Multitiered Architecture
Web Services

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Outline

- ☐ Definition and origin of web services
- ☐ General web services
- ☐ RESTful web services
- ☐ Using JAX-WS (General web services)
- ☐ Using JAX-RS (RESTful web services)

Web Service – Definitions

a service offered by an electronic device to another electronic device, communicating with each other via the world wide web

wikipedia

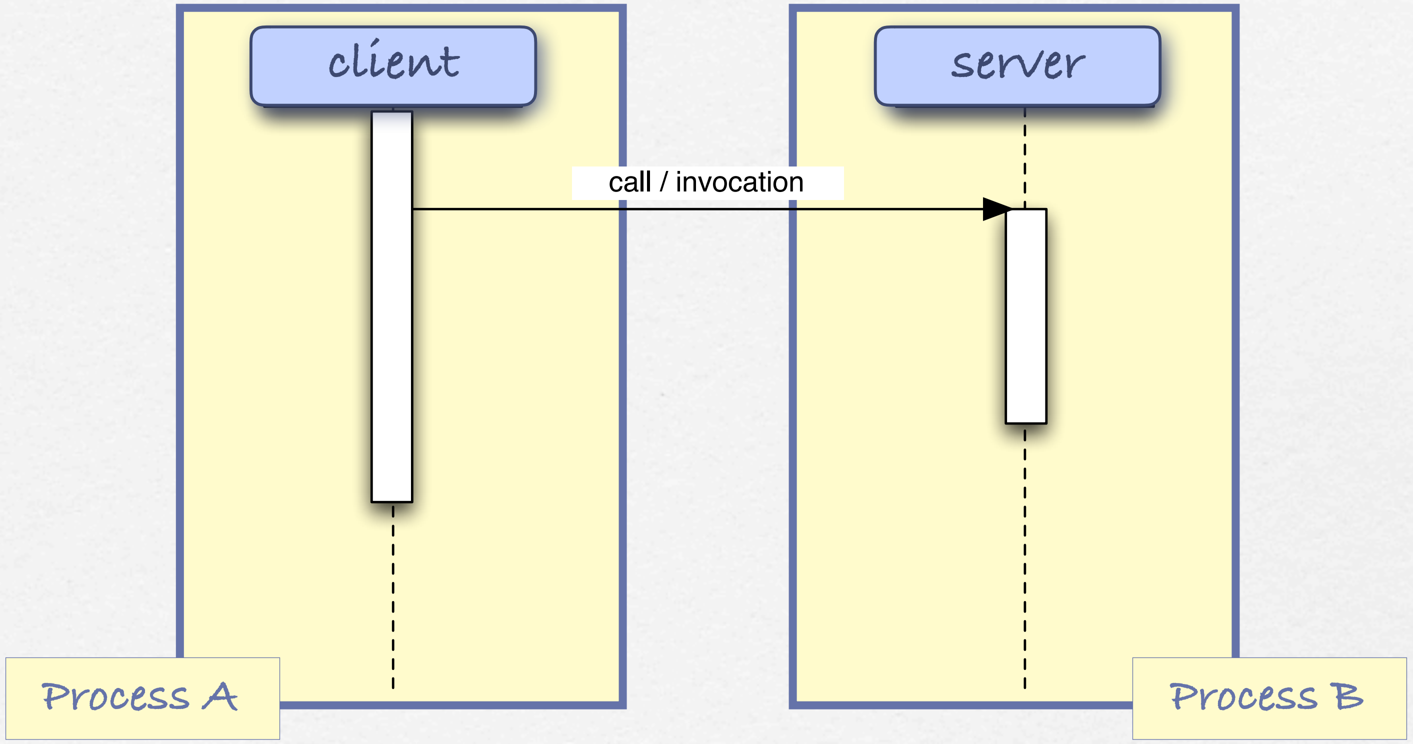
rmi* on http

*rmi ⇔ remote method invocation

software system designed to support interoperable machine-to-machine interaction over a network

world wide web consortium (w3c)

RMI | Fundamental Idea



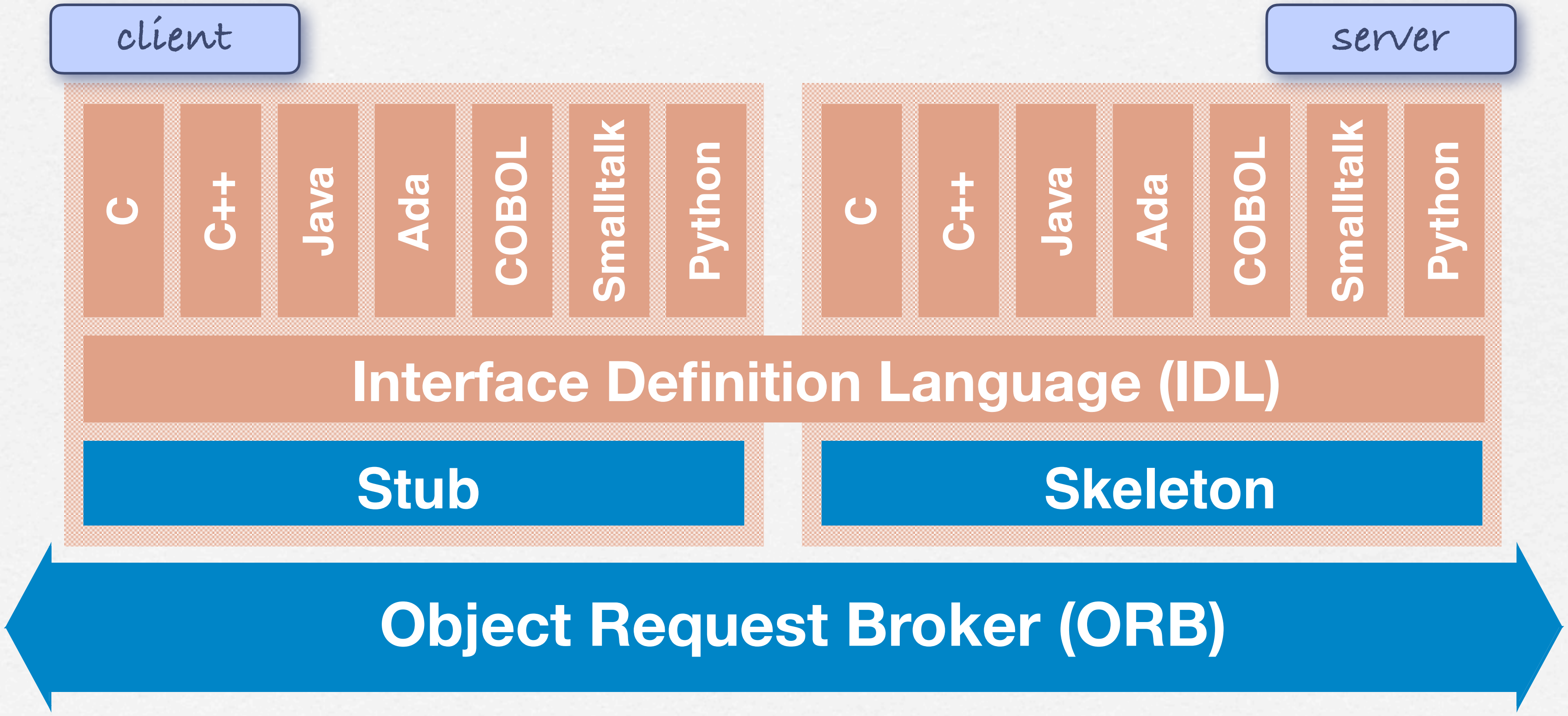
A remote method (procedure) is transparently invoked (called) across the network, as if it was local

RMI | Some history

1979	Bill Joy introduces the "Berkeley Enhancements", mainly interprocess communication (IPC) facilities. The modern network Unix is born (BSD).
mid 80's	Sun Microsystems uses BSD Unix as operating system for their workstations. They extends it with RPC, on top of which they build NFS and NIS (later on NIS+).
1988	The Open Software Foundation (OSF) is formed to develop a portable open system platform, known as the Distributed Computing Environment (DCE). The latter proposes DCE RPC as basic communication mechanism.
mid 90's	The Object Management Group (OMG) follows the same approach to devise the Common Object Request Broker Architecture (CORBA) for object-based middleware. At the same time, Sun greatly simplifies & extends the RMI paradigm its Java & Jini platforms.
Today	Web Services are a widespread approach to invoke remote services on the web but they are really just a web-flavored version of the good old RPC/RMI paradigm, using HTTP & XML/JSON.

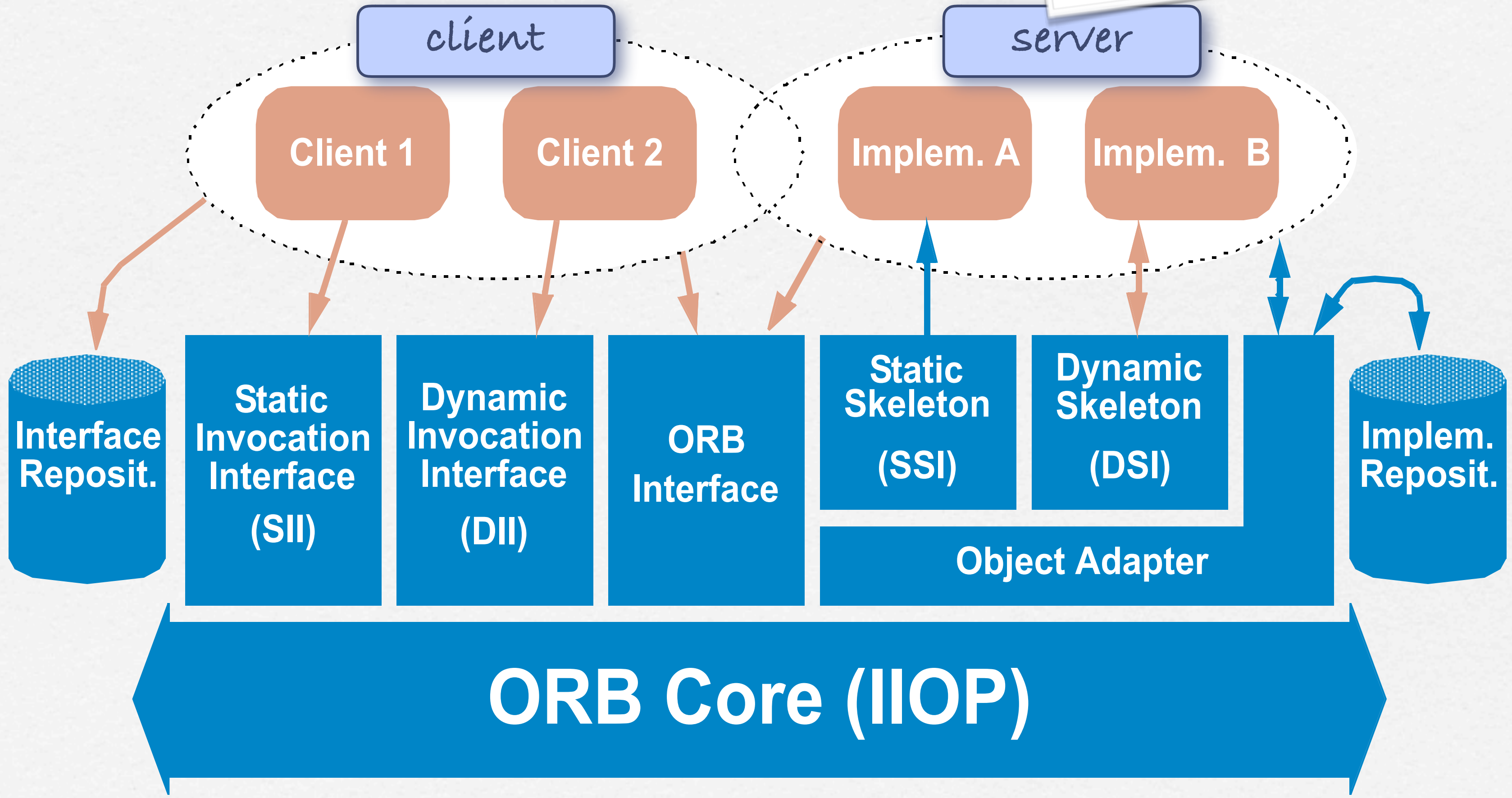
A glimpse at the CORBA promise

Common Object Request Broker Architecture



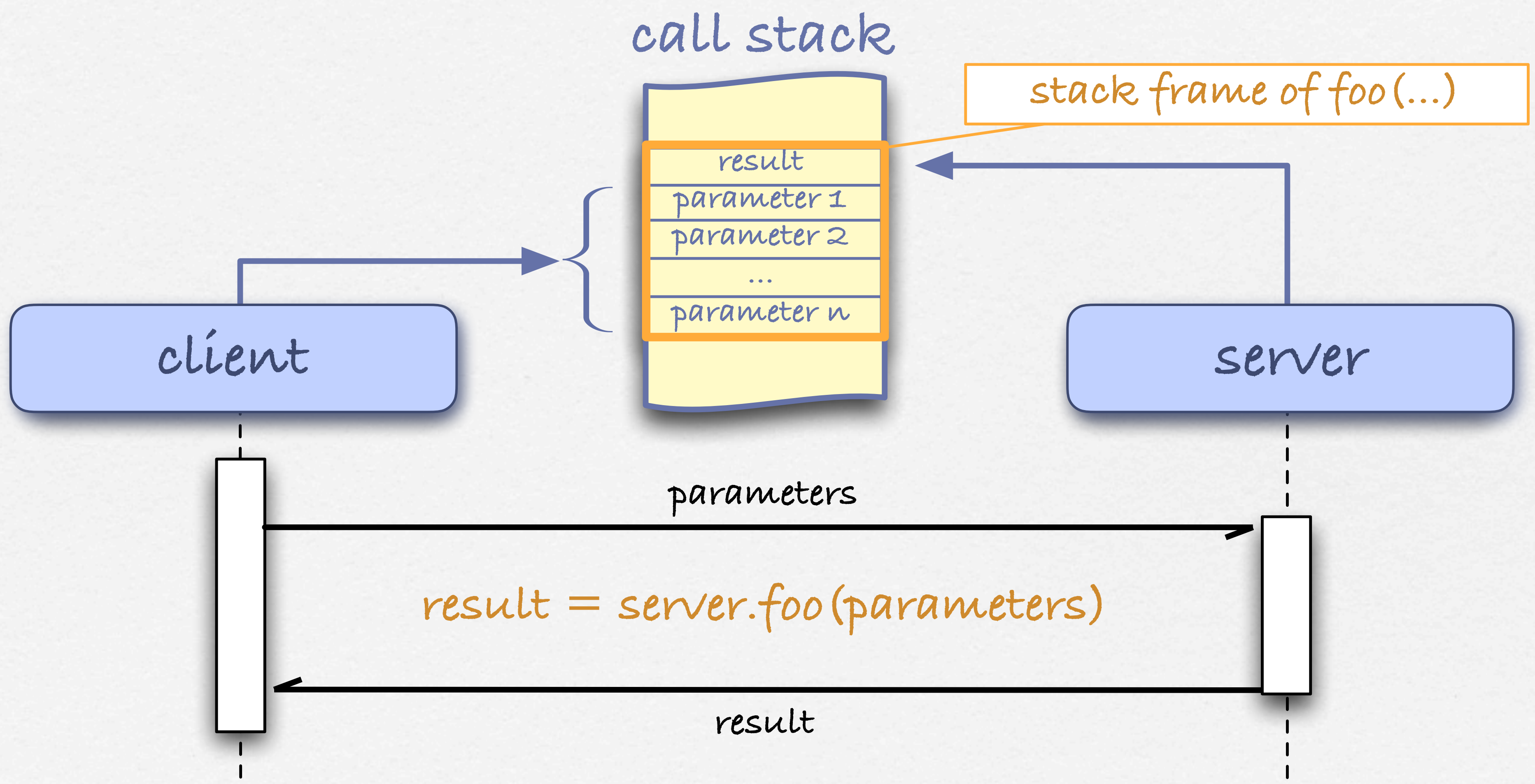
A glimpse at the CORBA reality

Common Object Request Broker Affliction

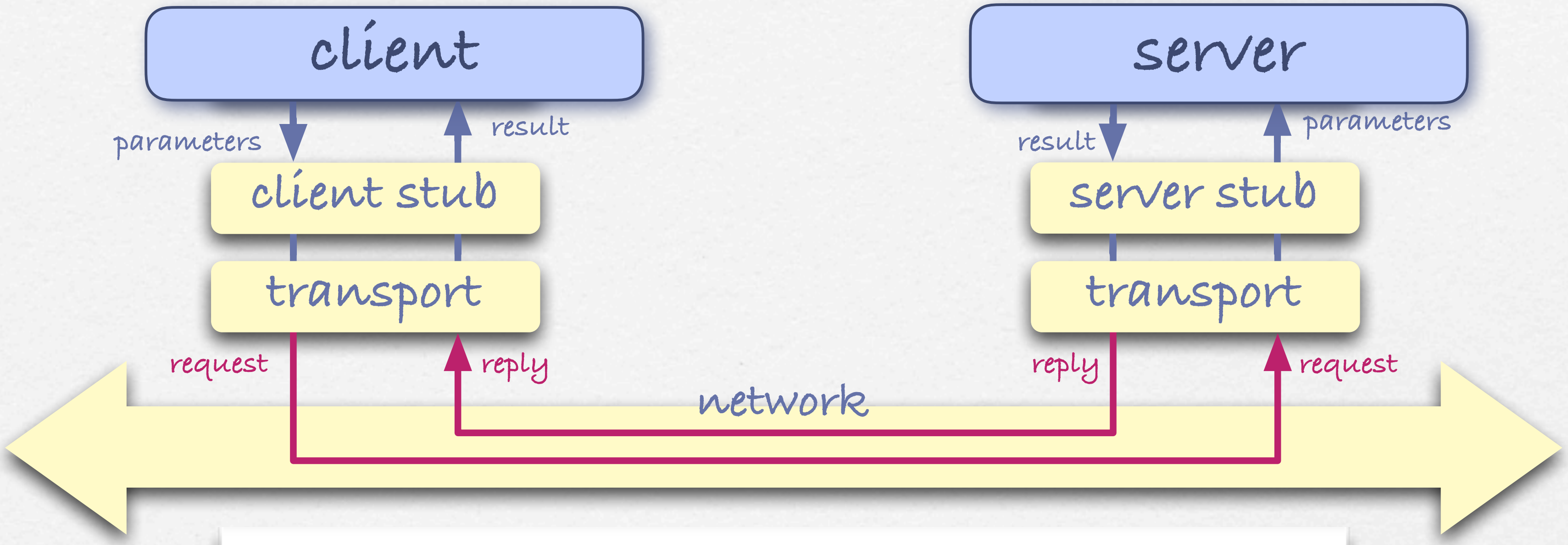


IIOP ⇔ Internet Inter-ORB Protocol

Local Method Invocations



Remote Method Invocation

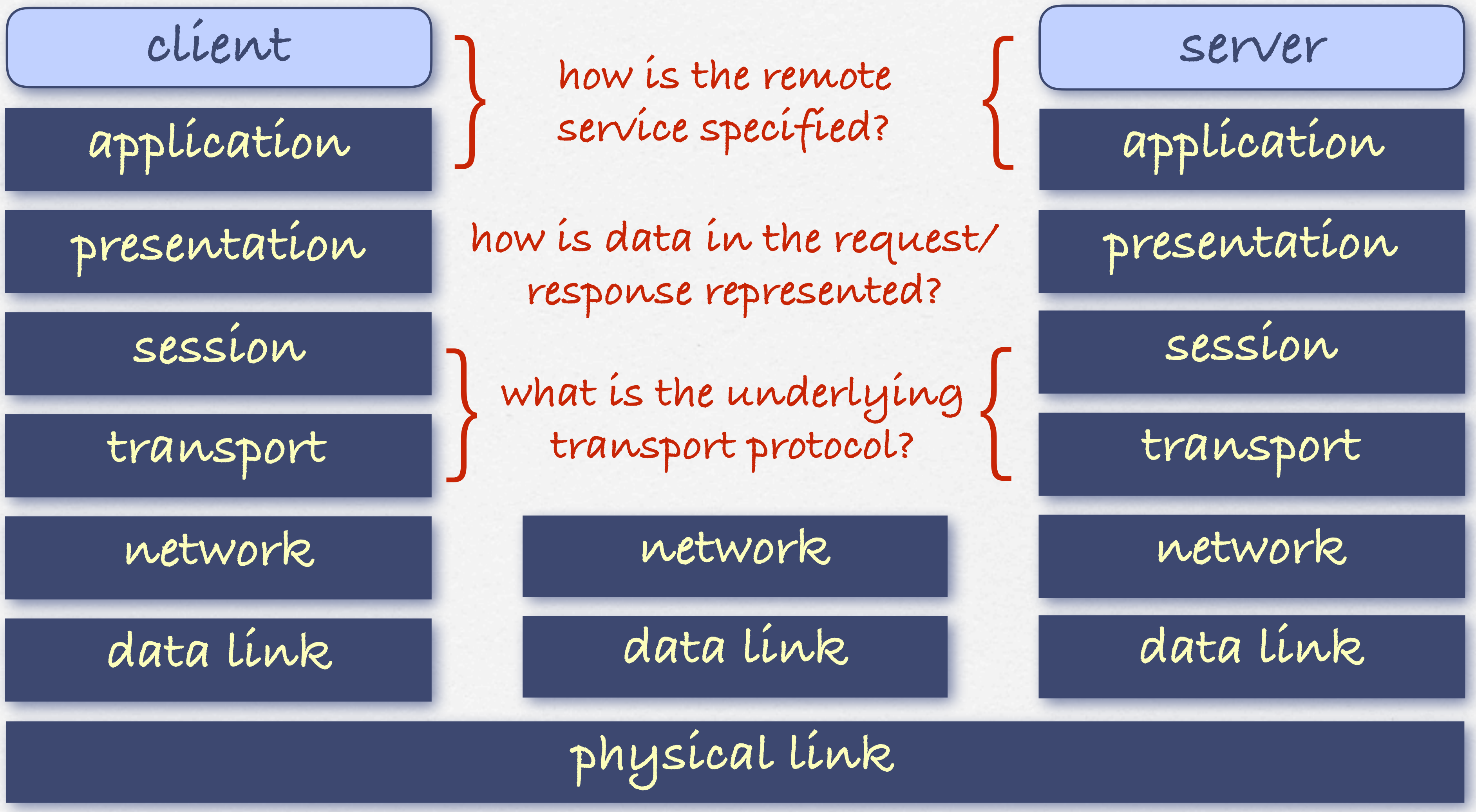


how is the remote service specified?

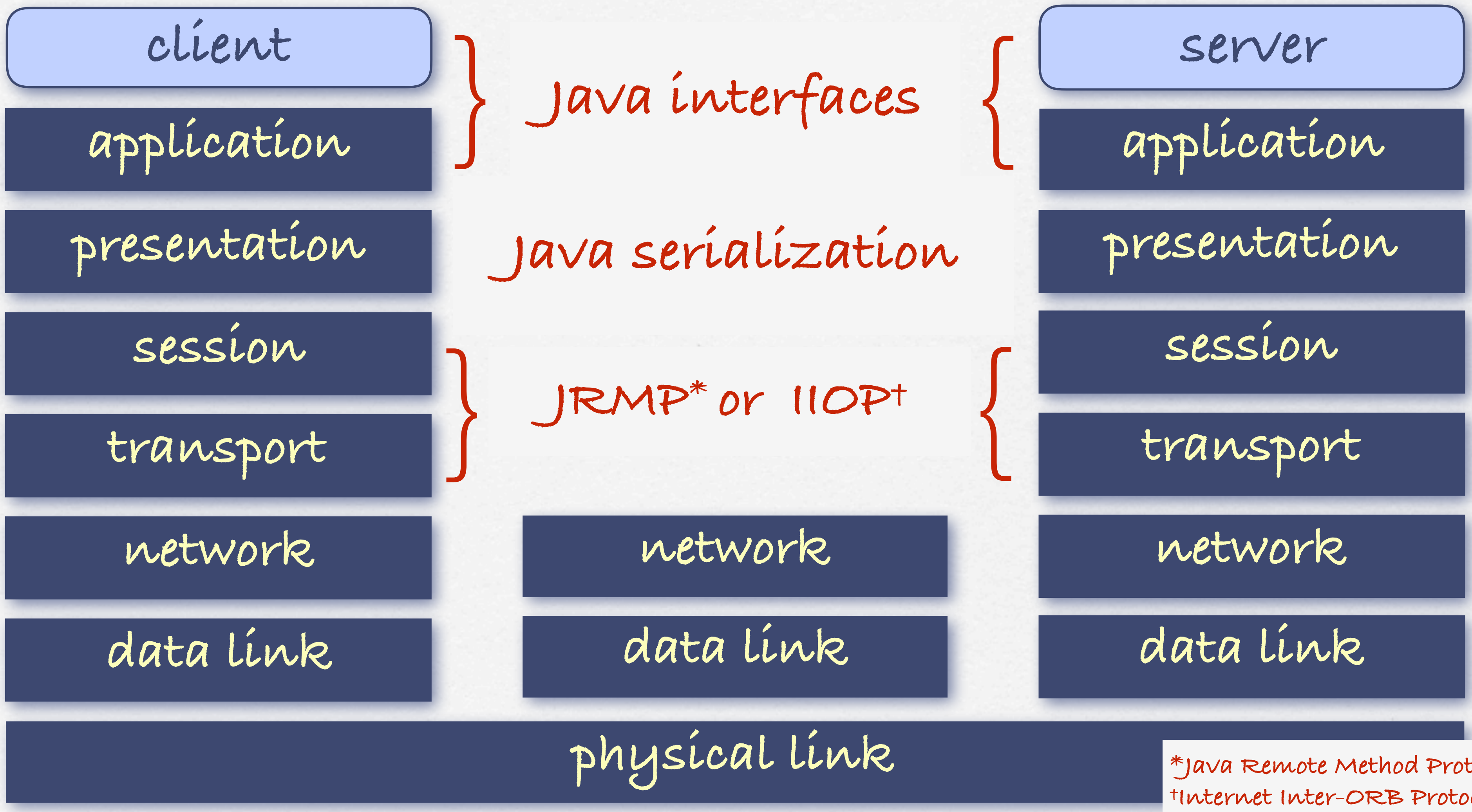
how is data in the request/response represented?

what is the underlying transport protocol?

The OSI model | Reminder

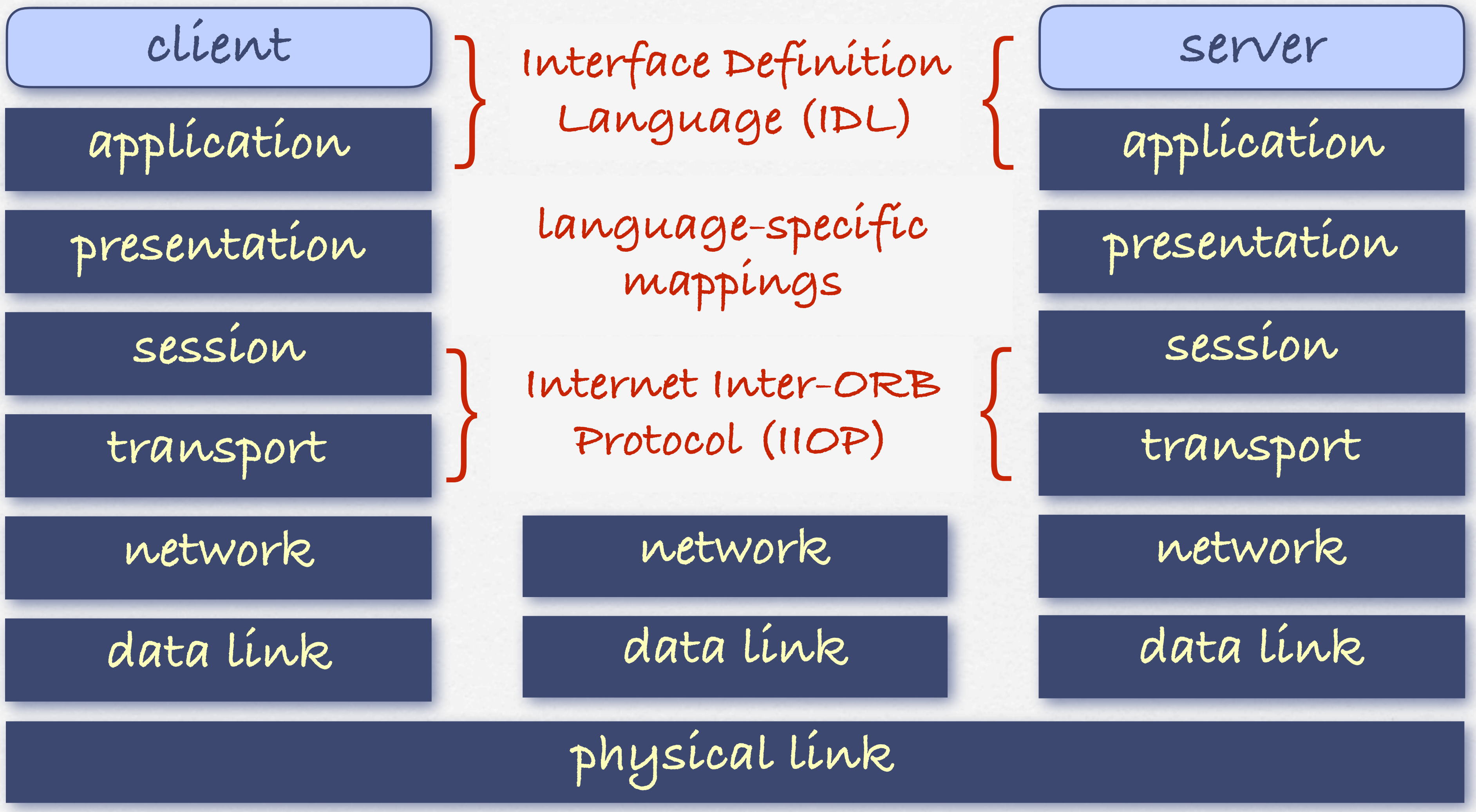


The OSI model | Java RMI



*Java Remote Method Protocol
†Internet Inter-ORB Protocol

The OSI model | CORBA



Service specification with Java RMI

```
public interface CalendarService extends Remote {
    public DayCalendar createCalendar(String name) throws RemoteException, CalendarException;
    public DayCalendar getCalendar(String name) throws RemoteException, CalendarException;
    public ArrayList getCalendars() throws RemoteException;
    public boolean exists(String name) throws RemoteException;
}
```

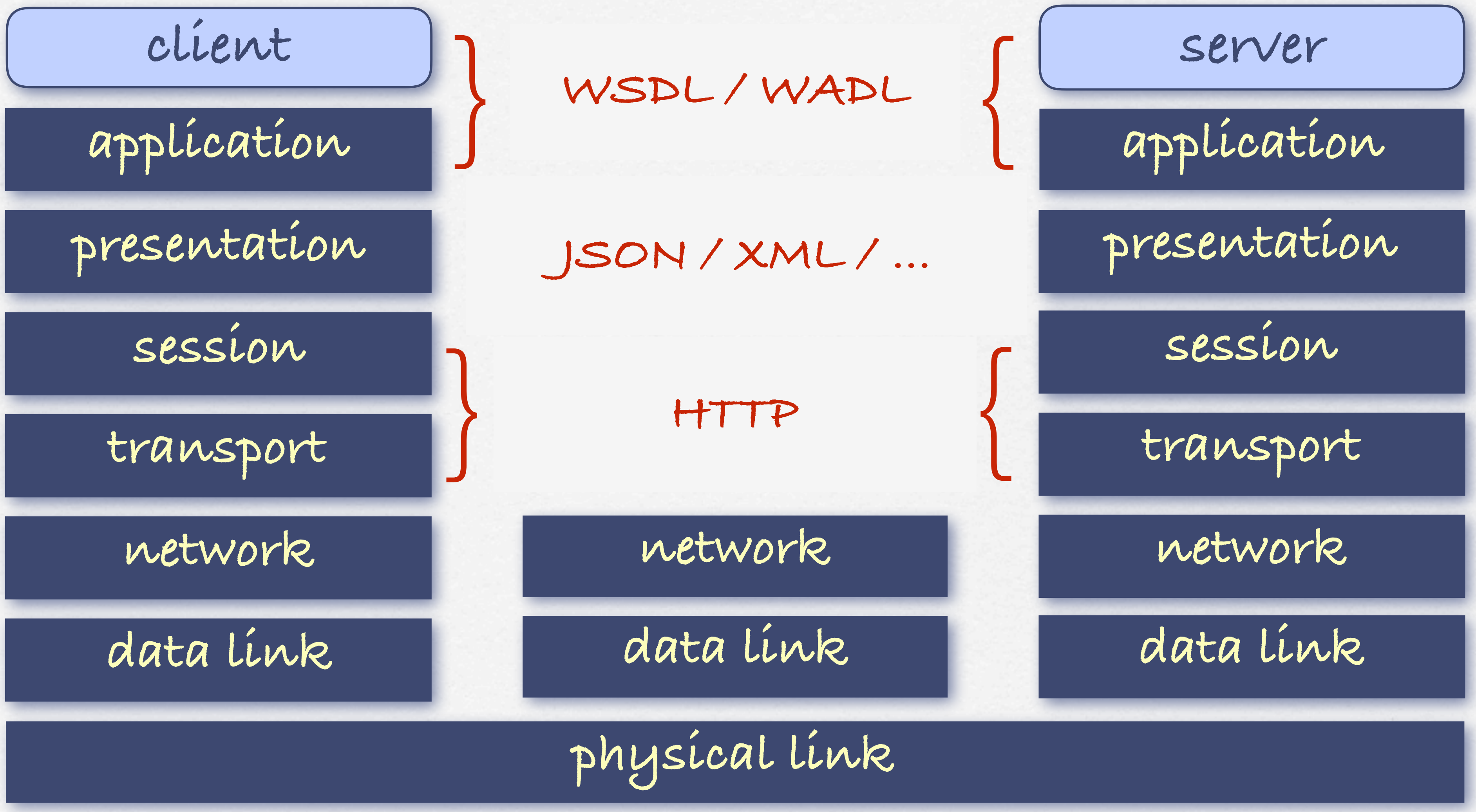
```
public class CalendarServer extends UnicastRemoteObject implements CalendarService  {
   ...
   public DayCalendar createCalendar(String name) throws RemoteException, CalendarException {
        if (calendars.containsKey(name)) throw new CalendarException(name + "\" already exists.");
        DayCalendar newCal= new DayCalendarImpl(name);
        calendars.put(name, newCal);
        return newCal;
    }
    public DayCalendar getCalendar(String name) throws RemoteException, CalendarException {
        if (!calendars.containsKey(name)) throw new CalendarException(name + "\" does not exist.");
        return ((DayCalendar) calendars.get(name));
    }
    public ArrayList getCalendars() throws RemoteException {
        return new ArrayList(calendars.values());
    }
    public boolean exists(String name) throws RemoteException {
        return calendars.containsKey(name);
    }
}
```

Service Specification with CORBA IDL

IDL Type	Java Type
module	package
boolean	boolean
char, wchar	char
octet	byte
string, wstring	java.lang.String
short, unsigned short	short
long, unsigned long	int
long long, unsigned long	long
float	float
double	double
fixed	java.math.BigDecimal
enum, struct, union	class
sequence, array	array
...	...

```
module employee {
  struct EmployeeInfo {
    wstring name;
    long number;
    double salary;
  };


  exception SQLError {
    wstring message;
  };


  interface Employee {
    EmployeeInfo getEmployee (in wstring name) raises (SQLError);
    EmployeeInfo getEmployeeForUpdate (in wstring name) raises (SQLError);
    void updateEmployee (in EmployeeInfo name) raises (SQLError);
  };
};
```

The OSI model | Web Services



Web service types

- There exists two types of web services:
  - General web services, which provide support to remotely call any kind of operations
  - RESTful web services, which focus on state transfer

REST = Representational State Transfer

Roy Thomas Fielding. 2000. ***Architectural Styles and the Design of Network-Based Software Architectures***. Ph.D. Dissertation. University of California, Irvine.

- They both requires a significant amount of boilerplate code to function

General web services

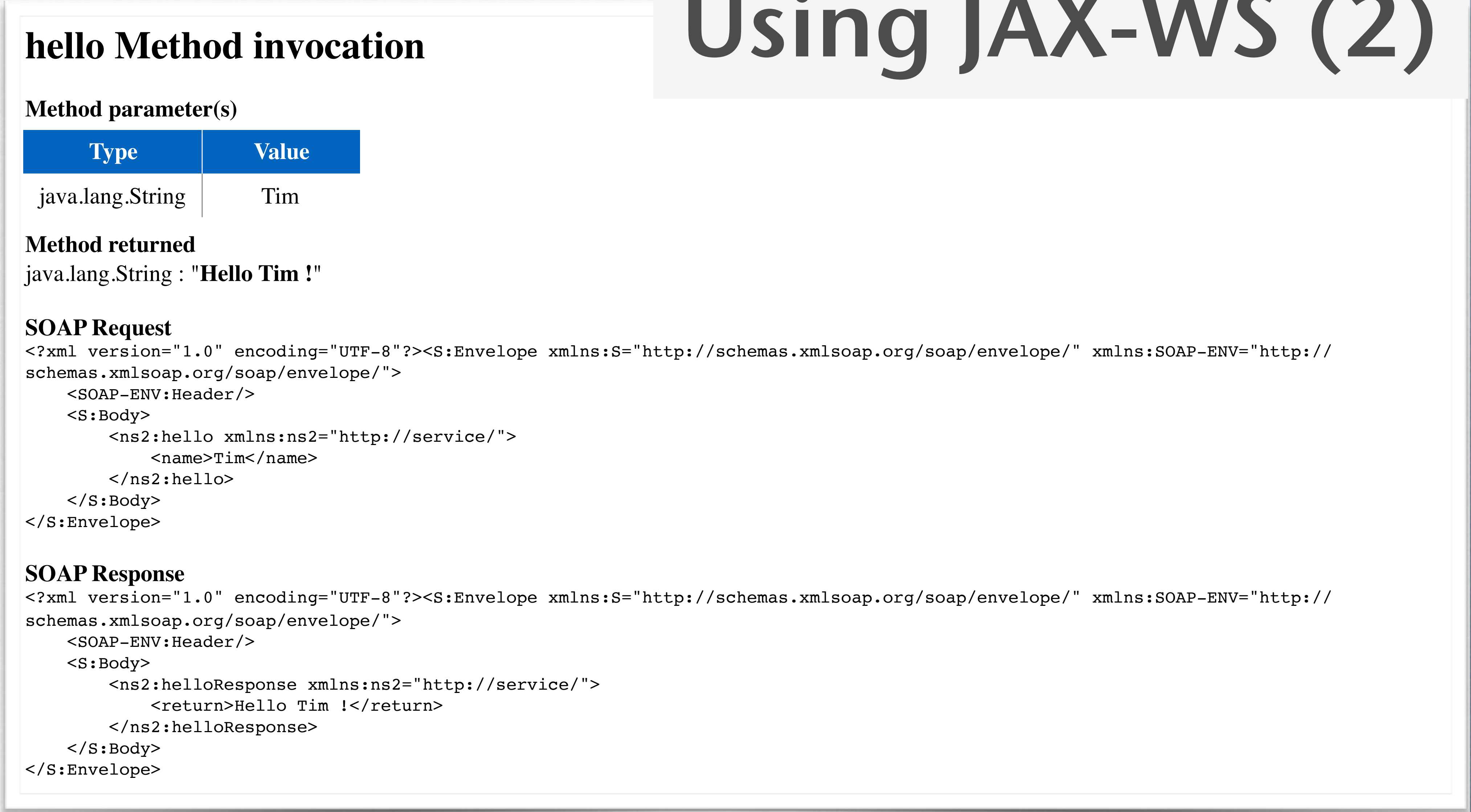
- They provide support to remotely call any kind of operations
- They rely on the Web Services Description Language (WSDL)
- They rely on the Simple Object Access Protocol (SOAP), an XML standard defining a message architecture and format
- In Java, JAX-WS is the technology that encapsulates (part of) the complexity of defining and using general web services

Using JAX-WS (1)

```xml
<definitions xmlns:wsu="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-utility-1.0.xsd" xmlns:wsp="http://
www.w3.org/ns/ws-policy" xmlns:wsp1_2="http://schemas.xmlsoap.org/ws/2004/09/policy" xmlns:wsam="http://www.w3.org/2007/05/addressing/
metadata" xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/" xmlns:tns="http://service/" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns="http://schemas.xmlsoap.org/wsdl/" targetNamespace="http://service/" name="HelloWorld">
<types>
<xsd:schema>
<xsd:import namespace="http://service/" schemaLocation="http://localhost:8080/HelloWorld/HelloWorld?xsd=1"/>
</xsd:schema>
</types>
<message name="hello">
<part name="parameters" element="tns:hello"/>
</message>
<message name="helloResponse">
<part name="parameters" element="tns:helloResponse"/>
</message>
<portType name="HelloWorld">
<operation name="hello">
<input wsam:Action="http://service/HelloWorld/helloRequest" message="tns:hello"/>
<output wsam:Action="http://service/HelloWorld/helloResponse" message="tns:helloResponse"/>
</operation>
</portType>
<binding name="HelloWorldPortBinding" type="tns:HelloWorld">
<soap:binding transport="http://schemas.xmlsoap.org/soap/http" style="document"/>
<operation name="hello">
<soap:operation soapAction=""/>
<input>
<soap:body use="literal"/>
</input>
<output>
<soap:body use="literal"/>
</output>
</operation>
</binding>
<service name="HelloWorld">
<port name="HelloWorldPort" binding="tns:HelloWorldPortBinding">
<soap:address location="http://localhost:8080/HelloWorld/HelloWorld"/>
</port>
</service>
</definitions>
```

WSDL

Using JAX-WS (2)



hello Method invocation

Method parameter(s)

Type	Value
java.lang.String	Tim

Method returned

java.lang.String : "**Hello Tim !**"

SOAP Request

```
<?xml version="1.0" encoding="UTF-8"?><S:Envelope xmlns:S="http://schemas.xmlsoap.org/soap/envelope/" xmlns:SOAP-ENV="http://
schemas.xmlsoap.org/soap/envelope/">
    <SOAP-ENV:Header/>
    <S:Body>
        <ns2:hello xmlns:ns2="http://service/">
            <name>Tim</name>
        </ns2:hello>
    </S:Body>
</S:Envelope>
```

SOAP Response

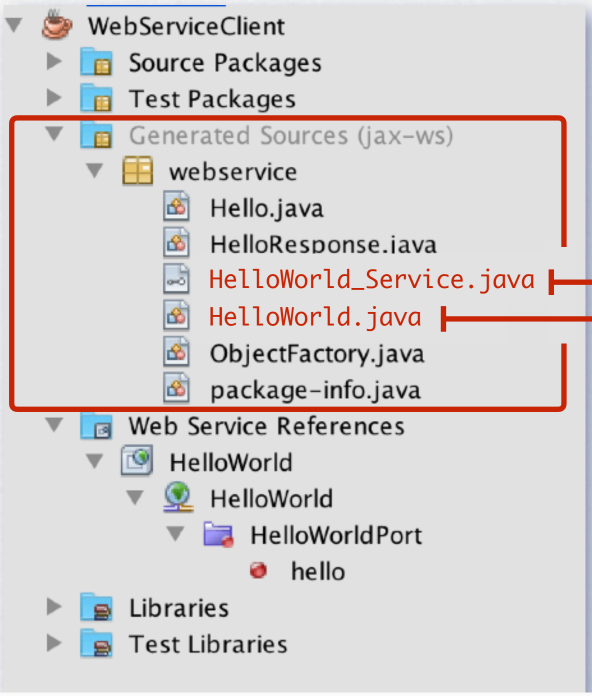
```
<?xml version="1.0" encoding="UTF-8"?><S:Envelope xmlns:S="http://schemas.xmlsoap.org/soap/envelope/" xmlns:SOAP-ENV="http://
schemas.xmlsoap.org/soap/envelope/">
    <SOAP-ENV:Header/>
    <S:Body>
        <ns2:helloResponse xmlns:ns2="http://service/">
            <return>Hello Tim !</return>
        </ns2:helloResponse>
    </S:Body>
</S:Envelope>
```

Using JAX-WS (3)

```java
@WebService(serviceName = "HelloWorld")
@Stateless()
public class HelloWorld {

  @WebMethod(operationName = "hello")
  public String hello(@WebParam(name = "name") String name) {
    System.out.println("I received a call with " + name + " as parameter");
    return "Hello " + name + " !";
  }
}
```

```java
public class Client {

  public static void main(String[] args) {
    String response = hello("Tim");
    System.out.println("response = " + response);
  }

  private static String hello(java.lang.String name) {
    webservice.HelloWorld_Service service = new webservice.HelloWorld_Service();
    webservice.HelloWorld port = service.getHelloWorldPort();
    return port.hello(name);
  }
}
```

Using JAX-WS (4)



```
WebServiceClient
    Source Packages
    Test Packages
    Generated Sources (jax-ws)
        webservice
            Hello.java
            HelloResponse.java
            HelloWorld_Service.java
            HelloWorld.java
            ObjectFactory.java
            package-info.java
    Web Service References
        HelloWorld
            HelloWorld
                HelloWorldPort
                    hello
    Libraries
    Test Libraries
```

```java
@WebServiceClient(name = "HelloWorld",
                  targetNamespace = "http://service/",
                  wsdlLocation = "http://localhost:8080/HelloWorld/HelloWorld?wsdl")
public class HelloWorld_Service
    extends Service
{
    private final static URL HELLOWORLD_WSDL_LOCATION;
    private final static WebServiceException HELLOWORLD_EXCEPTION;
    private final static QName HELLOWORLD_QNAME = new QName("http://service/", "HelloWorld");
    static {
        URL url = null;
        WebServiceException e = null;
        try {
            url = new URL("http://localhost:8080/HelloWorld/HelloWorld?wsdl");
        } catch (MalformedURLException ex) {
            e = new WebServiceException(ex);
        }
        HELLOWORLD_WSDL_LOCATION = url;
        HELLOWORLD_EXCEPTION = e;
    }
    public HelloWorld_Service() {
        super(__getWsdlLocation(), HELLOWORLD_QNAME);
    }
    ...
    @WebEndpoint(name = "HelloWorldPort")
    public HelloWorld getHelloWorldPort() {
        return super.getPort(new QName("http://service/", "HelloWorldPort"), HelloWorld.class);
    }
    ...
}
```

```java
@WebService(name = "HelloWorld",
            targetNamespace = "http://service/")
@XmlSeeAlso({
    ObjectFactory.class
})
public interface HelloWorld {
   @WebMethod
    @WebResult(targetNamespace = "")
    @RequestWrapper(localName = "hello", targetNamespace = "http://service/",
                    className = "webservice.Hello")
    @ResponseWrapper(localName = "helloResponse", targetNamespace = "http://service/",
                     className = "webservice.HelloResponse")
    @Action(input = "http://service/HelloWorld/helloRequest",
            output = "http://service/HelloWorld/helloResponse")
    public String hello(
        @WebParam(name = "name", targetNamespace = "")
        String name);

}
```

RESTful web services (1)

- They focus on state transfer, usually from/to some persistent storage, e.g., a relational database
- They manipulate state as resources accessed using Uniform Resource Identifiers (URIs) and four HTTP verbs as CRUD operations

HTTP	CRUD
PUT	CREATE
GET	READ
POST	UPDATE
DELETE	DELETE

Uniform Resource Identifier	GET	PUT	POST	DELETE
Collection, such as: `http://myservice.com/items/`	**list** the URIs and perhaps other details of the collection's items	**replace** the entire collection with another collection	**create** a new item in the collection, and return its automatically assigned URI	**delete** the entire collection
Item, such as: `http://myservice.com/items/item17`	**retrieve** a representation of the addressed item of the collection	**replace** the addressed item of the collection or **create** it, if it does not exist	**not often used**. Treat the addressed item as a collection and **create** a new item in it	**delete** the addressed item

RESTful web services (2)

- They do not formally require data to be represented using a particular format, although JSON and XML are very often used for structured data today
- They do not formally require an interface definition language, although it is now common practice to use the Web Application Definition Language (WADL) in Java
- In Java, JAX-RS is the technology that encapsulates (part of) the complexity of defining and using RESTful web services and Jersey is the reference implementation of JAX-RS

Using JAX-RS (1)

```xml
<application xmlns="http://wadl.dev.java.net/2009/02">
<doc xmlns:jersey="http://jersey.java.net/" jersey:generatedBy="Jersey: 2.10.4 2014-08-08 15:09:00"/>
<doc xmlns:jersey="http://jersey.java.net/" jersey:hint="This is simplified WADL with user and core resources only. To get full
WADL with extended resources use the query parameter detail. Link: http://localhost:8080/CustomerDB/webresources/application.wadl?
detail=true"/>
<grammars>
<include href="application.wadl/xsd0.xsd">
<doc title="Generated" xml:lang="en"/>
</include>
</grammars>
<resource path="entities.customer">
<method id="findAll" name="GET">
<response>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/xml"/>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/json"/>
</response>
</method>
<method id="create" name="POST">
<request>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/xml"/>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/json"/>
</request>
</method>
<resource path="{id}">
<param xmlns:xs="http://www.w3.org/2001/XMLSchema" name="id" style="template" type="xs:int"/>
<method id="edit" name="PUT">
<request>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/xml"/>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/json"/>
</request>
</method>
<method id="remove" name="DELETE"/>
<method id="find" name="GET">
<response>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/xml"/>
<ns2:representation xmlns:ns2="http://wadl.dev.java.net/2009/02" xmlns="" element="customer" mediaType="application/json"/>
</response>
</method>
</resource>
</resource>
...
</application>
```

WADL

Using JAX-RS (2)

```java
@Entity
@Table(name = "CUSTOMER")
@XmlRootElement
@NamedQueries({
  @NamedQuery(name = "Customer.findAll",
              query = "SELECT c FROM Customer c"), ...})
public class Customer implements Serializable {
 @Id
  @Basic(optional = false)
  @NotNull
  @Column(name = "CUSTOMER_ID")
  private Integer customerId;
  @Basic(optional = false)
  @NotNull
  @Size(min = 1, max = 10)
  @Column(name = "ZIP")
  private String zip;
  ...
 public Integer getCustomerId() {
    return customerId;
  }
  public void setCustomerId(Integer customerId) {
    this.customerId = customerId;
  }
  public String getZip() {
    return zip;
  }
  public void setZip(String zip) {
    this.zip = zip;
  }
  ...
}
```

```java
@Stateless
@Path("entities.customer")
public class CustomerFacadeREST extends AbstractFacade<Customer> {
 @PersistenceContext(unitName = "CustomerDBPU")
  private EntityManager em;
  public CustomerFacadeREST() {
    super(Customer.class);
  }
  @POST
  @Override
  @Consumes({MediaType.APPLICATION_XML, MediaType.APPLICATION_JSON})
  public void create(Customer entity) {
    super.create(entity);
  }
  @PUT
  @Path("{id}")
  @Consumes({MediaType.APPLICATION_XML, MediaType.APPLICATION_JSON})
  public void edit(@PathParam("id") Integer id, Customer entity) {
    super.edit(entity);
  }
  @DELETE
  @Path("{id}")
  public void remove(@PathParam("id") Integer id) {
    super.remove(super.find(id));
  }
  @GET
  @Path("{id}")
  @Produces({MediaType.APPLICATION_XML, MediaType.APPLICATION_JSON})
  public Customer find(@PathParam("id") Integer id) {
    return super.find(id);
  }
  @GET
  @Override
  @Produces({MediaType.APPLICATION_XML, MediaType.APPLICATION_JSON})
  public List<Customer> findAll() {
    return super.findAll();
  }
 ...
}
```

Using JAX-RS (3)

```java
public class Main {
  public static void main(String[] args) {
    CustomerDBClient client = new CustomerDBClient();

    String response = client.countREST();
    System.out.println("Client response is : " + response);
    ...
    client.close();
  }
}
```

```java
public class CustomerDBClient {
 private WebTarget webTarget;
  private Client client;
  private static final String BASE_URI = "http://localhost:8080/CustomerDB/webresources";

  public CustomerDBClient() {
    client = javax.ws.rs.client.ClientBuilder.newClient();
    webTarget = client.target(BASE_URI).path("entities.customer");
  }
  public void create_XML(Object requestEntity) throws ClientErrorException {
    webTarget.request(javax.ws.rs.core.MediaType.APPLICATION_XML)
             .post(javax.ws.rs.client.Entity.entity(requestEntity, javax.ws.rs.core.MediaType.APPLICATION_XML));
  }
  public void create_JSON(Object requestEntity) throws ClientErrorException {
    webTarget.request(javax.ws.rs.core.MediaType.APPLICATION_JSON)
             .post(javax.ws.rs.client.Entity.entity(requestEntity, javax.ws.rs.core.MediaType.APPLICATION_JSON));
  }
  public String countREST() throws ClientErrorException {
    WebTarget resource = webTarget;
    resource = resource.path("count");
    return resource.request(javax.ws.rs.core.MediaType.TEXT_PLAIN).get(String.class);
  }
  public void remove(String id) throws ClientErrorException {
    webTarget.path(java.text.MessageFormat.format("{0}", new Object[]{id})).request().delete();
  }
  ...
  public void close() {
    client.close();
  }
}
```