Experiences with implementing some WS-* specifications

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Outline

- Overview of some Web Service specifications
- Implementation strategy
- Problems encountered

PART – I
WS-Addressing

WS-Addressing

- Web Services Addressing (WSA) provides transport-neutral mechanisms to address Web services and messages.
- WSA provides two very important constructs:
  - endpoint references (EPR) and
  - message information headers (MIH)
- WSA is leveraged by several WS-* specifications
  - WS-ReliableMessaging, WS-Eventing and WS-Notification.

Endpoint References (EPR)

- Endpoint references are a transport neutral way to identify and describe service instances and endpoints.
  - A typical scenario would involve a node sitting at the *edge* of an organization, directing traffic to the right instance based on the information maintained in the EPR.
  - EPRs are constructed and specified in the SOAP message by the entity that is initiating the communications

EPRs – Structure

- An address element which is a URI
- A reference properties element which is a set of properties required to identify a resource
- A reference parameters element which is a set of parameters associated with the endpoint that is necessary for facilitating specific interactions.

Message Information Headers (MIH)

- The MIH enables the identification and location of endpoints pertaining to an interaction.
  - The interactions include Request, Reply/Response, and Faults.

Message Information Headers - II

- **To** (mandatory element): This specifies the intended receiver of message.
- **From**: This identifies the originator of a message.
- **ReplyTo**: Specifies where replies to a message will be sent to.
- **FaultTo**: Specifies where faults, as a result of processing the message, should be sent to.

Message Information Headers III

- **Action**: This is a URI that identifies the semantics associated with the message. WSA also specifies rules on the generation of Action elements from the WSDL definition of a service.
  - In the WSDL case this is generally a combination of **[target namespace]/[port type name]/[input/output name]** . For e.g. http://schemas.xmlsoap.org/ws/2004/08/eventing/Subscribe is a valid action element.
- **MessageId**: This is typically a UUID which uniquely identifies a message. This is sometimes also used correlate responses with previously issued requests..
- **RelatesTo**: This identifies how a message relates to a previous message. This field typically contains the messageId of a previously issued message

WSA Rules

- Identifies how the EPR elements should be added to the Header of the SOAP Message while targeting an endpoint.
- Has rules pertaining to the generation of responses and faults.
  - Contents of the wsa:RelatesTo and/or the wsa:Action field.

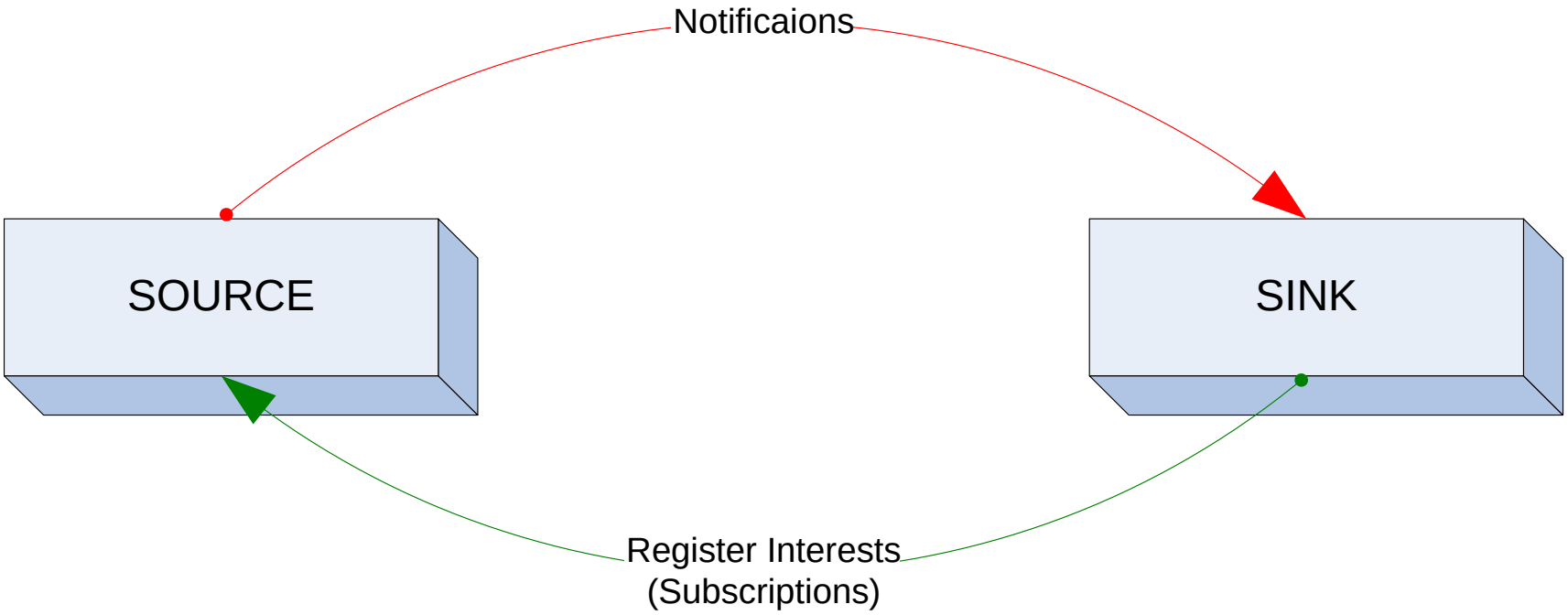
WSA Rules

- WSA also outlines the rules related to targeting of replies and faults.
  - In the case of faults, it also outlines the content of the wsa:Action element.
- It outlines rules related to the generation of the wsa:RelatesTo element.

Part -II
WS-Eventing

Overview of Notifications

- Entities communicate through the exchange of messages.
- A ***notification*** is a message encapsulating an *occurrence of interest* to the entities.
- Notification based systems are an instance of messaging-based systems where entities have two distinct roles viz. source and sink.


Notificaions
SOURCE
SINK
Register Interests
(Subscriptions)

Routing Notifications from Source

- A sink first needs to register its interest in a situation, this operation is generally referred to as a subscribe operation.
- The source first wraps *occurrences* into notification messages.
- Next, the source checks to see if the message satisfies the constraints specified in the previously registered subscriptions.
  - If so, the source routes the message to the sink.
  - This routing of the message from the source to the sink is referred to as a notification.

Loosely-coupled & Tightly-coupled Systems

- Depending on the nature of the underlying frameworks the *coupling* between the sources and sinks can vary.
- In loosely-coupled systems a source need not be aware of the sinks.
  - The source generates events and an intermediary, typically a messaging middleware, is responsible for routing the message to appropriate sinks.
- In tightly-coupled systems there is no intermediary between the source and the sink.

WS-Eventing

- WS-Eventing is an instance of a tightly-coupled notification system.
  - There is no intermediary between the source and the sink.
    - The source is responsible for the routing of notifications to the registered consumers.
- WS-Eventing, however introduces another entity – the subscription manager – within the system.

Subscriptions in WS-Eventing

- Subscriptions within WS-Eventing have an identifier and expiration times associated with them.
  - The *identifier* uniquely identifies a specific subscription, and is a UUID.
  - The *expiration time* corresponds to the time after which the source will stop routing notifications corresponding to the expired subscription.
- Also specifies the *dialect* (XPath, Regular expressions etc) and the *constraint* associated with the subscription.

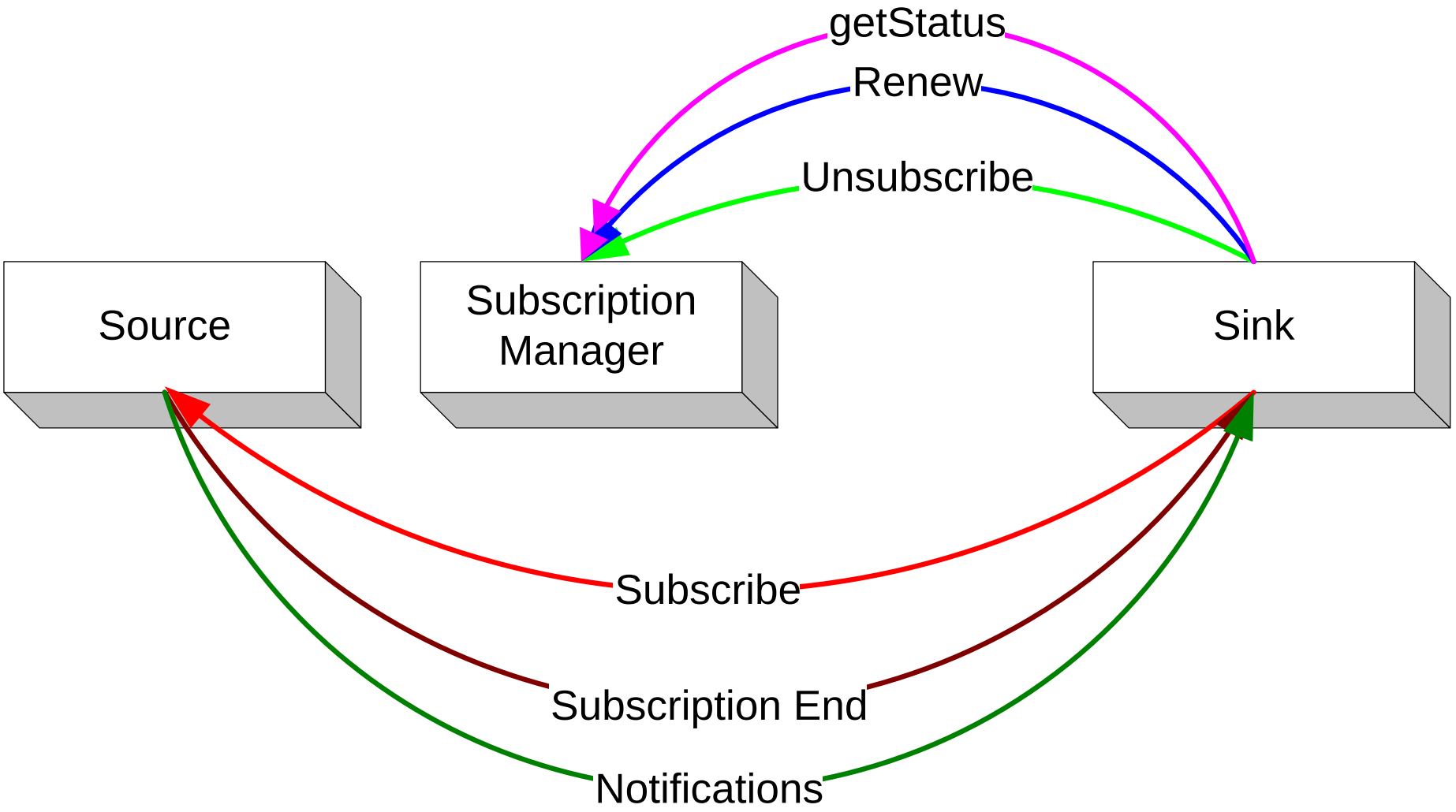
Subscription Manager

- A subscription manager is responsible for operations related to the management of subscriptions.
- Every source has a subscription manager associated with it.
- The specification does not either prescribe or prescribe the collocation of the source and the subscription manager on the same machine.

Subscription Manager Operations

- It enables sinks to retrieve the status of their subscriptions. These subscriptions are the ones that the sinks had previously registered with the source.
- It manages the renewals of the managed subscriptions.
- It is responsible for processing unsubscribe requests from the sinks.

WS-Eventing Entity Interactions I



WS-Eventing Entity Interactions - II

- When the sink subscribes with the source, the source includes information regarding the subscription manager in its response.
- Subsequent operations –- such as getting the status of, renewing and unsubscribing –- pertaining to previously registered subscriptions are all directed to the subscription manager.
- The source sends both notifications and a message signifying the end of registered subscriptions to the sink.

Part III
WS-ReliableMessaging

WSRM

- WSRM describes a protocol that facilitates the reliable delivery of messages between two web service endpoints in the presence of component, system or network failures.
- WSRM facilitates the reliable delivery of messages from the source (or originator) of messages to the sink (or destination) of messages.
- The delivery (and ordering) guarantees are valid over a group of messages, which is referred to as a ***sequence***.

Creation of Sequences

- In WSRM prior to ensuring reliable delivery of messages between the endpoints, the source initiates an exchange with the sink pertaining to the creation of a Sequence.
- This Sequence is intended to facilitate the grouping of a set of related messages.
- This Sequence is identified by an identifier, typically a UUID. Other information associated with the Sequence include information regarding –
  - The source and the sink
  - Policy information related to protocol constants such as acknowledgement and retransmission intervals.
  - Security related information if needed.

WSRM Sequences

- In WSRM all messages issued by a source exist within the context of a Sequence that was established prior to communications.
- Once a source has determined that all messages within a Sequence have been received at the sink, the source initiates an exchange to terminate this sequence.
- The specification allows for a maximum of 2^{64} -1 messages within a Sequence.
- The specification places no limits on the number of Sequences between a specific source and sink.
  - However, it is expected that at any given time there is NO more than 1 active Sequence between 2 specific endpoints.

Publishing Messages in WSRM

- Every message from the source contains two pieces of information –
  - The Sequence that this message is a part of and
  - A monotonically increasing Message Number within this Sequence.
- These Message Numbers enable the tracking of problems, if any, in the intended message delivery at a sink.
  - Message Numbers enable the determination of out of order receipt of messages as well as message losses.

Issuing Acknowledgments

- In WSRM a sink is expected to issue acknowledgements back to the source upon receipt of messages.
- This acknowledgement contains information about
  - The Sequence and
  - The Message Numbers within this Sequence.
- An acknowledgement must be issued only after a certain time — the *acknowledgement interval* — has elapsed since the receipt of the first unacknowledged message.
- This acknowledgement may cover a single message or a group of messages within a Sequence.

Processing Acknowledgments

- Upon receipt of this acknowledgement a source can determine which messages might have been lost in transit and proceed to retransmit the *missed* messages.
- Thus if a sink has acknowledged the receipt of messages 1 — 10 and 13 — 18.
  - The source can conclude that messages with Message Numbers 11 and 12 were lost en route to the sink and proceed to retransmit these messages.

Retransmissions and Error Corrections

- A source may also pro-actively initiate the retransmission of a message for which that an acknowledgement has not been received within a specified time — the *retransmission interval* — after which it was issued.
- In WSRM error corrections can also be initiated at the sink; this is done through the use of *negative acknowledgements*.
  - Negative acknowledgments identify the message numbers that have not been received at a sink.
- Message Numbers increase monotonically. If Message Numbers 1,2,3,4 and 8 within a specific Sequence have been received at a sink.
  - This sink can easily conclude that it has not received messages with message numbers 5,6 and 7 from the source.

Notification of Errors

- WSRM provides for notification of errors in processing between the endpoints involved in reliable delivery.
  - These are routed back as SOAP Faults.
- The range of errors can vary from an inability to decipher a message's content to complex errors pertaining to violations in implied agreements between the interacting source and sink.
- All errors are reported as faults with the appropriate `wsa:Action` attribute, and encapsulated in WSRM fault elements.

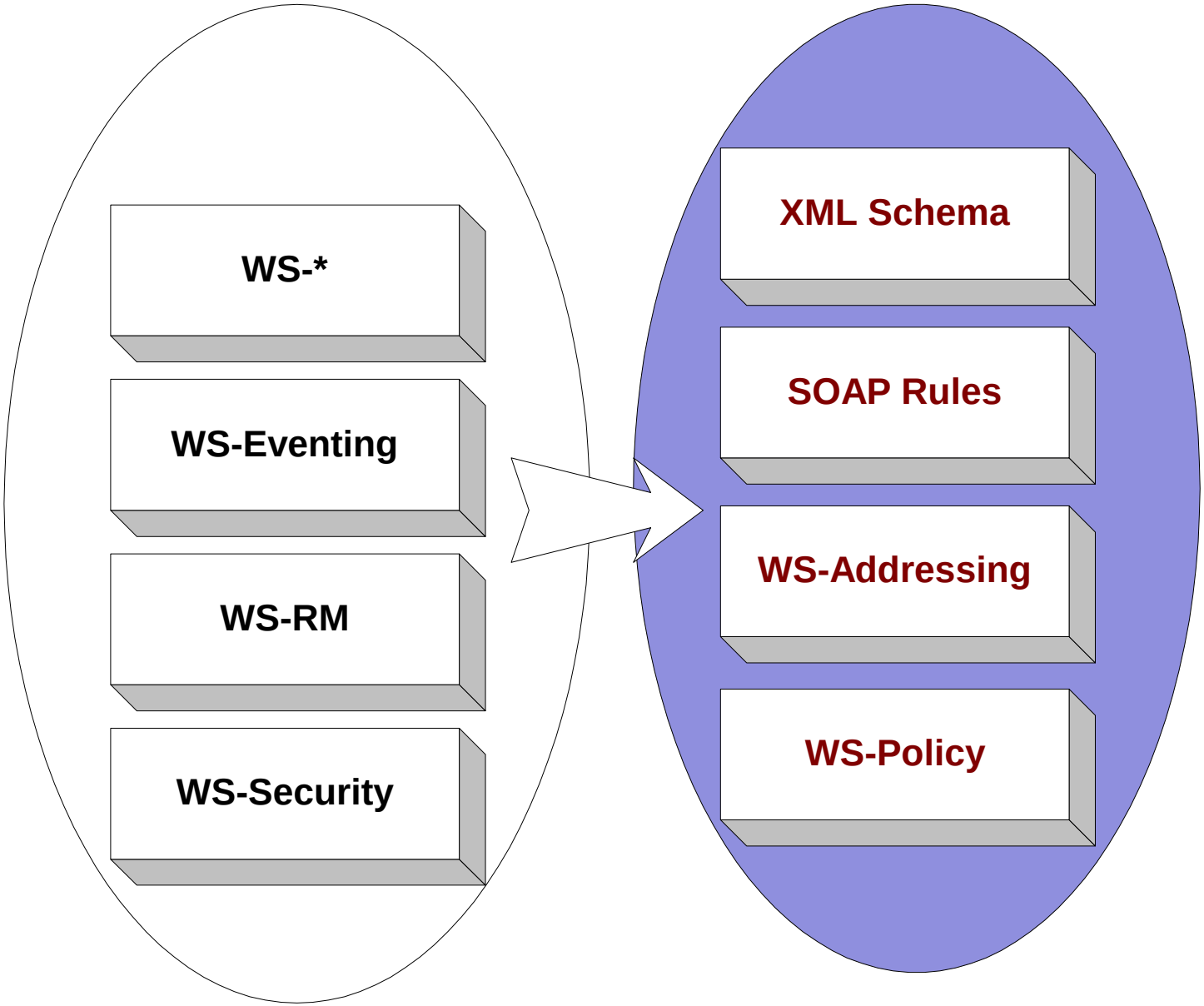
Part IV
Reflections on Implementing WS-* specifications

Some quick observations about WS-*

- Typically addresses core areas or those where the demand is substantial enough to eschew proprietary ad hoc solutions.
- In some cases common issues across various WS-* specifications mandate additional WS-* specifications.
  - Exemplars include WS-Addressing, WS-Policy.
- Various specifications are intended to incrementally augment capabilities at an endpoint.
  - For e.g. if you need reliable messaging capabilities simply plug in a WSRM module. If you need notification capability plug in WS-Eventing or WS-Notification.

Some quick observations about WS-*

- Functionality of specifications encapsulated within stand-alone SOAP messages.
  - They typically also include a WSDL definitions of operations, but all functionality is encapsulated in SOAP messages.
- Primary interaction model is one-way, asynchronous SOAP messaging.
- Lot of these specifications are also intended to be stackable.


WS-*
WS-Eventing
WS-RM
WS-Security
XML Schema
SOAP Rules
WS-Addressing
WS-Policy

Typical implementation strategy

- Develop strategy for processing the XML Schema associated with the specification.
  - This would allow you to process the XML messages from Java (or language of choice).
  - XML generated over the wire should be conformant to the relevant schemas.
    - This allows one to interact with other implementations.
- Develop Processor to enforce rules and processing associated with the specification.
  - This would include performing actions, issuing requests/responses and faults.
- Ensure that rules and processing related to leveraged specifications are enforced.

Processing XML Schemas

- We were looking for a solution that allowed us to process XML from within the Java domain.
- There are 4 choices
  - Develop Java classes ourselves
  - Use wsdl2java to do this
  - Use the JAXB Data Binding Framework
  - Use a schema compiler such as Castor or XMLBeans

Writing one's own classes

- Approach used by Apache's Sandesha project.
  - Implementation of WSRM
- Error prone and quite difficult
  - Increasingly the developer has to deal with several other specifications.
- Another approach is to just process messages based on DOM.
  - Quite difficult to do. No examples that we are currently aware of.

WSDL2Java Problems

- Issues (in version 1.2) related to this tool's support for schemas have been documented in http://www-106.ibm.com/developerworks/webservices/library/ws-castor/ .
- Specifically, the problems relate to insufficient (and in some cases incorrect) support for complex schema types, XML validation and serialization issues.

JAXB Issues

- JAXB is a specification from Sun to deal with XML and Java data-bindings.
- JAXB though better than what is generated using Axis' *wsdl2java* still does not provide complete support for the XML Schema.
  - JSR 31 expert group decided NOT to attempt full compatibility with the XML Schema standard.
  - You may run into situations where you may find an inaccessible data inside your schema.
- We looked at both the JAXB reference implementation from Sun and JaxMe from Apache (which is an open source implementation of the JAXB Framework).

Rationale for the choice of XMLBeans

- We settled on XMLBeans because of two reasons.
  - It is an open source effort. Originally developed by BEA it was contributed by BEA to the Apache Software Foundation.
  - In our opinion, it provides the best and most complete support for the XML schema of all the tools currently available.
- XMLBeans allows us to validate instance documents and also facilitates simple but sophisticated navigation through XML documents.
- The XML generated by the corresponding Java classes is true XML which conforms to (and can be validated against) the original schema.

Developing WS-* Processors

- In some cases there would be more than one role associated with a specification. Ensure that processing related to each role is done.
  - E.g. WSRM and WSE.
- Processing the SOAP Messages
  - Direction of the message is important.
    - Messages processed differently depending on whether it was received over the network or from application.
- When problems are encountered the processor needs to throw exceptions and/or issue faults.
  - Faults need to conform to rules outlined in both SOAP and WS-Addressing.

Common Problems

- Schemas seem to change quite often.
- WS-* specifications typically leverage other specifications.
  - Changes in the schemas of these specifications can affect the one being implemented.
- Container problems

WS-* specs have compatibility issues

- Every new version has a new target namespace.
- This ensures that an implementation of a specific version of a specification will ONLY work with other implementations of the same version.
- This is the equivalent of having a new package name for every class every time you release a new version of your software.
  - Applications developed using the old class names will not work without major updates.
- You can generate classes for every version of the spec.
  - Lots and lots of duplicate classes. Code re-use and manageability is sacrificed.

A General comment on Web Service Containers

- It is based on supporting the RPC model which is out-of-sync with several new WS specifications.
  - Every message needs to be a request (invocation of a remote method) or the corresponding response.
  - Focal point is WSDL not SOAP.
    - Similar to IDL-centric CORBA approach.
  - SOAP 1.2 clearly states primary purpose is one-way messaging NOT the carrying of RPC invocations.
- Problems
  - It is difficult to fit the RPC model for say WS-Eventing
    - Where would a RPC request (notification) be made? There are multiple destinations that the message needs to be sent to.
  - Forcing every exchange, ACKs/Retransmissions to be based on the RPC request/response model is very limiting.

The Handler Approach

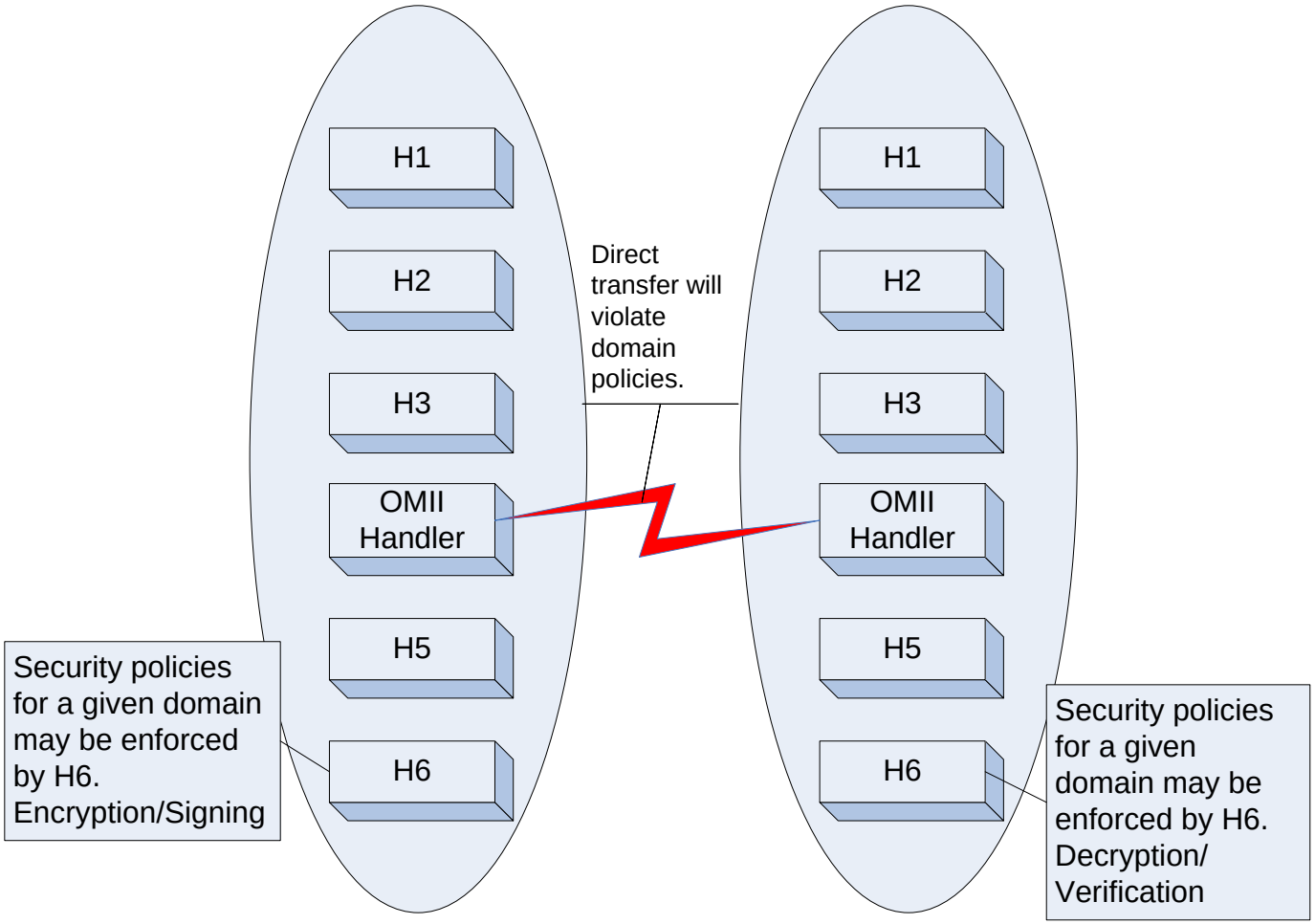
- A handler is a module that can reside in the processing path of SOAP messages as they traverse between service endpoints.
- A handler may be configured to reside in the paths associated with the message exchanges such as requests, responses or faults
- Handlers facilitate the incremental addition of capabilities to services.
  - No need to change service implementations themselves.
- Handlers are autonomous entities
  - A given handler has complete access to the entire SOAP message. Read, Write, and Replace.
- Handlers can be cascaded to form Handler chains

Handlers: Problems

- Handlers are statically pre-configured.
  - No dynamic re-configuration of the handler-chain.
- Handlers cannot pro-actively inject messages into the processing path between the service endpoints.
  - In WSRM, a node needs to issue acknowledgements or initiate retransmissions at regular intervals.
  - Sometimes, a given SOAP message may result in multiple SOAP messages being forked off.
    - In WS-Eventing a message may need to routed to multiple *interested* consumers for that message.
  - The current handler model precludes us from easily supporting these scenarios.
- The handler model in the proposed JAX RPC 2.0 specification does not address these issues.
  - We hope Axis will incorporate support for richer interactions.

Handlers: What they should support

- Injecting messages
  - A given notification message may spawn multiple copies of the message being routed to consumers.
  - In WSRM, this would facilitate retransmissions and responses.
- Ability to generate responses and stop message processing
  - Some messages need not be propagated to application at all. For e.g. an application need not know about WSRM acks or naks.



- In WS-Eventing: You do not want a notification message to traverse H1, H2, H3. In WSRM you do not wish for retransmissions to be processed by H1, H2, H3.
- But messages need to traverse H5 and H6.

Final Comments

- WS-* specifications still have some way to go.
  - Stability and compatibility
- WS Containers need some changes
  - Better support for the one-way messaging model
- Handler/Filter model needs to be richer.