> [Reason] </faultstring>
961     </S11:Fault>
962   </S11:Body>
963 </S11:Envelope>

```

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

```

966 <S11:Envelope>
967   <S11:Body>
968     <S11:Fault>
969       <faultcode> [Subcode] </faultcode>
970       <faultstring> [Reason] </faultstring>
971     </S11:Fault>
972   </S11:Body>
973 </S11:Envelope>

```

## 974 4.1 SequenceFault Element

975 The purpose of the `SequenceFault` element is to carry the specific details of a fault generated during  
 976 the reliable messaging specific processing of a message belonging to a Sequence. WS-  
 977 ReliableMessaging nodes MUST use the `SequenceFault` container only in conjunction with the SOAP  
 978 1.1 fault mechanism. WS-ReliableMessaging nodes MUST NOT use the `SequenceFault` container in  
 979 conjunction with the SOAP 1.2 binding.

980 The following exemplar defines its syntax:

```

981 <wsrm:SequenceFault ...>
982   <wsrm:FaultCode> wsrm:FaultCodes </wsrm:FaultCode>
983   <wsrm:Detail> ... </wsrm:Detail> ?
984   ...
985 </wsrm:SequenceFault>

```

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

987 /wsrm:SequenceFault

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

989 /wsrm:SequenceFault/wsrm:FaultCode

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

992 `/wsrm:SequenceFault/wsrm:Detail`

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

994 `/wsrm:SequenceFault/wsrm:Detail/{any}`

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

996 `/wsrm:SequenceFault/wsrm:Detail/@{any}`

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

998 `/wsrm:SequenceFault/{any}`

999 This is an extensibility mechanism to allow different (extensible) types of information, based on a schema,  
1000 to be passed.

1001 `/wsrm:SequenceFault/@{any}`

1002 This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the  
1003 element.

## 1004 4.2 Sequence Terminated

1005 The Endpoint that generates this fault SHOULD make every reasonable effort to notify the corresponding  
1006 Endpoint of this decision.

1007 Properties:

1008 [Code] Sender or Receiver

1009 [Subcode] `wsrn:SequenceTerminated`

1010 [Reason] The Sequence has been terminated due to an unrecoverable error.

1011 [Detail]

1012 `<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.

## 1013 4.3 Unknown Sequence

1014 Properties:

1015 [Code] Sender

1016 [Subcode] `wsrn:UnknownSequence`

1017 [Reason] The value of wsrn:Identifier is not a known Sequence identifier.

1018 [Detail]

1019 `<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.

## 1020 4.4 Invalid Acknowledgement

1021 An example of when this fault is generated is when a message is Received by the RM Source containing  
1022 a SequenceAcknowledgement covering messages that have not been sent.

1023 [Code] Sender

1024 [Subcode] wsrn:InvalidAcknowledgement

1025 [Reason] The SequenceAcknowledgement violates the cumulative Acknowledgement invariant.

1026 [Detail]

1027 `<wsrm:SequenceAcknowledgement ...> ... </wsrm:SequenceAcknowledgement>`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source.	In response to a SequenceAcknowledgement that violate the invariants stated in 2.3 or any of the requirements in 3.6 about valid combinations of AckRange, Nack and None in a single SequenceAcknowledgement element or with respect to already Received such elements.	Unspecified.	Unspecified.

## 1028 4.5 Message Number Rollover

1029 If the condition listed below is reached, the RM Destination MUST generate this fault.

1030 Properties:

1031 [Code] Sender

1032 [Subcode] wsrn:MessageNumberRollover

1033 [Reason] The maximum value for wsrn:MessageNumber has been exceeded.

1034 [Detail]

```
1035 <wsrm:Identifier ...> xs:anyURI </wsrm:Identifier>
1036 <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.

## 1037 4.6 Create Sequence Refused

1038 Properties:

1039 [Code] Sender

1040 [Subcode] wsrm:CreateSequenceRefused

1041 [Reason] The create Sequence request has been refused by the RM Destination.

1042 [Detail]

```
1043 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.

## 1044 4.7 Sequence Closed

1045 This fault is generated by an RM Destination to indicate that the specified Sequence has been closed.

1046 This fault MUST be generated when an RM Destination is asked to accept a message for a Sequence that  
1047 is closed or when an RM Destination is asked to close a Sequence that is already closed.

1048 Properties:

1049 [Code] Sender

1050 [Subcode] wsrm:SequenceClosed

1051 [Reason] The Sequence is closed and can not accept new messages.

1052 [Detail]

1053 `<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.

## 1054 4.8 WSRM Required

1055 If an RM Destination requires the use of WS-RM, this fault is generated when it Receives an incoming  
1056 message that did not use this protocol.

1057 Properties:

1058 [Code] Sender

1059 [Subcode] wsrm:WSRMRequired

1060 [Reason] The RM Destination requires the use of WSRM.

1061 [Detail]

1062 `xs:any`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Destination.	On receipt of a message that does not use this protocol and for which this protocol is required.	Unspecified.	Unspecified.

## 1063 4.9 Unsupported Selection

1064 The QName of the unsupported element(s) are included in the detail.

1065 Properties:

1066 [Code] Receiver

1067 [Subcode] wsrm:UnsupportedSelection

1068 [Reason] The extension element used in the message selection is not supported by the RM Source

1069 [Detail]

1070 `<wsrm:UnsupportedElement> xs:QName </wsrm:UnsupportedElement>+`

Generated by	Condition	Action Upon Generation	Action Upon Receipt
RM Source or RM Destination.	In response to a <code>MakeConnection</code> message containing a selection criteria in the extensibility section of the message that is not support.ed	Unspecified.	Unspecified.

## 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

1151 Source that initiated its creation (i.e. that sent the `CreateSequence` message) and the RM Destination that  
1152 serves as its terminus (i.e. that sent the `CreateSequenceResponse` message). To counter sequence  
1153 spoofing attempts the RM Destination SHOULD ensure that every message or fault that it Receives that  
1154 refers to a particular Sequence originated from the RM Source that jointly owns the referenced Sequence.  
1155 For its part the RM Source SHOULD ensure that every message or fault that it Receives that refers to a  
1156 particular Sequence originated from the RM Destination that jointly owns the referenced Sequence.

1157 For the RM Destination to be able to identify its sequence peer it MUST be able to identify and  
1158 authenticate the entity that sent the `CreateSequence` message. Similarly for the RM Source to identify its  
1159 sequence peer it MUST be able to identify and authenticate the entity that sent the  
1160 `CreateSequenceResponse` message. For either the RM Destination or the RM Source to determine if a  
1161 message was sent by its sequence peer it MUST be able to identify and authenticate the initiator of that  
1162 message and, if necessary, correlate this identity with the sequence peer identity established at sequence  
1163 creation time.

## 1164 5.2 Security Solutions and Technologies

1165 The security threats described in the previous sections are neither new nor unique. The solutions that  
1166 have been developed to secure other SOAP-based protocols can be used to secure WS-RM as well. This  
1167 section maps the facilities provided by common web services security solutions against countermeasures  
1168 described in the previous sections.

1169 Before continuing this discussion, however, some examination of the underlying requirements of the  
1170 previously described countermeasures is necessary. Specifically it should be noted that the technique  
1171 described in Section 5.1.2.1 has two components. Firstly, the RM Destination identifies and authenticates  
1172 the issuer of a `CreateSequence` message. Secondly, the RM Destination to performs an authorization  
1173 check against this authenticated identity and determines if the RM Source is permitted to create  
1174 Sequences with the RM Destination. Since the facilities for performing this authorization check (runtime  
1175 infrastructure, policy frameworks, etc.) lie completely within the domain of individual implementations, any  
1176 discussion of such facilities is considered to be beyond the scope of this specification.

### 1177 5.2.1 Transport Layer Security

1178 This section describes how the the facilities provided by SSL/TLS [RFC 4346] can be used to implement  
1179 the countermeasures described in the previous sections. The use of SSL/TLS is subject to the constraints  
1180 defined in Section 4 of the Basic Security Profile 1.0 [BSP 1.0].

1181 The description provided here is general in nature and is not intended to serve as a complete definition on  
1182 the use of SSL/TLS to protect WS-RM. In order to interoperate implementations need to agree on the  
1183 choice of features as well as the manner in which they will be used. The mechanisms described in the  
1184 Web Services Security Policy Language [SecurityPolicy] MAY be used by services to describe the  
1185 requirements and constraints of the use of SSL/TLS.

#### 1186 5.2.1.1 Model

1187 The basic model for using SSL/TLS is as follows:

- 1188 1. The RM Source establishes an SSL/TLS session with the RM Destination.
- 1189 2. The RM Source uses this SSL/TLS session to send a `CreateSequence` message to the RM  
1190 Destination.

- 1191 3. The RM Destination establishes an SSL/TLS session with the RM Source and sends an  
1192 asynchronous `CreateSequenceResponse` using this session. Alternately it may respond with a  
1193 synchronous `CreateSequenceResponse` using the session established in (1).
- 1194 4. For the lifetime of the Sequence the RM Source uses the SSL/TLS session from (1) to Transmit  
1195 any and all messages or faults that refer to that Sequence.
- 1196 5. For the lifetime of the Sequence the RM Destination either uses the SSL/TLS session established  
1197 in (3) to Transmit any and all messages or faults that refer to that Sequence or, for synchronous  
1198 exchanges, the RM Destination uses the SSL/TLS session established in (1).

### 1199 5.2.1.2 Countermeasure Implementation

1200 Used in its simplest fashion (without relying upon any authentication mechanisms), SSL/TLS provides the  
1201 necessary integrity qualities to counter the threats described in Section 5.1.1. Note, however, that the  
1202 nature of SSL/TLS limits the scope of this integrity protection to a single transport level session. If  
1203 SSL/TLS is the only mechanism used to provide integrity, any intermediaries between the RM Source and  
1204 the RM Destination MUST be trusted to preserve the integrity of the messages that flow through them.

1205 As noted, the technique described in Sections 5.1.2.1 involves the use of authentication. This specification  
1206 advocates either of two mechanisms for authenticating entities using SSL/TLS. In both of these methods  
1207 the SSL/TLS server (the party accepting the SSL/TLS connection) authenticates itself to the SSL/TLS  
1208 client using an X.509 certificate that is exchanged during the SSL/TLS handshake.

- 1209 • **HTTP Basic Authentication:** This method of authentication presupposes that a SOAP/HTTP  
1210 binding is being used as part of the protocol stack beneath WS-RM. Subsequent to the  
1211 establishment of the the SSL/TLS session, the sending party authenticates itself to the receiving  
1212 party using HTTP Basic Authentication [RFC 2617]. For example, a RM Source might  
1213 authenticate itself to a RM Destination (e.g. when transmitting a Sequence Traffic Message) using  
1214 BasicAuth. Similarly the RM Destination might authenticate itself to the RM Source (e.g. when  
1215 sending an Acknowledgement) using BasicAuth.
- 1216 • **SSL/TLS Client Authentication:** In this method of authentication, the party initiating the  
1217 connection authenticates itself to the party accepting the connection using an X.509 certificate  
1218 that is exchanged during the SSL/TLS handshake.

1219 To implement the countermeasures described in section 5.1.2.1 the RM Source must authenticate itself  
1220 using one the above mechanisms. The authenticated identity can then be used to determine if the RM  
1221 Source is authorized to create a Sequence with the RM Destination.

1222 This specification advocates implementing the countermeasures described in section 5.1.3.2 by requiring  
1223 an RM node's Sequence peer to be equivalent to their SSL/TLS session peer. This allows the  
1224 authorization decisions described in section 5.1.3.2 to be based on SSL/TLS session identity rather than  
1225 on authentication information. For example, an RM Destination can determine that a Sequence Traffic  
1226 Message rightfully belongs to its referenced Sequence if that message arrived over the same SSL/TLS  
1227 session that was used to carry the `CreateSequence` message for that Sequence. Note that requiring a  
1228 one-to-one relationship between SSL/TLS session peer and Sequence peer constrains the lifetime of a  
1229 SSL/TLS-protected Sequence to be less than or equal to the lifetime of the SSL/TLS session that is used  
1230 to protect that Sequence.

1231 This specification does not preclude the use of other methods of using SSL/TLS to implement the  
1232 countermeasures (such as associating specific authentication information with a Sequence) although such  
1233 methods are not covered by this document.

1234 Issues specific to the life-cycle management of SSL/TLS sessions (such as the resumption of a SSL/TLS  
1235 session) are outside the scope of this specification.

## 1236 **5.2.2 SOAP Message Security**

1237 The mechanisms described in WS-Security may be used in various ways to implement the  
1238 countermeasures described in the previous sections. This specification advocates using the protocol  
1239 described by WS-SecureConversation [SecureConversation] (optionally in conjunction with WS-Trust  
1240 [Trust]) as a mechanism for protecting Sequences. The use of WS-Security (as an underlying component  
1241 of WS-SecureConversation) is subject to the constraints defined in the Basic Security Profile 1.0.

1242 The description provided here is general in nature and is not intended to serve as a complete definition on  
1243 the use of WS-SecureConversation/WS-Trust to protect WS-RM. In order to interoperate implementations  
1244 need to agree on the choice of features as well as the manner in which they will be used. The  
1245 mechanisms described in the Web Services Security Policy Language MAY be used by services to  
1246 describe the requirements and constraints of the use of WS-SecureConversation.

### 1247 **5.2.2.1 Model**

1248 The basic model for using WS-SecureConversation is as follows:

- 1249 1. The RM Source and the RM Destination create a WS-SecureConversation security context. This  
1250 may involve the participation of third parties such as a security token service. The tokens  
1251 exchanged may contain authentication claims (e.g. X.509 certificates or Kerberos service tickets).
- 1252 2. During the `CreateSequence` exchange, the RM Source SHOULD explicitly identify the security  
1253 context that will be used to protect the Sequence. This is done so that, in cases where the  
1254 `CreateSequence` message is signed by more than one security context, the RM Source can  
1255 indicate which security context should be used to protect the newly created Sequence.
- 1256 3. For the lifetime of the Sequence the RM Source and the RM Destination use the session key(s)  
1257 associated with the security context to sign (as defined by WS-Security) at least the body and any  
1258 relevant WS-RM-defined headers of any and all messages or faults that refer to that Sequence.

### 1259 **5.2.2.2 Countermeasure Implementation**

1260 Without relying upon any authentication information, the per-message signatures provide the necessary  
1261 integrity qualities to counter the threats described in Section 5.1.1.

1262 To implement the countermeasures described in section 5.1.2.1 some mutually agreed upon form of  
1263 authentication claims must be provided by the RM Source to the RM Destination during the establishment  
1264 of the Security Context. These claims can then be used to determine if the RM Source is authorized to  
1265 create a Sequence with the RM Destination.

1266 This specification advocates implementing the countermeasures described in section 5.1.3.2 by requiring  
1267 an RM node's Sequence peer to be equivalent to their security context session peer. This allows the  
1268 authorization decisions described in section 5.1.3.2 to be based on the identity of the message's security  
1269 context rather than on any authentication claims that may have been established during security context  
1270 initiation. Note that other methods of using WS-SecurityConversation to implement the countermeasures  
1271 (such as associating specific authentication claims to a Sequence) are possible but not covered by this  
1272 document.

1273 As with transport security, the requisite equivalence of a security context peer and with a Sequence peer  
1274 limits the lifetime of a Sequence to the lifetime of the protecting security context. Unlike transport security,

1275 the association between a Sequence and its protecting security context cannot always be established  
1276 implicitly at Sequence creation time. This is due to the fact that the `CreateSequence` and  
1277 `CreateSequenceResponse` messages may be signed by more than one security context.

1278 Issues specific to the life-cycle management of WS-SecurityConversation security contexts (such as  
1279 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>
```

`/wsrm:CreateSequence/wsse:SecurityTokenReference`

This element uses the extensibility mechanism defined for the `CreateSequence` element (defined in section 3.1) 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 with the requirements listed above. In order to achieve this, the RM Source SHOULD include the `UsesSequenceSTR` element as a SOAP header block within the `CreateSequence` message. This element MUST include a `soap:mustUnderstand` attribute with a value of 'true'. Thus the RM Source

1328 can be assured that a RM Destination that responds with a `CreateSequenceResponse` understands  
1329 and conforms with the requirements listed above. Note that an RM Destination understanding this header  
1330 does not mean that it has processed and understood any WS-Security headers, the fault behavior defined  
1331 in WS-Security still applies.

1332 The following exemplar defines the `UsesSequenceSTR` syntax:

```
1333 <wsrm:UsesSequenceSTR ... />
```

1334 `/wsrm:UsesSequenceSTR`

1335 This element SHOULD be included as a SOAP header block in `CreateSequence` messages that use the  
1336 extensibility mechanism described above in this section. The `soap:mustUnderstand` attribute value  
1337 MUST be 'true'. The receiving RM Destination MUST understand and correctly implement the extension  
1338 described above or else generate a `soap:MustUnderstand` fault, thus aborting the requested  
1339 Sequence creation.

1340 The following is an example of a `CreateSequence` message using the

1341 `wsse:SecurityTokenReference` extension and the `UsesSequenceSTR` header block:

```
1342 <soap:Envelope ...>
1343   <soap:Header>
1344     ...
1345     <wsrm:UsesSequenceSTR soap:mustUnderstand='true' />
1346     ...
1347   </soap:Header>
1348   <soap:Body>
1349     <wsrm:CreateSequence>
1350       <wsrm:AcksTo>
1351         <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1352       </wsrm:AcksTo>
1353       <wsse:SecurityTokenReference>
1354         ...
1355       </wsse:SecurityTokenReference>
1356     </wsrm:CreateSequence>
1357   </soap:Body>
1358 </soap:Envelope>
```

## 1359 6.2 Securing Sequences Using SSL/TLS

1360 One mechanism for protecting a Sequence is to bind the Sequence to the underlying SSL/TLS session(s).  
1361 The RM Source indicates to the RM Destination that a Sequence is to be bound to the underlying  
1362 SSL/TLS session(s) via the `UsesSequenceSSL` header block. If the RM Source wishes to bind a  
1363 Sequence to the underlying SSL/TLS sessions(s) it MUST include the `UsesSequenceSSL` element as a  
1364 SOAP header block within the `CreateSequence` message.

1365 The following exemplar defines the `UsesSequenceSSL` syntax:

```
1366 <wsrm:UsesSequenceSSL soap:mustUnderstand="true" ... />
```

1367 `/wsrm:UsesSequenceSSL`

1368 The RM Source MAY include this element as a SOAP header block of a `CreateSequence` message to  
1369 indicate to the RM Destination that the resulting Sequence is to be bound to the SSL/TLS session that was  
1370 used to carry the `CreateSequence` message. If included, the RM Source MUST mark this header with a  
1371 `soap:mustUnderstand` attribute with a value of 'true'. The receiving RM Destination MUST understand  
1372 and correctly implement the functionality described in Section 5.2.1 or else generate a  
1373 `soap:MustUnderstand` fault, thus aborting the requested Sequence creation.



1374 Note that the use inclusion of the above header by the RM Source implies that all Sequence-related  
1375 information (Sequence Lifecycle or Acknowledgment messages or Sequence-related faults) flowing from  
1376 the RM Destination to the RM Source will be bound to the SSL/TLS session that is used to carry the  
1377 `CreateSequenceResponse` message.



## 7 References

### 7.1 Normative

#### [KEYWORDS]

S. Bradner, "[Key words for use in RFCs to Indicate Requirement Levels](#)," RFC 2119, Harvard University, March 1997

#### [SOAP 1.1]

W3C Note, "[SOAP: Simple Object Access Protocol 1.1](#)," 08 May 2000.

#### [SOAP 1.2]

W3C Recommendation, "[SOAP Version 1.2 Part 1: Messaging Framework](#)" June 2003.

#### [URI]

T. Berners-Lee, R. Fielding, L. Masinter, "[Uniform Resource Identifiers \(URI\): Generic Syntax](#)," RFC 3986, MIT/LCS, U.C. Irvine, Xerox Corporation, January 2005.

#### [UUID]

P. Leach, M. Mealling, R. Salz, "[A Universally Unique Identifier \(UUID\) URN Namespace](#)," RFC 4122, Microsoft, Refactored Networks - LLC, DataPower Technology Inc, July 2005

#### [XML]

W3C Recommendation, "[Extensible Markup Language \(XML\) 1.0 \(Second Edition\)](#)", October 2000.

#### [XML-ns]

W3C Recommendation, "[Namespaces in XML](#)," 14 January 1999.

#### [XML-Schema Part1]

W3C Recommendation, "[XML Schema Part 1: Structures](#)," 2 May 2001.

#### [XML-Schema Part2]

W3C Recommendation, "[XML Schema Part 2: Datatypes](#)," 2 May 2001.

#### [XPath 1.0]

W3C Recommendation, "[XML Path Language \(XPath\) Version 1.0](#)," 16 November 1999.

#### [WSDL 1.1]

W3C Note, "[Web Services Description Language \(WSDL 1.1\)](#)," 15 March 2001.

#### [WS-Addressing]

W3C Recommendation, "[Web Services Addressing 1.0 - Core](#)", May 2006.

W3C Recommendation, "[Web Services Addressing 1.0 – SOAP Binding](#)", May 2006.

### 7.2 Non-Normative

#### [BSP 1.0]

WS-I Working Group Draft. "[Basic Security Profile Version 1.0](#)," March 2006

#### [RDDL 2.0]

1412 Johnathan Borden, Tim Bray, eds. "[Resource Directory Description Language \(RDDL\) 2.0](#)," January 2004

1413 **[RFC 2617]**

1414 J. Franks, P. Hallam-Baker, J. Hostetler, S. Lawrence, P. Leach, A. Loutonen, L. Stewart, "[HTTP](#)

1415 [Authentication: Basic and Digest Access Authentication](#)," June 1999.

1416 **[RFC 4346]**

1417 T. Dierks, E. Rescorla, "[The Transport Layer Security \(TLS\) Protocol Version 1.1](#)," April 2006.

1418 **[WS-Policy]**

1419 W3C Member Submission, "[Web Services Policy Framework \(WS-Policy\)](#)," April 2006.

1420 **[WS-PolicyAttachment]**

1421 W3C Member Submission, "[Web Services Policy Attachment \(WS-PolicyAttachment\)](#)," April 2006.

1422 **[WS-Security]**

1423 Anthony Nadalin, Chris Kaler, Phillip Hallam-Baker, Ronald Monzillo, eds. "[OASIS Web Services Security:](#)

1424 [SOAP Message Security 1.0 \(WS-Security 2004\)](#)", OASIS Standard 200401, March 2004.

1425 Anthony Nadalin, Chris Kaler, Phillip Hallam-Baker, Ronald Monzillo, eds. "[OASIS Web Services Security:](#)

1426 [SOAP Message Security 1.1 \(WS-Security 2004\)](#)", OASIS Standard 200602, February 2006.

1427 **[RTTM]**

1428 V. Jacobson, R. Braden, D. Borman, "[TCP Extensions for High Performance](#)", RFC 1323, May

1429 1992.

1430 **[SecurityPolicy]**

1431 G. Della-Libra, et. al. "[Web Services Security Policy Language \(WS-SecurityPolicy\)](#)", July 2005

1432 **[SecureConversation]**

1433 S. Anderson, et al, "[Web Services Secure Conversation Language \(WS-SecureConversation\)](#)," February

1434 2005.

1435 **[Trust]**

1436 S. Anderson, et al, "Web Services Trust Language (WS-Trust)," February 2005.

## 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/200608/wsrn-1.1-schema-200608.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/200608"
targetNamespace="http://docs.oasis-open.org/ws-rx/wsrn/200608"
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>
```

```

1493     <xs:anyAttribute namespace="##other" processContents="lax"/>
1494 </xs:complexType>
1495 <xs:element name="Sequence" type="wsrm:SequenceType"/>
1496 <xs:element name="SequenceAcknowledgement">
1497   <xs:complexType>
1498     <xs:sequence>
1499       <xs:element ref="wsrm:Identifier"/>
1500       <xs:choice>
1501         <xs:sequence>
1502           <xs:choice>
1503             <xs:element name="AcknowledgementRange" maxOccurs="unbounded">
1504               <xs:complexType>
1505                 <xs:sequence/>
1506                 <xs:attribute name="Upper" type="xs:unsignedLong"
1507 use="required"/>
1508                 <xs:attribute name="Lower" type="xs:unsignedLong"
1509 use="required"/>
1510               <xs:anyAttribute namespace="##other" processContents="lax"/>
1511             </xs:complexType>
1512           </xs:element>
1513           <xs:element name="None">
1514             <xs:complexType>
1515               <xs:sequence/>
1516             </xs:complexType>
1517           </xs:element>
1518         </xs:choice>
1519         <xs:element name="Final" minOccurs="0">
1520           <xs:complexType>
1521             <xs:sequence/>
1522           </xs:complexType>
1523         </xs:element>
1524       </xs:sequence>
1525       <xs:element name="Nack" type="xs:unsignedLong"
1526 maxOccurs="unbounded"/>
1527     </xs:choice>
1528     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1529 maxOccurs="unbounded"/>
1530   </xs:sequence>
1531   <xs:anyAttribute namespace="##other" processContents="lax"/>
1532 </xs:complexType>
1533 </xs:element>
1534 <xs:complexType name="AckRequestedType">
1535   <xs:sequence>
1536     <xs:element ref="wsrm:Identifier"/>
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 name="AckRequested" type="wsrm:AckRequestedType"/>
1543 <xs:complexType name="MessagePendingType">
1544   <xs:sequence>
1545     <xs:any namespace="##other" processContents="lax" minOccurs="0"
1546 maxOccurs="unbounded"/>
1547   </xs:sequence>
1548   <xs:attribute name="pending" type="xs:boolean"/>
1549   <xs:anyAttribute namespace="##other" processContents="lax"/>
1550 </xs:complexType>
1551 <xs:element name="MessagePending" type="wsrm:MessagePendingType"/>
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:complexType name="MakeConnectionType">
1577     <xs:sequence>
1578         <xs:element ref="wsrm:Identifier" minOccurs="0" maxOccurs="1"/>
1579         <xs:element ref="wsrm:Address" minOccurs="0" maxOccurs="1"/>
1580         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1581 maxOccurs="unbounded"/>
1582     </xs:sequence>
1583     <xs:anyAttribute namespace="##other" processContents="lax"/>
1584 </xs:complexType>
1585 <xs:element name="MakeConnection" type="wsrm:MakeConnectionType"/>
1586 <xs:simpleType name="MessageNumberType">
1587     <xs:restriction base="xs:unsignedLong">
1588         <xs:minInclusive value="1"/>
1589         <xs:maxInclusive value="9223372036854775807"/>
1590     </xs:restriction>
1591 </xs:simpleType>
1592 <!-- Fault Container and Codes -->
1593 <xs:simpleType name="FaultCodes">
1594     <xs:restriction base="xs:QName">
1595         <xs:enumeration value="wsrm:SequenceTerminated"/>
1596         <xs:enumeration value="wsrm:UnknownSequence"/>
1597         <xs:enumeration value="wsrm:InvalidAcknowledgement"/>
1598         <xs:enumeration value="wsrm:MessageNumberRollover"/>
1599         <xs:enumeration value="wsrm:CreateSequenceRefused"/>
1600         <xs:enumeration value="wsrm:SequenceClosed"/>
1601         <xs:enumeration value="wsrm:WSRMRequired"/>
1602         <xs:enumeration value="wsrm:UnsupportedSelection"/>
1603     </xs:restriction>
1604 </xs:simpleType>
1605 <xs:complexType name="SequenceFaultType">
1606     <xs:sequence>
1607         <xs:element name="FaultCode" type="wsrm:FaultCodes"/>
1608         <xs:element name="Detail" type="wsrm:DetailType" minOccurs="0"/>
1609         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1610 maxOccurs="unbounded"/>
1611     </xs:sequence>
1612     <xs:anyAttribute namespace="##other" processContents="lax"/>
1613 </xs:complexType>
1614 <xs:complexType name="DetailType">
1615     <xs:sequence>
1616         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1617 maxOccurs="unbounded"/>
1618     </xs:sequence>

```

```

1619     <xs:anyAttribute namespace="##other" processContents="lax"/>
1620 </xs:complexType>
1621 <xs:element name="SequenceFault" type="wsrm:SequenceFaultType"/>
1622 <xs:element name="CreateSequence" type="wsrm:CreateSequenceType"/>
1623 <xs:element name="CreateSequenceResponse"
1624 type="wsrm:CreateSequenceResponseType"/>
1625 <xs:element name="CloseSequence" type="wsrm:CloseSequenceType"/>
1626 <xs:element name="CloseSequenceResponse"
1627 type="wsrm:CloseSequenceResponseType"/>
1628 <xs:element name="TerminateSequence" type="wsrm:TerminateSequenceType"/>
1629 <xs:element name="TerminateSequenceResponse"
1630 type="wsrm:TerminateSequenceResponseType"/>
1631 <xs:complexType name="CreateSequenceType">
1632 <xs:sequence>
1633 <xs:element ref="wsrm:AcksTo"/>
1634 <xs:element ref="wsrm:Expires" minOccurs="0"/>
1635 <xs:element name="Offer" type="wsrm:OfferType" minOccurs="0"/>
1636 <xs:any namespace="##other" processContents="lax" minOccurs="0"
1637 maxOccurs="unbounded">
1638 <xs:annotation>
1639 <xs:documentation>
1640 It is the authors intent that this extensibility be used to
1641 transfer a Security Token Reference as defined in WS-Security.
1642 </xs:documentation>
1643 </xs:annotation>
1644 </xs:any>
1645 </xs:sequence>
1646 <xs:anyAttribute namespace="##other" processContents="lax"/>
1647 </xs:complexType>
1648 <xs:complexType name="CreateSequenceResponseType">
1649 <xs:sequence>
1650 <xs:element ref="wsrm:Identifier"/>
1651 <xs:element ref="wsrm:Expires" minOccurs="0"/>
1652 <xs:element name="IncompleteSequenceBehavior"
1653 type="wsrm:IncompleteSequenceBehaviorType" minOccurs="0"/>
1654 <xs:element name="Accept" type="wsrm:AcceptType" minOccurs="0"/>
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="CloseSequenceType">
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="CloseSequenceResponseType">
1669 <xs:sequence>
1670 <xs:element ref="wsrm:Identifier"/>
1671 <xs:any namespace="##other" processContents="lax" minOccurs="0"
1672 maxOccurs="unbounded"/>
1673 </xs:sequence>
1674 <xs:anyAttribute namespace="##other" processContents="lax"/>
1675 </xs:complexType>
1676 <xs:complexType name="TerminateSequenceType">
1677 <xs:sequence>
1678 <xs:element ref="wsrm:Identifier"/>
1679 <xs:element name="LastMsgNumber" type="wsrm:MessageNumberType"/>
1680 <xs:any namespace="##other" processContents="lax" minOccurs="0"
1681 maxOccurs="unbounded"/>

```

```

1682     </xs:sequence>
1683     <xs:anyAttribute namespace="##other" processContents="lax"/>
1684 </xs:complexType>
1685 <xs:complexType name="TerminateSequenceResponseType">
1686     <xs:sequence>
1687         <xs:element ref="wsrm:Identifier"/>
1688         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1689 maxOccurs="unbounded"/>
1690     </xs:sequence>
1691     <xs:anyAttribute namespace="##other" processContents="lax"/>
1692 </xs:complexType>
1693 <xs:element name="AcksTo" type="wsa:EndpointReferenceType"/>
1694 <xs:complexType name="OfferType">
1695     <xs:sequence>
1696         <xs:element ref="wsrm:Identifier"/>
1697         <xs:element name="Endpoint" type="wsa:EndpointReferenceType"/>
1698         <xs:element ref="wsrm:Expires" minOccurs="0"/>
1699         <xs:element name="IncompleteSequenceBehavior"
1700 type="wsrm:IncompleteSequenceBehaviorType" minOccurs="0"/>
1701         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1702 maxOccurs="unbounded"/>
1703     </xs:sequence>
1704     <xs:anyAttribute namespace="##other" processContents="lax"/>
1705 </xs:complexType>
1706 <xs:complexType name="AcceptType">
1707     <xs:sequence>
1708         <xs:element ref="wsrm:AcksTo"/>
1709         <xs:any namespace="##other" processContents="lax" minOccurs="0"
1710 maxOccurs="unbounded"/>
1711     </xs:sequence>
1712     <xs:anyAttribute namespace="##other" processContents="lax"/>
1713 </xs:complexType>
1714 <xs:element name="Expires">
1715     <xs:complexType>
1716         <xs:simpleContent>
1717             <xs:extension base="xs:duration">
1718                 <xs:anyAttribute namespace="##other" processContents="lax"/>
1719             </xs:extension>
1720         </xs:simpleContent>
1721     </xs:complexType>
1722 </xs:element>
1723 <xs:simpleType name="IncompleteSequenceBehaviorType">
1724     <xs:restriction base="xs:string">
1725         <xs:enumeration value="DiscardEntireSequence"/>
1726         <xs:enumeration value="DiscardFollowingFirstGap"/>
1727         <xs:enumeration value="NoDiscard"/>
1728     </xs:restriction>
1729 </xs:simpleType>
1730 <xs:element name="UsesSequenceSTR">
1731     <xs:sequence/>
1732     <xs:anyAttribute namespace="##other" processContents="lax"/>
1733 </xs:element>
1734 <xs:element name="UsesSequenceSSL">
1735     <xs:sequence/>
1736     <xs:anyAttribute namespace="##other" processContents="lax"/>
1737 </xs:element>
1738 <xs:element name="UnsupportedElement">
1739     <xs:simpleType>
1740         <xs:restriction base="xs:QName"/>
1741     </xs:simpleType>
1742 </xs:element>
1743 </xs:schema>

```

## Appendix B. WSDL

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

<http://docs.oasis-open.org/ws-rx/wsrn/200608/wsd/wsrn-1.1-wsd-200608.wsd>

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FOR A PARTICULAR PURPOSE.
-->
<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:rm="http://docs.oasis-
open.org/ws-rx/wsrn/200608" xmlns:tns="http://docs.oasis-open.org/ws-
rx/wsrn/200608/wsd" targetNamespace="http://docs.oasis-open.org/ws-
rx/wsrn/200608/wsd">

  <wsdl:types>
    <xs:schema>
      <xs:import namespace="http://docs.oasis-open.org/ws-rx/wsrn/200608"
schemaLocation="http://docs.oasis-open.org/ws-rx/wsrn/200608/wsrn-1.1-schema-
200608.xsd"/>
    </xs:schema>
  </wsdl:types>

  <wsdl:message name="CreateSequence">
    <wsdl:part name="create" element="rm:CreateSequence"/>
  </wsdl:message>
</wsdl:definitions>
```



```

1799     </wsdl:message>
1800     <wsdl:message name="CreateSequenceResponse">
1801         <wsdl:part name="createResponse" element="rm:CreateSequenceResponse"/>
1802     </wsdl:message>
1803     <wsdl:message name="CloseSequence">
1804         <wsdl:part name="close" element="rm:CloseSequence"/>
1805     </wsdl:message>
1806     <wsdl:message name="CloseSequenceResponse">
1807         <wsdl:part name="closeResponse" element="rm:CloseSequenceResponse"/>
1808     </wsdl:message>
1809     <wsdl:message name="TerminateSequence">
1810         <wsdl:part name="terminate" element="rm:TerminateSequence"/>
1811     </wsdl:message>
1812     <wsdl:message name="TerminateSequenceResponse">
1813         <wsdl:part name="terminateResponse"
1814 element="rm:TerminateSequenceResponse"/>
1815     </wsdl:message>
1816     <wsdl:message name="MakeConnection">
1817         <wsdl:part name="makeConnection" element="rm:MakeConnection"/>
1818     </wsdl:message>
1819
1820     <wsdl:portType name="SequenceAbstractPortType">
1821         <wsdl:operation name="CreateSequence">
1822             <wsdl:input message="tns:CreateSequence" wsaw:Action="http://docs.oasis-
1823 open.org/ws-rx/wsr/200608/CreateSequence"/>
1824             <wsdl:output message="tns:CreateSequenceResponse"
1825 wsaw:Action="http://docs.oasis-open.org/ws-
1826 rx/wsr/200608/CreateSequenceResponse"/>
1827         </wsdl:operation>
1828         <wsdl:operation name="CloseSequence">
1829             <wsdl:input message="tns:CloseSequence" wsaw:Action="http://docs.oasis-
1830 open.org/ws-rx/wsr/200608/CloseSequence"/>
1831             <wsdl:output message="tns:CloseSequenceResponse"
1832 wsaw:Action="http://docs.oasis-open.org/ws-
1833 rx/wsr/200608/CloseSequenceResponse"/>
1834         </wsdl:operation>
1835         <wsdl:operation name="TerminateSequence">
1836             <wsdl:input message="tns:TerminateSequence"
1837 wsaw:Action="http://docs.oasis-open.org/ws-rx/wsr/200608/TerminateSequence"/>
1838             <wsdl:output message="tns:TerminateSequenceResponse"
1839 wsaw:Action="http://docs.oasis-open.org/ws-
1840 rx/wsr/200608/TerminateSequenceResponse"/>
1841         </wsdl:operation>
1842         <wsdl:operation name="MakeConnection">
1843             <wsdl:input message="tns:MakeConnection" wsaw:Action="http://docs.oasis-
1844 open.org/ws-rx/wsr/200608/MakeConnection"/>
1845         </wsdl:operation>
1846     </wsdl:portType>
1847
1848 </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/200608"
  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/200608/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/200608"
  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/200608/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:~~

## 1897 Message 1

```
1898 <?xml version="1.0" encoding="UTF-8"?>
1899 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1900 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200608"
1901 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1902   <S:Header>
1903     <wsa:MessageID>
1904       http://Business456.com/guid/71e0654e-5ce8-477b-bb9d-34f05cfc9e
1905     </wsa:MessageID>
1906     <wsa:To>http://example.com/serviceB/123</wsa:To>
1907     <wsa:From>
1908       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1909     </wsa:From>
1910     <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1911     <wsmr:Sequence>
1912       <wsmr:Identifier>http://Business456.com/RM/ABC</wsmr:Identifier>
1913       <wsmr:MessageNumber>1</wsmr:MessageNumber>
1914     </wsmr:Sequence>
1915   </S:Header>
1916   <S:Body>
1917     <!-- Some Application Data -->
1918   </S:Body>
1919 </S:Envelope>
```

## 1920 Message 2

```
1921 <?xml version="1.0" encoding="UTF-8"?>
1922 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1923 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200608"
1924 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1925   <S:Header>
1926     <wsa:MessageID>
1927       http://Business456.com/guid/daa7d0b2-c8e0-476e-a9a4-d164154e38de
1928     </wsa:MessageID>
1929     <wsa:To>http://example.com/serviceB/123</wsa:To>
1930     <wsa:From>
1931       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
1932     </wsa:From>
1933     <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1934     <wsmr:Sequence>
1935       <wsmr:Identifier>http://Business456.com/RM/ABC</wsmr:Identifier>
1936       <wsmr:MessageNumber>2</wsmr:MessageNumber>
1937     </wsmr:Sequence>
1938   </S:Header>
1939   <S:Body>
1940     <!-- Some Application Data -->
1941   </S:Body>
1942 </S:Envelope>
```

## 1943 Message 3

```
1944 <?xml version="1.0" encoding="UTF-8"?>
1945 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1946 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200608"
1947 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1948   <S:Header>
1949     <wsa:MessageID>
1950       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546819
1951     </wsa:MessageID>
1952     <wsa:To>http://example.com/serviceB/123</wsa:To>
1953     <wsa:From>
1954       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
```

```

1955 </wsa:From>
1956 <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
1957 <wsrm:Sequence>
1958 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
1959 <wsrm:MessageNumber>3</wsrm:MessageNumber>
1960 </wsrm:Sequence>
1961 <wsrm:AckRequested>
1962 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
1963 </wsrm:AckRequested>
1964 </S:Header>
1965 <S:Body>
1966 <!-- Some Application Data -->
1967 </S:Body>
1968 </S:Envelope>

```

## 1969 Appendix C.3 First Acknowledgement

1970 Message number 2 has not been accepted by the RM Destination due to some transmission error so it  
1971 responds with an Acknowledgement for messages 1 and 3:

```

1972 <?xml version="1.0" encoding="UTF-8"?>
1973 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
1974 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200608"
1975 xmlns:wsa="http://www.w3.org/2005/08/addressing">
1976 <S:Header>
1977 <wsa:MessageID>
1978 http://example.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546810
1979 </wsa:MessageID>
1980 <wsa:To>http://Business456.com/serviceA/789</wsa:To>
1981 <wsa:From>
1982 <wsa:Address>http://example.com/serviceB/123</wsa:Address>
1983 </wsa:From>
1984 <wsa:Action>
1985 http://docs.oasis-open.org/ws-rx/wsrn/200608/SequenceAcknowledgement
1986 </wsa:Action>
1987 <wsrm:SequenceAcknowledgement>
1988 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
1989 <wsrm:AcknowledgementRange Upper="1" Lower="1"/>
1990 <wsrm:AcknowledgementRange Upper="3" Lower="3"/>
1991 </wsrm:SequenceAcknowledgement>
1992 </S:Header>
1993 <S:Body/>
1994 </S:Envelope>

```

## 1995 Appendix C.4 Retransmission

1996 The RM Sourcediscovers that message number 2 was not accepted so it resends the message and  
1997 requests an Acknowledgement:

```

1998 <?xml version="1.0" encoding="UTF-8"?>
1999 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2000 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200608"
2001 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2002 <S:Header>
2003 <wsa:MessageID>
2004 http://Business456.com/guid/daa7d0b2-c8e0-476e-a9a4-d164154e38de
2005 </wsa:MessageID>
2006 <wsa:To>http://example.com/serviceB/123</wsa:To>
2007 <wsa:From>
2008 <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2009 </wsa:From>

```

```

2010 <wsa:Action>http://example.com/serviceB/123/request</wsa:Action>
2011 <wsrm:Sequence>
2012 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2013 <wsrm:MessageNumber>2</wsrm:MessageNumber>
2014 </wsrm:Sequence>
2015 <wsrm:AckRequested>
2016 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2017 </wsrm:AckRequested>
2018 </S:Header>
2019 <S:Body>
2020 <!-- Some Application Data -->
2021 </S:Body>
2022 </S:Envelope>

```

## 2023 Appendix C.5 Termination

2024 The RM Destination now responds with an Acknowledgement for the complete Sequence which can then  
 2025 be terminated: the third message is identified as the last message in the Sequence:

```

2026 <?xml version="1.0" encoding="UTF-8"?>
2027 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2028 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsr/200608"
2029 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2030 <S:Header>
2031 <wsa:MessageID>
2032 http://example.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546811
2033 </wsa:MessageID>
2034 <wsa:To>http://Business456.com/serviceA/789</wsa:To>
2035 <wsa:From>
2036 <wsa:Address>http://example.com/serviceB/123</wsa:Address>
2037 </wsa:From>
2038 <wsa:Action>
2039 http://docs.oasis-open.org/ws-rx/wsr/200608/SequenceAcknowledgement
2040 </wsa:Action>
2041 <wsrm:SequenceAcknowledgement>
2042 <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2043 <wsrm:AcknowledgementRange Upper="3" Lower="1"/>
2044 </wsrm:SequenceAcknowledgement>
2045 </S:Header>
2046 <S:Body/>
2047 </S:Envelope>

```

## 2048 Terminate Sequence

```

2049 <?xml version="1.0" encoding="UTF-8"?>
2050 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2051 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsr/200608"
2052 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2053 <S:Header>
2054 <wsa:MessageID>
2055 http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546812
2056 </wsa:MessageID>
2057 <wsa:To>http://example.com/serviceB/123</wsa:To>
2058 <wsa:Action>
2059 http://docs.oasis-open.org/ws-rx/wsr/200608/TerminateSequence
2060 </wsa:Action>
2061 <wsa:From>
2062 <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2063 </wsa:From>
2064 </S:Header>
2065 <S:Body>
2066 <wsrm:TerminateSequence>

```

```

2067     <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2068     <wsrm:LastMsgNumber>3</wsrm:LastMsgNumber>
2069   </wsrm:TerminateSequence>
2070 </S:Body>
2071 </S:Envelope>

```

## 2072 Terminate Sequence Response

```

2073 <?xml version="1.0" encoding="UTF-8"?>
2074 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2075   xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrm/200608"
2076   xmlns:wsa="http://www.w3.org/2005/08/addressing">
2077   <S:Header>
2078     <wsa:MessageID>
2079       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546813
2080     </wsa:MessageID>
2081     <wsa:To>http://example.com/serviceA/789</wsa:To>
2082     <wsa:Action>
2083       http://docs.oasis-open.org/ws-rx/wsrm/200608/TerminateSequenceResponse
2084     </wsa:Action>
2085     <wsa:RelatesTo>
2086       http://Business456.com/guid/0baaf88d-483b-4ecf-a6d8-a7c2eb546812
2087     </wsa:RelatesTo>
2088     <wsa:From>
2089       <wsa:Address>http://Business456.com/serviceA/789</wsa:Address>
2090     </wsa:From>
2091   </S:Header>
2092   <S:Body>
2093     <wsrm:TerminateSequenceResponse>
2094       <wsrm:Identifier>http://Business456.com/RM/ABC</wsrm:Identifier>
2095     </wsrm:TerminateSequenceResponse>
2096   </S:Body>
2097 </S:Envelope>

```

## 2098 Appendix C.6 MakeConnection

2099 To illustrate how a `MakeConnection` message exchange can be used to deliver messages to an  
 2100 Endpoint that is not addressable, consider the case of a pub/sub scenario in which the Endpoint to which  
 2101 notifications are to be delivered (the "event consumer") is not addressable by the notification sending  
 2102 Endpoint (the "event producer"). In this scenario the event consumer must initiate the connections in order  
 2103 for the notifications to be delivered. One possible set of message exchanges (using HTTP) that  
 2104 demonstrate how this can be achieved using `MakeConnection` is shown below.

2105 **Step 1** – During a "subscribe" operation, the event consumer's EPR specifies the RM anonymous URI  
 2106 and the RM Policy Assertion to indicate whether or not RM is required:

```

2107 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2108   xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrm/200608"
2109   xmlns:wsrmp="http://docs.oasis-open.org/ws-rx/wsrmp/200608"
2110   xmlns:wsa="http://www.w3.org/2005/08/addressing">
2111   <S:Header>
2112     <wsa:To> http://example.org/subscriptionService </wsa:To>
2113     <wsa:MessageID> http://client456.org/id-a6d8-a7c2eb546813</wsa:MessageID>
2114     <wsa:ReplyTo>
2115       <wsa:To> http://client456.org/response </wsa:To>
2116     </wsa:ReplyTo>
2117   </S:Header>
2118   <S:Body>
2119     <sub:Subscribe xmlns:sub="http://exaaple.org/subscriptionService">
2120       <!-- subscription service specific data -->
2121       <targetEPR>

```

```

2122     <wsa:Address>http://docs.oasis-open.org/ws-
2123 rx/wsrn/200608/anonymous?id=550e8400-e29b-11d4-a716-446655440000</wsa:Address>
2124     <wsa:Metadata>
2125         <wsp:Policy wsu:Id="MyPolicy">
2126             <wsrmp:RMAssertion/>
2127         </wsp:Policy>
2128     </wsa:Metadata>
2129 </targetEPR>
2130 </sub:Subscribe>
2131 </S:Body>
2132 </S:Envelope>

```

2133 In this example the `subscribe` and `targetEPR` elements are simply examples of what a subscription  
2134 request message might contain. Note: the `wsa:Address` element contains the RM anonymous URI  
2135 indicating that the notification producer needs to queue the messages until they are requested using the  
2136 `MakeConnection` message exchange. The EPR also contains the RM Policy Assertion indicating the RM  
2137 must be used when notifications related to this subscription are sent.

2138 **Step 2** – Once the subscription is established, the event consumer checks for a pending message:

```

2139 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2140 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200608"
2141 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2142     <S:Header>
2143         <wsa:Action>http://docs.oasis-open.org/ws-
2144 rx/wsrn/200608/MakeConnection</wsa:Action>
2145         <wsa:To> http://example.org/subscriptionService </wsa:To>
2146     </S:Header>
2147     <S:Body>
2148         <wsrm:MakeConnection>
2149             <wsrm:Address>http://docs.oasis-open.org/ws-
2150 rx/wsrn/200608/anonymous?id=550e8400-e29b-11d4-a716-
2151 446655440000</wsrm:Address>
2152         </wsrm:MakeConnection>
2153     </S:Body>
2154 </S:Envelope>

```

2155 **Step 3** – If there are messages waiting to be delivered then a message will be returned back to the event  
2156 consumer. However, because WS-RM is being used to deliver the messages, the first message returned  
2157 is a `CreateSequence`:

```

2158 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2159 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrn/200608"
2160 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2161     <S:Header>
2162         <wsa:Action>http://docs.oasis-open.org/ws-
2163 rx/wsrn/200608/CreateSequence</wsa:Action>
2164         <wsa:To>http://docs.oasis-open.org/ws-
2165 rx/wsrn/200608/anonymous?id=550e8400-e29b-11d4-a716-446655440000</wsa:To>
2166         <wsa:ReplyTo> http://example.org/subscriptionService </wsa:ReplyTo>
2167         <wsa:MessageID> http://example.org/id-123-456 </wsa:MessageID>
2168     </S:Header>
2169     <S:Body>
2170         <wsrm:CreateSequence>
2171             <wsrm:AcksTo>
2172                 <wsa:Address> http://example.org/subscriptionService </wsa:Address>
2173             </wsrm:AcksTo>
2174         </wsrm:CreateSequence>
2175     </S:Body>

```

2176 </S:Envelope>

2177 Notice from the perspective of how the RM Source on the event producer interacts with the RM  
2178 Destination of those messages, nothing new is introduced by the use of the `MakeConnection`, the use  
2179 of RM protocol is the same as the case where the event consumer is addressable.

2180 **Step 4** – The event consumer will respond with a `CreateSequenceResponse` message per normal WS-  
2181 Addressing rules:

```
2182 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"  
2183 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200608"  
2184 xmlns:wsa="http://www.w3.org/2005/08/addressing">  
2185   <S:Header>  
2186     <wsa:Action>http://docs.oasis-open.org/ws-  
2187 rx/wsmr/200608/CreateSequenceResponse</wsa:Action>  
2188     <wsa:To> http://example.org/subscriptionService </wsa:To>  
2189     <wsa:RelatesTo> http://example.org/id-123-456 </wsa:RelatesTo>  
2190   </S:Header>  
2191   <S:Body>  
2192     <wsmr:CreateSequenceResponse>  
2193       <wsmr:Identifier> http://example.org/rmid-456 </wsmr:Identifier>  
2194     </wsmr:CreateSequenceResponse>  
2195   </S:Body>  
2196 </S:Envelope>
```

2197 Note, this message is carried on an HTTP request directed to the `wsa:ReplyTo` EPR, and the HTTP  
2198 response will be an HTTP 202.

2199 **Step 5** – The event consumer checks for another message pending:

```
2200 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"  
2201 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200608"  
2202 xmlns:wsa="http://www.w3.org/2005/08/addressing">  
2203   <S:Header>  
2204     <wsa:Action>http://docs.oasis-open.org/ws-  
2205 rx/wsmr/200608/MakeConnection</wsa:Action>  
2206     <wsa:To> http://example.org/subscriptionService </wsa:To>  
2207   </S:Header>  
2208   <S:Body>  
2209     <wsmr:MakeConnection>  
2210       <wsmr:Address>http://docs.oasis-open.org/ws-  
2211 rx/wsmr/200608/anonymous?id=550e8400-e29b-11d4-a716-  
2212 446655440000</wsmr:Address>  
2213     </wsmr:MakeConnection>  
2214   </S:Body>  
2215 </S:Envelope>
```

2216 Notice this is the same message as the one sent in step 2.

2217 **Step 6** – If there is a message pending for this destination then it is returned on the HTTP response:

```
2218 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"  
2219 xmlns:wsmr="http://docs.oasis-open.org/ws-rx/wsmr/200608"  
2220 xmlns:wsa="http://www.w3.org/2005/08/addressing">  
2221   <S:Header>  
2222     <wsa:Action> http://example.org/eventType1 </wsa:Action>  
2223     <wsa:To>http://docs.oasis-open.org/ws-  
2224 rx/wsmr/200608/anonymous?id=550e8400-e29b-11d4-a716-446655440000</wsa:To>
```



```

2225     <wsrm:Sequence>
2226         <wsrm:Identifier> http://example.org/rmid-456 </wsrm:Identifier>
2227     </wsrm:Sequence>
2228     <wsrm:MessagePending pending="true"/>
2229 </S:Header>
2230 <S:Body>
2231     <!-- event specific data -->
2232 </S:Body>
2233 </S:Envelope>

```

2234 As noted in step 3, the use of the RM protocol does not change when using `MakeConnection`. The  
 2235 format of the messages, the order of the messages sent and the timing of when to send it remains the  
 2236 same.

2237 **Step 7** – At some later interval, or immediately due to the `MessagePending` header's "pending"  
 2238 attribute being set to "true", the event consumer will poll again:

```

2239 <S:Envelope xmlns:S="http://www.w3.org/2003/05/soap-envelope"
2240 xmlns:wsrm="http://docs.oasis-open.org/ws-rx/wsrm/200608"
2241 xmlns:wsa="http://www.w3.org/2005/08/addressing">
2242     <S:Header>
2243         <wsa:Action>http://docs.oasis-open.org/ws-
2244 rx/wsrm/200608/MakeConnection</wsa:Action>
2245         <wsa:To> http://example.org/subscriptionService </wsa:To>
2246     </S:Header>
2247     <S:Body>
2248         <wsrm:MakeConnection>
2249             <wsrm:Address>http://docs.oasis-open.org/ws-
2250 rx/wsrm/200608/anonymous?id=550e8400-e29b-11d4-a716-
2251 446655440000</wsrm:Address>
2252         </wsrm:MakeConnection>
2253     </S:Body>
2254 </S:Envelope>

```

2255 Notice this is the same message as the one sent in steps 2 and 5. As in steps 3 and 6, the response to  
 2256 the `MakeConnection` can be any message destined to the specified Endpoint. This allows the event  
 2257 producer to send not only application messages but RM protocol messages (e.g. `CloseSequence`,  
 2258 `TerminateSequence` or even additional `CreateSequences`) as needed.

2259 **Step 8** – If at any point in time there are no messages pending, in response to a `MakeConnection` the  
 2260 event producer returns an HTTP 202 back to the event consumer. The process then repeats (back to step  
 2261 7) until the subscription ends.

## Appendix D. State Tables

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

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

Legend:

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

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

Where:

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

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}

Where:

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

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

2289 Table 1 RM Source Sequence State Transition Table

Events	Sequence States					
	None	Creating	Created	Closing	Closed	Terminating
<b>Create Sequence</b> [unspec] {3.1}	Xmit Create Sequence [Creating] {3.1}	N/A	N/A	N/A	N/A	N/A
<b>Create Sequence Response</b> [msg] {3.1}		Process Create Sequence Response [Created] {3.1}				
<b>Create Sequence Refused Fault</b> [msg] {3.1}		No action [None] {4.6}				
<b>Send message</b> [app] {2.1}	N/A	N/A	Xmit message [Same] {2}	No action [Same] {2}	N/A	N/A
<b>Retransmit of un-ack'd message</b> [int] {2.1}	N/A	N/A	Xmit message [Same] {2.4}	Xmit message [Same] {2.4}	N/A	N/A
<b>SeqAck (non-final)</b> [msg] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Process Ack ranges [Same] {3.6}	Process Ack ranges [Same] {3.6}	Process Ack ranges [Same] {3.6}	Process Ack ranges [Same] {3.6}
<b>Nack</b> [msg] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	<Xmit message(s)> [Same] {3.6}	<Xmit message(s)> [Same] {3.6}	No action [Same]	No action [Same]
<b>Message Number Rollover Fault</b> [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]
<b>&lt;Close Sequence&gt;</b> [int] {3.2}	N/A		Xmit Close Sequence [Closing] {3.2}	N/A	N/A	N/A
<b>Close Sequence Response</b> [msg] {3.2}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}		No action [Closed] {3.2}	No action [Same] {3.2}	No action [Same] {3.2}
<b>SeqAck (final)</b> [msg] {3.6}	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}	Process Ack ranges [Closed] {3.6}	Process Ack ranges [Closed] {3.6}	Process Ack ranges [Same]	Process Ack ranges [Same]
<b>Sequence Closed Fault</b> [msg] {4.7}	Generate Unknown Sequence Fault	Generate Unknown Sequence Fault	No action [Closed] {4.7}	No action [Closed] {4.7}	No action [Same]	No action [Same]

Events	Sequence States					
	None	Creating	Created	Closing	Closed	Terminating
{4.7}	[Same] {4.3}	[Same] {4.3}				
<b>Unknown Sequence Fault</b> [msg] {4.3}			Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}
<b>Sequence Terminated Fault</b> [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}
<b>Terminate Sequence</b> [int]	N/A	No action [None] {unspec}	Xmit Terminate Sequence [Terminating]	Xmit Terminate Sequence [Terminating]	Xmit Terminate Sequence [Terminating]	N/A
<b>Terminate Sequence Response</b> [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Generate Unknown Sequence Fault [Same] {4.3}				Terminate Sequence [None] {3.3}
<b>Expires exceeded</b> [int]	N/A	Terminate Sequence [None] {3.4}	Terminate Sequence [None] {3.4}	Terminate Sequence [None] {3.4}	Terminate Sequence [None] {3.4}	Terminate Sequence [None] {3.4}
<b>Invalid Acknowledgement</b> [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}

2289 Table 2 RM Destination Sequence State Transition Table

Events	Sequence States		
	None	Created	Closed
<b>CreateSequence (successful)</b> [msg/int] {3.1}	Xmit Create Sequence Response [Created] {3.1}	N/A	N/A
<b>CreateSequence (unsuccessful)</b> [msg/int] {3.1}	Generate Create Sequence Refused Fault [None] {3.1}	N/A	N/A
<b>Message (with message number within range)</b> [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Accept Message; <Xmit SeqAck> [Same]	Generate Sequence Closed Fault (with SeqAck+Final) [Same] {3.2}
<b>Message (with message number outside of range)</b> [msg]	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Message Number Rollover Fault [Same] {3.4}{4.5}	Generate Sequence Closed Fault (with SeqAck+Final) [Same] {3.2}
<b>&lt;AckRequested&gt;</b> [msg] {3.5}	Generate Unknown Seq Fault [Same] {4.3}	Xmit SeqAck [Same] {3.5}	Xmit SeqAck+Final [Same] {3.6}

Events	Sequence States		
	None	Created	Closed
<b>CloseSequence</b> [msg] {3.2}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit CloseSequence Response with SeqAck+Final [Closed] {3.2}	Generate Sequence Closed Fault [Same] {4.7}
<b>&lt;CloseSequence autonomously&gt;</b> [int]	N/A	No Action [Closed]	N/A
<b>TerminateSequence</b> [msg] {3.3}	Generate Unknown Sequence Fault [Same] {4.3}	Xmit Terminate Sequence Response [None] {3.3}	Xmit Terminate Sequence Response [None] {3.3}
<b>UnknownSequence Fault</b> [msg] {4.3}		Terminate Sequence [None] {4.3}	Terminate Sequence [None] {4.3}
<b>SequenceTerminated Fault</b> [msg] {4.2}		Terminate Sequence [None] {4.2}	Terminate Sequence [None] {4.2}
<b>Invalid Acknowledgement Fault</b> [msg] {4.4}	N/A		
<b>Expires exceeded</b> [int]	N/A	Terminate Sequence [None] {3.4}	Terminate Sequence [None] {3.4}
<b>&lt;Seq Acknowledgement autonomously&gt;</b> [int] {3.6}	N/A	Xmit SeqAck [Same] {3.6}	Xmit SeqAck+Final [Same] {3.6}
<b>Non WSRM message when WSRM required</b> [msg] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	Generate WSRMRequired Fault [Same] {4.8}	Generate WSRMRequired Fault [Same] {4.8}

2290 The following two tables apply only if the `MakeConnection` mechanism is utilized.

2291 Table 3 Sending Endpoint Message Transfer Engine

Event	None	Queued n=1	Queued, n>1
Message destined to anon Endpoint when channel unavailable [int] {3.7}	Queue message [Queued n=1]	Queue message [Queued n>1]	Queue message [Queued n>1]
MakeConnection [msg] {3.7}		Send message [none]	Xmit message with MessagePending [if n=2 then (Queued n=1) else (Queued n>1)]

2292 Table 4 Receiving Endpoint Message Transfer Engine

Event	None	Polling
Expectation of unreceived message [int, unspecified]	No Action [Polling]	No Action [Same]
Polling trigger [int, unspecified]		Xmit MakeConnection [Polling] (3.7)

## Appendix E. Acknowledgments

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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 <a href="http://docs.oasis-open.org/wsrn/200510/">http://docs.oasis-open.org/wsrn/200510/</a> )
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



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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

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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.

## 2329 **Appendix G. Notices**

2330 OASIS takes no position regarding the validity or scope of any intellectual property or other rights that  
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