Data-centric XML

SOAP

What is SOAP

- http://www.w3.org/TR/2000/NOTE-SOAP-20000508/
  - 1.2: http://www.w3.org/TR/soap12-part0/, -part1, -part2
- “lightweight protocol for exchange of information in a decentralized, distributed environment”
- three parts:
  - envelope structure for defining messages
  - set of encoding rules for encoding application-specific data types
  - convention for doing RPC
- Current version 1.2 (W3C XML Protocols group)
  - Version 1.1 widely used (Don Box, DevelopMentor)
- Supports potentially multiple transport mechanisms
  - only HTTP specified

SOAP Companions

- WSDL: Web Services Definition Language
  - http://www.w3.org/TR/wsdl
  - interface definition: endpoints, operations, and messages
  - XML vocabulary for describing services (SOAP, HTTP, MIME)
- UDDI: Universal Description Discovery and Integration
  - http://uddi.org/pubs/uddi-v3.0.1-20031014.htm
  - repository service for discovery of services
  - XML schemas for various information models
  - not covered here
- Web Services Interoperability
- Web Services Security

Usage Scenarios

- Fire-and-forget to single/multiple receiver (notifications)
- Request/response asynchronous communication
- RPC
- Request with acknowledgement
- Request with encrypted payload
- (Multiple) Third party intermediary
- Multiple asynchronous responses
- Caching
- Routing
- …

SOAP Non-Goals

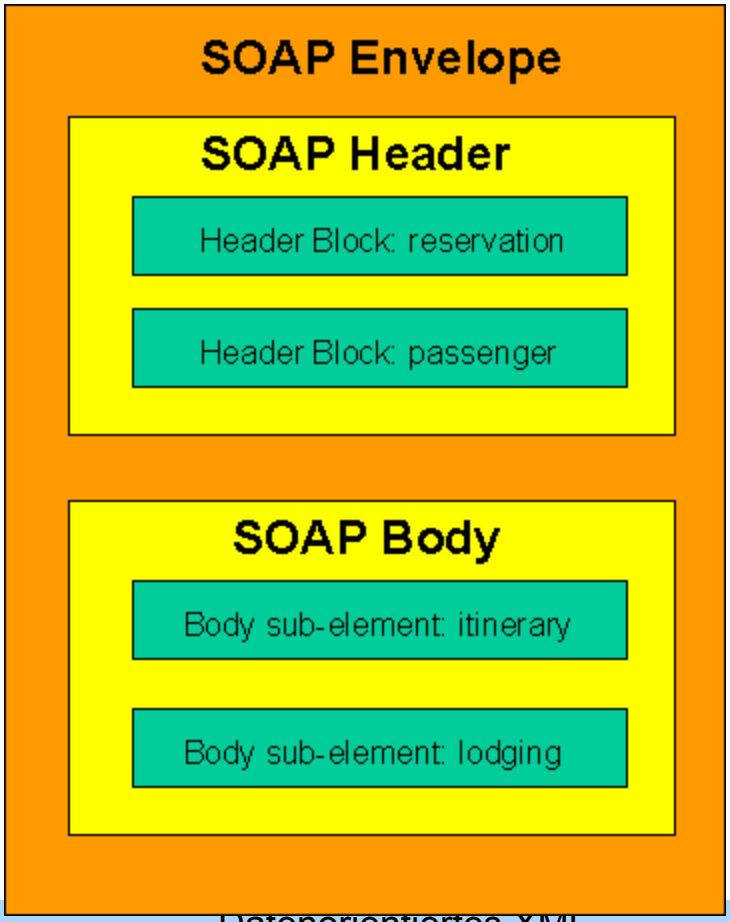
- Distributed Garbage Collection
- Boxcarring/batching of messages
- objects-by-reference
- activation

Namespaces

- xmlns:ENV="http://schemas.xmlsoap.org/soap/envelope/"
  - SOAP 1.2: http://www.w3.org/2003/05/soap-envelope
- xmlns:ENC="http://schemas.xmlsoap.org/soap/encoding/"
  - SOAP 1.2: http://www.w3.org/2003/05/soap-encoding

Messages

- Emitted by *sender*, targeted at *ultimate receiver*, through *intermediaries*



Envelope

```
<?xml version='1.0' ?>
<env:Envelope xmlns:env="http://www.w3.org/2003/05/soap-envelope">
  <env:Header> … </env:Header>
  <env:Body> … </env:Body>
</env:Envelope>
```

Header

```
<env:Header>
 <m:reservation xmlns:m="http://travelcompany.example.org/reservation"
        env:role="http://www.w3.org/2003/05/soap-envelope/role/next"
         env:mustUnderstand="true">
  <m:reference>uuid:093a2da1-q345-739r-ba5d-pqff98fe8j7d</
   m:reference>
  <m:dateAndTime>2001-11-29T13:20:00.000-05:00</m:dateAndTime>
 </m:reservation>
 <n:passenger xmlns:n="http://mycompany.example.com/employees"
        env:role="http://www.w3.org/2003/05/soap-envelope/role/next"
         env:mustUnderstand="true">
  <n:name>Åke Jógvan Øyvind</n:name>
 </n:passenger>
</env:Header>
```

Body

```
<env:Body>
  <p:itinerary  xmlns:p="http://travelcompany.example.org/reservation/travel">
   <p:departure>
     <p:departing>New York</p:departing>
     <p:arriving>Los Angeles</p:arriving>
     <p:departureDate>2001-12-14</p:departureDate>
     <p:departureTime>late afternoon</p:departureTime>
     <p:seatPreference>aisle</p:seatPreference>
   </p:departure>
   <p:return>
     <p:departing>Los Angeles</p:departing>
     <p:arriving>New York</p:arriving>
     <p:departureDate>2001-12-20</p:departureDate>
     <p:departureTime>mid-morning</p:departureTime>
     <p:seatPreference/>
   </p:return>
  </p:itinerary>
</env:Body>
```

Roles

- Target roles specified in ENV:role of headers
  - SOAP 1.1: ENV:actor
- Possible roles
  - "http://www.w3.org/2003/05/soap-envelope/role/next"
  - "http://www.w3.org/2003/05/soap-envelope/role/none"
  - "http://www.w3.org/2003/05/soap-envelope/role/ultimateReceiver"
- ENV:mustUnderstand specifies whether target is required to process the header
- Intermediary may drop, modify, or add headers
  - headers targeted at intermediary are dropped, unless ENV:relay is true (and unless processing of the header reinserts it)

Body Processing

- Targeted at ultimate receiver
- Structure completely application-defined, except for faults
- Structure of body specified in ENV:encodingStyle
  - 1.1: typically specified on ENV:Envelope
  - 1.2: specified on header block, child of body that is not a Fault element, child of a Detail element, or descendents thereof

Faults

- ENV:Fault
- Mandatory children
  - ENV:Code
    - ENV:Value, with values Env:{VersionMismatch, MustUnderstand, DataEncodingUnknown, Sender, Receiver}
      - Additional Header elements may provide more detail
    - Optional ENV:Subcode child
  - ENV:Reason, with optional ENV:Text children
- Optional children
  - ENV:Node, with URI content
  - ENV:Role, with URI content
  - ENV:Detail, with arbitrary attributes and child elements

SOAP Data Model

- Optional part of SOAP
- Intended for RPC, accompanied by encoding style
- Data are represented as directed edge-labeled graph of nodes
  - outbound edges may be distinguished either by label or position
  - labels are QNames
  - nodes may be referenced just once, or have multiple references
- Structs are nodes with all outbound edges distinguished by label
- Arrays are nodes with all outbound edges distinguished by position

SOAP Encodings

- Support for multiple encoding styles
- Only one standard encoding
  - "http://www.w3.org/2003/05/soap-encoding"
- Graph edges represented by elements
  - label of the edge is element name
  - ENC:ref=“id” (type IDREF) can be used for multiple references
  - ENC:id=“id” (type ID) specifies target of the reference
- Simple values are encoded in element content
- Compound values are encoded through child elements
  - outgoing labelled edges again denoted through child element name

SOAP Encodings (2)

- ENC:nodeType can be used to specify one of “simple”, “struct”, “array”
- Arrays: Element names of child elements are not significant
  - ENC:itemType specifies the array element type
  - ENC:arraySize allows the specification of multi-dimensional arrays
- Integration with XML Schema
  - xsi:type can specify the node type
  - if not specified, ENC:itemType may apply
  - otherwise, graph node has unspecified type

Using SOAP for RPC

- Multiple bindings to protocols, only HTTP binding specified
- RPC usage must identify RPC resource
  - e.g. encoding of identified resources in URL query parameters
  - pure GET operations may not include any SOAP envelope
- RPC Invocation is a single struct, with outbound edges for parameters
  - name of struct node equals operation name
- RPC Response is a single struct, whose name is irrelevant
- Faults should be used to indicate errors in the RPC invocation

WSDL

- http://www.w3.org/TR/2001/NOTE-wsdl-20010315
- Definition of *services* as a collection of *ports* (network endpoints)
- Definition of *messages*: data that are exchanged
- Definition of *port types*: abstract collections of operations
- Definition of *bindings*: specification of protocol and data format for a type

Example

```
<?xml version="1.0"?>
<definitions name="StockQuote“ targetNamespace="http://example.com/
    stockquote.wsdl"
        xmlns:tns="http://example.com/stockquote.wsdl"
        xmlns:xsd1="http://example.com/stockquote.xsd"
        xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
        xmlns="http://schemas.xmlsoap.org/wsdl/">
   <types>…</types>
  <message>…</message>
  <portType>…</portType>
  <binding>…</binding>
  <service>…</service>
</definitions
```

Example: Types

```
<types>
    <schema targetNamespace="http://example.com/stockquote.xsd"
            xmlns="http://www.w3.org/2000/10/XMLSchema">
        <element name="TradePriceRequest">
            <complexType>
                <all>
                    <element name="tickerSymbol" type="string"/>
                </all>
            </complexType>
        </element>
        <element name="TradePrice">
            <complexType>
                <all>
                    <element name="price" type="float"/>
                </all>
            </complexType>
        </element>
    </schema>
  </types>
```

Example: Messages

```
<message name="GetLastTradePriceInput">
   <part name="body" element="xsd1:TradePriceRequest"/
>
</message>

<message name="GetLastTradePriceOutput">
   <part name="body" element="xsd1:TradePrice"/>
</message>
```

Example: Port Types

```
<portType name="StockQuotePortType">
  <operation name="GetLastTradePrice">
    <input message="tns:GetLastTradePriceInput"/>
    <output message="tns:GetLastTradePriceOutput"/>
  </operation>
</portType>
```

Example: Bindings

```
<binding name="StockQuoteSoapBinding"
   type="tns:StockQuotePortType">
      <soap:binding style="document"                transport="http://
   schemas.xmlsoap.org/soap/http"/>
      <operation name="GetLastTradePrice">
         <soap:operation soapAction="http://example.com/
   GetLastTradePrice"/>
         <input>
            <soap:body use="literal"/>
         </input>
         <output>
            <soap:body use="literal"/>
         </output>
      </operation>
   </binding>
```

Example: Services

```
<service name="StockQuoteService">
    <documentation>My first service</documentation>
    <port name="StockQuotePort" binding="tns:StockQuoteBinding">
      <soap:address location="http://example.com/stockquote"/>
    </port>
  </service>
```

WSDL Document Structure

- Specification uses informal grammar to describe document structure, e.g.

```
<definitions .... >
    <types>
        <xsd:schema .... />*
    </types>
</definitions>
```

means: The “definitions” element contains a “types” element, which can contain multiple “xsd:schema” elements

WSDL Definitions

- Types: List of schema types
- Messages: Consist of multiple parts
  - each part specified either as an element or a type
  - actual (XML) representation depends on the binding
- port types: List of operations
  - Each operation has optional input, output, faults
- Bindings: Lists of inputs, outputs, faults, mixed with extension elements
- Service: List of ports
  - Each port has name, binding, optional extensions

WSDL SOAP Binding

- Extensions soap:binding, soap:operation, soap:body, soap:header, soap:headerFault, soap:address, …
- soap:binding specifies transport= (default HTTP) and style= (“document” | “rpc”)
- soap:operation specifies soapAction= target URL (SOAPAction: header), and optional style=
- soap:body specifies parts= included in the body, use= type of encoding (“literal” | “encoded”), optional encodingStyle=, and optional namespace=
- soap:address specifies location= of HTTP server

SOAP Styles

```
<message name=“fooRequest">
   <part name=“param1" type="xsd:int"/> <!-- encoded
   requires to use type= -->
</message>

<portType name="PT">
   <operation name=“foo">
      <input message=“fooRequest"/>
   </operation>
</portType>
```

RPC/encoded

```
<ENV:Envelope …>
   <ENV:Body>
      <foo>
         <param1 xsi:type="xsd:int">5</param1>
      </foo>
   </ENV:Body>
</ENV:Envelope>
```

RPC/literal

```
<ENV:Envelope …>
   <ENV:Body>
      <foo>
         <param1>5</param1>
      </foo>
   </ENV:Body>
</ENV:Envelope>
```

Document/encoded

- not specified; meaningless

Document/literal

```
 <types>
   <schema>
      <element name=“IntValue" type="xsd:int"/>
   </schema>
</types>

<message name=“fooRequest">
   <part name=“param" element=“IntValue"/>
       <!-- type= is discouraged for document-style operations in WS-I -->
</message>

<portType name="PT">
   <operation name=“foo">
      <input message=“fooRequest"/>
   </operation>
</portType>
```

Document/literal

```
<ENV:Envelope …>
   <ENV:Body>
        <IntValue>5</IntValue>
   </ENV:Body>
</ENV:Envelope>
```

- with <part name="param" type="xsd:int"/>, the Body child would become <param>5</param>
  - confusing, since there is no element definition for a "param" element

Document/wrapped

- WSDL style convention
- Create an XML element for each message, use that in element=for each part
  - allows to identify the operation name from the body

Interoperability

- Sources of non-interoperability
  - Under-specification (optional features, implementation-defined behavior)
  - Non-compliance of implementation
- Web-Services Interoperability Organization aims at improving interoperability
  - through specifications
  - through testing technology
- Multiple profiles of WS-I, depending on application domain

Basic Profile

- Basic Profile Version 1.0a
  - http://www.ws-i.org/Profiles/Basic/2003-08/BasicProfile-1.0a.html
- Requirements on XML, SOAP, WSDL, and UDDI usage
  - UDDI out of scope for this presentation

Basic Profile Requirements

- An INSTANCE MUST be described by a WSDL 1.1 service description, by a UDDI binding template, or both.
- Conformance claims
  - A MESSAGE MAY contain conformance claims, as specified in the conformance claim schema
  - MESSAGE's conformance claims MUST be carried as SOAP header blocks.
  - A MESSAGE MAY contain conformance claims for more than one profile.
  - A SENDER MUST NOT use the soap:mustUnderstand attribute when sending a SOAP header block containing a conformance claim.

Basic Profile Requirements (2)

- XML Representation
  - A RECEIVER MUST accept messages that include the Unicode Byte Order Mark (BOM)
  - When a MESSAGE contains a soap:Fault element, that element MUST NOT have element children other than faultcode, faultstring, faultactor and detail.
  - When a MESSAGE contains a soap:Fault element its element children MUST be unqualified.
    - Violation of SOAP 1.2?
  - A RECEIVER MUST accept fault messages that have any number of elements, including zero, appearing as children of the detail element. Such children can be qualified or unqualified.
  - …

Basic Profile Requirements (3)

- XML Usage
  - A MESSAGE MUST NOT contain a Document Type Declaration.
  - A MESSAGE MUST NOT contain Processing Instructions.
  - A RECEIVER MUST accept messages that contain an XML Declaration.
  - A MESSAGE MUST NOT have any element children of soap:Envelope following the soap:Body element.
    - unspecified in SOAP 1.1
  - A MESSAGE MUST be serialized as either UTF-8 or UTF-16.
  - The media type of a MESSAGE's envelope MUST indicate the correct character encoding, using the charset parameter.
  - A MESSAGE containing a soap:mustUnderstand attribute MUST only use the lexical forms "0" and "1".
  - The children of the soap:Body element in a MESSAGE MUST be namespace qualified.

Basic Profile Requirements (4)

- XML Requirements
  - A RECEIVER MUST generate a fault if they encounter a message whose document element has a local name of "Envelope" but a namespace name that is not "http://schemas.xmlsoap.org/soap/envelope/".
  - A RECEIVER MUST NOT mandate the use of the xsi:type attribute in messages except as required in order to indicate a derived type (see XML Schema Part 1: Structures, Section 2.6.1).

Basic Profile Requirements (5)

- SOAP Requirements
  - A RECEIVER MUST handle messages in such a way that it appears that all checking of mandatory header blocks is performed before any actual processing.
  - A RECEIVER MUST generate a "soap:MustUnderstand" fault when a message contains a mandatory header block (i.e., one that has a soap:mustUnderstand attribute with the value "1") targeted at the receiver (via soap:actor) that the receiver does not understand.

Basic Profile Requirements (6)

- HTTP Requirements
  - A MESSAGE SHOULD be sent using HTTP/1.1.
  - A MESSAGE MUST be sent using either HTTP/1.1 or HTTP/1.0.
  - A RECEIVER MUST interpret SOAP messages containing only a soap:Fault element as a Fault.
    - I.e. do not rely on HTTP status to determine fault presence
  - A HTTP request MESSAGE MUST use the HTTP POST method.
  - A MESSAGE MUST NOT use the HTTP Extension Framework (RFC2774).
  - An INSTANCE MUST use a 2xx HTTP status code for responses that indicate a successful outcome of a request.
  - An INSTANCE MUST use a "500 Internal Server Error" HTTP status code if the response message is a SOAP Fault.
  - …

Basic Profile Requirements (7)

- WSDL requirements
  - A DESCRIPTION using the WSDL namespace (prefixed "wsdl" in this Profile) MUST be valid according to the XML Schema found at "http://schemas.xmlsoap.org/wsdl/2003-02-11.xsd".
  - A DESCRIPTION MUST NOT use QName references to elements in namespaces that have been neither imported, nor defined in the referring WSDL document.
  - A wsdl:portType in a DESCRIPTION MUST have operations with distinct values for their name attributes.
  - …

Basic Profile Requirements (8)

- SOAP Requirements
  - A wsdl:binding element in a DESCRIPTION MUST use WSDL SOAP Binding as defined in WSDL 1.1 Section 3.
  - A wsdl:binding element in a DESCRIPTION MUST specify the HTTP transport protocol with SOAP binding. Specifically, the transport attribute of its soapbind:binding child MUST have the value "http://schemas.xmlsoap.org/soap/http".
  - A wsdl:binding in a DESCRIPTION MUST use the value of "literal" for the use attribute in all soapbind:body, soapbind:fault, soapbind:header and soapbind:headerfault elements.
  - A wsdl:binding in a DESCRIPTION that contains one or more soapbind:body, soapbind:fault, soapbind:header or soapbind:headerfault elements that do not specify the use attribute MUST be interpreted as though the value "literal" had been specified in each case.
    - WSDL 1.1 spec and schema are inconsistent as to whether use= is optional

Basic Profile Requirements (9)

- SOAP Requirements
  - A DESCRIPTION SHOULD NOT have more than one wsdl:port with the same value for the location attribute of the soapbind:address element.
  - For one-way operations, an INSTANCE MUST NOT return a HTTP response that contains a SOAP envelope. Specifically, the HTTP response entity-body must be empty.
  - A CONSUMER MUST ignore a SOAP response carried in a response from a one-way operation.
  - A MESSAGE MUST include all soapbind:headers specified on a wsdl:input or wsdl:output of a wsdl:operation of a wsdl:binding that describes it.
    - unspecified in WSDL 1.1

Basic Profile Requirements (10)

- HTTP Requirements
  - A HTTP request MESSAGE MUST contain a SOAPAction HTTP header field with a quoted value equal to the value of the soapAction attribute of soapbind:operation, if present in the corresponding WSDL description.
  - An INSTANCE MAY require the use of HTTPS.
  - If an INSTANCE requires the use of HTTPS, the location attribute of the soapbind:address element in its wsdl:port description MUST be a URI whose scheme is "https"; otherwise it MUST be a URI whose scheme is "http".