# Web Development using Java, JSP, and Web Services

Web Services

Lecture #10 2008

## Web Services

- *Service*: A software component accessed *over a network* that provides functionality to a service requester
- *Web Service*: A service which publishes a service interface in WSDL and uses a message-driven protocol (usually via SOAP / HTTP)
- Built on a host of XML-based technologies
  - XML (data exchanged)
  - XML Schema (validation of data exchanged)
  - SOAP (XML-serialized transfer protocol)
  - WSDL (Web Service interface description, XML Schema)
- Uses a *deployment descriptor* to configure service (XML-based configuration file for the service container)

## Service Oriented Architectures (SOA)

- A style of building distributed systems where functionality is provided by modular services
- Focuses on *loose coupling* between interacting services (i.e., minimizing formal knowledge between components)
- Services are *virtualized* as much as possible (i.e., focus is placed on interfaces, not implementations)
- Usually built on Web Services (today)

## SOA Characteristics

- Logical view - No implementation details are revealed
- Coarse-grained - few operations, large messages
- Platform- (and language-) neutral
- Wide-spread technology base (XML, HTTP, TCP/IP)

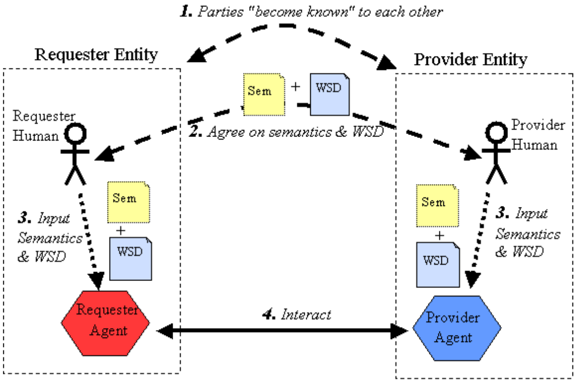
## SOA Service Characteristics

- Message-oriented - communicate by exchanging messages
  - abstract - interface defined in terms of messages
  - encapsulated - implementation details hidden
  - technology independent (platform, OS, API etc)
- Self-describing: provides machine-readable metadata (advertises capabilities, service interface, protocols etc)
- Discoverable: dynamic "on-demand" service discovery (includes service location, service interface, protocols etc)

## SOA Service Characteristics

- Modular: solves one well-defined task
  - used individually (by different services / applications)
  - can be composed (by other services)
  - facilitates reusability
  - self-contained or dependent on other services / resources
- Interoperable: standardized service access
  - standardized protocols
  - standardized data formats

## Interactions



## Loose Coupling

- Components minimize built-in knowledge of each other (focus placed on interfaces, not implementations)
- Services are dynamically discovered when needed (includes interfaces, supported protocols, location etc)
- Ideal: zero-coupling (”frictionless”) (services used without providing any information)

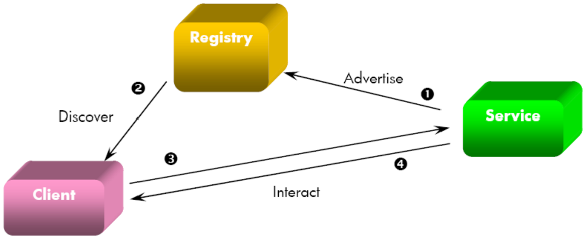
## Benefits Of Loose Coupling

- Flexibility: services can be (re)located on any server
- Scalability: services can be added / removed on demand (load balancing)
- Replacability: service implementations can be replaced (without user disruptions)
- Fault tolerance: upon failures, clients can query registries for alternative services offering the same functionality

## Publish, Find, Bind

1. Advertisement: service publishes information in a registry
2. Discovery: client queries registry for services
3. Connection establishment: client contacts service
4. Interaction: client and service interact

## Publish, Find, Bind



## WSDL

- XML Schema-based language for describing Web Services
- Completely describes the Web Service interface
- Constitutes a "contract" between the client and the service
- Can be generated from code, or vice versa
- Two major parts
  - abstract: interface (types, operations and messages)
  - physical: deployment (encodings, protocols, bindings)

## Developing Web Services

- Two main approaches
  - generate WSDL from code
  - generate code (stubs) from WSDL
- Generated WSDL tend to be platform / tool-dependent (quick and easy, but incompatibility issues may arise)
- Generating stubs from WSDL ensures compatibility (but require more work from all parties involved)
- **GOAL: interoperability** (favor the WSDL approach)

## Calling a Web Service

1. Locate Web Service (discovery)
2. Obtain WSDL description
3. Generate stubs from WSDL description
4. Use stubs to invoke Web Service methods

## Calling a Web Service (alt)

1. Locate Web Service (discovery)
2. Obtain WSDL description
3. Instantiate and configure generic WS API stubs
4. Use stubs to invoke Web Service methods

## WSDL

```
<definitions name="CounterService"
    targetNamespace="http://course.example/Counter"
    xmlns:counter="http://course.example/Counter"
    xmlns="http://schemas.xmlsoap.org/wsdl/">

  <types>
    ...
  </types>

  <message>
    ...
  </message>

  <portType>
    <operation> ... </operation>
  </portType>

</definitions>
```

## WSDL Types

```
<types>
  <schema targetNamespace="http://course.example/Counter"
          xmlns="http://www.w3.org/2001/XMLSchema">
    <element name="IncrementRequest">
      <complexType>
        <sequence>
          <element name="Value" type="int"
                   minOccurs="1" maxOccurs="unbounded"/>
        </sequence>
      </complexType>
    </element>
    <element name="IncrementResponse">
      <complexType/>
    </element>

    <element name="GetValueRequest">
      <complexType/>
    </element>
    <element name="GetValueResponse">
      <complexType>
        <sequence>
          <element name="Value" type="int"/>
        </sequence>
      </complexType>
    </element>
  </schema>
</types>
```

## WSDL Messages

```
<!-- Message definitions for Increment -->
<message name="IncrementRequestMessage">
  <part name="parameter" element="counter:IncrementRequest"/>
</message>
<message name="IncrementResponseMessage">
  <part name="parameter" element="counter:IncrementResponse"/>
</message>

<!-- Message definitions for GetValue -->
<message name="GetValueRequestMessage">
  <part name="parameter" element="counter:GetValueRequest"/>
</message>
<message name="GetValueResponseMessage">
  <part name="parameter" element="counter:GetValueResponse"/>
</message>
```

## WSDL portTypes

```
<portType name="Counter">

  <operation name="Increment">
    <input  message="counter:IncrementRequestMessage"/>
    <output message="counter:IncrementResponseMessage"/>
  </operation>

  <operation name="GetValue">
    <input  message="counter:GetValueRequestMessage"/>
    <output message="counter:GetValueResponseMessage"/>
  </operation>

</portType>
```

## SOAP

- Formerly known as *Simple Object Access Protocol*
- XML-based protocol to invoke Web Services (XML-serializes web service requests / responses)
- Usually transported via HTTP (in HTTP body)
- Can send messages
  - point-to-point (directly)
  - via intermediaries (in chains of actors)

## SOAP Messages

- Outer layer (e.g., HTTP data)
- Envelope (message root element)
- Header (optional)
  - factorization
  - different recipients (actors)
- Body
  - application specific data (message payload)
  - XML elements
  - Faults (error messages)

## SOAP Message

```
<soap:Envelope
    xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/"
    soap:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <soap:Body>
    <w:Greeting xmlns:w="http://www.wrox.com/helloworld/">
      <w:message>Hello world!</w:message>
    </w:Greeting>
  </soap:Body>
</soap:Envelope>
```

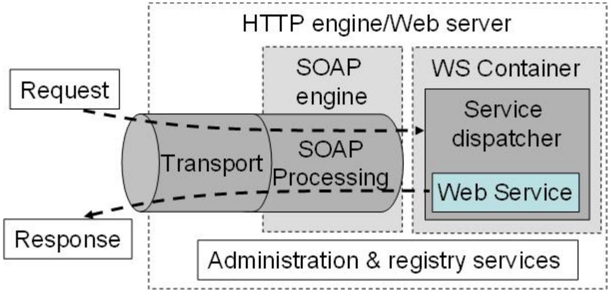
## SOAP Faults

- Faults reported in SOAP message body
- Error messages
- Comparable to exceptions in Java
- Fault information
  - `faultcode`: error identifier
  - `faultstring`: human readable identifier
  - `faultactor`: origin of error
  - `detail`: additional fault information

## SOAP Fault

```
<soap:Envelope
    xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
  <soap:Body>
    <soap:Fault>
      <faultcode>soap:Server</faultcode>
      <faultstring>Insufficient funds</faultstring>
      <detail>
        <t:TransferError xmlns:t="http://course.example/transaction">
          <sourceAccount>accountX</sourceAccount>
          <transferAmount>1000.00</transferAmount>
          <currentBalance>910.50</currentBalance>
        </t:TransferError>
      </detail>
    </soap:Fault>
  </soap:Body>
</soap:Envelope>
```

## SOAP Processing



## Representational State Transfer (REST)

- Alternative to SOAP for invoking Web Services
- Calls conveyed directly in HTTP bodies
- No extra encoding layers
- Simpler than SOAP
- Less versatile than SOAP

## Asynchronous JavaScript and XML (AJAX)

- Group of techniques used to increase interactivity in web applications
- Decreases response times by performing background HTTP and Web Service requests
- Usually some form of XML-based remote procedure calls done in JavaScript
- Alleviates the response time burden in web applications
- Dynamically updated pages not available in bookmarks, browser histories & search engines

## Web Service Resource Framework (WSRF)

- Framework to enable development of stateful Web Services
- Focuses on representations of state: *resources*
- Contains a whole host of specifications
- Provides
  - resource discovery
  - resource addressing
  - resource lifetime management
  - notification (publish / subscribe based state updates)
  - renewable references
  - service groups
  - base fault representations

## Summary

- Web Services are
  - accessible over networks
  - technology and platform-independent
  - hosted in service containers (e.g., Apache Axis)
  - accessed through generated stubs or APIs
  - not very efficient
  - very versatile
- Service Oriented Architectures draw up guidelines for (large-scale) deployment of Web Services

## Next Time

- Web Development Best Practices