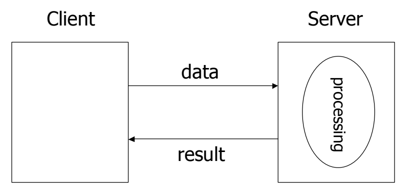
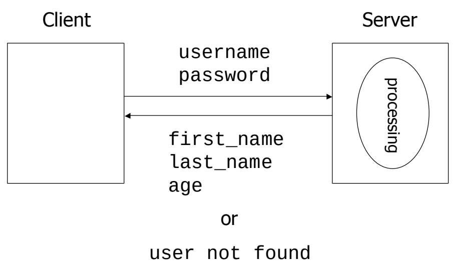
CS520 Web Programming
Web Services

Chengyu Sun
California State University, Los Angeles

Client-Server Architecture



Client-Server Example

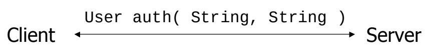


Socket Programming – Client

```
create socket
write string to socket                              }  data -> packet
write string to socket
read string from socket
    if( "user not found" ) return null;             }  App-specific protocol
    else
        return new User(
            read string from socket                 }
            read string from socket                 }  data <- packet
            read integer from socket                }
        )
close socket
```

- Lots of networking code that has nothing to do with application logic and has to be repeated for each application

Client-Server Interaction as Function Calls



Client side:

```
User user = auth( username, password );
```

Server side:

```
User auth( String username, String password )
{
    …
    if ( isValid ) return user;
    else return null;
}
```

Remote Procedure Call

- Remote Procedure Call (RPC)
  - C
- CORBA
  - Cross platform
  - Interface Definition Language (IDL)
- Remote Method Invocation (RMI)
  - Java
- Web services
  - *XML as IDL*

RMI – Server Side

- ◈Implement the service method(s)
- ◈Create a service object
- ◈Register the service object with RMI registry

Interface

- ◈Must extends `java.rmi.Remote`
- ◈Shared by both client and server code
- ◈E.g. `AuthInterface`

```
public interface AuthInterface extends java.rmi.Remote
{
    User auth( String username, String password )
        throws java.rmi.RemoteException;
}
```

Remote Object

```
public class AuthImpl implements AuthInterface
{
    public User auth( String username, String password )
        throws java.rmi.RemoteException
    {
        // user authentication
    }
}
```

RMI – Client Side

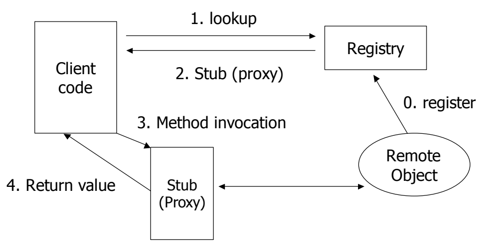
- ◈Get a reference to the remote service object
  - *What's the type of the reference??*
  - *What if the type is unknown at compilation time??*
- ◈Invoke the service method(s)

Stub

- ◈Created automatically

```
public class AuthStub implements AuthInterface
{
    public User auth( String username, String password )
        throws java.rmi.RemoteException
    {
        // connect to the server
        // send username and password to the server
        // return the result
    }
}
```

RMI



More About RMI

- SUN's RMI tutorial at http://java.sun.com/docs/books/tutorial/rmi/
  - Compilation and Execution
- Spring support for RMI
  - *Professional Java Development with the Spring Framework*, Chapter 8, RMI

Other Alternatives to RMI (Supported by Spring)

Name	Language	Message Type	Port
RMI	Java-to-Java	Binary	Default 1099
Hessian	Mostly Java-to-Java	Binary	HTTP
Burlap	Any	XML	HTTP
Spring HTTP Invoker	Java-to-Java	Binary	HTTP
Web services	Any	XML	HTTP

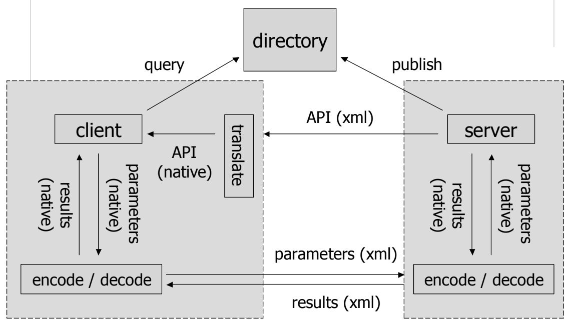
Web Services

- Roughly speaking, anything that encodes RPC calls in *XML messages* and transport them over *HTTP*
- Simple Object Access Protocol (SOAP)
- Web Service Description Language (WSDL)
- Universal Description, Discovery, and Integration (UDDI)

Issues Involved

- A server, written in C, provides a service that can turn stone into gold
  - `gold_t convert(stone_t stone) {...}`
- A client, written in Java, wants to turn stone into gold, but doesn't know how
  - `Gold convert(Stone stone) {??}`
- The server and client do not know each other. *What can we do??*

The Big Picture



SOAP

- http://www.w3.org/TR/soap/
- Format conventions for message content and routing directions in the form of an *envelope*
- Rules for encoding custom data types
- Application of the envelop and the data encoding rules for representing RPC calls and responses
- Transport protocol binding (usually HTTP)

A Sample SOAP Message

```
<?xml version='1.0' encoding='UTF-8'?>

<SOAP-ENV:Envelope
      xmlns:SOAP-ENV=http://schemas.xmlsoap.org/soap/envelope/
      xmlns:xsi=http://www.w3.org/1999/XMLSchema-instance
      xmlns:xsd="http://www.w3.org/1999/XMLSchema">
 <SOAP-ENV:Body>
  <ns1:doSpellingSuggestion xmlns:ns1="urn:GoogleSearch"
      SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
    <key xsi:type="xsd:string">00000000000000000000000000000000</key>
    <phrase xsi:type="xsd:string">britney speers</phrase>
  </ns1:doSpellingSuggestion>
 </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Things to Note

- Namespaces
- <Envelop>
  - Optional <Header> - for information related to processing of the message
  - <Body>
- encodingStyle
- <Fault>
  - Only sub-element of <Body> defined by SOAP

SOAP Encoding

- http://schemas.xmlsoap.org/encoding
- Include all built-in data types of *XML Schema Part 2: Datatypes*
  - `xsi` and `xsd` name spaces

SOAP Encoding Examples

int a = 10;	<a xsi:type="xsd:int">10</a>
float x = 3.14159;	<x xsi:type="xsd:float">3.14159</x>
String s = "SOAP";	<s xsi:type="xsd:string">SOAP</s>

Compound Values and Other Rules

```
<iArray xsi:type=SOAP-ENC:Array SOAP-ENC:arrayType="xsd:int[3]">
   <val>10</val>
   <val>20</val>
   <val>30</val>
</iArray>

<Sample>
   <iVal xsi:type="xsd:int">10</iVal>
   <sVal xsi:type="xsd:string">Ten</sVal>
</Sample>
```

- References, default values, custom types, `root` attribute, complex types, custom serialization …

SOAP RPC Elements

- Target object URI in HTTP header
- Namespace qualified method name and method parameters
- Optional SOAP header for additional data that's not part of the parameter list

A Sample SOAP RPC Response

```
<?xml version='1.0' encoding='UTF-8'?>

<SOAP-ENV:Envelope
   xmlns:SOAP-ENV=http://schemas.xmlsoap.org/soap/envelope/
   xmlns:xsi=http://www.w3.org/1999/XMLSchema-instance
   xmlns:xsd="http://www.w3.org/1999/XMLSchema">
   <SOAP-ENV:Body>
      <ns1:doSpellingSuggestionResponse xmlns:ns1="urn:GoogleSearch"
         SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
         <return xsi:type="xsd:string">britney spears</return>
      </ns1:doSpellingSuggestionResponse>
   </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

A Sample Fault Response

```
<SOAP-ENV:Envelope
   xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
   SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
   <SOAP-ENV:Body>
      <SOAP-ENV:Fault>
         <faultcode>SOAP-ENV:Client</faultcode>
         <faultstring>Client Error</faultstring>
         <detail>
            <m:dowJonesfaultdetails xmlns:m="DowJones">
               <message>Invalid Currency</message>
               <errorcode>1234</errorcode>
            </m:dowJonesfaultdetails>
         </detail>
      </SOAP-ENV:Fault>
   </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

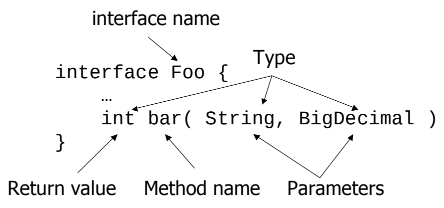
WSDL

- A language for describing web services
  - Where the service is
  - What the service does
  - How to invoke the operations of the service
- *Why do we need WSDL when we have API documentation??*

Sample WSDL Documents

- Amazon ECS - http://webservices.amazon.com/AWSECommerceService/AWSECommerceService.wsdl
- Google Web APIs (*no longer supported*) - http://api.google.com/GoogleSearch.wsdl
- Evelyn Library Service - http://localhost:8080/evelyn/axis/LibraryService?wsdl

How Do We Describe an API?


```
interface Foo {
   …
   int bar( String, BigDecimal )
}
```

How Do We Describe an Web Service API?

	WSDL
Type	<types>
Parameters	<message> (request and response)
Return values	
Method name	<operation>
Interface name	<portType>

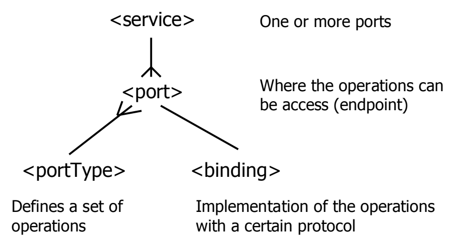
A Little More Details

- The name attribute uniquely identifies a <message>, an <operation>, or a <portType>
- Operation behavior patterns
  - Client initiated
    - Request-response
    - One-way
  - Server initiated
    - Solicit-response
    - Notification
- <fault>

Other WSDL Elements

- <definitions>
  - targetNamespace
- <import>
- <binding> - concrete protocol and format specification for a <portType>
  - E.g. <input> should be in SOAP header or body, what encoding rules should be used etc.
- <service>

Service



<service>
One or more ports
<port>
Where the operations can be access (endpoint)
<portType>
<binding>
Defines a set of operations
Implementation of the operations with a certain protocol

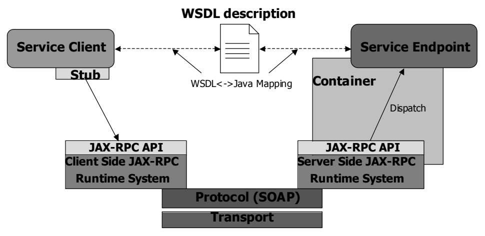
Provide and Access Web Services using Java

- JAX-RPC / JAX-WS
- Axis / Axis2

JAX-RPC

- An API specification for building SOAP based web services and clients using Java
  - https://jax-rpc.dev.java.net/
  - http://sun.calstatela.edu/~cysun/www/teaching/cs520/extras/jaxrpc-1_1-fr-spec.pdf
- Superseded by JAX-WS
  - https://jax-ws.dev.java.net/
  - http://sun.calstatela.edu/~cysun/www/teaching/cs520/extras/jaxws-2_1-mrel2-spec.pdf

JAX-RPC Architecture



Source: http://www.pankaj-k.net/axis4tag/

Apache Axis

- http://ws.apache.org/axis/
- An implementation of the JAX-RPC API
- Features
  - Create WSDL document from Java source code
  - Create Java classes from WSDL document
  - Encode and decode XML requests and responses
  - …
- Axis2 - http://ws.apache.org/axis2/

Provide a Web Service with Axis and Spring

- Code
  - JaxRpc wrapper around POJO service object
- Axis configuration
  - Axis servlet in web.xml
  - server-config.wsdd under /WEB-INF
- The Evelyn Library Service example

Access a Web Service

- The Evelyn WS client example

```
int n = 0;

// invoke the web service and get the number
// of items in the library
              ??

System.out.println( n + " items in the library" );
```

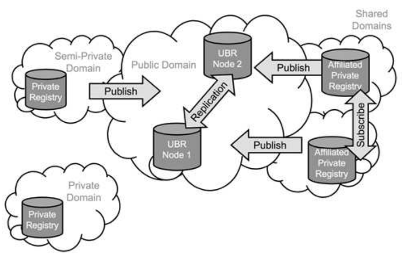
Service Invocation Patterns

- Static binding
  - statically generated stub
- Dynamic binding
  - service interface
  - javax.xml.rpc.Service.getPort()
- Dynamic Invocation Interface (DII)
  - `javax.xm.rpc.Call`

UDDI

- A registry for web services
  - Information about the service providers
  - Classifications of services
  - Technical information about the service interfaces
- A web API for publishing, retrieving, and managing information in the registry

Registries



Core Data Types

- <businessEntity>
- <businessService>
- <bindingTemplate>
- <tModel>

http://www.uddi.org/schema/uddi_v1.xsd
http://www.uddi.org/schema/uddi_v2.xsd
http://www.uddi.org/schema/uddi_v3.xsd

<businessEntity>

- Information about the service provider

```
<businessEntity businessKey="uuid:xxxxxxxxxxxxxxxxxxxxx"
            operator="http://some.com"
            authorizedName="John Doe">
  <name>Some Company</name>
  <description>We provide web services</description>
  <contacts>...</contacts>
  <businessServices>
    ...
  </businessServices>
    ...
</businessEntity>
```

<businessService>

- Descriptive information about services

```
<businessService serviceKey="uuid:xxxxxxxxxxxxxxxxxxx"
                 businessKey="uuid:xxxxxxxxxxxxxxxxxxxx">
  <name>Hello World</name>
  <description>A great web service</description>
  <bindingTemplates>
    ...
  </bindingTemplates>
</businessService>
```

<bindingTemplate>

- Technical information about services

```
<bindingTemplate bindingKey="xxxxxxxxxxxxxxxx"
            serviceKey="xxxxxxxxxxxxxxxx">
  <description xml:lang="en">
    SOAP binding for Hello World
  </description>
  <accessPoint URLType="http">
    http://localhost:8080/soap
  </accessPoint>
  <tModelInstanceDetails>
    <tModelInstanceInfo tModelKey="xxxxxxxxxxxxx" />
  </tModelInstanceDetails>
</bindingTemplate>
```

<tModel>

- Interface specification about services

```
<tModel TModelKey="uuid:xxxxxxxxxxxxxxxxxxxxxxx"
         operator="http://some.com"
         authorizedName="John Doe">
  <name>Hello World Port Type</name>
  <description>
    Interface for a great web service
  </description>
  <overviewDoc>
    <overviewURL>
      http://localhost:8080/soap/helloworld.wsdl
    </overviewURL>
  </overviewDoc>
</tModel>
```

UDDI APIs

- Node API Sets
  - Interaction among registry nodes
- Client API Sets
  - Publish services to a registry
  - Search a registry for services

WSDL for UDDI Client API

- http://www.uddi.org/wsdl/publish_v2.wsdl
- http://www.uddi.org/wsdl/inquire_v2.wsdl

Tools and Libraries

- http://uddi.org/solutions.html
- Ruddi - http://www.ruddi.biz/