Web Services

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Middleware

- Facilitate the interaction among applications across heterogeneous computing platforms
  - they offer programming abstractions that hide complexity
- Remote Procedure Call (RPC)
  - hides communication details behind procedure calls
  - Serialization: marshaling/unmarshaling of values
  - Stubs
- Component-oriented programming
  - CORBA, RMI, EJB
  - COM
  - .NET
- Next generation heterogeneous distributed applications:
  - Service-oriented Computing
    - the basic element is a service

What are Web Services?

- Services available via the Web
  - Mostly for application-to-application communication
  - Enables business-to-business transactions
- Note:
  - web sites are for humans
  - web services are for software applications
- Examples:
  - stock quote service
  - weather service
  - map service
  - web search service

Why Web Services?

- They are platform and language independent
- They are appropriate for loosely coupled systems
  - don't need to have any prior knowledge of Web Services
- Based on XML
  - SOAP: Simple Object Access Protocol
  - WSDL: Web Service Description Language
  - UDDI: Universal Description, Discovery, and Integration
- Typical Web Service interaction:

  ![Diagram of Web Service Interaction](image-url)
**SOAP**

- A lightweight protocol for exchanging information in a distributed, heterogeneous environment
- Enables cross-platform interoperability
  - programming language neutral
  - hardware independent
  - protocol independent
- Works over existing Internet infrastructure
  - on top of HTTP
- Builds on XML standards
- Defines
  - message format
  - data encoding
  - headers for sending messages & receiving responses

**A SOAP Request**

- SOAP requests are HTTP POST requests
  - POST /DictService/DictService.asmx HTTP/1.1
  - Host: services.aonaware.com
  - Content-Type: text/xml; charset=utf-8
  - Content-Length: length
  - SOAPAction: "http://services.aonaware.com/webservices/DefineInDict"

```xml
<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmni:nsd="http://www.w3.org/2001/XMLSchema"
xmni:soap="http://schemas.xmlsoap.org/soap/envelope/">
  <soap:Body>
    <DefineInDict xmlns="http://services.aonaware.com/webservices/">
      <dictId>...</dictId>
      <word>...</word>
    </DefineInDict>
  </soap:Body>
</soap:Envelope>
```

**Message Layout**

- **SOAP Message**:
  - complete SOAP message
  - protocol binding headers

- **SOAP Envelope**:
  - encloses payload
  - encloses headers
  - individual headers

- **SOAP Body**:
  - contains SOAP message name
  - XML-encoded SOAP message name & data

**Message Format**

- The SOAP schema can be defined in an XML document

```xml
<?xml version="1.0"?>
<soap:Envelope ...
  <soap:Header ...
    ...
  </soap:Header>
  <soap:Body>
    <add xmlns="http://services.aonaware.com/webservices/">
      <left>...</left>
      <right>...</right>
    </add>
  </soap:Body>
</soap:Envelope>
```
Server Response

WSDL: Web Services Description Language

- XML Schema for describing Web Services
  - Service interface definition
  - Service implementation definition
    - concrete end points and network addresses where Web Service can be invoked
  - Used primarily to describe SOAP services
  - Describes four critical pieces of data:
    - Interface information describing all publicly available functions
    - Data type information for all message requests and message responses
    - Binding information about the transport protocol to be used
    - Address information for locating the specified service

Main Structure

<definition namespace = "...">
  <type> XML schema types </type>
  <message> ... </message>
  <port> a set of operations </port>
  <binding> communication protocols </binding>
  <service> a list of binding and ports </service>
  <definition>

WSDL Parts

- <types> define types used in message declaration
  - XML Schema must be supported by any vendor of WSDL conformant products
- The <message> element defines the data elements of an operation
  - each message may consist of one or more parts
    - similar to the parameters of a function call in a traditional programming language
- The <portType> defines a web service, the operations that can be performed, and the messages that are involved
  - defines the connection point to a web service, an instance of <portType>
  - similar to a function library in a traditional programming language
  - each operation can be compared to a function in a traditional programming language
**UDDI**

- UDDI = Universal Description, Discovery, and Integration
- Industry initiative to address discovery
  - a registration database for Web Services
- Specifications
  - schema for service providers and descriptions
  - API for publishing and searching
  - developed on industry standards (XML, HTTP, TCP/IP, SOAP)
  - applies to both XML and non-XML services
- Implementation
  - public and private instances of specification

**Web Services and Sun’s J2EE**

- JWSDP: Sun Java Web Services Developer Pack
  - JAXP: Java API for XML processing
  - JAXB: Java architecture for XML binding
    - marshaling/unmarshaling: mapping Java objects to XML
  - JAXM: Java API for XML (SOAP) messaging
    - SAAJ: SOAP with attachments API for Java
    - JAX-RPC: Java API for XML-based RPC
    - JAXR: Java API for XML registries (UDDI)
      - Java WSDL registry server

**JAXB**

- JAXB uses the XML Schema to convert Java objects to XML and vice versa
  - generates a set of Java classes from the XML Schema
  - also generates javadoc
- Based on Java Beans
  - For each element with tagname “tag”, generates
    - a getter getTag()
    - a setter method setTag(value)
- List<GradStudent> sl = dept.getGradstudent();
  - Iterator<GradStudent> i = sl.iterator();
  - while (i.hasNext()) {
    - GradStudent s = i.next();
    - System.out.println(s.getName().getLastName());
  }
- Provides the classes Marshaller and Unmarshaller

**JAXM**

```java
MessageFactory msgFactory = MessageFactory.newInstance();
SOAPMessage msg = msgFactory.createMessage();
SOAPPart soapPart = msg.getSOAPPart();
SOAPEnvelope envelope = soapPart.getEnvelope();
SOAPHeader header = envelope.getHeader();
SOAPBody body = envelope.getBody();
header.detachNode();
Name methodName =
  envelope.createName("GetHoroscope", "ASTRO","http://www.astro.com");
SOAPBodyElement getHoroscope = body.addChildElement(methodName);
Name dobParamName = envelope.createName("DateOfBirth");
SOAPElement dobParam = getHoroscope.addChildElement(dobParamName);
dobParam.addTextNode("05/03/1964");
Name colorParamName = envelope.createName("FavoriteColor");
SOAPElement colorParam = getHoroscope.addChildElement(colorParamName);
colorParam.addTextNode("Purple");
```
**Request & Response**

```java
SOAPMessage response = conn.call(msg, endPoint);
conn.close();
System.out.println("Received reply");
SOAPPart soapRespPart = response.getSOAPPart();
SOAPEnvelope soapRespEnv = soapRespPart.getEnvelope();
SOAPBody soapRespBody = soapRespEnv.getBody();
Iterator it = soapRespBody.getBodyElements();
SOAPBodyElement bodyElement = (SOAPBodyElement)it.next();
String horoscope = bodyElement.getValue();
System.out.println("Horoscope returned: " + horoscope);
```

**JAX-RPC**

- The generated stubs client model
- Stub and tie classes are generated from WSDL
- Dynamic proxy
  - acquires the signature of the service call at run-time and constructs a proxy that can then be used to call the service