ID2212 Network Programming with Java
Lecture 12

Enterprise JavaBeans (EJBs) and WebSockets

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Enterprise JavaBeans (EJB)

`javax.ejb`

home page:
http://www.oracle.com/technetwork/java/index-jsp-140203.html

Outline

- **Enterprise JavaBeans (EJB)**
  - **Session**
  - **Message-Driven**
- **Example: Bank Account Application – to be considered at Exercise 4 (see slides of Exercise 4)**

Enterprise JavaBeans (EJB)

- **An EJB is a server-side components that exposes methods for performing application logic**
- EJB 3
  - *Session Beans* **(stateless and stateful) represent actions (a single action, a session)**
    - **Performs a task for a client; optionally may implement a web service**
  - *Message-driven Beans*
    - **Acts as a listener for a particular messaging type, such as the Java Message Service (JMS)**
- **EJB 2**
  - *Session Beans* **(stateless and stateful)**
  - *Entity Beans* **represent persistent stateful entity (e.g. account, person, customer). An entity bean – a row in a database**
  - **Entity beans have been replaced by Java Persistence API entities.**

Session Beans

- **Business process objects, for example, business logic, workflow and similar**
- **A *session bean* represents a single client inside the Application Server.**
  - **Used only by one client at a time**
  - **Lives for the session (or lifetime) of the calling client**
- **Two kind of sessions EJBs**
  - *Stateless session EJBs*
  - *Stateful session EJB*

A Stateful Session Bean

- **The bean class is annotated as `@Stateful`**
- **Spans multiple client calls and retains state on behalf of the individual client (conversational state).**
- **One bean instance per client.**
  - **Values of instance variables represent the state of a unique client session.**
    - **A.k.a. the *conversational state***
  - **If the client removes the bean or terminates, the session ends and the state disappears.**
- **Example: A shopping cart**

A Stateless Session Bean

- **The bean class is annotated as `@Stateless`**
- **Accommodates only a single request.**
- **Does not maintain a conversational state with the client.**
  - **May contain state, but not conversational state related to a specific client.**
- **A pool of beans**
  - **All instances of a stateless bean are equivalent**
  - **Better scalability than stateful beans.**
- **Example: A currency converter**

Business Interface of a Session Bean

- **A client uses a session bean through the methods of the bean's *business interface*.**
  - **The interface includes the business methods exposed by the bean's class**
  - **The bean class implements the business interface**
- **A client of a session bean can be a web component, an application client, or another EJB**

Business Interface of a Session Bean (contd)

- **The client gets a reference to the session bean's interface either through *injection or JNDI lookup***
- **The following example illustrates both options. Note that JNDI lookup is *very seldom* required.**

```
@WebServlet(name = "AdderServlet", urlPatterns = {"/AdderServlet"})
public class AdderServlet extends HttpServlet {
    @EJB
    private AdderRemote adder; //injection
    //private AdderRemote adder = lookupAdderBeanRemote(); // through lookup
    private AdderRemote lookupAdderBeanRemote() {
        try {
            Context c = new InitialContext();
            return (AdderRemote) c.lookup(
                        "java:global/Adder/Adder-ejb/AdderBean!adder.AdderRemote");
        } catch (NamingException ne) {
            Logger.getLogger(getClass().getName()).log(Level.SEVERE,
                                                    "exception caught", ne);
            throw new RuntimeException(ne);
        }
    }
```

Business Interface Design Options

- *Local interface* **for local clients on the same JVM**
- *Remote interface* **for remote clients on different JVM**
  - **Remote interface obeys the rules of Java RMI.**
- *No-interface* **view for local clients**
  - **All public methods of the bean class are automatically exposed to the client**
  - **Does not require a separate interface; there is no the `implements` clause**
  - **The same behavior as the local interface view**
  - **Simplifies programming**
- *Web Services interface*
  - **Exposing business methods as Web Services**
  - **Stateless session beans can be invoked over SOAP/HTTP**

A Session EJB with a Remote Interface

- **An interface for remote access**
- **Annotate the interface with the `@Remote` annotation:**

```
@Remote
public interface InterfaceName {
    ...
}
```

- **Annotate the bean class with `@Remote`, specifying the business interface(s):**

```
@Remote(InterfaceName.class)
public class BeanName implements InterfaceName
 {
    ...
}
```

A Session EJB with a Local Interface

- **An interface for local access**
- **Annotate the interface with the `@Local` annotation:**

```
@Local
public interface InterfaceName {
    ...
}
```

- **Annotate the bean class with `@Local`, specifying the business interface(s):**

```
@Local (InterfaceName.class)
public class BeanName implements InterfaceName
 {
    ...
}
```

A Session EJB without Interface

- **Annotate the bean class with `@LocalBean` annotation**

```
@LocalBean
public class BeanName {
    ...
}
```

Deciding on Remote or Local Access

- **Tight or loose coupling of related beans:**
  - **Tightly coupled beans depend on one another, and they are good candidates for *local access*.**
- **Type of client:**
  - **To enable clients accessing the EJB direct, not through a web interface, the EJB must allow *remote access*,**
  - **For EJBs accessed by web components or other EJBs, *local access* is almost always preferred.**

Deciding on Remote or Local Access (contd)

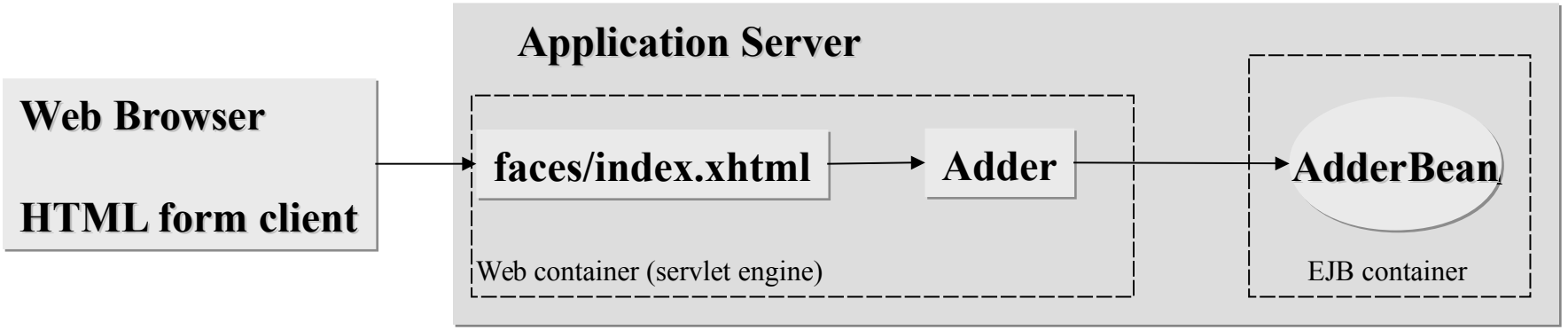
- **Semantics:**

  Remote calls use pass-by-value semantics, local calls use pass-by-reference.

- **Component distribution:**
  - **Server-side components can be distributed among multiple machines for scalability.**
  - **Web components may run on a different server than EJBs, but this is very seldom useful.**
- **Performance:**
  - **Remote calls are slower than local calls.**

Example: Adder Service

- A client-server application
  - A user enters an integer number via an HTML form and gets a sum accumulated by the Adder application.
- The Adder application includes:
  - The index.xhtml JSF page
  - The Adder managed bean
  - The AdderBean EBJ (session, stateful) that accumulates a sum of integers entered by a user, and returns the sum on request



Client

- **An HTML Form in a Web page (index.xhtml)**

```
<?xml version='1.0' encoding='UTF-8' ?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml"
      xmlns:h="http://java.sun.com/jsf/html">
    <h:head>
        <title>Adder site</title>
    </h:head>

    <h:body>
        <h1>Adder Site</h1>
        <h3>The running total is #{adder.total}</h3>
        <h:form>
            <p><h:outputLabel for="operand" value="Please enter an integer: "/>
                <h:inputText id="operand" value="#{adder.operand}"/>
            </p>
            <p><h:commandButton value="Add"/></p>
        </h:form>
    </h:body>
</html>
```

Adder Managed Bean

- **The Adder managed bean is a client of the Adder EJB**

```
package se.kth.id2212.lec12.view;

import java.io.Serializable;
import javax.ejb.EJB;
import javax.enterprise.context.SessionScoped;
import javax.inject.Named;
import se.kth.id2212.lec12.model.AdderBean;

@Named(value = "adder")
@SessionScoped
public class Adder implements Serializable {

    private static final long serialVersionUID = -3552965833778221283L;
    @EJB
    private AdderBean adderBean;
```

Adder Managed Bean (cont'd)

```
public int getTotal() {
    return adderBean.getTotal();
}

public void setOperand(Integer operand) {
    adderBean.add(operand);
}

public Integer getOperand() {
    return null;
}
```

Adder EJB (Stateful Session Bean)

- **Interface operations:**

```
public void add (int number)
public int getTotal()
```

- `private int total; // state of the bean`

Adder EJB (contd)

```
package se.kth.id2212.lec12.model;

import javax.ejb.Stateful;

@Stateful
public class AdderBean {
    private int total;

    public void add(int operand) {
        total = total + operand;
    }

    public int getTotal() {
        return total;
    }

}
```

Message-Driven Beans

- **A *message-driven bean* is an EJB that allows Java EE applications to process messages *asynchronously*.**
  - **Normally acts as a *JMS message listener*.**

- **Defference between m-d beans and session beans**
  - **Clients do not access m-d beans by method calls through interfaces;**
  - **M-d bean instead implements the `MessageListener` interface with the `onMessage` method.**

- **A m-d bean resembles a stateless session bean**
  - **M-d bean instances retain no conversational state for a specific client;**
  - **All instances of a m-d bean are equivalent;**
  - **A single m-d bean can process messages from multiple clients.**

Features of Message-Driven EJBs

- **Stateless.**
- **Execute upon receipt of a single client message.**
- **Invoked asynchronously.**
- **Can be transaction-aware.**

- **An example is a log service**

Client Interaction with a Message-Driven Bean

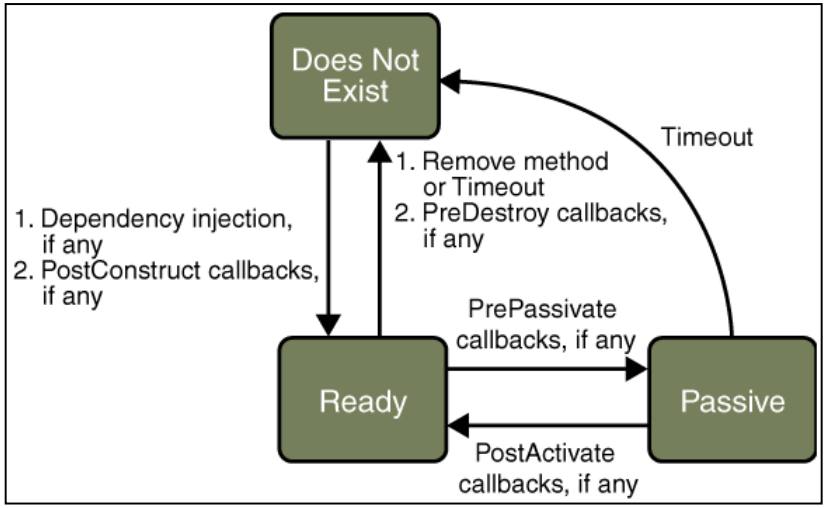
- **A client interacts with a m-d bean through JMS by sending messages to the destination for which the message-driven bean class is the JMS message listener.**

- **An m-d bean's class is annotated `@MessageDriven` with a name of the bean's destination, e.g.**
  `@MessageDriven(mappedName = "jms/Queue")`

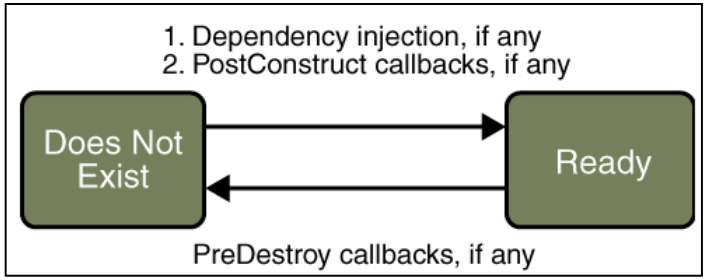
- **When a message arrives, the container calls the message-driven bean's `onMessage` method to process the message.**

Life Cycles of EJBs

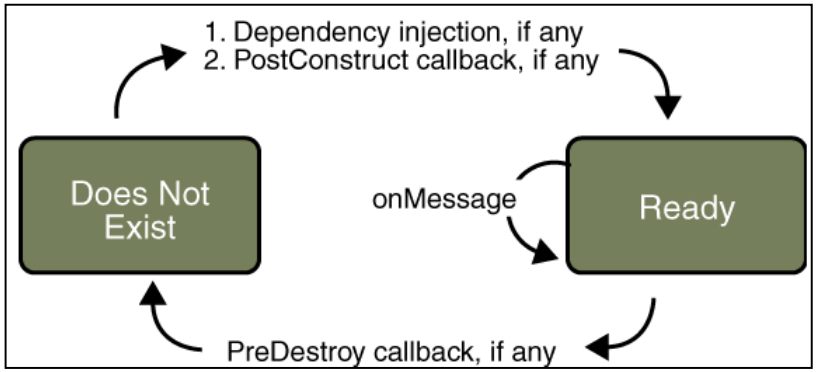
- **Stateful session bean**



- **Stateless session bean**



- **Message-driven bean**



- **During the bean's lifetime, the EJB Container invokes methods annotated `@PostConstruct`, `@PrePassivate`, `@PostActivate`, `@PreDestroy`, `@Remove`.**
- **When a client calls a business method on a bean, which does not exists or is passive, the container constructs the bean or activates the bean to make it ready.**

Networking with WebSockets

`javax.websocket`

home page:
http://www.oracle.com/technetwork/articles/java/jsr356-1937161.html

Outline

- Web Based Communication
  - HTTP Limitations
  - WebSocket Contribution
- The WebSocket API in JavaEE
  - Endpoints
  - Sending/Receiving Messages
  - Encoders/Decoders
  - Accessing Sessions
  - WebSocket Clients

HTTP Limitations

Half-Duplex (Request / Response based)

- A ***client*** requests a resource and the ***server*** provides access to it

Verbose (adds communication overhead)

Complicated when resources change *frequently*

- eg. *Social networking, gaming, collaborative editing, financial applications etc*.
- Polling is **inefficient**

HTTP Limitations

Long Polling (Comet) offered small improvement

- Establishes a persistent connection and waits for the server to push data when it becomes available
- Still requires a new connection (handshake) per update
- Still adds the communication overhead of HTTP

WebSockets Contribution

- **WebSockets** (RFC 6455) build on a **single** TCP connection and offer **bi-directional**, **full-duplex** communication through the web (HTTP)
- **Message-Based** communication (text, binary and ping-pong messages)
- Offers *addressing* and *protocol naming* mechanisms to support multiple services on one port (eg. 80)

WebSockets Contribution

- WebSocket connection **endpoints** can be represented by URIs:
  - **ws://host:port/path?query** ***(plain websocket connection)***
  - **wss://host:port/path?query** ***(encrypted websocket connection)***

- They are currently supported by modern browsers through a JavaScript API to allow
  - Endpoints connection
  - Callbacks for Sending/Receiving messages and connection state events

WebSockets Contribution

A websocket connection is established by upgrading a HTTP connection. Browser and server exchange the following handshake.

```
GET /path/to/websocket/endpoint HTTP/1.1
Host: localhost
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Key: xqBt3ImNzJbYqRINxEFlkg==
Origin: http://localhost
Sec-WebSocket-Version: 13

HTTP/1.1 101 Switching Protocols
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Accept: K7DJLdLooIwIG/MOpvWFB3y3FE8=
```

Messaging Over WebSockets

- WebSockets is a protocol enabling transport over a network, much like TCP or UDP.
- It is often convenient to use a higher level protocol on top of WebSockets, instead of using plain websockets endpoints.
- There are many such protocols, for example
    - Web Application Messaging Protocol, WAMP
    - Java Message Service, JMS
    - Advanced Message Queuing Protocol, AMQP
    - Extensible Messaging and Presence Protocol, XMPP

WebSockets in Java

- WebSockets were introduced in JavaEE 7.0
  - javax.websocket and javax.websocket.server
  - Supported by Web Containers (Tomcat 8, Glassfish 4.0, Jetty, WildFly)

- **Endpoints** are instances of the javax.websocket.Endpoint class
- There are **two** ways of defining Endpoints:
  - **Programmatic Endpoints:** Extending javax.websocket.Endpoint and overriding lifecycle methods
  - **Annotated Endpoints:** Decorating classes with provided annotations. *This is generally **preferred** to the programmatic approach.*

Endpoints

- WebSocket Endpoints are **not** sockets! Sockets are **stream-based** while Endpoints are **message-based**.

- WebSocket Server Endpoints are **not** servlets! The container creates **one** Endpoint instance **per connection**.

- Any POJO can be converted into an Endpoint simply via using appropriate WebSocket annotations.

Annotated Endpoints

- Easier to Write
- A simple Endpoint that echoes back every text message:

```
@ServerEndpoint("/echo")
public class EchoEndpoint {

   @OnMessage
   public String doEcho(String textMsg) {
     return textMsg;
   }
}
```

Programmatic Endpoints

- More complicated to write.
- A simple Endpoint that echoes back every text message:

```
public class EchoEndpoint extends Endpoint {

   @Override
   public void onOpen(final Session session, EndpointConfig
   eConf) {
   session.addMessageHandler(new MessageHandler.Whole<String>() {

      @Override
       public void onMessage(String textMsg) {
          try{
             session.getBasicRemote().sendText(textMsg);
          } catch(IOException ioe) {
   ...
          }
        }
     });
   }
}
```

Annotated Endpoints

Easier to Write

A simple Endpoint that echoes back every text message:

```
@ServerEndpoint("/echo")
public class EchoEndpoint {

   @OnMessage
   public String doEcho(String textMsg) {
     return textMsg;
   }
}
```

Annotated Endpoints

- Annotated Endpoints are simpler and automatically deployed with the Web Application on the relative path defined by the ServerEndpoint annotation.
- There are annotations for every Endpoint lifecycle event:

Annotation	Lifecycle Event	Expected Parameters
OnOpen	Connection Opened	Session, EndpointConfig, PathParam
OnMessage	Message Received	Session, String|ByteBuffer|PongMessage|POJO, PathParam
OnError	Error Occurred	Session, Throwable, PathParam
OnClose	Connection Closed	Session, CloseReason, PathParam

Receiving Messages

- Currently the following message types are supported:

Message Type	Description
String	A message decoded and wrapped as a character string
ByteBuffer	A message passed as a byte sequence to be manually de-serialized
Pong	Dummy message to be used for checking the connection

Receiving Messages

- An Endpoint can have up to three message handlers

```
@ServerEndpoint("/ireadeverything")
public class ThreeTypeEndpoint {

   @OnMessage
   public void receiveText(Session session, String textMsg) {
   }

   @OnMessage
   public void receiveBinary(Session session, ByteBuffer
   binaryMsg) {
   }

   @OnMessage
   public void receivePong(Session session, PongMessage pongMsg)
   {
   }
}
```

Sending Messages

- Each connection's session object exposes two remote peer interfaces for sending messages:
  - RemoteEndpoint.Basic for blocking communication
  - RemoteEndpoint.Async for asynchronous communication

```
@OnMessage
Public void messageBack(Session session, String str)
{
   session.getBasicRemote().sendText(str); //blocks
   session.getAsyncRemote().sendText(str): //returns
   instantly
}
```

Encoders/Decoders

- For converting messages to/from POJOs the API offers the following interfaces:

Interface	Description
Encoder.Text<T>	Encode from T to String
Encoder.Binary<T>	Encode from T to binary
Decoder.Text<T>	Decode from String to T
Decoder.Binary<T>	Decode from binary to T

Encoders/Decoders

•For each server Endpoint we can define many encoders and at most **one** decoder per input type (String, Binary) as ServerEndpoint annotation parameters.

```
@ServerEndpoint(
   value = "/echoserver",
   encoders = {MyEncoderA.class,
   MyEncoderB.class},
   decoders = {MyDecoder.class}
)
public class EchoServer{
   @OnMessage
   public void message(Session session, MyMessage
   msg){
   …
   }
}
```

Encoders/Decoders

- Defining an encoder

```
public class MyEncoderA implements
   Encoder.Text<MyMessageA>{
   @Override
   public void init(EndpointConfig econf){}
   @Override
   public void destroy(){}
   @Override
   public String encode(MyMessageA myMsg){
   return myMsg.getJson();
   }
}
```

- Same for MyMessageB…

Encoders/Decoders

- Defining the decoder. For multiple type support there should be one **common superclass/interface** defined.

```
public class MyDecoder implements Decoder.Text<MyMessage>{
   @Override
   public void init(EndpointConfig econf){}
   @Override
   public void destroy(){}
   @Override
   public MyMessage decode(String textMsg) throws
   DecodeException{
   //parse textMsg
   …
   // MyMessageA and MyMessageB should inherit MyMessage
   return new MyMessageA(textMsg);
   … //or
   return new MyMessageB(textMsg);
   }
   …
}
```

Encoders/Decoders

- For sending a custom Message use the sendObject method of a RemoteEndpoint.

```
MyMessageA myA = new MyMessageA();
MyMessageB myB = new MyMessageB();

Session.getBasicRemote.sendObject(myA);
Session.getAsyncRemote.sendObject(myA);
```

Accessing Sessions

- A Session object provides access to all sessions connected to the same endpoint. (useful for web applications where users interact eg. chat, games, collaborative editing etc.)

```
@ServerEndpoint("/myblackboard")
public class Blackboard {
   @OnMessage
   public void onMessage(Session session, String msg){
   try{
     for(Session userSession : session.getOpenSession())
   {
        if(userSession.isOpen())
   userSession.getBasicRemote().sendText(msg);
     }
   }
   }
}
```

http://docs.oracle.com/javaee/7/tutorial/doc/websocket005.htm

WebSocket Clients

- Typically WebSocket clients run in browsers, written in JavaScript.

```
var myWebscoket;

function connect() {
   myWebSocket = new
   WebSocket("ws://test.kth.se:8080/myblackboard");
   myWebSocket.onmessage = messageHandl;
}

var blackboardPanel = document.getElementById("mypanel");

function messageHandl(blackboardMsg){
   blackboardPanel.innerHTML += blackBoardMsg;
}
```

More Info

- Javax.websocket API
  - http://docs.oracle.com/javaee/7/api/javax/websocket/package-summary.html
- Specification
  - http://tools.ietf.org/html/rfc6455