Open Source Frameworks (OSF)
An Introduction to Java Enterprise Edition (Java EE)

Open Source Frameworks (OSF)
Master of Science in Engineering (MSE)
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The Notion of Systemic Quality

The notion of systemic quality

- How do we specify the **requirements** of a system?
  - We always build systems to deliver some sort of "**service**" (web, messaging, access control, customer management, etc.).
  - We first have to specify “**what**” the system should do. In other words, we have to specify **functional requirements**.
    - We also have to specify “**how**” the system should behave, i.e. what qualities it should exhibit. These are the **non-functional requirements**.
- Non-functional requirements characterize **systemic qualities, or “-ilities”**:
  - There are lots of different systemic qualities. Depending on the system, some are more important than others.
  - Choices made when defining the system architecture have a large impact on the systemic qualities.
  - Your life as an architect will be to deal with **trade-offs** in addressing conflicting systemic qualities.

Example

System
Vehicle

Functional requirements
Move people around

Non-functional requirements
Performance
Capacity
Reliability
Cost
Aestethics
Ease of use

Different systemic qualities often create **opposing forces**.

Defining the “right” architecture for a system means finding the right **balance** between these forces.

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Some systemic qualities...

- **Response time**
  - Measures the time required to present a result to the user
  - Important for the end-user
- **Throughput**
  - Measures the number of requests that can be processed in a given time frame
  - Important for the service provier
- **Scalability**
  - Measures how easy/costly it is to adapt the system in order to handle additional load
  - Ideally: linear scalability. "2 x more users => 2 x more servers”
- **Availability**
  - Measures the percentage of time during which the system can be used
  - 99% availability = average unavailability of 3.65 jours per year, i.e 1 hour and 41 minutes per week.

http://en.wikipedia.org/wiki/Ilities

Some systemic qualities...

- **Reliability**
  - Mesure la capacité du système à "remplir sa fonction" sur une période.
  - Un système peut avoir une fiabilité plus élevée que celle d'un de ces sous-système (notamment grâce à la redondance).
  - Mesure exprimée en "temps moyen entre 2 pannes" (Mean Time Between Failures).
- **Evolutivity**
  - Mesure la facilité avec laquelle le système pourra être adapté pour satisfaire à de nouvelles exigences (fonctionnelles et non-fonctionnelles!).
- **Security**
  - Mesure la capacité du système à empêcher une utilisation abusive.
- **Manageability**
  - Mesure la facilité avec laquelle l'état du système pourra être surveillé, les pannes détectées, des opérations de maintenance réalisées, etc.

http://en.wikipedia.org/wiki/Ilities

Java Enterprise Edition (Java EE)

What is Java Enterprise Edition?

- It is a development platform: it provides high-level APIs to develop software components.

- It is an execution platform: it provides an environment to deploy and bring these components “to live”.

- It is an entreprise platform: it provides support for distributed transactions, security, integration, etc.

- Separation of concerns: "The developer takes care of the business logic. Java EE takes care of the systemic qualities".

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Java EE and standards

- Java EE is a specification
  - Defined through the JCP, it is a specification that software editors can decide to implement. Java EE 5 is defined in JSR 244.
- Java EE is an “umbrella” specification
  - Java EE builds upon other specifications (servlets, EJBs, JDBC, etc.) and specifies which specifications (and which versions) need to be implemented by a Java EE certified application server.
  - Java EE also defines a programming model and defines several roles (developer, assembler, deployer, etc.).

Java Community Process

Specification Lead
Bill Shannon — Sun Microsystems, Inc.

Expert Group

Barreto, Charlton	BEA Systems	Borland Software Corporation
Capgemini	Chandrasekaran, Muralidharan	Crawford, Scott
Dudney, Bill	E.piphany, Inc.	Genender, Jeff
Hewlett-Packard	IBM	Ironflare AB
Kohen, Elika S.	Leme, Felipe	Novell, Inc.
Oracle	OW2	Pramati Technologies
Pratap, Rama Murthy Amar	Raible, Matt	Red Hat Middleware LLC
Reinshagen, Dirk	SAP AG	SeeBeyond Technology Corp.
Shah, Suneet	Sun Microsystems, Inc.	Sybase
Tiwari, Ashish	Tmax Soft, Inc.	Trifork
Umapathy, Sivasundaram		

J2EE or Java EE?

- Java Enterprise Edition is **not** a recent specification.
- The SDK 1.2 was published in 1999.
- The specification is managed through the JCP since version 1.3
- We used to talk about "Java 2 Enterprise Edition 1.3", or J2EE 1.3
- We then moved from J2EE 1.3 to J2EE 1.4 to... **Java EE 5**
- Today, we should speak of Java EE, but J2EE is still sometimes used...
- Today, most application servers implement Java EE 6
- The early draft 2 for Java EE 7 has been submitted in November 2012; final spec expected for Q2 2013

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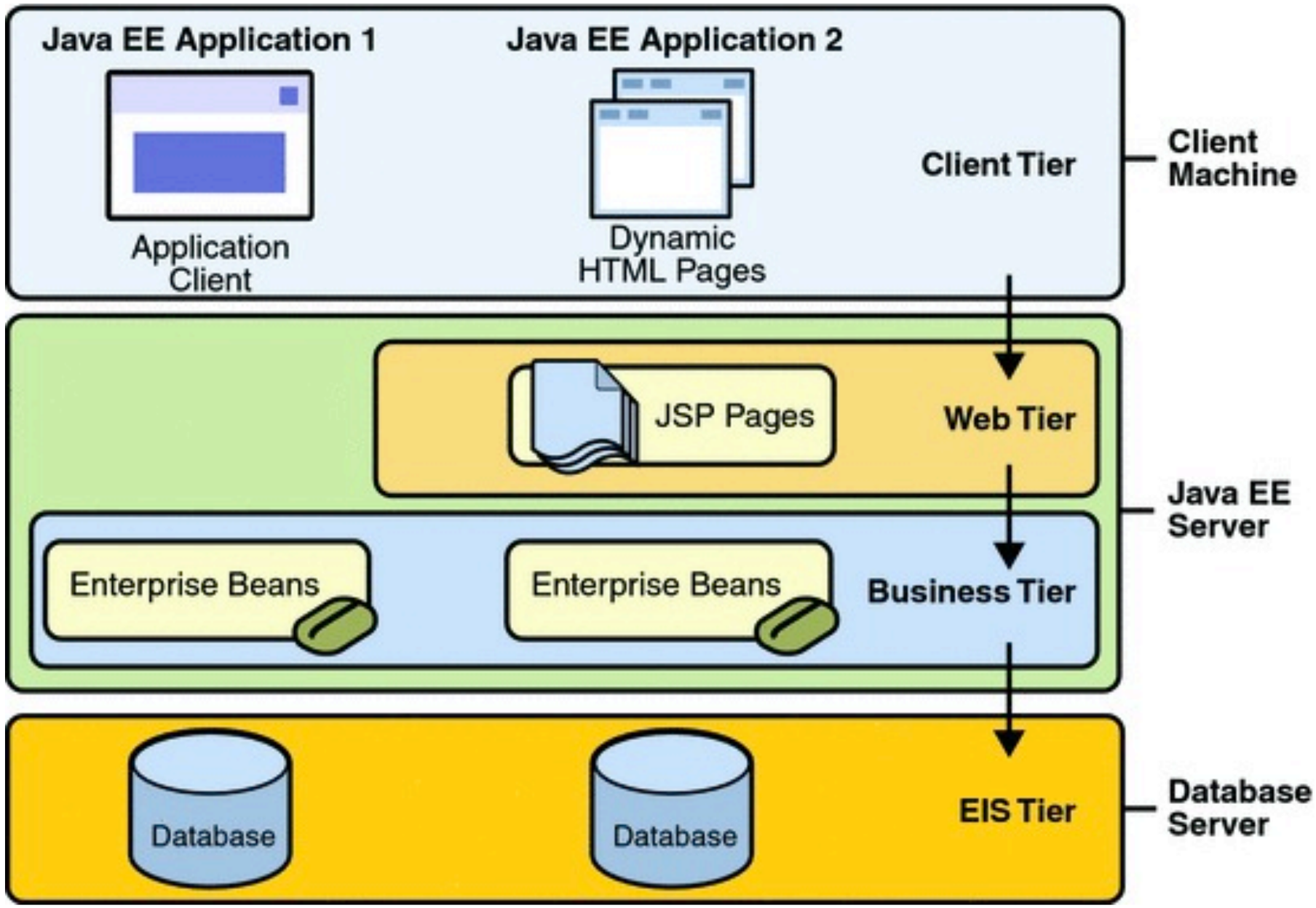
Sybase
Trifork

Architecture

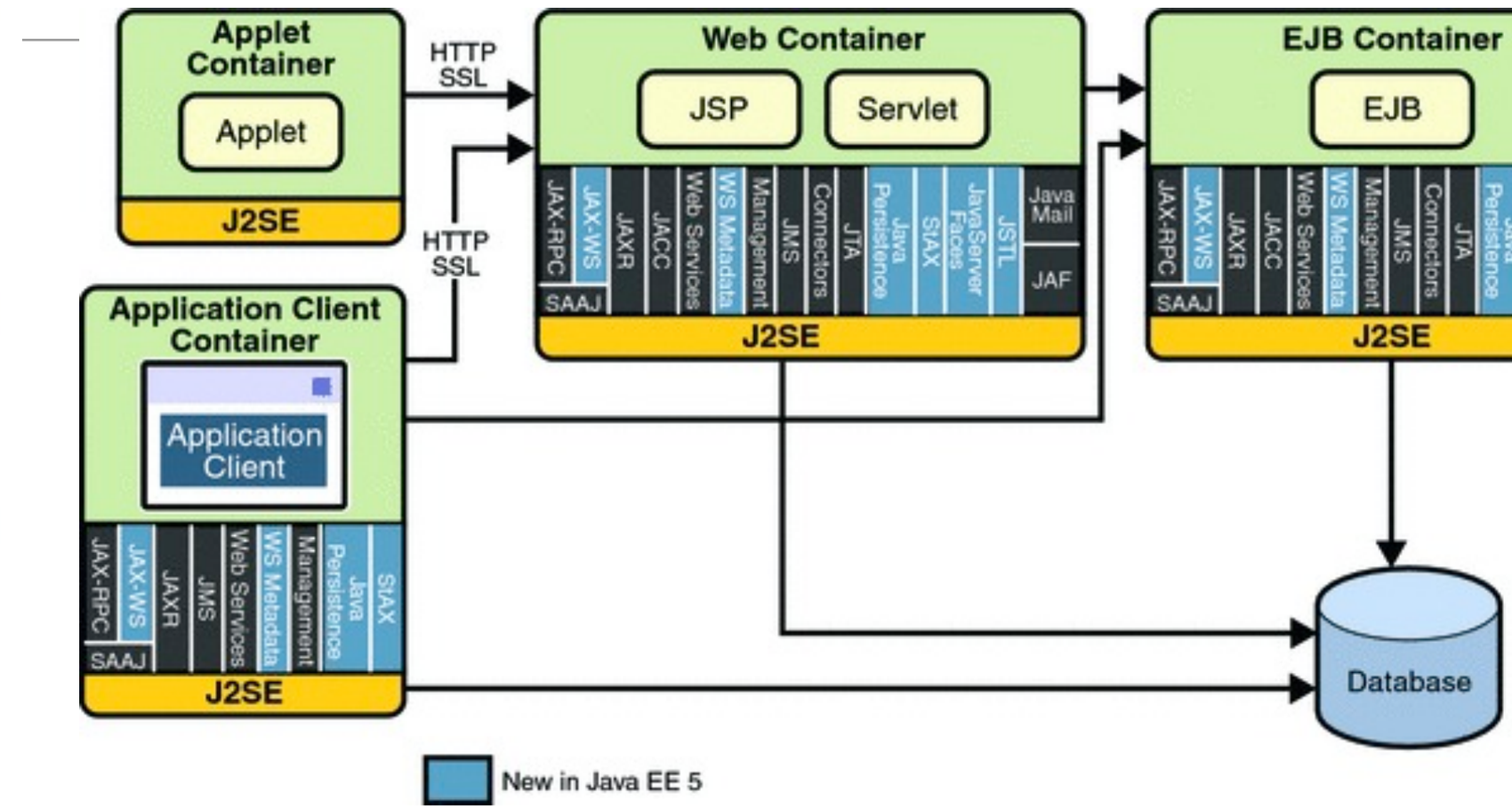
- The software that implements the Java EE specification is called an "**application server**"
  - There are **open source** and **proprietary** application servers.
  - Glassfish, JBoss, WebSphere, BEA WebLogic are examples of application servers.
    - Editors compete on aspects that are not defined the specification (clustering, administration, etc.).
- Key notion in the Java EE architecture: the **containers**
  - a container is an **environment** in which we deploy components;
  - a container **provides services** (transactions, security, etc.) through APIs;
  - there are different containers in Java EE: the "**web**" container, the "**ejb**" container and even a "**client**" container that can be used for rich clients.



http://java.sun.com/javaee/5/docs/tutorial/doc/bnaay.html

Java EE 5 APIs

- Enterprise JavaBeans Technology
- Java Servlet Technology
- JavaServer Pages Technology
- JavaServer Pages Standard Tag Library
- JavaServer Faces
- Java Message Service API
- Java Transaction API
- JavaMail API
- JavaBeans Activation Framework
- Java API for XML Processing
- Java API for XML Web Services (JAX-WS)
- Java Architecture for XML Binding (JAXB)
- SOAP with Attachments API for Java
- Java API for XML Registries
- J2EE Connector Architecture
- Java Database Connectivity API
- Java Persistence API
- Java Naming and Directory Interface
- Java Authentication and Authorization Service
- Simplified Systems Integration



http://java.sun.com/javaee/5/docs/tutorial/doc/bnacj.html

Components, packaging & deployment

- The first version of J2EE put a lot of emphasis on the separation of roles:
  - **Component developer** builds self-contained, reusable **components** and focuses on business logic (“Here is a customer management brick”, “Here is a pricing brick”).
  - **Application assemblers** create **applications** by gluing together different components (“I connect the customer management and the pricing bricks in order to have an insurance application”).
  - **Deployers** have to take applications and to put them into production. Every application needs resources (DBs, user repositories, etc.). The deployer has to connect the application to the resources (declaratively!!).
- We also want to be able to manage the life-cycle of applications and to have control on the release of new versions. It really helps to create **packages**!

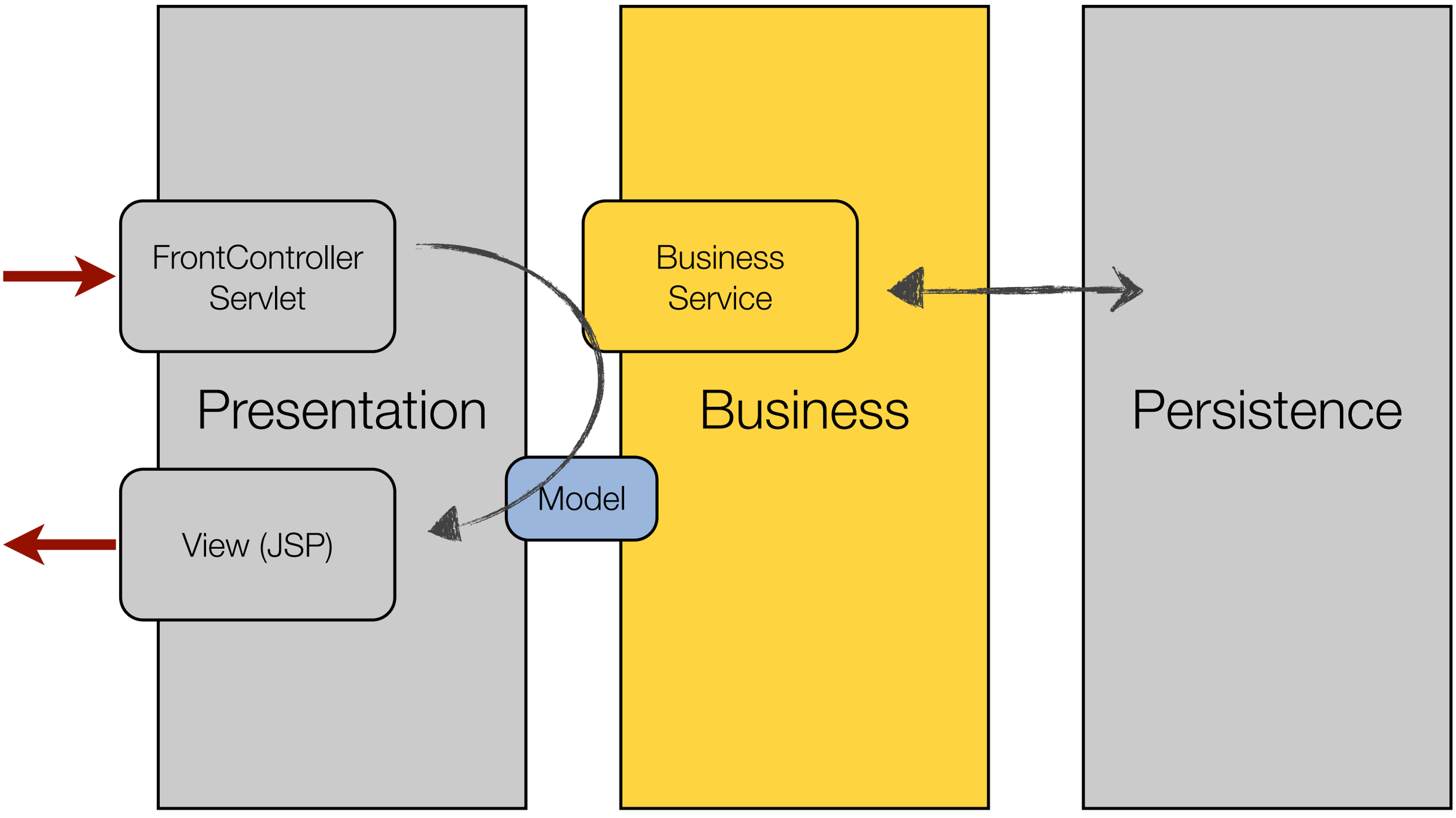
Components, packaging & deployment

- Different types of components, different types of packages/archives:
  - Java libraries are useful in enterprise applications; we can bundle classes into **traditional .jar files (Java ARchives)** and integrate them in our applications.
  - Some applications do not require all the features provided by the Java EE platform; they are “lightweight” can live entirely in the web container. We package these applications in **.war files (Web ARchives)**.
  - Business services can be packaged and deployed independently from a presentation front-end. We can package **EJBs in .jar files**.
  - Full-blown Java EE applications bundle together web-tier components, service components, libraries. A Java EE application is packaged in a **.ear file (Enterprise ARchive)**. The .ear file contains a .war files and one or more .jar files.

Content of archives

- In .war, .jar and .ear files, we find:
  - **Compiled classes and libraries**
  - **Resources** (images, property files, configuration files, etc.)
  - **Deployment descriptors**
- Deployment descriptors make it possible to alter the system-level behavior of the application **declaratively**, at deployment time:
  - Change security mappings, change transaction isolation level, change database connection parameters, change URL mappings, etc.
- In J2EE, deployment descriptors were mandatory and quite a pain to write (IDE added support over time, and XDoclet introduced a way to generate them automatically).
- In Java EE, deployment descriptors are still available but are largely replaced by @annotations. In Java EE 5, annotations are generally used for EJBs. The web.xml deployment descriptor is still used.

The Business Tier



Agenda

- Containers & components
- Enterprise Java Beans (EJB)
  - Stateless and stateful session beans (SLSB and SFSB)
  - Message-driven beans (MDB) will be presented later (JMS)
- Resource pooling
- Life cycle
- Getting a reference to the service: lookup vs. dependency injection
- Interceptors

Containers and components

- There are **different ways** to design, build and deploy the “business service” components.
- In the **simplest scenario**, think of a plain vanilla web application, where you create a “controllers”, a “services” and a “model” packages. Here, you implement services as POJOs and **do everything yourself**:
  - Instantiation of services, concurrency control, transactions, security, etc.
- When the application/system has some complexity (because of the functionality, because of the volume of transactions, because of the integration, etc.), it becomes interesting to use **“managed” components**.
- The idea is to let “something” in the **infrastructure** manage the life cycle of your service components. That “something” can take different shapes.
- In Java EE, that “something” is the Enterprise Java Bean **container**.

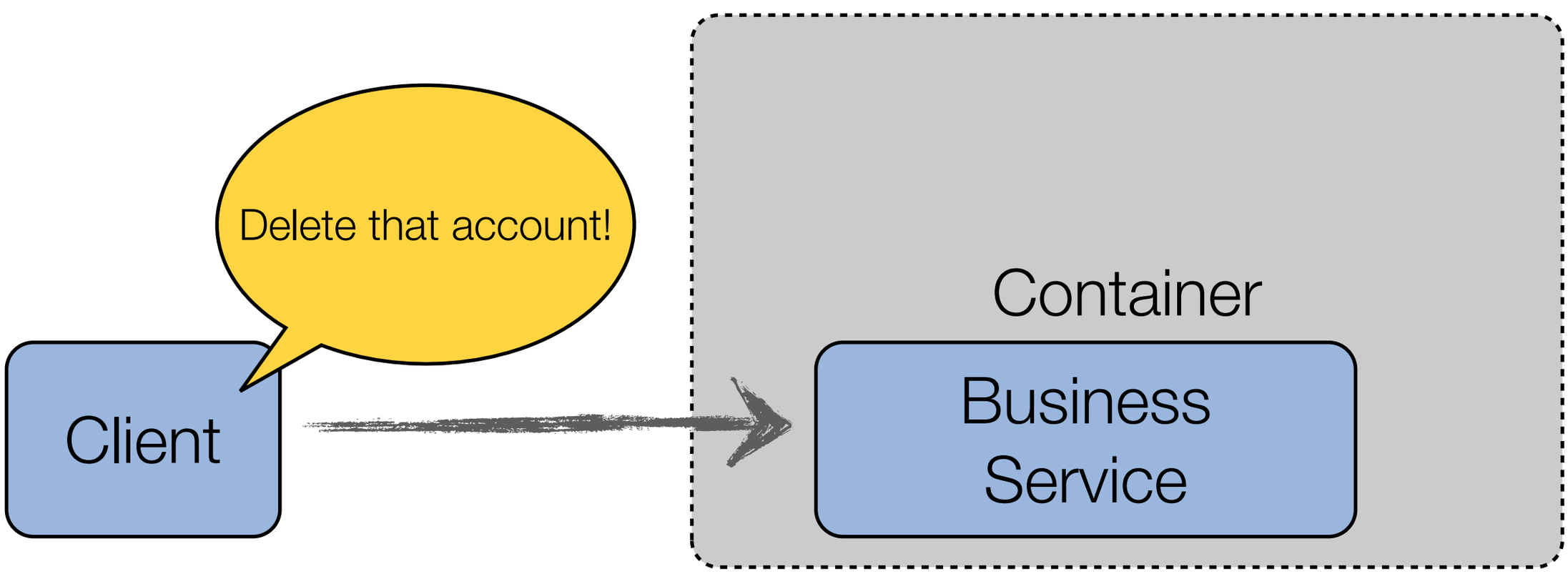
Containers and components

- The **EJB container** is one sub-system of the Java EE container.
- It provides a **runtime environment** for the business services, implemented as Enterprise Java Beans.
- The **developer** knows that services will be “available” to its components, once they are deployed in the container. He can thus use these services through standard **APIs**.
- The **production manager** configures the EJB container and tunes it in different ways (this is implementation specific).
- With **some application servers**, the EJB container can be **distributed** over several physical nodes (for scalability and availability purposes). This distribution is **transparent to the clients** - they sill only see “one runtime environment”.

From the specs: what are EJBs (v3)

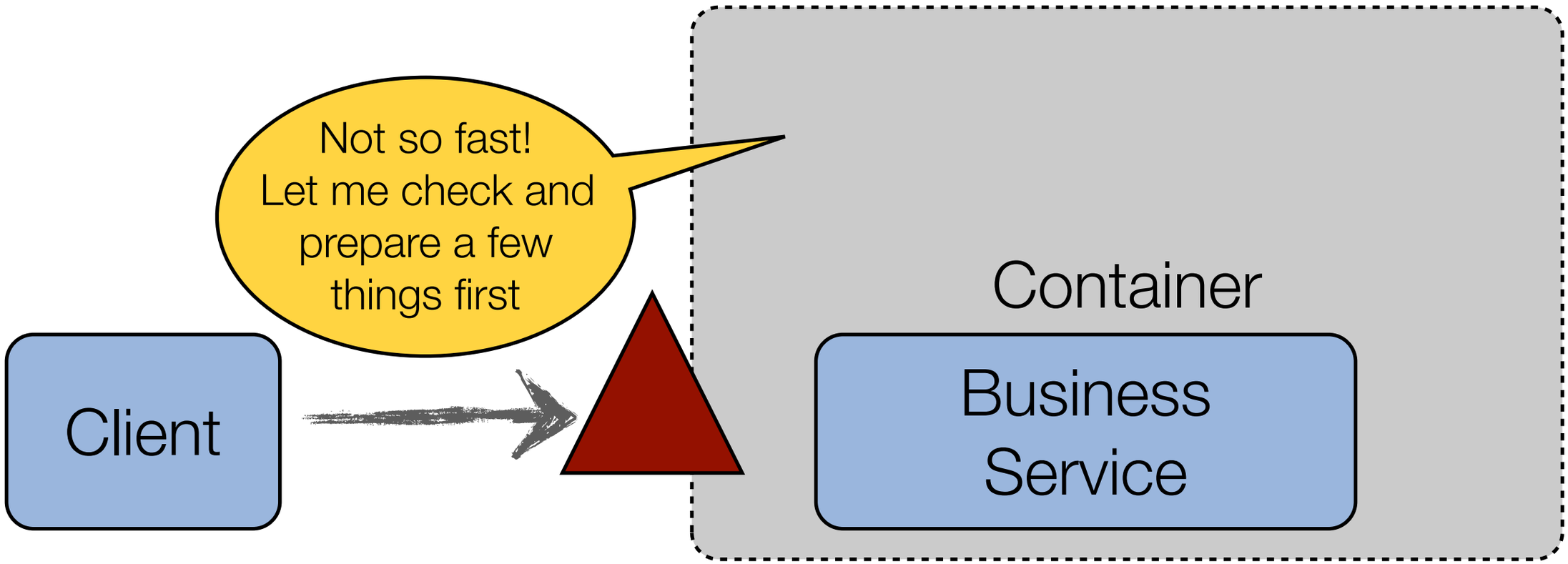
- “An enterprise bean typically contains **business logic** that operates on the **enterprise’s data**.
- An enterprise bean’s instances are **managed at runtime by a container**.
- An enterprise bean can be **customized at deployment time** by editing its environment entries.
- Various service information, such as **transaction** and **security** attributes, may be specified **together** with the business logic of the enterprise bean class in the form of **metadata annotations**, or **separately**, in an **XML deployment descriptor**. This service information may be extracted and managed by tools during application assembly and deployment.
- Client **access is mediated by the container** in which the enterprise bean is deployed.”

Mediated access




```
deleteAccount();
```

Mediated access

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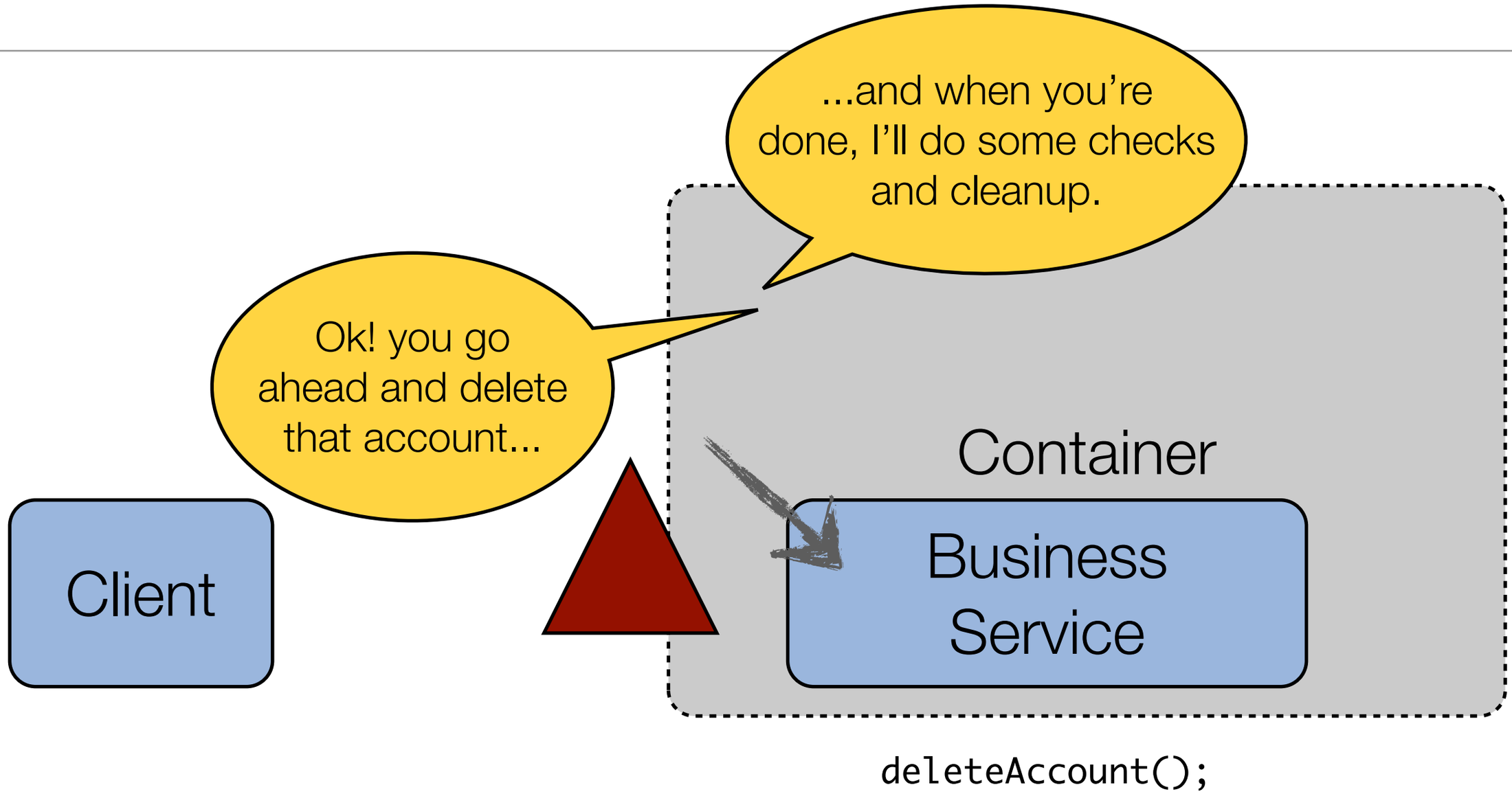


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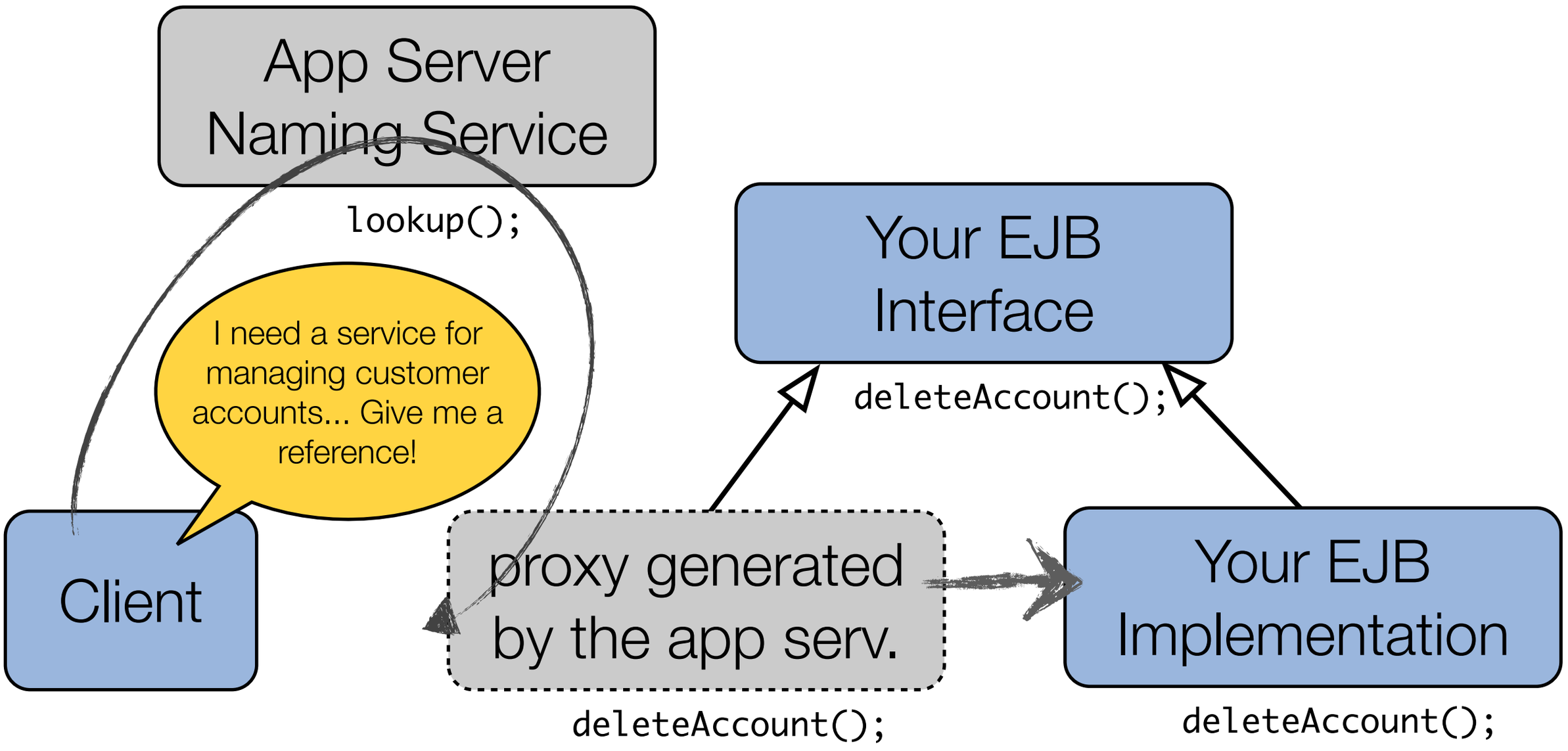
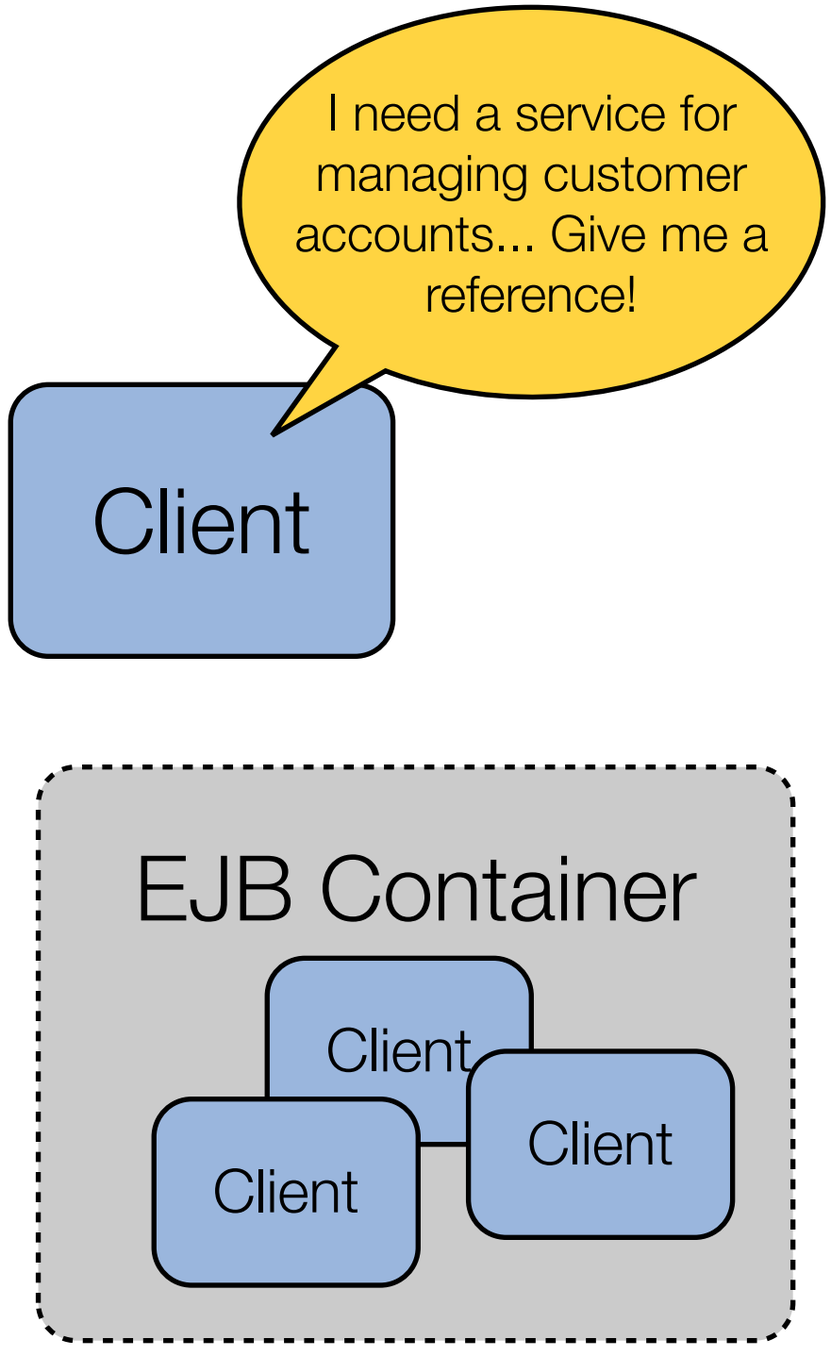


Resource pooling

- As a developer, you define a **service interface** and provide an **implementation**.
- **You do not instantiate the service** - the application server takes care of that.
- The container does not instantiate only one instance of a class implementing your interface; **it creates several instances that are placed into a pool**.
- When a client comes along, a **free instance** is picked from the pool and **dedicated** to the client (no concurrency issue).
- In production, you can tune the size of pools (tradeoff between processing **bandwidth** and resource **consumption**).



From the specs: component types

- “The enterprise bean architecture is flexible enough to implement the following:
  - An object that represents a **stateless service**.
  - An object that represents a stateless service and that implements a **web service endpoint**.
  - An object that represents a stateless service and whose invocation is **asynchronous**, **driven by the arrival of messages**.
  - An object that represents a **conversational session** with a particular client. Such session objects automatically maintain their **conversational state** across multiple client-invoked methods.
  - An entity object that represents a **fine-grained persistent object**.”

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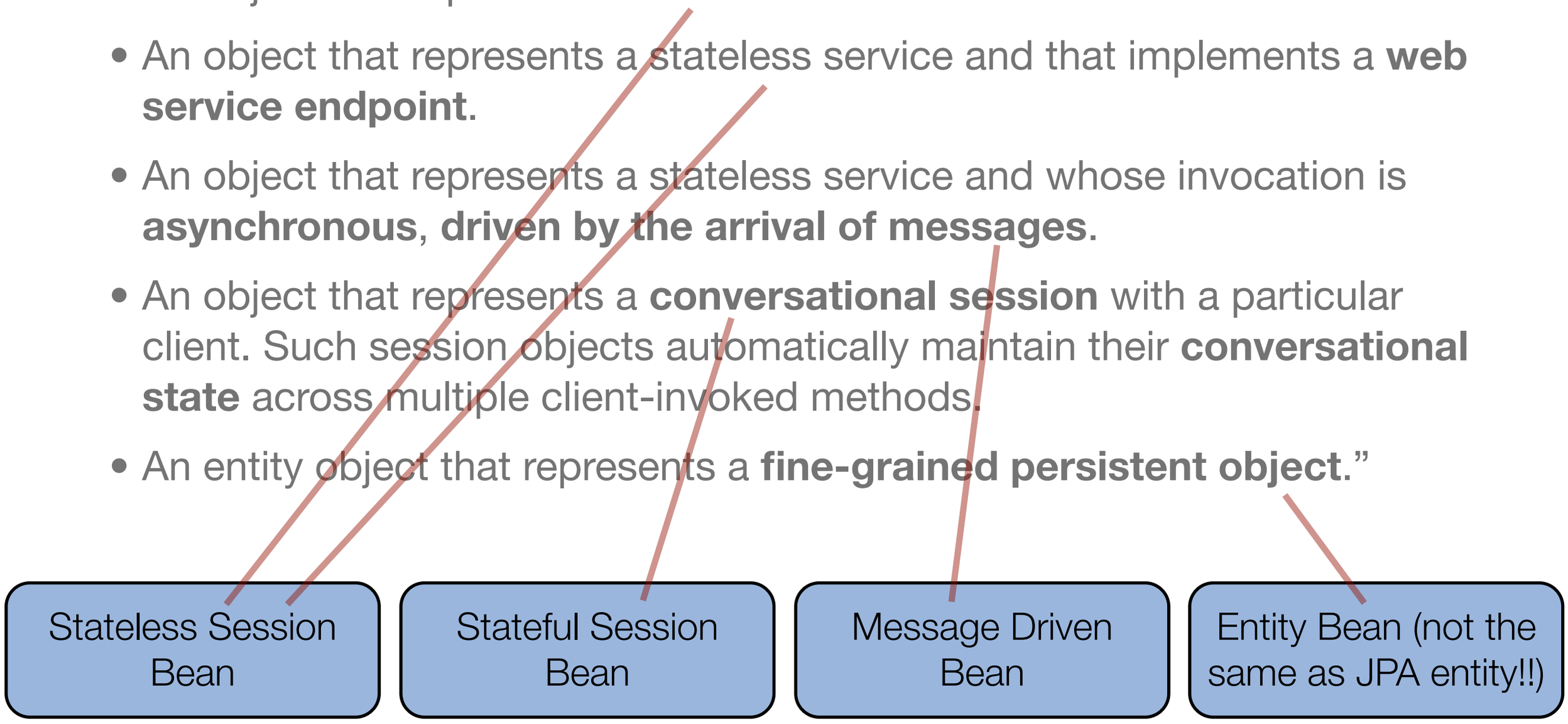


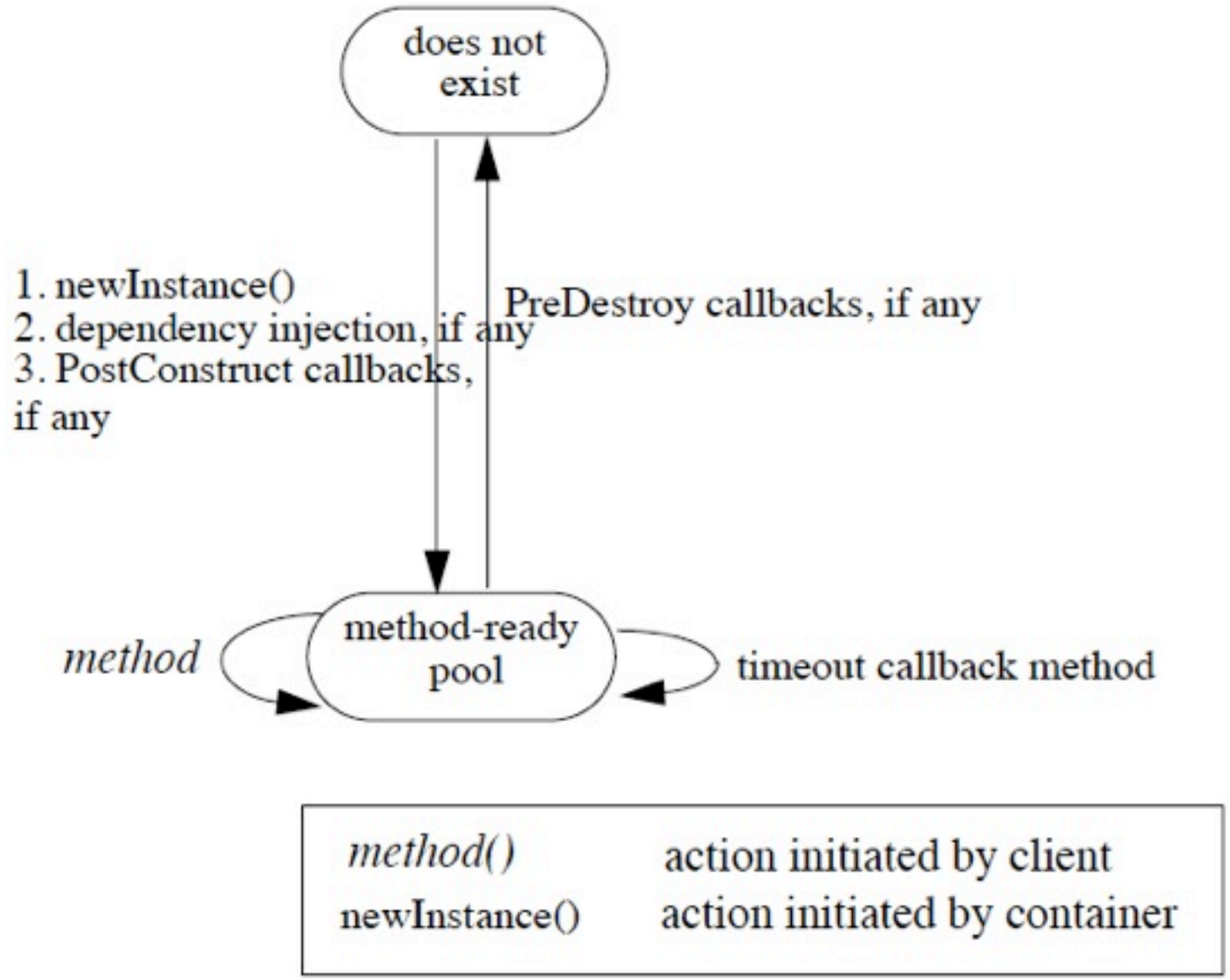
Session Beans (EJB)

- A session bean may be either:
  - **stateless**—the session bean instances contain no conversational state between methods; **any instance** can be used for any client.
  - **stateful**—the session bean instances contain **conversational state** which must be **retained** across methods and transactions.

- Notes:
  - The term “**stateless**” signifies that an instance has no state **for a specific client**. However, the instance variables of the instance **can** contain the state across client-invoked method calls. Examples of such state include an open database connection and an object reference to an enterprise bean object.
  - The lifetime of stateful session bean is controlled by the client (the client call myStatefulService.remove())

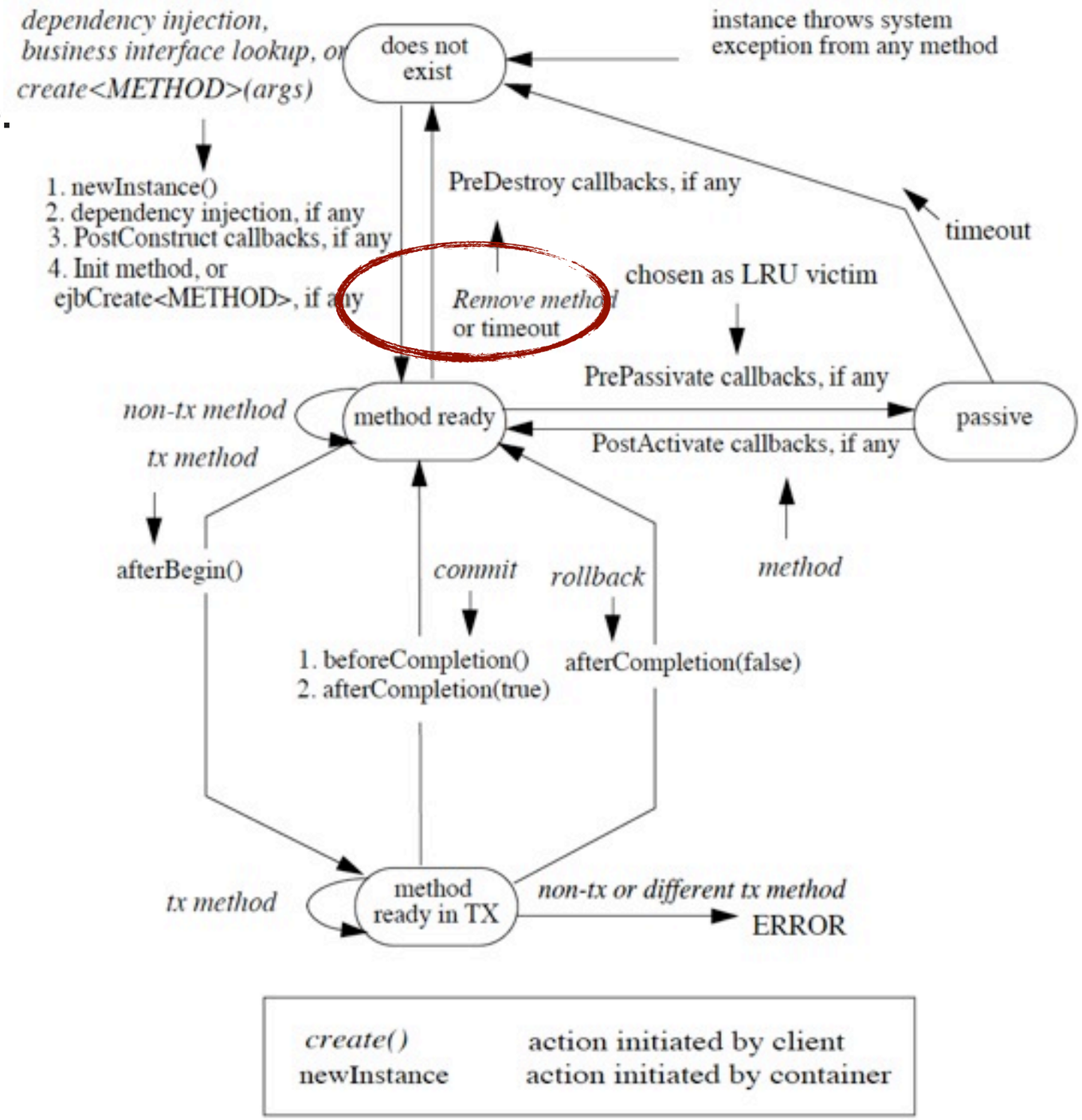
Stateless Session Bean Life Cycle

- The container manages the life cycle of the beans.
- The developer may implement callback methods, invoked when the state changes (e.g. for init/ clean-up tasks).
- With EJB3, you can do that with method annotations.
- Remember that you don't know how many instances there are, you don't know which one you're talking to.



Stateful Session Bean Lifecycle

- Things are more complicated here, because we manage client-specific state.
- What happens when we run out of memory? We need to move the state of “some beans” to secondary memory.
- This is called “passivation”.
- When a client comes back and wants to invoke a method on a passivated bean, we need to bring it back to life.
- This is called “activation”.
- You typically “remove” a bean at the end of the use case (conversation).
- Check out the JBoss Seam Framework for an architecture that makes use of SFSB.

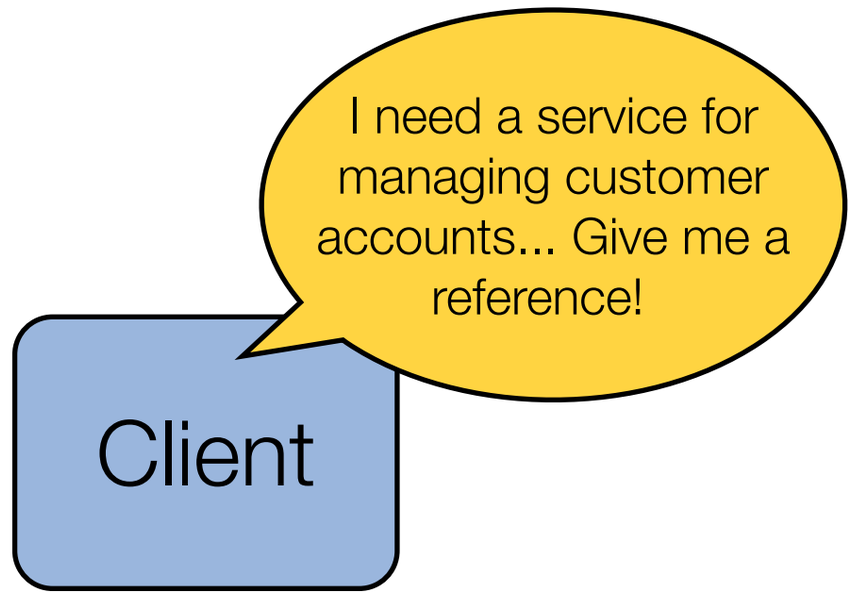


The client view: reaching the service

- Before using a service, the client needs to obtain a **reference** to a component that implements th service.
- Two approaches: **lookup** and **dependency injection**
- From the original J2EE model, we can do a lookup - the application server provides a **naming service** through JNDI.
- **Dependency injection** was introduced in the EJB3 / Java EE 5 specification. Here, the app server injects a reference into the client.

```
InitialContext ic = new InitialContext();
CustomerService service = (CustomerService)
ic.lookup("customerService")
```

```
@EJB
CustomerService service
```



Interceptors

- We have seen the notion of “**mediation**” by the container.
- The idea is that the container “**intercepts**” every method call on the EJBs and gets a change to “do its stuff”.
- As a developer, you do not directly control what the container is doing at interception time. However, you **declare your intentions** (the application-level semantics).
  - With some annotations, you declare how transactions should be managed (no transaction, stay in the same transaction, start a new one, etc.).
  - With other annotations, you declare how security should be managed (does the user have to be in a role to invoke the method, etc.).
- We EJB 3, the developer now can also provide its own interceptors.
  - For instance, think about creating an audit log for all method access.
  - This is very similar to the notion of “aspect oriented programming” that we will come back to when looking at the Spring Framework.

From the specs: Interceptors

- “Interceptors are used to **interpose** on **business method invocations** and **lifecycle events** that occur on an enterprise bean instance.
- **Any number** of interceptor classes may be defined for a bean class.
- It is possible to **carry state across multiple interceptor method invocations** for a single business method invocation or lifecycle callback event for a bean in the context data of the `InvocationContext` object.”

```
public interface InvocationContext {
  public Object getTarget();
  public Method getMethod();
  public Object[] getParameters();
  public void setParameters(Object[] params);
  public java.util.Map<String, Object> getContextData();
  public Object proceed() throws Exception;
}
```

Interceptors

- “Interceptor methods may be defined for business methods of sessions beans and for the message listener methods of message-driven beans.
- Business method interceptor methods are denoted by the `Around-Invoke` **annotation** or `around-invoke` **deployment descriptor** element.”

```
@Stateful
@Interceptors({MethodProfiler.class})
public class StringServiceBean
   implements StringServiceRemote {
   ...
}
```

```
import javax.interceptor.AroundInvoke;
  public class MethodProfiler {
      public MethodProfiler() {}

      @AroundInvoke
      private Object profile(InvocationContext invCtx) throws Exception {
          long t1 = System.nanoTime();
          Object result = invCtx.proceed();
          long t2 = System.nanoTime();
          System.out.println(invCtx.getMethod().getName() +
                "(" + invCtx.getParameters()[0] + ") took: " +
                ((t2 - t1)/ 1000.0) + " nano seconds.");
              return result;
      }
  }
```

Interceptors

- Interceptors can be “attached” at different levels
  - Default interceptors (in deployment descriptor)
  - Class-level
  - Method-level
- The specification gives all the details for the syntax and the rules

```
@Stateless
public class MyBean ... {
    public void notIntercepted() {}

    @Interceptors(org.acme.MyInterceptor.class)
    public void someMethod() {
    }

    @Interceptors(org.acme.MyInterceptor.class)
    public void anotherMethod() {
    }
```

Want to try it yourself?

- To experiment with Java EE, you will need:
  - A **Java EE application server** (e.g. glassfish, jboss, websphere, etc.). This is mandatory.
  - An **IDE** (e.g. Netbeans, eclipse, etc.). This is not strictly mandatory, but it will help you a lot.
  - A **build management system** (e.g. maven, gradle, etc.). This is not strictly mandatory either, but if you are working on a real project, it is not even a question.
  - *The Netbeans Java EE Download bundle gives you a complete and integrated environment.*
- There is a **ton of information** available in books and on-line. A good idea is to start with the official Java EE tutorial:
  - http://docs.oracle.com/javaee/6/tutorial/doc/