CS144 Notes: Web Services

What is a Web service?

- **Q: What is the Web?**
  - Web sites and Web pages
    * static textual pages created for human consumption.

- **Q: If we want to build a service that integrates services from expedia, weather, and frommers --- given departure and destination cities, provide maps, weather and tourist destinations --- what needs to be done?**
  - Remarks:
    * "screen scraping"
    * extracting data from html pages is labor intensive and fragile
    * how can we make them easy to "integrate" or "mash-up"?

- **"Web service" is the Web for applications**
  - Each service provides a particular functionality
    * travel booking, dictionary, weather forecast, ...
  - Each service exchanges request and result through a well-defined standard
    * makes it possible to build web services independently of the platform
  - Each service "describes" its interface using a well-defined standard
    * makes it easy to build the "glue" between services

<show WSDL and SOAP examples>

http://www.webservicex.net

http://www.soapclient.com/soaptest.html

- Remark:
  * all output is formatted in XML: no more screen scraping
  * we can "invoke" a service without writing any software code due to WSDL.

- **Important standards**

  1. SOAP (Simple Object Access Protocol)

     - Standard for making "request" and receiving "response"

  2. WSDL (Web Service Definition Language)

     - Standard for "describing" a particular Web service
     - This should provide (1) location (2) list of "operations" and (3) the input and output parameters

Web Service example

- **Temperature conversion service**
  - Fahrenheit -> Celsius

- **In Java**

```
public class Converter {
        public double fahrenheitToCelsius(double fahrenheit) {
                // convert Fahrenheit to Celsius
                return (fahrenheit-32.0)*5.0/9.0;
        }
}
```

SOAP

- **message exchange standard for Web services**
  - standard for "method invocation"

  - e.g., calling "fahrenheitCelsius" with parameter 80

  - assume the service is available at http://oak.cs.ucla.edu/cs144/Converter

```
<?xml version="1.0"?>
 <soap:Envelope xmlns:soap="http://www.w3.org/2001/12/soap-envelope">
    <soap:Body>
      <fahrenheitToCelsius>
        <fahrenheit>80</fahrenheit>
      </fahrenheitToCelsius>
    </soap:Body>
 </soap:Envelope>
```

  - The root element is <Envelope>

        * Any soap message should be wrapped in <Envelope> element

    - <Envelope> has a child element <Body>

        * The main message should be wrapped in <Body> element

    - e.g., response from "Converter"

```
<?xml version="1.0"?>
  <soap:Envelope xmlns:soap="http://www.w3.org/2001/12/soap-envelope">
    <soap:Body>
      <fahrenheitToCelsiusResponse>
        <fahrenheitToCelsiusReturn>26.67</fahrenheitToCelsiusReturn>
      </fahrenheitToCelsiusResponse>
    </soap:Body>
  </soap:Envelope>
```

    - Skeleton SOAP message

```
 <?xml version="1.0"?>
  <soap:Envelope xmlns:soap="http://www.w3.org/2001/12/soap-envelope">
  <soap:Header> ... </soap:Header>   <-- optional
        <soap:Body>
  ...
        <soap:Fault> ... </soap:Fault>     <-- optional
        ...
  </soap:Body>
  </soap:Envelope>
```

    - Remarks:
        * Header
            - optional first subelement of <Envelope>
            - contains optional information about the message

        * Body
            - main message

        * Fault
            - optional subelement of <Body> to deliver an error message
            - may contain <faultcode>, <faultstring>, <detail>, ...

    - Remark: SOAP itself does not specify the exact format of <Body>. The exact format of <Body> is defined by WSDL. The above format is just a common convention. It could well be

```
...
<soap:Body>
  <Celsius>26.67</Celsius>
</soap:Body>
...
```

WSDL

- **Standard for describing a particular Web service**
- **Q: What information needs to be given in a Web service description?**
  - The location of a service: appears in <service>
    - List of "functions": appears in <portType>
    - Function parameters: appears in <types>

```
<service>: ** the location **
   ^
   |
<binding>: protocol and encoding scheme
   ^
   |
<portType>: ** the list of operations and the parameters **
   ^
   |
<message>: the message structure
   ^
   |
<types>: ** the format of input/output parameters **
```

<give students time to go over the WSDL example>
e.g.,

```
<?xml version="1.0"?>
 <definitions xmlns="http://schemas.xmlsoap.org/wsdl/"
              xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
              xmlns:xs="http://www.w3.org/2001/XMLSchema"
              targetNamespace="http://oak.cs.ucla.edu/cs144/Converter"
              xmlns:tn="http://oak.cs.ucla.edu/cs144/Converter">

   <!-- types element specifies the "type" of input/output parameters -->
   <types>
     <xs:schema targetNamespace="http://oak.cs.ucla.edu/cs144/Converter">
       <!-- fahrenheightToCelsisus will be the root request element -->
       <xs:element name="fahrenheitToCelsius">
         <xs:complexType>
           <xs:sequence>
             <xs:element name="fahrenheit" type="xs:double"/>
```

```
            </xs:sequence>
          </xs:complexType>
        </xs:element>

        <!-- fahrenheitToCelsiusReponse is the root response element -->
        <xs:element name="fahrenheitToCelsiusResponse">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="farenheitToCelsiusReturn" type="xs:double"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
      </xs:schema>
    </types>

    <!-- message element specifies request and response message format
         message element may consist of multiple parts like header, body,
faultcode, etc-->
    <message name="convertRequest">
      <part name="requestBody" element="tn:fahrenheitToCelsius"/>
    </message>
    <message name="convertResponse">
      <part name="responseBody" element="tn:fahrenheitToCelsiusResponse"/>
    </message>

    <!-- portType element specifies the available operations (= methods)
         and the associated input/output message format -->
    <portType name="ConverterPortType">
      <operation name="fahrenheitToCelsius">
        <input message="tn:convertRequest"/>
        <output message="tn:convertResponse"/>
      </operation>
    </portType>

    <!-- binding element specifies the transfer protocol
         and the message MIME encoding of the service
                every operation specified here should have a corresponding
                operation in the associated portType -->
    <binding type="tn:ConverterPortType" name="ConverterBinding">
      <soap:binding style="document"
                    transport="http://schemas.xmlsoap.org/soap/http"/>
      <operation name="fahrenheitToCelsius">
        <soap:operation soapAction=""/>
        <input>
                <soap:body use="literal"/>
          </input>
          <output>
              <soap:body use="literal"/>
        </output>
      </operation>
    </binding>

    <!-- service element specifies the URL where the service is
         available -->
    <service name="ConverterService">
      <port binding="tn:ConverterBinding" name="Converter">
        <soap:address location="http://oak.cs.ucla.edu/cs144/Converter"/>
```

```
    </port>
  </service>
</definitions>
```

- WSDL:

  * everything should be wrapped in <definitions> ... </definitions>
  * <definition> has 5 children

    - <types>
    - <message>
    - <portTypes>
    - <binding>
    - <service>

  * of which the following three contain the "core" information

    - <service>: service URL - location attr of address element
    - <portType>: list of functions - operation element
    - <types>: XML type definitions for message format

    - <service> is associated with <portType> through <binding>
      - <binding> makes it possible to use non-HTTP protocol and different encoding
        * use="literal" or "encoded".
          - "encoded" means special encoding is used (like mime64)

        * style="rpc" or "document".
        * "rpc" implies that "request and response" model and that all requests are wrapped in an element with the name of the invoked operation.

    - <portType> is associated with <types> through <message>
      - <message> allows complex message formatting with multiple parts
        * like header, body, etc.
        * in many cases, the actual "message format" is defined as a type

* Notes on Namespace
    - most of the elements should belong to the WSDL namespace
    - Elements in <types> should belong to XML Schema namespace
    - SOAP binding related elements should belong to SOAP namespace
    - User defined types and elements should belong to its own namespace

REST (Representational State Transfer)

- **SOAP is good, but it is too complicated**
    - too much additional layers
    - very difficult to read
    - difficult to read and understand messages and description

- **REST**
    - Instead of complex SOAP request, request is encoded in URL (in most cases) e.g., Yahoo Map

    - http://oak.cs.ucla.edu/cs144/Converter?method=fahrenheitToCelsius&fahrenheit=80

    - response is typically encoded either in simple XML (without additional messaging layer) or in JSON (more about JSON later)

```
<?xml version="1.0"?>
<Celsius>26.67</Celsius>
```

- **REST web services are:**
    - Lightweight - not a lot of extra xml markup
    - Human Readable Results
    - Easy to build - no toolkits required

- **SOAP also has some advantages:**
    - Rigid - type checking, adheres to a contract
    - Automatic development tools

- **REST interface tends to be more popular**
    - easier to learn and use using simple tools

- **Q: How it Web Service different from RPC?**

```
A: - XML based
   - typically use HTTP
   -> less compatibility issues
```

Distributed transactions

- **Example: a travel site that arranges both flight and hotel**
  - communicates with banks, hotels, and airlines through Web services
  - the user wants to book the flight F and hotel H using credit card C

  - Q: How should the site handle the booking?

  - Q: What if the credit card authorizations fail?
    What if the flight is no longer available?
    What if the hotel is no longer available?

  - Remark: No one can "commit" unless everyone else commits.

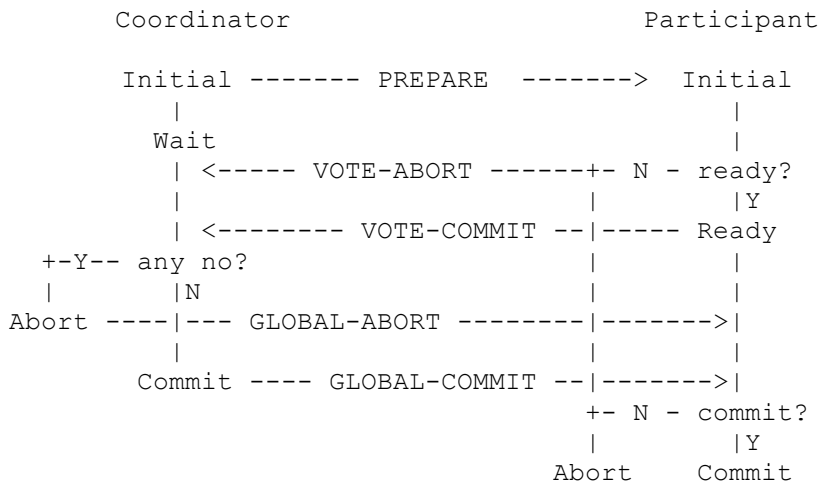
Two-phase commit

- **Before commit, ask everyone whether they are ready**

  - PREPARE -> VOTE-COMMIT/VOTE-ABORT
  - Note: Anyone who said ready cannot say otherwise later

- **If everyone says yes, commit**

  - if anyone says no, abort



- Q: Any potential problem of two phase commit?

- Q: Where should we add timeout to avoid indefinite wait?

- Remark: Do not get confused with two-phase locking

Asynchronous transaction

- **Q: What if one participant is very slow?**
  - Example: Starbucks. Cashier faster. Barista slower.
  - Q: What does two-phase commit mean in this scenario?
- **Q: How can we let each participant go ahead without waiting for the slow one?**
  - Q: What does Starbucks do?

- **Asynchronous transaction**
  - Each participant "commits" whenever he is done and moves ahead
    * Transaction = sequence of smaller transactions by each participant
  - The entire transaction is done when every participant commits
  - No coordinated wait and synchronous commit

- **Q: What if the coffee machine breaks down after customer paid?**

  - Compensating transaction
    * a transaction that "rolls back" a committed transaction
  - The coordinator should keep track of the "dependency" of transactions
    * together with their compensating transactions
  - If any transaction aborts, run compensating transaction for all committed transactions

- **Q: When should we use two-phase commit/asynchronous transaction?**

  - importance of individual commit guarantee
  - duration of individual transaction
  - probability of abort

- **Remark**
  - There exist a number of standards for distributed transactions onWeb Services
    * WS-Coordination, WS-AtomicTransaction, ...
  - Popular Web Application Servers support some of them
    * JBoss, BEA WebLogic, IBM WebSphere, ...