SPRING DISTRIBUTED SERVICES

Knowledge is present everywhere

Remote Service Definition

- Remote services are services hosted on remote servers
- Accessed by clients over the network.
- Spring features integration classes for remoting support using various technologies.
- The remoting support eases the development of remote-enabled services, implemented by your usual (Spring) POJOs.
- Spring Remoting exposes services over the web for Spring clients to consume as easily as though they were locally instantiated.

Remoting Technologies

RMI- Remote Method Invocation - Use RMI to invoke a remote method. The java objects are serialized. RMI also has firewall issues.

Hessian- Transfer binary data between the client and the server.

Burlap- Transfer XML data between the client and the server. It is the XML alternative to Hessian.

Hessian and Burlap are portable; integrate with other languages such as C# and PHP

Spring's HTTP invoker- Spring provides a special remoting strategy which allows for Java serialization via HTTP, supporting any Java interface .

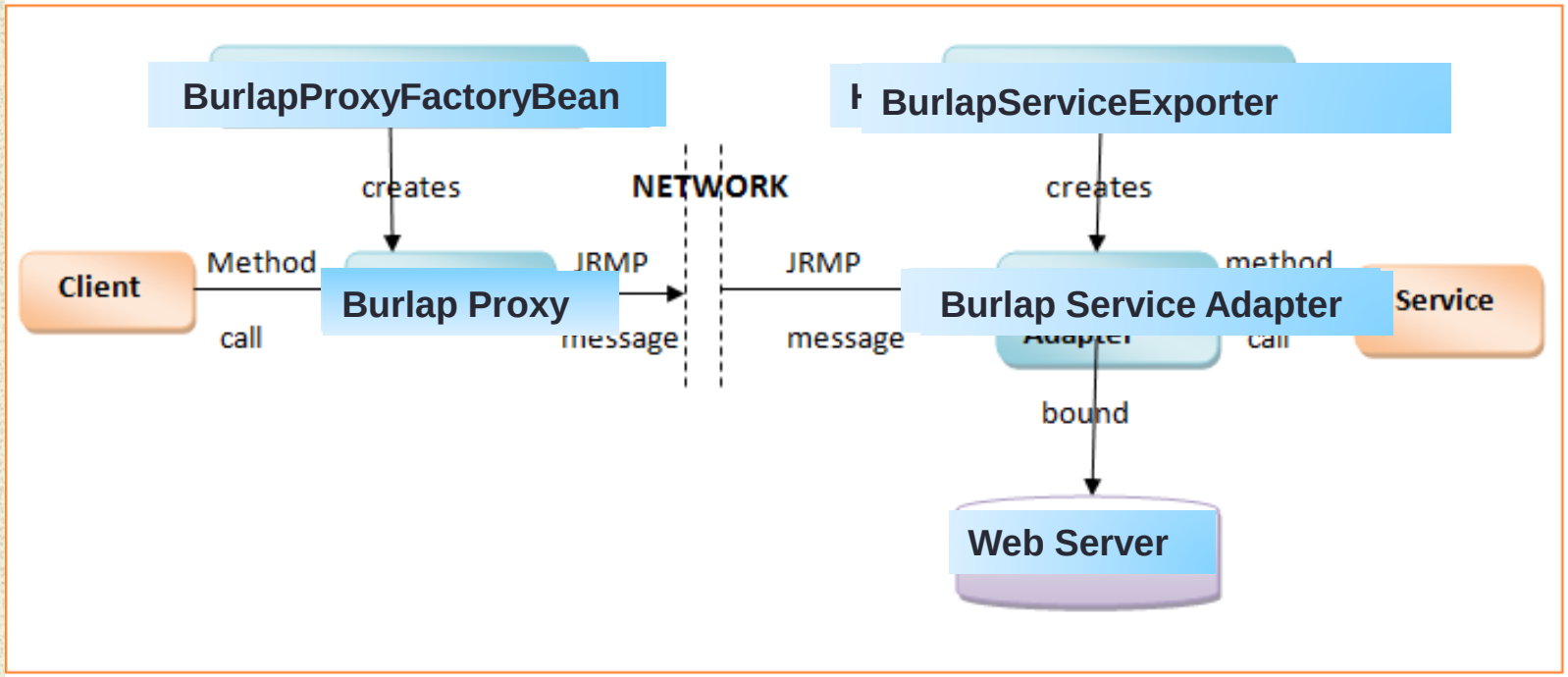
Both client and server applications have to be based on Spring.

JMS- Remoting using JMS is supported via the JmsInvokerServiceExporter and JmsInvokerProxyFactoryBean classes.

AMQP- Remoting using AMQP as underlying protocol - supported by the Spring AMQP project.

JAX-WS. Spring provides remoting support for web services via JAX-WS [SOAP]

RMI, Http, Hessian & Burlap



Configure HTTP Server/Client

- **SERVER**

```
@Bean(name = "/weather")
    public HttpInvokerServiceExporter exporter() {
 HttpInvokerServiceExporter exporter=new HttpInvokerServiceExporter();
        exporter.setService(weatherService());
        exporter.setServiceInterface(WeatherService.class);
        return exporter;
    }
```

CLIENT

```
 @Bean
public HttpInvokerProxyFactoryBean weatherService() {
 HttpInvokerProxyFactoryBean factory =
                                    new HttpInvokerProxyFactoryBean();
 factory.setServiceUrl("http://localhost:8080/HTTPInvokerServer/weather");
 factory.setServiceInterface(WeatherService.class);
 return factory;
}
```

WeatherService…proxy interface

Configure Hessian Server/Client

- **SERVER**
- @Bean(name = "/weather")
- public HessianServiceExporter exporter() {
- HessianServiceExporter exporter = new HessianServiceExporter();
- exporter.setService(weatherService());
- exporter.setServiceInterface(WeatherService.class);
- return exporter;
- }

WeatherService…proxy interface

- **CLIENT**
- @Bean
- public HessianProxyFactoryBean weatherService() {

```
  HessianProxyFactoryBean factory = new HessianProxyFactoryBean();
  factory.setServiceUrl("http://localhost:8080/HessianServer/weather");
  factory.setServiceInterface(WeatherService.class);
  return factory;
}
```

Main Point

- Distribution of work makes possible better organized more specialized and scalable systems.
- ***Science of Consciousness****: Pure Consciousness has infinite organizing power.*

Service Oriented Architecture(SOA) Some Definitions

Web Service

- Usually single function, e.g., producing data, validating a customer, or providing simple analytical services.

Service-Oriented Architecture

A collection of services.

Sequenced data passing

Multiple services coordinating some activity.

A way of aggregating services to business processes.

Defined by service directories, service governance, Security, SLA, orchestration…

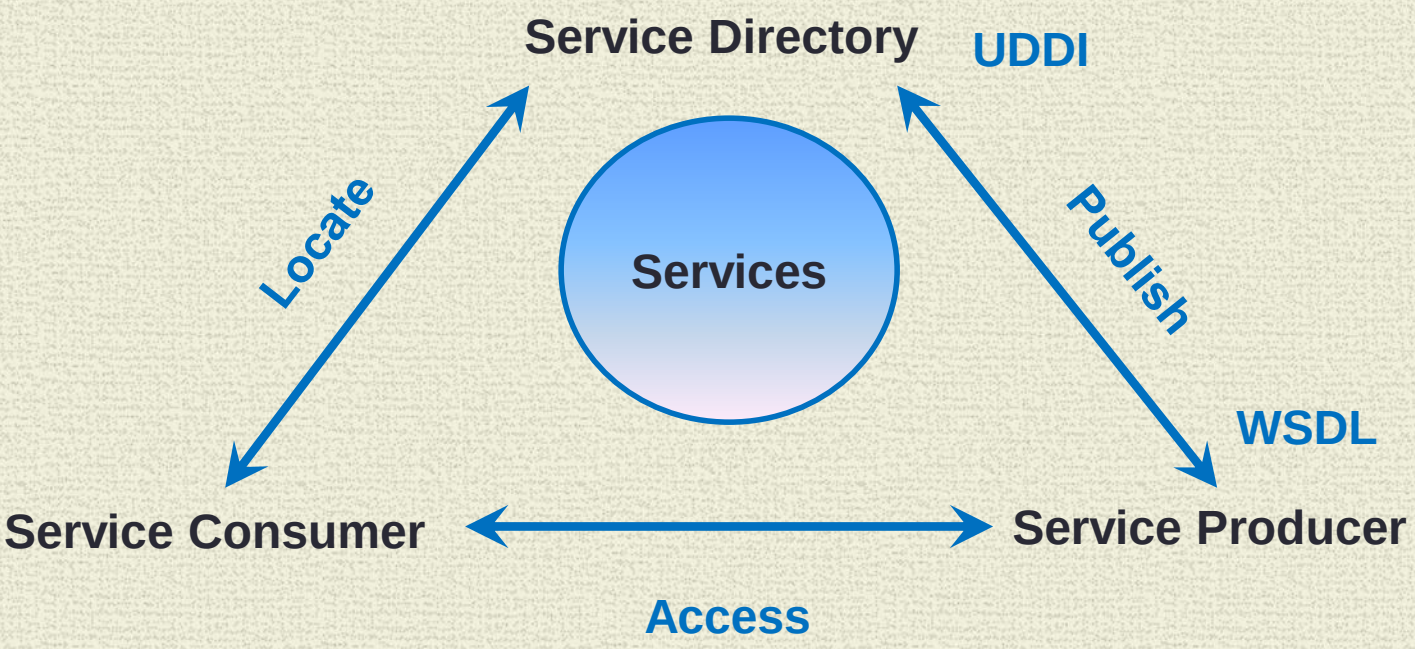
Orchestration

Provides central control over a business process[AKA Workflow].

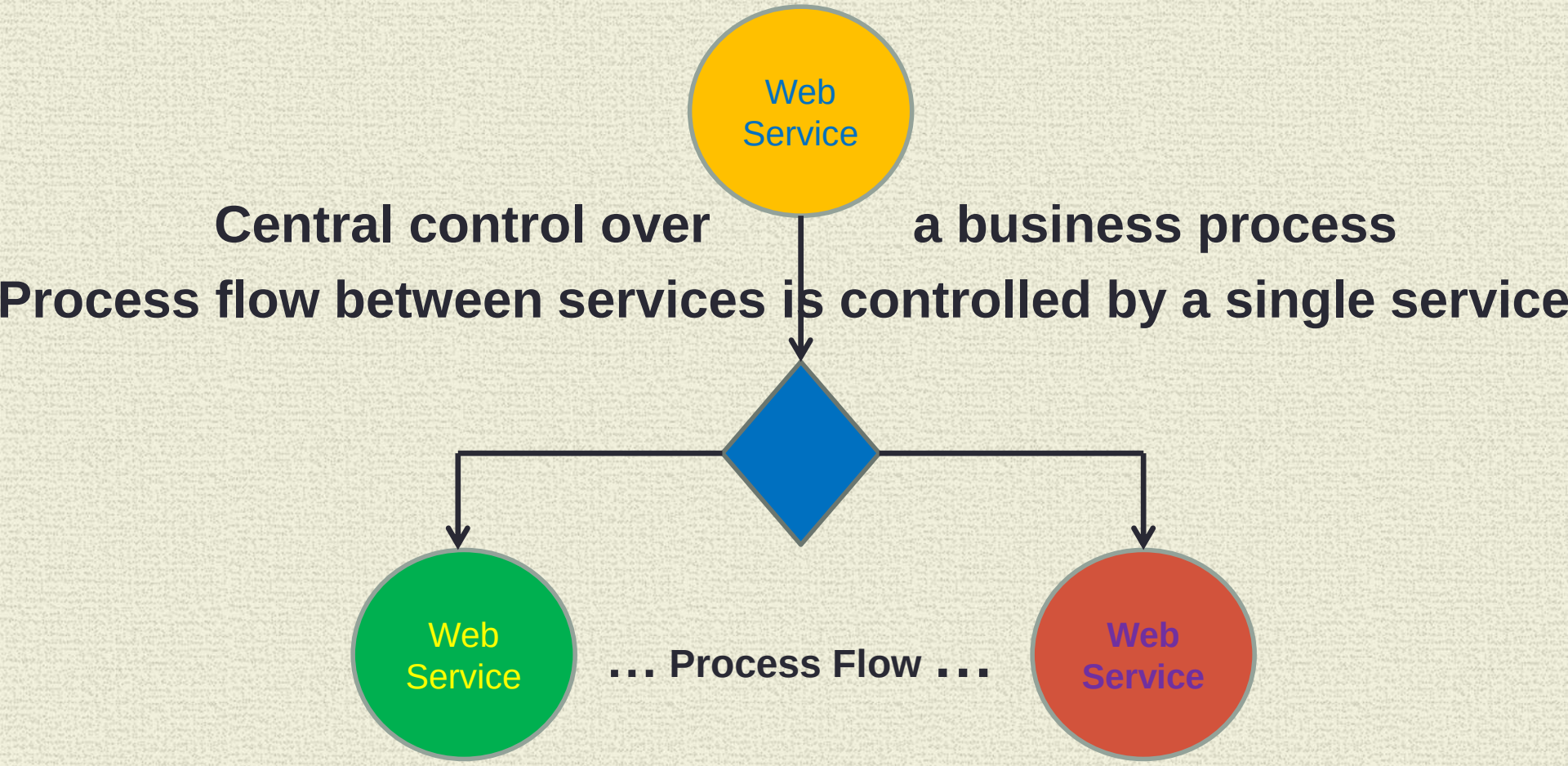
Choreography

Global description of the participating services, a decentralized approach for service composition.

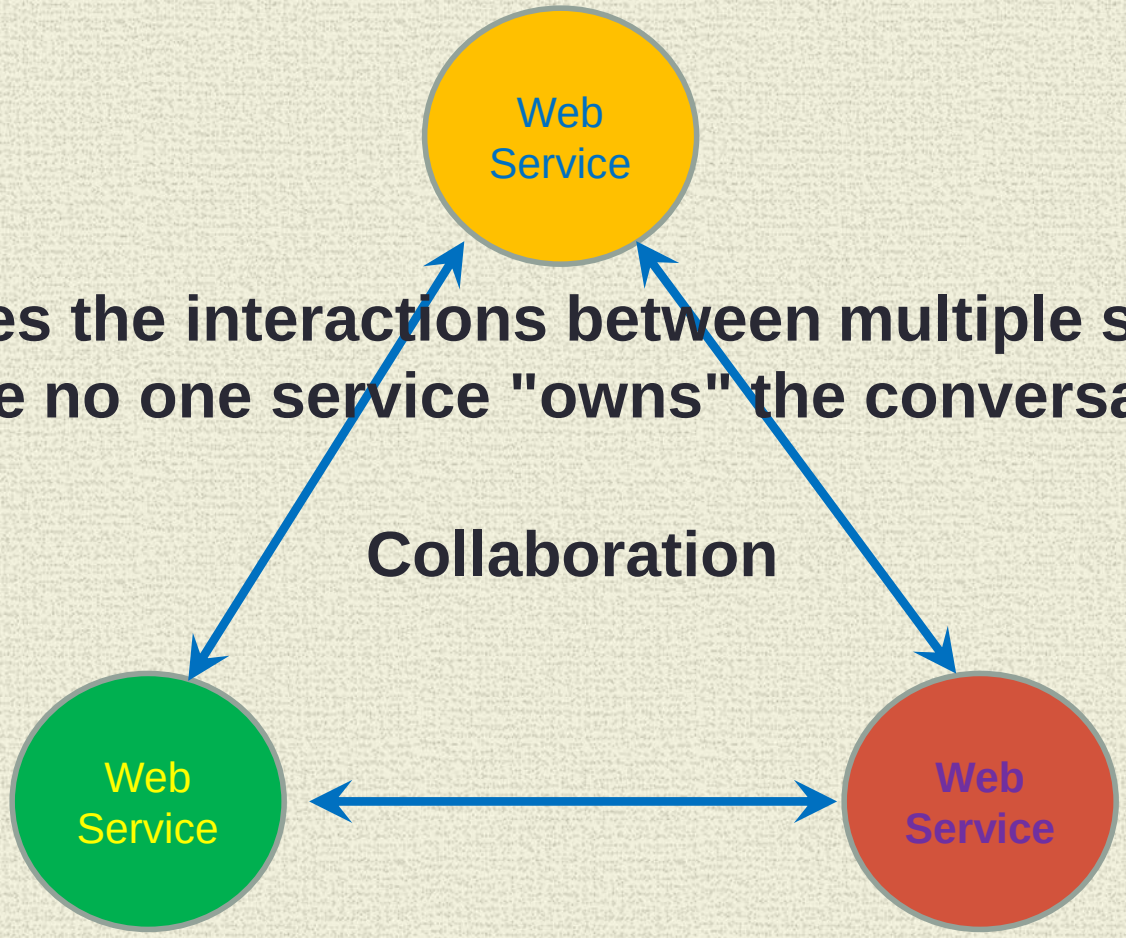
Services Oriented Architecture Publish & Lookup



SOA Orchestration



SOA Choreography



Describes the interactions between multiple services, where no one service "owns" the conversation.

Collaboration

Simple Object Access Protocol SOAP

- Language, platform, and transport independent
  (not only HTTP)
- Works well in distributed enterprise environments
- Standardized
- Built-in error handling
- Provided document style to better represent domain model
- Strong enterprise adoption – B2B
- **Built-in Security**
- Business Process Language {BPEL}

Web Services Description Language for SOAP

- XML format for describing network services as a set of endpoints operating on messages containing either **document-oriented or procedure-oriented** information.

Procedure-oriented : RPC Style

- Defines that the SOAP message body is viewed as a single structure consisting of a method name and a set of parameters.

Document-oriented: Document Style

- Defines of data/information [Domain Object] payload .vs. RPC.

- The operations and messages are described abstractly, and then **bound to a concrete network protocol** and message format to define an endpoint

Web Service Generation

- **Contract-first web service**
- The "contract" (a WSDL definition[**XML**] of operations and endpoints and **XML** schema of the messages) is created first, without actually writing any service code.
- **Contract-last web service**
- Existing logic is "exposed" as a web service and the contract is Generated from it.

- **Spring WS**

  "Features …a solution for contract-first, document-driven web services - highly recommended for building modern, future-proof web services."

Generate WSDL from an XML schema definition [Domain Model]

Generate Java classes from the WSDL XML schema definition

Artifacts to “Manually” Construct

- **Create the SOAP XML Schema definitions**:
- AccountDetails.xsd ---------- Domain Model Schema
- AccountDetailsServiceOperations.xsd --------- Request/response schema

- Build using eclipse→ run as→ Maven Build [goal: clean install]

- **Create SOAP Implementation Classes**
- AccountService.java ---------- Service Interface
- AccountServiceImpl.java ---------- @Service access “dao”
- AccountServiceEndPoint.java ---------- Handles Request

- Eclipse run as→ Run on Server

  Click on URL on displayed Web Page : [Generate WSDL]

Domain Model Schema

```
• <xs:element name="Account" type="Account"/>
    <xs:complexType name="Account">
        <xs:sequence>
            <xs:element name="AccountNumber" type="xs:string"/>
            <xs:element name="AccountName" type="xs:string"/>
            <xs:element name="AccountBalance" type="xs:double"/>
            <xs:element name="AccountStatus" type="EnumAccountStatus"/>
        </xs:sequence>
    </xs:complexType>
        <xs:simpleType name="EnumAccountStatus">
            <xs:restriction base="xs:string">
                <xs:enumeration value="Active"/>
                <xs:enumeration value="Inactive"/>
            </xs:restriction>
        </xs:simpleType>
```

Generate Domain Classes

Based on XML schema

The right approach is do this automatically during build time using a maven plugin

```
<plugin>
      <groupId>org.codehaus.mojo</groupId>
      <artifactId>jaxb2-maven-plugin</artifactId>
…
      <goals>
            <goal>xjc</goal>
      </goals>
…
</plugin>
```

- JAXB simplifies access to an XML document from a Java program - binds the schema for XML document to set of Java classes that represents the schema.
- XJC binding compiler from the JAXB distribution

Main Point

- SOAP is characterized by standards and tools based on those standards that automatically generate Client-Server connectivity.
- *The Laws of Nature are conventions [or standards] that spontaneous supports the underlying structure that provides continuity to Life.*

Messaging Systems [JMS & AMQP]

Loosely coupled - asynchronous - reliable – communication between applications

Performance

improved response times by doing some tasks asynchronously

Decoupling

Reduced complexity by decoupling and isolating applications

Scalability

Scale distribute tasks across machines based on load

High-quality, cost-effective

Build apps based on specific function - easier to develop, debug, test

High availability

Robustness and reliability- message queue persistence -

- potential zero-downtime redeploys

JMS & AMQP

JMS has queues and topics.

- A message sent on a queue is consumed by no more than one client.
- A message sent on a topic may be consumed by multiple consumers.

AMQP only has queues….and exchanges

- Queues are consumed by a single receiver
- AMQP doesn't publish directly to queues.

  A message is published to an exchange

  routed to one queue or multiple queues

  Emulating [JMS] queues and topics.

Java Messaging Service

- A **specification[**JSR 914**]** that describes a common way for **Java programs** to create, send, receive and read distributed enterprise messages
- *loosely coupled* communication
- *Asynchronous* messaging
- *Reliable* delivery
  - A message is guaranteed to be delivered once and only once.
- Outside the specification
  - **Security services**
  - **Management services**

JMS Terminology

Broker

Responsible for receiving, routing, and dispensing messages to consumers.

- **Client**

  Application - uses message **broker** to communicate with other applications.

- **Consumer**

  Application that consumes messages from a messaging **destination**.

- **Destination**

  Holding area for messages in **broker**. Clients publish/consume from…

- **Durable Subscriber**

  Consumer receives all messages published on a topic- even after inactive

- **Message**

  An atomic unit of data that is passed between two or more clients.

- **Producer**

  Application that creates and posts messages to a messaging **destination**.

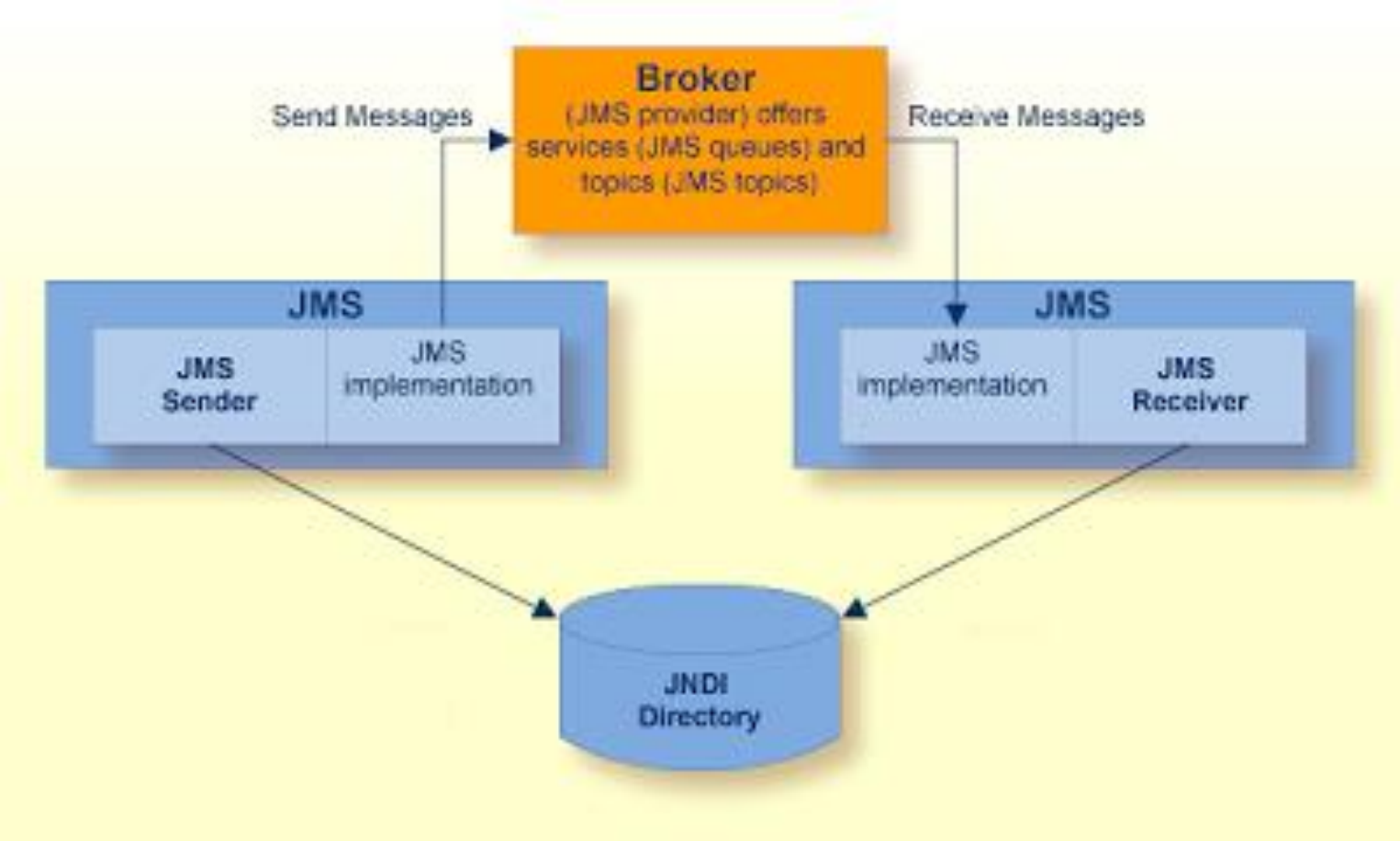
- **Queue**

  A **destination** that uses first in/first out semantics.

- **Topic**

  A **destination** that uses publish and subscribe semantics.

Decoupled Distributed Messaging [JMS Example]



Main Point

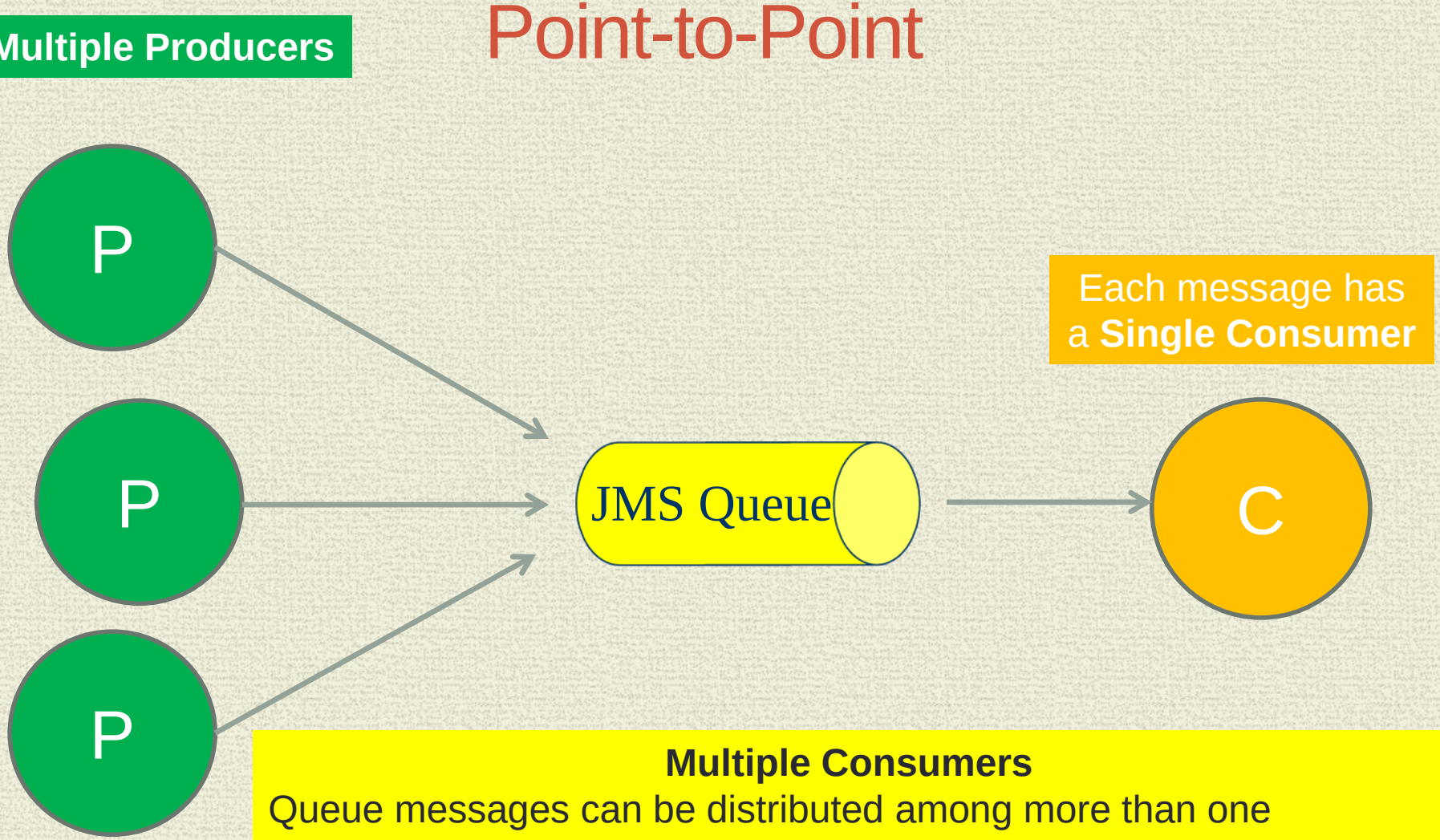
Messaging oriented services guarantee a reliable communication and simplify the complexity of the applications.

Science of Consciousness: *Pure Consciousness is simple, reliable, efficient and precise.*

JMS Services

- Point-to-Point (PTP)
  - Built around the concept of a message queue
  - Each message has only one consumer
  - Multiple producers
- Publish-Subscribe systems
  - Uses a “topic” to send and receive messages
  - Each message has multiple subscribers
  - Single publisher

JMS
Point-to-Point

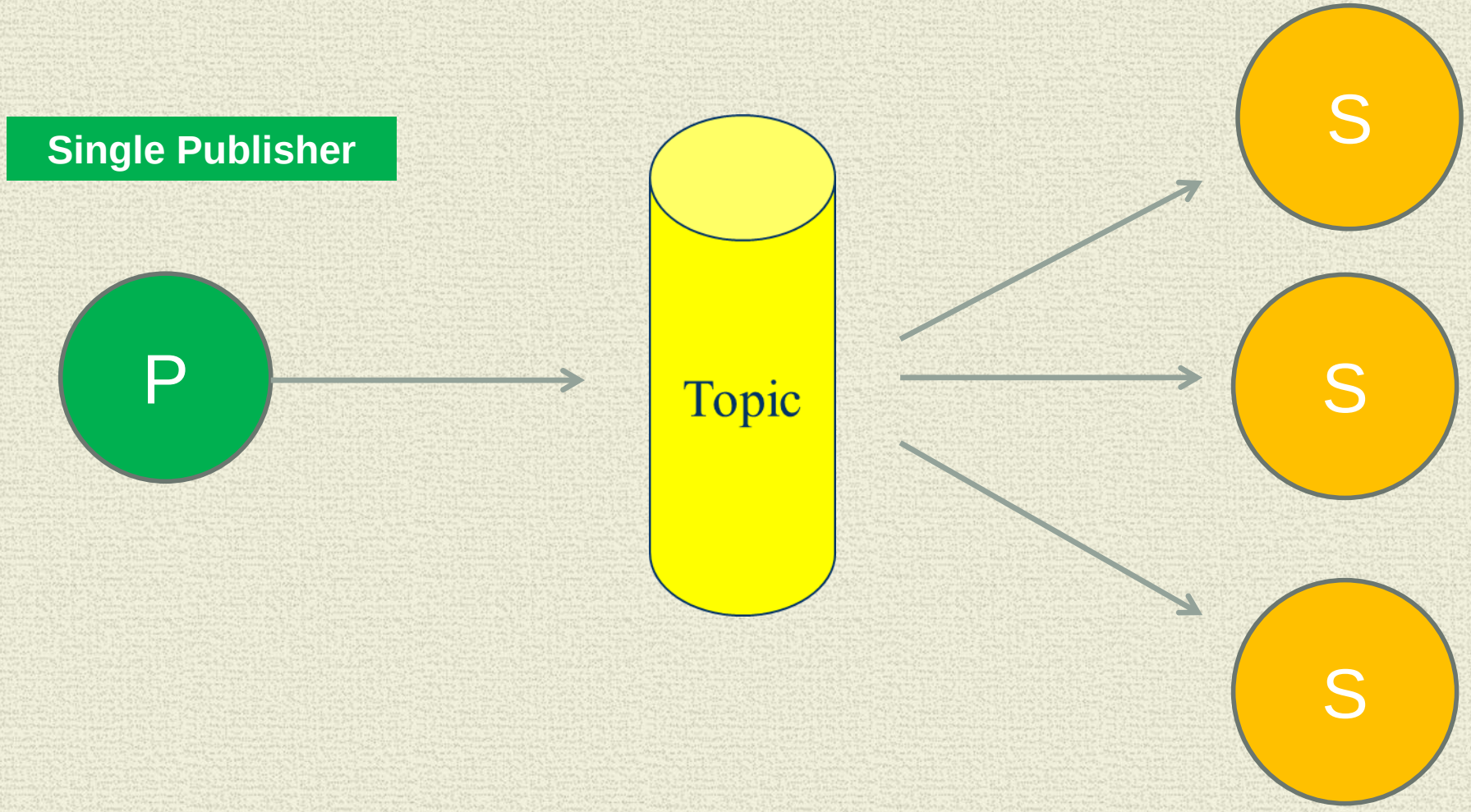


Multiple Consumers

Queue messages can be distributed among more than one consumer. With multiple consumers, a message in the queue is delivered to one and only one consumer [in round robin fashion].

JMS Publish/Subscribe

Every message is received by all Subscribers



Client Message Access

- Synchronously
  - A subscriber or a receiver explicitly fetches the message from the destination by calling the receive method.
  - The receive method can *block* until a message arrives or can time out if a message does not arrive within a specified time limit.
- Asynchronously
  - A client can register a *message listener* with a consumer.
  - Whenever a message arrives at the destination, the JMS provider delivers the message by calling the listener's onMessage() method.

Message Types

- **TextMessage** A java.lang.String object
- **MapMessage** A set of name/value pairs
- **BytesMessage** A stream of uninterpreted bytes
-
- **StreamMessage** A stream of primitive values
- ***ObjectMessage*** A Serializable object

JMS PTP Demo

Connect to BROKER – every JMS app needs to connect

JMSProducer, JMSProducerToo, JMSConsumer

```
<bean id="connFactory" class="org.apache...ActiveMQConnectionFactory"
   p:brokerURL="tcp://localhost:61616"
```

Create PTP Queue – Needs to be created ONCE [could use Admin Console]

```
<bean id="mumEAQueue"  class="org.apache...ActiveMQQueue" />
```

Create Queue Producer – every JMS PTP Producer App

JMSProducer, JMSProducerToo

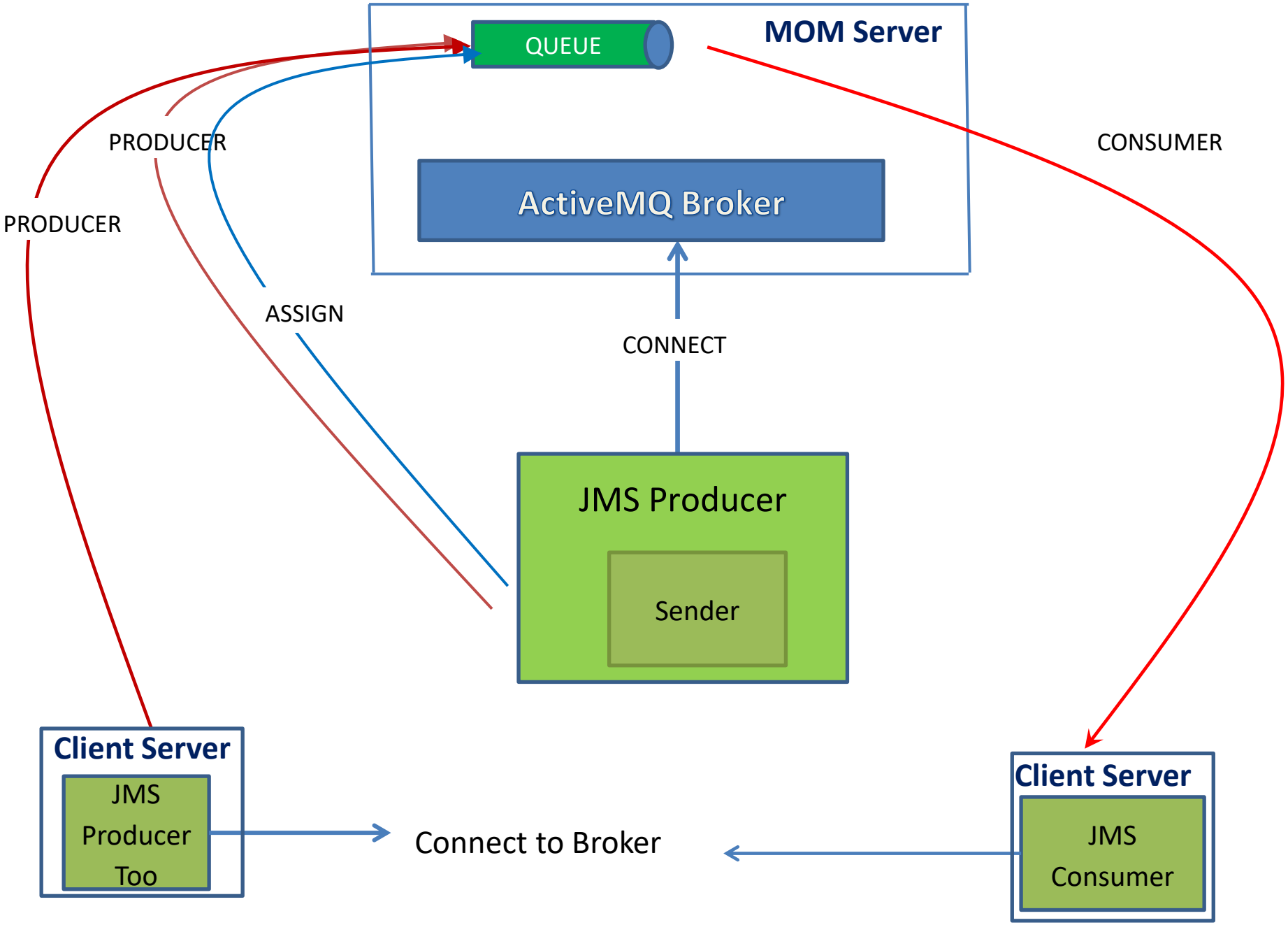
```
<bean id="jmsTemplate" class="org...jms.core.JmsTemplate">
                name="defaultDestinationName" value="mumEAQueue"/>
```

Create Queue Consumer – every JMS PTP Consumer App

JMSConsumer

```
 <jms:listener destination="mumEAQueue" ref="ptpMessageListener"
```

JMS PTP DEMO


MOM Server
QUEUE
ActiveMQ Broker
PRODUCER
PRODUCER
ASSIGN
CONSUMER
CONNECT
JMS Producer
Sender
Client Server
JMS Producer Too
Connect to Broker
Client Server
JMS Consumer

JMS Pub/Sub Demo

Connect to BROKER – every JMS app needs to connect

JMSPublisher, JMSSubscriber, JMSSubscriberToo

```
<bean id="connFactory" class="org.apache...ActiveMQConnectionFactory"
   p:brokerURL="tcp://localhost:61616"
```

Assign Broker Topic –- Needs to be created ONCE [could use Admin Console]

```
<bean id="mumEATopic"  class="org.apache...ActiveMQTopic" />
```

Create Topic Publisher

JMSPublisher

```
<bean id="jmsTopicTemplate" class="org...jms.core.JmsTemplate">
                name="defaultDestinationName" value="mumEATopic"/>
```

Create Topic Subscriber

JMSSubscriber, JMSSubscriberToo

```
 <jms:listener destination="mumEATopic" ref="PubSubMessageListener"
```

JMS Selector

PUB-SUB Model

Subscribers only need a subset of the total messages published.

Selector allow you to *filter the messages that a subscriber will receive*.

Syntax is based on a subset of the SQL92 conditional expressions

Selector Syntax

EXAMPLE :

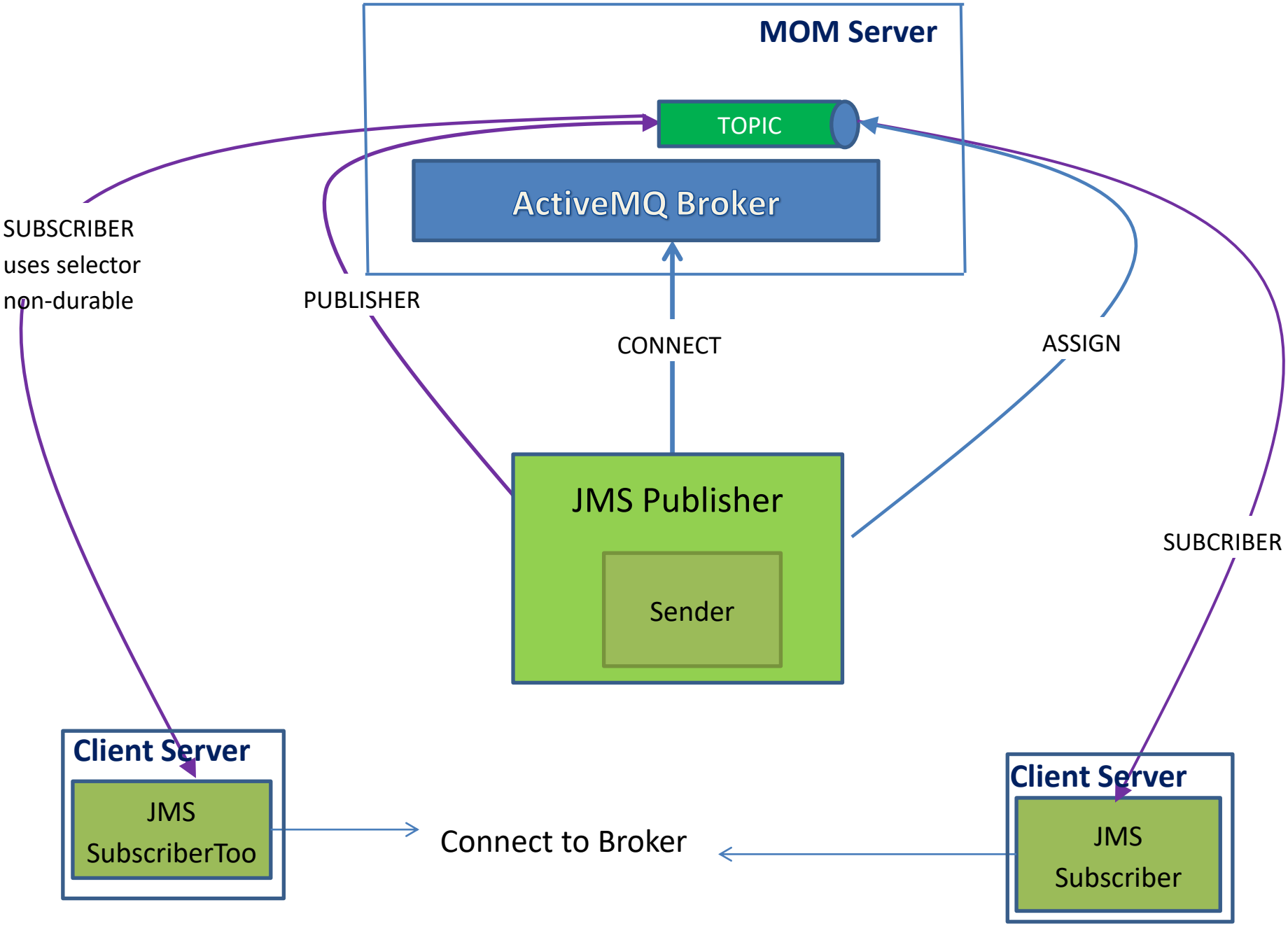
JMS Publisher:

```
selector = "online";
value="true";
objectMessage.setStringProperty(selector, value);
```

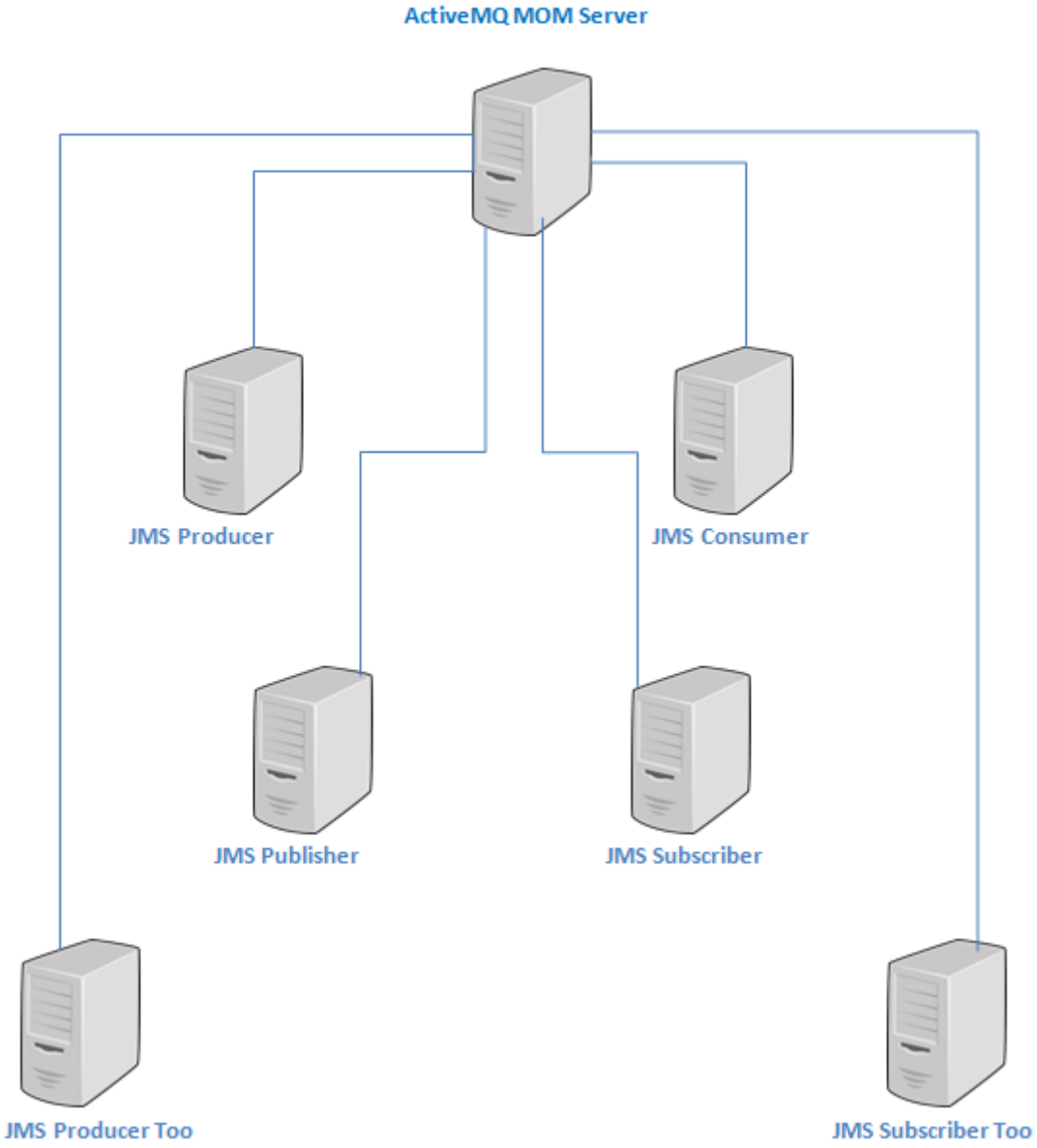
JMS Subscriber:

```
<jms:listener destination="mumEA.topic" ref= pubSubMessageListener"
        selector="online='true'" method="onMessage" />
```

JMS TOPIC DEMO



Distributed Server View of JMS Demo



AMQP
(Advanced Message Queuing Protocol)

AMQP is an open proto[illegible]tandard f[illegible]essage Oriented Middleware

For queue-[illegible] com[illegible]tions between applications

Developed for the fina[illegible] dustr[illegible]organ – 2006]

AMQP defines a wire-[illegible] finitio[illegible]oss platform interoperability

All AMQP clients can [illegible]rs

Diverse programm[illegible]e easily

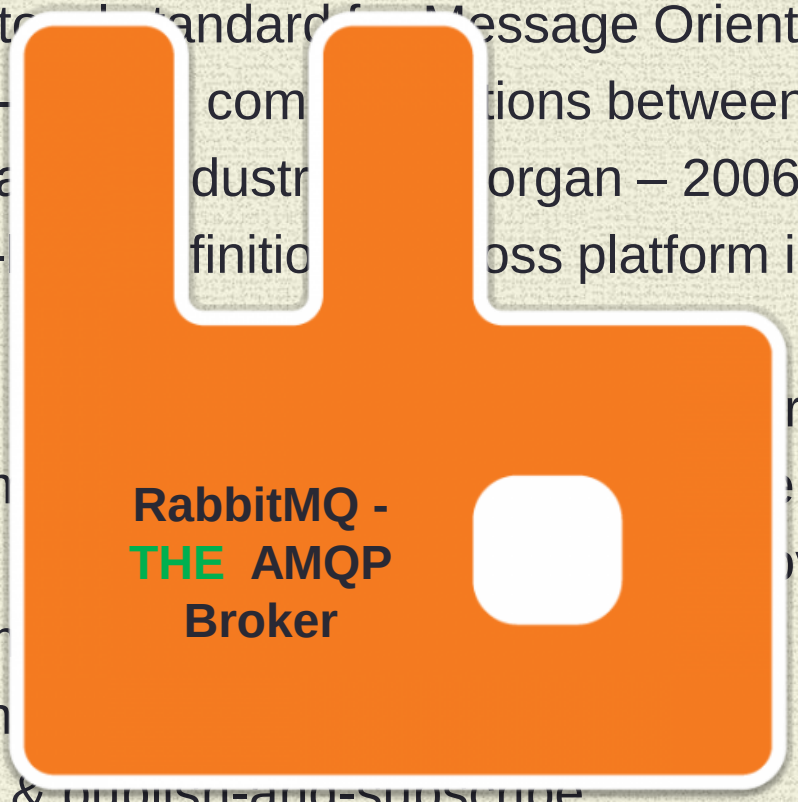
Legacy message [illegible]ve proprietary

protocols from [illegible]

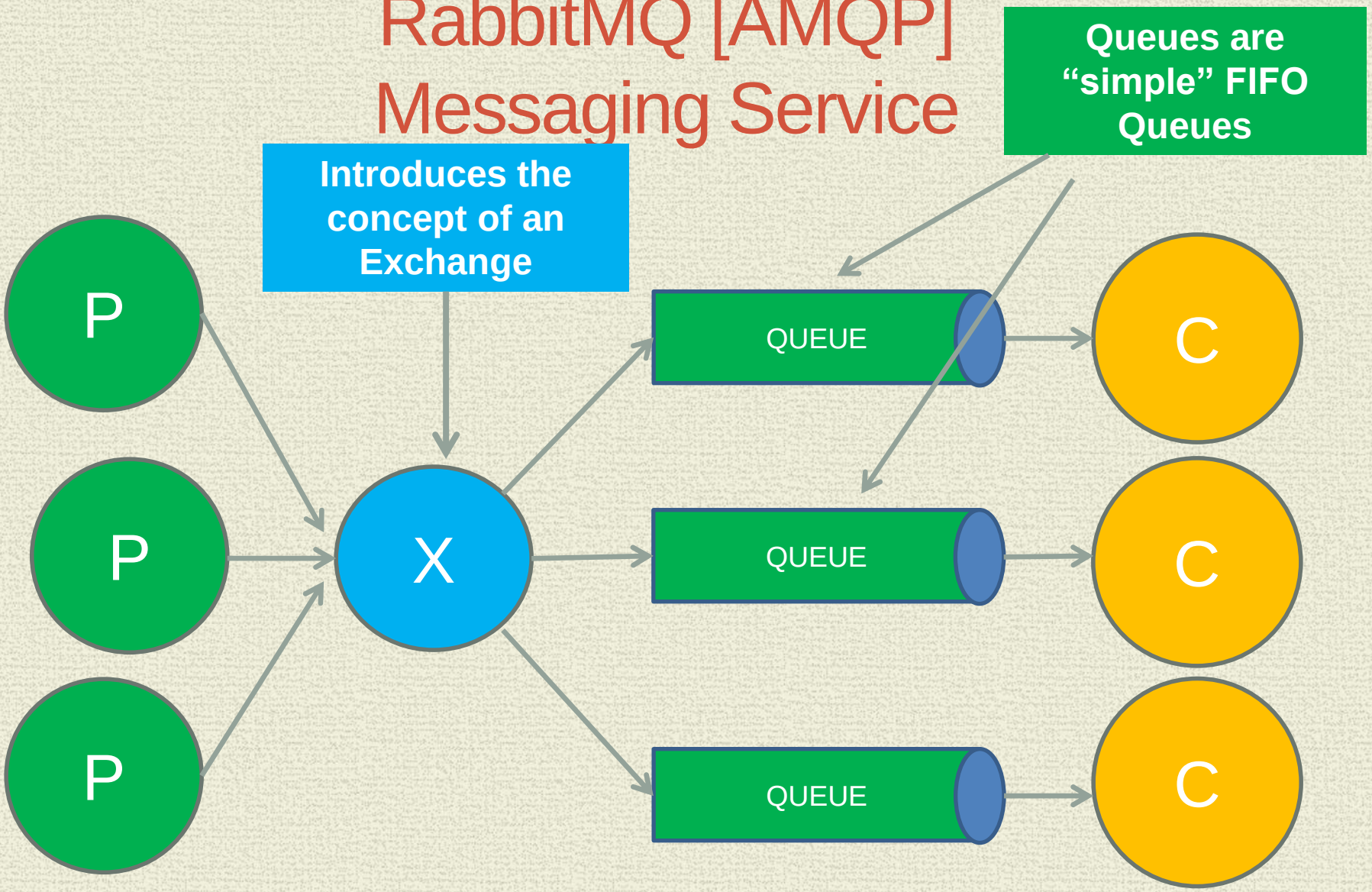
Enables messagin[illegible]

Can emulate PTP & publish-and-subscribe

Transactional messaging functionality



RabbitMQ [AMQP] Messaging Service



Producer .vs. Consumer Centric Queues

Queues are only consumed by a single receiver

Producer Centric queue

If more than one consumer subscribes to the queue, the messages are dispensed in a round-robin fashion.

AKA a work queue

Consumer defined queue[s]

Multiple queues, bound to the same exchange/routing key

Emulate a broadcast message

“A queue per consumer”

See AmqpClient Demo

AMQP Concepts

- **Exchanges** - Message routing agents; accept messages from producers routes to queues
- **Bindings** - binds/maps a queue & exchange
- **Routing Key** - optional attribute to customize binding/routing
- **Queues** - Message placeholders

AMQP Exchanges

- **Direct** - Queue binding requires a direct match based on a "simple" Routing Key. Corresponds to JMS PTP.

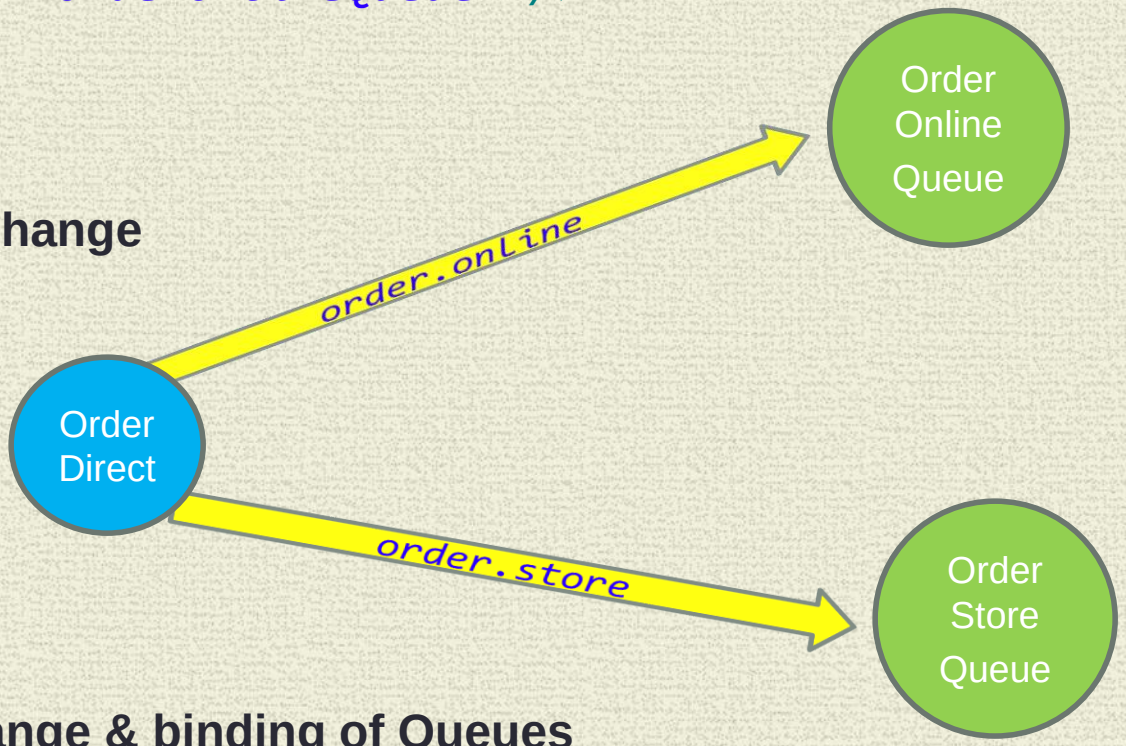
  NOTE: can have multiple Queues/Consumers
- **Fanout** - Queue is bound directly to exchange no Routing Key. Corresponds to "basic" JMS Pub/Sub.
- **Topic** - Queue binding requires a direct match based on a "complex" Routing Key [***beyond basic JMS Pub/Sub***]
- **Headers** - Similar to Topic only uses message headers instead of explicit Routing Key

- Direct & Fanout are identified as ***MANDATORY*** by AMQP

DEMO - Direct Exchange

Declaration of Queues

```
<rabbit:queue name="orderStoreQueue" />
<rabbit:queue name="orderOnlineQueue" />
```



Declaration of Exchange & binding of Queues

```
<rabbit:direct-exchange name="orderDirectExchange">
<rabbit:binding queue="orderOnlineQueue " key="order.online"
<rabbit:binding queue="orderStoreQueue" key="order.store"
```

Demo Direct Exchange

Direct Producer:

```
<rabbit:template id="directTemplate" connection-factory= "connectionFactory"
                routing-key="order.online" exchange="orderDirectExchange " />
```

Producer code : DirectServiceImpl.java

Producer interacts with exchange

```
• public class DirectServiceImpl implements OrderService {
•     public void publish(RabbitTemplate directTemplate) {
        rabbitTemplate.convertAndSend(orderItem)
```

Direct Consumer Example:

Consumer interacts with queue

```
<rabbit:listener ref="queueListener" method="listen"
                                queue-names="orderOnlineQueue" />
  <bean id="queueListener" class="edu.mum.amqp.DirectListener" />
```

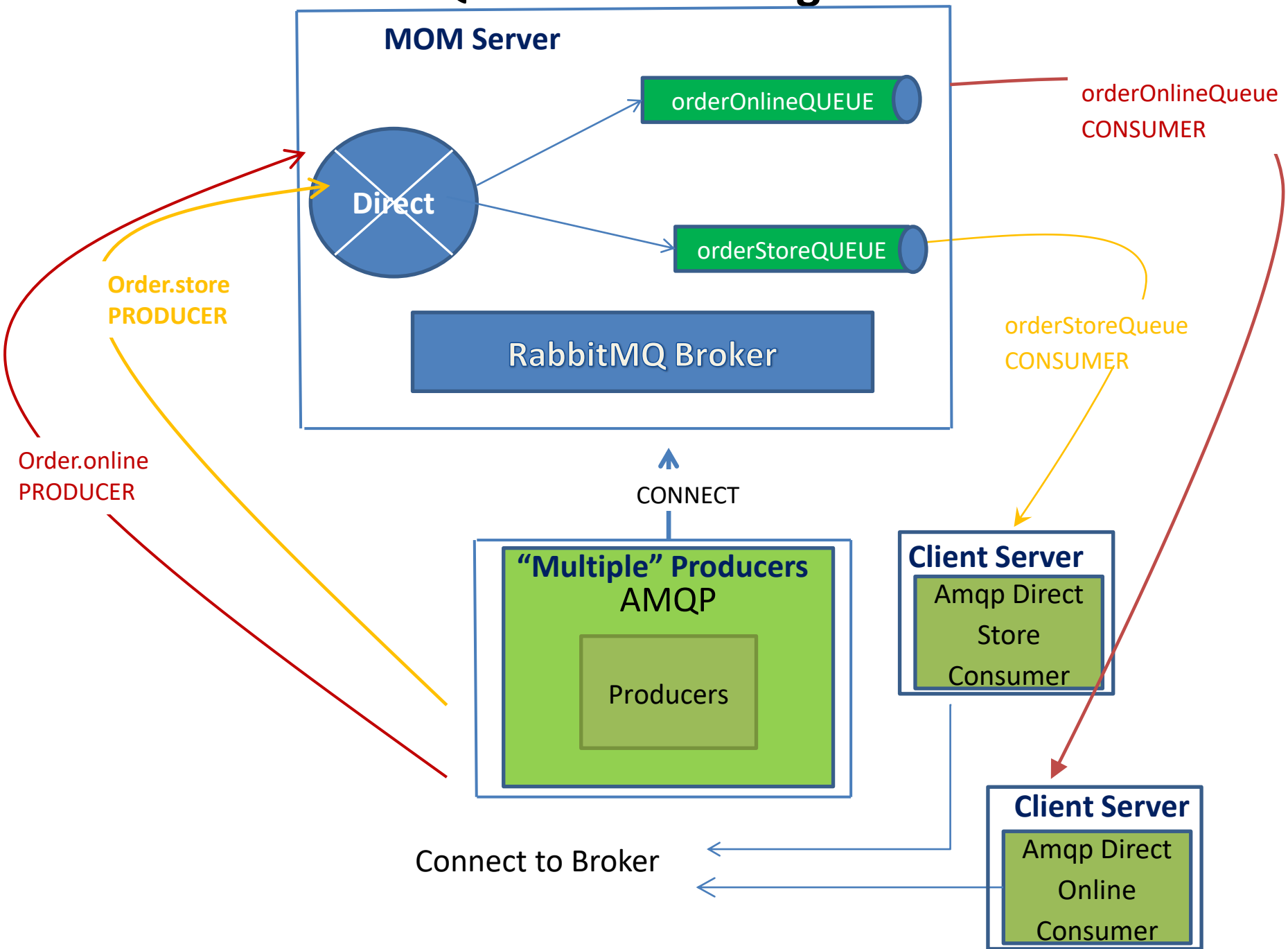
• **Consumer code : DirectListener.java**

```
      public class DirectListener {
            public void listen(Order order) {
```

DEMO – invoking the Producer

```
public static void main(String[] args) {

 // Publish to "direct" exchange on order.key == directQueue
 RabbitTemplate directTemplate =
                context.getBean(“directTemplate",RabbitTemplate.class);
 OrderService directService = new DirectServiceImpl();
 directService.publish(directTemplate);
```

AMQP Direct Exchange DEMO



Topic Demo Use Case

- **Use Case**
- A Company's Order Processing capability need to send orders based on whether the orders are the result of in-store purchases OR online purchases.
- Furthermore, online purchases that are for inventory that is "vintage"[classic] needs special processing.
- **Solution**
- Broadcast the Order to the Warehouse using RabbitMQ **Topic Exchange**. Marking messages as appropriate:
- *purchases.store.#*
- *purchases.online.#*
- *purchases.online.classic.#*

Topic Exchange Routing key

Consists of a list of attributes

Delimited by periods [“.”]

Up to 255 characters in length

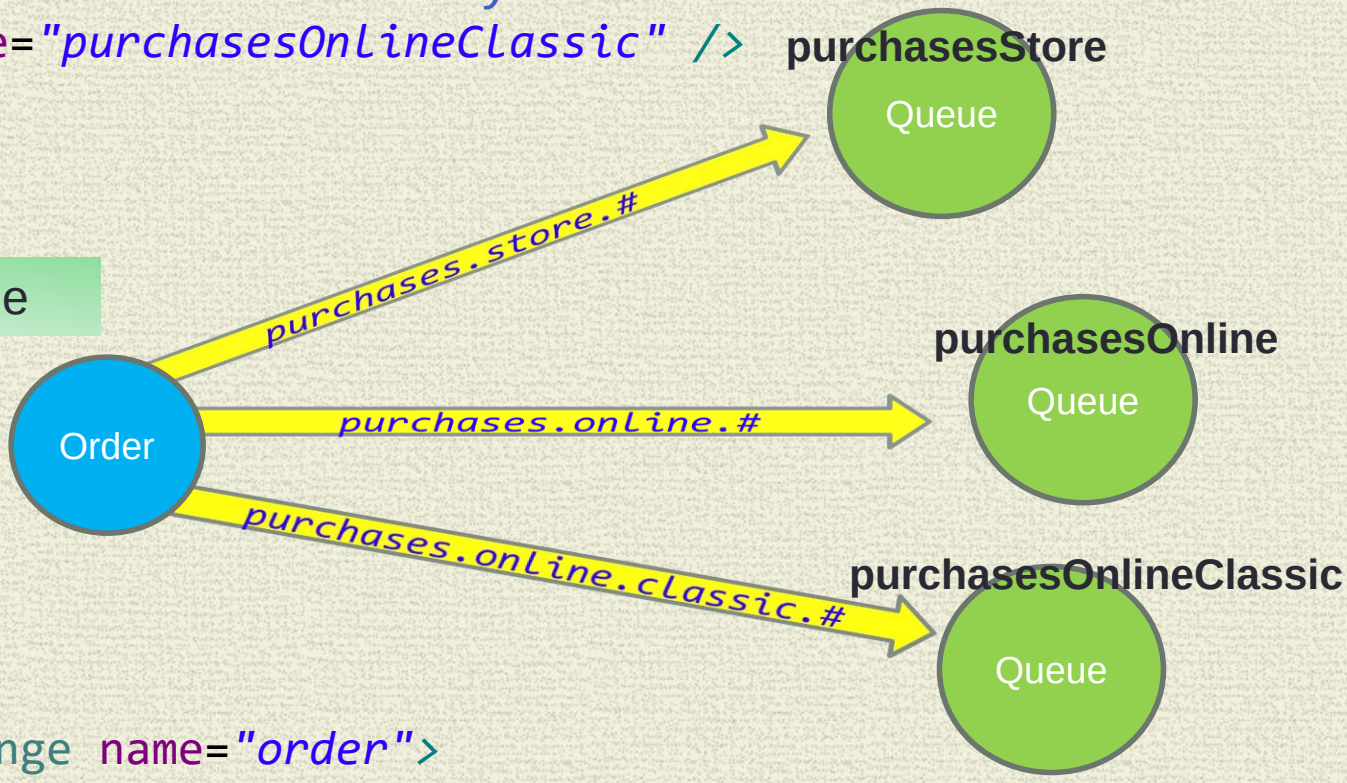
- Wild cards:
- * (asterisk) can substitute for exactly one word.
- # (hash) can substitute for zero or more words.
- Examples:

Routing Key

```
<rabbit:binding queue="purchasesStore" pattern="purchases.store.#" />
<rabbit:binding queue="purchasesOnline" pattern="purchases.online.#" />
<rabbit:binding queue=" purchasesOnlineClassic"
                                pattern="purchases.online.classic.#" />
```

DEMO - Topic Exchange – Order

```
<rabbit:queue name="purchasesStore" />
<rabbit:queue name="purchasesOnline" />
<!--  added topic filter to bind only orders that are "classic" -->
<rabbit:queue name="purchasesOnlineClassic" />
```



Bind Queue to Exchange

```
<rabbit:topic-exchange name="order">
<rabbit:binding queue="purchasesOnline" pattern="purchases.online.#"
<rabbit:binding queue="purchasesStore" pattern="purchases.store.#"
<rabbit:binding queue="purchasesOnlineClassic“
                                    pattern="purchases.online.classic.#"
```

Demo Topic Exchange

Topic Producer:

```
<rabbit:template id="topicTemplate" connection-factory= "connectionFactory“
                                routing-key="purchases.store“ exchange="order" />
```

Producer code : OrderServiceImpl.java

```
public class OrderServiceImpl implements OrderService {
    public void publish(RabbitTemplate rabbitTemplate) {
        rabbitTemplate.convertAndSend("purchases.store",order);
```

Topic Consumer Example:

```
<rabbit:listener ref="orderListener" method="listen"
                                queue-names="purchasesStore" />
  <bean id="orderListener" class="edu.mum.amqp.OrderListener" />
```

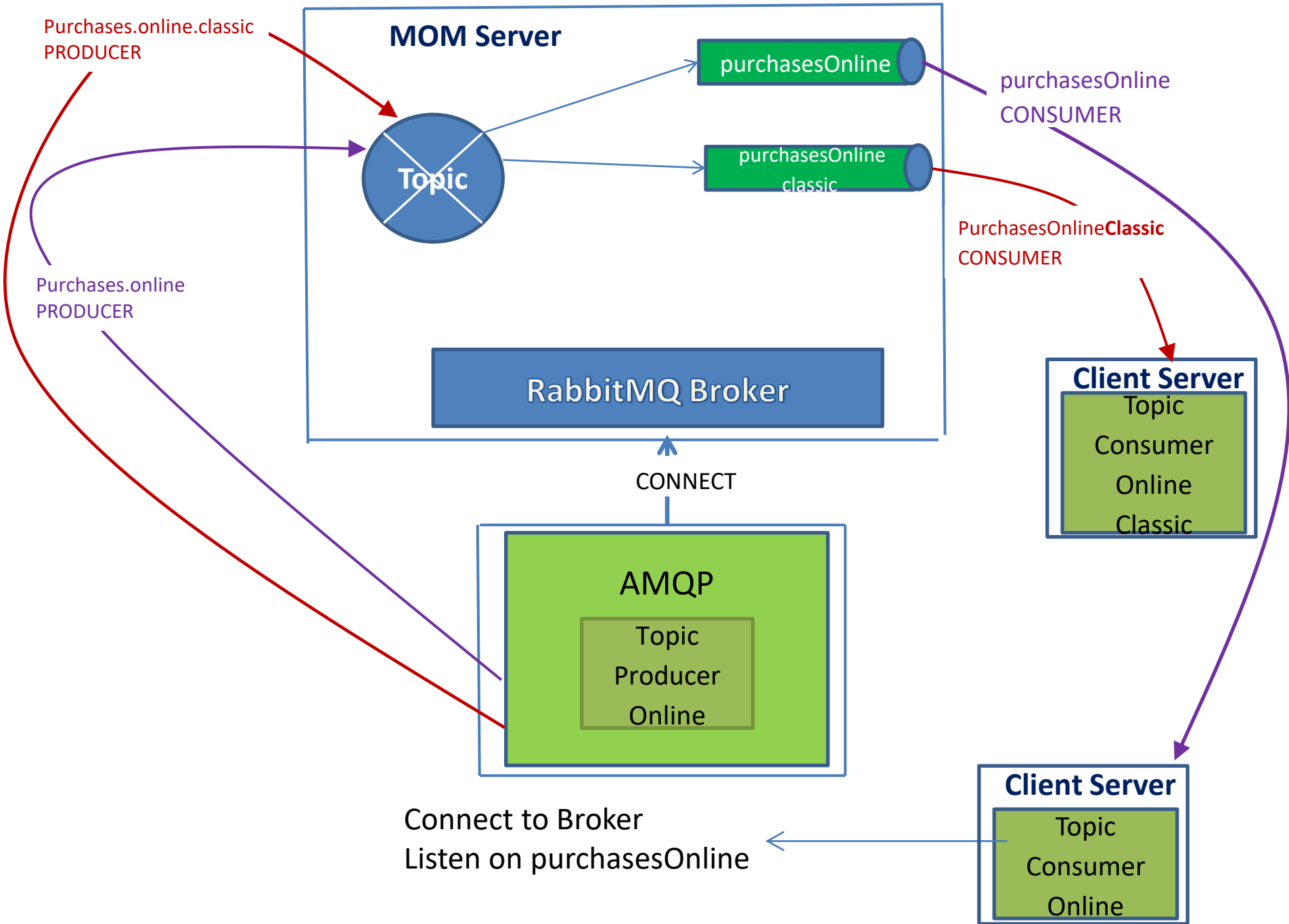
- **Consumer code : OrderListener.java**

```
public class OrderListener {
        public void listen(Order order) {
```

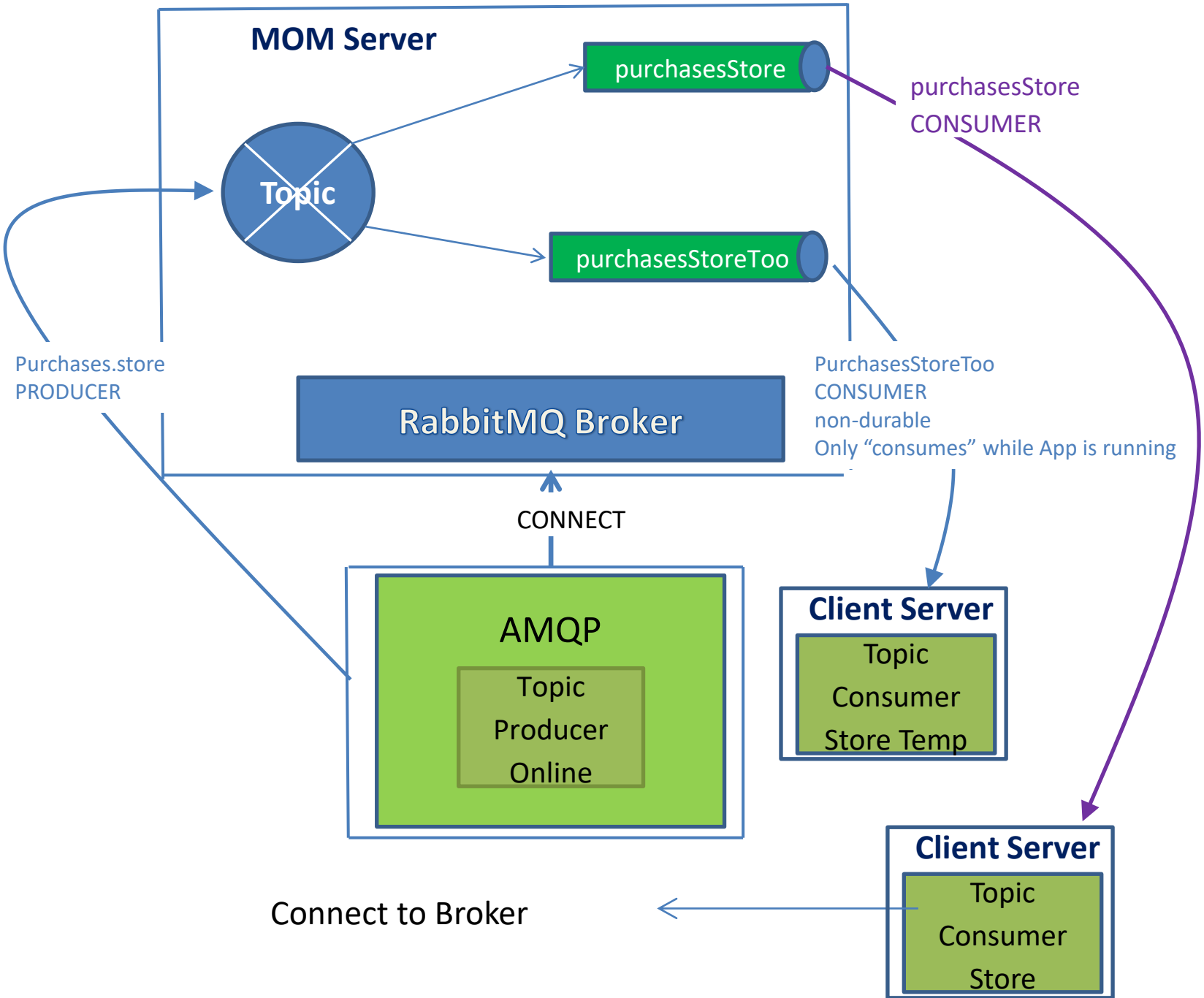
DEMO – invoking the Producer

```
public static void main(String[] args) {

// Publish to Topic
 RabbitTemplate topicTemplate =
      context.getBean("topicTemplate",RabbitTemplate.class);
 OrderService orderService = new OrderServiceImpl();
 orderService.publish(topicTemplate);

 );
```

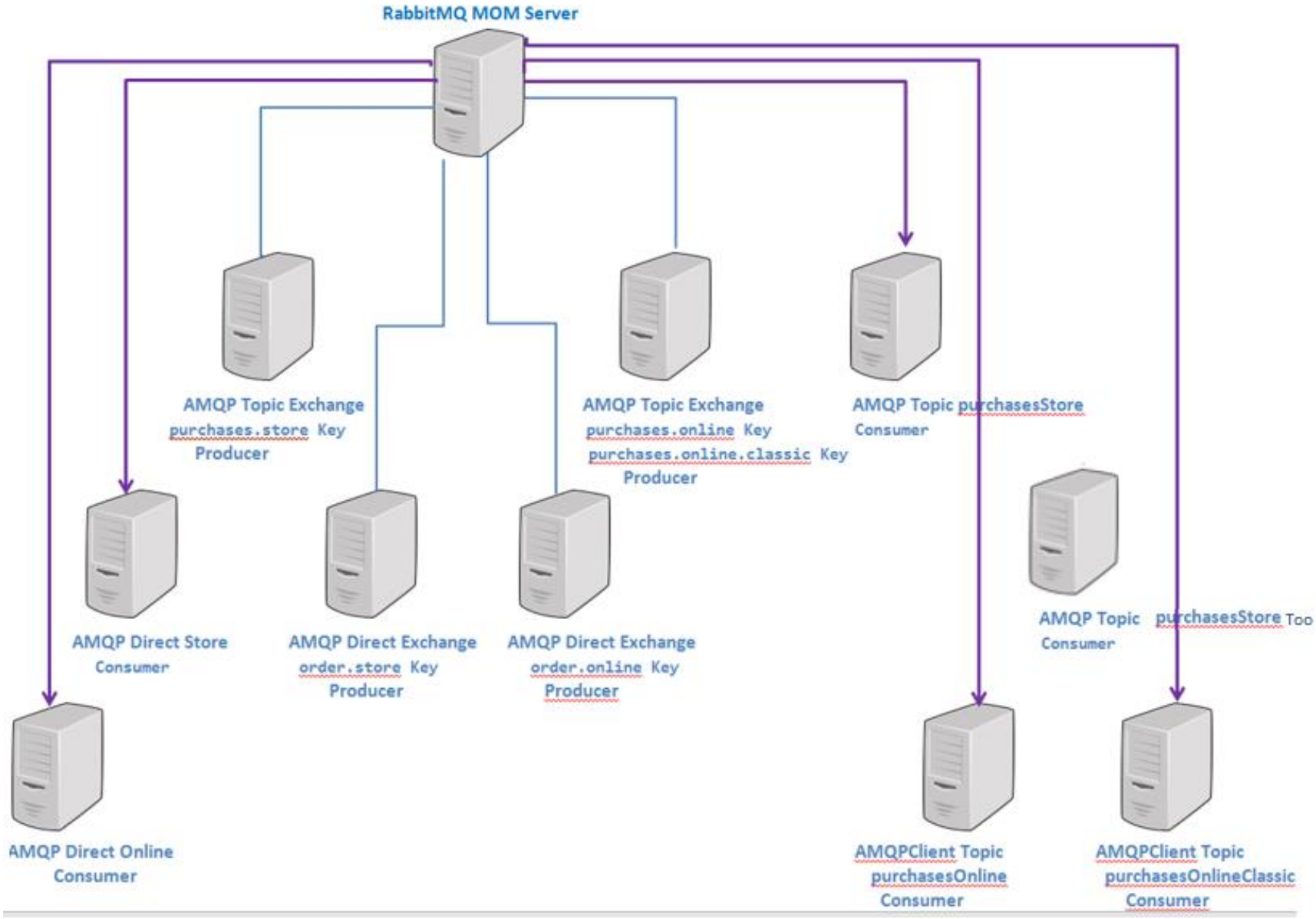
AMQP TOPIC DEMO



AMQP TOPIC Temp Queue DEMO



Distributed Server View of AMQP Demo



Apache Kafka

Distributed real-time streaming platform

Provides **an ordered durable message store, similar to a audit log,**

High volume Pub/Sub [messages arranged by Topic]

An Alternative to JMS, RabbitMQ

Premier Use Case:

Solution to event sourcing in high volume data read environments [e.g., microservices]

Supports Event Sourcing/CQRS model [eventual consistency model]

Event Sourcing - state changes are logged in a real time ordered sequence.

CQRS [Command Query Responsibility Segregation]

Essentially separate data stores for Read operations vs. Write operations

Every change[event] in the write DB needs to be streamed to the read DB

Main Point

- AMQP integrates heterogeneous systems through the introduction of a basic wire protocol.

- ***Science of Consciousness:*** *Acting from the level of Transcendental Consciousness, thoughts and actions are more integrated and harmonious*