Introduction to SOAP

(Simple Object Access Protocol)

What is SOAP?

- SOAP is a simple, lightweight XML protocol for exchanging structured and typed information on the Web
- Overall design goal: KISS (keep it simple and stupid)
  - Can be implemented in a weekend
  - Stick to absolutely minimum of functionality
- Make it Modular and Extensible
  - No application semantics and no transport semantics
  - Think “XML datagram”

SOAP Contains Four Parts:

- An extensible envelope expressing *(mandatory)*
  - **what** features and services are represented in a message;
  - **who** should deal with them,
  - **whether** they are optional or mandatory.
- A set of encoding rules for data *(optional)*
  - Exchange instances of application-defined data types and directed graphs
  - Uniform model for serializing abstract data models that can not directly be expressed in XML schema
- A Convention for representation RPC *(optional)*
  - How to make calls and responses
- A protocol binding to HTTP and HTTP-EF *(optional)*

SOAP Example in HTTP

SOAP-HTTP Binding
HTTP Request
SOAP Body
SOAP Header
SOAP Envelope

```
POST /Accounts/Henrik HTTP/1.1
Host: www.webservicebank.com
Content-Length: nnnn
Content-Type: text/xml; charset="utf-8"
SOAPAction: "Some-URI"
```

```
<SOAP:Envelope xmlns:SOAP="http://schemas.xmlsoap.org/soap/envelope/"
  SOAP:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP:Header>
      <t:Transaction xmlns:t="some-URI" SOAP:mustUnderstand="1">
            5
      </t:Transaction>
   </SOAP:Header>
   <SOAP:Body>
      <m:Deposit xmlns:m="Some-URI">
         <m:amount>200</m:amount>
      </m:Deposit>
   </SOAP:Body>
</SOAP:Envelope>
```

SOAP Example in SIP (session initial protocol)

```
SERVICE sip:broker.ubiquity.net SIP/2.0
To: sip:broker.ubiquity.net
From: sip:proxy.ubiquity.net
Call-ID:648324@193.195.52.30
CSeq: 1 SERVICE
Via: SIP/2.0/UDP proxy.ubiquity.net
Content-Type: text/xml
Content-Length: 381
```

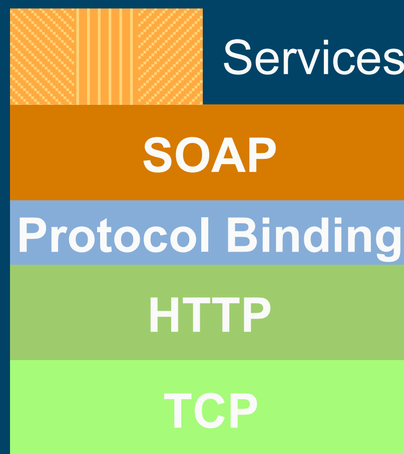
SOAP-SIP Binding
SIP Request
SOAP Body
SOAP Envelope

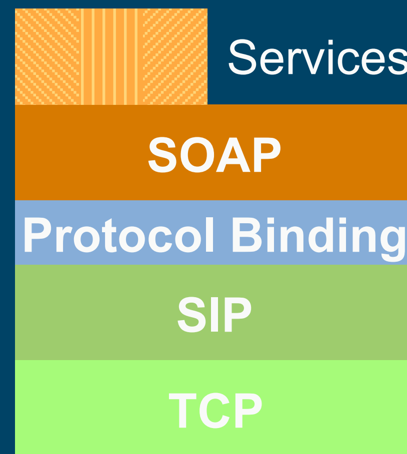
```
<SOAP:Envelope xmlns:SOAP="http://schemas.xmlsoap.org/soap/envelope”
  SOAP:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP:Body>
      <m:SetCreditStatus xmlns:m="http://www.ubiquity.net/sipservices">
         <m:user>sip:jo@ubiquity.net</m:user>
         <m:status>super</m:status>
      </m:SetCreditStatus>
   </SOAP:Body>
</SOAP:Envelope>
```

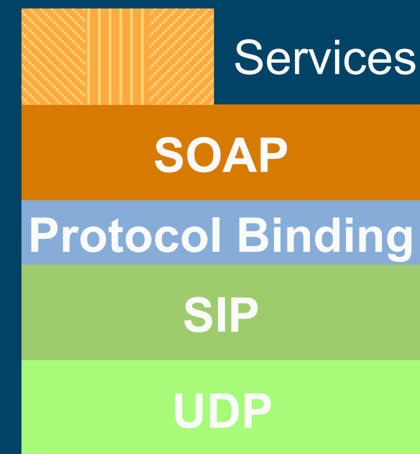
... or SOAP by Itself...

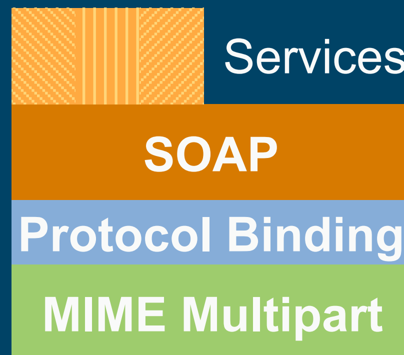
```
<SOAP:Envelope xmlns:SOAP="http://schemas.xmlsoap.org/soap/envelope"
  SOAP:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP:Header>
      <m:MessageInfo xmlns:m="http://www.info.org/soap/message">
            <m:to href="mailto:you@your.com"/>
            <m:from href="mailto:me@my.com"/>
            <m:contact href="mailto:someone@my.com">
      </m:MessageInfo>
   </SOAP:Header>
   <SOAP:Body>
      <msg:Message xmlns:m="http://www.info.org/soap/message">
            <msg:subject>Your house is on fire!</msg:subject>
            <msg:feed href="ram://livenews.com/yourhouse"/>
      </msg:Message>
   </SOAP:Body>
</SOAP:Envelope>
```

SOAP Stack Examples









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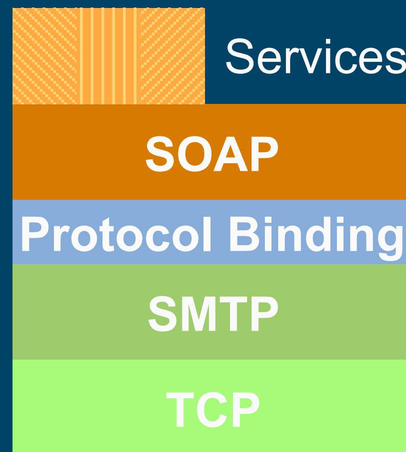
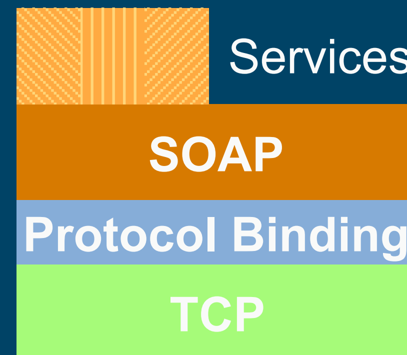
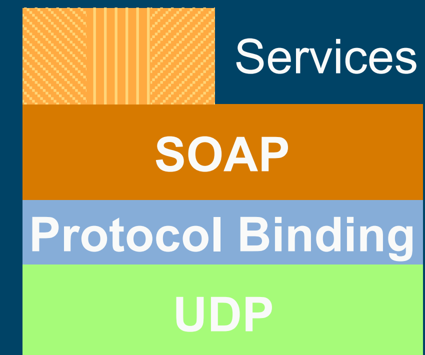






Note Again: SOAP is a Protocol!

- What does this mean?
  - It is ***not*** a distributed object system
  - It is ***not*** an RPC system
  - It is ***not even*** a Web application
- Your application decides what your application is!
  - You can build a tightly coupled system

  …or…

  - You can build a loosely coupled system
- Tunneling is a property of the application, not the protocol

SOAP is Designed for Evolvability

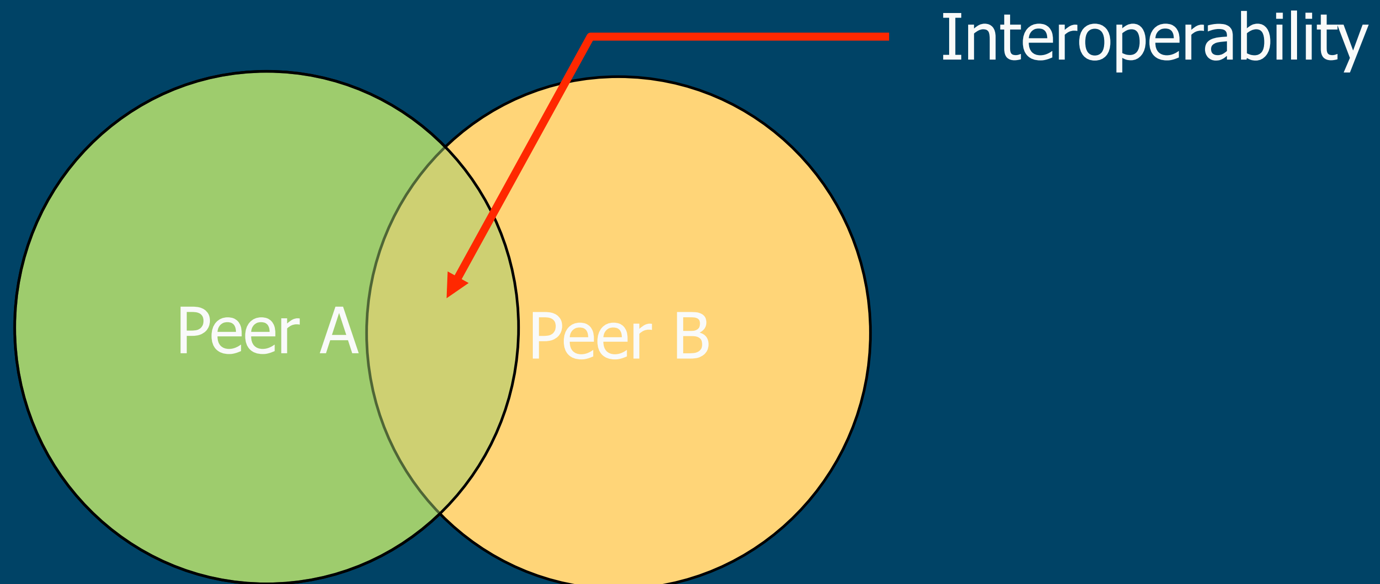
- How are features and services deployed in the Web?
  - Often by extending existing applications
  - Spreading from in the small to the large over time
- This means that:
  - Applications have different capabilities at all times
  - We have to support this
- This requires that:
  - Applications supporting a particular feature or service should be able to employ this with no prior agreement;
  - Applications can require that the other party either understand and abide by the new feature or service or abort the operation

Why Not Roll My Own XML Protocol?

- SOAP allows you to define your particular feature or service in such a way that it can co-exist with other features and services within a SOAP message
- What is a feature or a service?
  - Authentication service
  - Payment service
  - Security service
  - Transaction management service
  - Privacy service
- Not owning the message means easier deployment and better interoperability

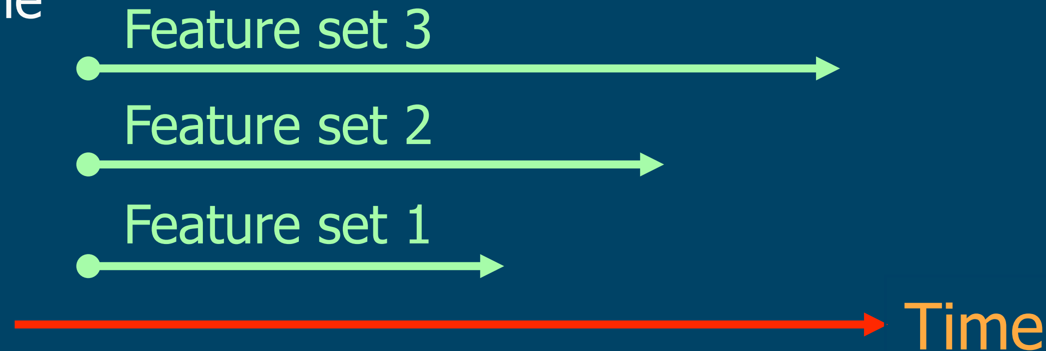
What is Interoperability?

- Interoperability is the intersection of features and service supported by two or more communicating peers:

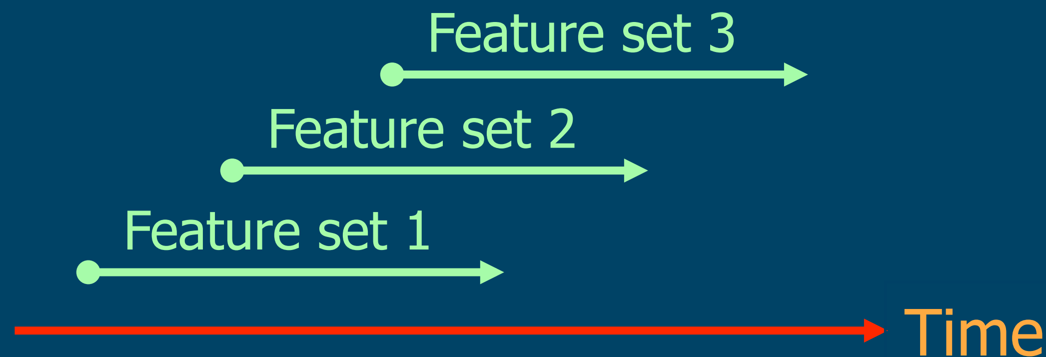


Extensibility vs. Evolvability

- Extensibility: Cost pr new feature/service increases over time



- Evolvability: Cost pr new feature/service is flat



SOAP and Composability

- We are looking at two types of composability of features and services within a message:
  - *Vertical:* multiple features and services can exist simultaneously within the same message
  - *Horizontal:* features and services within a message can be intended for different recipients.
    - This is not boxcarring but rather the HTTP proxy model and as we shall see, the SOAP messaging model as well

Vertical Composability

- Allows for independent features to co-exist

```
<SOAP:Envelope xmlns:SOAP="http://schemas.xmlsoap.org/soap/envelope”
  SOAP:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP:Header>
      <a:authentication …>…</a:authentication>
      <s:security …> … </s:security>
      <t:transactions …> … </t:transactions>
      <p:payment …> … </p:payment>
   </SOAP:Header>
   <SOAP:Body>
      <m:mybody> … </m:mybody>
   </SOAP:Body>
</SOAP:Envelope>
```

Horizontal Composability

- Allows for intermediaries

```
<SOAP:Envelope xmlns:SOAP="http://schemas.xmlsoap.org/soap/envelope”
  SOAP:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP:Header>
      <a:authentication actor="intermediary a"…>…</a:authentication>
      <s:security actor="intermediary b"…> … </s:security>
      <t:transactions actor="intermediary c"…> … </t:transactions>
      <p:payment actor="destination"…> … </p:payment>
   </SOAP:Header>
   <SOAP:Body>
      <m:mybody> … </m:mybody>
   </SOAP:Body>
</SOAP:Envelope>
```

Modularity through XML Namespaces

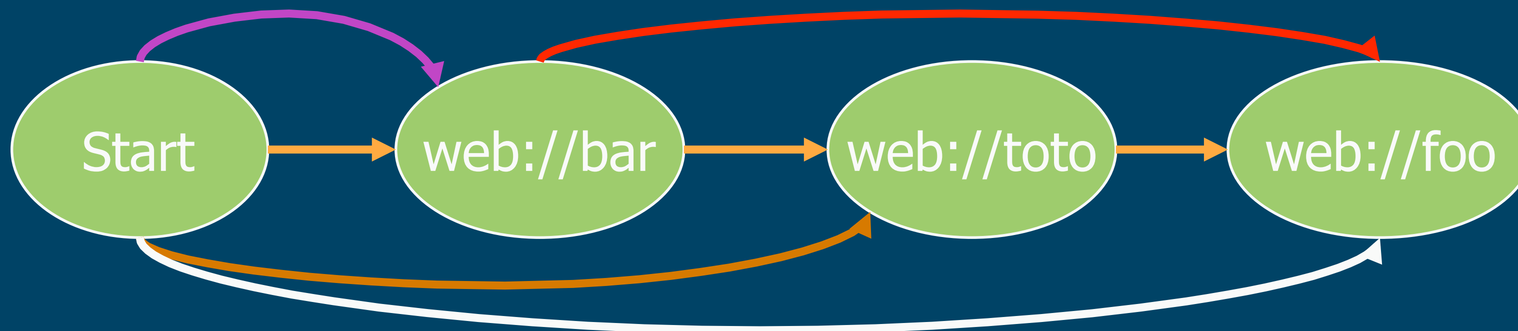
- The SOAP envelope namespace
  - http://schemas.xmlsoap.org/soap/envelope/
  - Resolves to the SOAP Envelope Schema
- The SOAP encoding namespace
  - http://schemas.xmlsoap.org/soap/encoding/
  - Resolves to the SOAP Encoding Schema
- Separate namespaces help enforce modularity
- SOAP Envelope Schema provides formal definition of Envelope

The SOAP Envelope

- A SOAP envelope defines a SOAP message
  - Basic unit of exchange between SOAP processors
- SOAP messages are one-way transmissions
  - From sender through intermediaries to receiver
  - Often combined to implement patterns such as request/response
- Messages are routed along a "message path"
  - Allows for processing at one or more intermediate nodes in addition to the ultimate destination node.
  - A node is a SOAP processor and is identified by a URI
- Envelopes can be nested
  - Only outer envelope is "active" to the receiving SOAP processor

SOAP Headers

- Allows for modular addition of features and services
  - Open-ended set of headers
    - Authentication, privacy, security etc. etc.
  - Can address any SOAP processor using the "actor" attribute
  - Can be optional/mandatory using the "mustUnderstand" attribute



Semantics of SOAP Headers

- Contract between sender and recipient
  - Recipient is described by "actor" attribute
- Allows for different types of negotiation:
  - Take it or leave it directly supported
  - Let's talk about it can be built on top
- And for different settings:
  - Server dictated
  - Peer-to-peer
  - Dictated by third party

The SOAP actor Attribute

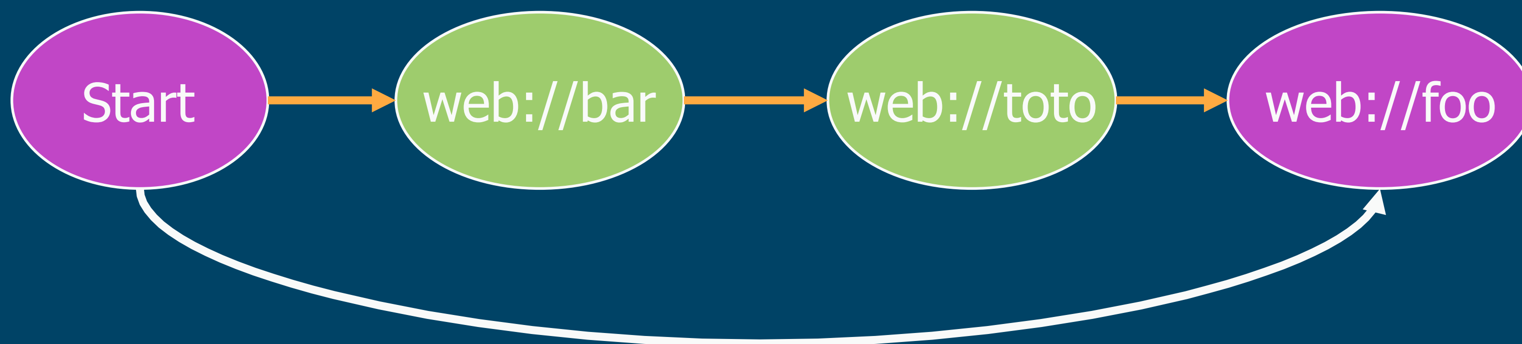
- The "Actor" attribute is a generalization of the HTTP Connection header field
  - Instead of hop-by-hop vs. end-to-end, the actor attribute can address any SOAP processor because it is a URI
  - Special cases:
    - "next hop" has a special URI assigned to it
    - "end" is the default destination for a header
    - "end" is the destination for the body

The SOAP mustUnderstand Attribute

- The "mustUnderstand" is the same as "mandatory" in the HTTP Extension Framework
  - Requires that the receiving SOAP processor must accept, understand and obey semantics of header or fail
    - It is up to the application to define what "understand" means
  - This allows old applications to gracefully fail on services that they do not understand

SOAP Body

- Special case of header
  - Default contract between sender and ultimate recipient
  - Different from HTTP's header/body separation
  - Defined as a header with attributes set to:
    - Implicit mustUnderstand attribute is always "yes"
    - Implicit actor attribute is always "the end"



SOAP Fault

- The SOAP Fault mechanism is designed to support the composability model
  - Is not a scarce resource as in HTTP where there can be only one (the Highlander principle)
- A SOAP message can carry one SOAP Fault element
  - Must be placed in the Body of the message
- The Fault Detail element carries information for faults resulting from the body
- Detail information for faults resulting from headers are carried in the header
- The SOAP fault code extension mechanism is for SOAP only
  - Application faults should use existing SOAP fault codes
  - Client code is for request faults
  - Server code is for processing faults

SOAP Fault Example

- A SOAP message containing an authentication service:

```
<SOAP:Envelope xmlns:SOAP="http://schemas.xmlsoap.org/soap/envelope”
  SOAP:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP:Header>
      <m:Authentication xmlns:m="http://www.auth.org/simple">
            <m:credentials>Henrik</m:credentials>
      </m:Authentication>
   </SOAP:Header>
   <SOAP:Body>
      … body goes here …
   </SOAP:Body>
</SOAP:Envelope>
```

SOAP Fault Example… 2

- …results in a fault because the credentials were bad:

```
<SOAP:Envelope xmlns:SOAP="http://schemas.xmlsoap.org/soap/envelope”
  SOAP:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP:Header>
      <m:Authentication xmlns:m="http://www.auth.org/simple">
              <m:realm>Magic Kindom</m:realm>
      </m:Authentication>
   </SOAP:Header>
   <SOAP:Body>
      <SOAP:Fault>
           <SOAP:faultcode>SOAP:Client</faultcode>
           <SOAP:faultstring>Client Error</faultstring>
       </SOAP:Fault>
   </SOAP:Body>
</SOAP:Envelope>
```

SOAP and "Binary" Data

- "Binary" can in fact mean any data that is to be tunneled through SOAP
  - Encrypted data, images, XML documents, SOAP envelopes as data
- Can be carried in two ways
  - Within the envelope as binary blob
  - Referenced from within the SOAP envelope
- References can point to anything including
  - MIME multipart, HTTP accessible resources etc.
  - Integrity can be obtained through manifest

Binding to HTTP

- The purpose of the HTTP protocol binding is two-fold
  - To ensure that SOAP is carried in a way that is consistent with HTTP's message model
    - Intent is not to break HTTP
  - To indicate to HTTP servers that this is a SOAP message
    - Allows HTTP servers to act on a SOAP message without knowing SOAP
- Binding only works for HTTP POST requests
- SOAP intermediary is not the same as HTTP intermediary
  - Only HTTP origin server can be SOAP intermediary

HTTP Request

- Use HTTP POST request method name
- Use the SOAPAction HTTP header field
  - It cannot be computed – the sender must know
  - It should indicate the intent – not the destination
- SOAP request doesn't require SOAP response

```
POST /Accounts/Henrik HTTP/1.1
Content-Type: text/xml; charset="utf-8“
Content-Length: nnnn
SOAPAction: "http://electrocommerce.org/MyMessage"
SOAPAction: "http://electrocommerce.org/MyMessage"

<SOAP:Envelope...
```

HTTP Response

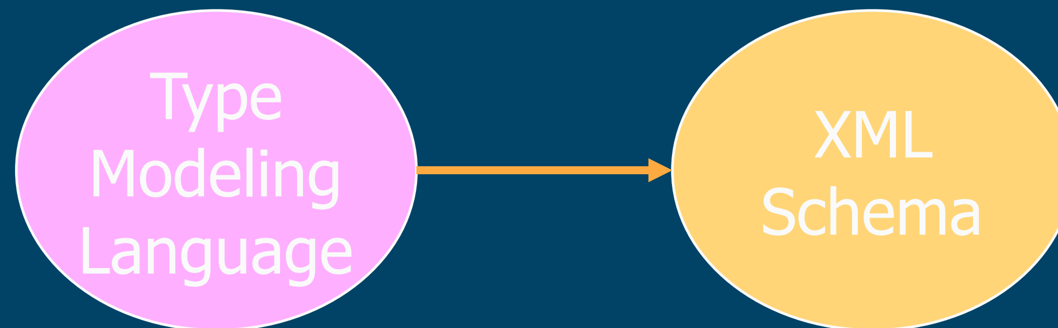
- Successful responses can 2xx status codes
- All 3xx, 4xx, and 5xx status codes work as normal
- SOAP faults must use 500 status code
- SOAP response doesn't require SOAP request
  - Response can in fact be empty

```
HTTP/1.1 200 Ok
Content-Type: text/xml; charset="utf-8“
Content-Length: nnnn

<SOAP:Envelope...
```

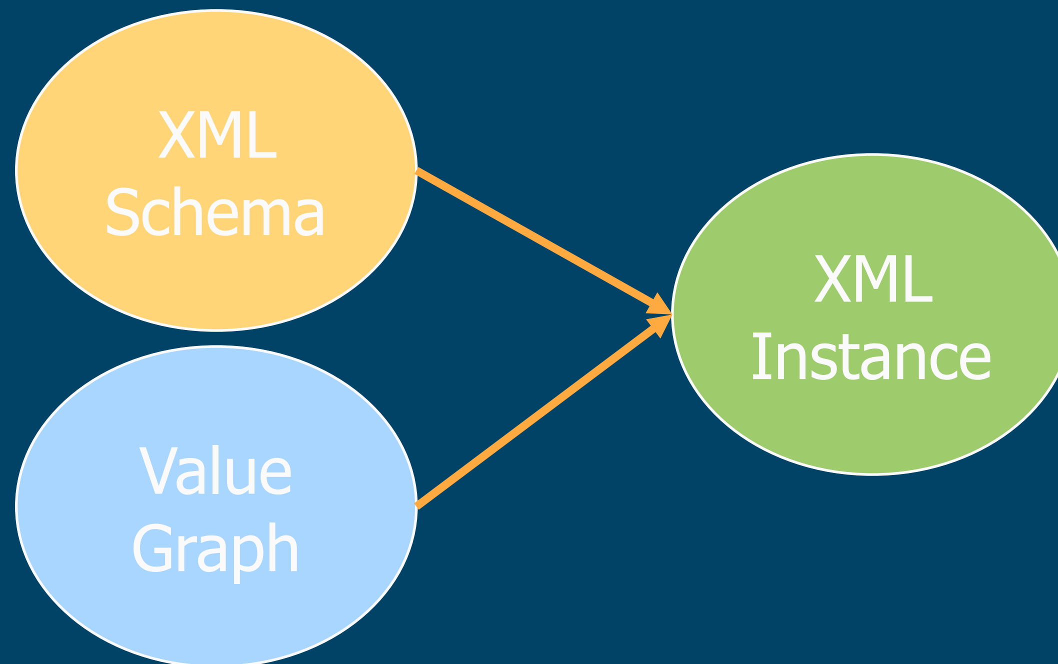
Purpose of SOAP Encoding

- Given a schema in any notation consistent with the data model defined by SOAP, a schema for an XML grammar may be constructed



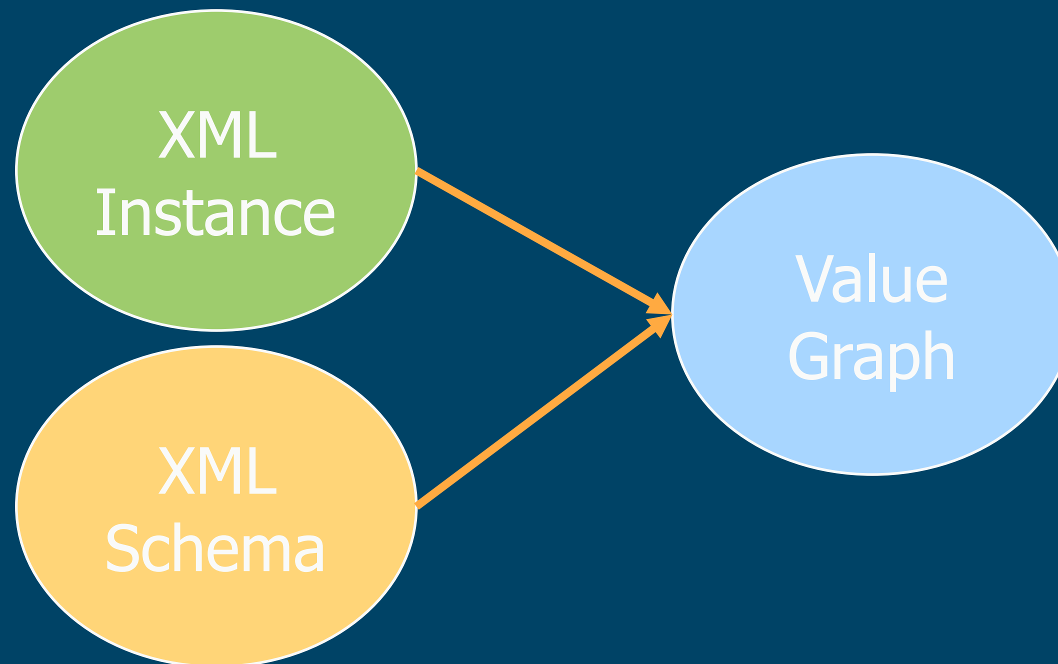
Purpose of SOAP Encoding… 2

- Given a type-system schema and a particular graph of values conforming to that schema, an XML instance may be constructed.



Purpose of SOAP Encoding... 3

- Given an XML instance produced in accordance with these rules, and given also the original schema, a copy of the original value graph may be constructed.



Simple Example

```
<Address id="Address-3">
    <street>28 Sea Dr #103</street>
    <city>Unicity</city>
    <state>CA</state>
</Address>

<Student id="Student-2567">
    <name>Michael</name>
    <dormaddr href="#Address-3"/>
    <attends href="#Course-19"/>
    <attends href="#Course-253"/>
</Student>
```

Basic Rules (in part)

- All values are represented as element content
- An element may be "independent" (top level of serialization) or "embedded" (everything else)
- Values can be single-reference or multi-reference
- A multi-reference value is represented as the content of an independent element. It has an unqualified attribute named "id" and of type "ID".
- An accessor can point to a multi-reference value with a local, unqualified attribute named "href" and of type "uri -reference"
- The root attribute can be used to indicate roots that are not true roots in a graph

Indicating the Type

- For each element containing a value, the type of the value is represented by at least one of the following conditions:
  - The containing element instance contains an xsi:type attribute,
  - The containing element instance is itself contained within an element containing a (possibly defaulted) SOAP-ENC:arrayType attribute or
  - The name of the element bears a definite relation to the type, that type then determinable from a schema.

Simple Types

- A "simple type" is a class of simple values
- SOAP uses all the types found in the section "Built-in data types" of "XML Schema Part 2: Datatypes"
- A simple value is represented as character data, that is, without any sub-elements

Simple Type Examples

```
<element name="age" type="int"/>
<element name="height" type="float"/>
<element name="displacement"
         type="negativeInteger"/>
<element name="color">
  <simpleType base="xsd:string">
    <enumeration value="Green"/>
    <enumeration value="Blue"/>
  </simpleType>
</element>
```

```
<age>45</age>
<height>5.9</height>
<displacement>-450</displacement>
<color>Blue</color>
```

Compound Types

- A “compound” type is a class of compound values
- Each related value is potentially distinguished by a role name, ordinal or both (accessor)
- Supports traditional types like structs and arrays
- Supports nodes with with many distinct accessors, some of which occur more than once
- Preserves order but doesn't require ordering distinction in the underlying data model

Struct Compound Type

- A compound value in which accessor name is the only distinction among member values, and no accessor has the same name as any other

```
<e:Book>
   <author>Henry Ford</author>
   <preface>When I…</preface>
   <intro>This is a book.</intro>
</e:Book>
```

Array Compound Type

- A compound value in which ordinal position serves as the only distinction among member values

```
<SOAP-ENC:Array
 SOAP-ENC:arrayType="xyz:Order[2]">
   <Order>
        <Product>Apple</Product>
        <Price>1.56</Price>
   </Order>
   <Order>
        <Product>Peach</Product>
        <Price>1.48</Price>
   </Order>
</SOAP-ENC:Array>
```

General Compound Type

- A compound value with a mixture of accessors distinguished by name and accessors distinguished by both name and ordinal position

```
<PurchaseLineItems>
   <Order>
       <Product>Apple</Product>
       <Price>1.56</Price>
   </Order>
   <Order>
       <Product>Peach</Product>
       <Price>1.48</Price>
   </Order>
</PurchaseLineItems>
```

Serializing Relationships

- The root element of the serialization serves only as lexical container.
- Elements can reflect arcs or nodes
- Independent elements always reflect nodes
- Embedded elements always reflect arcs
- Element names correspond to node or arc labels
- Arcs are always encoded as embedded elements

1:1 Relationships

- A 1:1 relationship is expressed by simple containment. For example, if a student attends a course, the canonical XML looks like

```
<Student>
   <name>Alice</name>
   <attends>
      <name>Greek</name>
   </attends>
</Student>
```

1:n and n:1 Relationships

- A 1:many relationship is expressed by multiple elements for the 1:many direction or single element for the many :1 direction.

```
<Teacher id="Teacher-1">
   <name>Alice</name>
   <teaches>
       <name>Greek</name>
   </teaches>
   <teaches >
      <name>English History</name>
   </teaches>
</Teacher>
```

m:n Relationships

- A many:many relationship is expressed by using references in both directions.

```
<Student id="Student-1">
   <name>Alice<name>
   <attends href="#Course-1"/>
   <attends href="#Course-2"/>
</Student>
<Course id="Course-1">
   <name>Greek</name>
   <attendee href="Student-1"/>
</Course>
```

SOAP and RPC

- A method invocation is modeled as a struct
- A method response is modeled as a struct
- Struct contains an accessor for each [in] or [in/out] or [out] parameter.
- The request struct is both named and typed identically to the method name.
- The response struct name is not important
- The first accessor is the return value followed by the parameters in the same order as in the method signature

Summary

- SOAP envelope provides
  - Composability in the vertical (Shopping basket)
  - Composability in the horizontal (Amtrak)
- SOAP can be used with many protocols
  - Easy to deploy with existing infrastructure
- SOAP is fundamentally a one-way message
  - Supports request/response, RPC etc.
  - Your application decides what it is!