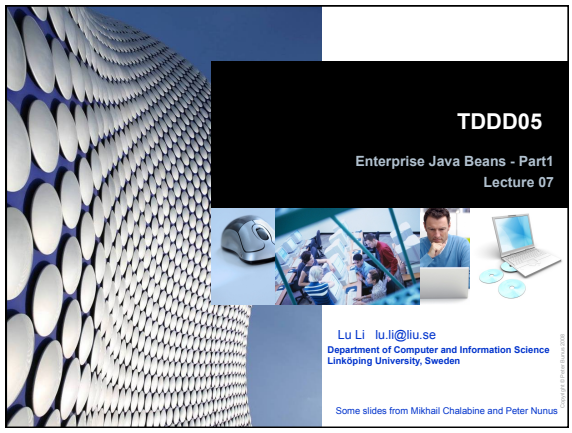


Definition

- **EJB** – **component model** for building distributed server-side Java-based enterprise application components
- An **EJB** – **distributed** server-side non-visual **component** encapsulating application business logic

EJB

Developers say

- **EJB** is a piece of **code** executing in a special **container**
- **EJB = ?+ Bean**
  - Bean encapsulates business logic
  - Distributed objects with distinct address spaces
  - Programmer writes Beans to a standard
  - Portability and scalability
  - Components with lifecycle management
  - Transactional access to remote objects
  - Container services; out of the box
  - *[...]*

EJB

EJBs Provide (1)

- **Model** for defining **server-side components**
- **Model** for defining **distributed client interfaces** to services provided by server-side components
- **Framework** for building server-side components
- **Standard operations** and **semantics** for allowing a container to **create**, **destroy**, **allocate**, **persist**, **activate**, and **invoke** component instances
- **Model** for defining a component that maintains a **session** with a client where the session is **managed by the container**

EJB

EJBs Provide (2)

- **Model** for defining a **component** that encapsulates a data source entry **with object-to-relational data mapping** handled by the container – a.k.a. Entity bean (EJB2) or JPA Entity (EJB3)
- **Model** for defining a **component** that encapsulates an asynchronous message consumer **with messaging service** handled by the container – a.k.a. Message-driven beans
- **Model** for defining a **component** that encapsulates a **Web service** with SOAP messaging interactions handled by the container

EJB

EJBs Provide (3)

- **Standard** for **configuring** and **deploying** distributed components
- **Standard** for declaratively **specifying** the **security** attributes of a component
- **Standard** for declaratively **specifying** the **transactions** attributes of a component
- **Standard** component **interface contract** allowing components to run in any vendor-compliant container/server which implements this standard interface contract

[J2EE Developer's Handbook, Perrone, Chaganti and Schwenk, 2003, p. 1084] EJB

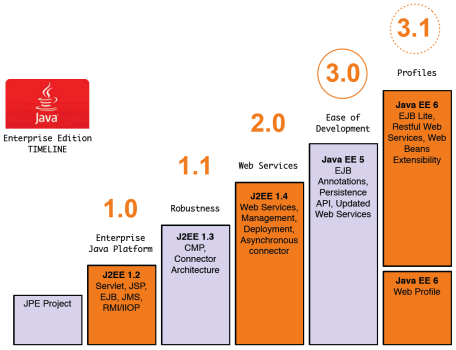
Implementation

- **EJB** ∈ **Java EE** standard **(a.k.a. J2EE)**
  - Component **specification**
  - Distributed component model **standard**
- Implementation by independent vendors
  - Tools and Containers
    - **Proprietary**: IBM (WebSphere), BEA (WebLogic), Sun and Netscape (iPlanet), Oracle, Borland
    - **Open source**: GlassFish, JBoss

EJB vs. JavaBeans

- **JavaBeans model** – a means for building Java components
- **Enterprise JavaBeans model** – a means for building Java components for use in containers that offer distributed client connectivity, have exclusive server-side semantics, provide various standard services and offer sophisticated component lifecycle management

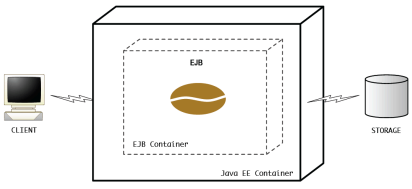
EJB & Java Evolution



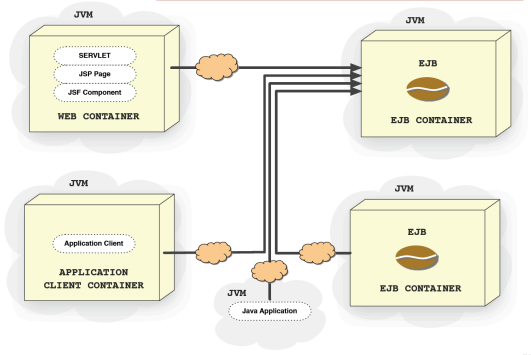
EJB Architecture Basics

EJB Architecture Basics (1)

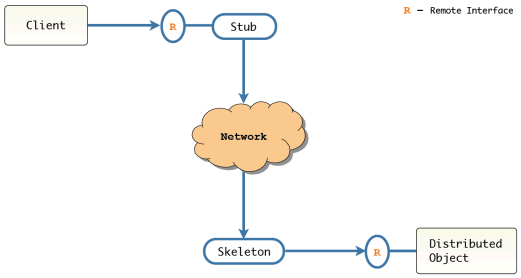
EJB Architecture Basics (2)



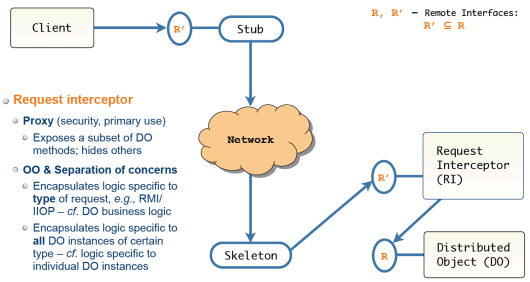
Clients — EJB Architecture Basics (3)



Distributed Objects (1)

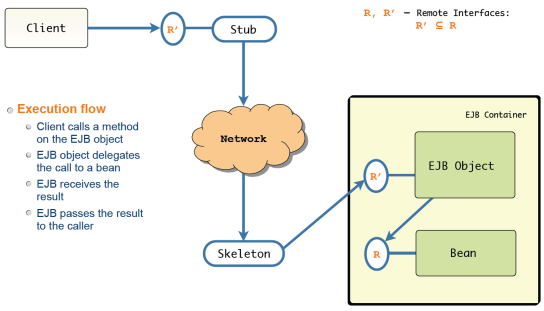


Distributed Objects (2)



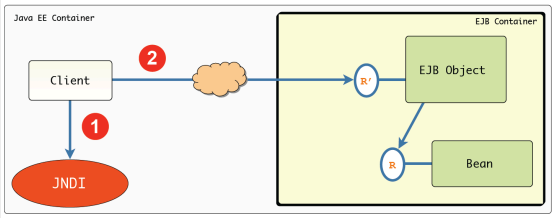
- **Request interceptor**
  - **Proxy** (security, primary use)
    - Exposes a subset of DO methods; hides others
  - **OO & Separation of concerns**
    - Encapsulates logic specific to **type** of request, *e.g.*, RMI/IIOP – *cf.* DO business logic
    - Encapsulates logic specific to **all** DO instances of certain type – *cf.* logic specific to individual DO instances

Distributed Objects (3)



- **Execution flow**
  - Client calls a method on the EJB object
  - EJB object delegates the call to a bean
  - EJB receives the result
  - EJB passes the result to the caller

Discover EJBs – JNDI (1)

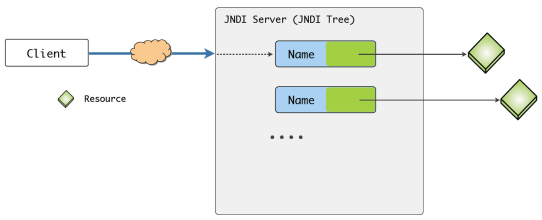


R, R′ – Remote Interfaces: R′ ⊆ R

Java Naming and Directory Interface (JNDI)

- Similar to CORBA naming service

Discover EJBs – JNDI (2)



Java Naming and Directory Interface (JNDI)

- **Maps** resource names to physical (network) locations
- **Global names** visible across **Java EE container**
  - No need to hardcode addresses to EJB objects in the Client

Discover EJBs – JNDI (3)

Java Naming and Directory Interface (JNDI)

- **Centralized repository**
  - No metalevel descriptions
  - Resources identified by names submitted to JNDI server
    - **Example**: mappedName = "ejb/TDDD05" (see below)
    - Client **must know** the **name** of **EJB** to get it
      - No metalevel description of EJB component semantics
        - Not possible: Get me EJB that computes (a + b)
        - Possible: Get me EJB with name "A"

```
import javax.ejb.Stateless;

@Stateless( mappedName="ejb/TDDD05")
public class SimpleSessionBean implements SimpleSession {
 ...
}
```

EJB

EJB 2

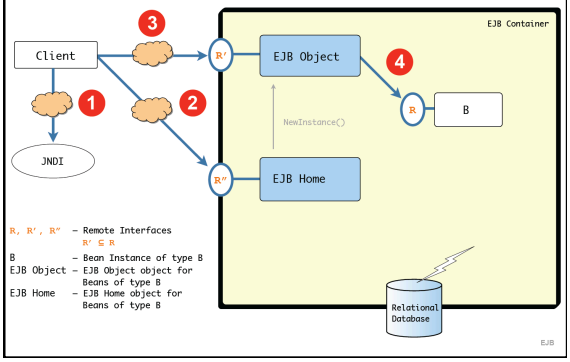
EJB 2

EJB 2

- **EJB 2 – EJB component (distributed object) configurable through XML descriptors**
  - **Remote interface**
    - Bean's business methods
    - Amenable to Reflection metadata analysis
  - **Home interface**
    - Bean's lifecycle management
      - Create
      - Find
      - Remove
  - **Bean class**
    - Business logic

EJB

EJB 2 Architecture (1)



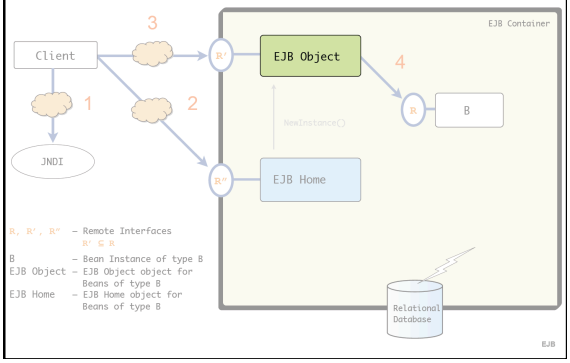
EJB

EJB 2 Architecture (2)

1. – **Client** obtains a **reference** to the **EJB Home** object (JNDI Lookup, address)
2. – **Client** calls `create()` on EJB Home to obtain Bean's **Remote Interface** (EJB Object)
   - Container creates a **new** EJB Object **per client** and Bean type
   - Container associates a Bean instance from the pool with the newly created EJB Object
     - **Ready state**
3. – **Client** calls a **method** on Beans Remote Interface (EJB Object)
4. – **EJB Object delegates** the call to Bean **Instance** associated with it

EJB

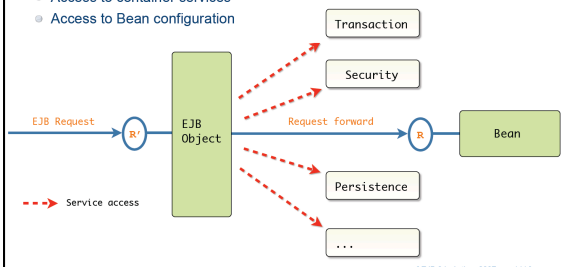
EJB Object – Remote Interface (1)



EJB

EJB Object – Remote Interface (2)

- Acts as **Proxy**
  - One per client request and Bean type (component type)
  - Either none or single associated Bean instance
  - Access to container services
  - Access to Bean configuration



[EJB 3 in Action, 2007, pp. 141] EJB

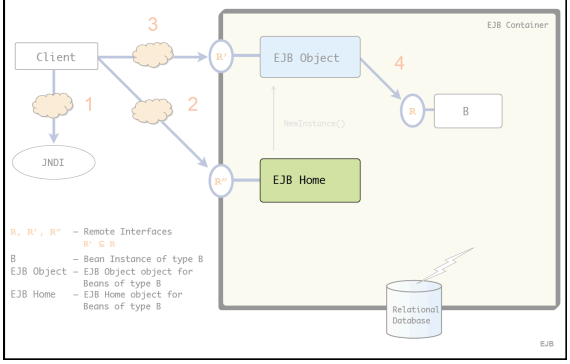
EJB Object – Remote Interface (3)

- **Must** extend `javax.ejb.EJBObject`
- Lists **business methods** available to clients
- Created via `EJBHome` object factory

```
public interface SimpleSession extends javax.ejb.EJBObject {
   public String sayHello() throws java.rmi.RemoteException;
}
```

EJB

EJB Home – Home Interface (1)



EJB

EJB Home – Home Interface (2)

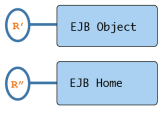
- **Must** extend `javax.ejb.EJBHome`
- **Factory** to **create EJB Object** instances
- **Singleton** – one instance per EJB component
- Allows clients to **create** / **remove** / **locate** EJBs
- **Generated** by the container
- Registered to JNDI
  - **Access point** for clients

```
public interface SimpleSessionHome extends javax.ejb.EJBHome {
       SimpleSession create() throws java.rmi.RemoteException,
                                     javax.ejb.CreateException;
}
```

EJB

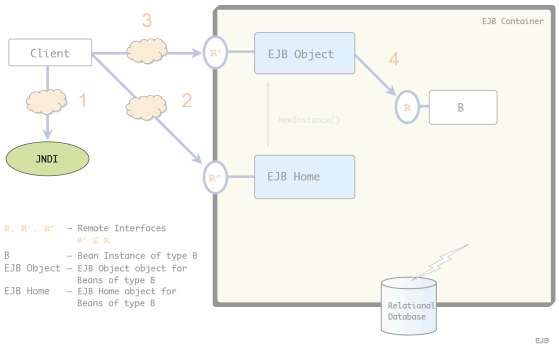
EJB 2 Architecture (3)

- **Combine EJB Home and EJB Object in one ?**
  - **No good, because**
    - **EJB Home** is a **Singleton**
      - One factory per EJB component sufficient
        - Can create as many EJB Object instances as needed
        - **Obs! EJB Object** – one instance per Client and EJB component
      - EJB Home as singleton is **good OO** – reduces code duplication
    - **Separation of Concerns** (see AOP lecture)
      - **EJB Home** encapsulates no Bean's Business Logic
      - **EJB Home** encapsulates EJB framework code
        - Create / destroy / locate EJBs



EJB

Discover EJBs (1)



EJB

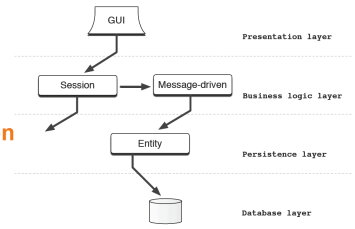
Discover EJBs (2)

- **Classical JNDI lookup** (*cf.* DI in EJB 3)
  - Gives the Client a reference to `EJBHome` object
  - Clients reference JNDI server via `InitialContext` (see example)
- JNDI implementation
  - Vendor specific
  - Bound to J2EE server implementation

```
Context        ctx       = new InitialContext();
HelloWorldHome ejbHome   = (HelloWorldHome) PortableRemoteObject.narrow(
                                                 ctx.lookup("HelloWorld"),
                                                 HelloWorldHome.class );
HelloObject    ejbObject = ejbHome.create();
String         message   = ejbObject.sayHello();
```


EJB 2 Bean Types

- **Session**
  - **Stateless**
  - **Stateful**
- **Entity**
- **Message-Driven**



Session Beans (1)

- **Distributed objects, components**
  - Home Interface, Remote / Local interface, Bean class
- **Act as agents to the client**
  - **No** DB **persistence**
  - Low resource requirements
  - Won't survive a server crash or shutdown
  - **Fast** response
  - **Perfect** for short requests to perform a **unit of work**
- **Types**
  - **Stateless**
  - **Stateful**

[EJB 3 in Action, 2007, pp. 14, 72]

Session Beans (2)

- **Stateless**
  - **Single request** business model
    - **No client – conversational – state** maintained across client requests
      - **Conversational state spans over a single method call**
        - Container may **destroy / return to pool** Bean instance after each method call
      - **Client-independent state can be kept in member variables**
        - Bean member variables can be populated at server start
          - Heavy computations done once
    - **Data** provided as parameters or **retrieved**
  - Require **little** container **resources**
    - No state
    - Data always in RAM or destroyed
    - Efficient Instance Pooling

[See also Instance Pooling under the <<Container Services>> section below]

Session Beans (3)

- **Stateful (1)**
  - Designed to service **business processes** that **span** over multiple method calls (requests) or **transactions**
    - **Conversational state**
      - Maintained by EJB **container**
      - Maintained for lifetime of Bean's service to client
      - Maintained in container cache
  - **Require** more **resources** from the container
  - No Bean Instance Pooling
    - **Activation** / **Passivation** instead

[See also Instance Pooling under the <<Container Services>> section below]

Session Beans (4)

- **Stateful (2)**
  - **Limitations and Alternatives**
    - **Performance**
      - Preserving state comes at a cost
    - **Memory**
      - Complex states require much memory
    - **Alternatives**
      - Combine Stateless Bean with Persistence
      - Code state persistence yourself (memory, file)
      - Maintain session in Web Container instead (Java Servlet API)
  - **No, No!** [More under Dependency Injection in <<Container Services>> section below]
    - Use (instantiate) **Stateful** EJB in a Stateless EJB
      - **Conversational state of a client may leak**

[EJB 3 in Action, 2007, pp. 105, 107, 108]

Entity Beans (1)

- **Reusable EJB component with automated persistence**
  - **View** into a **data source** a.k.a. relational database
    - Represent **business data** stored in a database
      - Bean instances map to database table records
    - Changes in Bean properties (Bean state) persisted automatically to associated data source
    - Data source outside Java EE application
      - *Cf.* secondary storage for Stateful Session Beans inside Java EE
  - **Distributed object**
    - Alike Session Beans and Message-driven Beans
    - **Can have remote clients from outside JVM**
      - ***Cf.*** EJB 3 JPA Entity
        - JPA Entity – POJO, **not distributed object**
        - **All clients must be local to the JVM**

Entity Beans (2)

- **EJBHome contains**
  - `create()`
  - `findByPrimaryKey()`
  - Optionally other ***finder*** method declarations
- **Bean class contains**
  - **Properties**
  - **Getters / Setters**
  - **Callbacks**
    - `ejbCreate()`
    - `ejbLoad()`
    - `ejbStore()`
    - `ejbRemove()`
    - `ejbActivate()`
    - `ejbPassivate()`
    - `setEntityContext()`
  - ***Finder*** **methods implementations**

```
...
Context          ctx    = new InitialContext();
MyEntityBeanHome home   = (MyEntityBeanHome)
                           PortableRemoteObject.narrow(
                                 ctx.lookup("MyEntity"),
                                   MyEntityHome.class );
MyEntityBean     myEb   = home.findByPrimaryKey(5);
...
myEb.setCourseName( "TDDD05" );
...
Course           course = myEb.getCourse("TDDD05");
```


Entity Beans (3)

- **EJB 2 Persistence (1)**
  - Object to relational database mapping (common)
  - Object databases (less common)
  - Container generates persistence code
    - All in case of Container Managed Persistence
    - Parts in case of Bean Managed Persistence
  - EJB-QL, query language
    - No client SQL code (SELECT, *etc.*)

Entity Beans (4)

- **EJB 2 Persistence (2)** [programmer **must** choose]
  - **Container managed** (CMP, implicit)
    - Entity Bean defined as Abstract class
    - Abstract getters / setters
    - At deployment container creates concrete implementation classes
  - **Bean managed** (BMP, explicit)
    - Entity Bean defined as a class
    - Programmer codes getters / setters using JDBC
    - Programmer also codes using JDBC
      - **Callbacks**
        - `ejbCreate()`
        - `ejbLoad()`
        - `ejbStore()`
        - `ejbFindByPrimaryKey()`
      - **Other *Finder* methods implementations**

Entity Beans (5)

- **Traditional vs. EJB Persistence**
  - **Traditional** DB persistence (manual, explicit)
    - Each client requires a DB connection
    - Business logic resides in both client and DB
    - Little reusability
  - **Entity Beans** (implicit persistence)
    - Container handles DB connections
    - Business logic in a server side EJB
    - **Further free** container services
      - Transactions
      - Redundancy
      - Security

[See also <<Container Services>> section below]

Entity Beans (6)

- **Limitations**
  - Record oriented
    - **No business logic** beyond getters / setters and basic validation
    - No inheritance
      - **Semantics** of *Table1.id* inherits *Table2.id* **is undefined**
    - No polymorphism
    - No good for Domain-driven Design (DDD)
  - **Not usable outside EJB container**
  - Difficult to test

Message-Driven Beans (1)

- **No Home**, **Remote** or **Local** interfaces
- Have a single business method
  - `onMessage()`
- No static type check
- No return values
- No exceptions
- Stateless

Message-Driven Beans (2)

- **Why MDBs?**
  - Performance
  - Reliability
  - Support for multiple senders and receivers
  - "Easy" integration with legacy systems

EJB 2 elements

- Enterprise Bean class
- Supporting classes
- EJB Object
- Remote interface
- Home object
- Deployment descriptor (XML)
- Vendor-specific files
- (Local interface)

EJB-jar file

EJB 2 Deployment

- EJB deployment descriptor (XML)
- ejb-jar.xml
- Attributes of the beans specified declaratively
- Deployment descriptor language is a composition language
- EJB-jar file is verified by container
- Container generates stubs and skeletons

XDoclet

- Deployment descriptor
- Generate from declarative specification
  - Remote interface
  - home interface
  - local interface
  - local home interface
  - primary key class
- Specification as comments in the Bean class

EJB 2 Final thoughts

- **Not object-oriented**
  - Data and operations separated
    - Entity beans encapsulate data (DB record-oriented)
    - Session beans encapsulate functionality (no data)
  - No component inheritance (EJB 2.0)
    - EJB 3.0 – Beans are POJOs
      - Component inheritance implemented as classical OO inheritance
- **Development and Application**
  - Strict architecture
  - Complex
  - Beans are difficult to test
    - Container required
    - Deployment errors mistaken for Business Logic errors