

# Middleware and Web Services

## Lecture 5: Messaging Systems

**doc. Ing. Tomáš Vitvar, Ph.D.**

tomas@vitvar.com • @TomasVitvar • <http://vitvar.com>



Czech Technical University in Prague

Faculty of Information Technologies • Software and Web Engineering • <http://vitvar.com/courses/mdw>



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## Overview

- **Messaging Systems**
  - *Point-to-Point*
  - *Error Handling*
  - *Publish/Subscribe*
- **Store and Forward**

## Recall: Asynchronous via Intermediary

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- Intermediary
  - *A component that decouples a client-server communication*
  - *It increases reliability and performance*
    - *The server may not be available when a client sends a request*
    - *There can be multiple servers that can handle the request*

## Messaging Systems

- Messaging Systems
  - *Also "Messaging Middleware" or "Message-Oriented Middleware" (MOM)*
  - *Two roles: a message consumer and a message producer*
  - *Asynchronous communication*
  - *"anonymity" between producers and consumers*
    - *no matter "who", "where", "when" produced a message*
  - *Ensures reliability and scalability*
- Loose coupling of applications
  - *A producer does not need to know about a consumer*
    - *Messaging systems decouple a producer and a consumer*
- Two types (Messaging Domains)
  - *Point-to-Point (message queue — MQ)*
  - *Publish/Subscribe (event-based)*

## Java Message Service

- JMS – Java Message Service
  - *Java API for Message-Oriented Middleware*
  - *Java programs to create, send, receive and read messages*
  - *Standardized in JSR 914* [🔗](#)
- Terminology
  - **JMS Provider** – *implementation of JMS system, part of application server*
  - **JMS Client** – *application that sends or receives JMS messages*
    - **JMS producer/publisher** – *creates and sends messages*
    - **JMS consumer/subscriber** – *receives and processes the messages*
  - **JMS Message** – *an object with data (payload) and properties*
  - **JMS Queue** – *storage that contains sent messages that are to be received; messages are processed only once*
  - **JMS Topic** – *storage that distributes messages to multiple subscribers*

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## Conceptual Architecture

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- "1 : 1" relationship between a producer and a consumer
  - **one message must be processed by one consumer**
- **no time-dependency** between message producer and consumer
  - consumer does not need to exist when producer sends a message
- Message exists in the queue until it is used by a consumer
- message consumers take as many messages as they are able to serve

## Basic Types of Queues

- Queues in client-server architecture (request-response)
- Input Queue
  - a client places a message to the queue
  - a server reads the message and process it
- Output Queue
  - a server places output message (response) to the queue
  - a client reads the message
- Error Queue
  - a server reads the message from the input queue
  - when processing of the message fails, the server places the message to the error queue
  - there can be several attempts to process the message before it is placed to the error queue

## JMS Queues

- JMS Provider implemented by Weblogic
- Configuration
  1. Create a **JMS server**, targeted to a managed server
    - In a cluster, every managed server has its own JMS server
    - JMS server has a persistent store where it stores messages in queues (persistent store can be file-based or JDBC-based)
  2. Create a queue, specify a JNDI name for the queue
    - a **queue** targeted to a single JMS server
    - a **distributed queue** targeted to the cluster (all JMS servers)
  3. Create a **connection factory** (optional), specify a JNDI name for the connection factory
    - A JMS client uses the connection factory to create a connection with the JMS server
- Run a JMS client
  - a JMS producer – sends a message to the queue
  - a JMS consumer – receives a message from the queue

## JMS Message

- JMS Message Header
  - Priority
    - priority that will be used to consume the message
    - normal priority – 1-4, high priority 5-9
  - Delivery mode
    - persistent – message stored in a storage during send operation
    - non-persistent – JMS server only stores the message in memory
  - Time to live
    - The time the message stays in the queue, the message is removed after it elapses
    - The JMS consumer must consume the message before the time elapses
  - Message ID
    - ID of the message set by the client (in request-response communication)
  - Reply To
    - A response queue set by the client
  - Correlation ID
    - ID of the message set by the receiver for response
- Payload (data)
  - text, map message (key-values), byte message, object message (serializable java)

## Conversation in Request-Response

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- Steps
  1. Client sends a message to the request queue with some message ID1
  2. Server receives it, process it and sends a response to the response queue
    - The response message has its own message ID3 and a correlation ID that has a value of message ID1
  3. Client receives the response message and correlates with the request message

## Example Queues Configuration in Weblogic

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# Weblogic Configuration

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## JMS Producer Example (1)

```
1  public class JMSProducer {
2
3      // connection factory, connection, session, sender, message
4      private QueueConnectionFactory qconFactory;
5      private QueueConnection qcon;
6      private QueueSession qsession;
7      private QueueSender qsender;
8      private Queue queue;
9      private TextMessage msg;
10
11      // creates a connection to the WLS using a JNDI context
12      public void init(Context ctx, String queueName) throws NamingException, JMSException
13      {
14          // creates connection factory based on JNDI and a connection, creates a session
15          qconFactory = (QueueConnectionFactory) ctx.lookup(Config.JMS_FACTORY);
16          qcon = qconFactory.createQueueConnection();
17          qsession = qcon.createQueueSession(false, Session.AUTO_ACKNOWLEDGE);
18
19          // lookups the queue using the JNDI context
20          queue = (Queue) ctx.lookup(queueName);
21
22          // create sender and message
23          qsender = qsession.createSender(queue);
24          msg = qsession.createTextMessage();
25      }
26
27      // close sender, connection and the session
28      public void close() throws JMSException {
29          qsender.close(); qsession.close();
30          qcon.close();
31      }
32  }
```

## JMS Producer Example (2)

```
32 // sends the message to the queue
33 public void send(String queueName, String message) throws Exception {
34     // create a JNDI context to lookup JNDI objects (connection factory and queue)
35     Hashtable env = new Hashtable();
36     env.put(Context.INITIAL_CONTEXT_FACTORY, Config.JNDI_FACTORY);
37     env.put(Context.PROVIDER_URL, Config.PROVIDER_URL);
38
39     InitialContext ic = new InitialContext(env);
40     init(ic, queueName);
41
42     // send the message and close
43     try {
44         msg.setText(message);
45         qsender.send(msg, DeliveryMode.PERSISTENT, 8, 0);
46         System.out.println("The message was sent to the destination " +
47                             qsender.getDestination().toString());
48     } finally {
49         close();
50     }
51 }
52
53 public static void main(String[] args) throws Exception {
54     // JNDI name of the queue and a text message
55     String msg = args[0];
56     String queueName = args[1];
57
58     // create the producer object and send the message
59     JMSProducer producer = new JMSProducer();
60     producer.send(msg, queueName);
61 }
62 }
```

## JMS Producer Example (3)

- Send a message to the queue
  - You need to create a VPN connection to the environment
    - JMS Producer connects to the cluster  
(or one of the managed servers in the cluster)
  - Arguments: (1) JNDI name of the queue, and (2) text message
    - **/jms/mdw-queue** or **/jms/mdw-dist-queue**

```
1 $ ./jmsproducer.sh /jms/mdw-queue message_from_mdw_lecture
2 $ The message was sent to the destination mdw-module!mdw-queue
```



## Monitor the JMS Queue

- How many messages
  - *Messages current*
    - number of messages in the queue waiting to be processed (**backlog**)
  - *Messages pending*
    - number of messages being processed (either being sent by a producer or being received by a consumer). Such messages have not been committed (acknowledged)

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## JMS Consumer Example (1)

```
1 public class JMSConsumer implements MessageListener {
2
3     // connection factory
4     private QueueConnectionFactory qconFactory;
5
6     // connection to a queue
7     private QueueConnection qcon;
8
9     // session within a connection
10    private QueueSession qsession;
11
12    // queue receiver that receives a message to the queue
13    private QueueReceiver qreceiver;
14
15    // queue where the message will be sent to
16    private Queue queue;
17
18    // callback when the message exist in the queue
19    public void onMessage(Message msg) {
20        try {
21            String msgText;
22            if (msg instanceof TextMessage) {
23                msgText = ((TextMessage) msg).getText();
24            } else {
25                msgText = msg.toString();
26            }
27            System.out.println("Message Received: " + msgText);
28        } catch (JMSException jmse) {
29            System.err.println("An exception occurred: " + jmse.getMessage());
30        }
31    }
32 }
```

## JMS Consumer Example (2)

```
32 // create a connection to the WLS using a JNDI context
33 public void init(Context ctx, String queueName)
34     throws NamingException, JMSException {
35
36     qconFactory = (QueueConnectionFactory) ctx.lookup(Config.JMS_FACTORY);
37     qcon = qconFactory.createQueueConnection();
38     qsession = qcon.createQueueSession(false, Session.AUTO_ACKNOWLEDGE);
39     queue = (Queue) ctx.lookup(queueName);
40
41     qreceiver = qsession.createReceiver(queue);
42     qreceiver.setMessageListener(this);
43
44     qcon.start();
45 }
46
47 // start receiving messages from the queue
48 public void receive(String queueName) throws Exception {
49     Hashtable env = new Hashtable();
50     env.put(Context.INITIAL_CONTEXT_FACTORY, Config.JNDI_FACTORY);
51     env.put(Context.PROVIDER_URL, Config.PROVIDER_URL);
52
53     InitialContext ic = new InitialContext(env);
54     init(ic, queueName);
55
56     System.out.println("Connected to " + queue.toString() + ", receiving messages...");
57
58     // loop until ctrl+c
59     while (true) {
60         this.wait();
61     }
62 }
```

## JMS Consumer Example (3)

- Receive a message from the queue
  - You need to create a VPN connection to the environment
    - JMS Consumer connects to the cluster  
(or one of the managed servers in the cluster)
  - Arguments: (1) JNDI name of the queue
    - **/jms/mdw-queue** or **/jms/mdw-dist-queue**

```
1 $ ./jmsconsumer.sh /jms/mdw-queue
2 $ Connected to mdw-module!mdw-queue, receiving messages...
3 Message Received: message-from-mdw-lecture1
4 Message Received: message-from-mdw-lecture2
```

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## Error Handling Using Timeout

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- *message consumers or message processing may fail*
- **visibility timeout** – *time during which the message exist in the queue, and need to be deleted by the consumer (~ 30 seconds)*
- *Example technology: Amazon Simple Queue Service (SQS)*

# Error Handling Using Transactions

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- ***transaction*** – message consumer opens a transaction and deletes the message; when the processing is successful the transaction is committed otherwise it is rolled back and the message appears in the queue again
- Example technology: JMS, Weblogic server

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# Publish/Subscribe System

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- *occurrence of a message = event that triggers one or more processes*
- *a "1 : N" relationship between producer and consumer*
  - ***one message can be processed by many different subscribers***
- ***time-dependency*** between publisher and subscriber
  - *subscriber must first subscribe to a topic and then publisher can publish a message under that topic*
- *a message is deleted when all its subscribers consume it*



# Publish/Subscribe API

- **lookupTopic**
  - *lookups or creates a topic*
  - *called by the subscriber first and then by the publisher*
- **receiveMessage**
  - *request to receive (read) a message under the topic*
  - *called by the subscriber*
  - *Implementation specific:*
    - *synchronous – blocking, with timeout*
    - *asynchronous – through event listener*
- **publishMessage**
  - *publishes a message under the topic*
  - *called by the publisher*

## Event-driven Communication

- Event
  - *Occurrence of a message with certain topic*
- Event-driven Process
  - *events trigger actions*
  - *one event may trigger more actions*
  - *loose coupling – not all actions need to be known at design time*

## Event-driven Process Example

- Conceptual process 
- Event-driven process implementation 

## Overview

- Messaging Systems
- Store and Forward

## Store and Forward Agents

- Motivation
  - Several environments (*integration middleware, OSM, CRM*)
  - Sending messages across environments
  - A need to "decouple" environments
  - Destination (queue) might not be always available
    - Destination environment is down or busy
- SAF = Store and Forward
  - Agent – a component deployed to an application server instance
    - has a queue and its own storage
    - has configured a remote destination
- Scenario
  1. JMS producer sends a message to the agent's queue
  2. Agent forwards the message to the remote destination
  3. When the remote destination is not available, the agent keeps the message in its queue and retries to send the message after some time
  4. As a result of the unavailability, there can be a **backlog** of messages in the agent's queue

## Example SAF Agent Architecture



## Example SAF Agent Backlog



- Messages received
  - number of messages received to the SAF agent queue in every hour
- Backlog
  - number of messages waiting to be sent across to the destination queue
  - Destination system cannot catch up with number of messages being sent across