CS520 Web Programming
Introduction to Web Services

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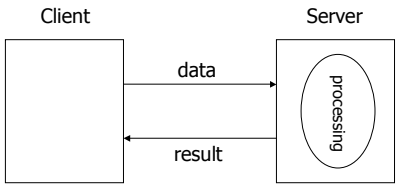
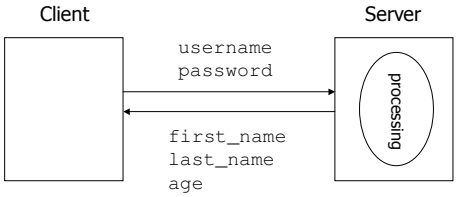
Client-Server Architecture



Client-Server Example



or

```
user not found
```

Socket Programming – Client

```
create socket
write string to socket
write string to socket
read string from socket
    if( "user not found" ) return null;
    else
        return new User(
            read string from socket
            read string from socket
            read integer from socket
        )
close socket
```

- Tedious networking code
- Application specific data exchange protocols

Client-Server Interaction as Function Calls

Client

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

- Automatically translate function calls to network operations
  - Encode and decode parameters and return values
  - Send and receive data between the client and the server

Server

```
User auth(String u, String p)
{ … return user; }
```

RPC and RMI

- Remote Procedure Call (RPC)
  - C
- Remote Method Invocation (RMI)
  - Java

RMI – Server

- Create a service interface
  - Remote interface
  - Declares the methods to be remotely invoked
- Create a service implementation
  - Remote object
  - Implements the methods to be remotely invoked
- Register the service with a RMI registry so a client can find and use this service

RMI – Client

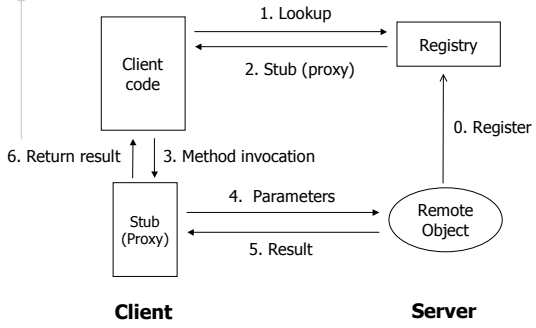
- Connect to the RMI registry
- Look up the service by name
- Invoke the service

RMI Example: AuthService

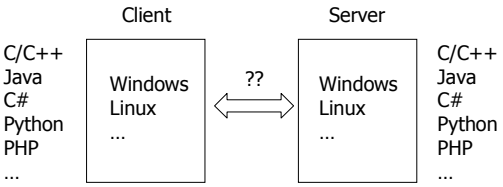
- Shared by both server and client
  - `AuthService`
  - `User`
- Server
  - `AuthServiceImpl`
  - `AuthServiceStartup`
- Client
  - `AuthServiceClient`

Why does `User` *have to implement the* `Serializable` *interface?*
What exactly does `registry.lookup()` *return?*

How RMI Works



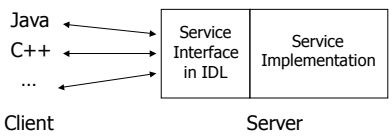
Cross Platform RPC



- The client and the server use different languages and/or platforms

CORBA

- Common Object Request Broker Architecture
- Use Interface Definition Language (IDL) to describe service interface
- Provide mappings from IDL to other languages such as Java, C++, and so on.



IDL Example

```
module bank {

  interface BankAccount {

    exception ACCOUNT_ERROR { long errcode; string message;};

    long querybalance(in long acnum) raises (ACCOUNT_ERROR);
    string queryname(in long acnum) raises (ACCOUNT_ERROR);
    string queryaddress(in long acnum) raises (ACCOUNT_ERROR);

    void setbalance(in long acnum, in long balance) raises (ACCOUNT_ERROR);
    void setaddress(in long acnum, in string address) raises (ACCOUNT_ERROR);
  };

};
```

Web Services

- RPC over HTTP
  - Client and server communicate using HTTP requests and responses

Web Service Example: HashService

- HashService
  - `@WebService`
  - `@WebMethod`
- web.xml
- sun-jaxws.xml
  - `<endpoint>`

Metro

- http://metro.java.net/
- A Java web service library backed by SUN/Oracle
- Implementation of the latest Java web service specifications
- Guaranteed interoperability with .NET Windows Communication Foundation (WCF) web services
- Easy to use

Other Java Web Service Libraries

- Apache Axis2
  - http://axis.apache.org/axis2/java/core/
- Apache CXF
  - http://cxf.apache.org/

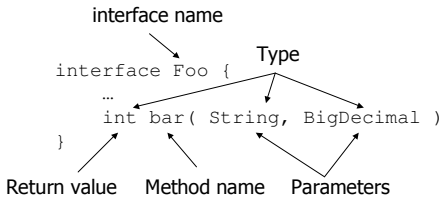
WSDL

- A language for describing web services
  - Where the service is
  - What the service does
  - How to invoke the operations of the service
- Plays a role similar to IDF in CORBA

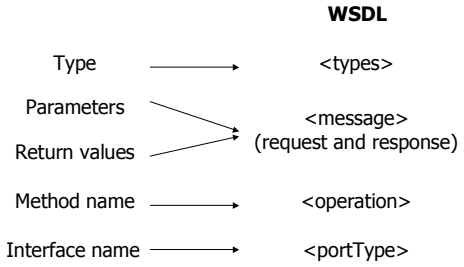
Sample WSDL Documents

- HashService - http://localhost:8084/ws/hash?wsdl
- Amazon ECS - http://webservices.amazon.com/AWSECommerceService/AWSECommerceService.wsdl

How Do We Describe an API



How Do We Describe an Web Service API



Web Service Example: Consume HashService

- Generate client side interface and stub from WSDL using Metro's `wsimport`
- Write client code

SOAP

- http://www.w3.org/TR/soap/
- Simple Object Access Protocol

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>
```

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
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, complex types, custom serialization …

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>
```

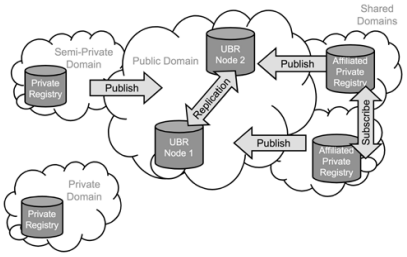
A Sample Fault Response

```
<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>
```

UDDI

- Universal Description Discovery and Integration
- A registry for web services
- A web API for publishing, retrieving, and managing information in the registry

UDDI Registries



Other Web Services

- Differences between web services
  - Language support
    - Single language vs. Language independent
  - Message encoding
    - Text vs. Binary
  - Transport layer
    - HTTP vs. non-HTTP
- *RESTful Web Services*

REST

- REpresentational State Transfer
- Introduced by Roy Fielding in his Ph.D. dissertation on network-base software architecture

The REST Constraints

- Client and server
- Stateless
- Support caching
- Uniformly accessible
- Layered
- (Optional) support code-on-demand

Common Characteristics of RESTful Web Services

- Access through URL instead of method calls
- Request and response in XML or JSON
- Stateless
- Use HTTP request methods explicitly

Map HTTP Request Methods to CRUD

HTTP Method		Data management
`POST`	⟷	Create
`GET`	⟷	Retrieve
`PUT`	⟷	Update
`DELETE`	⟷	Delete

RESTful Web Service Example

- Manage student data
  - List
  - Add
  - Get
  - Update
  - Delete

Sample Data

```
<students>
  <student>
    <name>Joe</name>
    <age>20</name>
  </student>
  <student>
    <name>Jane</name>
    <age>21</name>
  </student>
</students>
```

HTTP Request - List All Students

```
GET /students HTTP 1.1
Host: myserver
```

HTTP Request – Add A Students

```
POST /students/Tom HTTP 1.1
Host: myserver
Content-Type: application/xml
<?xml version="1.0"?>
<student>
  <name>Tom</name>
  <age>18</age>
</student>
```

HTTP Request – Get A Students

```
GET /students/Tom HTTP 1.1
Host: myserver
```

HTTP Request – Update A Students

```
PUT /students/Tom HTTP 1.1
Host: myserver
Content-Type: application/xml
<?xml version="1.0"?>
<student>
  <name>Tom</name>
  <age>19</age>
</student>
```

HTTP Request – Delete A Students

```
DELETE /students/Tom HTTP 1.1
Host: myserver
```

Advantages of RESTful Web Services

- Do not depend on complex specifications and library, i.e. easy to create
- Language independent, i.e. easy to use
- Take full advantage of infrastructure support for HTTP, e.g. caching

Summary

- RPC and RMI
- CORBA
  - IDL
- SOAP, WSDL, UDDI
  - Create and consume SOAP web services using Metro
- RESTful web services

Further Readings

- *Java Web Services Up and Running* by Martin Kalin
- *RESTful Java Web Services* by Jose Sandoval
- *The Rise and Fall of CORBA* by Michi Henning