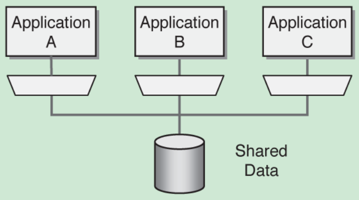
# Enterprise Integration Patterns

You can print out and use ***The Enterprise Integration Pattern*** electronic flashcards to visually piece together an integration solution.

Based on the book *Enterprise Integration Patterns* (**Addison-Wesley**)

## Shared Database



Integrate applications by having them store their data in a single Shared Database, and define the schema of the database to handle all the needs of the different applications.

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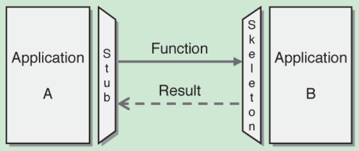
## Remote Procedure Invocation



Develop each application as a large-scale object or component with encapsulated data. Provide an interface to allow other applications to interact with the running application.

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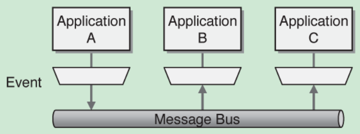
## Messaging



Use Messaging to transfer packets of data frequently, immediately, reliably, and asynchronously, using customizable formats.

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CONTENTS INCLUDE:

# Camel Essential Components

*By Christian Posta*

## WHAT IS CAMEL?

Camel is an open-source, lightweight, integration library that allows your applications to accomplish intelligent routing, message transformation, and protocol mediation using the established Enterprise Integration Patterns and out-of-the-box adapters with a highly expressive Domain Specific Language (Java, XML, or Scala). With Camel you can implement integration solutions as part of an overarching ESB solution, or as integration routes deployed to any container such as Tomcat, OSGI (FuseESB), or even a stand-alone java process.

## WHY USE CAMEL?

Camel simplifies systems integrations with an easy-to-use DSL to create routes that clearly identify the integration intentions and endpoints. Camel's out of the box integration components are modeled after the Enterprise Integration Patterns cataloged in Gregor Hohpe and Bobby Wolf's book (http://www.eaipatterns.com). You can use these EIPs as pre-packaged units, along with any custom processors or external adapters you may need, to easily assemble otherwise complex routing and transformation routes.

```
from( "jms:incomingQueue" )
  .convertBodyTo( String.class )
  .unmarshal( jaxb )
  .process(new Processor() {
       @Override
       public void process( Exchange exchange ) throws Exception {
                 .... Custom Logic If Needed ....
       }
    })
  .marshal( jaxb )
  .convertBodyTo( String.class )
  .to( "jms:outgoingQueue" );
```

Camel allows you to integrate with quite a few protocols out of the box and the community is constantly adding more. Each component is highly flexible and can be easily configured using Camel's consistent URI syntax. This Refcard introduces you to the more popular and widely used components and their configurations:

- Log
- JMS/ActiveMQ
- CXF
- File
- SEDA/Direct
- Mock

## CONFIGURING CAMEL COMPONENTS

All Camel components can be configured with a familiar URI syntax. Usually, components are specified in the from() clause (beginning of a route) or the to() clause (typically termination points in the route, but not always). A component "creates" specific "endpoint" instances. Think of a component as an "endpoint factory" where an endpoint is the actual object listening for a message (in the "from" scenario) or sending a message (in the "to" scenario).

An endpoint URI usually has the form:

```
<component:><//endpoint-local-name><?config=value&config=value>
```

The component is listed first, followed by some local name specific to the endpoint, and finally some endpoint-specific configuration

Example:

```
jms:test-queue?preserveMessageQos=true
```

This URI creates a JMS endpoint that listens to the "test-queue" and sets the preserveMessageQos option to "true".

There are over 100 Camel components and each one has configuration options to finely tune its behavior. See the Camel components list to see if a component is available for the types of integrations you might need:

http://camel.apache.org/components.html

## ESSENTIAL COMPONENTS

### Bean Component

Camel implements the Service Activator pattern (from the EIPs) which allows you to plug a service into your route through a thin layer that's responsible for mediating between the messaging system (or integration route) and the service. Camel implements the Service Activator with its "bean" component and allows you to bind to and invoke POJO beans within your route.

**Basic usage**

Define your bean in the Camel registry (usually the spring context if you are instantiating from a Spring application context).

```
<bean id="beanName" class="com.some.class.ClassName"> ... </bean>
```

Then from your route, you can invoke a method on the bean:

```
from("direct:incoming").beanRef("beanName", "methodName")
```

Instead of relying on the registry to have the bean, you could just let Camel instantiate and manage the bean by supplying the class:

```
from("direct:incoming").bean(InvokeCustomLogicService.class, "methodName")
```

**How is a method chosen?**
You don't always have to supply an explicit method name, but if you do it makes it easier on both Camel and reading the route. If you don't supply an explicit method name, Camel will do its best to resolve the correct method using the following rules:

- Is there a header with the key "CamelBeanMethodName" with a non-null value?
- If there is only a single method, Camel will try to use that.
- If there are multiple methods, camel will try to select one that has only one parameter.
- If there is an @Handler annotation, Camel will use that one.
- Lastly, Camel will try to match a method's parameters by type to the incoming message body.

**How does Camel bind parameters?**
Camel will automatically try to bind the first parameter to the body of the incoming message. Otherwise, if you have parameters of these types, they will automatically be bound, regardless of order:

- CamelContext – Use when you need access to the full context, components defined in the context, or to create objects that require the context.
- Registry – The registry is the object that holds all of the beans that might be used in a CamelContext; usually the Spring BeanFactory/ApplicationFactory (but not always).
- Exchange – Contains headers, body, properties, and overall state for processing a message unit including a reply.
- Message – The incoming message.
- TypeConverter – Part of Camel's type conversion internals; can be used to explicitly convert types.

You can also use annotations to specifically bind certain parts of the Exchange to parameters in your methods. See the Camel documentation (http://camel.apache.org/parameter-binding-annotations.html) for more.

**Further Reading**
For more information on the bean component, see
http://camel.apache.org/bean.html

## Log Component

We always advise using logging in your routes to make it clear what steps in the processing have completed successfully. One way to do that is through the Log Component. The logging mechanism that's used is slf4j. Slf4j allows you to configure different types of logger implementations including log4j, logback, and the JDK's built in logging.

**Logging**
To log an exchange at debug level:

```
from("direct:start").to("log:com.fusesource.examples?level=DEBUG")
```

This will output the exchange type (InOnly/InOut) and the body of the In message. You some control over what is logged; for example, to see the headers along with the exchange:

```
from("direct:start")
       .to("log:com.fusesource.examples?showHeaders=true")
```

To make the Exchange logging easier to read, consider enabling multiline printing:

```
from("direct:start")   .to("log:com.fusesource.examples?showHeaders=true&mult
iline=true")
```

For logging streams, you must determine whether you want to cache the stream first before logging it. Streams are read-once entities, and if you don't cache them, they won't be available to processors further down the chain. To cache streams and log them:

```
from("direct:start").streamCaching()   .to("log:com.fusesource.examples?showHe
aders=true&showStreams=true")
```

**Formatting**
You can add configurations to fine-tune exactly what's logged. Note that formatting options don't apply to groups when using groupSize, groupInterval, etc.

| Option | Description |
|---|---|
| showAll | Turns all options on, such as headers, body, out, stackTrace, etc. |
| showExchangeId | Prints out the exchange ID. |
| showHeaders | Shows all headers for in the in message. |
| showBodyType | Shows the Java type for the body. |
| showBody | Shows the actual contents of the body. |
| showOut | Shows the out message. |
| showException | If there's an exception in the exchange, shows the exception. Doesn't show the full stacktrace. |
| showStackTrace | Prints the stacktrace from the exception. |
| multiline | Logs each part of the exchange and its details on separate lines for better readability. |
| maxChars | The maximum number of characters logged per line. |

**Further Reading**
For more information on the log component, see
http://camel.apache.org/log.html

## JMS and ActiveMQ Component

The Camel JMS component allows you to write Camel routes with endpoints producing to or consuming from a JMS provider. Most commonly, JMS and associated routes are used for asynchronous inOnly style messaging. However, Camel-JMS understands request-reply or inOut style messaging and uses temporary queues to implement under the covers. Use the activemq-camel component for JMS endpoints that rely on an ActiveMQ provider as it provides some simple optimizations.

**Consume from a queue**
Note that you can specify "jms:queue:incomingOrders" but "queue" is default, so it can be left off:

```
from("jms:incomingOrders")
.process(<some processing>).to("jms:inventoryCheck");
```

**Consume from a topic**

```
from("jms:topic:incomingOrders")
.process(<some processing>).to("jms:inventoryCheck");
```

**Set up pooled resources**
JMS resources are often expensive to create. Connections, Sessions, Producers, Consumers should be cached where it makes sense, and setting up the appropriate caching starts with a pooled connection factory. If you're using ActiveMQ, you can use the org.apache.activemq.pool.PooledConnectionFactory. Alternatively for general purpose JMS connection pooling, you can use the Spring's CachingConnectionFactory. See the documentation for using the CachingConnectionFactory.

When using ActiveMQ::

```
<bean id="connectionFactory" class="org.apache.activemq.
ActiveMQConnectionFactory">
   <property name="brokerURL" value="tcp://localhost:61616" />
</bean>

<bean id="jmsPooledConnectionFactory" class="org.apache.activemq.pool.
PooledConnectionFactory">
   <property name="connectionFactory" ref="connectionFactory">
   </property>
</bean>
```

**Request/Reply**
By default, Camel will use a Message Exchange Pattern of InOnly when dealing with JMS. However, it will be changed to InOut if there is a JMSReplyTo header or if explicitly set:

```
from("direct:incoming").inOut().to("jms:outgoingOrders").process(process the
jms response here and continue your route)
```

In the previous example, the MEP was set to InOut which means before sending to the outgoingOrders queue, Camel will create a temporary destination, listen to it, and set the JMSReplyTo header to the temporary destination before it sends the JMS message. Some other consumer will need to listen to outgoingOrders queue and send a reply to the destination named in the JMSReplyTo header. The response received over the temporary destination will be used in further processing in the route. Camel will listen for a default 20s on the temporary destination before it times out. If you prefer to use named queues instead of temporary ones, you can set the replyTo configuration option:

```
from("direct:incoming").inOut().to("jms:outgoingOrders?replyTo=outgoingOrdersR
eply").process(process the jms response here and continue your route)
```

**Transactions**
To use transactions with Camel-JMS, you should set up a pooled connection factory, a transaction manager, and configure the Camel-JMS configuration in a JMSConfiguration object:

```
<!-- JmsConfiguration object -->
<bean id="jmsConfig" class="org.apache.camel.component.jms.JmsConfiguration" >
<property name="connectionFactory"          ref="jmsPooledConnectionFactory"
/>
  <property name="transacted" value="true" />
  <property name="transactionManager" ref="jmsTransactionManager" />
  <property name="cacheLevelName" value="CACHE_CONSUMER" />
</bean>

<!-- Spring Transaction Manager -->
<bean id="jmsTransactionManager" class="org.springframework.jms.connection.
JmsTransactionManager">
<property name="connectionFactory"                                  ref="jmsPo
oledConnectionFactory" />
</bean>

<!-- Set up Pooled Connection Factory -->
<bean id="jmsPooledConnectionFactory" class="org.apache.activemq.pool.
PooledConnectionFactory">
  <property name="connectionFactory">
    <bean class="org.apache.activemq.ActiveMQConnectionFactory">
      <property name="brokerURL" value="tcp://localhost:61616" />
    </bean>
  </property>
</bean>
```

Make sure to set the cache level to CACHE_CONSUMER so that your consumers, sessions, and connections are cached between messages.

Updated for Camel 2.10, you can now use "local" transactions with the Camel-JMS consumer (you don't have to specify an external transaction manager):

```
<bean id="jmsConfig" class="org.apache.camel.component.jms.JmsConfiguration" >
            <property name="connectionFactory" ref="jmsPooledConnectionFacto
ry" />
            <property name="transacted" value="true" />
            <property name="cacheLevelName" value="CACHE_CONSUMER" />
</bean>
```

**Common configuration options:**

| Option | Default | Description |
|---|---|---|
| concurrent Consumers | 1 | Specifies the number of consumers to create to listen on the destination. |
| disableReplyTo | false | Sets this endpoint to not do inOut messaging. |
| durableSubscription Name | null | Explicitly sets the name of a durable subscription (per JMS, must be used with clientId). |
| clientId | null | JMS client id for this endpoint. Must be unique. |
| replyTo | null | Specifies the name of a destination to be included as a JMSReplyTo header on outgoing messages. |
| selector | null | JMS selector to specify a predicate for what messages the broker should deliver to this endpoint consumer. |
| timeToLive | null | Time to live (in milliseconds) for the message as it travels through a broker (possible network of brokers). |
| transacted | false | Specifies whether to do send and receives in a transaction. |
| acknowledgement ModeName | AUTO_ ACKNOWLEDGE | JMS acknowledgement mode. |
| asyncConsumer | false | Whether to process a message from a destination asynchronously. By default this is false. |
| cacheLevelName | CACHE_AUTO | Caches consumers, sessions, and connections. For example, CACHE_AUTO, and CACHE_CONSUMER. |

**Further Reading**
For more information on the jms component, see
http://camel.apache.org/jms.html

## CXF Component
When you want to expose or consume a SOAP or REST style web service for use in an integration route. sometimes a solution you're working on requires a web-service endpoint to kick off a larger process, or enrich data before calling another web service, or just act as a proxy to another service. Camel works nicely with CXF to allow you to configure a web-service endpoint that hooks into and leverages the power of Camel's routing and mediation engine.

You can use Camel-CXF as a consumer (from() clause) which internally starts up a Jetty server to publish the web service. It can also be used as a producer, which will send SOAP or REST requests. You can alternatively configure your endpoint to deploy into an existing servlet container instead of relying on the built-in Jetty server.

**JAX-WS (SOAP)**
Using the JAX-WS front end for CXF with Camel requires you to set up your contract (WSDL) or Java classes first and follow the correct wsdl2java or java annotations to describe your web service. Once you've done this, you can use Camel to hook the endpoint into a route.

**Configuration**
As a bean (easier to read in the DSL)

To configure the JAX-WS component, specify a <cxfEndpoint> with an ID attribute that can be later referenced by a Camel route:

```
<cxf:cxfEndpoint id="helloWorld"
                     wsdlURL="wsdl/HelloWorld.wsdl"
                     serviceClass="org.helloworld.HelloWorld"
                     address="http://localhost:9090/helloworld" >
</cxf:cxfEndpoint>
```

Note that for this configuration, you'll need this namespace in your spring application context:

```
http://camel.apache.org/schema/cxf
http://camel.apache.org/schema/cxf/camel-cxf.xsd
```

Then, in your Camel route, you can refer to the CXF endpoint with:

```
from("cxf:bean:helloWorld").log("This is what was said: ${body}").
transform(constant("Hello to you good sir!"));
```

**With the URI** (more convenient, not as easy to read in the DSL)

You can leave out the bean config in the registry (spring XML) altogether and configure options directly on the endpoint:

```
from(“cxf://http://localhost:9090/helloworld?serviceClass=org.apache.
helloworld.HelloWorld&wsdlURL=wsdl/HelloWorld.wsdl&dataFormat=MESSAGE”)
```

In this example, org.apache.helloworld.HelloWorld is the SEI (Service Endpoint Interface). Note, there is no *Impl class that implements the SEI, as camel takes care of that.

**DataFormat**
Camel allows you to work with the SOAP message in three different formats:

- POJO (default) – a list of Java objects that represent the parameters to the service being called
- MESSAGE – Raw message, no SOAP processing
- PAYLOAD – just deal with the SOAP body of the message

**JAX-RS (REST)**
Just like with JAX-WS, you'll need to set up your Java classes with the correct JAX-RS annotations and use Camel to expose the REST endpoint

**Configuration**
As a bean

Note that for this configuration, you'll need this namespace in your spring application context:

```
http://camel.apache.org/schema/cxf http://camel.apache.org/schema/cxf/camel-
cxf.xsd

<cxf:rsServer id=”rsServer” address=”http://localhost:9090/route”
serviceClass=”com.fusesource.samples.CustomerServiceResource”>
```

Then, within your route (just like the bean for the JAX-WS web service) you can refer to the bean like this:

```
from(“cxfrs:bean:rsServer”)
```

**With the URI**

```
from(“cxfrs://http://localhost:9090/route?resourceClasses=com.fusesource.
samples.CustomerServiceResource”)
```

**Further Reading**
For more information on the CXF component, see
http://camel.apache.org/cxf.html

For more about Camel, CXF, and JAX-RS see:
http://www.christianposta.com/blog/?p=229

## File Component

When reading or writing files (CSV, XML, fixed-format, for example) to or from the file system, use the Camel File component. File-based integrations are fairly common with legacy applications but can be tedious to interact with. With a file consumer endpoint, you can consume files from the file system and work with them as exchanges in your camel route. Conversely, you can also persist the content of your exchanges to disk.

**Read Files**
When used in a “from” DSL clause, the file component will be used in “consumer” mode or “read”.

```
from(“file:/location/of/files?configs”).log(“${body}”)
```

**Common Configuration Options for Reading Files**

| Option | Default | Description |
|---|---|---|
| delay | 500ms | Sets how long (in milliseconds) to wait before polling the file system for the next file. |
| delete | false | Sets whether to delete the file after it has been processed. |
| doneFileName | null | Names of files that must exist before Camel starts processing files from the folder. |
| exclude | null | Regex for file patterns to ignore. |
| filter | null | A custom filter class used to filter out files/folders you don't want to process (specify as a bean name: #beanName). |
| idempotent | false | Skips already-processed files following the Idempotent consumer pattern. |
| include | null | Regex for file patterns to include. |
| move | .camel | Sets the default place to move files after they've been processed. |
| noop | false | If true, the file is not moved or deleted after it has been processed. |
| readLock | markerFile | Camel will only process files that it can get a read-lock for. Specifies a strategy for how to determine whether it has read-lock access. |
| readLock Timeout | 10000ms | Sets the timeout i(n milliseconds) for how long to wait to acquire a read-lock. |
| recursive | false | Recurs through sub-directories as well. |

**Things to Watch Out For**

- Locking of files that are being processed (on reads) until route is complete (by default).
- Will ignore files that start with “.”
- By default, will move processed files to “.camel” directory.
- Moving/deleting files will happen after routing.

**Write Files**

```
from(<endpoint>).to(“file:/location/of/files?fileName=<filename>”)
```

**Common Configuration Options for Writing Files**

| Option | Description |
|---|---|
| doneFileName | Name of file that must exist before Camel starts processing files from the folder. |
| fileExist | What to do if a file exists: override, append, ignore, or fail. |
| fileName | Name of file to be written. |
| tempFileName | A temporary name given to the file as it's being written. Will change to real name when writing is finished. |

**Big Files**
Sometimes you need to process files that are too large to fit into memory, or would be too large to process efficiently if loaded into memory.
A common approach to dealing with such files using the Camel-file component is to stream them and process them in chunks. Generally, the files are structured in such a way that it makes sense to process them in chunks and we can leverage the power of camel's EIP processors to “split” a file into those chunks. Here's an example route:

```
from(“file:/location/of/files”).split(body().tokenize(“\n”)).streaming().
log(“${body}”).end()
```

This route splits on newlines in the file, streaming and processing one line at a time.

For more information on splitting large files, see http://www.davsclaus.com/2011/11/splitting-big-xml-files-with-apache.html

**Headers**
Headers are automatically inserted (consumer) for use in your routes or can be set in your route and used by the file component (producer). Here are some of the headers that are set automatically by the file consumer endpoint:

- CameFileName - Name of the file consumed as a relative location with the offset from the directory configured in the endpoint.
- CamelFileNameOnly - File name with no location offset.
- CamelFileAbsolute - A Boolean that specifies whether the path is absolute or not.
- CamelFileAbsolutePath - Will be the absolute path if the CamelFileAbsolute header is true.
- CamelFilePath - Starting directory + relative filename.
- CamelFileRelativePath - Just the relative path.
- CamelFileParent - Just the parent path.
- CamelFileLength - Length of the file.
- CamelFileLastModified - Date of the last modified timestamp.

Headers that, if set, will be used by the file producer endpoint:

- CamelFileName - Name of the file to write to the output directory (usually an expression).
- CamelFileNameProduced - The actual filename produced (absolute file path).

Further Reading
For more information on the file component, see http://camel.apache.org/file2.html

## SEDA and Direct Component
You can still use messaging as a means of communicating with or between your routes without having to use an external messaging broker. Camel allows you to do in-memory messaging via synchronous or asynchronous queues. Use the “direct” component for synchronous processing and use the “seda” for asynchronous, “staged,” event-driven processing.

**Direct**
Use the direct component to break up routes using synchronous messaging:

```
from(“direct:channelName”).process(<process something>).
to(“direct:outgoingChannel”);
from(“direct:outgoingChannel”).transform(<transform something>).
to(“jms:outgoingOrders”)
```

**SEDA**
SEDA endpoints and their associated routes will be run in separate threads and process exchanges asynchronously. Although the pattern of usage is similar to the “direct” component, the semantics are quite different.

```
from(“<any component>”).choice().when(header(“accountType”).
endsWith(“Consumer”)).to(“seda:consumerAccounts”)

        .when(header(“accountType”).endsWith(“Business”)).
to(“seda:businessAccounts”)

from(“seda:consumerAccounts”).process(<process logic>)

from(“seda:businessAccounts”).process(<process logic>)
```

You can set up the SEDA endpoint to use multiple threads to do its processing by adding the concurrentConsumers configuration:

```
from(“seda:consumerAccounts?concurrentConsumers=20”).process(<process logic>)
```

Keep in mind that using SEDA (or any asynchronous endpoint) will behave differently in a transaction, i.e., the consumers of the SEDA queue will not participate in the transaction as they are in different threads.

**Common configuration options**
The “direct” component does not have any configuration options.

**SEDA commonly used options:**

| Option | Default | Description |
|---|---|---|
| size | Unbounded | Max capacity of the in-memory queue. |
| concurrentConsumers | 1 | The number of concurrent threads that can process exchanges. |
| multipleConsumers | false | Determines whether multiple consumers are allowed. |
| blockWhenFull | false | Blocks a thread that tries to write to a full SEDA queue instead of throwing an exception. |

**Further Reading**
For more information on the direct and SEDA component, see http://camel.apache.org/direct.html and http://camel.apache.org/seda.html respectively

## Mock Component
Testing your routes is an important aspect in integration development and Camel makes it easier with the mock component. The component can be used in your JUnit or TestNG tests. You can declare a set of expectations on a mock such as how many messages were processed, or that certain headers must be present at an endpoint, and then run your route. At the completion of the route, you can verify that the intended expectations were met and fail the test if they were not.

**Mocks**
You start by obtaining the mock endpoint from the route:

```
MockEndpoint mock = context.getEndpoint(“mock:outgoing”,
MockEndpoint.class);
```

Next, you declare expectations. Methods that declare expectations start with “expect”, for example:

```
mock.expectedMessageCount( 1 )
```

Then you run your route.
Finally, you assert that the declared expectations were met:

```
mock.assertIsSatisfied()
```

**Expectation Methods:**

- expectedMessageCount(int)
- expectedMinimumMessageCount(int)
- expectedBodiesReceived()
- expectedHeadersReceived()
- expectsAscending(Expression)
- expectsDescending(Expression)
- expectsNoDuplicate(Expression)

**AssertionMethods:**

- assertIsSatisfied()
- assertIsNotSatisfied()

**Mocking existing endpoints**
Sometimes, you'll have routes with live endpoints that you cannot change (or don't want to change) for testing. For such routes, you can insert mocks where the live mocks are to do some testing.

```
RouteDefinition route = context.getRouteDefinition("advice");

route.adviceWith(context, new AdviceWithRouteBuilder() {
    @Override
    public void configure() throws Exception {
        mockEndpoints(<pattern>);
    }
});
```

<pattern> allows you to specify which endpoints to mock. For example, to mock out only the JMS components, you would do mockEndpoints("jms*"). To mock all endpoints, leave off the pattern completely.

Note that inserting mocks at the location of the endpoints does not replace the endpoints, i.e., the live endpoints will still exist. Updated for Camel 2.10, you can now skip sending the exchange to the live endpoint:

```
RouteDefinition route = context.getRouteDefinition("advice");

route.adviceWith(context, new AdviceWithRouteBuilder() {
    @Override
    public void configure() throws Exception {
        mockEndpointsAndSkip(<pattern>);
    }
});
```

**Further Reading**
For more information on the mock component, see http://camel.apache.org/mock.html

## ABOUT THE AUTHOR

Based in Phoenix, AZ, I'm a Senior Consultant and Architect at Red Hat and I specialize in messaging-based enterprise integrations. I'm passionate about software development, love solving tough technical problems, and enjoy learning new languages and programing paradigms. Favorite languages include Python and Scala, but spend a lot of time writing Java. I am a committer on Apache ActiveMQ and Apache Apollo projects and frequently blog at http://www.christianposta.com/blog as well as tweet about interesting technology @christianposta.

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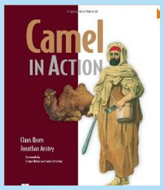

DZone, Inc.
150 Preston Executive Dr.
Suite 201
Cary, NC 27513

888.678.0399
919.678.0300

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