

Spring AMQP - Reference Documentation

1.1.0.RELEASE

Mark Pollack, Mark Fisher, Oleg Zhurakousky, Dave Syer, Gary Russell

Copyright © 2010-2012 Copies of this document may be made for your own use and for distribution to others, provided that you do not charge any fee for such copies and further provided that each copy contains this Copyright Notice, whether distributed in print or electronically.

Preface	iii
I. Introduction	1
1. Quick Tour for the impatient	2
1.1. Introduction	2
1.1.1. Very, Very Quick	2
1.1.2. With XML Configuration	2
1.1.3. With Java Configuration	3
II. Reference	4
2. Using Spring AMQP	5
2.1. AMQP Abstractions	5
2.2. Connection and Resource Management	7
2.3. AmqpTemplate	9
2.4. Sending messages	9
2.5. Receiving messages	10
2.6. Message Converters	12
2.7. Request/Reply Messaging	14
2.8. Configuring the broker	14
2.8.1. Federated Exchanges	17
2.9. Exception Handling	17
2.10. Transactions	18
2.10.1. A note on Rollback of Received Messages	19
2.10.2. Using the RabbitTransactionManager	19
2.11. Message Listener Container Configuration	20
2.12. Resilience: Recovering from Errors and Broker Failures	21
2.12.1. Automatic Declaration of Exchanges, Queues and Bindings	22
2.12.2. Failures in Synchronous Operations and Options for Retry	22
2.12.3. Message Listeners and the Asynchronous Case	22
3. Erlang integration	24
3.1. Introduction	24
3.2. Communicating with Erlang processes	24
3.2.1. Executing RPC	24
3.2.2. ErlangConverter	24
3.3. Exceptions	25
4. Sample Applications	26
4.1. Introduction	26
4.2. Hello World	26
4.2.1. Synchronous Example	26
4.2.2. Asynchronous Example	27
4.3. Stock Trading	28
III. Spring Integration - Reference	32
5. Spring Integration AMQP Support	33
5.1. Introduction	33
5.2. Inbound Channel Adapter	33
5.3. Outbound Channel Adapter	33
5.4. Inbound Gateway	33
5.5. Outbound Gateway	33
IV. Other Resources	35
6. Further Reading	36
Bibliography	37

Preface

The Spring AMQP project applies core Spring concepts to the development of AMQP-based messaging solutions. We provide a "template" as a high-level abstraction for sending and receiving messages. We also provide support for Message-driven POJOs. These libraries facilitate management of AMQP resources while promoting the use of dependency injection and declarative configuration. In all of these cases, you will see similarities to the JMS support in the Spring Framework. The project consists of both Java and .NET versions. This manual is dedicated to the Java version. For links to the .NET version's manual or any other project-related information visit the Spring AMQP project [homepage](#).

Part I. Introduction

This first part of the reference documentation is a high-level overview of Spring AMQP and the underlying concepts and some code snippets that will get you up and running as quickly as possible.

Chapter 1. Quick Tour for the impatient

1.1. Introduction

This is the 5 minute tour to get started with Spring AMQP.

Prerequisites: install and run the RabbitMQ broker (<http://www.rabbitmq.com/download.html>). Then grab the spring-rabbit JAR and all its dependencies - the easiest way to do that is to declare a dependency in your build tool, e.g. for Maven:

```
<dependency>
  <groupId>org.springframework.amqp</groupId>
  <artifactId>spring-rabbit</artifactId>
  <version>1.0.0.RELEASE</version>
</dependency>
```

1.1.1. Very, Very Quick

Using plain, imperative Java to send and receive a message:

```
ConnectionFactory connectionFactory = new CachingConnectionFactory();

AmqpAdmin admin = new RabbitAdmin(connectionFactory);
admin.declareQueue(new Queue("myqueue"));

AmqpTemplate template = new RabbitTemplate(connectionFactory);
template.convertAndSend("myqueue", "foo");

String foo = (String) template.receiveAndConvert("myqueue");
```

Note that there is a `ConnectionFactory` in the native Java Rabbit client as well. We are using the Spring abstraction in the code above. We are relying on the default exchange in the broker (since none is specified in the send), and the default binding of all queues to the default exchange by their name (hence we can use the queue name as a routing key in the send). Those behaviours are defined in the AMQP specification.

1.1.2. With XML Configuration

The same example as above, but externalizing the resource configuration to XML:

```
ApplicationContext context = new GenericXmlApplicationContext("classpath:/rabbit-context.xml");
AmqpTemplate template = context.getBean(AmqpTemplate.class);

template.convertAndSend("myqueue", "foo");

String foo = (String) template.receiveAndConvert("myqueue");
```

```
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:rabbit="http://www.springframework.org/schema/rabbit"
  xsi:schemaLocation="http://www.springframework.org/schema/rabbit
    http://www.springframework.org/schema/rabbit/spring-rabbit-1.0.xsd
    http://www.springframework.org/schema/beans
    http://www.springframework.org/schema/beans/spring-beans-3.0.xsd">

  <rabbit:connection-factory id="connectionFactory"/>

  <rabbit:template id="amqpTemplate" connection-factory="connectionFactory"/>

  <rabbit:admin connection-factory="connectionFactory"/>

</beans>
```

```
<rabbit:queue name="myqueue"/>
</beans>
```

The `<rabbit:admin/>` declaration by default automatically looks for beans of type `Queue`, `Exchange` and `Binding` and declares them to the broker on behalf of the user, hence there is no need to use that bean explicitly in the simple Java driver. There are plenty of options to configure the properties of the components in the XML schema - you can use auto-complete features of your XML editor to explore them and look at their documentation.

1.1.3. With Java Configuration

The same example again with the external configuration in Java:

```
ApplicationContext context = new AnnotationConfigApplicationContext(RabbitConfiguration.class);
AmqpTemplate template = context.getBean(AmqpTemplate.class);

template.convertAndSend("myqueue", "foo");

String foo = (String) template.receiveAndConvert("myqueue");
```

```
@Configuration
public class RabbitConfiguration {

    @Bean
    public ConnectionFactory connectionFactory() {
        CachingConnectionFactory connectionFactory = new CachingConnectionFactory("localhost");
        return connectionFactory;
    }

    @Bean
    public AmqpAdmin amqpAdmin() {
        return new RabbitAdmin(connectionFactory());
    }

    @Bean
    public RabbitTemplate rabbitTemplate() {
        return new RabbitTemplate(connectionFactory());
    }

    @Bean
    public Queue myQueue() {
        return new Queue("myqueue");
    }
}
```

Part II. Reference

This part of the reference documentation details the various components that comprise Spring AMQP. The main chapter covers the core classes to develop an AMQP application. This part also includes a chapter on integration with Erlang and a chapter about the sample applications.

Chapter 2. Using Spring AMQP

In this chapter, we will explore the interfaces and classes that are the essential components for developing applications with Spring AMQP.

2.1. AMQP Abstractions

Spring AMQP consists of a handful of modules, each represented by a JAR in the distribution. These modules are: `spring-amqp`, `spring-rabbit` and `spring-erlang`. The `'spring-amqp'` module contains the `org.springframework.amqp.core` package. Within that package, you will find the classes that represent the core AMQP "model". Our intention is to provide generic abstractions that do not rely on any particular AMQP broker implementation or client library. End user code will be more portable across vendor implementations as it can be developed against the abstraction layer only. These abstractions are then used implemented by broker-specific modules, such as `'spring-rabbit'`. For the 1.0 release there is only a RabbitMQ implementation however the abstractions have been validated in .NET using Apache Qpid in addition to RabbitMQ. Since AMQP operates at the protocol level in principle the RabbitMQ client can be used with any broker that supports the same protocol version, but we do not test any other brokers at present.

The overview here assumes that you are already familiar with the basics of the AMQP specification already. If you are not, then have a look at the resources listed in Part IV, "Other Resources"

2.1.1. Message

The 0-8 and 0-9-1 AMQP specifications do not define a `Message` class or interface. Instead, when performing an operation such as `'basicPublish'`, the content is passed as a byte-array argument and additional properties are passed in as separate arguments. Spring AMQP defines a `Message` class as part of a more general AMQP domain model representation. The purpose of the `Message` class is to simply encapsulate the body and properties within a single instance so that the API can in turn be simpler. The `Message` class definition is quite straightforward.

```
public class Message {  
  
    private final MessageProperties messageProperties;  
  
    private final byte[] body;  
  
    public Message(byte[] body, MessageProperties messageProperties) {  
        this.body = body;  
        this.messageProperties = messageProperties;  
    }  
  
    public byte[] getBody() {  
        return this.body;  
    }  
  
    public MessageProperties getMessageProperties() {  
        return this.messageProperties;  
    }  
}
```

The `MessageProperties` interface defines several common properties such as `'messageId'`, `'timestamp'`, `'contentType'`, and several more. Those properties can also be extended with user-defined `'headers'` by calling the `setHeader(String key, Object value)` method.

2.1.2. Exchange

The `Exchange` interface represents an AMQP Exchange, which is what a Message Producer sends to. Each Exchange within a virtual host of a broker will have a unique name as well as a few other properties:

```
public interface Exchange {

    String getName();

    String getExchangeType();

    boolean isDurable();

    boolean isAutoDelete();

    Map<String, Object> getArguments();

}
```

As you can see, an Exchange also has a 'type' represented by constants defined in `ExchangeTypes`. The basic types are: `Direct`, `Topic`, `Fanout`, `Headers` and `Federated`. In the core package you will find implementations of the `Exchange` interface for each of those types. The behavior varies across these Exchange types in terms of how they handle bindings to Queues. For example, a `Direct` exchange allows for a Queue to be bound by a fixed routing key (often the Queue's name). A `Topic` exchange supports bindings with routing patterns that may include the '*' and '#' wildcards for 'exactly-one' and 'zero-or-more', respectively. The `Fanout` exchange publishes to all Queues that are bound to it without taking any routing key into consideration. For much more information about these and the other Exchange types, check out Part IV, "Other Resources".

Note

The AMQP specification also requires that any broker provide a "default" `Direct` Exchange that has no name. All Queues that are declared will be bound to that default Exchange with their names as routing keys. You will learn more about the default Exchange's usage within Spring AMQP in Section 2.3, "AmqpTemplate".

2.1.3. Queue

The `Queue` class represents the component from which a Message Consumer receives Messages. Like the various Exchange classes, our implementation is intended to be an abstract representation of this core AMQP type.

```
public class Queue {

    private final String name;

    private volatile boolean durable;

    private volatile boolean exclusive;

    private volatile boolean autoDelete;

    private volatile Map<String, Object> arguments;

    /**
     * The queue is durable, non-exclusive and non auto-delete.
     *
     * @param name the name of the queue.
     */
    public Queue(String name) {
        this(name, true, false, false);
    }

    // Getters and Setters omitted for brevity
}
```

Notice that the constructor takes the Queue name. Depending on the implementation, the admin template may provide methods for generating a uniquely named Queue. Such Queues can be useful as a "reply-to" address or other *temporary* situations. For that reason, the 'exclusive' and 'autoDelete' properties of an auto-generated Queue would both be set to 'true'.

2.1.4. Binding

Given that a producer sends to an Exchange and a consumer receives from a Queue, the bindings that connect Queues to Exchanges are critical for connecting those producers and consumers via messaging. In Spring AMQP, we define a `Binding` class to represent those connections. Let's review the basic options for binding Queues to Exchanges.

You can bind a Queue to a `DirectExchange` with a fixed routing key.

```
new Binding(someQueue, someDirectExchange, "foo.bar")
```

You can bind a Queue to a `TopicExchange` with a routing pattern.

```
new Binding(someQueue, someTopicExchange, "foo.*")
```

You can bind a Queue to a `FanoutExchange` with no routing key.

```
new Binding(someQueue, someFanoutExchange)
```

We also provide a `BindingBuilder` to facilitate a "fluent API" style.

```
Binding b = BindingBuilder.bind(someQueue).to(someTopicExchange).with("foo.*");
```

Note

The `BindingBuilder` class is shown above for clarity, but this style works well when using a static import for the 'bind()' method.

By itself, an instance of the `Binding` class is just holding the data about a connection. In other words, it is not an "active" component. However, as you will see later in Section 2.8, "Configuring the broker", `Binding` instances can be used by the `AmqpAdmin` class to actually trigger the binding actions on the broker. Also, as you will see in that same section, the `Binding` instances can be defined using Spring's `@Bean`-style within `@Configuration` classes. There is also a convenient base class which further simplifies that approach for generating AMQP-related bean definitions and recognizes the Queues, Exchanges, and Bindings so that they will all be declared on the AMQP broker upon application startup.

The `AmqpTemplate` is also defined within the core package. As one of the main components involved in actual AMQP messaging, it is discussed in detail in its own section (see Section 2.3, "AmqpTemplate").

2.2. Connection and Resource Management

Whereas the AMQP model we described in the previous section is generic and applicable to all implementations, when we get into the management of resources, the details are specific to the broker implementation. Therefore, in this section, we will be focusing on code that exists only within our

"spring-rabbit" module since at this point, RabbitMQ is the only supported implementation.

The central component for managing a connection to the RabbitMQ broker is the `ConnectionFactory` interface. The responsibility of a `ConnectionFactory` implementation is to provide an instance of `org.springframework.amqp.rabbit.connection.Connection` which is a wrapper for `com.rabbitmq.client.Connection`. The only concrete implementation we provide is `CachingConnectionFactory` which establishes a single connection proxy that can be shared by the application. Sharing of the connection is possible since the "unit of work" for messaging with AMQP is actually a "channel" (in some ways, this is similar to the relationship between a `Connection` and a `Session` in JMS). As you can imagine, the connection instance provides a `createChannel` method. The `CachingConnectionFactory` implementation supports caching of those channels, and it maintains separate caches for channels based on whether they are transactional or not. When creating an instance of `CachingConnectionFactory`, the 'hostname' can be provided via the constructor. The 'username' and 'password' properties should be provided as well. If you would like to configure the size of the channel cache (the default is 1), you could call the `setChannelCacheSize()` method here as well.

```
CachingConnectionFactory connectionFactory = new CachingConnectionFactory("somehost");
connectionFactory.setUsername("guest");
connectionFactory.setPassword("guest");

Connection connection = connectionFactory.createConnection();
```

When using XML, the configuration might look like this:

```
<bean id="connectionFactory"
      class="org.springframework.amqp.rabbit.connection.CachingConnectionFactory">
  <constructor-arg value="somehost"/>
  <property name="username" value="guest"/>
  <property name="password" value="guest"/>
</bean>
```

Note

There is also a `SingleConnectionFactory` implementation which is only available in the unit test code of the framework. It is simpler than `CachingConnectionFactory` since it does not cache channels, but it is not intended for practical usage outside of simple tests due to its lack of performance and resilience. If you find a need to implement your own `ConnectionFactory` for some reason, the `AbstractConnectionFactory` base class may provide a nice starting point.

A `ConnectionFactory` can be created quickly and conveniently using the rabbit namespace:

```
<rabbit:connection-factory
  id="connectionFactory"/>
```

In most cases this will be preferable since the framework can choose the best defaults for you. The created instance will be a `CachingConnectionFactory`. Keep in mind that the default cache size for channels is 1. If you want more channels to be cached set a larger value via the 'channelCacheSize' property. In XML it would look like this:

```
<bean id="connectionFactory"
      class="org.springframework.amqp.rabbit.connection.CachingConnectionFactory">
  <constructor-arg value="somehost"/>
  <property name="username" value="guest"/>
  <property name="password" value="guest"/>
  <property name="channelCacheSize" value="25"/>
</bean>
```

And with the namespace you can just add the 'channel-cache-size' attribute:

```
<rabbit:connection-factory
  id="connectionFactory" channel-cache-size="25"/>
```

Host and port attributes can be provided using the namespace

```
<rabbit:connection-factory
  id="connectionFactory" host="somehost" port="5672" />
```

Alternatively, if running in a clustered environment, use the addresses attribute.

```
<rabbit:connection-factory
  id="connectionFactory" addresses="host1:5672,host2:5672" />
```

2.3. AmqpTemplate

As with many other high-level abstractions provided by the Spring Framework and related projects, Spring AMQP provides a "template" that plays a central role. The interface that defines the main operations is called `AmqpTemplate`. Those operations cover the general behavior for sending and receiving Messages. In other words, they are not unique to any implementation, hence the "AMQP" in the name. On the other hand, there are implementations of that interface that are tied to implementations of the AMQP protocol. Unlike JMS, which is an interface-level API itself, AMQP is a wire-level protocol. The implementations of that protocol provide their own client libraries, so each implementation of the template interface will depend on a particular client library. Currently, there is only a single implementation: `RabbitTemplate`. In the examples that follow, you will often see usage of an "AmqpTemplate", but when you look at the configuration examples, or any code excerpts where the template is instantiated and/or setters are invoked, you will see the implementation type (e.g. "RabbitTemplate").

As mentioned above, the `AmqpTemplate` interface defines all of the basic operations for sending and receiving Messages. We will explore Message sending and reception, respectively, in the two sections that follow.

2.4. Sending messages

When sending a Message, one can use any of the following methods:

```
void send(Message message) throws AmqpException;
void send(String routingKey, Message message) throws AmqpException;
void send(String exchange, String routingKey, Message message) throws AmqpException;
```

We can begin our discussion with the last method listed above since it is actually the most explicit. It allows an AMQP Exchange name to be provided at runtime along with a routing key. The last parameter is the callback that is responsible for actual creating of the Message instance. An example of using this method to send a Message might look this this:

```
amqpTemplate.send("marketData.topic", "quotes.nasdaq.FOO", new Message("12.34".getBytes(), someProperties));
```

The "exchange" property can be set on the template itself if you plan to use that template instance to send to the same exchange most or all of the time. In such cases, the second method listed above may be used instead. The following example is functionally equivalent to the previous one:

```
amqpTemplate.setExchange("marketData.topic");
```

```
amqpTemplate.send("quotes.nasdaq.FOO", new Message("12.34".getBytes(), someProperties));
```

If both the "exchange" and "routingKey" properties are set on the template, then the method accepting only the `Message` may be used:

```
amqpTemplate.setExchange("marketData.topic");
amqpTemplate.setRoutingKey("quotes.nasdaq.FOO");
amqpTemplate.send(new Message("12.34".getBytes(), someProperties));
```

A better way of thinking about the exchange and routing key properties is that the explicit method parameters will always override the template's default values. In fact, even if you do not explicitly set those properties on the template, there are always default values in place. In both cases, the default is an empty `String`, but that is actually a sensible default. As far as the routing key is concerned, it's not always necessary in the first place (e.g. a Fanout Exchange). Furthermore, a `Queue` may be bound to an `Exchange` with an empty `String`. Those are both legitimate scenarios for reliance on the default empty `String` value for the routing key property of the template. As far as the `Exchange` name is concerned, the empty `String` is quite commonly used because the AMQP specification defines the "default `Exchange`" as having no name. Since all `Queues` are automatically bound to that default `Exchange` (which is a `Direct Exchange`) using their name as the binding value, that second method above can be used for simple point-to-point Messaging to any `Queue` through the default `Exchange`. Simply provide the queue name as the "routingKey" - either by providing the method parameter at runtime:

```
RabbitTemplate template = new RabbitTemplate(); // using default no-name Exchange
template.send("queue.helloWorld", new Message("Hello World".getBytes(), someProperties));
```

Or, if you prefer to create a template that will be used for publishing primarily or exclusively to a single `Queue`, the following is perfectly reasonable:

```
RabbitTemplate template = new RabbitTemplate(); // using default no-name Exchange
template.setRoutingKey("queue.helloWorld"); // but we'll always send to this Queue
template.send(new Message("Hello World".getBytes(), someProperties));
```

2.5. Receiving messages

Message reception is always a bit more complicated than sending. The reason is that there are two ways to receive a `Message`. The simpler option is to poll for a single `Message` at a time with a synchronous, blocking method call. The more complicated yet more common approach is to register a listener that will receive `Messages` on-demand, asynchronously. We will look at an example of each approach in the next two sub-sections.

2.5.1. Synchronous Consumer

The `AmqpTemplate` itself can be used for synchronous `Message` reception. There are two 'receive' methods available. As with the `Exchange` on the sending side, there is a method that requires a queue property having been set directly on the template itself, and there is a method that accepts a queue parameter at runtime.

```
Message receive() throws AmqpException;
Message receive(String queueName) throws AmqpException;
```

Just like in the case of sending messages, the `AmqpTemplate` has some convenience methods for receiving

POJOs instead of `Message` instances, and implementations will provide a way to customize the `MessageConverter` used to create the Object returned:

```
Object receiveAndConvert() throws AmqpException;

Object receiveAndConvert(String queueName) throws AmqpException;
```

2.5.2. Asynchronous Consumer

For asynchronous `Message` reception, a dedicated component (not the `AmqpTemplate`) is involved. That component is a container for a `Message` consuming callback. We will look at the container and its properties in just a moment, but first we should look at the callback since that is where your application code will be integrated with the messaging system. There are a few options for the callback. The simplest of these is to implement the `MessageListener` interface:

```
public interface MessageListener {

    void onMessage(Message message);

}
```

If your callback logic depends upon the AMQP Channel instance for any reason, you may instead use the `ChannelAwareMessageListener`. It looks similar but with an extra parameter:

```
public interface ChannelAwareMessageListener {

    void onMessage(Message message, Channel channel) throws Exception;

}
```

If you prefer to maintain a stricter separation between your application logic and the messaging API, you can rely upon an adapter implementation that is provided by the framework. This is often referred to as "Message-driven POJO" support. When using the adapter, you only need to provide a reference to the instance that the adapter itself should invoke.

```
MessageListener listener = new MessageListenerAdapter(somePojo);
```

Now that you've seen the various options for the `Message`-listening callback, we can turn our attention to the container. Basically, the container handles the "active" responsibilities so that the listener callback can remain passive. The container is an example of a "lifecycle" component. It provides methods for starting and stopping. When configuring the container, you are essentially bridging the gap between an AMQP Queue and the `MessageListener` instance. You must provide a reference to the `ConnectionFactory` and the queue name or Queue instance(s) from which that listener should consume `Messages`. Here is the most basic example using the default implementation, `SimpleMessageListenerContainer`:

```
SimpleMessageListenerContainer container = new SimpleMessageListenerContainer();
container.setConnectionFactory(rabbitConnectionFactory);
container.setQueueNames("some.queue");
container.setMessageListener(new MessageListenerAdapter(somePojo));
```

As an "active" component, it's most common to create the listener container with a bean definition so that it can simply run in the background. This can be done via XML:

```
<rabbit:listener-container connection-factory="rabbitConnectionFactory">
  <rabbit:listener queues="some.queue" ref="somePojo" method="handle"/>
</rabbit:listener-container>
```

Or, you may prefer to use the `@Configuration` style which will look very similar to the actual code snippet above:

```
@Configuration
public class ExampleAmqpConfiguration {

    @Bean
    public MessageListenerContainer messageListenerContainer() {
        SimpleMessageListenerContainer container = new SimpleMessageListenerContainer();
        container.setConnectionFactory(rabbitConnectionFactory());
        container.setQueueName("some.queue");
        container.setMessageListener(exampleListener());
        return container;
    }

    @Bean
    public ConnectionFactory rabbitConnectionFactory() {
        CachingConnectionFactory connectionFactory = new CachingConnectionFactory("localhost");
        connectionFactory.setUsername("guest");
        connectionFactory.setPassword("guest");
        return connectionFactory;
    }

    @Bean
    public MessageListener exampleListener() {
        return new MessageListener() {
            public void onMessage(Message message) {
                System.out.println("received: " + message);
            }
        };
    }
}
```

2.6. Message Converters

The `AmqpTemplate` also defines several methods for sending and receiving `Messages` that will delegate to a `MessageConverter`. The `MessageConverter` itself is quite straightforward. It provides a single method for each direction: one for converting *to* a `Message` and another for converting *from* a `Message`. Notice that when converting to a `Message`, you may also provide properties in addition to the object. The "object" parameter typically corresponds to the `Message` body.

```
public interface MessageConverter {

    Message toMessage(Object object, MessageProperties messageProperties)
        throws MessageConversionException;

    Object fromMessage(Message message) throws MessageConversionException;
}
```

The relevant `Message`-sending methods on the `AmqpTemplate` are listed below. They are simpler than the methods we discussed previously because they do not require the `Message` instance. Instead, the `MessageConverter` is responsible for "creating" each `Message` by converting the provided object to the byte array for the `Message` body and then adding any provided `MessageProperties`.

```
void convertAndSend(Object message) throws AmqpException;

void convertAndSend(String routingKey, Object message) throws AmqpException;

void convertAndSend(String exchange, String routingKey, Object message) throws AmqpException;

void convertAndSend(Object message, MessagePostProcessor messagePostProcessor) throws AmqpException;

void convertAndSend(String routingKey, Object message, MessagePostProcessor messagePostProcessor)
    throws AmqpException;

void convertAndSend(String exchange, String routingKey, Object message,
```

```
MessagePostProcessor messagePostProcessor) throws AmqpException;
```

On the receiving side, there are only two methods: one that accepts the queue name and one that relies on the template's "queue" property having been set.

```
Object receiveAndConvert() throws AmqpException;
Object receiveAndConvert(String queueName) throws AmqpException;
```

2.6.1. SimpleMessageConverter

The default implementation of the `MessageConverter` strategy is called `SimpleMessageConverter`. This is the converter that will be used by an instance of `RabbitTemplate` if you do not explicitly configure an alternative. It handles text-based content, serialized Java objects, and simple byte arrays.

2.6.1.1. Converting From a Message

If the content type of the input `Message` begins with "text" (e.g. "text/plain"), it will also check for the content-encoding property to determine the charset to be used when converting the `Message` body byte array to a `Java String`. If no content-encoding property had been set on the input `Message`, it will use the "UTF-8" charset by default. If you need to override that default setting, you can configure an instance of `SimpleMessageConverter`, set its "defaultCharset" property and then inject that into a `RabbitTemplate` instance.

If the content-type property value of the input `Message` is set to "application/x-java-serialized-object", the `SimpleMessageConverter` will attempt to deserialize (rehydrate) the byte array into a `Java object`. While that might be useful for simple prototyping, it's generally not recommended to rely on `Java serialization` since it leads to tight coupling between the producer and consumer. Of course, it also rules out usage of non-`Java systems` on either side. With `AMQP` being a wire-level protocol, it would be unfortunate to lose much of that advantage with such restrictions. In the next two sections, we'll explore some alternatives for passing rich domain object content without relying on `Java serialization`.

For all other content-types, the `SimpleMessageConverter` will return the `Message` body content directly as a byte array.

2.6.1.2. Converting To a Message

When converting to a `Message` from an arbitrary `Java Object`, the `SimpleMessageConverter` likewise deals with byte arrays, `Strings`, and `Serializable` instances. It will convert each of these to bytes (in the case of byte arrays, there is nothing to convert), and it will set the content-type property accordingly. If the `Object` to be converted does not match one of those types, the `Message` body will be null.

2.6.2. JsonMessageConverter

As mentioned in the previous section, relying on `Java serialization` is generally not recommended. One rather common alternative that is more flexible and portable across different languages and platforms is `JSON (JavaScript Object Notation)`. An implementation is available and can be configured on any `RabbitTemplate` instance to override its usage of the `SimpleMessageConverter` default.

```
<bean class="org.springframework.amqp.rabbit.core.RabbitTemplate">
  <property name="connectionFactory" ref="rabbitConnectionFactory"/>
  <property name="messageConverter">
    <bean class="org.springframework.amqp.support.converter.JsonMessageConverter">
```

```

    <!-- if necessary, override the DefaultClassMapper -->
    <property name="classMapper" ref="customClassMapper" />
  </bean>
</property>
</bean>

```

2.6.3. MarshallingMessageConverter

Yet another option is the `MarshallingMessageConverter`. It delegates to the Spring OXM library's implementations of the `Marshaller` and `Unmarshaller` strategy interfaces. You can read more about that library [here](#). In terms of configuration, it's most common to provide the constructor argument only since most implementations of `Marshaller` will also implement `Unmarshaller`.

```

<bean class="org.springframework.amqp.rabbit.core.RabbitTemplate">
  <property name="connectionFactory" ref="rabbitConnectionFactory" />
  <property name="messageConverter">
    <bean class="org.springframework.amqp.support.converter.MarshallingMessageConverter">
      <constructor-arg ref="someImplementationOfMarshallerAndUnmarshaller" />
    </bean>
  </property>
</bean>

```

2.7. Request/Reply Messaging

The `AmqpTemplate` also provides a variety of `sendAndReceive` methods that accept the same argument options that you have seen above for the one-way send operations (exchange, routingKey, and Message). Those methods are quite useful for request/reply scenarios since they handle the configuration of the necessary "reply-to" property before sending and can listen for the reply message on an exclusive Queue that is created internally for that purpose.

Similar request/reply methods are also available where the `MessageConverter` is applied to both the request and reply. Those methods are named `convertSendAndReceive`. See the Javadoc of `AmqpTemplate` for more detail.

By default, a new temporary queue is used for each reply. However, a single reply queue can be configured on the template, which allows you to set arguments on that queue (such as 'ha_args="all"' for mirrored queues). In this case, however, you must also provide a `<reply-listener/>` sub element. This element provides a listener container for the reply queue, with the template being the listener. All of the Section 2.11, "Message Listener Container Configuration" attributes allowed on a `<listener-container/>` are allowed on the element, except for connection-factory and message-converter, which are inherited from the template's configuration.

```

<rabbit:template id="amqpTemplate"
  connection-factory="connectionFactory" reply-queue="replies">
  <rabbit:reply-listener />
</rabbit:template>

```

While the container and template share a connection factory, they do not share a channel and therefore requests and replies are not performed within the same transaction (if transactional).

2.8. Configuring the broker

The AMQP specification describes how the protocol can be used to configure Queues, Exchanges and Bindings on the broker. These operations which are portable from the 0.8 specification and higher are present in the `AmqpAdmin` interface in the `org.springframework.amqp.core` package. The `RabbitMQ` implementation of that

class is `RabbitAdmin` located in the `org.springframework.amqp.rabbit.core` package.

The `AmqpAdmin` interface is based on using the Spring AMQP domain abstractions and is shown below:

```
public interface AmqpAdmin {
    // Exchange Operations
    void declareExchange(Exchange exchange);
    void deleteExchange(String exchangeName);

    // Queue Operations
    Queue declareQueue();
    void declareQueue(Queue queue);
    void deleteQueue(String queueName);
    void deleteQueue(String queueName, boolean unused, boolean empty);
    void purgeQueue(String queueName, boolean noWait);

    // Binding Operations
    void declareBinding(Binding binding);
}
```

The no-arg `declareQueue()` method defines a queue on the broker whose name is automatically generated. The additional properties of this auto-generated queue are `exclusive=true`, `autoDelete=true`, and `durable=false`.

Note

Removing a binding was not introduced until the 0.9 version of the AMQP spec.

The RabbitMQ implementation of this interface is `RabbitAdmin` which when configured using Spring XML would look like this:

```
<rabbit:connection-factory id="connectionFactory" />
<rabbit:admin id="amqpAdmin" connection-factory="connectionFactory" />
```

The `RabbitAdmin` implementation does automatic lazy declaration of Queues, Exchanges and Bindings declared in the same `ApplicationContext`. These components will be declared as soon as a `Connection` is opened to the broker. There are some namespace features that make this very convenient, e.g. in the Stocks sample application we have:

```
<rabbit:queue id="tradeQueue" />
<rabbit:queue id="marketDataQueue" />

<fanout-exchange name="broadcast.responses" xmlns="http://www.springframework.org/schema/rabbit">
  <bindings>
    <binding queue="tradeQueue" />
  </bindings>
</fanout-exchange>

<topic-exchange name="app.stock.marketdata" xmlns="http://www.springframework.org/schema/rabbit">
  <bindings>
    <binding queue="marketDataQueue" pattern="${stocks.quote.pattern}" />
  </bindings>
</topic-exchange>
```

In the example above we are using anonymous Queues (actually internally just Queues with names generated by the framework, not by the broker) and refer to them by ID. We can also declare Queues with explicit names, which also serve as identifiers for their bean definitions in the context. E.g.

```
<rabbit:queue name="stocks.trade.queue"/>
```

To see how to use Java to configure the AMQP infrastructure, look at the Stock sample application, where there is the `@Configuration` class `AbstractStockRabbitConfiguration` which in turn has `RabbitClientConfiguration` and `RabbitServerConfiguration` subclasses. The code for `AbstractStockRabbitConfiguration` is shown below

```
@Configuration
public abstract class AbstractStockAppRabbitConfiguration {

    @Bean
    public ConnectionFactory connectionFactory() {
        CachingConnectionFactory connectionFactory = new CachingConnectionFactory("localhost");
        connectionFactory.setUsername("guest");
        connectionFactory.setPassword("guest");
        return connectionFactory;
    }

    @Bean
    public RabbitTemplate rabbitTemplate() {
        RabbitTemplate template = new RabbitTemplate(connectionFactory());
        template.setMessageConverter(jsonMessageConverter());
        configureRabbitTemplate(template);
        return template;
    }

    @Bean
    public MessageConverter jsonMessageConverter() {
        return new JsonMessageConverter();
    }

    @Bean
    public TopicExchange marketDataExchange() {
        return new TopicExchange("app.stock.marketdata");
    }

    // additional code omitted for brevity
}
```

In the Stock application, the server is configured using the following `@Configuration` class:

```
@Configuration
public class RabbitServerConfiguration extends AbstractStockAppRabbitConfiguration {

    @Bean
    public Queue stockRequestQueue() {
        return new Queue("app.stock.request");
    }
}
```

This is the end of the whole inheritance chain of `@Configuration` classes. The end result is the the `TopicExchange` and `Queue` will be declared to the broker upon application startup. There is no binding of the `TopicExchange` to a queue in the server configuration, as that is done in the client application. The stock request queue however is automatically bound to the AMQP default exchange - this behavior is defined by the specification.

The client `@Configuration` class is a little more interesting and is shown below.

```
@Configuration
public class RabbitClientConfiguration extends AbstractStockAppRabbitConfiguration {
```

```

@Value("${stocks.quote.pattern}")
private String marketDataRoutingKey;

@Bean
public Queue marketDataQueue() {
    return amqpAdmin().declareQueue();
}

/**
 * Binds to the market data exchange. Interested in any stock quotes
 * that match its routing key.
 */
@Bean
public Binding marketDataBinding() {
    return BindingBuilder.bind(
        marketDataQueue()).to(marketDataExchange()).with(marketDataRoutingKey);
}

// additional code omitted for brevity
}

```

The client is declaring another queue via the `declareQueue()` method on the `AmqpAdmin`, and it binds that queue to the market data exchange with a routing pattern that is externalized in a properties file.

2.8.1. Federated Exchanges

Rabbit supports federation; federated exchanges are backed by one of the other exchange types. Therefore, when configuring a federated exchange, it is important to supply bindings of the appropriate type for the backing exchange. Examples include...

```

<federated-exchange name="fedDirect" backing-type="direct"
    upstream-set="upstream-set">
  <direct-bindings>
    <binding queue="bucket" />
  </direct-bindings>
</federated-exchange>

<federated-exchange name="fedTopic" backing-type="topic"
    upstream-set="upstream-set">
  <topic-bindings>
    <binding queue="bucket" pattern="bucket.#"/>
  </topic-bindings>
</federated-exchange>

```

Notice that the child element, e.g. `<direct-bindings/>` matches the `backing-type` attribute.

2.9. Exception Handling

Many operations with the RabbitMQ Java client can throw checked Exceptions. For example, there are a lot of cases where `IOExceptions` may be thrown. The `RabbitTemplate`, `SimpleMessageListenerContainer`, and other Spring AMQP components will catch those Exceptions and convert into one of the Exceptions within our runtime hierarchy. Those are defined in the `'org.springframework.amqp'` package, and `AmqpException` is the base of the hierarchy.

If you are using a `SimpleMessageListenerContainer` you will also be able to inject a Spring `ErrorHandler` instance that can be used to react to an exception in the listener. The `ErrorHandler` cannot prevent the exception from eventually propagating, but it can be used to log or alert another component that there is a problem.

2.10. Transactions

The Spring Rabbit framework has support for automatic transaction management in the synchronous and asynchronous use cases with a number of different semantics that can be selected declaratively, as is familiar to existing users of Spring transactions. This makes many if not most common messaging patterns very easy to implement.

There are two ways to signal the desired transaction semantics to the framework. In both the `RabbitTemplate` and `SimpleMessageListenerContainer` there is a flag `channelTransacted` which, if true, tells the framework to use a transactional channel and to end all operations (send or receive) with a commit or rollback depending on the outcome, with an exception signaling a rollback. Another signal is to provide an external transaction with one of Spring's `PlatformTransactionManager` implementations as a context for the ongoing operation. If there is already a transaction in progress when the framework is sending or receiving a message, and the `channelTransacted` flag is true, then the commit or rollback of the messaging transaction will be deferred until the end of the current transaction. If the `channelTransacted` flag is false, then no transaction semantics apply to the messaging operation (it is auto-acked).

The `channelTransacted` flag is a configuration time setting: it is declared and processed once when the AMQP components are created, usually at application startup. The external transaction is more dynamic in principle because the system responds to the current `Thread` state at runtime, but in practice is often also a configuration setting, when the transactions are layered onto an application declaratively.

For synchronous use cases with `RabbitTemplate` the external transaction is provided by the caller, either declaratively or imperatively according to taste (the usual Spring transaction model). An example of a declarative approach (usually preferred because it is non-invasive), where the template has been configured with `channelTransacted=true`:

```
@Transactional
public void doSomething() {
    String incoming = rabbitTemplate.receiveAndConvert();
    // do some more database processing...
    String outgoing = processInDatabaseAndExtractReply(incoming);
    rabbitTemplate.convertAndSend(outgoing);
}
```

A `String` payload is received, converted and sent as a message body inside a method marked as `@Transactional`, so if the database processing fails with an exception, the incoming message will be returned to the broker, and the outgoing message will not be sent. This applies to any operations with the `RabbitTemplate` inside a chain of transactional methods (unless the `Channel` is directly manipulated to commit the transaction early for instance).

For asynchronous use cases with `SimpleMessageListenerContainer` if an external transaction is needed it has to be requested by the container when it sets up the listener. To signal that an external transaction is required the user provides an implementation of `PlatformTransactionManager` to the container when it is configured. For example:

```
@Configuration
public class ExampleExternalTransactionAmqpConfiguration {

    @Bean
    public MessageListenerContainer messageListenerContainer() {
        SimpleMessageListenerContainer container = new SimpleMessageListenerContainer();
        container.setConnectionFactory(rabbitConnectionFactory());
        container.setTransactionManager(transactionManager());
        container.setChannelTransacted(true);
        container.setQueueName("some.queue");
        container.setMessageListener(exampleListener());
        return container;
    }
}
```

```
}

```

In the example above, the transaction manager is added as a dependency injected from another bean definition (not shown), and the `channelTransacted` flag is also set to true. The effect is that if the listener fails with an exception the transaction will be rolled back, and the message will also be returned to the broker. Significantly, if the transaction fails to commit (e.g. a database constraint error, or connectivity problem), then the AMQP transaction will also be rolled back, and the message will be returned to the broker. This is sometimes known as a **Best Efforts 1 Phase Commit**, and is a very powerful pattern for reliable messaging. If the `channelTransacted` flag was set to false in the example above, which is the default, then the external transaction would still be provided for the listener, but all messaging operations would be auto-acked, so the effect is to commit the messaging operations even on a rollback of the business operation.

2.10.1. A note on Rollback of Received Messages

AMQP transactions only apply to messages and acks sent to the broker, so when there is a rollback of a Spring transaction and a message has been received, what Spring AMQP has to do is not just rollback the transaction, but also manually reject the message (sort of a nack, but that's not what the specification calls it). Such messages (and any that are unacked when a channel is closed or aborts) go to the back of the queue on a Rabbit broker, and this behaviour is not what some users expect, especially if they come from a JMS background, so it's good to be aware of it. The re-queuing order is not mandated by the AMQP specification, but it makes the broker much more efficient, and also means that if it is under load there is a natural back off before the message can be consumed again.

2.10.2. Using the RabbitTransactionManager

The [RabbitTransactionManager](#) is an alternative to executing Rabbit operations within, and synchronized with, external transactions. This Transaction Manager is an implementation of the [PlatformTransactionManager](#) interface and should be used with a single Rabbit ConnectionFactory.

Important

This strategy is not able to provide XA transactions, for example in order to share transactions between messaging and database access.

Application code is required to retrieve the transactional Rabbit resources via `ConnectionFactoryUtils.getTransactionalResourceHolder(ConnectionFactory, boolean)` instead of a standard `Connection.createChannel()` call with subsequent Channel creation. When using Spring's [RabbitTemplate](#), it will autodetect a thread-bound Channel and automatically participate in it.

With Java Configuration you can setup a new `RabbitTransactionManager` using:

```
@Bean
public RabbitTransactionManager rabbitTransactionManager() {
    return new RabbitTransactionManager(connectionFactory);
}

```

If you prefer using XML configuration, declare the following bean in your XML Application Context file:

```
<bean id="rabbitTxManager"
      class="org.springframework.amqp.rabbit.transaction.RabbitTransactionManager">
  <property name="connectionFactory" ref="connectionFactory"/>
</bean>

```

2.11. Message Listener Container Configuration

There are quite a few options for configuring a `SimpleMessageListenerContainer` related to transactions and quality of service, and some of them interact with each other.

When configuring with the XML namespace, the convention is to use hyphenated attributes rather than camel case; for example, for property 'connectionFactory', the XML equivalent is 'connection-factory'.

Table 2.1. Configuration options for a message listener container

Property	Description
<code>channelTransacted</code>	Boolean flag to signal that all messages should be acknowledged in a transaction (either manually or automatically)
<code>acknowledgeMode</code>	<code>NONE</code> = no acks will be sent (the default and incompatible with <code>channelTransacted=true</code>). RabbitMQ calls this "autoack" because the broker assumes all messages are acked without any action from the consumer. <code>MANUAL</code> = the listener must acknowledge all messages by calling <code>Channel.basicAck()</code> . <code>AUTO</code> = the container will acknowledge the message automatically. Note that <code>acknowledgeMode</code> is complementary to <code>channelTransacted</code> - if the channel is transacted then the broker requires a commit notification in addition to the ack.
<code>transactionManager</code>	External transaction manager for the operation of the listener. Also complementary to <code>channelTransacted</code> - if the <code>Channel</code> is transacted then its transaction will be synchronized with the external transaction.
<code>prefetchCount</code>	The number of messages to accept from the broker in one socket frame. The higher this is the faster the messages can be delivered, but the higher the risk of non-sequential processing. Ignored if the <code>acknowledgeMode</code> is <code>NONE</code> .
<code>shutdownTimeout</code>	When a container shuts down (e.g. if its enclosing <code>ApplicationContext</code> is closed) it waits for in-flight messages to be processed up to this limit. Defaults to 10 seconds. After the limit is reached, if the channel is not transacted messages will be discarded.
<code>txSize</code>	If the channel is transacted or an external transaction manager is provided, the container will attempt to process up to this number of messages per transaction (waiting for each one up to the receive timeout setting).
<code>receiveTimeout</code>	The maximum time to wait for each message. If <code>acknowledgeMode=NONE</code> (the default) this has very

Property	Description
	little effect - the container just spins round and asks for another message. It has the biggest effect for a transactional <code>Channel</code> with <code>txSize > 1</code> , since it can cause messages already consumed not to be acknowledged until the timeout expires.
autoStartup	Flag to indicate that the container should start when the <code>ApplicationContext</code> does (as part of the <code>SmartLifecycle</code> callbacks which happen after all beans are initialized). Defaults to true, but set it to false if your broker might not be available on startup, and then call <code>start()</code> later manually when you know the broker is ready.
phase	When autoStartup is true, the lifecycle phase within which this container should start and stop. The lower the value the earlier this container will start and the later it will stop. The default is <code>Integer.MAX_VALUE</code> meaning the container will start as late as possible and stop as soon as possible.
adviceChain	An array of AOP Advice to apply to the listener execution. This can be used to apply additional cross cutting concerns such as automatic retry in the event of broker death. Note that simple re-connection after an AMQP error is handled by the <code>CachingConnectionFactory</code> , as long as the broker is still alive.
taskExecutor	A reference to a Spring <code>TaskExecutor</code> (or standard JDK 1.5+ <code>Executor</code>) for executing listener invokers. Default is a <code>SimpleAsyncTaskExecutor</code> , using internally managed threads.
errorHandler	A reference to an <code>ErrorHandler</code> strategy for handling any uncaught <code>Exceptions</code> that may occur during the execution of the <code>MessageListener</code> .
concurrency	The number of concurrent consumers to start for each listener.
connectionFactory	A reference to the <code>connectionFactory</code> ; when configuring using the XML namespace, the default referenced bean name is "rabbitConnectionFactory".
messageConverter	A reference to the <code>MessageConverter</code> strategy for converting AMQP Messages to listener method arguments for any referenced 'listener' that is a POJO. Default is a <code>SimpleMessageConverter</code> .

2.12. Resilience: Recovering from Errors and Broker Failures

Some of the key (and most popular) high-level features that Spring AMQP provides are to do with recovery and automatic re-connection in the event of a protocol error or broker failure. We have seen all the relevant components already in this guide, but it should help to bring them all together here and call out the features and recovery scenarios individually.

The primary reconnection features are enabled by the `CachingConnectionFactory` itself. It is also often beneficial to use the `RabbitAdmin` auto-declaration features. In addition, if you care about guaranteed delivery, you probably also need to use the `channelTransacted` flag in `RabbitTemplate` and `SimpleMessageListenerContainer` and also the `AcknowledgeMode.AUTO` (or manual if you do the acks yourself) in the `SimpleMessageListenerContainer`.

2.12.1. Automatic Declaration of Exchanges, Queues and Bindings

The `RabbitAdmin` component can declare exchanges, queues and bindings on startup. It does this lazily, through a `ConnectionListener`, so if the broker is not present on startup it doesn't matter. The first time a `Connection` is used (e.g. by sending a message) the listener will fire and the admin features will be applied. A further benefit of doing the auto declarations in a listener is that if the connection is dropped for any reason (e.g. broker death, network glitch, etc.) they will be applied again the next time they are needed.

2.12.2. Failures in Synchronous Operations and Options for Retry

If you lose your connection to the broker in a synchronous sequence using `RabbitTemplate` (for instance), then Spring AMQP will throw an `AmqpException` (usually but not always `AmqpIOException`). We don't try to hide the fact that there was a problem, so you have to be able to catch and respond to the exception. The easiest thing to do if you suspect that the connection was lost, and it wasn't your fault, is to simply try the operation again. You can do this manually, or you could look at using Spring Retry to handle the retry (imperatively or declaratively).

Spring Retry provides a couple of AOP interceptors and a great deal of flexibility to specify the parameters of the retry (number of attempts, exception types, backoff algorithm etc.). Spring AMQP also provides some convenience factory beans for creating Spring Retry interceptors in a convenient form for AMQP use cases, with strongly typed callback interfaces for you to implement custom recovery logic. See the Javadocs and properties of `StatefulRetryOperationsInterceptor` and `StatelessRetryOperationsInterceptor` for more detail. Stateless retry is appropriate if there is no transaction or if a transaction is started inside the retry callback. Note that stateless retry is simpler to configure and analyse than stateful retry, but it is not usually appropriate if there is an ongoing transaction which must be rolled back or definitely is going to roll back. A dropped connection in the middle of a transaction should have the same effect as a rollback, so for reconnection where the transaction is started higher up the stack, stateful retry is usually the best choice.

2.12.3. Message Listeners and the Asynchronous Case

If a `MessageListener` fails because of a business exception, the exception is handled by the message listener container and then it goes back to listening for another message. If the failure is caused by a dropped connection (not a business exception), then the consumer that is collecting messages for the listener has to be cancelled and restarted. The `SimpleMessageListenerContainer` handles this seamlessly, and it leaves a log to say that the listener is being restarted. In fact it loops endlessly trying to restart the consumer, and only if the consumer is very badly behaved indeed will it give up. One side effect is that if the broker is down when the container starts, it will just keep trying until a connection can be established.

Business exception handling, as opposed to protocol errors and dropped connections, might need more thought and some custom configuration, especially if transactions and/or container acks are in use. AMQP has no

definition of dead letter behaviour, so by default a message that is rejected or rolled back because of a business exception can be redelivered ad infinitum. To put a limit in the client on the number of re-deliveries your best choice is a `StatefulRetryOperationsInterceptor` in the advice chain of the listener. The interceptor can have a recovery callback that implements a custom dead letter action: whatever is appropriate for your particular environment.

Chapter 3. Erlang integration

3.1. Introduction

There is an open source project called JInterface that provides a way for Java applications to communicate with an Erlang process. The API is very low level and rather tedious to use and throws checked exceptions. The Spring Erlang module makes accessing functions in Erlang from Java easy, often they can be one liners.

3.2. Communicating with Erlang processes

3.2.1. Executing RPC

The interface `ErlangOperations` is the high level API for interacting with an Erlang process.

```
public interface ErlangOperations {

    <T> T execute(ConnectionCallback<T> action) throws OtpException;

    OtpErlangObject executeErlangRpc(String module, String function, OtpErlangList args)
        throws OtpException;

    OtpErlangObject executeErlangRpc(String module, String function, OtpErlangObject... args)
        throws OtpException;

    OtpErlangObject executeRpc(String module, String function, Object... args)
        throws OtpException;

    Object executeAndConvertRpc(String module, String function,
        ErlangConverter converterToUse, Object... args) throws OtpException;

    // Sweet!
    Object executeAndConvertRpc(String module, String function, Object... args)
        throws OtpException;

}
```

The class that implements this interface is called `ErlangTemplate`. There are a few convenience methods, most notably `executeAndConvertRpc`, as well as the `execute` method which gives you access to the 'native' API of the JInterface project. For simple functions, you can invoke `executeAndConvertRpc` with the appropriate Erlang module name, function, and arguments in a one-liner. For example, here is the implementation of the `RabbitBrokerAdmin` method 'DeleteUser'

```
@ManagedOperation
public void deleteUser(String username) {
    erlangTemplate.executeAndConvertRpc(
        "rabbit_access_control", "delete_user", username.getBytes());
}
```

As the JInterface library uses specific classes such as `OtpErlangDouble` and `OtpErlangString` to represent the primitive types in Erlang RPC calls, there is a converter class that works in concert with `ErlangTemplate` that knows how to translate from Java primitive types to their Erlang class equivalents. You can also create custom converters and register them with the `ErlangTemplate` to handle more complex data format translations.

3.2.2. ErlangConverter

The ErlangConverter interface is shown below.

```
public interface ErlangConverter {  
  
    /**  
     * Convert a Java object to a Erlang data type.  
     * @param object the object to convert  
     * @return the Erlang data type  
     * @throws ErlangConversionException in case of conversion failure  
     */  
    OtpErlangObject toErlang(Object object) throws ErlangConversionException;  
  
    /**  
     * Convert from a Erlang data type to a Java object.  
     * @param erlangObject the Erlang object to convert  
     * @return the converted Java object  
     * @throws ErlangConversionException in case of conversion failure  
     */  
    Object fromErlang(OtpErlangObject erlangObject) throws ErlangConversionException;  
  
    /**  
     * The return value from executing the Erlang RPC.  
     */  
    Object fromErlangRpc(String module, String function, OtpErlangObject erlangObject)  
        throws ErlangConversionException;  
}
```

3.3. Exceptions

The JInterface checked exception hierarchy is translated into a parallel runtime exception hierarchy when executing operations through ErlangTemplate.

Chapter 4. Sample Applications

4.1. Introduction

The [Spring AMQP Samples](#) project includes two sample applications. The first is a simple "Hello World" example that demonstrates both synchronous and asynchronous message reception. It provides an excellent starting point for acquiring an understanding of the essential components. The second sample is based on a stock-trading use case to demonstrate the types of interaction that would be common in real world applications. In this chapter, we will provide a quick walk-through of each sample so that you can focus on the most important components. The samples are both Maven-based, so you should be able to import them directly into any Maven-aware IDE (such as [SpringSource Tool Suite](#)).

4.2. Hello World

The Hello World sample demonstrates both synchronous and asynchronous message reception. You can import the 'spring-rabbit-helloworld' sample into the IDE and then follow the discussion below.

4.2.1. Synchronous Example

Within the 'src/main/java' directory, navigate to the 'org.springframework.amqp.helloworld' package. Open the HelloWorldConfiguration class and notice that it contains the @Configuration annotation at class-level and some @Bean annotations at method-level. This is an example of Spring's Java-based configuration. You can read more about that [here](#).

```
@Bean
public ConnectionFactory connectionFactory() {
    CachingConnectionFactory connectionFactory = new CachingConnectionFactory("localhost");
    connectionFactory.setUsername("guest");
    connectionFactory.setPassword("guest");
    return connectionFactory;
}
```

The configuration also contains an instance of RabbitAdmin, which by default looks for any beans of type Exchange, Queue, or Binding and then declares them on the broker. In fact, the "helloWorldQueue" bean that is generated in HelloWorldConfiguration is an example simply because it is an instance of Queue.

```
@Bean
public Queue helloWorldQueue() {
    return new Queue(this.helloWorldQueueName);
}
```

Looking back at the "rabbitTemplate" bean configuration, you will see that it has the helloWorldQueue's name set as its "queue" property (for receiving Messages) and for its "routingKey" property (for sending Messages).

Now that we've explored the configuration, let's look at the code that actually uses these components. First, open the Producer class from within the same package. It contains a main() method where the Spring ApplicationContext is created.

```
public static void main(String[] args) {
    ApplicationContext context = new AnnotationConfigApplicationContext(RabbitConfiguration.class);
    AmqpTemplate amqpTemplate = context.getBean(AmqpTemplate.class);
    amqpTemplate.convertAndSend("Hello World");
    System.out.println("Sent: Hello World");
}
```

```
}

```

As you can see in the example above, the `AmqpTemplate` bean is retrieved and used for sending a `Message`. Since the client code should rely on interfaces whenever possible, the type is `AmqpTemplate` rather than `RabbitTemplate`. Even though the bean created in `HelloWorldConfiguration` is an instance of `RabbitTemplate`, relying on the interface means that this code is more portable (the configuration can be changed independently of the code). Since the `convertAndSend()` method is invoked, the template will be delegating to its `MessageConverter` instance. In this case, it's using the default `SimpleMessageConverter`, but a different implementation could be provided to the "rabbitTemplate" bean as defined in `HelloWorldConfiguration`.

Now open the `Consumer` class. It actually shares the same configuration base class which means it will be sharing the "rabbitTemplate" bean. That's why we configured that template with both a "routingKey" (for sending) and "queue" (for receiving). As you saw in Section 2.3, "AmqpTemplate", you could instead pass the 'routingKey' argument to the `send` method and the 'queue' argument to the `receive` method. The `Consumer` code is basically a mirror image of the `Producer`, calling `receiveAndConvert()` rather than `convertAndSend()`.

```
public static void main(String[] args) {
    ApplicationContext context = new AnnotationConfigApplicationContext(RabbitConfiguration.class);
    AmqpTemplate amqpTemplate = context.getBean(AmqpTemplate.class);
    System.out.println("Received: " + amqpTemplate.receiveAndConvert());
}

```

If you run the `Producer`, and then run the `Consumer`, you should see the message "Received: Hello World" in the console output.

4.2.2. Asynchronous Example

Now that we've walked through the synchronous Hello World sample, it's time to move on to a slightly more advanced but significantly more powerful option. With a few modifications, the Hello World sample can provide an example of asynchronous reception, a.k.a. *Message-driven POJOs*. In fact, there is a sub-package that provides exactly that: `org.springframework.amqp.samples.helloworld.async`.

Once again, we will start with the sending side. Open the `ProducerConfiguration` class and notice that it creates a "connectionFactory" and "rabbitTemplate" bean. This time, since the configuration is dedicated to the message sending side, we don't even need any `Queue` definitions, and the `RabbitTemplate` only has the 'routingKey' property set. Recall that messages are sent to an `Exchange` rather than being sent directly to a `Queue`. The AMQP default `Exchange` is a direct `Exchange` with no name. All `Queues` are bound to that default `Exchange` with their name as the routing key. That is why we only need to provide the routing key here.

```
public RabbitTemplate rabbitTemplate() {
    RabbitTemplate template = new RabbitTemplate(connectionFactory());
    template.setRoutingKey(this.helloWorldQueueName);
    return template;
}

```

Since this sample will be demonstrating asynchronous message reception, the producing side is designed to continuously send messages (if it were a message-per-execution model like the synchronous version, it would not be quite so obvious that it is in fact a message-driven consumer). The component responsible for sending messages continuously is defined as an inner class within the `ProducerConfiguration`. It is configured to execute every 3 seconds.

```
static class ScheduledProducer {
    @Autowired
    private volatile RabbitTemplate rabbitTemplate;
}

```

```

private final AtomicInteger counter = new AtomicInteger();

@Scheduled(fixedRate = 3000)
public void sendMessage() {
    rabbitTemplate.convertAndSend("Hello World " + counter.incrementAndGet());
}
}

```

You don't need to understand all of the details since the real focus should be on the receiving side (which we will cover momentarily). However, if you are not yet familiar with Spring 3.0 task scheduling support, you can learn more [here](#). The short story is that the "postProcessor" bean in the `ProducerConfiguration` is registering the task with a scheduler.

Now, let's turn to the receiving side. To emphasize the Message-driven POJO behavior will start with the component that is reacting to the messages. The class is called `HelloWorldHandler`.

```

public class HelloWorldHandler {

    public void handleMessage(String text) {
        System.out.println("Received: " + text);
    }

}

```

Clearly, that *is* a POJO. It does not extend any base class, it doesn't implement any interfaces, and it doesn't even contain any imports. It is being "adapted" to the `MessageListener` interface by the Spring AMQP `MessageListenerAdapter`. That adapter can then be configured on a `SimpleMessageListenerContainer`. For this sample, the container is created in the `ConsumerConfiguration` class. You can see the POJO wrapped in the adapter there.

```

@Bean
public SimpleMessageListenerContainer listenerContainer() {
    SimpleMessageListenerContainer container = new SimpleMessageListenerContainer();
    container.setConnectionFactory(connectionFactory());
    container.setQueueName(this.helloWorldQueueName);
    container.setMessageListener(new MessageListenerAdapter(new HelloWorldHandler()));
    return container;
}

```

The `SimpleMessageListenerContainer` is a Spring lifecycle component and will start automatically by default. If you look in the `Consumer` class, you will see that its `main()` method consists of nothing more than a one-line bootstrap to create the `ApplicationContext`. The `Producer's` `main()` method is also a one-line bootstrap, since the component whose method is annotated with `@Scheduled` will also start executing automatically. You can start the `Producer` and `Consumer` in any order, and you should see messages being sent and received every 3 seconds.

4.3. Stock Trading

The `Stock Trading` sample demonstrates more advanced messaging scenarios than the `Hello World` sample. However, the configuration is very similar - just a bit more involved. Since we've walked through the `Hello World` configuration in detail, here we'll focus on what makes this sample different. There is a server that pushes market data (stock quotes) to a `Topic Exchange`. Then, clients can subscribe to the market data feed by binding a `Queue` with a routing pattern (e.g. `"app.stock.quotes.nasdaq.*"`). The other main feature of this demo is a request-reply "stock trade" interaction that is initiated by the client and handled by the server. That involves a private "replyTo" `Queue` that is sent by the client within the order request `Message` itself.

The `Server's` core configuration is in the `RabbitServerConfiguration` class within the

`org.springframework.amqp.rabbit.stocks.config.server` package. It extends the `AbstractStockAppRabbitConfiguration`. That is where the resources common to the Server and Client(s) are defined, including the market data Topic Exchange (whose name is 'app.stock.marketdata') and the Queue that the Server exposes for stock trades (whose name is 'app.stock.request'). In that common configuration file, you will also see that a `JsonMessageConverter` is configured on the `RabbitTemplate`.

The Server-specific configuration consists of 2 things. First, it configures the market data exchange on the `RabbitTemplate` so that it does not need to provide that exchange name with every call to send a `Message`. It does this within an abstract callback method defined in the base configuration class.

```
public void configureRabbitTemplate(RabbitTemplate rabbitTemplate) {
    rabbitTemplate.setExchange(MARKET_DATA_EXCHANGE_NAME);
}
```

Secondly, the stock request queue is declared. It does not require any explicit bindings in this case, because it will be bound to the default no-name exchange with its own name as the routing key. As mentioned earlier, the AMQP specification defines that behavior.

```
@Bean
public Queue stockRequestQueue() {
    return new Queue(STOCK_REQUEST_QUEUE_NAME);
}
```

Now that you've seen the configuration of the Server's AMQP resources, navigate to the 'org.springframework.amqp.rabbit.stocks' package under the 'src/test/java' directory. There you will see the actual Server class that provides a `main()` method. It creates an `ApplicationContext` based on the 'server-bootstrap.xml' config file. In there you will see the scheduled task that publishes dummy market data. That configuration relies upon Spring 3.0's "task" namespace support. The bootstrap config file also imports a few other files. The most interesting one is 'server-messaging.xml' which is directly under 'src/main/resources'. In there you will see the "messageListenerContainer" bean that is responsible for handling the stock trade requests. Finally have a look at the "serverHandler" bean that is defined in "server-handlers.xml" (also in 'src/main/resources'). That bean is an instance of the `ServerHandler` class and is a good example of a Message-driven POJO that is also capable of sending reply `Messages`. Notice that it is not itself coupled to the framework or any of the AMQP concepts. It simply accepts a `TradeRequest` and returns a `TradeResponse`.

```
public TradeResponse handleMessage(TradeRequest tradeRequest) { ... }
```

Now that we've seen the most important configuration and code for the Server, let's turn to the Client. The best starting point is probably `RabbitClientConfiguration` within the 'org.springframework.amqp.rabbit.stocks.config.client' package. Notice that it declares two queues without providing explicit names.

```
@Bean
public Queue marketDataQueue() {
    return amqpAdmin().declareQueue();
}

@Bean
public Queue traderJoeQueue() {
    return amqpAdmin().declareQueue();
}
```

Those are private queues, and unique names will be generated automatically. The first generated queue is used by the Client to bind to the market data exchange that has been exposed by the Server. Recall that in AMQP, consumers interact with Queues while producers interact with Exchanges. The "binding" of Queues to Exchanges is what instructs the broker to deliver, or route, messages from a given Exchange to a Queue. Since

the market data exchange is a Topic Exchange, the binding can be expressed with a routing pattern. The `RabbitClientConfiguration` declares that with a `Binding` object, and that object is generated with the `BindingBuilder`'s fluent API.

```
@Value("${stocks.quote.pattern}")
private String marketDataRoutingKey;

@Bean
public Binding marketDataBinding() {
    return BindingBuilder.bind(
        marketDataQueue()).to(marketDataExchange()).with(marketDataRoutingKey);
}
```

Notice that the actual value has been externalized in a properties file ("client.properties" under `src/main/resources`), and that we are using Spring's `@Value` annotation to inject that value. This is generally a good idea, since otherwise the value would have been hardcoded in a class and unmodifiable without recompilation. In this case, it makes it much easier to run multiple versions of the Client while making changes to the routing pattern used for binding. Let's try that now.

Start by running `org.springframework.amqp.rabbit.stocks.Server` and then `org.springframework.amqp.rabbit.stocks.Client`. You should see dummy quotes for NASDAQ stocks because the current value associated with the 'stocks.quote.pattern' key in `client.properties` is 'app.stock.quotes.nasdaq.*'. Now, while keeping the existing Server and Client running, change that property value to 'app.stock.quotes.nyse.*' and start a second Client instance. You should see that the first client is still receiving NASDAQ quotes while the second client receives NYSE quotes. You could instead change the pattern to get all stocks or even an individual ticker.

The final feature we'll explore is the request-reply interaction from the Client's perspective. Recall that we have already seen the `ServerHandler` that is accepting `TradeRequest` objects and returning `TradeResponse` objects. The corresponding code on the Client side is `RabbitStockServiceGateway` in the 'org.springframework.amqp.rabbit.stocks.gateway' package. It delegates to the `RabbitTemplate` in order to send Messages.

```
public void send(TradeRequest tradeRequest) {
    getRabbitTemplate().convertAndSend(tradeRequest, new MessagePostProcessor() {
        public Message postProcessMessage(Message message) throws AmqpException {
            message.getMessageProperties().setReplyTo(new Address(defaultReplyToQueue));
            try {
                message.getMessageProperties().setCorrelationId(
                    UUID.randomUUID().toString().getBytes("UTF-8"));
            }
            catch (UnsupportedEncodingException e) {
                throw new AmqpException(e);
            }
            return message;
        }
    });
}
```

Notice that prior to sending the message, it sets the "replyTo" address. It's providing the queue that was generated by the "traderJoeQueue" bean definition shown above. Here's the `@Bean` definition for the `StockServiceGateway` class itself.

```
@Bean
public StockServiceGateway stockServiceGateway() {
    RabbitStockServiceGateway gateway = new RabbitStockServiceGateway();
    gateway.setRabbitTemplate(rabbitTemplate());
    gateway.setDefaultReplyToQueue(traderJoeQueue());
    return gateway;
}
```

If you are no longer running the Server and Client, start them now. Try sending a request with the format of '100 TCKR'. After a brief artificial delay that simulates "processing" of the request, you should see a confirmation message appear on the Client.

Part III. Spring Integration - Reference

This part of the reference documentation provides a quick introduction to the AMQP support within the Spring Integration project.

Chapter 5. Spring Integration AMQP Support

5.1. Introduction

The [Spring Integration](#) project includes AMQP Channel Adapters and Gateways that build upon the Spring AMQP project. Those adapters are developed and released in the Spring Integration project. In Spring Integration, "Channel Adapters" are unidirectional (one-way) whereas "Gateways" are bidirectional (request-reply). We provide an inbound-channel-adapter, outbound-channel-adapter, inbound-gateway, and outbound-gateway.

Since the AMQP adapters are part of the Spring Integration release, the documentation will be available as part of the Spring Integration distribution. As a taster, we just provide a quick overview of the main features here.

5.2. Inbound Channel Adapter

To receive AMQP Messages from a Queue, configure an `<inbound-channel-adapter>`

```
<amqp:inbound-channel-adapter channel="fromAMQP"
                             queue-names="some.queue"
                             connection-factory="rabbitConnectionFactory" />
```

5.3. Outbound Channel Adapter

To send AMQP Messages to an Exchange, configure an `<outbound-channel-adapter>`. A 'routing-key' may optionally be provided in addition to the exchange name.

```
<amqp:outbound-channel-adapter channel="toAMQP"
                               exchange-name="some.exchange"
                               routing-key="foo"
                               amqp-template="rabbitTemplate" />
```

5.4. Inbound Gateway

To receive an AMQP Message from a Queue, and respond to its reply-to address, configure an `<inbound-gateway>`.

```
<amqp:inbound-gateway request-channel="fromAMQP"
                      reply-channel="toAMQP"
                      queue-names="some.queue"
                      connection-factory="rabbitConnectionFactory" />
```

5.5. Outbound Gateway

To send AMQP Messages to an Exchange and receive back a response from a remote client, configure an `<outbound-gateway>`. A 'routing-key' may optionally be provided in addition to the exchange name.

```
<amqp:outbound-gateway request-channel="toAMQP"
                      reply-channel="fromAMQP" />
```

```
exchange-name="some.exchange"  
routing-key="foo"  
amqp-template="rabbitTemplate"/>
```

Part IV. Other Resources

In addition to this reference documentation, there exist a number of other resources that may help you learn about AMQP.

Chapter 6. Further Reading

For those who are not familiar with AMQP, the [specification](#) is actually quite readable. It is of course the authoritative source of information, and the Spring AMQP code should be very easy to understand for anyone who is familiar with the spec. Our current implementation of the RabbitMQ support is based on their 2.8.x version, and it officially supports AMQP 0.8 and 0.9.1. We recommend reading the 0.9.1 document.

There are many great articles, presentations, and blogs available on the RabbitMQ [Getting Started](#) page. Since that is currently the only supported implementation for Spring AMQP, we also recommend that as a general starting point for all broker-related concerns.

Finally, be sure to visit the Spring AMQP [Forum](#) if you have questions or suggestions. With this first GA release, we are looking forward to a lot of community feedback!

Bibliography

[jinterface-00] Ericsson AB. [jinterface User Guide](#). Ericson AB . 2000.