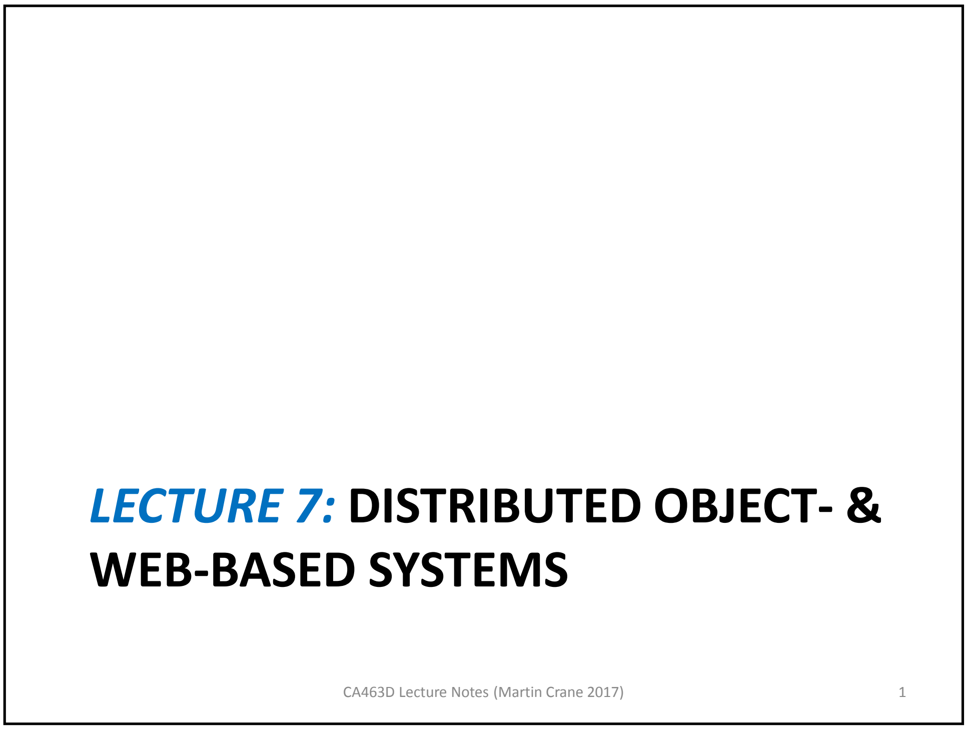
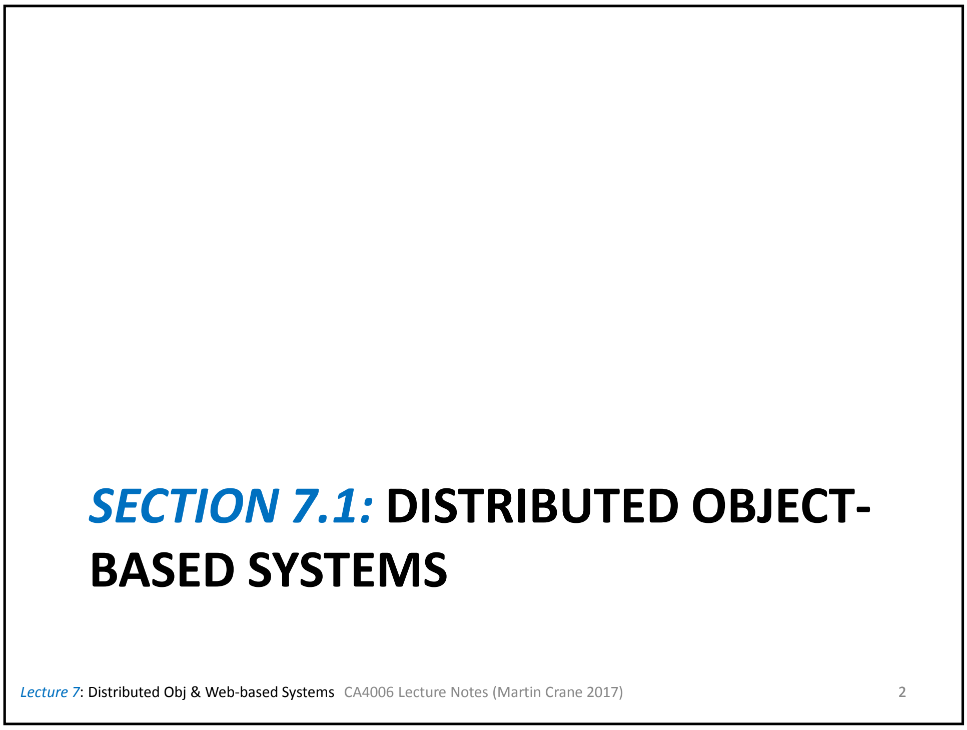


LECTURE 7: DISTRIBUTED OBJECT- & WEB-BASED SYSTEMS



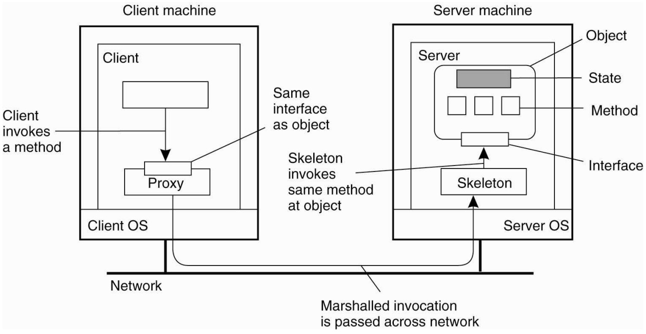
SECTION 7.1: DISTRIBUTED OBJECT-BASED SYSTEMS

Distributed Objects

- *Introduction*
  - In *distributed object-based* systems, an object plays a key role in getting *distribution transparency*.
  - Everything is treated as an object & clients are offered services/resources as objects that they can invoke.
  - Distributed objects form an important paradigm as it's 'easy' to hide distribution aspects behind an object's interface.
  - As object can be almost anything, also useful paradigm for building systems.
  - Key feature of objects is they encapsulate data (aka *state*), & operations on those data, (aka *methods*)
  - Methods are made available through an *interface*.
  - Process can only access/change object's state by invoking methods made available via an object's interface.
  - An object may implement multiple interfaces and for an interface definition, can be several objects offering an implementation of it.

Distributed Objects (/2)

- *Architecture*
  - The separation between interfaces & objects implementing them is crucial for distributed systems.
  - It allows for placing interface at one machine, with object itself on another machine.
  - This organization is commonly referred to as a *distributed object definition*.



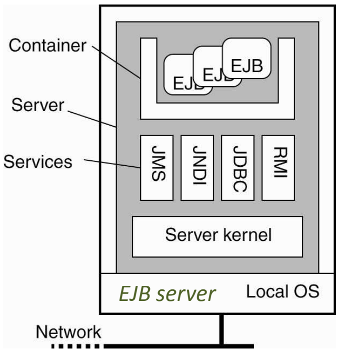
Organization of a Distributed Object with a Client-Side Proxy

Distributed Objects (/3)

- *Architecture*
  - Data & operations *encapsulated* in an object,
  - Operations implemented as methods grouped into interfaces
  - Object offers only its *interface* to clients
  - *Object server* is responsible for a collection of objects
  - *Client stub* (proxy) implements interface, marshals call
  - *Server skeleton* handles (un)marshalling and object invocation (+other stuff)
- *Types of objects I*
  - *Compile-time objects*: Language-level objects, from which proxy and skeletons are automatically generated.
  - *Runtime objects*: Implementable in any language, but need *object adapter* to make implementation appear as an object.
- *Types of objects II*
  - *Transient objects*: live only due to server: if server exits, so will the object.
  - *Persistent objects*: live independently of server: if server exits, object state & code remain (passively) on disk

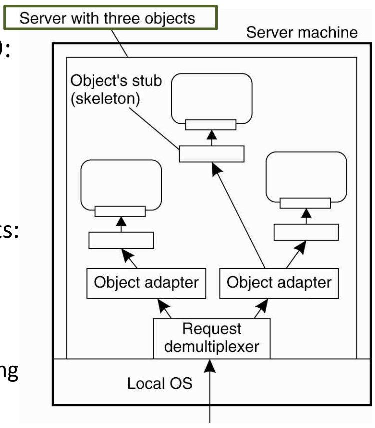
Distributed Objects (/4)

- *Example: Enterprise Java Beans (EJB)*
  - Def: Java object hosted by special server that allows for different means of calling the object by remote clients.
  - Four Different Types of EJBs
    - *Stateless session bean*: Transient object, called once, does its work and is done.
      E.g.: execute SQL query, return result.
    - *Stateful session bean*: Transient object, but keeps client-related state until session end.
      E.g.: shopping cart.
    - *Entity bean*: Persistent, stateful object, can be invoked over many sessions.
      E.g.: object maintaining client info on last number of sessions.
    - *Message-driven bean*: Reactive objects, often triggered by message types. Used to implement publish/subscribe forms of communication.



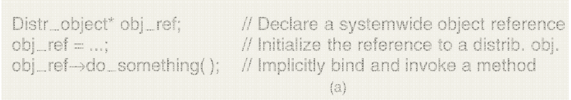
Distributed Objects (/5)

- *Processes: Object servers*
  - *Servant:* Object implementation, sometimes only implements methods:
    - Collection of C or COBOL functions, that act on structs, records, DB tables, etc.
    - Java or C++ classes
  - *Skeleton:* Server-side stub handles n/w I/O:
    - Unmarshalls incoming requests, calls relevant servant code
    - Marshalls results and sends reply message
    - Generated from interface specifications
  - *Object adapter*: "Manager" of a set of objects:
    - Inspects (as first) incoming requests
    - Ensures referenced object is 'activated' (requires identification of servant)
    - Passes request to appropriate skeleton, following specific 'activation' policy
    - Responsible for generating object references



Distributed Objects (/6)

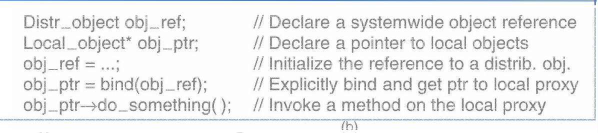
- *Client-to-object binding:*
- Object reference
  - Having an object reference allows a client to *bind* to an object:
  - Reference denotes server, object, and communication protocol
  - Client loads associated stub code
  - Stub is instantiated and initialized for specific object
- Two ways of binding
  - *Implicit*: Methods are Invoked directly on referenced object



```
Distr_object* obj_ref;       // Declare a systemwide object reference
obj_ref = ...;               // Initialize the reference to a distrib. obj.
obj_ref→do_something( );     // Implicitly bind and invoke a method
```

(a)

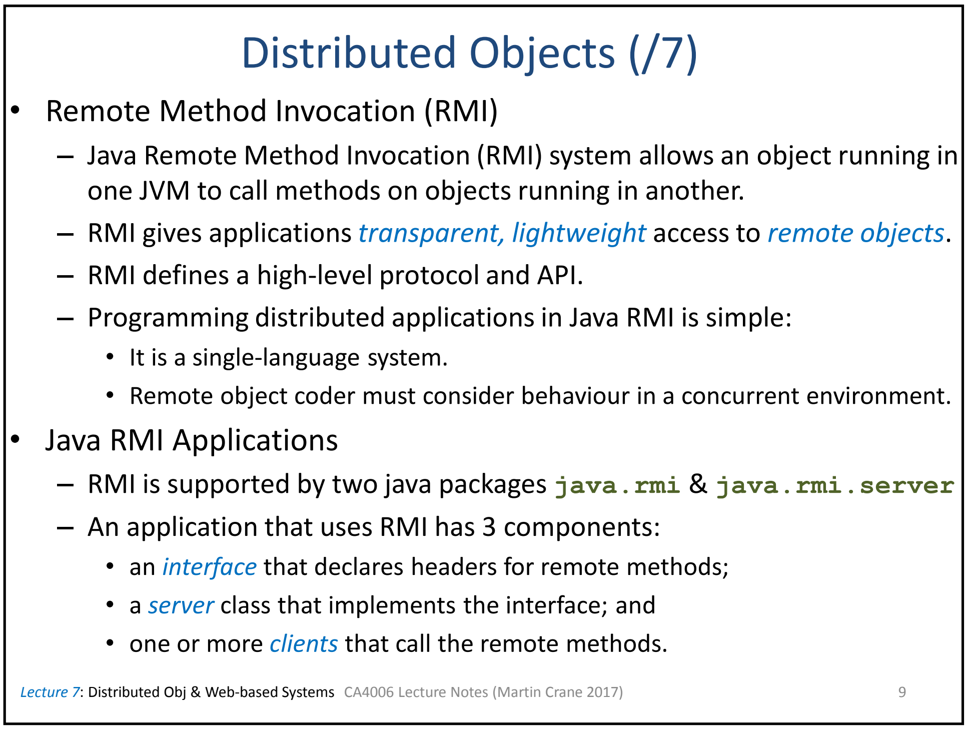
  - *Explicit*: Client must explicitly bind to object first before invoking it



```
Distr_object obj_ref;        // Declare a systemwide object reference
Local_object* obj_ptr;       // Declare a pointer to local objects
obj_ref = ...;               // Initialize the reference to a distrib. obj.
obj_ptr = bind(obj_ref);     // Explicitly bind and get ptr to local proxy
obj_ptr→do_something( );     // Invoke a method on the local proxy
```

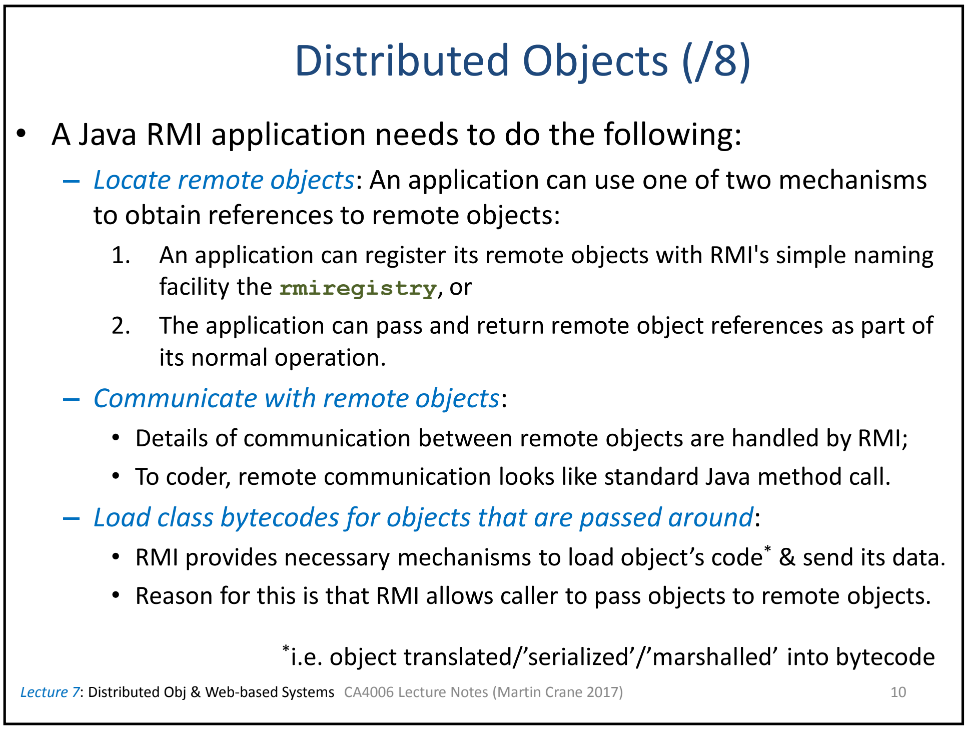
(b)

- Remote-object references allow us to pass references as parameters.
- This was difficult with ordinary RPCs.



Distributed Objects (/7)

- Remote Method Invocation (RMI)
  - Java Remote Method Invocation (RMI) system allows an object running in one JVM to call methods on objects running in another.
  - RMI gives applications *transparent, lightweight* access to *remote objects*.
  - RMI defines a high-level protocol and API.
  - Programming distributed applications in Java RMI is simple:
    - It is a single-language system.
    - Remote object coder must consider behaviour in a concurrent environment.
- Java RMI Applications
  - RMI is supported by two java packages `java.rmi` & `java.rmi.server`
  - An application that uses RMI has 3 components:
    - an *interface* that declares headers for remote methods;
    - a *server* class that implements the interface; and
    - one or more *clients* that call the remote methods.



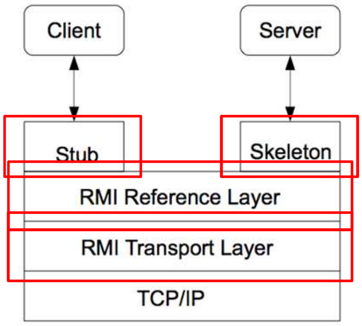
Distributed Objects (/8)

- A Java RMI application needs to do the following:
  - *Locate remote objects*: An application can use one of two mechanisms to obtain references to remote objects:
    1. An application can register its remote objects with RMI's simple naming facility the `rmiregistry`, or
    2. The application can pass and return remote object references as part of its normal operation.
  - *Communicate with remote objects*:
    - Details of communication between remote objects are handled by RMI;
    - To coder, remote communication looks like standard Java method call.
  - *Load class bytecodes for objects that are passed around*:
    - RMI provides necessary mechanisms to load object's code* & send its data.
    - Reason for this is that RMI allows caller to pass objects to remote objects.

*i.e. object translated/'serialized'/'marshalled' into bytecode

Distributed Objects (/9)

- RMI Architecture
  - *Stub*: lives client-side; pretends to be the remote object
  - *Skeleton*: lives on server; talks with true remote object
  - *Reference Layer*: determines if referenced object is local or remote
  - *Transport Layer*: - packages remote invocations;
    - dispatches messages between stub & skeleton



Distributed Objects (/10)

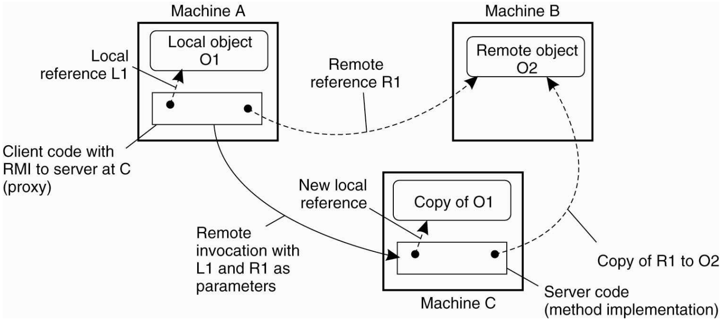
- Java RMI Basics: (Assumes client stub, server skeleton in place)
  - Client invokes method at *stub*
  - *Stub* marshals request and sends it to server
  - Server ensures referenced object is active:
    - Create separate process to hold object
    - Load the object into server process
    - ...
  - Object *skeleton* unmarshalls request & referenced method is invoked
  - If request contains object reference, invocation is applied recursively (i.e., server acts as client)
  - Result is marshalled and passed back to client
  - Client *stub* unmarshalls reply & passes result to client application

Distributed Objects (/10)

- RMI: Parameter passing
- *Object reference*: Much easier than in the case of RPC:
  - Server can simply bind to referenced object, and invoke methods
  - Unbind when referenced object is no longer needed
- *Object-by-value*: Client may also pass a complete object as parameter value:
  - An object has to be marshalled:
    - Marshall its state
    - Marshall its methods, or give ref to where an implementation can be found
  - Server unmarshalls object (n.b. now have copy of original object)
  - Object-by-value passing tends to introduce nasty problems

Distributed Objects (/11)

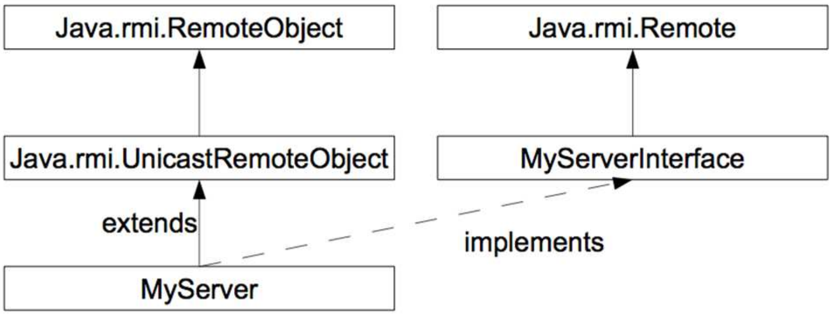
- RMI Parameter Passing
  - *Note*: System-wide object reference usually contains:
    - Server address
    - Port to which adapter listens, and
    - Local object ID.
  - *Extra*: Info on protocol between client & server (TCP, UDP, SOAP, etc.)



Distributed Objects (/12)

- RMI Registry
  - A simple server-side bootstrap naming facility allowing remote clients to get a reference to a remote object
    - Servers name & register their objects to be accessed remotely with the RMI Registry.
    - Clients use the name to find server objects and obtain a remote reference to those objects from the RMI Registry.
  - Registry service is background program with a list of registered server names on a host and invoked by: `rmiregistry port &`
  - Registry service is provided by a Naming object providing two key methods:
    - *Bind:* to register a name and server
    - *Lookup:* to retrieve the server bound to a name

RMI Inheritance



Java.rmi.RemoteObject

Java.rmi.Remote

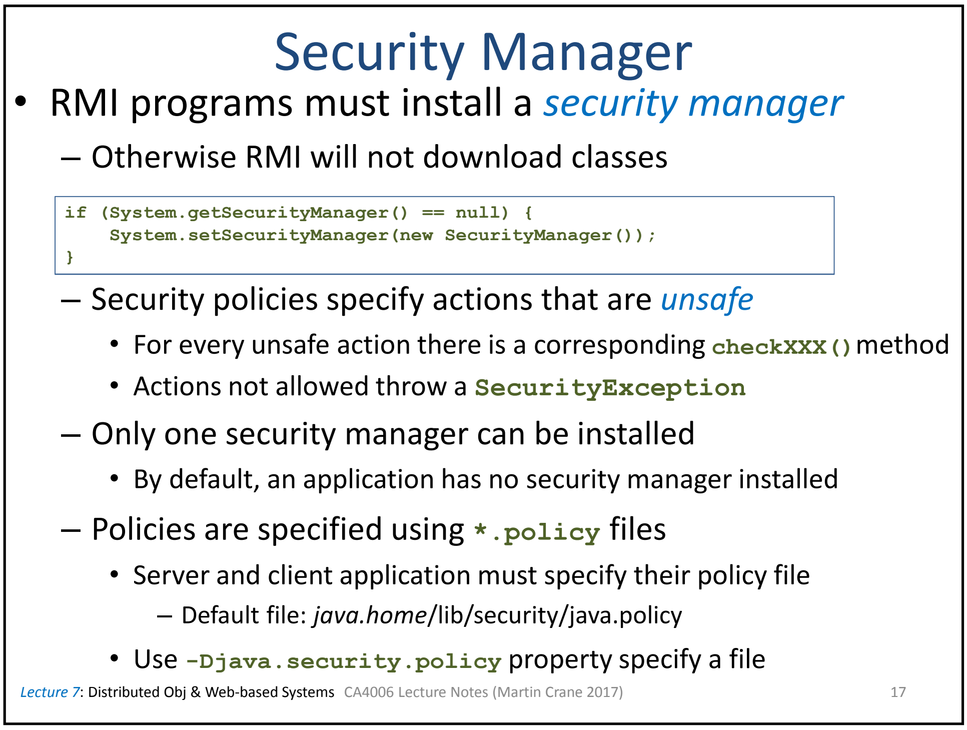
Java.rmi.UnicastRemoteObject

MyServerInterface

extends

implements

MyServer

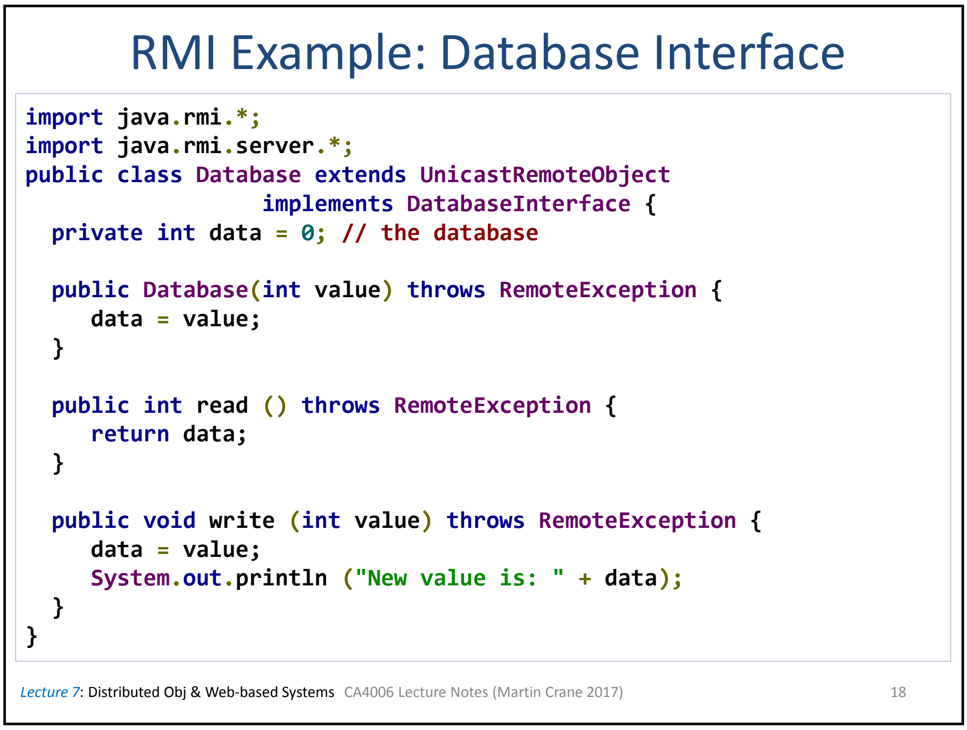


Security Manager

- RMI programs must install a *security manager*
  - Otherwise RMI will not download classes

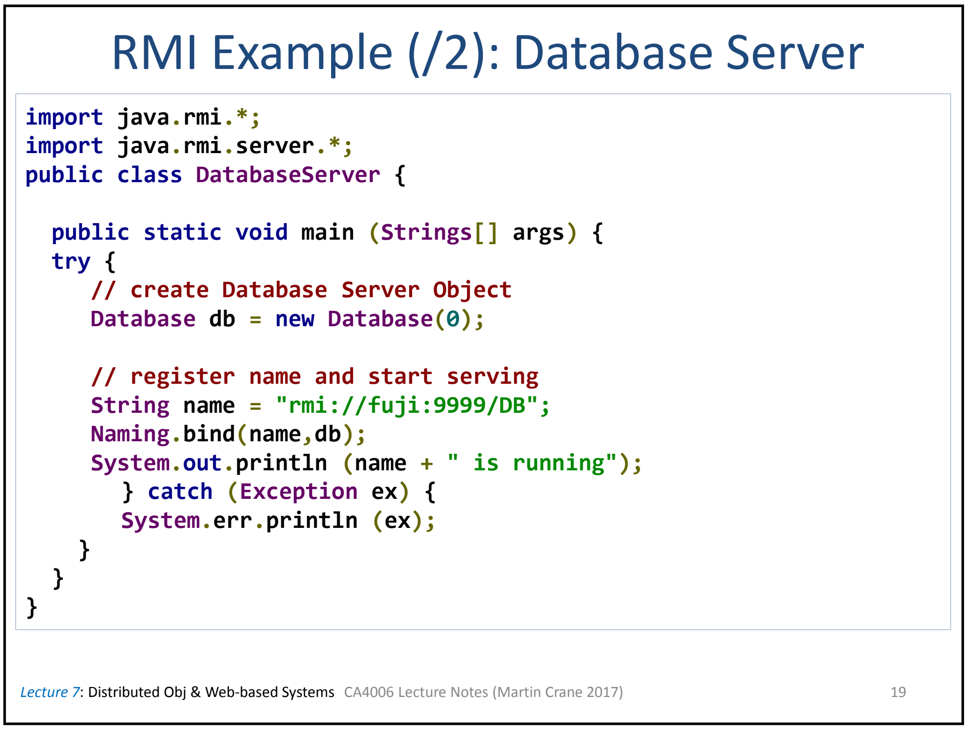
```
if (System.getSecurityManager() == null) {
    System.setSecurityManager(new SecurityManager());
}
```

  - Security policies specify actions that are *unsafe*
    - For every unsafe action there is a corresponding `checkXXX()` method
    - Actions not allowed throw a `SecurityException`
  - Only one security manager can be installed
    - By default, an application has no security manager installed
  - Policies are specified using `*.policy` files
    - Server and client application must specify their policy file
      - Default file: *java.home*/lib/security/java.policy
    - Use `-Djava.security.policy` property specify a file



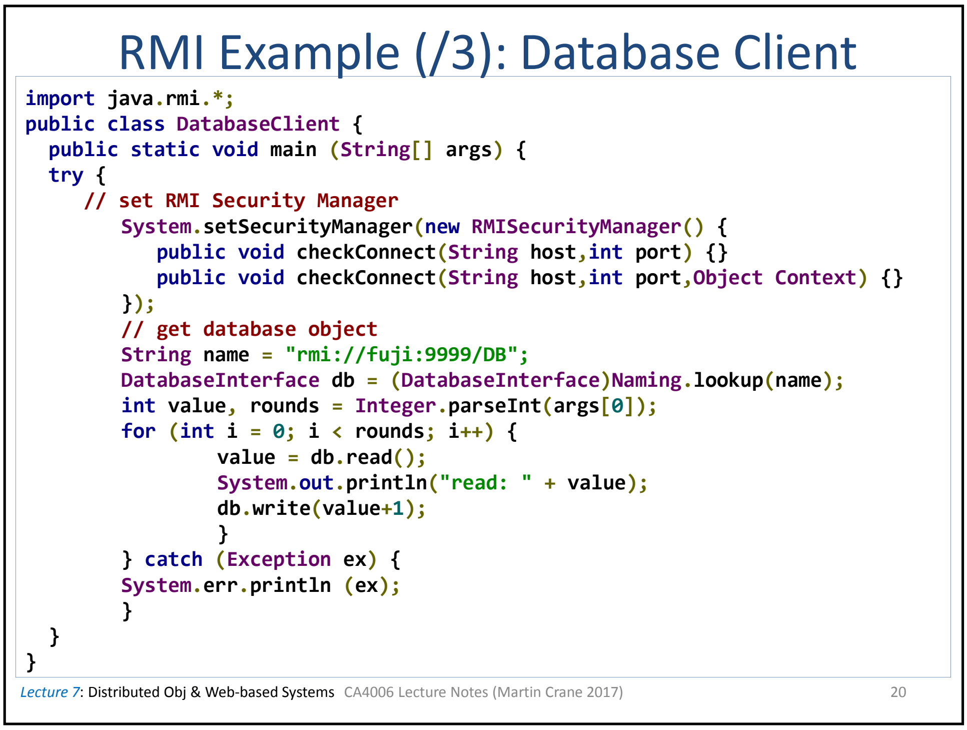
RMI Example: Database Interface

```
import java.rmi.*;
import java.rmi.server.*;
public class Database extends UnicastRemoteObject
                  implements DatabaseInterface {
  private int data = 0; // the database

  public Database(int value) throws RemoteException {
     data = value;
  }

  public int read () throws RemoteException {
     return data;
  }

  public void write (int value) throws RemoteException {
     data = value;
     System.out.println ("New value is: " + data);
  }
}
```



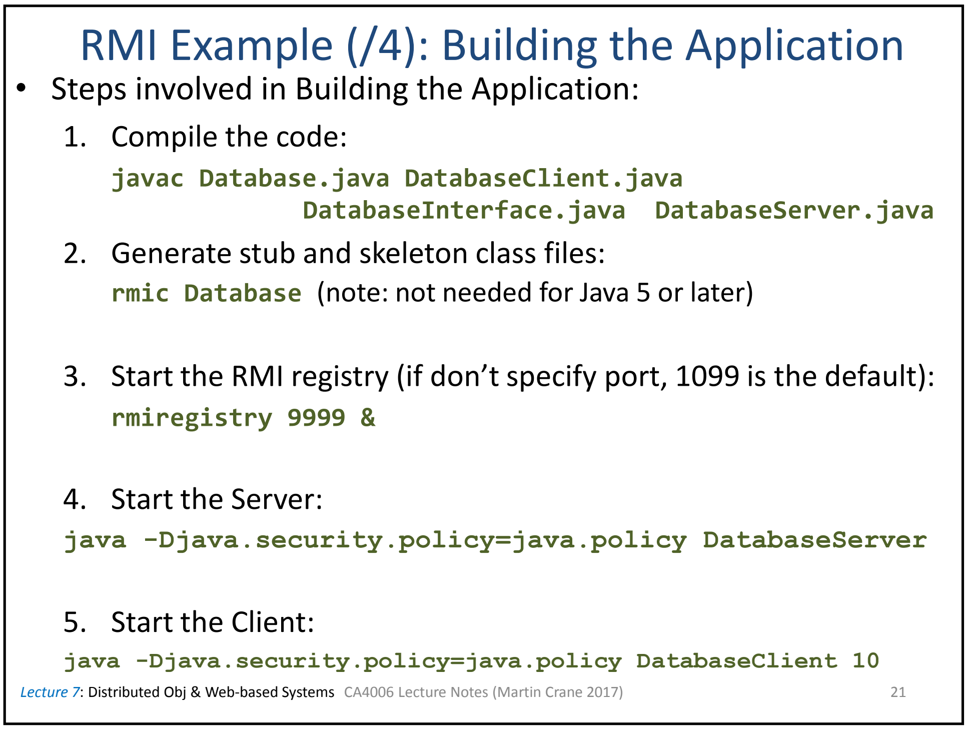
RMI Example (/2): Database Server

```
import java.rmi.*;
import java.rmi.server.*;
public class DatabaseServer {

  public static void main (Strings[] args) {
  try {
     // create Database Server Object
     Database db = new Database(0);

     // register name and start serving
     String name = "rmi://fuji:9999/DB";
     Naming.bind(name,db);
     System.out.println (name + " is running");
       } catch (Exception ex) {
       System.err.println (ex);
    }
  }
}
```



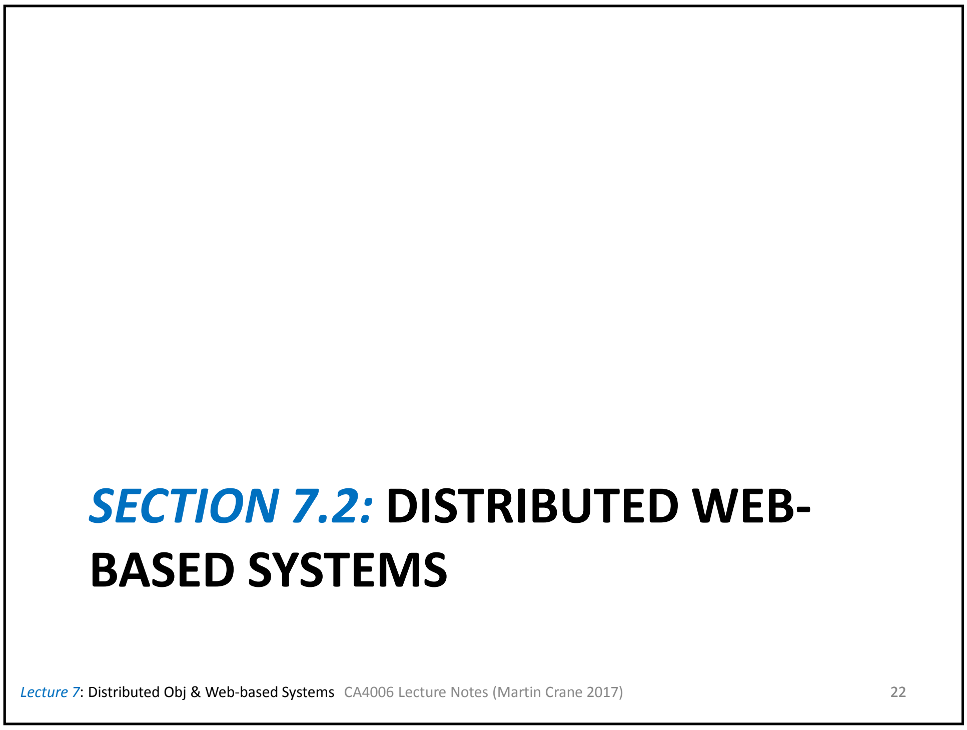
RMI Example (/3): Database Client

```
import java.rmi.*;
public class DatabaseClient {
  public static void main (String[] args) {
  try {
     // set RMI Security Manager
        System.setSecurityManager(new RMISecurityManager() {
           public void checkConnect(String host,int port) {}
           public void checkConnect(String host,int port,Object Context) {}
        });
        // get database object
        String name = "rmi://fuji:9999/DB";
        DatabaseInterface db = (DatabaseInterface)Naming.lookup(name);
        int value, rounds = Integer.parseInt(args[0]);
        for (int i = 0; i < rounds; i++) {
                value = db.read();
                System.out.println("read: " + value);
                db.write(value+1);
                }
        } catch (Exception ex) {
        System.err.println (ex);
        }
  }
}
```



RMI Example (/4): Building the Application

- Steps involved in Building the Application:
  1. Compile the code:
     ```
     javac Database.java DatabaseClient.java
                  DatabaseInterface.java  DatabaseServer.java
     ```
  2. Generate stub and skeleton class files:
     `rmic Database` (note: not needed for Java 5 or later)
  3. Start the RMI registry (if don't specify port, 1099 is the default):
     ```
     rmiregistry 9999 &
     ```
  4. Start the Server:
     ```
     java -Djava.security.policy=java.policy DatabaseServer
     ```
  5. Start the Client:
     ```
     java -Djava.security.policy=java.policy DatabaseClient 10
     ```



SECTION 7.2: DISTRIBUTED WEB-BASED SYSTEMS

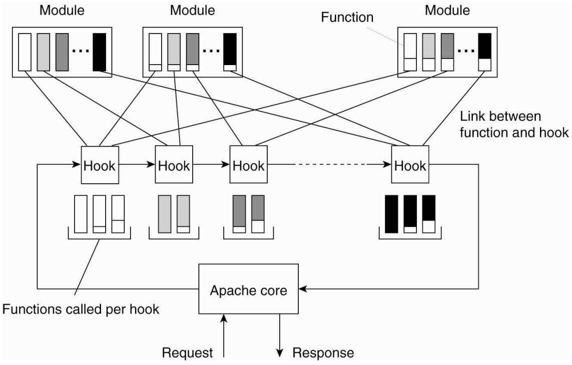
Introduction to Web Services

- WS offered by one electronic device to another, communicating via web
- Here, web technology (e.g. HTTP), originally to be used for human-to-machine comms, is used for M2M chatter, e.g. in XML and JSON.
- HTTP defines message format, how sent and what Web servers & browsers do in turn
- WS typically provides OO web-based interface to a DB server, used by another web server, or mobile apps showing UI to end users
- In 2002, W3C defined a WS Architecture,
  - Req'd standardized "Web service" impln with interface described in WSDL.
- Other systems interact with the WS using SOAP* messages, typically using HTTP with XML serialization with other Web-related standards.
- Later extended to include
  - REST-compliant WS, where service changes forms of Web resources (URIs) using a uniform set of stateless operations (aka 'CRUD')
  - Arbitrary WS where service exposes arbitrary operations (little used)

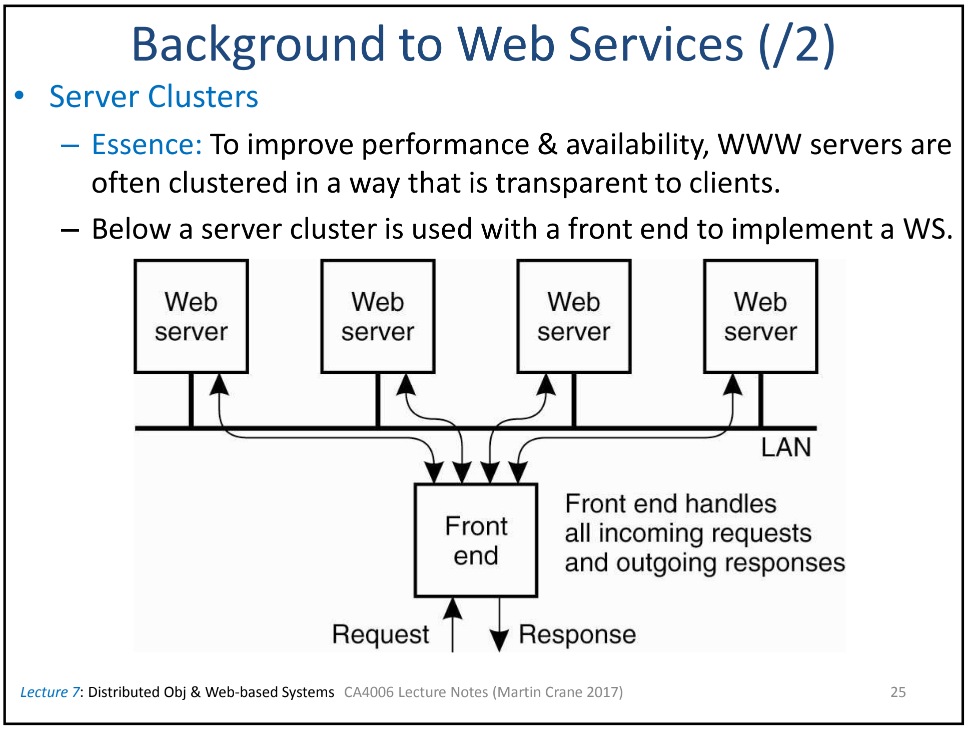
**Simple Object Access Protocol*, now largely falling out of use, though with some specialist applications

Background to Web Services

- Apache Web servers
  - *Observation*: More than 37% of all 1 billion* Websites are Apache.
  - Server is internally organised roughly according to steps needed to process an HTTP request.
  - The anatomy of an Apache Web Server is shown below:



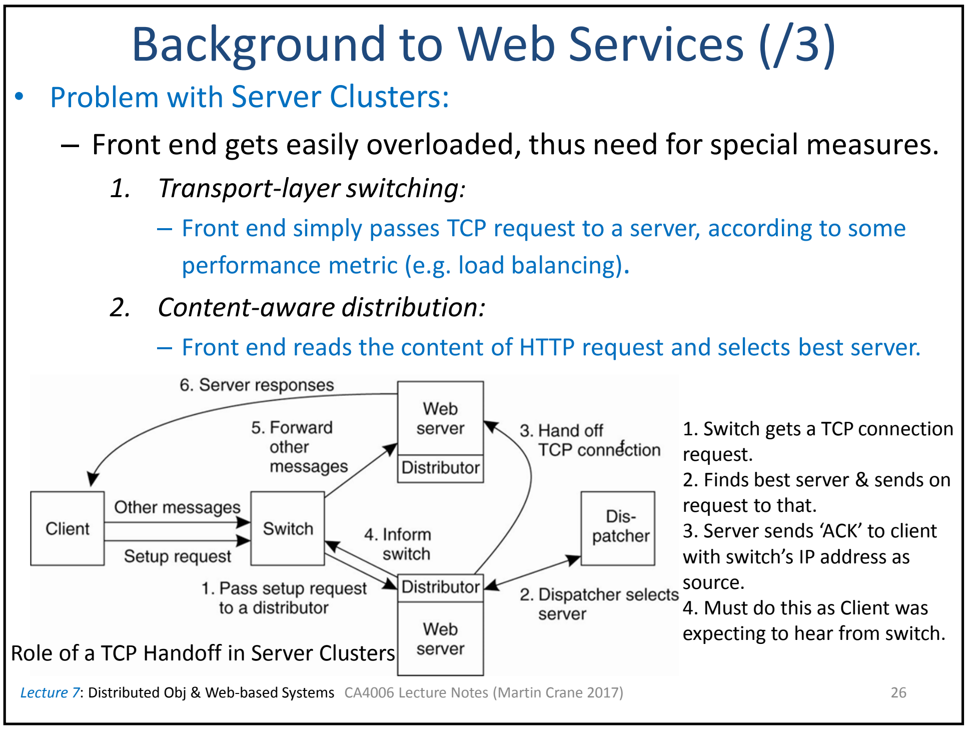
*Actually 902,997,800 in Nov 2015, source news.netcraft.com/archives/category/web-server-survey/



Background to Web Services (/2)

- Server Clusters
  - Essence: To improve performance & availability, WWW servers are often clustered in a way that is transparent to clients.
  - Below a server cluster is used with a front end to implement a WS.

Web server
Web server
Web server
Web server
LAN
Front end
Front end handles all incoming requests and outgoing responses
Request
Response



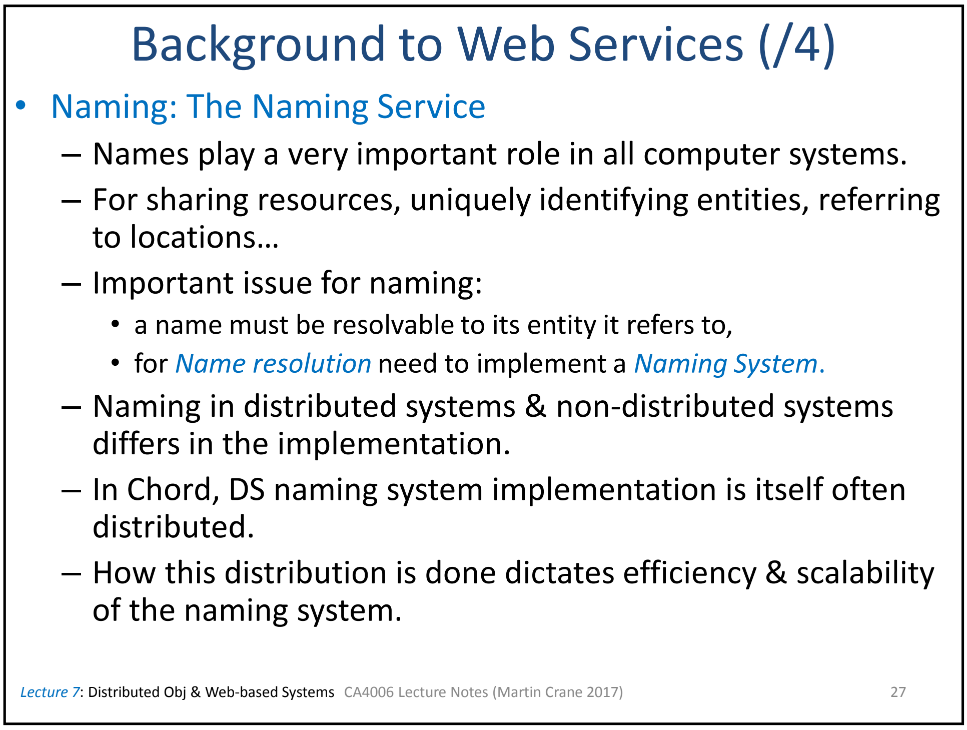
Background to Web Services (/3)

- Problem with Server Clusters:
  - Front end gets easily overloaded, thus need for special measures.
    1. *Transport-layer switching:*
       - Front end simply passes TCP request to a server, according to some performance metric (e.g. load balancing).
    2. *Content-aware distribution:*
       - Front end reads the content of HTTP request and selects best server.

6. Server responses
5. Forward other messages
Web server
Distributor
3. Hand off TCP connection
Client
Other messages
Setup request
Switch
4. Inform switch
Dis-patcher
1. Pass setup request to a distributor
Distributor
2. Dispatcher selects server
Web server

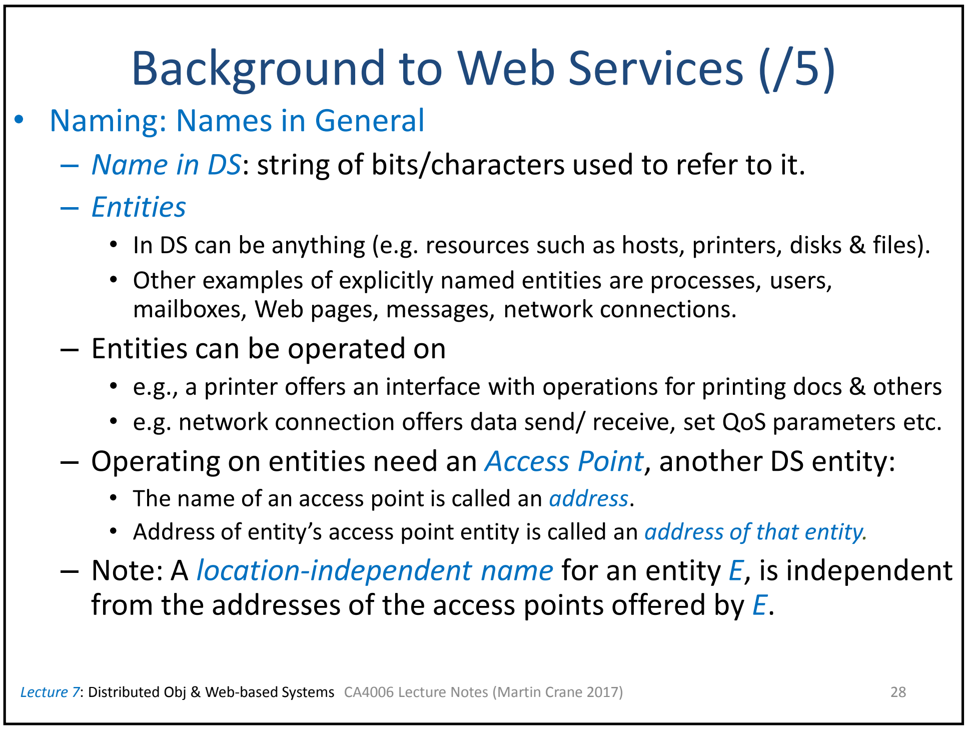
1. Switch gets a TCP connection request.
2. Finds best server & sends on request to that.
3. Server sends ‘ACK’ to client with switch’s IP address as source.
4. Must do this as Client was expecting to hear from switch.

Role of a TCP Handoff in Server Clusters



Background to Web Services (/4)

- Naming: The Naming Service
  - Names play a very important role in all computer systems.
  - For sharing resources, uniquely identifying entities, referring to locations…
  - Important issue for naming:
    - a name must be resolvable to its entity it refers to,
    - for *Name resolution* need to implement a *Naming System*.
  - Naming in distributed systems & non-distributed systems differs in the implementation.
  - In Chord, DS naming system implementation is itself often distributed.
  - How this distribution is done dictates efficiency & scalability of the naming system.



Background to Web Services (/5)

- Naming: Names in General
  - *Name in DS*: string of bits/characters used to refer to it.
  - *Entities*
    - In DS can be anything (e.g. resources such as hosts, printers, disks & files).
    - Other examples of explicitly named entities are processes, users, mailboxes, Web pages, messages, network connections.
  - Entities can be operated on
    - e.g., a printer offers an interface with operations for printing docs & others
    - e.g. network connection offers data send/ receive, set QoS parameters etc.
  - Operating on entities need an *Access Point*, another DS entity:
    - The name of an access point is called an *address*.
    - Address of entity's access point entity is called an *address of that entity.*
  - Note: A *location-independent name* for an entity *E*, is independent from the addresses of the access points offered by *E*.

Background to Web Services (/6)

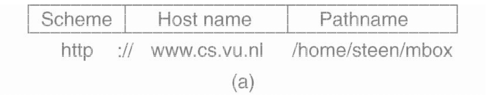
- Naming: Names in General (cont’d)
  - Entities can offer more than one access point
    - e.g. phone is person’s access point, with phone number as address
    - people have many phone numbers, for their many addresses.
  - In DS, a typical access point is a host running a specific server.
    - address is e.g. IP address+port (i.e. server's transport-level address).
  - Entities may change access points over course time.
    - laptop moves location, it’s often assigned a different IP address
    - similarly, changing jobs or ISPs, means changing e-mail addresses.

Background to Web Services (/7)

- Naming: Identifiers
  - Pure name
    - A name that has no meaning at all; it is just a random string.
    - Pure names can be used for comparison only.
  - Identifier: A name having the following properties:
    - P1: Each identifier refers to at most one entity
    - P2: Each entity is referred to by at most one identifier
    - P3: An identifier always refers to the same entity (prohibits reusing an identifier)
  - Observation
    - Identifier needn’t necessarily be a pure name i.e. can have content

Background to Web Services (/8)

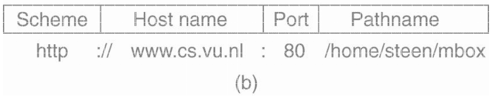
- Naming: Uniform Resource Locator (URL)
- Often contain information on how/where to access a document.
- Some URLs
  - Using only a DNS Name



Scheme		Host name	Pathname
http	://	www.cs.vu.nl	/home/steen/mbox

(a)

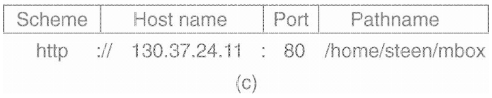
  - Combining a DNS name with a port number



Scheme		Host name		Port	Pathname
http	://	www.cs.vu.nl	:	80	/home/steen/mbox

(b)

  - Combining a DNS name with a port number



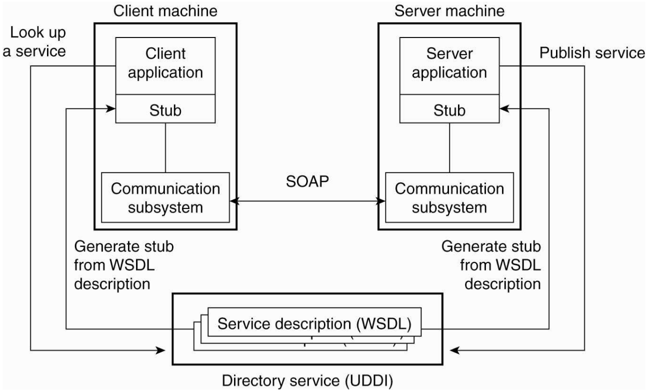
Scheme		Host name		Port	Pathname
http	://	130.37.24.11	:	80	/home/steen/mbox

(c)

SECTION 7.2.1: SOAP-BASED WEB SERVICES

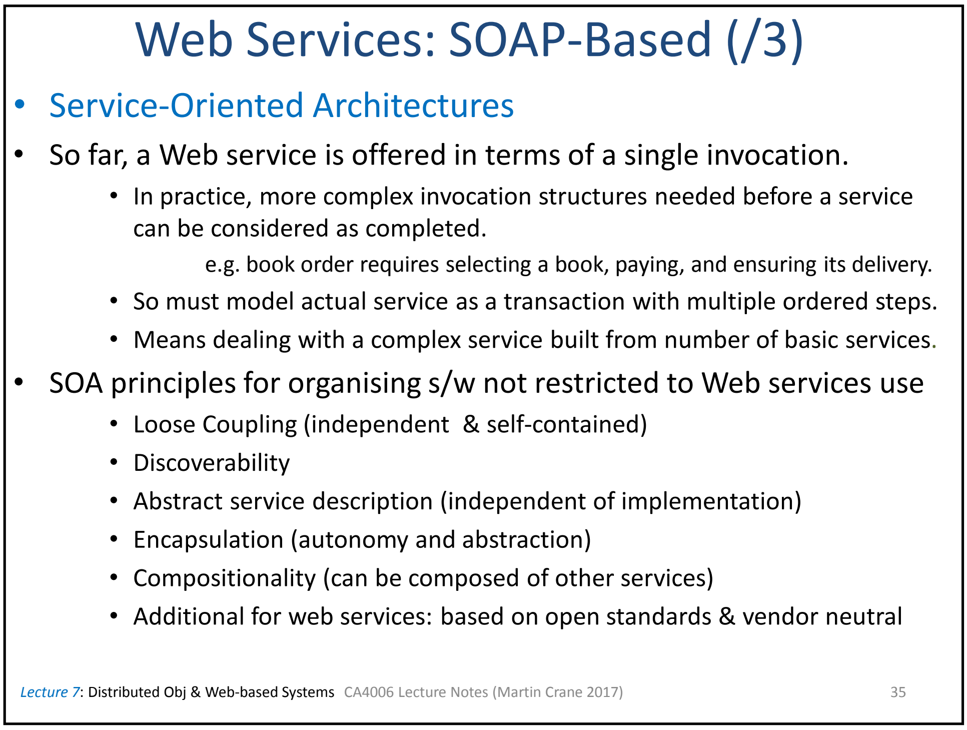
Web Services: SOAP-Based

- The Principle of a Web Service
  - Standardization dictates how those services are described such that they can be looked up by a client application.
  - Also, need to ensure that service call proceeds according to server application rules.
  - This is no different from what is needed to realize a remote procedure call.



Web Services: SOAP-Based (/2)

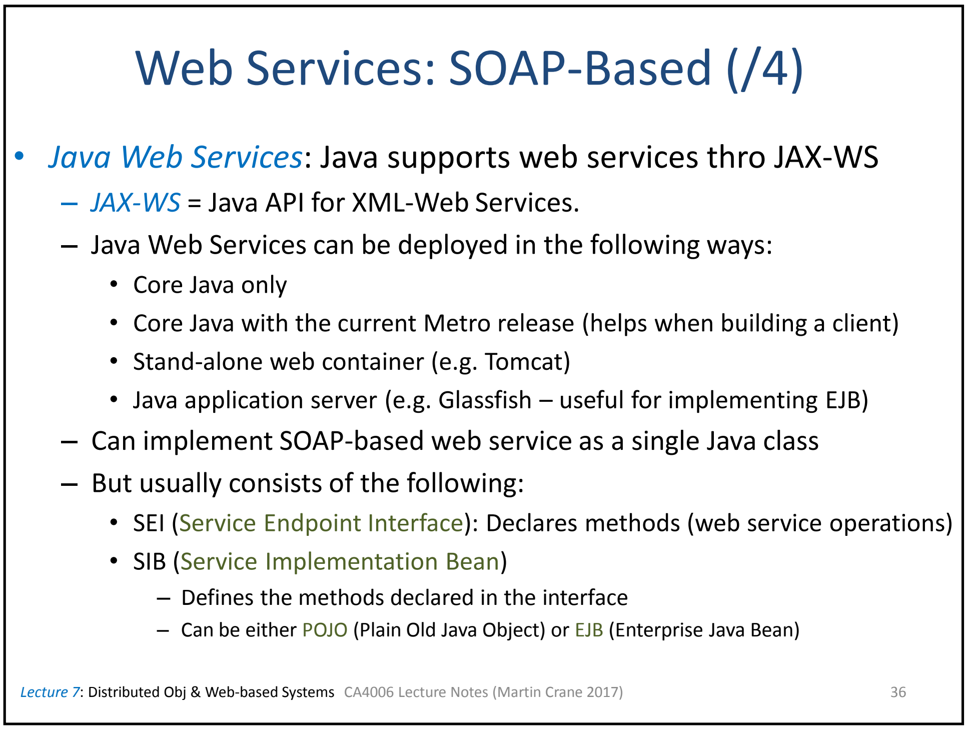
- Standardization needed so client can look up/access services.
  - Three Components:
  - *Directory Service*: Stores service descriptions.
    - Adheres to Universal Description, Discovery & Integration standard (UDDI).
    - As its name suggests, this prescribes DB layout with service descriptions.
    - Allows Web service clients to browse for relevant services.
  - *Interface*: Services described in Web Services Definition Lang (WSDL).
    - Formal language akin to IDLs used to support RPC-based communication.
    - Description contains precise definitions of interfaces provided by a service.
      - e.g. procedure specification, data types, (logical) location of services, etc.
    - A WSDL description is one that can be automatically translated to client-side and server-side stubs, akin to in ordinary RPC-based systems.
  - *Communication*: Simple Object Access Protocol (SOAP) is used
    - Specification of how communication takes place.
    - SOAP is used, which is essentially a framework for standardizing communication between two processes.



Web Services: SOAP-Based (/3)

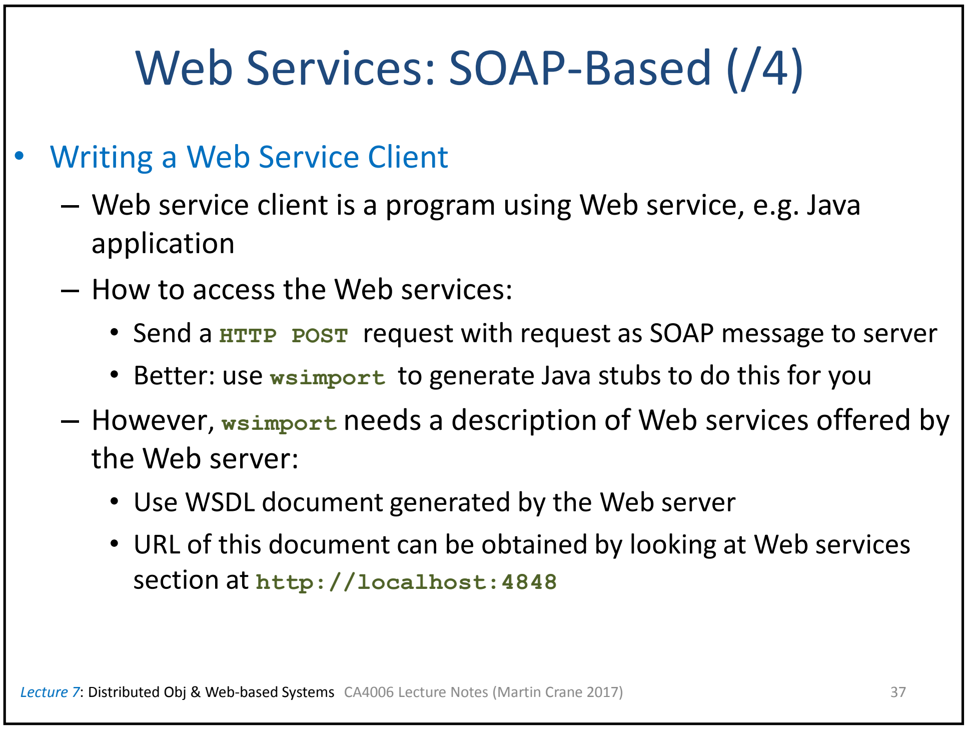
- Service-Oriented Architectures
- So far, a Web service is offered in terms of a single invocation.
  - In practice, more complex invocation structures needed before a service can be considered as completed.

    e.g. book order requires selecting a book, paying, and ensuring its delivery.
  - So must model actual service as a transaction with multiple ordered steps.
  - Means dealing with a complex service built from number of basic services.
- SOA principles for organising s/w not restricted to Web services use
  - Loose Coupling (independent & self-contained)
  - Discoverability
  - Abstract service description (independent of implementation)
  - Encapsulation (autonomy and abstraction)
  - Compositionality (can be composed of other services)
  - Additional for web services: based on open standards & vendor neutral



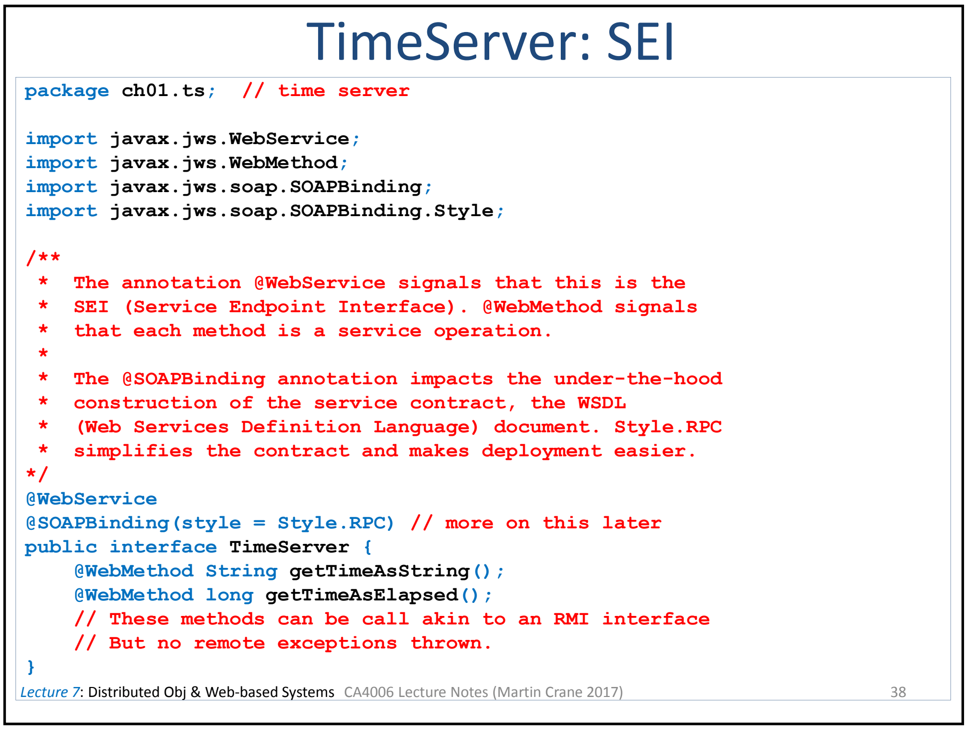
Web Services: SOAP-Based (/4)

- *Java Web Services*: Java supports web services thro JAX-WS
  - *JAX-WS* = Java API for XML-Web Services.
  - Java Web Services can be deployed in the following ways:
    - Core Java only
    - Core Java with the current Metro release (helps when building a client)
    - Stand-alone web container (e.g. Tomcat)
    - Java application server (e.g. Glassfish – useful for implementing EJB)
  - Can implement SOAP-based web service as a single Java class
  - But usually consists of the following:
    - SEI (Service Endpoint Interface): Declares methods (web service operations)
    - SIB (Service Implementation Bean)
      - Defines the methods declared in the interface
      - Can be either POJO (Plain Old Java Object) or EJB (Enterprise Java Bean)



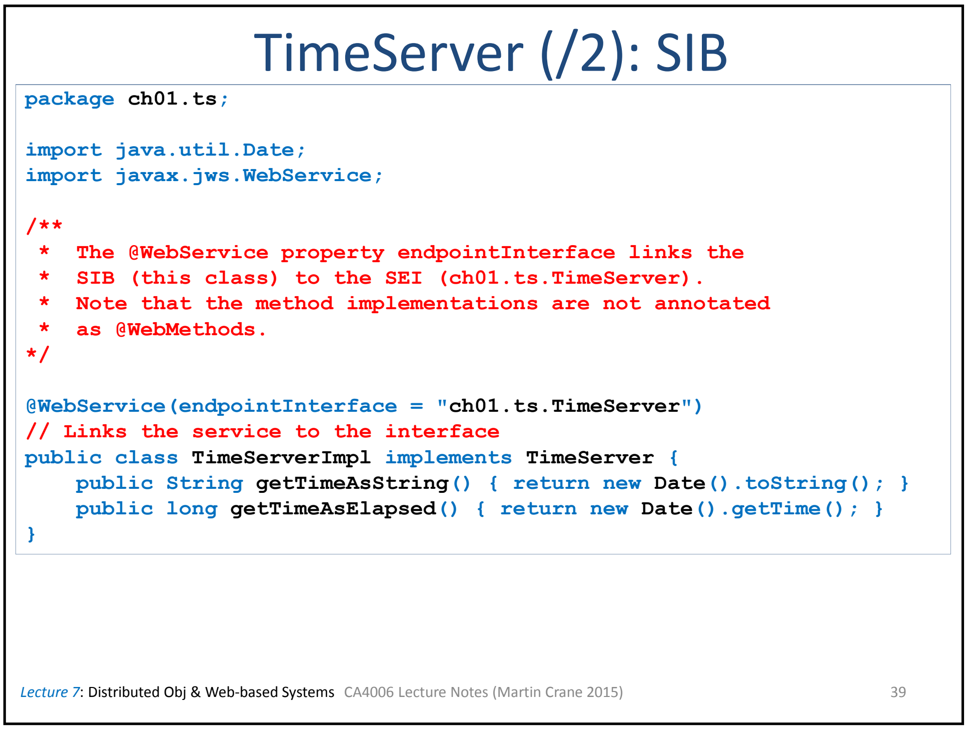
Web Services: SOAP-Based (/4)

- Writing a Web Service Client
  - Web service client is a program using Web service, e.g. Java application
  - How to access the Web services:
    - Send a `HTTP POST` request with request as SOAP message to server
    - Better: use `wsimport` to generate Java stubs to do this for you
  - However, `wsimport` needs a description of Web services offered by the Web server:
    - Use WSDL document generated by the Web server
    - URL of this document can be obtained by looking at Web services section at `http://localhost:4848`



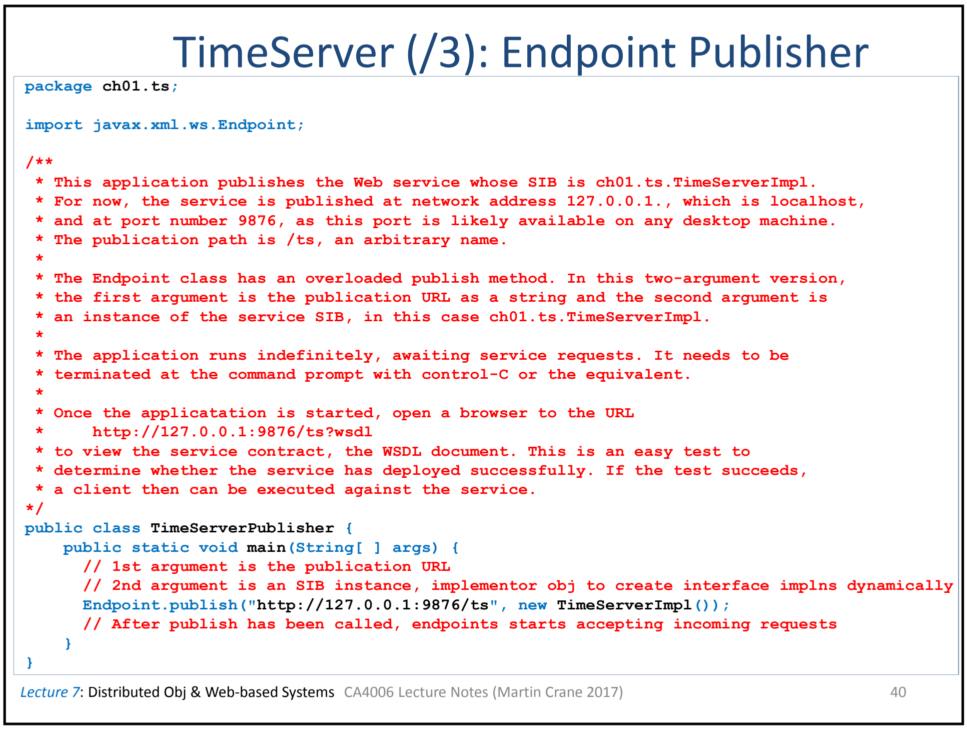
TimeServer: SEI

```
package ch01.ts;  // time server

import javax.jws.WebService;
import javax.jws.WebMethod;
import javax.jws.soap.SOAPBinding;
import javax.jws.soap.SOAPBinding.Style;

/**
 *  The annotation @WebService signals that this is the
 *  SEI (Service Endpoint Interface). @WebMethod signals
 *  that each method is a service operation.
 *
 *  The @SOAPBinding annotation impacts the under-the-hood
 *  construction of the service contract, the WSDL
 *  (Web Services Definition Language) document. Style.RPC
 *  simplifies the contract and makes deployment easier.
*/
@WebService
@SOAPBinding(style = Style.RPC) // more on this later
public interface TimeServer {
    @WebMethod String getTimeAsString();
    @WebMethod long getTimeAsElapsed();
    // These methods can be call akin to an RMI interface
    // But no remote exceptions thrown.
}
```



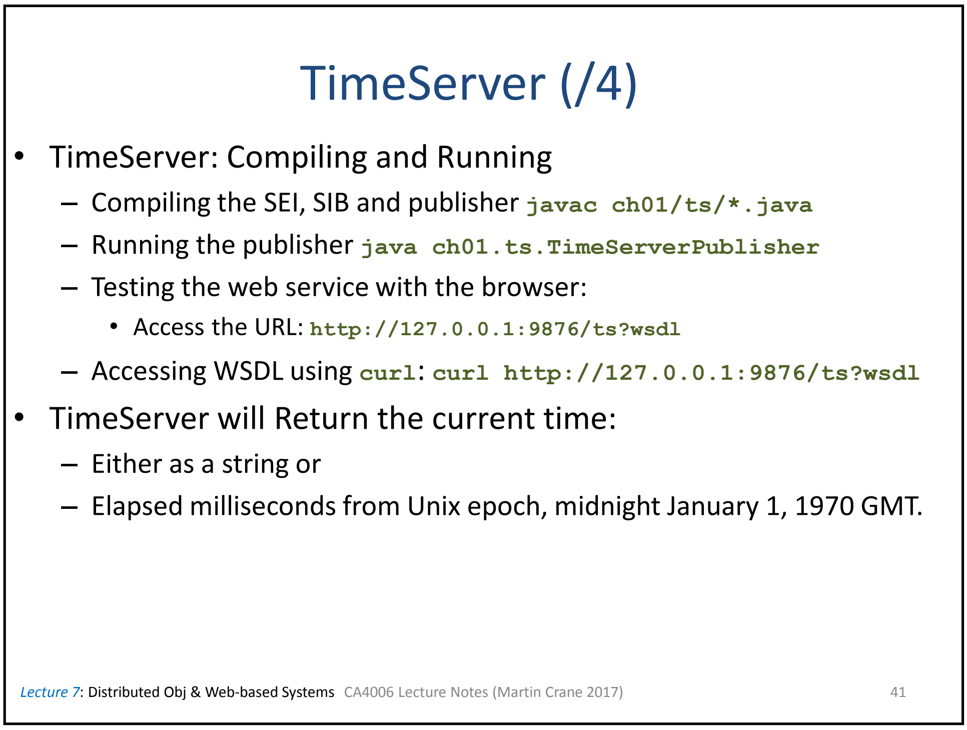
TimeServer (/2): SIB

```
package ch01.ts;

import java.util.Date;
import javax.jws.WebService;

/**
 *  The @WebService property endpointInterface links the
 *  SIB (this class) to the SEI (ch01.ts.TimeServer).
 *  Note that the method implementations are not annotated
 *  as @WebMethods.
*/

@WebService(endpointInterface = "ch01.ts.TimeServer")
// Links the service to the interface
public class TimeServerImpl implements TimeServer {
    public String getTimeAsString() { return new Date().toString(); }
    public long getTimeAsElapsed() { return new Date().getTime(); }
}
```



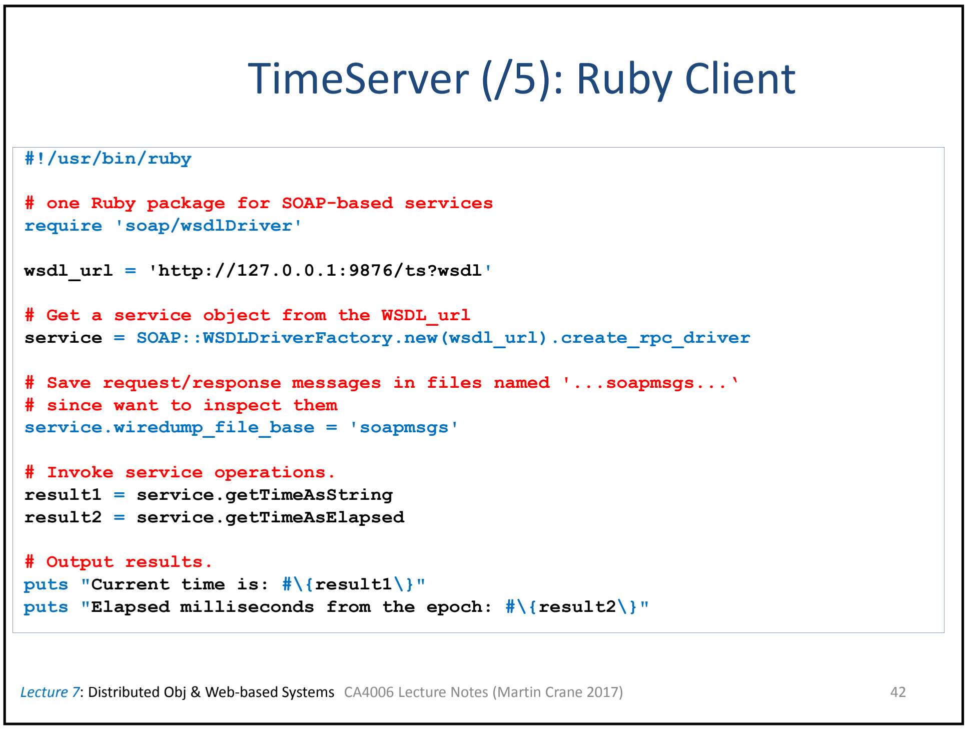
TimeServer (/3): Endpoint Publisher

```
package ch01.ts;

import javax.xml.ws.Endpoint;

/**
 * This application publishes the Web service whose SIB is ch01.ts.TimeServerImpl.
 * For now, the service is published at network address 127.0.0.1., which is localhost,
 * and at port number 9876, as this port is likely available on any desktop machine.
 * The publication path is /ts, an arbitrary name.
 *
 * The Endpoint class has an overloaded publish method. In this two-argument version,
 * the first argument is the publication URL as a string and the second argument is
 * an instance of the service SIB, in this case ch01.ts.TimeServerImpl.
 *
 * The application runs indefinitely, awaiting service requests. It needs to be
 * terminated at the command prompt with control-C or the equivalent.
 *
 * Once the applicatation is started, open a browser to the URL
 *     http://127.0.0.1:9876/ts?wsdl
 * to view the service contract, the WSDL document. This is an easy test to
 * determine whether the service has deployed successfully. If the test succeeds,
 * a client then can be executed against the service.
*/
public class TimeServerPublisher {
    public static void main(String[ ] args) {
      // 1st argument is the publication URL
      // 2nd argument is an SIB instance, implementor obj to create interface implns dynamically
      Endpoint.publish("http://127.0.0.1:9876/ts", new TimeServerImpl());
      // After publish has been called, endpoints starts accepting incoming requests
    }
}
```



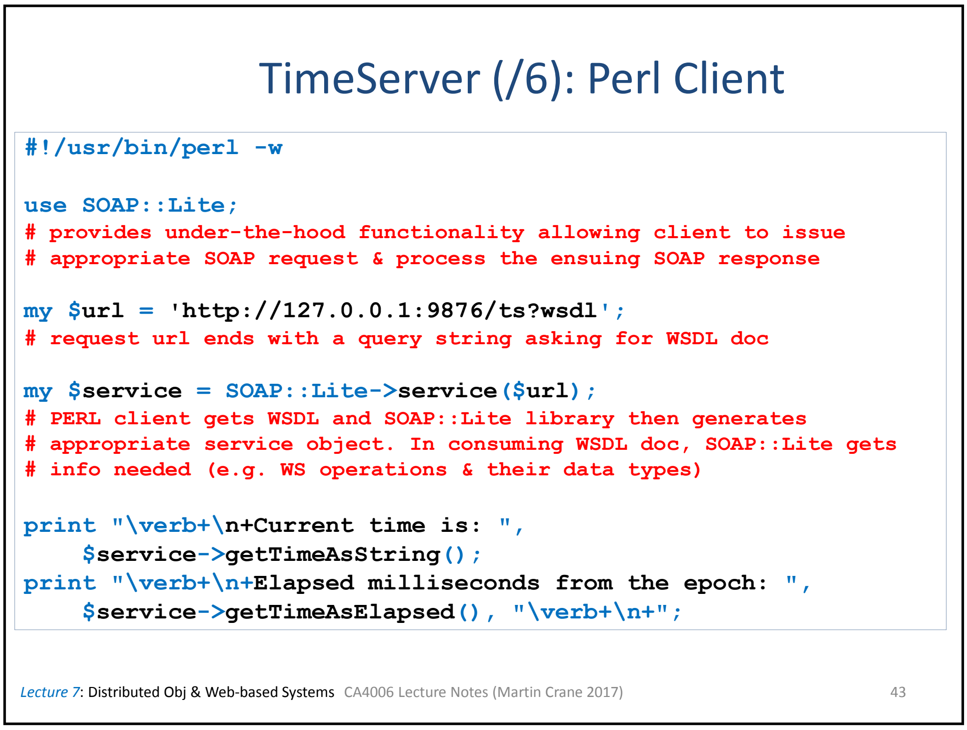
TimeServer (/4)

- TimeServer: Compiling and Running
  - Compiling the SEI, SIB and publisher `javac ch01/ts/*.java`
  - Running the publisher `java ch01.ts.TimeServerPublisher`
  - Testing the web service with the browser:
    - Access the URL: `http://127.0.0.1:9876/ts?wsdl`
  - Accessing WSDL using `curl`: `curl http://127.0.0.1:9876/ts?wsdl`
- TimeServer will Return the current time:
  - Either as a string or
  - Elapsed milliseconds from Unix epoch, midnight January 1, 1970 GMT.



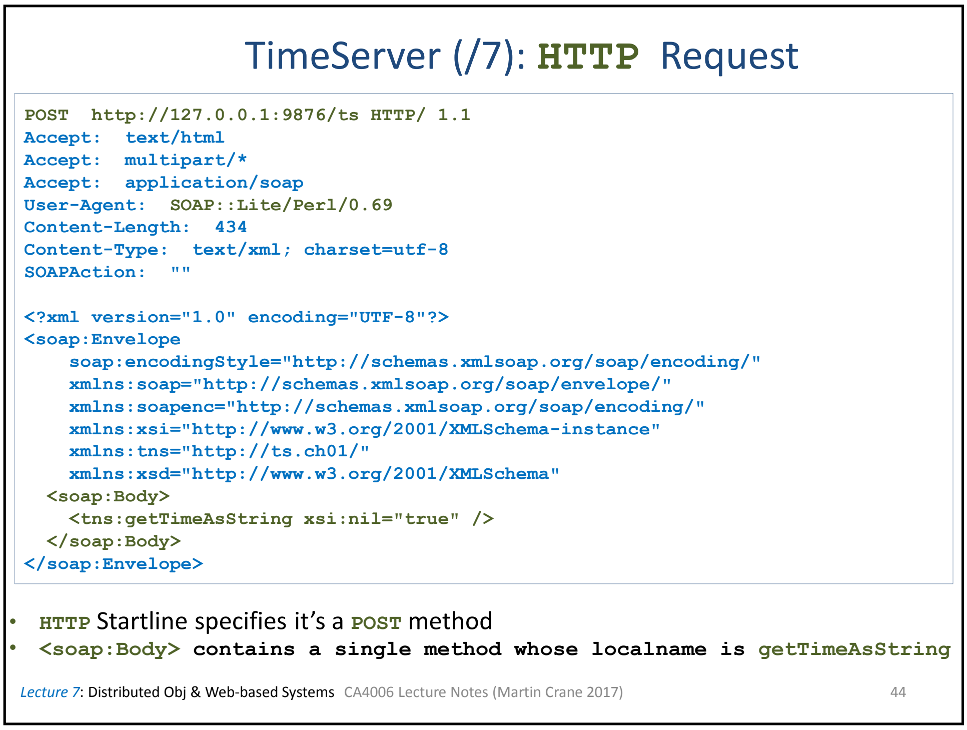
TimeServer (/5): Ruby Client

```
#!/usr/bin/ruby

# one Ruby package for SOAP-based services
require 'soap/wsdlDriver'

wsdl_url = 'http://127.0.0.1:9876/ts?wsdl'

# Get a service object from the WSDL_url
service = SOAP::WSDLDriverFactory.new(wsdl_url).create_rpc_driver

# Save request/response messages in files named '...soapmsgs...'
# since want to inspect them
service.wiredump_file_base = 'soapmsgs'

# Invoke service operations.
result1 = service.getTimeAsString
result2 = service.getTimeAsElapsed

# Output results.
puts "Current time is: #\{result1\}"
puts "Elapsed milliseconds from the epoch: #\{result2\}"
```



TimeServer (/6): Perl Client

```
#!/usr/bin/perl -w

use SOAP::Lite;
# provides under-the-hood functionality allowing client to issue
# appropriate SOAP request & process the ensuing SOAP response

my $url = 'http://127.0.0.1:9876/ts?wsdl';
# request url ends with a query string asking for WSDL doc

my $service = SOAP::Lite->service($url);
# PERL client gets WSDL and SOAP::Lite library then generates
# appropriate service object. In consuming WSDL doc, SOAP::Lite gets
# info needed (e.g. WS operations & their data types)

print "\verb+\n+Current time is: ",
    $service->getTimeAsString();
print "\verb+\n+Elapsed milliseconds from the epoch: ",
    $service->getTimeAsElapsed(), "\verb+\n+";
```



TimeServer (/7): `HTTP` Request

```
POST  http://127.0.0.1:9876/ts HTTP/ 1.1
Accept:  text/html
Accept:  multipart/*
Accept:  application/soap
User-Agent:  SOAP::Lite/Perl/0.69
Content-Length:  434
Content-Type:  text/xml; charset=utf-8
SOAPAction:  ""

<?xml version="1.0" encoding="UTF-8"?>
<soap:Envelope
    soap:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"
    xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/"
    xmlns:soapenc="http://schemas.xmlsoap.org/soap/encoding/"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:tns="http://ts.ch01/"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  <soap:Body>
    <tns:getTimeAsString xsi:nil="true" />
  </soap:Body>
</soap:Envelope>
```

- `HTTP` Startline specifies it's a `POST` method
- `<soap:Body>` `contains a single method whose localname is` `getTimeAsString`

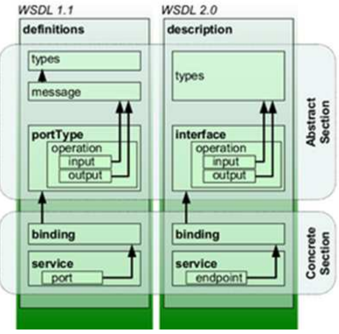
TimeServer (/8): HTTP Response

```
HTTP/1.1 200 OK
Content-Length: 323
Content-Type: text/html; charset=utf-8
Client-Date: Mon, 28 Apr 2008 02:12:54 GMT
Client-Peer: 127.0.0.1:9876
Client-Response-Num: 1

<?xml version="1.0"?>
<soapenv:Envelope
    xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
    xmlns:xsd=http://www.w3.org/2001/XMLSchema

  <soapenv:Body>
    <ans:getTimeAsStringResponse xmlns:ans="http://ts.ch01/">
      <return>Thu Mar 21 14:45:17 GMT 2013</return>
    </ans:getTimeAsStringResponse>
  </soapenv:Body>

</soapenv:Envelope>
```

- `HTTP/1.1 200 OK` **signals all processed normally**

TimeServer (/9): WSDL Document Structure

- A WSDL document has two parts:
  - Interface (abstract)
    - Available services: operations grouped in `portType`s
    - Which `message`s are needed by operations: A message can have parts
    - Used data `types` and XML-elements
  - Implementation (concrete)
    - `binding` to message layer (e.g. SOAP): How message parts mapped to body/header elements of SOAP messages
    - `binding`s to transport layer (e.g. HTTP): Where do I find the service?
    - A `service` may offer several `port`s, i.e. ways to call it



TimeServer (/10): WSDL Document Structure

```
<message name="getTimeAsString"></message>
<message name="getTimeAsStringResponse">
   <part name="return" type="xsd:string"></part>
</message>
<message name="getTimeAsElapsed"></message>
<message name="getTimeAsElapsedResponse">
   <part name="return" type="xsd:long"></part>
</message>
```

- For the `Timeserver` service, four messages

```
<portType name="TimeServer">
   <operation name="getTimeAsString" parameterOrder="">
      <input message="tns:getTimeAsString"></input>
      <output message="tns:getTimeAsStringResponse"></output>
   </operation>
   <operation name="getTimeAsElapsed" parameterOrder="">
      <input message="tns:getTimeAsElapsed"></input>
      <output message="tns:getTimeAsElapsedResponse"></output>
   </operation>
</portType>
```

- `portType` for `TimeService` has two operations, each with one input message & one output message

TimeServer (/11): Generating Client Support Code From WSDL

- After **`TimeServerPublisher`** generated WSDL, execute:
  `wsimport -keep -p client http://localhost:9876/ts?wsdl`
  - The **`-keep`** option specifies that the source files should be kept
  - The **`-p client`** option specifies Java package in which generated files are to be placed
  - Above command generates two source & two compiled files in the subdirectory **`client`**
- Approaches to Web Services 1: The Contract-First Approach
  - Above approach, where WSDL contract is used to generate all required artifacts for WS development, deployment, & invocation is known as the *Contract-First Approach*.

TimeServer (/12): Generating WS Artifacts From Java Code

- Approaches to Web Services 2: The Code-First Approach
  - A second approach, where Java classes are available and used to generate all required artifacts for WS development, deployment, & invocation is known as *Code-First Approach.*
  - Command `wsgen -cp . [Compiled Java Code]` achieves this.
  - Run the publisher to deploy the web service.
- This contrasts with the *Contract-First* seen earlier which was a top-down approach to generate JAX-WS Artifacts
- In general, for a number of reasons *Contract-First* approach is preferred to *Code-First*

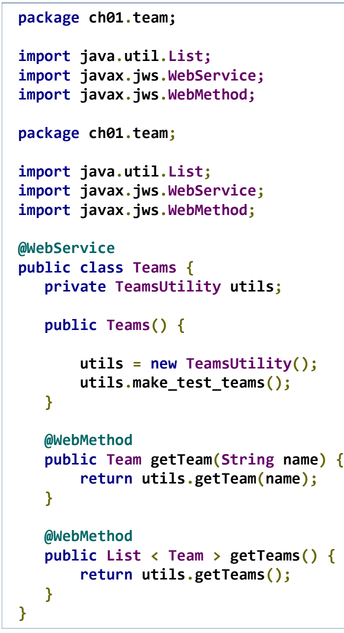
TimeServer (/12): How to pick a tool?

- Following lists process to create a WS starting from Java sources, classes, or a WSDL file (server side):
- Starting from Java classes use *Code-First*:
  - Use `wsgen` to generate portable artifacts (e.g. SE Interface & Implementation classes etc).
  - Deploy the Web Service
- Starting from a WSDL file use *Contract-First*:
  - Use `wsimport` to generate portable artifacts.
  - Implement the service endpoint.
  - Deploy the Web Service
- Following lists the process to invoke a web service (client side):
  - Starting from deployed web service's WSDL
  - Use `wsimport` to generate the client-side artifacts.
  - Implement the client to invoke the web service.

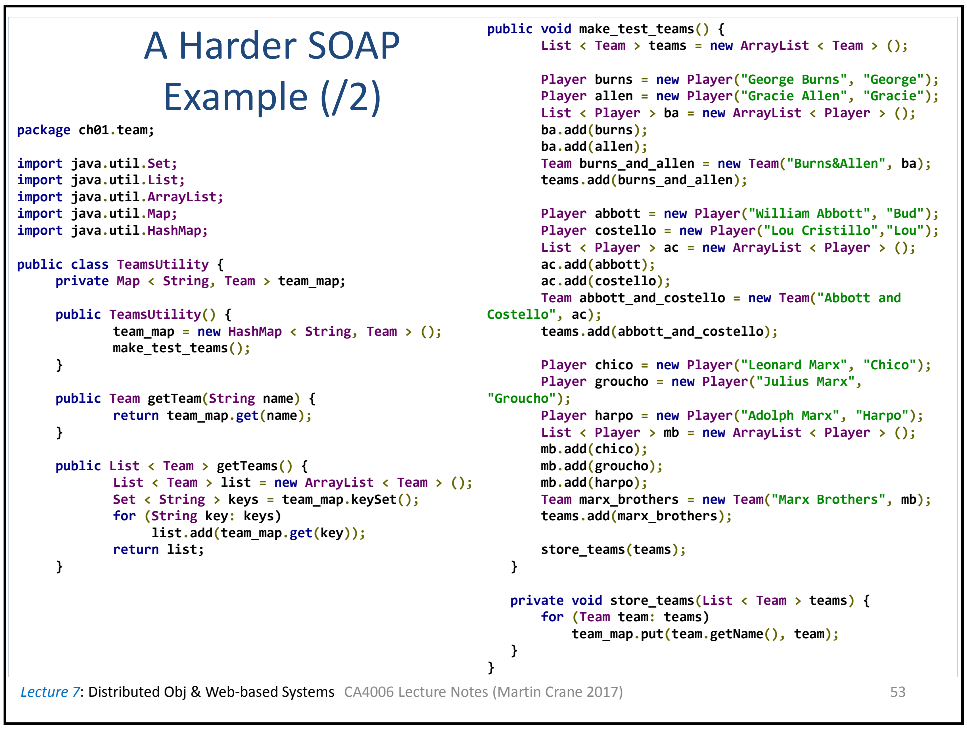
TimeServer (/13): A Compromise Approach

- A third Approach: *Code First, Contract Aware*
  - Updating Code-First service, might find that WSDL changes too.
  - To get around this, there is a style called *Code First, Contract Aware*.
  - Write code first but annotate to tightly constrain generated WSDL.
- Some annotations:
  - `@WebMethod`, indicates a method exposed as Web Service operation,
  - `@SOAPBinding` specifies WS mapping onto SOAP message protocol
  - `@WebParam` maps a parameter to a WS msg part & XML element,
  - `@WebResult` specifies that operation result in generated WSDL is something other than default return e.g. `IntegerOutput`.

A Harder SOAP Example: The Teams Web Service



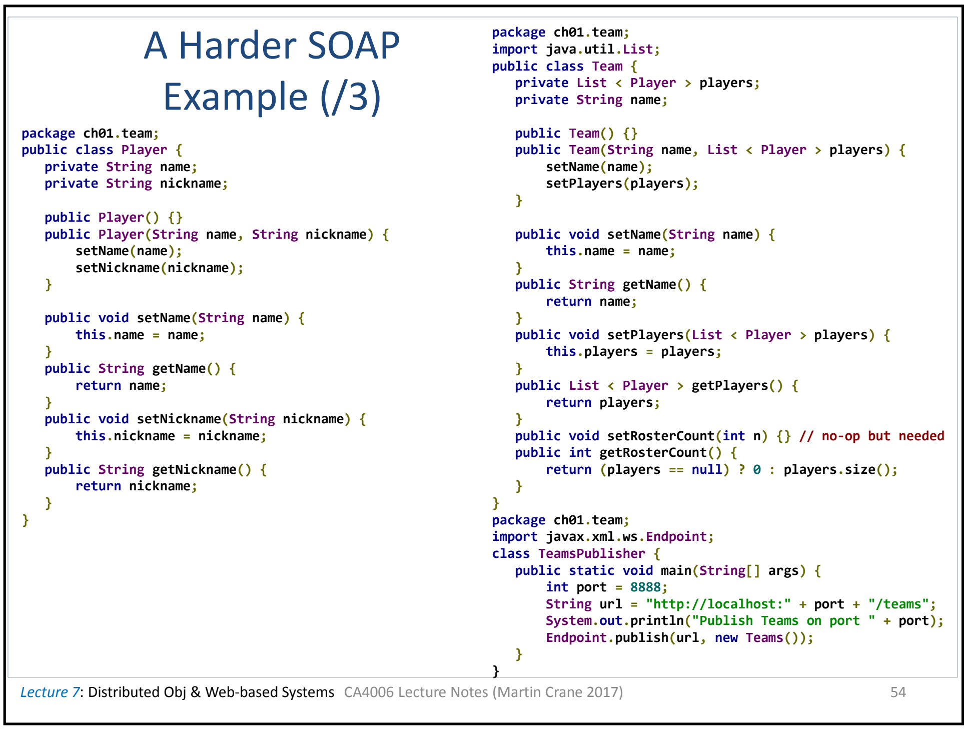
```
package ch01.team;

import java.util.List;
import javax.jws.WebService;
import javax.jws.WebMethod;

package ch01.team;

import java.util.List;
import javax.jws.WebService;
import javax.jws.WebMethod;

@WebService
public class Teams {
   private TeamsUtility utils;

   public Teams() {

       utils = new TeamsUtility();
       utils.make_test_teams();
   }

   @WebMethod
   public Team getTeam(String name) {
       return utils.getTeam(name);
   }

   @WebMethod
   public List < Team > getTeams() {
       return utils.getTeams();
   }
}
```



A Harder SOAP Example (/2)

```java
package ch01.team;

import java.util.Set;
import java.util.List;
import java.util.ArrayList;
import java.util.Map;
import java.util.HashMap;

public class TeamsUtility {
     private Map < String, Team > team_map;

     public TeamsUtility() {
             team_map = new HashMap < String, Team > ();
             make_test_teams();
     }

     public Team getTeam(String name) {
             return team_map.get(name);
     }

     public List < Team > getTeams() {
             List < Team > list = new ArrayList < Team > ();
             Set < String > keys = team_map.keySet();
             for (String key: keys)
                  list.add(team_map.get(key));
             return list;
     }
```

```java
public void make_test_teams() {
       List < Team > teams = new ArrayList < Team > ();

       Player burns = new Player("George Burns", "George");
       Player allen = new Player("Gracie Allen", "Gracie");
       List < Player > ba = new ArrayList < Player > ();
       ba.add(burns);
       ba.add(allen);
       Team burns_and_allen = new Team("Burns&Allen", ba);
       teams.add(burns_and_allen);

       Player abbott = new Player("William Abbott", "Bud");
       Player costello = new Player("Lou Cristillo","Lou");
       List < Player > ac = new ArrayList < Player > ();
       ac.add(abbott);
       ac.add(costello);
       Team abbott_and_costello = new Team("Abbott and
Costello", ac);
       teams.add(abbott_and_costello);

       Player chico = new Player("Leonard Marx", "Chico");
       Player groucho = new Player("Julius Marx",
"Groucho");
       Player harpo = new Player("Adolph Marx", "Harpo");
       List < Player > mb = new ArrayList < Player > ();
       mb.add(chico);
       mb.add(groucho);
       mb.add(harpo);
       Team marx_brothers = new Team("Marx Brothers", mb);
       teams.add(marx_brothers);

       store_teams(teams);
   }

   private void store_teams(List < Team > teams) {
       for (Team team: teams)
           team_map.put(team.getName(), team);
   }
}
```



A Harder SOAP Example (/3)

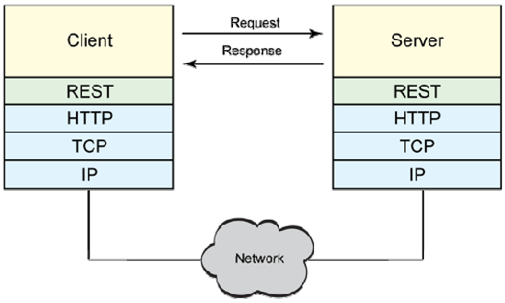
```java
package ch01.team;
public class Player {
   private String name;
   private String nickname;

   public Player() {}
   public Player(String name, String nickname) {
       setName(name);
       setNickname(nickname);
   }

   public void setName(String name) {
       this.name = name;
   }
   public String getName() {
       return name;
   }
   public void setNickname(String nickname) {
       this.nickname = nickname;
   }
   public String getNickname() {
       return nickname;
   }
}
```

```java
package ch01.team;
import java.util.List;
public class Team {
   private List < Player > players;
   private String name;

   public Team() {}
   public Team(String name, List < Player > players) {
       setName(name);
       setPlayers(players);
   }

   public void setName(String name) {
       this.name = name;
   }
   public String getName() {
       return name;
   }
   public void setPlayers(List < Player > players) {
       this.players = players;
   }
   public List < Player > getPlayers() {
       return players;
   }
   public void setRosterCount(int n) {} // no-op but needed
   public int getRosterCount() {
       return (players == null) ? 0 : players.size();
   }
}
package ch01.team;
import javax.xml.ws.Endpoint;
class TeamsPublisher {
   public static void main(String[] args) {
       int port = 8888;
       String url = "http://localhost:" + port + "/teams";
       System.out.println("Publish Teams on port " + port);
       Endpoint.publish(url, new Teams());
   }
}
```

SECTION 7.2.2: REST-BASED WEB SERVICES

Introduction to REST

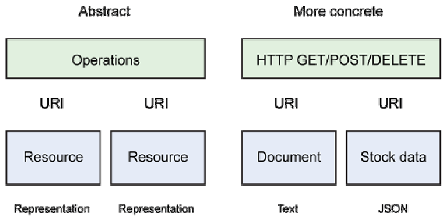
- *REST*, or REpresentational State Transfer, is a distributed communication architecture
  - Overall SOAP WS architecture has many layers with protocols & standards for security & reliability=>tedious for WS developers.
  - REST is fast becoming the lingua franca for Cloud Computing
  - Central REST abstraction is the *Resource* i.e. anything with a URI.
  - In practice, resource is an info item that has hyperlinks to it.



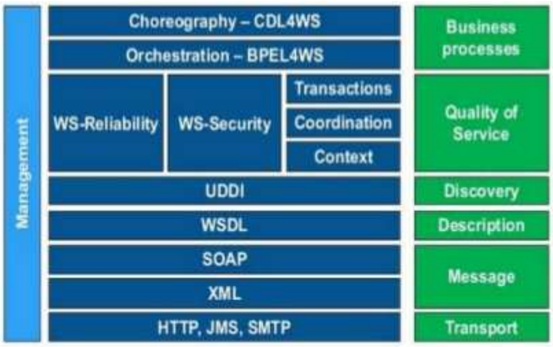
Contrast Between SOAP & REST

- REST & SOAP are quite different

SOAP & REST: Protocol Layering

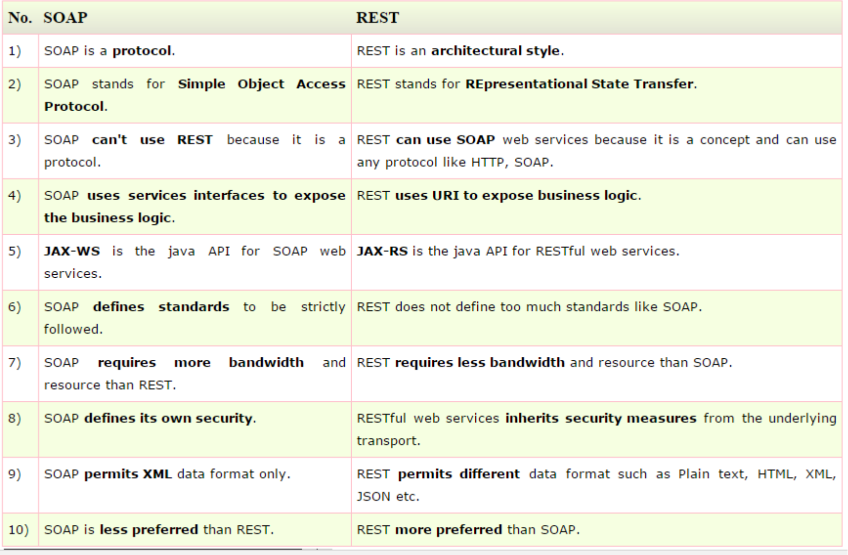


SOAP Technology Stack

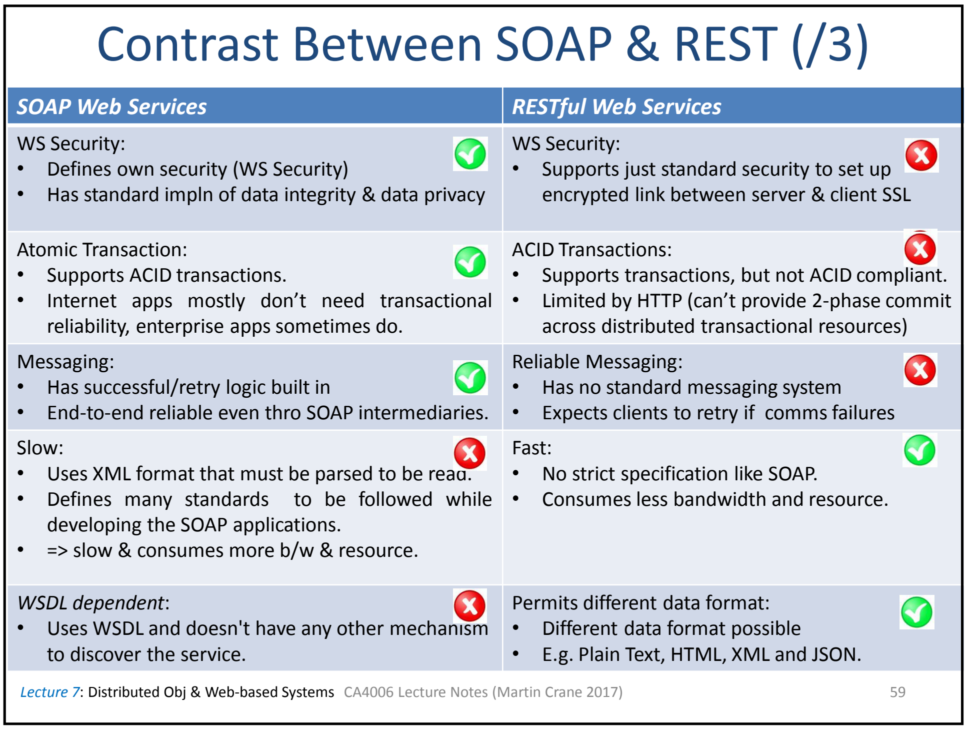


Contrast Between SOAP & REST (/2)

- REST & SOAP are quite different

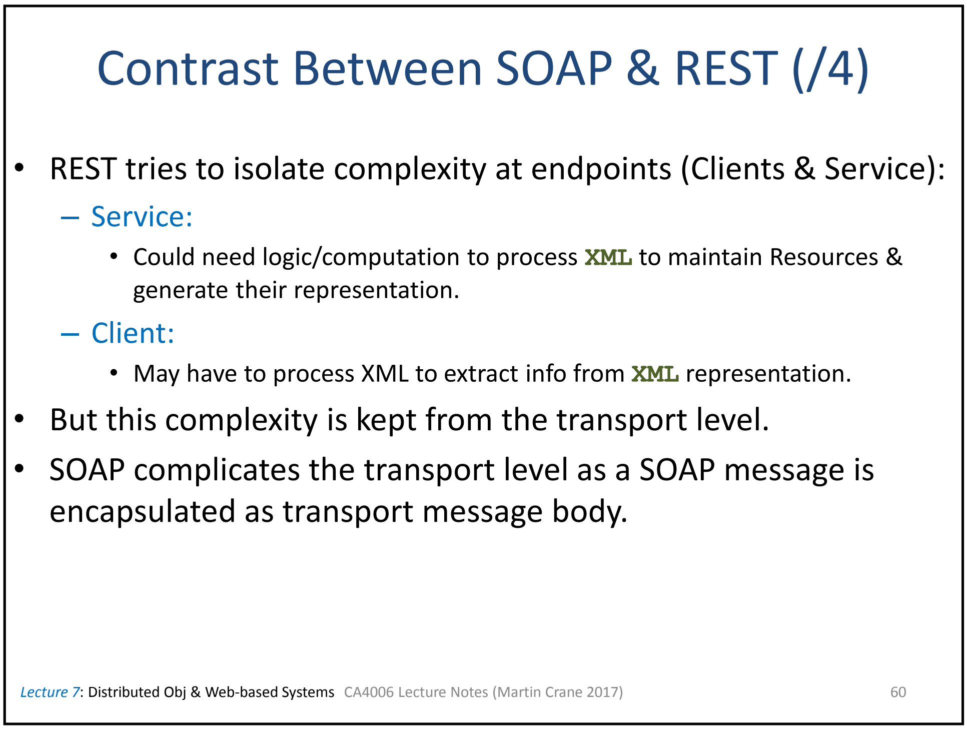


No.	SOAP	REST
1)	SOAP is a **protocol**.	REST is an **architectural style**.
2)	SOAP stands for **Simple Object Access Protocol**.	REST stands for **REpresentational State Transfer**.
3)	SOAP **can't use REST** because it is a protocol.	REST **can use SOAP** web services because it is a concept and can use any protocol like HTTP, SOAP.
4)	SOAP **uses services interfaces to expose the business logic**.	REST **uses URI to expose business logic**.
5)	**JAX-WS** is the java API for SOAP web services.	**JAX-RS** is the java API for RESTful web services.
6)	SOAP **defines standards** to be strictly followed.	REST does not define too much standards like SOAP.
7)	SOAP **requires more bandwidth** and resource than REST.	REST **requires less bandwidth** and resource than SOAP.
8)	SOAP **defines its own security**.	RESTful web services **inherits security measures** from the underlying transport.
9)	SOAP **permits XML** data format only.	REST **permits different** data format such as Plain text, HTML, XML, JSON etc.
10)	SOAP is **less preferred** than REST.	REST **more preferred** than SOAP.



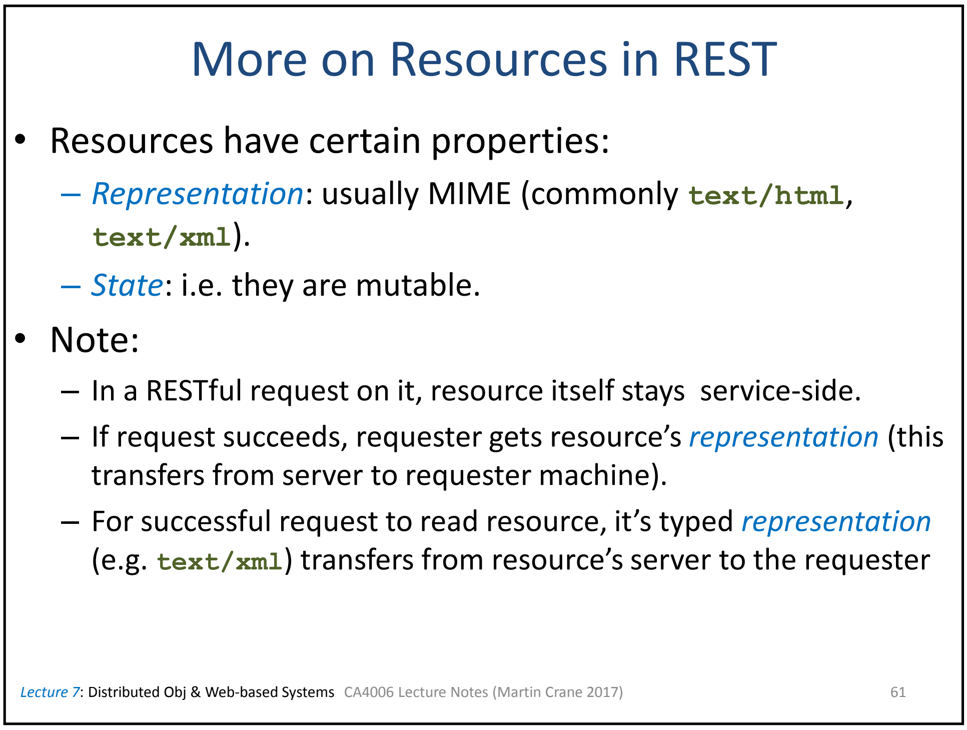
Contrast Between SOAP & REST (/3)

SOAP Web Services	***RESTful Web Services***
WS Security: ✓ • Defines own security (WS Security) • Has standard impln of data integrity & data privacy	WS Security: ✗ • Supports just standard security to set up encrypted link between server & client SSL
Atomic Transaction: ✓ • Supports ACID transactions. • Internet apps mostly don't need transactional reliability, enterprise apps sometimes do.	ACID Transactions: ✗ • Supports transactions, but not ACID compliant. • Limited by HTTP (can't provide 2-phase commit across distributed transactional resources)
Messaging: ✓ • Has successful/retry logic built in • End-to-end reliable even thro SOAP intermediaries.	Reliable Messaging: ✗ • Has no standard messaging system • Expects clients to retry if comms failures
Slow: ✗ • Uses XML format that must be parsed to be read. • Defines many standards to be followed while developing the SOAP applications. • => slow & consumes more b/w & resource.	Fast: ✓ • No strict specification like SOAP. • Consumes less bandwidth and resource.
WSDL dependent: ✗ • Uses WSDL and doesn't have any other mechanism to discover the service.	Permits different data format: ✓ • Different data format possible • E.g. Plain Text, HTML, XML and JSON.



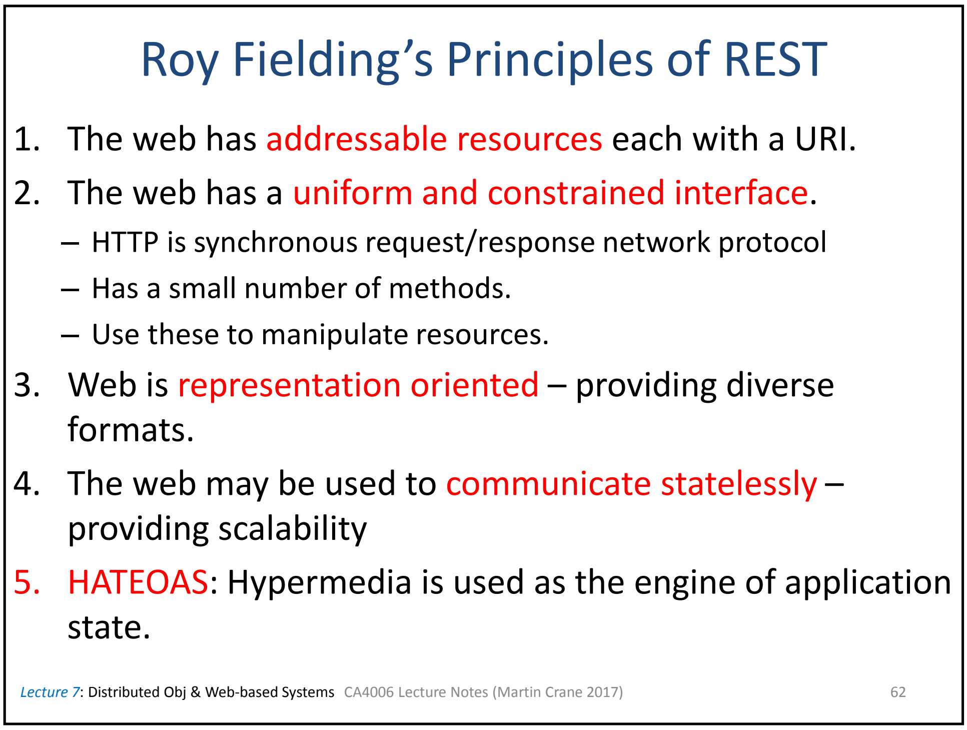
Contrast Between SOAP & REST (/4)

- REST tries to isolate complexity at endpoints (Clients & Service):
  - Service:
    - Could need logic/computation to process `XML` to maintain Resources & generate their representation.
  - Client:
    - May have to process XML to extract info from `XML` representation.
- But this complexity is kept from the transport level.
- SOAP complicates the transport level as a SOAP message is encapsulated as transport message body.



More on Resources in REST

- Resources have certain properties:
  - *Representation*: usually MIME (commonly `text/html`, `text/xml`).
  - *State*: i.e. they are mutable.
- Note:
  - In a RESTful request on it, resource itself stays service-side.
  - If request succeeds, requester gets resource's *representation* (this transfers from server to requester machine).
  - For successful request to read resource, it's typed *representation* (e.g. `text/xml`) transfers from resource's server to the requester



Roy Fielding's Principles of REST

1. The web has addressable resources each with a URI.
2. The web has a uniform and constrained interface.
   - HTTP is synchronous request/response network protocol
   - Has a small number of methods.
   - Use these to manipulate resources.
3. Web is representation oriented – providing diverse formats.
4. The web may be used to communicate statelessly – providing scalability
5. HATEOAS: Hypermedia is used as the engine of application state.

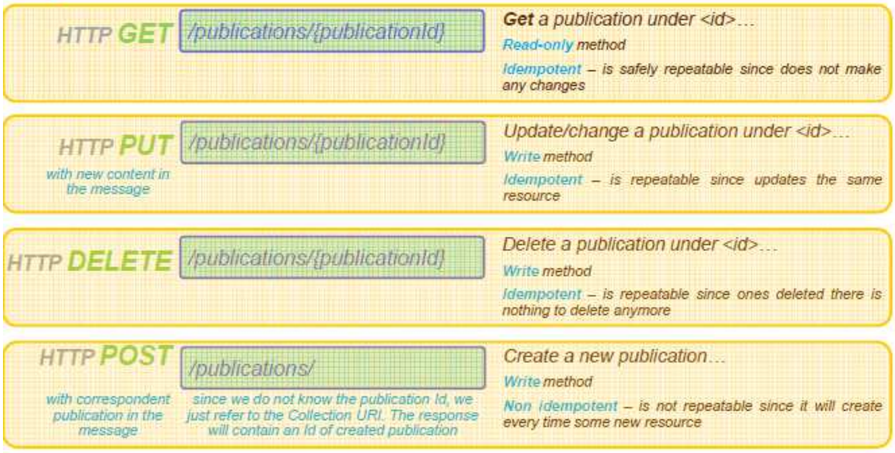
Principles of REST 1: Addressability

`scheme://host:port/path?queryString#fragment`

- The scheme need not be HTTP. May be FTP or HTTPS.
- The host field may be a DNS name or a IP address.
- The port may be derived from the scheme. Using HTTP implies port 80.
- The path is a set of text segments delimited by the "/".
- The queryString is a list of parameters represented as **`name=value`** pairs with each delimited by an "`&`".
- The fragment is used to point to a parCcular place in a document.

REST Principles 2: Uniform Constrained Interface

- Small number of HTTP Operations:
  - No need for IDL
  - Interoperability

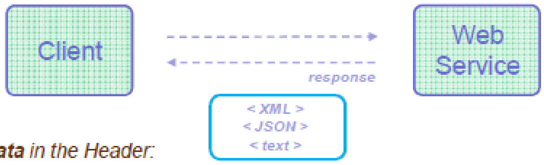


HTTP **GET**	/publications/{publicationId}	**Get** a publication under <id>… *Read-only* method *Idempotent* – is safely repeatable since does not make any changes
HTTP **PUT** with new content in the message	/publications/{publicationId}	Update/change a publication under <id>… *Write* method *Idempotent* – is repeatable since updates the same resource
HTTP **DELETE**	/publications/{publicationId}	Delete a publication under <id>… *Write* method *Idempotent* – is repeatable since ones deleted there is nothing to delete anymore
HTTP **POST** with correspondent publication in the message	/publications/ since we do not know the publication Id, we just refer to the Collection URI. The response will contain an Id of created publication	Create a new publication… *Write* method *Non idempotent* – is not repeatable since it will create every time some new resource

REST Principles 2: Uniform Constrained Interface(/2)

REST Response...

*... is a **representation** of a resource. It could have several representations (e.g. XML, JSON, text, etc.)*



*... contains **metadata** in the Header:*

- ❑ *Status Code*
- ❑ *Message length*
- ❑ *Date*
- ❑ *Content Type*
- ❑ *Etc.*

Status Codes

- ❑ *"200 OK"*
- ❑ *"201 Created"*
- ❑ *"204 No Content"*
- ❑ *"302 Found"*
- ❑ *"304 Not modified"*
- ❑ *"307 Temporary Redirect"*

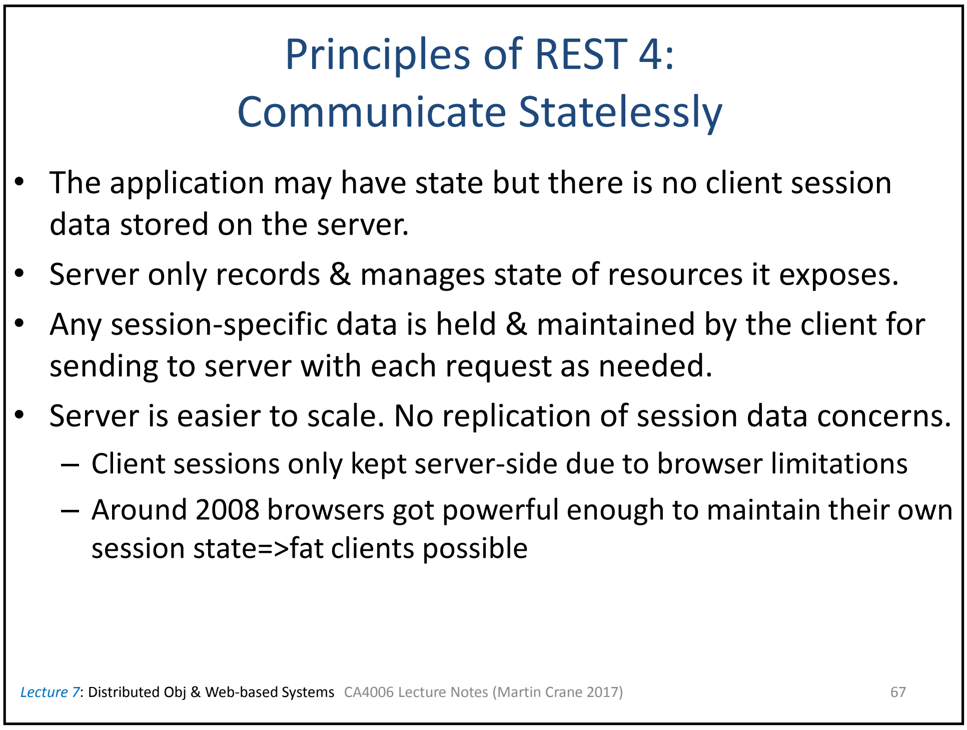
- ❑ *"400 Bad Request"*
- ❑ *"401 Unauthorized"*
- ❑ *"403 Forbidden"*
- ❑ *"404 Not Found"*
- ❑ *"415 Unsupported Media Type"*
- ❑ *"500 Internal Service Error"*

5 classes of codes:

- ❑ *1xx – Informational code*
- ❑ *2xx – Success code*
- ❑ *3xx – Redirection code*
- ❑ *4xx – Client Error code*
- ❑ *5xx – Service Error code*

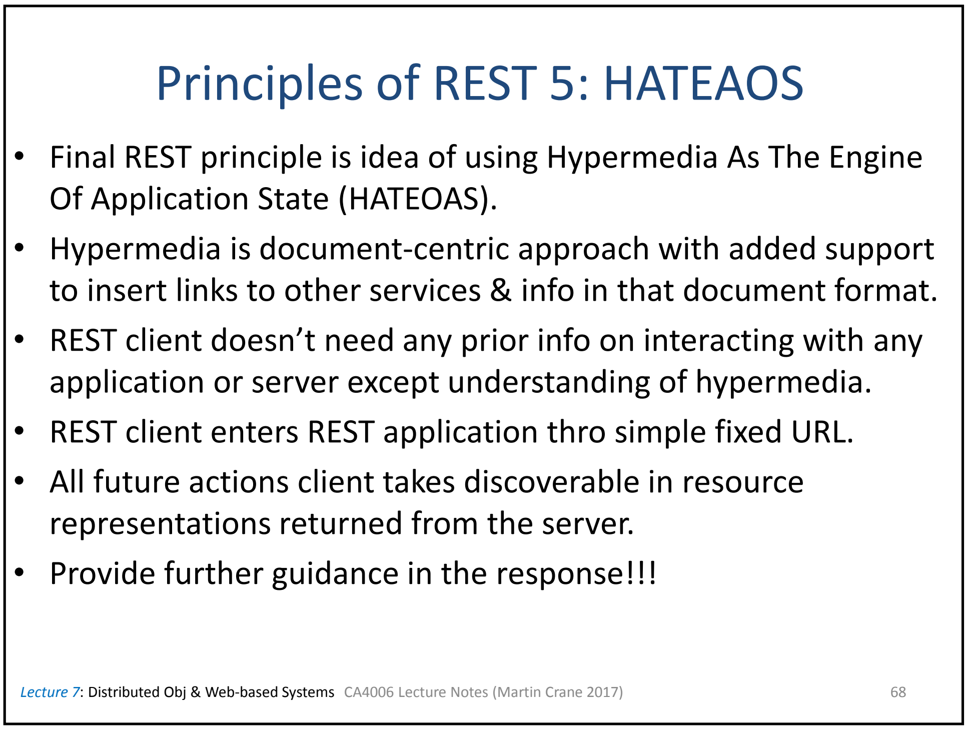
Principles of REST 3: Representation-Orientated

- Representations of resources are exchanged.
  - GET returns a representation.
  - PUT & POST sends representations to server so underlying resources may change.
- Representations may be in many formats: XML, JSON, etc.
- HTTP uses CONTENT-TYPE header to specify message format the server is sending.
- The value of the CONTENT-TYPE is a MIME typed string.
- Examples:
  - text/plain
  - text/html



Principles of REST 4: Communicate Statelessly

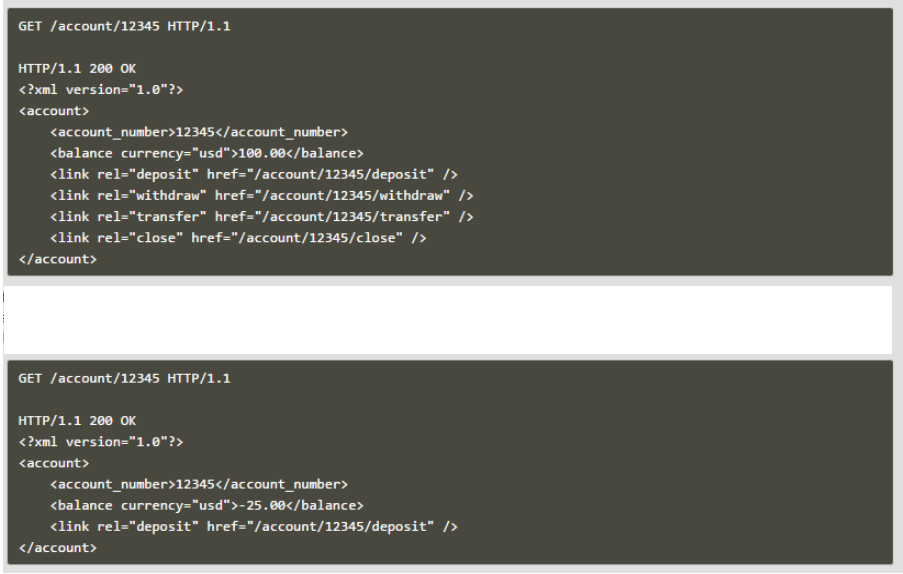
- The application may have state but there is no client session data stored on the server.
- Server only records & manages state of resources it exposes.
- Any session-specific data is held & maintained by the client for sending to server with each request as needed.
- Server is easier to scale. No replication of session data concerns.
  - Client sessions only kept server-side due to browser limitations
  - Around 2008 browsers got powerful enough to maintain their own session state=>fat clients possible



Principles of REST 5: HATEAOS

- Final REST principle is idea of using Hypermedia As The Engine Of Application State (HATEOAS).
- Hypermedia is document-centric approach with added support to insert links to other services & info in that document format.
- REST client doesn’t need any prior info on interacting with any application or server except understanding of hypermedia.
- REST client enters REST application thro simple fixed URL.
- All future actions client takes discoverable in resource representations returned from the server.
- Provide further guidance in the response!!!

Principles of REST 5: HATEAOS (/2)



```
GET /account/12345 HTTP/1.1

HTTP/1.1 200 OK
<?xml version="1.0"?>
<account>
    <account_number>12345</account_number>
    <balance currency="usd">100.00</balance>
    <link rel="deposit" href="/account/12345/deposit" />
    <link rel="withdraw" href="/account/12345/withdraw" />
    <link rel="transfer" href="/account/12345/transfer" />
    <link rel="close" href="/account/12345/close" />
</account>
```

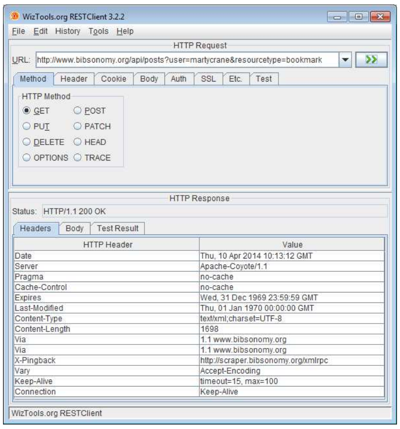
```
GET /account/12345 HTTP/1.1

HTTP/1.1 200 OK
<?xml version="1.0"?>
<account>
    <account_number>12345</account_number>
    <balance currency="usd">-25.00</balance>
    <link rel="deposit" href="/account/12345/deposit" />
</account>
```

A Subtlety: Opacity of URIs

- A URI is meant to be opaque
  - Means that URI: `http://bedrock/citizens/fred` has no inherent connection to the URI: `http://bedrock/citizens/`
  - Although Fred happens to be a citizen of Bedrock.
  - Of course, good designers devise URIs akin to what they identify, but URIs have no intrinsic hierarchical structure.
- A Note of caution
  - URI syntax resembles that for file system navigation, but this can mislead:
  - URIs are opaque identifiers, each naming exactly one resource.

A User Interface Client on a Web Service

- Example
  - The RestClient UI **Get**’s Bookmarks from Bibsonomy.com.
  - Note: password is user hash from registration with Bibsonomy.com.



WizTools.org RESTClient 3.2.2
File Edit History Tools Help
Method Header Cookie Body Auth SSL Etc. Test
Headers Body Test Result
WizTools.org RESTClient

HTTP Request

URL: http://www.bibsonomy.org/api/posts?user=martycrane&resourcetype=bookmark

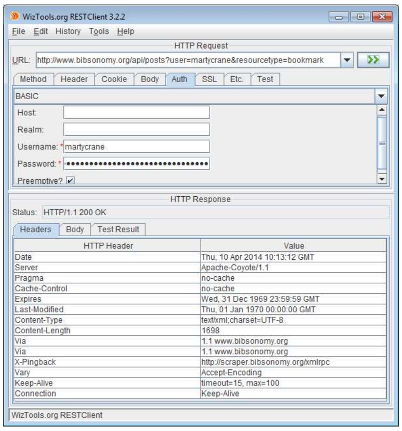
HTTP Method

● GET ○ POST
○ PUT ○ PATCH
○ DELETE ○ HEAD
○ OPTIONS ○ TRACE

HTTP Response

Status: HTTP/1.1 200 OK

HTTP Header	Value
Date	Thu, 10 Apr 2014 10:13:12 GMT
Server	Apache-Coyote/1.1
Pragma	no-cache
Cache-Control	no-cache
Expires	Wed, 31 Dec 1969 23:59:59 GMT
Last-Modified	Thu, 01 Jan 1970 00:00:00 GMT
Content-Type	text/xml;charset=UTF-8
Content-Length	1698
Via	1.1 www.bibsonomy.org
Via	1.1 www.bibsonomy.org
X-Pingback	http://scraper.bibsonomy.org/xmlrpc
Vary	Accept-Encoding
Keep-Alive	timeout=15, max=100
Connection	Keep-Alive



WizTools.org RESTClient 3.2.2
File Edit History Tools Help
Method Header Cookie Body Auth SSL Etc. Test
Headers Body Test Result
WizTools.org RESTClient

HTTP Request

URL: http://www.bibsonomy.org/api/posts?user=martycrane&resourcetype=bookmark

BASIC

Host:

Realm:

Username: * martycrane

Password: * ••••••••••••••••••••••••••••••••

Preemptive? ☑

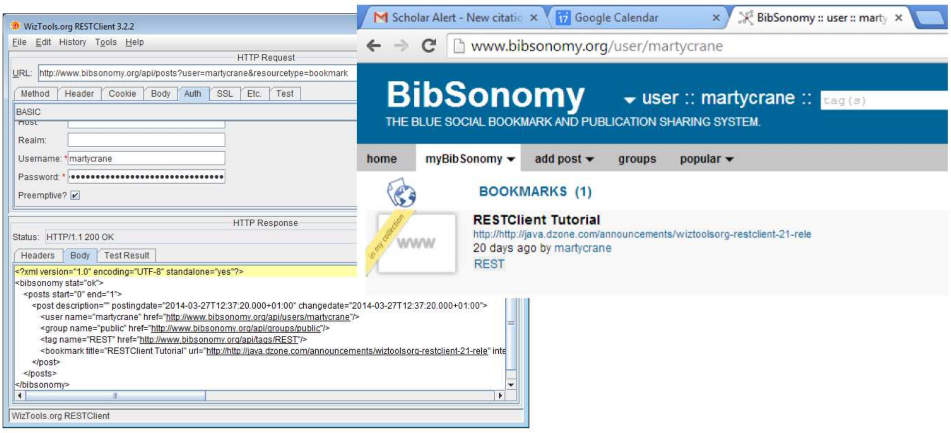
HTTP Response

Status: HTTP/1.1 200 OK

HTTP Header	Value
Date	Thu, 10 Apr 2014 10:13:12 GMT
Server	Apache-Coyote/1.1
Pragma	no-cache
Cache-Control	no-cache
Expires	Wed, 31 Dec 1969 23:59:59 GMT
Last-Modified	Thu, 01 Jan 1970 00:00:00 GMT
Content-Type	text/xml;charset=UTF-8
Content-Length	1698
Via	1.1 www.bibsonomy.org
Via	1.1 www.bibsonomy.org
X-Pingback	http://scraper.bibsonomy.org/xmlrpc
Vary	Accept-Encoding
Keep-Alive	timeout=15, max=100
Connection	Keep-Alive

A User Interface Client on a Web Service (/2)

- Example
  - The bookmark results of the previous **Get** operation.



WizTools.org RESTClient 3.2.2
File Edit History Tools Help
Method Header Cookie Body Auth SSL Etc. Test
Headers Body Test Result
WizTools.org RESTClient
Scholar Alert - New citatio
Google Calendar
BibSonomy :: user :: marty
home
myBibSonomy
add post
groups
popular

HTTP Request

URL: http://www.bibsonomy.org/api/posts?user=martycrane&resourcetype=bookmark

BASIC

Realm:

Username: * martycrane

Password: * ••••••••••••••••••••••••••••••••

Preemptive? ☑

HTTP Response

Status: HTTP/1.1 200 OK

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<bibsonomy stat="ok">
  <posts start="0" end="1">
    <post description="" postingdate="2014-03-27T12:37:20.000+01:00" changedate="2014-03-27T12:37:20.000+01:00">
      <user name="martycrane" href="http://www.bibsonomy.org/api/users/martycrane"/>
      <group name="public" href="http://www.bibsonomy.org/api/groups/public"/>
      <tag name="REST" href="http://www.bibsonomy.org/api/tags/REST"/>
      <bookmark title="RESTClient Tutorial" url="http://http://java.dzone.com/announcements/wiztoolsorg-restclient-21-rele" inte
    </post>
  </posts>
</bibsonomy>
```

www.bibsonomy.org/user/martycrane

BibSonomy user :: martycrane :: tag(s)

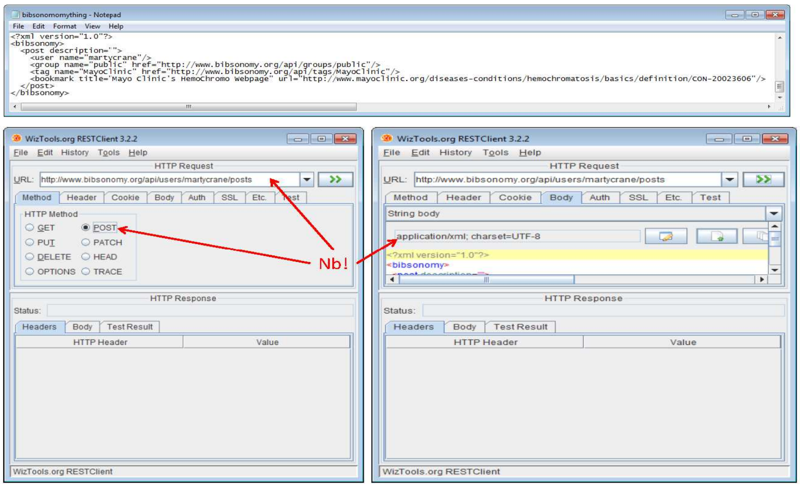
THE BLUE SOCIAL BOOKMARK AND PUBLICATION SHARING SYSTEM.

BOOKMARKS (1)

RESTClient Tutorial
http://http://java.dzone.com/announcements/wiztoolsorg-restclient-21-rele
20 days ago by martycrane
REST

A User Interface Client on a Web Service (/3)

- Example
  - RestClient uses **Post** to add a Bookmark to Bibsonomy.com.
  - Nb: Change content-type to application/**xml** & charset to **UTF-8**.



bibsonomomything - Notepad

```
<?xml version="1.0"?>
<bibsonomy>
  <post description="">
    <user name="martycrane"/>
    <group name="public" href="http://www.bibsonomy.org/api/groups/public"/>
    <tag name="MayoClinic" href="http://www.bibsonomy.org/api/tags/MayoClinic"/>
    <bookmark title="Mayo Clinic's HemoChromo Webpage" url="http://www.mayoclinic.org/diseases-conditions/hemochromatosis/basics/definition/CON-20023606"/>
  </post>
</bibsonomy>
```

WizTools.org RESTClient 3.2.2

URL: http://www.bibsonomy.org/api/users/martycrane/posts

HTTP Method: ○ GET ● POST ○ PUT ○ PATCH ○ DELETE ○ HEAD ○ OPTIONS ○ TRACE

WizTools.org RESTClient 3.2.2

URL: http://www.bibsonomy.org/api/users/martycrane/posts

String body: application/xml; charset=UTF-8

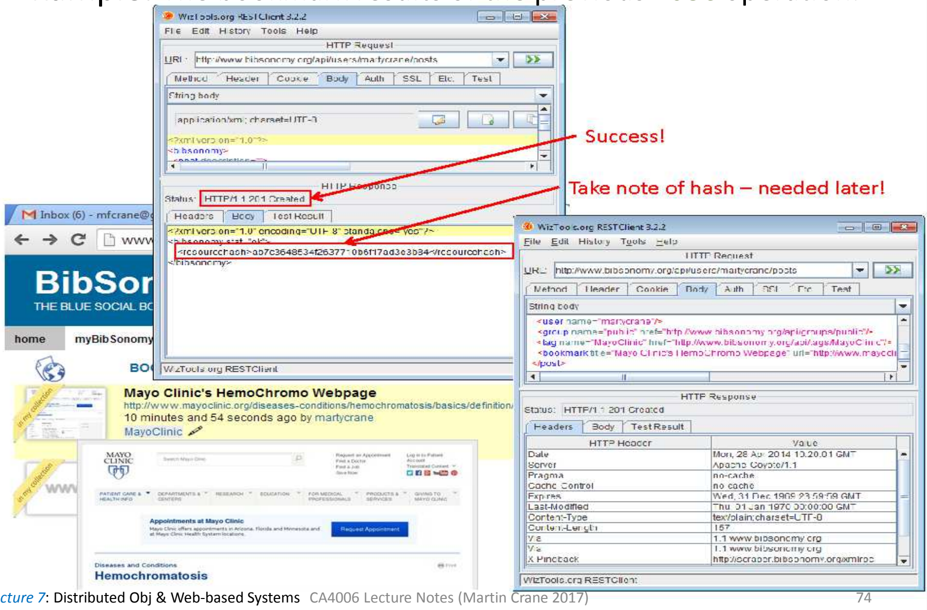
```
<?xml version="1.0"?>
<bibsonomy>
```

Nb!

File Edit Format View Help
File Edit History Tools Help
HTTP Request
Method Header Cookie Body Auth SSL Etc. Test
HTTP Response
Status:
Headers Body Test Result
HTTP Header
Value
WizTools.org RESTClient

A User Interface Client on a Web Service (/4)

- Example: The bookmark results of the previous **Post** operation.



Success!

Take note of hash – needed later!

WizTools.org RESTClient 3.2.2

URL: http://www.bibsonomy.org/api/users/martycrane/posts

String body: application/xml; charset=UTF-8

Status: HTTP/1.1 201 Created

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<bibsonomy stat="ok">
  <resourcehash>ab7c3648534f26377 0b6f17ad3e3b34</resourcehash>
</bibsonomy>
```

WizTools.org RESTClient 3.2.2

URL: http://www.bibsonomy.org/api/users/martycrane/posts

```
<user name="martycrane"/>
<group name="public" href="http://www.bibsonomy.org/api/groups/public"/>
<tag name="MayoClinic" href="http://www.bibsonomy.org/api/tags/MayoClinic"/>
<bookmark title="Mayo Clinic's HemoChromo Webpage" url="http://www.mayocli
</post>
```

Status: HTTP/1.1 201 Created

HTTP Header	Value
Date	Mon, 28 Apr 2014 10:20:01 GMT
Server	Apache-Coyote/1.1
Pragma	no-cache
Cache-Control	no-cache
Expires	Wed, 31 Dec 1969 23:59:59 GMT
Last-Modified	Thu, 01 Jan 1970 00:00:00 GMT
Content-Type	text/plain;charset=UTF-8
Content-Length	157
Via	1.1 www.bibsonomy.org
Via	1.1 www.bibsonomy.org
X-Pingback	http://scraper.bibsonomy.org/xmlrpc

Mayo Clinic's HemoChromo Webpage

http://www.mayoclinic.org/diseases-conditions/hemochromatosis/basics/definition/

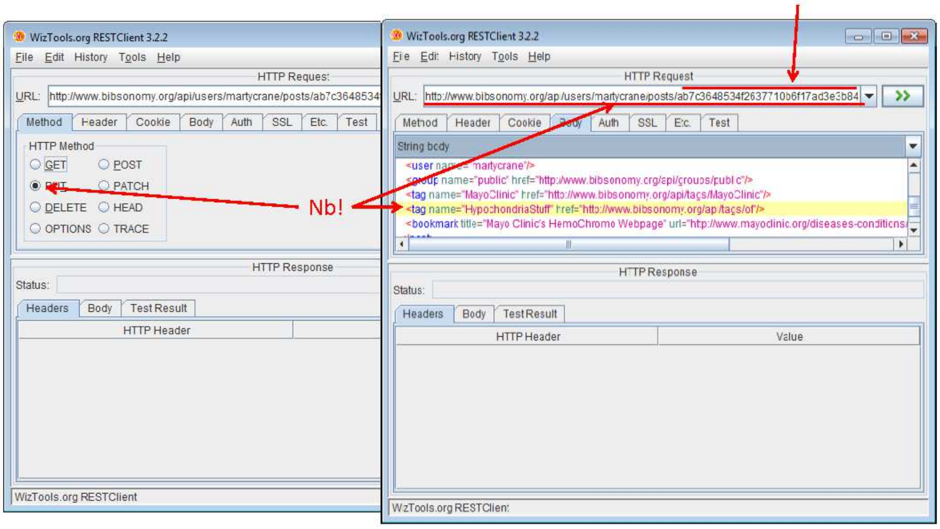
10 minutes and 54 seconds ago by martycrane

MayoClinic

A User Interface Client on a Web Service (/5)

- Example: RestClient uses `Put` to change a Bookmark thus
  `http://www.bibsonomy.org/api/users/martycrane/posts/hash`

Use of hash to alter/delete



URL: http://www.bibsonomy.org/api/users/martycrane/posts/ab7c3648534f2637710b6f17ad3e3b84

HTTP Method: ○ GET ○ POST ● PUT ○ PATCH ○ DELETE ○ HEAD ○ OPTIONS ○ TRACE

Nb!

String body

```
<user name="martycrane"/>
<group name="public" href="http://www.bibsonomy.org/api/groups/public"/>
<tag name="MayoClinic" href="http://www.bibsonomy.org/api/tags/MayoClinic"/>
<tag name="HypochondriaStuff" href="http://www.bibsonomy.org/api/tags/of"/>
<bookmark title="Mayo Clinic's HemoChromo Webpage" url="http://www.mayoclinic.org/diseases-conditions/
```

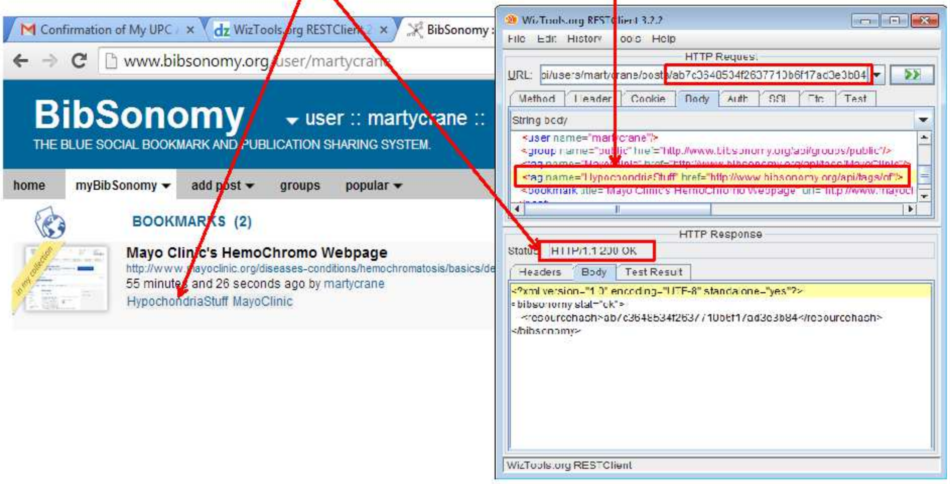
WizTools.org RESTClient 3.2.2
File Edit History Tools Help
HTTP Request
Method Header Cookie Body Auth SSL Etc. Test
HTTP Response
Status:
Headers Body Test Result
HTTP Header
Value
WizTools.org RESTClient

A User Interface Client on a Web Service (/6)

- Example: The bookmark results of the previous `Put` operation.

New Tag: "HypochondriaStuff"

Success!



www.bibsonomy.org/user/martycrane

BOOKMARKS (2)

Mayo Clinic's HemoChromo Webpage
http://www.mayoclinic.org/diseases-conditions/hemochromatosis/basics/de
55 minutes and 26 seconds ago by martycrane
HypochondriaStuff MayoClinic

URL: pi/users/martycrane/posts/ab7c3648534f2637710b6f17ad3e3b84

```
<user name="martycrane"/>
<group name="public" href="http://www.bibsonomy.org/api/groups/public"/>
<tag name="HypochondriaStuff" href="http://www.bibsonomy.org/api/tags/of"/>
<bookmark title="Mayo Clinic's HemoChromo Webpage" url="http://www.mayocl
```

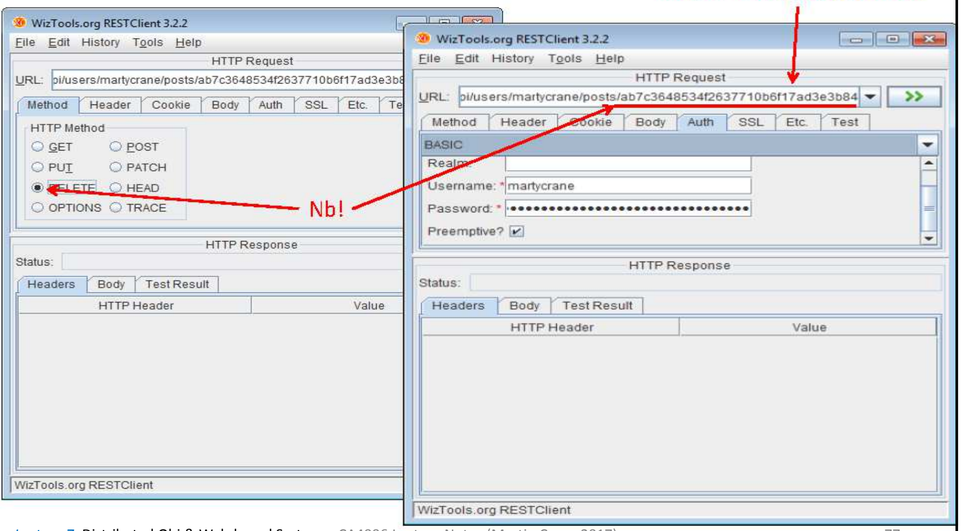
Status: HTTP/1.1 200 OK

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<bibsonomy stat="ok">
  <resourcehash>ab7c3648534f2637710b6f17ad3e3b84</resourcehash>
</bibsonomy>
```

A User Interface Client on a Web Service (/7)

- Example: RestClient uses `Delete` to remove a Bookmark thus `http://www.bibsonomy.org/api/users/martycrane/posts/hash`

Use of hash to alter/delete



WizTools.org RESTClient 3.2.2
File Edit History Tools Help
HTTP Request
Method Header Cookie Body Auth SSL Etc. Test
HTTP Response
Headers Body Test Result
HTTP Header Value
WizTools.org RESTClient
Nb!

URL: pi/users/martycrane/posts/ab7c3648534f2637710b6f17ad3e3b8

HTTP Method: ○ GET ○ POST ○ PUT ○ PATCH ● DELETE ○ HEAD ○ OPTIONS ○ TRACE

Status:

URL: pi/users/martycrane/posts/ab7c3648534f2637710b6f17ad3e3b84

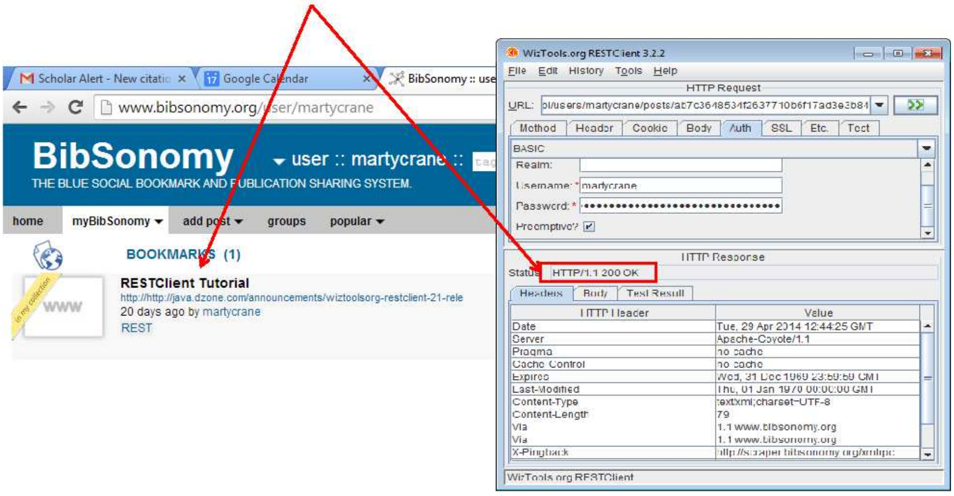
BASIC
Realm:
Username: * martycrane
Password: * ••••••••••••••••••••••••••••••
Preemptive? ☑

Status:

A User Interface Client on a Web Service (/8)

- Example: The bookmark results of the previous `Delete` operation.

Success!



Scholar Alert - New citatio
Google Calendar
BibSonomy :: use
www.bibsonomy.org/user/martycrane
BibSonomy
THE BLUE SOCIAL BOOKMARK AND PUBLICATION SHARING SYSTEM.
user :: martycrane ::
home
myBibSonomy
add post
groups
popular
in my collection
WWW
WizTools.org RESTClient 3.2.2
File Edit History Tools Help
HTTP Request
Method Header Cookie Body Auth SSL Etc. Test
HTTP Response
Headers Body Test Result
WizTools.org RESTClient

BOOKMARKS (1)

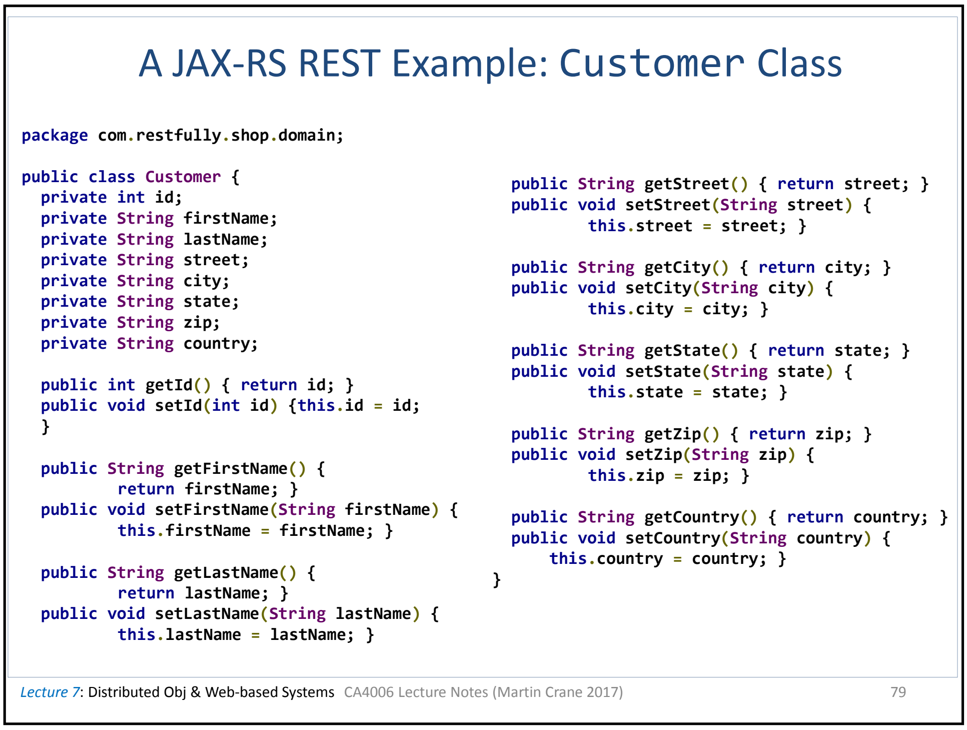
RESTClient Tutorial
http://http://java.dzone.com/announcements/wiztoolsorg-restclient-21-rele
20 days ago by martycrane
REST

URL: pi/users/martycrane/posts/ab7c3648534f2637710b6f17ad3e3b84

BASIC
Realm:
Username: * martycrane
Password: * ••••••••••••••••••••••••••••••
Preemptive? ☑

Status: HTTP/1.1 200 OK

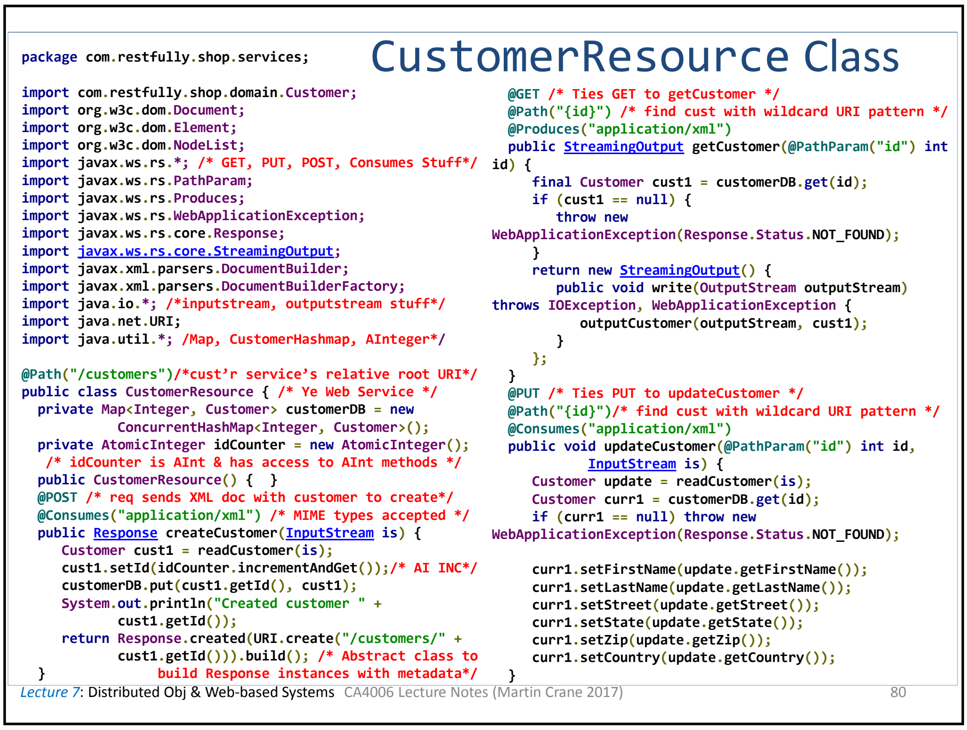
HTTP Header	Value
Date	Tue, 29 Apr 2014 12:44:25 GMT
Server	Apache-Coyote/1.1
Pragma	no cache
Cache Control	no cache
Expires	Wed, 31 Dec 1969 23:59:59 GMT
Last-Modified	Thu, 01 Jan 1970 00:00:00 GMT
Content-Type	text/xml;charset=UTF-8
Content-Length	79
Via	1.1 www.bibsonomy.org
Via	1.1 www.bibsonomy.org
X-Pingback	http://scraper.bibsonomy.org/xmlrpc



A JAX-RS REST Example: Customer Class

```
package com.restfully.shop.domain;

public class Customer {
  private int id;
  private String firstName;
  private String lastName;
  private String street;
  private String city;
  private String state;
  private String zip;
  private String country;

  public int getId() { return id; }
  public void setId(int id) {this.id = id;
  }

  public String getFirstName() {
          return firstName; }
  public void setFirstName(String firstName) {
          this.firstName = firstName; }

  public String getLastName() {
          return lastName; }
  public void setLastName(String lastName) {
          this.lastName = lastName; }
```

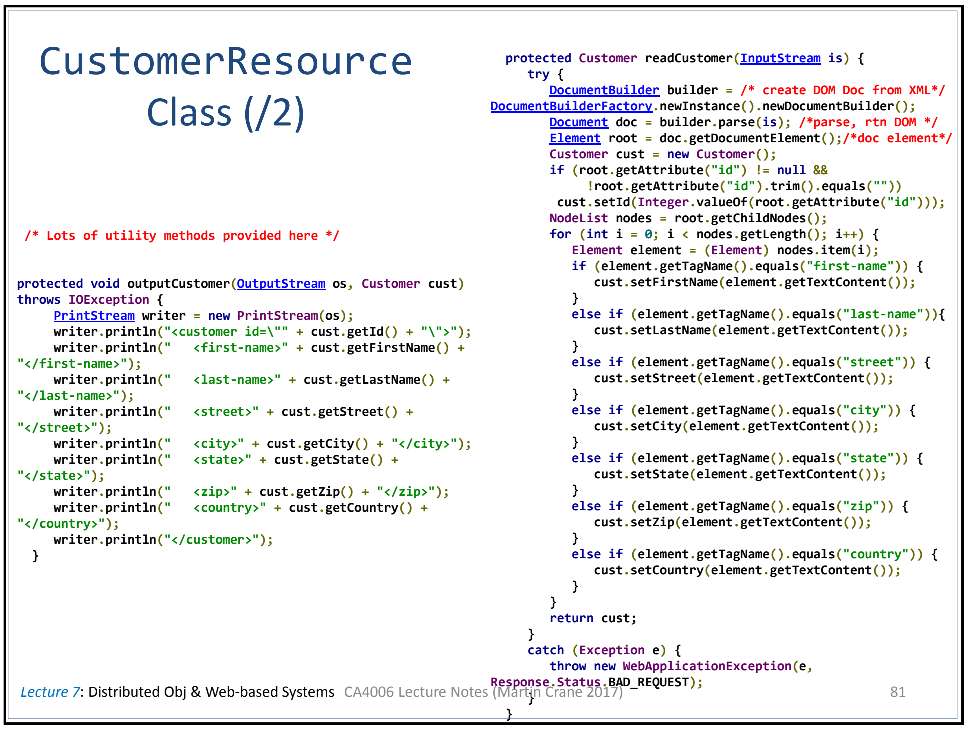
```
  public String getStreet() { return street; }
  public void setStreet(String street) {
          this.street = street; }

  public String getCity() { return city; }
  public void setCity(String city) {
          this.city = city; }

  public String getState() { return state; }
  public void setState(String state) {
          this.state = state; }

  public String getZip() { return zip; }
  public void setZip(String zip) {
          this.zip = zip; }

  public String getCountry() { return country; }
  public void setCountry(String country) {
      this.country = country; }
}
```



CustomerResource Class

```
package com.restfully.shop.services;

import com.restfully.shop.domain.Customer;
import org.w3c.dom.Document;
import org.w3c.dom.Element;
import org.w3c.dom.NodeList;
import javax.ws.rs.*; /* GET, PUT, POST, Consumes Stuff*/
import javax.ws.rs.PathParam;
import javax.ws.rs.Produces;
import javax.ws.rs.WebApplicationException;
import javax.ws.rs.core.Response;
import javax.ws.rs.core.StreamingOutput;
import javax.xml.parsers.DocumentBuilder;
import javax.xml.parsers.DocumentBuilderFactory;
import java.io.*; /*inputstream, outputstream stuff*/
import java.net.URI;
import java.util.*; /Map, CustomerHashmap, AInteger*/

@Path("/customers")/*cust'r service's relative root URI*/
public class CustomerResource { /* Ye Web Service */
  private Map<Integer, Customer> customerDB = new
            ConcurrentHashMap<Integer, Customer>();
  private AtomicInteger idCounter = new AtomicInteger();
   /* idCounter is AInt & has access to AInt methods */
  public CustomerResource() {  }
  @POST /* req sends XML doc with customer to create*/
  @Consumes("application/xml") /* MIME types accepted */
  public Response createCustomer(InputStream is) {
     Customer cust1 = readCustomer(is);
     cust1.setId(idCounter.incrementAndGet());/* AI INC*/
     customerDB.put(cust1.getId(), cust1);
     System.out.println("Created customer " +
            cust1.getId());
     return Response.created(URI.create("/customers/" +
            cust1.getId())).build(); /* Abstract class to
                 build Response instances with metadata*/
  }
```

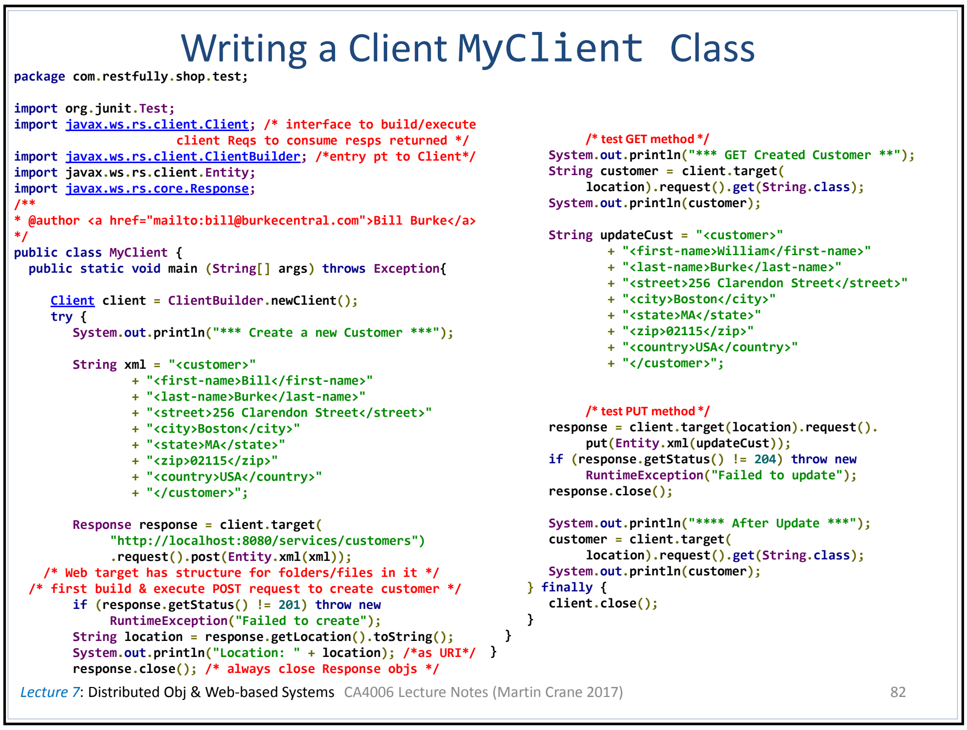
```
  @GET /* Ties GET to getCustomer */
  @Path("{id}") /* find cust with wildcard URI pattern */
  @Produces("application/xml")
  public StreamingOutput getCustomer(@PathParam("id") int
id) {
     final Customer cust1 = customerDB.get(id);
     if (cust1 == null) {
        throw new
WebApplicationException(Response.Status.NOT_FOUND);
     }
     return new StreamingOutput() {
        public void write(OutputStream outputStream)
throws IOException, WebApplicationException {
           outputCustomer(outputStream, cust1);
        }
     };
  }
  @PUT /* Ties PUT to updateCustomer */
  @Path("{id}")/* find cust with wildcard URI pattern */
  @Consumes("application/xml")
  public void updateCustomer(@PathParam("id") int id,
            InputStream is) {
     Customer update = readCustomer(is);
     Customer curr1 = customerDB.get(id);
     if (curr1 == null) throw new
WebApplicationException(Response.Status.NOT_FOUND);

     curr1.setFirstName(update.getFirstName());
     curr1.setLastName(update.getLastName());
     curr1.setStreet(update.getStreet());
     curr1.setState(update.getState());
     curr1.setZip(update.getZip());
     curr1.setCountry(update.getCountry());
  }
```



CustomerResource Class (/2)

```
 /* Lots of utility methods provided here */


protected void outputCustomer(OutputStream os, Customer cust)
throws IOException {
     PrintStream writer = new PrintStream(os);
     writer.println("<customer id=\"" + cust.getId() + "\">");
     writer.println("   <first-name>" + cust.getFirstName() +
"</first-name>");
     writer.println("   <last-name>" + cust.getLastName() +
"</last-name>");
     writer.println("   <street>" + cust.getStreet() +
"</street>");
     writer.println("   <city>" + cust.getCity() + "</city>");
     writer.println("   <state>" + cust.getState() +
"</state>");
     writer.println("   <zip>" + cust.getZip() + "</zip>");
     writer.println("   <country>" + cust.getCountry() +
"</country>");
     writer.println("</customer>");
  }
```

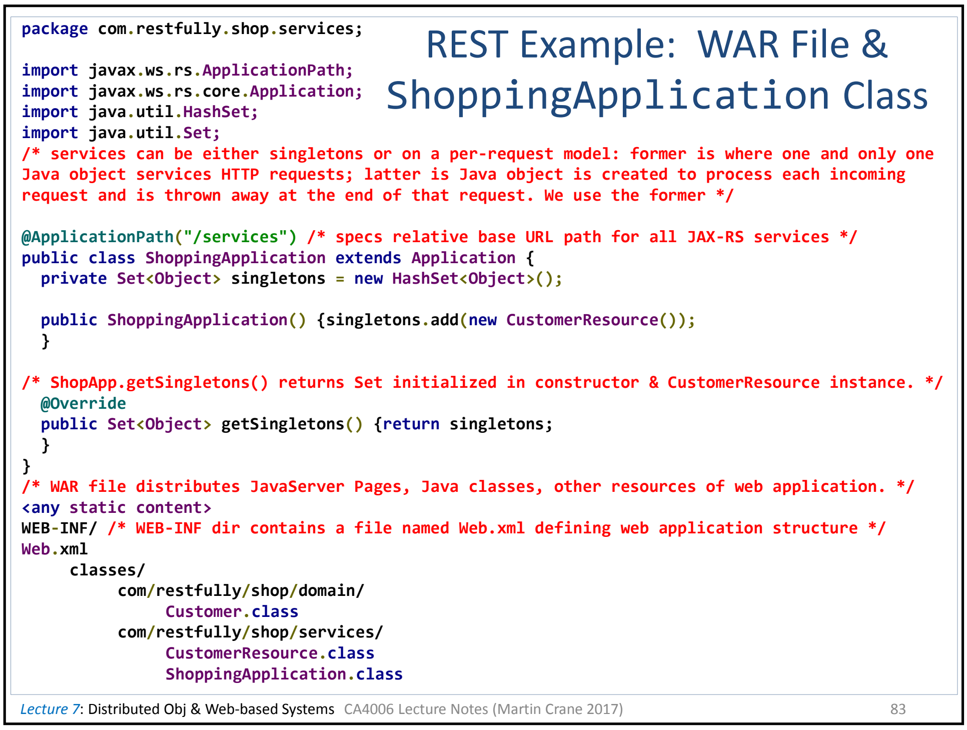
```
  protected Customer readCustomer(InputStream is) {
     try {
        DocumentBuilder builder = /* create DOM Doc from XML*/
DocumentBuilderFactory.newInstance().newDocumentBuilder();
        Document doc = builder.parse(is); /*parse, rtn DOM */
        Element root = doc.getDocumentElement();/*doc element*/
        Customer cust = new Customer();
        if (root.getAttribute("id") != null &&
             !root.getAttribute("id").trim().equals(""))
         cust.setId(Integer.valueOf(root.getAttribute("id")));
        NodeList nodes = root.getChildNodes();
        for (int i = 0; i < nodes.getLength(); i++) {
           Element element = (Element) nodes.item(i);
           if (element.getTagName().equals("first-name")) {
              cust.setFirstName(element.getTextContent());
           }
           else if (element.getTagName().equals("last-name")){
              cust.setLastName(element.getTextContent());
           }
           else if (element.getTagName().equals("street")) {
              cust.setStreet(element.getTextContent());
           }
           else if (element.getTagName().equals("city")) {
              cust.setCity(element.getTextContent());
           }
           else if (element.getTagName().equals("state")) {
              cust.setState(element.getTextContent());
           }
           else if (element.getTagName().equals("zip")) {
              cust.setZip(element.getTextContent());
           }
           else if (element.getTagName().equals("country")) {
              cust.setCountry(element.getTextContent());
           }
        }
        return cust;
     }
     catch (Exception e) {
        throw new WebApplicationException(e,
Response.Status.BAD_REQUEST);
     }
  }
```



Writing a Client MyClient Class

```
package com.restfully.shop.test;

import org.junit.Test;
import javax.ws.rs.client.Client; /* interface to build/execute
                      client Reqs to consume resps returned */
import javax.ws.rs.client.ClientBuilder; /*entry pt to Client*/
import javax.ws.rs.client.Entity;
import javax.ws.rs.core.Response;
/**
* @author <a href="mailto:bill@burkecentral.com">Bill Burke</a>
*/
public class MyClient {
  public static void main (String[] args) throws Exception{

     Client client = ClientBuilder.newClient();
     try {
        System.out.println("*** Create a new Customer ***");

        String xml = "<customer>"
                + "<first-name>Bill</first-name>"
                + "<last-name>Burke</last-name>"
                + "<street>256 Clarendon Street</street>"
                + "<city>Boston</city>"
                + "<state>MA</state>"
                + "<zip>02115</zip>"
                + "<country>USA</country>"
                + "</customer>";

        Response response = client.target(
             "http://localhost:8080/services/customers")
             .request().post(Entity.xml(xml));
    /* Web target has structure for folders/files in it */
  /* first build & execute POST request to create customer */
        if (response.getStatus() != 201) throw new
             RuntimeException("Failed to create");
        String location = response.getLocation().toString();
        System.out.println("Location: " + location); /*as URI*/
        response.close(); /* always close Response objs */
```

```
             /* test GET method */
        System.out.println("*** GET Created Customer **");
        String customer = client.target(
             location).request().get(String.class);
        System.out.println(customer);

        String updateCust = "<customer>"
                + "<first-name>William</first-name>"
                + "<last-name>Burke</last-name>"
                + "<street>256 Clarendon Street</street>"
                + "<city>Boston</city>"
                + "<state>MA</state>"
                + "<zip>02115</zip>"
                + "<country>USA</country>"
                + "</customer>";


             /* test PUT method */
        response = client.target(location).request().
             put(Entity.xml(updateCust));
        if (response.getStatus() != 204) throw new
             RuntimeException("Failed to update");
        response.close();

        System.out.println("**** After Update ***");
        customer = client.target(
             location).request().get(String.class);
        System.out.println(customer);
     } finally {
        client.close();
     }
   }
 }
```



REST Example: WAR File & ShoppingApplication Class

```
package com.restfully.shop.services;

import javax.ws.rs.ApplicationPath;
import javax.ws.rs.core.Application;
import java.util.HashSet;
import java.util.Set;
/* services can be either singletons or on a per-request model: former is where one and only one
Java object services HTTP requests; latter is Java object is created to process each incoming
request and is thrown away at the end of that request. We use the former */

@ApplicationPath("/services") /* specs relative base URL path for all JAX-RS services */
public class ShoppingApplication extends Application {
  private Set<Object> singletons = new HashSet<Object>();

  public ShoppingApplication() {singletons.add(new CustomerResource());
  }

/* ShopApp.getSingletons() returns Set initialized in constructor & CustomerResource instance. */
  @Override
  public Set<Object> getSingletons() {return singletons;
  }
}
/* WAR file distributes JavaServer Pages, Java classes, other resources of web application. */
<any static content>
WEB-INF/ /* WEB-INF dir contains a file named Web.xml defining web application structure */
Web.xml
     classes/
          com/restfully/shop/domain/
               Customer.class
          com/restfully/shop/services/
               CustomerResource.class
               ShoppingApplication.class
```