Component Middleware

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1 Foreword
2 Introduction

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2.1 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
2.2 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)
2.3 What is a component?

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

- According to [Szyperski, 1998]:
  - 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
2.4 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
2.5 Runtime environment of a component
2.5.1 Runtime environment of a component (cont.)

- 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
2.5.2 Technical services

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

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

**Tiers**

- **Presentation**
  - manages the delivery of information to the end user.
- **Logic**
  - split into two distinct tiers, the *business logic* deals with what we want the application to do, and the *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.
2.7 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...

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
2.7.1 The 6 Roles in Component Development (cont.)

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
2.8 Main component middleware

- **Entreprise Java Beans**
  - Supported by Oracle
  - Application server: Java EE
    - [http://www.oracle.com/technetwork/java/javaee](http://www.oracle.com/technetwork/java/javaee)
  - ONE LANGUAGE, MANY PLATFORMS

- **.NET**
  - Supported by Microsoft
    - [msdn.microsoft.com/net](msdn.microsoft.com/net)
  - MANY LANGUAGES, ONE PLATFORM (Windows)

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

- **CORBA Component Model (CCM)**
  - Supported by the Object Management Group (OMG)
    - [www.omg.org](www.omg.org)
  - Extends the EJB model
  - MANY LANGUAGES, MANY PLATFORMS
Vendor-neutral specification
3 Overview of EJB Technology

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3.1 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
  - 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
3.2 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 a member
3.3 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
3.3.1 EJB Container — Provided services

- Includes many **Java technologies**, that can be used independently of EJB
- Java 2 Platform, Standard Edition v8 (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
3.3.2 EJB Container — Provided services (cont.)

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

- EJB 3.2 APIs (javax package), including Java Persistence (JPA 2.1)
- Asynchronous communication: Java Messaging Service (JMS 2.0), JavaMail 1.5
- Connector
- Transaction: UserTransaction interface of JTA 1.2, Java Transaction Service (JTS) (specification based on CORBA Object Transaction Service)
- Security: Java Security API
- Web Services: JAX-RPC 1.1, JAX-WS 2.0, JAX-RS 2.0
3.3.3 EJB Container — Provided services (cont.)

- 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
3.4 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 for the Java EE Platform (CDI)
- Bean Validation: same set of validations can be shared by all layers of an application
- Java Server Faces (JSF) 2.0 supports Ajax
3.4.1 Java EE - Roadmap

**J2EE 1.2**
- Servlet, JSP, EJB, JMS, RMIIOP
- May 1998
- 10 specs

**J2EE 1.3**
- CMP, Connector Architecture
- Sep 2001
- 13 specs

**J2EE 1.4**
- Web Services, Management, Deployment, Async. Connector
- Nov 2003
- 20 specs

**Java EE 5**
- Ease of Development Annotations
- EJB 3.0
- Persistence API
- New and Updated Web Services
- May 2006
- 23 specs

**Java EE 6**
- Pruning Extensibility Profiles
- Ease-of-dev EJB Lite
- RESTful WS CDI
- Dec 2009
- 28 specs

**Java EE 7**
- Ease of use
- Complete Java EE 6
- April 2013
- 28+ specs
3.4.2 Java EE - Specifications

Java EE 7

CDI 1.1
Bean Validation 1.1
Interceptors 1.2
Concurrency 1.0

JSP
JSTL

EL 3.0

JSF 2.2

Servlet 3.1
Web Socket 1.0

JTA 1.2
EJB 3.2
JMS 2.0

JPA 2.1

JAX-RS 2.0
JSON-P 1.0
Batch 1.0
JavaMail 1.5
JCA 1.7
3.4.3 Java EE Architecture
3.4.4 Java EE — 3-tier Architecture
3.4.5 Java EE — 3-tier Architecture (cont.)

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

- **Application Server**
  - Reference implementation: Java EE 7 GlassFish (Oracle)
  - 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...)
3.5 EJB types

- **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)
3.5.1 EJB types (cont.)

- **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.
3.6 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.
- **@Local**: Applied to the session bean class or local business interface to designate a local 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.
Main EJB3 Annotations (cont.)

- **@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 only be specified if container-managed transaction demarcation is used. 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*
Main EJB3 Annotations (cont.)

- @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.
3.7 Bean development

- 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**
3.7.1 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.
3.8 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
3.8.1 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 javax.ejb.Remote;

@Remote
public interface 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);
}
```
3.8.2 Stateless Session Bean — Calculator Example - Implementation class

Possible to name a bean: \texttt{@Stateless(name = "myCalculator")}

```java
import javax.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;}
}
```
3.8.3 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 EJBCContext interface and the bean interface name

```java
import javax.naming.*;
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);
  }
}
```
3.8.4 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");
    ```
3.8.5 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 javax.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();
}
3.8.7 Stateful Session Bean — Cart Example — Implementation

class

import java.util.ArrayList;
import java.util.List;
import javax.ejb.Remove;
import javax.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;
        }
    }
}
3.8.8 Stateful Session Bean — Cart Example — Implementation

```java
    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
public void remove() { contents = null; }
```
3.8.9 Stateful Session Bean — Cart Example — Client side

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");
3.9 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
3.10 Asynchronous Method Invocation — Session bean side

- Annotate a method or a class with `@Asynchronous` (javax.ejb.Asynchronous)
- Asynchronous methods return either void or an implementation of the Future\(<V>\) interface

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

- Result is returned to the container, not directly to the client
- Check whether the client requested the invocation to be cancelled with method `javax.ejb.SessionContext.wasCancelled`

```java
@Asynchronous
class processPayment(Order order) throws PaymentException {
    ...
    if (SessionContext.wasCancelled()) {
        // clean up
    } else {
        // process the payment
    }
    ...
}
```
3.12 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
### 3.13 Entity Bean

- Represents 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
3.13.1 Entity Bean (cont.)

- **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
3.13.2 Entity Bean — Example

@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; }
    ...
}

### 3.13.3 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.
3.13.4 Multiplicities in Entity Relationships — OneToMany example

@javax.persistence.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;
    }

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

    public void addBook(String title) {
        Book aBook = new Book(this.name, title);
        getBooks().add(aBook);
    }
}
3.13.5 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
3.13.6 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
3.13.7 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;
```
3.13.8 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();
  ```
3.13.9 How to use the Entity Manager — Example

```java
import javax.ejb.*;
import javax.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);
    }
}
```
3.13.10 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
3.13.11 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>
```
3.14 Message-driven Beans (MDB)

- Can implement any messaging type. Most commonly, Java Message Service (JMS).
- 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
3.14.1 Message-driven Beans (MDB)

- 2 communications modes
  - ♦ Queue : n to 1
  - ♦ Topic : n to m
3.14.2 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
### 3.14.3 MDB development — Producer example

```java
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();
  }
}
```
3.14.4 MDB development — Consumer example

@MessageDriven(mappedName="jms/Queue")
public class SimpleMessageBean implements MessageListener {

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

### 3.15 Transaction Service

- 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 both operations complete successfully or none
  - **Consistency**: e.g. an account must never have a negative balance
  - **Isolation**: several parallel transfers must give the same result as if they were performed successively
  - **Durability**: Account state must be persistent and stored on stable storage
- Example: banking transfer with debit then credit operations
- Fully integrated within the EJB server
- Main advantage compared to the CORBA middleware
3.15.1 Transaction Service (cont.)

- 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
4 Conclusion

Advantages

- Framework taking in charge an important number of technical services
- Components are dedicated to business aspects
- Packaging and deployment made easy

Restrictions

- Only Java
- Some domains are not yet addressed: real-time or embedded systems, mobile computing...
5 References

http://www2.lifl.fr/~seinturi/middleware/javaee.pdf
JSR345 : https://www.jcp.org/en/jsr/detail?id=345

