Component Middleware

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Foreword

Structural Compositions

Activity Orchestrations

Application servers
- Life cycle (instantiate)
- Persistency

JavaEE

Publish/Subscribe

RabbitMQ

WebServices/JavaRMI
Synchronous Call

sockets
TCP/UDP

Component Middleware
Outline

1. Introduction

2. Overview of EJB Technology

3. References
1. Introduction

1.1 Limits of object-oriented programming
1.2 Motivations for Component Based Development
1.3 What is a component?
1.4 Runtime environment of a component
1.5 Multi-tier Architecture
1.6 Technologies for component middleware

2. Overview of EJB Technology

3. References
1.1 Limits of object-oriented programming

- A lot of tasks must be done manually
  - Object instantiation
  - Service invocation via direct access to object reference + explicit method call
  - Definition of dependencies between classes
  - Almost no tool for application deployment (installation of executable files on the various sites)

- Applications structure difficult to understand (= set of files)

- Difficult to modify or extend an existing application
  - communication mode
  - modification of system/technical services
  - assembly

- Building an application using black-box classes makes it difficult
  - to introduce new references to other objects
  - to inherit from other classes
1.2 Motivations for Component Based Development

*Programming in the large versus programming in the small*

- Applications are built by **assembling** existing components
- Notion of **connector**: Components are connected with one another defining a software architecture
- Formalism to describe **interactions** between components
- Formalism to describe the **deployment** of components
- Separation of concerns: Separate **functional** from non-functional or extra-functional aspects to allow for more **reusability**
- Focus on application concerns (functional) rather than technical problems (extra-functional)
1.3 What is a component?

No consensus on a unique definition. Each platform has its own definition!

- According to [1]:
  - A unit of composition with contractually specified interfaces and explicit context dependencies only. A software component can be deployed independently and is subject to composition by third parties.
  - Context dependencies: required interfaces and execution environments (platforms)
  - A binary unit - not source code!
    - This means that a class library is not a component
  - No persistent state - a component is not an instance of itself
    - Much like classes are not objects
1.3.1 Characterization of a component

A software module

- That is a *contractual specification* by exporting some attributes, properties and methods
- That *provides* interfaces to other components and *requires* some interfaces from other components
- That has no persistent state
- That has *pre- and post-conditions*
- That is *configurable* by setting properties
- That is independently deployable and composable
1.4 Runtime environment of a component

Client

Application Server

Container

Component

Service

Connections

System / Middleware

Application Server

Container

Component

Component

Service

Service

Service
1.4 Runtime environment of a component II

- **Container**
  - Encapsulates components
  - Provides system/technical services
  - Maintains connections between components
  - Deals with invocations and events

- **Application server**
  - Runtime environment for containers
  - Mediator between the containers and the system/middleware
1.4.1 Technical services

- Resource Management
  - Ressource pooling
  - Activation/deactivation mechanism
- Naming and directory
- Synchronous/asynchronous communication
- Transaction
- Persistence
- Security
1.5 Multi-tier Architecture

Developing the application from the ground up using distinct tiers (layers) should simplify development.

**Tiers**

- **Presentation**
  - Presenting the delivery of information to the end user.
  
- **Logic**
  - Business logic deals with what we want the application to do.
  - Application logic deals with how the application works with the platform.

- **Data Access**
  - How to get the information needed out of the database, and how to put it back in.

- **Data**
  - Concerned with data at a low level including performance management, indexing, backup, and logging.

[Diagram showing the multi-tier architecture with layers for Presentation, Logic, Data Access, and Data, including sub-layers for Public Facing Web Site, Administrative Web Site, Business Logic, and Application Logic.]
1.5.1 The 6 roles in component development

1. Component Provider
   - Develops components
   - Provides component metadata: structural information (component logical name, transaction demarcation, persistence requirements...) and component external dependencies
   - Metadata may be expressed in annotations or in an XML deployment descriptor

2. Application Assembler
   - Assembles application components into a single deployable unit
   - Defines security roles for application clients, method permissions...
1.5.1 The 6 roles in component development II

3. Deployer

- Uses information provided by the component provider and the assembler
- Resolves component dependencies
- Deploys the application in an operational environment including a container and a server

4. Server Provider

- Responsible of distributed transaction management, distributed objects management, low-level system tasks
- OS vendor, Middleware vendor or DBMS vendor
5. Container Provider
- Provides deployment tools and runtime support for components
- Focus on the development of a scalable, secure, transaction-enabled container

6. System Administrator
- Responsible for the configuration and administration of the enterprise’s computing and networking infrastructure
- Oversees the well-being of the deployed applications
- Monitors the log of non-application exceptions and errors logged by the container
- Takes actions to correct the problems caused by exceptions and errors
1.6 Technologies for component middleware

- **Entreprise Java Beans**
  - Supported by Eclipse Foundation, as part of Eclipse Enterprise for Java (EE4J) initiative https://projects.eclipse.org/projects/ee4j
  - Initially developed by Sun Microsystems in 2005, then sponsored by Oracle until 2019
  - Application server: Jakarta EE 9
    https://jakarta.ee/specifications/platform/9.1/
  - ONE LANGUAGE, MANY PLATFORMS

- **.NET**
  - Supported by Microsoft https://docs.microsoft.com/en-us/dotnet/
  - MANY LANGUAGES (C#, F#, or Visual Basic), MANY PLATFORMS (Initially only on Windows)
1.6 Technologies for component middleware II

- **Spring Framework**
  - Supported by Spring [https://spring.io/projects/spring-framework](https://spring.io/projects/spring-framework)
  - Relies on dependency injection and aspects
  - Lightweight application server enriched with a wide ecosystem

- **CORBA Component Model (CCM)**
  - Supported by the Object Management Group (OMG) [www.omg.org](http://www.omg.org)
  - EJB specification can be seen as a subset of CCM specification
  - MANY LANGUAGES, MANY PLATFORMS
1. Introduction

2. Overview of EJB Technology
   2.1 What is EJB?
   2.2 EJB Container
   2.3 Java EE at a glance
   2.4 Java EE Architecture
   2.5 EJB types
   2.6 Session Beans
   2.7 Entity Beans
   2.8 Message-driven Beans (MDB)
   2.9 Transaction Service

3. References
2.1 What is EJB?

- **Enterprise Java Beans**
- Java component model for distributed enterprise applications, released by Sun in 1998
- **EJB 3.0** specification (2006) - JSR 220
- **EJB 3.1** specification (2009) - JSR 318
- **EJB 3.2** specification (2013) - JSR 345
- Definitions [2, 3]:
  - EJB are standard server-side components for component transaction monitors (CTM)
  - EJB technology defines a model for the development of reusable Java server components that encapsulate the business logic of an application
2.1.1 The Java Community Process (JCP)

- www.jcp.org

- International developer community whose charter is to develop and evolve Java technology
  - specifications,
  - reference implementations,
  - and technology compatibility kits.

- Company, organization, or individual can be member
2.2 EJB Container

- **Runtime environment** for creation and lifecycle management of bean instances
- Gives access to a set of standardized services to beans
- Provides a context with:
  - Configuration properties
  - References to other components
  - References to technical services
2.2.1 EJB Container — Provided services

- Includes many Java technologies, that can be used independently of EJB
- Java 2 Platform, Standard Edition (J2SE) APIs
  - RMI-IIOP - remote method invocation based on CORBA Interoperable Inter-ORB Protocol
  - JDBC (Java DataBase Connectivity)
  - JSP (Java Server Pages) — Web clients
  - JAXP (Java API for XML Processing)
  - Java IDL — adds CORBA capability to the Java platform
2.2.1 EJB Container — Provided services II

- Current services are frozen

- Research initiatives (s.a. Objectweb JOnAS) provide extensible containers with pluggable services

- EJB APIs (javax package, now jakarta package in Eclipse implementation), including Java Persistence (JPA)

- Asynchronous communication: Java Messaging Service (JMS), JavaMail

- Connector

- Transaction: UserTransaction interface of JTA, Java Transaction Service (JTS) (specification based on CORBA Object Transaction Service)

- Security: Java Security API

- Web Services: JAX-RPC, JAX-WS, JAX-RS
2.2.1 EJB Container — Provided services III

- **Lifecycle service — Java Naming and Directory Interface**
  - Instances passivation
    - Temporary saving of a bean when container needs memory
  - Instances pooling
    - For performance reasons, the container can instantiate less beans than there are clients
    - Then several clients share the same bean
    - Possible only for beans without instance variables
- **Pooling of connections to the Database**
  - All the beans of a server share a pool of connections to the DB
  - Connections remain open and are used by beans
2.3 Java EE at a glance

- Java Platform, Enterprise Edition
- Application server technology based on EJBs
- Targets scalability, accessibility, security, integrity, and other requirements of enterprise-class applications
- Java API for RESTful Web Services (JAX-RS)
- Contexts and Dependency Injection (CDI)
- Bean Validation: same set of validations can be shared by all layers of an application
- Java Server Faces (JSF) supports Ajax
2.3.1 Families of Java EE APIs

Web Application
- Servlet, WebSocket,
  - JavaServer Faces,
    - JSON-P, JSON-B, etc.

Enterprise Application
- EJB, CDI, BV, JPA,
  - Batch, JMS, JTA, JavaMail,
    - JCA, Concurrency, etc.

Web Services
- JAX-RS, JAX-WS, SAAJ,
  - JAXP, JAXB, StAX, etc

Management / Security
- JMX, Management,
  - Security, JACC, JASPIC, etc.
2.3.2 From Java EE to Jakarta EE

High Level Roadmap

Eclipse GlassFish 5.1
29-JAN-19
Oracle GlassFish 5.0
Java EE 8
Eclipse GlassFish 5.2
Java EE 8
Community-Driven Innovation!

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2.4 Java EE Architecture
2.4.1 Java EE — 3-tier Architecture I
2.4.1 Java EE — 3-tier Architecture II

- **Client**
  - Heavy weight client — Java application (or possibly other language)
  - Light weight client — Web navigator

- **Application Server**
  - Reference implementation: GlassFish (Eclipse Foundation)
  - Commercial products: WebSphere (IBM), WebLogic (BEA)...
  - Open source distributions: jBoss, JOnAS (Objectweb), Geronimo, OpenEJB...

- **DBMS (DataBase Management System)**
  - Provide storage support for application data
  - Mostly using a relational DBMS (Oracle, SQL Server, PostGreSQL...)
2.5 EJB types I

- **Entity Beans**
  - Model real-world objects (e.g. Owner, Account) that exist in persistent storage (DBMS or other storage accessible using JDBC [Java Database Connectivity])
  - Persistent state is maintained through all method and server invocations
  - Identified by a primary key
  - Object-Relational mapping
  - Implementation using JPA (Java Persistence API)
2.5 EJB types II

- **Session Beans**
  - Model client activities
  - Perform a task or process, and are therefore transient
  - Do not exist outside a client session
  - No persistent state
  - Two kinds of session beans: stateless and stateful
  - Manage actions that may cross entity beans or go outside the concern of an entity bean
    - e.g. Teller may authenticate the user and transfer funds between accounts
    - e.g. Statement may include transactions from multiple accounts

- **Message-Driven Beans (since EJB 2.0)**
  - Listener processing messages asynchronously
  - Only a bean class. No interface.
2.5.1 Main EJB3 Annotations

- **@EJB**: Denotes a reference to an EJB business interface or home interface.
- **@PersistenceContext**: Used to express a dependency on an EntityManager.
- **@Stateful**: Used to annotate a class as a stateful session bean component.
- **@Stateless**: Used to annotate a class as a stateless session bean component.
- **@Remote**: Applied to the session bean class or remote business interface to designate a remote interface of the bean.
- **@MessageDriven**: Specifies a message-driven bean. A message-driven bean is a message consumer that can be called by its container.
Stateless Session Bean — Calculator Example

- **@TransactionManagement**: Declares whether a bean will have container-managed or bean-managed transactions.

- **@TransactionAttribute**: Applies a transaction attribute to all methods of a business interface or to individual business methods on a bean class. Can be specified on the bean class or on methods of the class that are methods of the business interface.
  Possible values:
  - MANDATORY
  - REQUIRED (default)
  - REQUIRES_NEW
  - SUPPORTS
  - NOT_SUPPORTED
  - NEVER

- **@WebService**: Used on a class or an interface to define a Web service.

- **@WebMethod**: Indicates whether the method is part or not of the interface service endpoint interface (SEI) of the web service. Exclude element false by default.

- **@WebServiceRef**: Used on the client to reference web services.
An EJB has a **remote interface** to be accessed by clients

- Describes the **provided services (methods)**
- No longer required for session beans

Possibly an EJB may provide an interface for local access

- Describe the provided services offered to local clients
- Same as remote services, or different ones (enables optimisation)
- Can only be used within the same JVM as the EJB
- Gets compiled by the `ejb` compiler to create local stubs for container to interpose transactions, access control, etc. on invocations.

An **implementation class**
2.5.3 Interfaces

■ Remote Interface

- Interface presented to the outside world (contract definition) specifying the business methods provided by the bean
- Gets compiled by the ejb compiler to create RMI stubs and skeletons
- Stubs are used by RMI to translate a method invocation to wire format
- Skeletons are used by RMI to translate wire format to a method invocation

■ NB: A client application never interacts with a bean class directly; It uses the methods of the bean’s interface.
2.6 Session Beans

■ Model **business process** being performed by a single client involving one or more entity beans

■ Life duration linked to client’s one

■ Two types of session bean
  ■ **Stateful session bean**
    ─ maintains the conversational state between a client and the session bean
    ─ may be serialized out and passivated to conserve system resources
    ─ will be serialized in and activated when needed in the future
    ─ e.g. Teller session bean logged into and transfers funds between accounts
  ■ **Stateless session bean**
    ─ does not maintain conversational state
    ─ to be used for generic tasks, to read persistent data
    ─ e.g. Statement that is given a list of accounts or an owner to generate a textual report for
    ─ consumes the least amount of resources among all the bean types
Stateless Session Bean — Calculator Example

- Calculator session bean: Simple calculator with 4 operations
- Implementation code:
  - Remote business interface (Calculator)
  - Session bean class (CalculatorBean)

```java
import jakarta.ejb.Remote;  // Formerly javax package

@Remote
class Calculator {
    public double add(double n1, double n2);
    public double sub(double n1, double n2);
    public double mul(double n1, double n2);
    public double div(double n1, double n2);
}
```
Stateless Session Bean — Calculator Example - Implementation class

Possible to name a bean: `@Stateless(name = "myCalculator")`

```java
import jakarta.ejb.Stateless;

@Stateless(name = "myCalculator")
public class CalculatorBean implements Calculator {
    public double add(double n1, double n2) {return n1+n2;}
    public double sub(double n1, double n2) {return n1-n2;}
    public double mul(double n1, double n2) {return n1*n2;}
    public double div(double n1, double n2) {return n1/n2;}
}
```
Stateless Session Bean — Calculator Example - Client side

2 ways to get the reference of the business interface

■ dependency injection:

```java
@EJB Calculator myCalc;
```

■ look-up in JNDI directory using the lookup method provided by EJBContext interface and the bean interface name

```java
import javax.naming.*; // NB: No change to this package name
public class myClient {
    public static void main(String args[]) throws Exception {
        Context myContext = new InitialContext();
        Calculator myCalc =
            (Calculator) myContext.lookup("myCalculator");
        double result = myCalc.mul(2,4);
    }
}
```
Stateless Session Bean — No-interface view

- When a bean does not have a remote interface, possible to access directly to the bean implementation class via the no-interface view
- But never use the new operator to acquire the reference
- A no-interface view is a variant of a local view that exposes the non-static public methods of the bean class
- 2 ways to get the reference of the no-interface view of a session bean
  - dependency injection:
    ```java
    @EJB CalculatorBean myCalc;
    ```
  - look-up in JNDI directory using the lookup method provided by EJBContext interface and the bean interface name
    ```java
    @Resource SessionContext myContext;
    ...
    CalculatorBean myCalc =
    (CalculatorBean) myContext.lookup("myCalculator");
    ```
Stateful Session Bean — Cart Example

- Cart session bean: represents a shopping cart in an online bookstore.
- The bean’s client can add a book to the cart, remove a book, or retrieve the cart’s contents.
- Implementation code:
  - Remote business interface (Cart)
  - Session bean class (CartBean)
import java.util.List;
import jakarta.ejb.Remote;

@Remote
public interface Cart {
    public void initialize(String person) throws BookException;
    public void initialize(String person, String id) throws BookException;
    public void addBook(String title);
    public void removeBook(String title) throws BookException;
    public List<String> getContents();
    public void remove();
}
import java.util.ArrayList;
import java.util.List;
import jakarta.ejb.Remove;
import jakarta.ejb.Stateful;

@Stateful
public class CartBean implements Cart {
    String customerName;
    String customerId;
    List<String> contents;
    public void initialize(String person) throws BookException {
        if (person == null) {
            throw new BookException("Null person not allowed.");
        } else { customerName = person; }
        customerId = "0";
        contents = new ArrayList<String>();
    }
}
public void addBook(String title) { contents.add(title); }

public void removeBook(String title) throws BookException {
    boolean result = contents.remove(title);
    if (result == false) {
        throw new BookException(title + " not in cart.");
    }
}

public List<String> getContents() { return contents; }

@Remove // The container will remove the bean
public void remove() { contents = null; }

From the client’s perspective, the business methods appear to run locally, but they actually run remotely in the session bean.

cart.create("Duke DeEarl");
...
cart.addBook("Bel Canto");
...
List<String> bookList = cart.getContents();
...
cart.removeBook("Gravity’s Rainbow");
2.6.1 Asynchronous Method Invocation

- Control returned to the client by the container before the method is invoked on the session bean instance
- Use Java SE concurrency API to retrieve the result, cancel the invocation, or check for exceptions
- Useful for long-running operations or to improve application response time
- The result implements `java.util.concurrent.Future<V>` interface, "V" is the result value type
Asynchronous Method Invocation — Session bean side

- Annotate a method or a class with @Asynchronous (jakarta.ejb.Asynchronous)
- Asynchronous methods return either void or an implementation of the Future <V> interface
- Result is returned to the container, not directly to the client

```java
@Asynchronous
public Future<String> processPayment(Order order) throws PaymentException {
    ...
    String status = ...;
    return new AsyncResult<String>(status);
}
```
Asynchronous Method Invocation — Session bean side

- Check whether the client requested the invocation to be cancelled with method `jakarta.ejb.SessionContext.wasCancelled`

```java
@Asynchronous
public Future<String> processPayment(Order order) throws PaymentException {
    ...
    if (SessionContext.wasCancelled()) {
        // clean up
    } else {
        // process the payment
    }
    ...
}
```
2.6.2 Asynchronous Method Invocation — Client side

- Retrieve result using `Future <V>.get()` methods (synchronous method)
- Use `Future <V>.isDone` to check whether processing has completed
- Call `Future <V>.cancel(boolean mayInterruptIfRunning)` to cancel the method invocation
- Method `Future <V>.isCancelled` returns true if the invocation was cancelled
2.7 Entity Beans I

- Represent a **business object** in a **persistent** storage mechanism
- Can be shared by multiple clients
- Can be linked to other entity beans (like relations in a relational DBMS)
- Primary key required
  - Defined using `@Id` annotation,
  - Possible key types (or of the properties or fields of a composite primary key): java primitive types (and associated wrapper classes), String, Date
2.7 Entity Beans II

- Object/relational mapping annotations to map entities and entity relationships to relational tables
  - Each EB class is mapped to one relational table
  - table name = class name by default
  - or use annotation @Table(name = "...")

- 2 exclusive modes for the definition of table columns
  - property-based access: annotate getter methods
  - field-based access: annotate attributes
@Entity
public class Book implements Serializable {
    private String bookId;
    private String author;
    private String title;
    public Book() {
    }
    public Book(String author, String title) {
        this.author = author;
        this.title = title;
    }
    @Id
    @GeneratedValue(strategy=GenerationType.AUTO)
    public String getBookId() { return this.bookId; }

    public String getTitle() { return this.title; }
    public void setTitle(String title) { this.title=title; }
    ...
}
2.7.1 Multiplicities in Entity Relationships

1. **One-to-one**: Each entity instance is related to a single instance of another entity.

2. **One-to-many**: An entity instance can be related to multiple instances of the other entities.

3. **Many-to-one**: Multiple instances of an entity can be related to a single instance of the other entity.

4. **Many-to-many**: The entity instances can be related to multiple instances of each other.
Multiplicities in Entity Relationships — One-ToMany example

@Entity
public class Author {
    private long id;
    private String name;
    private Collection<Book> books;

    public Author() { books = new ArrayList<Book>(); }
    public Author(String name) {this.name = name; }

    @OneToMany
    public Collection<Book> getBooks() {return books; }

    public void addBook(String title) {
        Book aBook = new Book(this.name, title);
        getBooks().add(aBook);
    } }

2.7.2 Persistence management mode

Persistence can be managed in two ways:

- **Container-managed** (CMP)
  - Simplest to develop
  - Bean code contains no database access calls

- **Bean-managed** (BMP)
  - The client is required to explicitly write persistence logic by providing implementation methods for Home interface
  - More flexibility in how state is managed between the bean instance and the database
  - Used when deployment tools are inadequate
2.7.3 Entity Manager

- Entry point of the persistence service
  - Creates and removes persistent entity instances
  - Finds entities by the entity’s primary key
  - Allows queries to be run on entities

- Associated with a persistence context
  - Defines the scope under which particular entity instances are created, persisted and removed
Container-Managed Entity Manager

- Propagation of the **persistence context** automatically to all application components that use the EntityManager instance within a single JTA (Java Transaction Architecture) transaction.

- To obtain an EntityManager instance, *inject* the entity manager into the application component:

```java
@PersistenceContext
EntityManager em;
```
### Application-Managed Entity Manager

- Each EntityManager creates a **new, isolated persistence context**
- Life cycle of EntityManager instances managed by the application: The EntityManager and its associated persistence context are **created and destroyed explicitly by the application**.
- To obtain an EntityManager instance, first get an EntityManagerFactory instance:

```java
@PersistenceUnit
EntityManagerFactory emf;
```

- Then, obtain an EntityManager from the EntityManagerFactory instance:

```java
EntityManager em = emf.createEntityManager();
```
import jakarta.ejb.*;
import jakarta.persistence.*;
public class BookDBAO {

    @PersistenceContext
    private EntityManager em;

    public void init() {
        Book b1 = new Book("Charles Beaudelaire","Les Fleurs du Mal");
        Book b2 = new Book("Jules Verne","Voyage au centre de la Terre");
        em.persist(b1);
        em.persist(b2);
    }
}
2.7.4 Persistence Unit — persistence.xml file

- Defines the set of all entity classes managed by EntityManager instances in an application
- Represents the data contained within a single data store
- Packaged with the application archive file
- XML elements:
  - `persistence` element: global schema, includes a persistence-unit element
  - `persistence-unit` element: name of a persistence unit and transaction type
  - Optional `description` element
  - `jta-data-source` element: specifies the global JNDI name of the JTA data source
Persistence Unit — persistence.xml file — Example

```xml
<persistence>
  <persistence-unit name="OrderManagement">
    <description>This unit manages orders and customers. It does not rely on any vendor-specific features and can therefore be deployed to any persistence provider.</description>
    <jta-data-source>jdbc/MyOrderDB</jta-data-source>
    <jar-file>MyOrderApp.jar</jar-file>
    <class>com.widgets.Order</class>
    <class>com.widgets.Customer</class>
  </persistence-unit>
</persistence>
```
2.8 Message-driven Beans (MDB)

- Can implement any messaging type
- Handle asynchronous messages
- Useful for non-blocking calls
- Producer/consumer concept
- Stateless — state is lost between 2 messages processing
- All instances of a same MDB class are equivalent
- Can process messages from several clients
- No remote interface
- The container delivers messages to a MDB using the onMessage() method
- Same lifecycle as a stateless session bean
Message-driven Beans types (MDB)

- 2 communication modes
  - Queue: 1 to 1 or n to 1
  - Topic: 1 to n or n to m

![Diagram of P2P: Point-to-Point and Pub/Sub: Publish and Subscribe]
JMS architecture

The Java Message service provides MDB management
MDB development
MDB development

1. Create a connection using a ConnectionFactory

2. Create a session (possibly several sessions per connection):
   - period of time for sending messages on a queue or topic
   - may be transactional

3. Create a message

4. Send the message

5. Close the session

6. Close the connection
public class myProducer {
    @Resource(mappedName="jms/ConnectionFactory")
    private static ConnectionFactory connectionFactory;
    @Resource(mappedName="jms/Queue")
    private static Queue queue;
    public void produce() {
        /* 1 */ Connection connection = connectionFactory.createConnection();
        /* 2 */ Session session = connection.createSession(false, Session.AUTO_ACKNOWLEDGE);
        MessageProducer messageProducer = session.createProducer(queue);
        /* 3 */ TextMessage message = session.createTextMessage();
        message.setText("This is a message ");
        /* 4 */ messageProducer.send(message);
        /* 5 */ session.close();
        /* 6 */ connection.close();
    } }
@MessageDriven(mappedName="jms/Queue")
public class SimpleMessageBean implements MessageListener {

    public void onMessage(Message m) {
        TextMessage message = (TextMessage) m;
        message.getText();

        ...
    }
}

2.9 Transaction Service I

- Controls concurrent accesses to data by multiple programs
- In case of a system failure, transactions make sure that after recovery the data will be in a consistent state
- Guarantees ACID properties for transactions
  - Atomicity: Either all operations in the transaction complete successfully or none.
  - Consistency: The database is always in a valid state, so that two users see the same value for any given data item.
  - Isolation: Concurrent transactions give the same result as if they were performed in isolation.
  - Durability: The content of the database is stored on stable storage in a persistent way and will not be lost.
- Fully integrated within the EJB server
- Main advantage compared to the CORBA middleware
2.9 Transaction Service II

- Specifies standard Java interfaces between a transaction manager and the parties involved in a distributed transaction system
  - Resource manager
  - Application server
  - Transactional applications

- Transaction manager
  - Decides whether to commit or rollback at the end of the transaction in a distributed system and coordinates various resource managers

- Resource manager
  - Responsible for controlling the access to common resources in the distributed system
3 References

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