• Common middleware services, such as databases, message-oriented middleware, and web servers

• Popular enterprise information systems, such as SAP/R3 and SalesForce

• Popular web sites and services, such as Amazon and Twitter • Apache Karaf, an OSGi container

• JBoss Enterprise Application Platform (EAP), a certified Enterprise Java (Java EE) application server

• Spring Boot, a popular framework for developing microservices

INTRODUCING APACHE CAMEL

The core component that enables agile integration in Red Hat Fuse is *Apache Camel*, an open source library that implements enterprise integration patterns (EIP).
Enterprise Integration Patterns (EIP) are proven solutions to recurring integration problems. EIPs describe design considerations and common issues, and are brought to life using messaging technologies. EIPs establish a technology-independent vocabulary and a visual notation to design and document integration solutions.
Besides ready-to-use implementations of most EIPs, the Apache Camel community provides connectors to:
Apache Camel also provides facilities for data transformation, supporting popular data formats such as XML, JSON, CSV, and HL7.
While Camel provides a lot of the heavy lifting with respect to integration development, Red Hat Fuse provides the reliability, performance, scalability, security, and high availability for integration solutions. Further, Red Hat Fuse subscriptions provides a certified set of Camel libraries and components, together with enterprise-level support with strict service-level agreements.

INTRODUCING RED HAT FUSE DISTRIBUTIONS AND RUNTIMES

Red Hat Fuse is provided in the form of three different distributions:

Fuse Standalone

This is the traditional distribution of Fuse that supports any operating system with a certified Java Virtual Machine.
This distribution is supported on the following application containers or runtimes:

- Apache Karaf, an OSGi container
- JBoss Enterprise Application Platform (EAP), a certified Enterprise Java (Java EE) application server
- Spring Boot, a popular framework for developing microservices

Fuse on OpenShift

This distribution supports deploying integration applications as containerized applications on OpenShift, which is Red Hat's enterprise distribution of Kubernetes.
All three runtimes supported for Fuse Standalone are supported by Fuse on OpenShift, providing a migration path from legacy deployments to containerized deployments.

Red Hat Fuse 7 provides a unified technology stack for all supported runtimes, which is built upon the following components:
• Apache Camel: Enterprise Integration Patterns (EIP)

• Apache CXF: SOAP-based Web Services

• AMQ clients: connect with an external AMQ broker

• Naranaya: distributed transaction manager

• Undertow: lightweight and high-performance web container based on asynchronous I/O

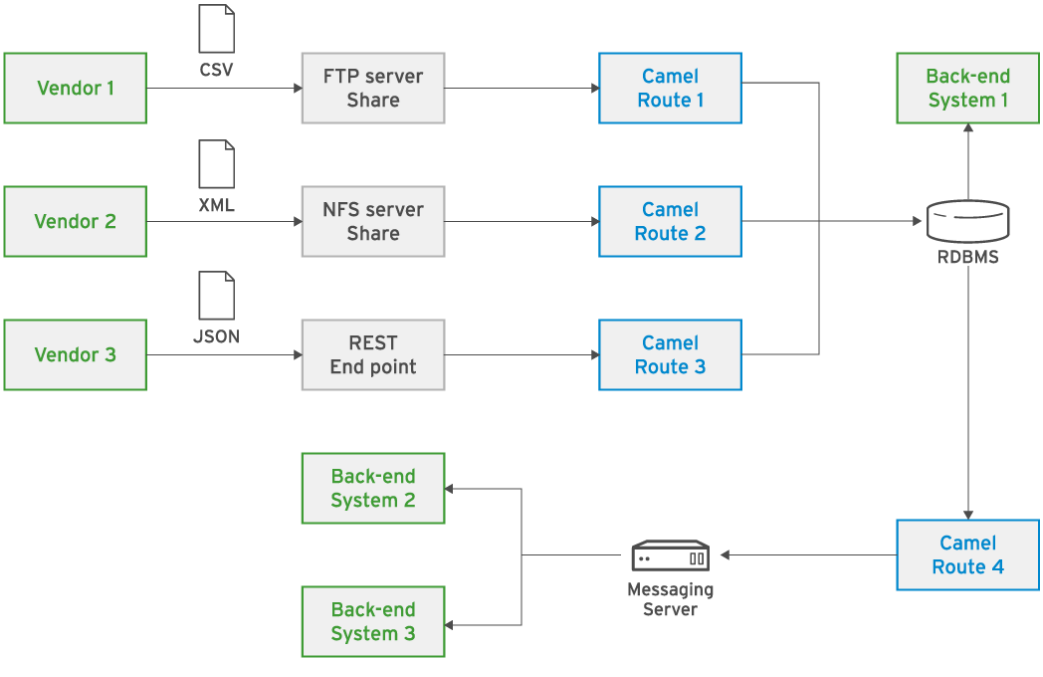
A Red Hat Fuse 7 subscription includes entitlements to two other Red Hat Middleware products:
• JBoss Enterprise Application Platform (EAP)

• Red Hat AMQ, a messaging server

To use Red Hat Fuse on OpenShift, you must have a subscription to Red Hat OpenShift Container Platform or any other edition of OpenShift, such as OpenShift.io.

SOLVING INTEGRATION PROBLEMS USING FUSE

To illustrate how Fuse and Camel helps solve integration problems, consider a typical order management system:
The system includes a number of endpoints and some business and integration logic. Vendors from traditional stores use legacy, scheduled *extract transform load* (ETL) processes to place orders.
These ETL processes drop files containing many orders per file on the file system to be processed later and saved into a *relational database management system* (RDBMS). Data from the RDBMS is in turn used to process order fulfilment and other internal business processes.
Different vendors generate orders using different formats, which require specific ETL processes for each, so they comply to the RDBMS database schema. For example, one vendor sends orders in a CVS format, produced by a mainframe application, while other vendor sends orders using a XML format produced by an *Enterprise Resource Planning* (ERP) package.
Vendors that use newer web-based storefronts place orders in real time using a REST API supported by an off-the-shelf online shopping application.
Further, these orders trigger events within your system, which starts back-end processes, such as payment confirmation and shipping of products, over a messaging middleware using *Java Message Service* (JMS).
Each new vendor requires a different set of data transformations and may use a different networking protocol. In the past, updating an integration application to support a new vendor was a time-consuming process that impacted the business ability to make new partnerships and lead to lost opportunities. Red Hat Fuse allows implementing integration services that are stateless,
fault-tolerant, and largely reusable. A new integration application can be quickly added to match a new vendor requirement, without impacting the integration applications already deployed to serve current vendors.
The following figure shows a high-level overview of the set of integration applications used to address the order management system:



• Receive data from FTP servers and file systems, transform, and save to the RDBMS

• Receive data from REST endpoints, transform the data, and then saves it to the RDBMS

• Watches for new records on the RDBMS and dispatch notification to the back-end systems

A developer designs and implements an integration application as a set of Camel *routes* that:
A developer builds Camel routes by connecting components that receive, marshal, transform, and send data.
Different components deal with different data sources (file systems, RDBMS), data formats (CSV, XML, JSON), and data sinks (RDBMS, JMS).
These routes could all be deployed as a single application or multiple applications on the same Fuse runtime, or they could be deployed as independent services over different Fuse runtimes. Depending on the deployment architecture,

you can view the set of Camel routes as a single integration application or as a loosely coupled set of integration applications.

PROBLEMS SOLVED BY ENTERPRISE INTEGRATION PATTERNS AND CAMEL

While every software application is distinct and unique, many technical problems are similar or common among all applications. To avoid such pitfalls and to approach application design in
a reliable way, software developers use *design patterns*. Java developers are used to design patterns, such as Singleton and Factory, that solve technical problems and provide a common vocabulary to describe solutions and their applicability.
Organizations deal with integration problems involving enterprise software by leveraging *Enterprise Integration Patterns*. In 2003, Hohpe and Woolf published the book *Enterprise Integration Patterns* (EIP) describing 65 separate patterns that represent common approaches for designing integration solutions. These EIPs provide the framework and inspiration for Apache Camel's approach to integration.
In their book, Hohpe and Woolf describe EIPs using the concept of *messaging*. Messaging in the context of EIPs and Camel is distinct from *message-oriented middleware* (MOM), such as Red Hat AMQ and *Java Message Service* (JMS) from *Java Enterprise Edition* (Java EE). Messaging in EIPs is a high-level concept that describes information flow from one system to another managed by EIPs.
Traditional integration applications approach integration by implementing XML-based *Simple Object Access Protocol* (SOAP) web services. The contemporary approach to application integration leverages messaging and EIPs using JSON-based *representation state transfer* (REST) HTTP APIs. Camel is able to use JMS, REST, and other messaging technologies with its implementation of EIPs.

DESCRIBING ENTERPRISE INTEGRATION PATTERNS

The following is a review of some of the Enterprise Integration Patterns (EIPs) used in this course. This is not an exhaustive list of all EIPs that Camel provides, rather this list illustrates some of the most common EIPs.

Splitter

This pattern separates a list or collection of items in a message payload into individual messages. This can be used when you need to process smaller, rather than larger, bulk messages.

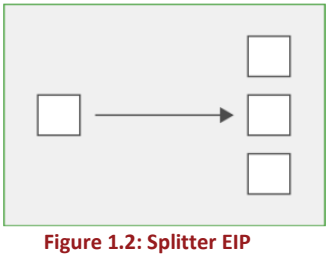


Figure 1.2: Splitter EIP

A benefit of the Splitter EIP is that when a message is split into chunks that can be processed independently of each other, an error within the split message does not cause all message processing to stop. A single split message can be retried, or an error response can be sent back to originating system while remaining messages are processed despite the error. Further, a
Splitter is useful for consuming messages in parallel, as discussed in detail in a later chapter about Concurrency.
An example of a Splitter EIP in action is an online order system that sends orders in batches.
The Splitter EIP is used to split individual orders from a single large batch message. With the messages split, each order is checked out from inventory. With an additional Splitter, each item in an order is individually validated to ensure that the item is in stock. Because of the Splitter, all of this processing occurs in parallel and simplifies the business logic by allowing each system to work with smaller messages.

Message Channel

The Message Channel pattern represents point-to-point communication between two applications or systems, with the additional benefits of providing asynchronous communication and decoupled endpoints using a messaging system.

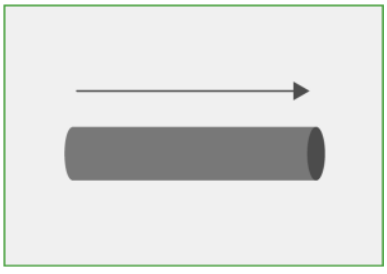


Figure 1.3: Message Channel EIP

Asynchronous and decoupled communication is typically implemented with the help of a message-oriented middleware, such as Red Hat AMQ, allowing an application to provide quick responses and continue servicing requests when there is a failure in some dependent system.

A message channel is a common pattern to use in e-commerce applications, such as an online store. When a user checks out the shopping cart, there is no need to wait for payment confirmation, checking inventory levels, and shipping. All these processes can work independently of each other, using message channels. Checking out the shopping cart puts a message in a channel, where it waits for the payment process. Then the payment process puts a message in another channel, where it waits for the inventory process. If a payment processor is unavailable, this does not prevent processing orders that require a different payment processor. Orders that require the unavailable payment processor keep waiting in a queue until that payment processor is available again.

Normalizer

This pattern processes messages from systems using different formats and converts the into a common format.

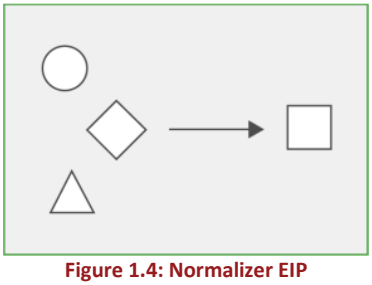


Figure 1.4: Normalizer EIP

For example, normalizer is useful for a company consumes orders from multiple vendors. Some vendors might use legacy mainframe systems and submit orders as CSV files. Other vendors use *enterprise resource planning (ERP)* systems that submit orders as XML files. And many vendors are switching to newer REST-based systems that submit orders as JSON files.

A normalizer converts all of these orders to the data format expected by the company's internal order processing system. A benefit of this approach is that the enterprise does not need to change their business logic as they expand to include new vendors that send orders in a specific format.
Rather, they only need to update their integration solution to support additional formats.

Transactional Client

A Transactional Client calls to another system to ensure delivery and ensure data integrity during the transaction.

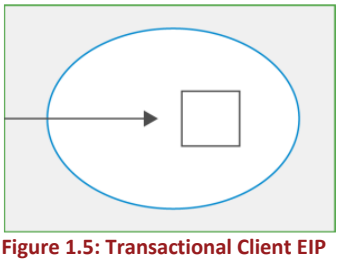


Figure 1.5: Transactional Client EIP

Many developers are familiar with the concept of a *transaction*, or *single unit of work*, from relational databases. However, transactions also apply to non-relational databases and messaging systems.

Consider a process that reads data from a message queue and saves the data to a database. One concern in this approach is that if the process reads the message from the queue, but the database writes fail, the message is lost because it is no longer available in the queue. To solve this, you want the message to remain in the queue in the event of a database write failure, so it can be read again later. Further, you want to ensure that if the write is successful to the database, that the message is removed from the queue.

Wrapping these three operations (reading a message from a queue, writing to a database, and removing a message from a queue) into a single transaction guarantee that either all operations succeed, or the system rolls back the entire operation to maintain data integrity.

Messaging Gateway

The Messaging Gateway pattern delegates the responsibility of messaging to a dedicated messaging layer so that business applications do not need to contain additional logic specific to messaging. The dedicated messaging layer becomes the source or destination of messages from EIPs.

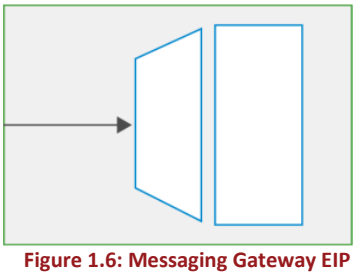


Figure 1.6: Messaging Gateway EIP

For example, a web server that throttles traffic and authenticates clients as they submit HTTP requests destined to business applications without regard for the request contents is an example of a messaging gateway. The gateway is able to process each request before passing the message to the business application without the business application needing to contain the added complexity of messaging protocols and logic.

This kind of functionality is the motivation for many *API Gateway* products in the market, such as Red Hat 3Scale. Red Hat Fuse provides an easy way to implement simple internal API gateways by combining EIPs, while Red Hat 3Scale provides built-in features, such as metering and billing, that simplifies implementing an API gateway for external users. These two products can be combined for more complex gateway scenarios.

Content Based Router

A Content Based Router pattern routes messages to an endpoint dynamically based on the content of the message's body or header.

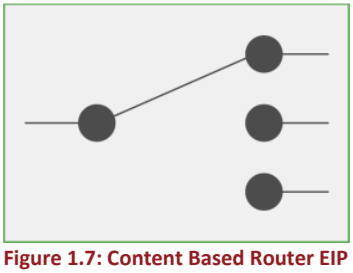


Figure 1.7: Content Based Router EIP

This pattern is useful in the following scenario: an online store, which used to sell only products from its own inventory, starts a partnership with local business to sell their items. Some orders are to be processed by the internal order processing system, but others need to be sent to external systems for fulfillment.

A content-based router would look at the products included in each order. If these products come from the store's own inventory, they are sent to the internal order fulfillment system. If the products come from the external vendor, they are sent to the external vendor system.

Aggregator

The Aggregator pattern collapses multiple messages into a single message. This is helpful to aggregate many business processes into a single event message to be delivered to another client or to re-join a list of messages which were previously split using the Split pattern.

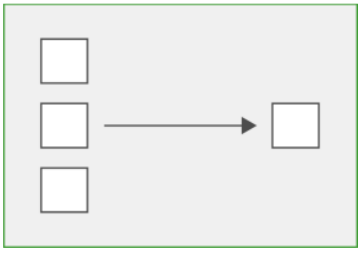


Figure 1.8: Aggregator EIP

The aggregator pattern makes efficient use of information systems that perform better when they process data in batches instead of as individual messages.

Consider a checking account system that processes transfers from other banks to customers' checking accounts. Because communication happens over slow WAN links, and there is no requirement that the funds transfer occur in real time, the checking accounts systems use an aggregator to batch transfer messages that send funds to the same bank. If a transfer operation is made to wait for too long, it is sent alone in a batch containing a single message.

COMPOSING MULTIPLE EIPS INTO A CAMEL INTEGRATION APPLICATION

A typical integration application relies on more than just a single EIP. One of the challenges of being a good Camel developer is understanding which patterns to use to provide the most reliable and efficient integration system.

Consider the example of an online web store that sells goods from external vendors. The same order could contain items from different vendors. A Splitter EIP generates multiple smaller orders, each one destined to a single vendor, and a Content Based Router EIP submits the individual smaller orders to the correct vendor.

A Camel route composes multiple EIPs into a pipeline that has a message source and one or more message destinations.

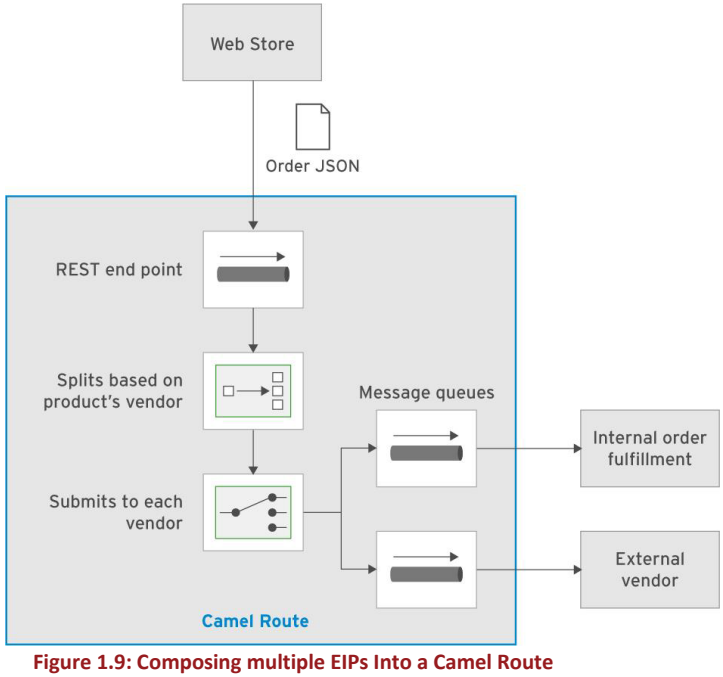


Figure 1.9: Composing multiple EIPs Into a Camel Route

A Camel route in the online web store example receives messages from a REST API end point, passes each message though a Splitter, then to a Content Router, which in turn submits each message to a Message Channel specific to each external vendor.

DESCRIBING CAMEL CONCEPTS

DESCRIBING THE CAMEL ARCHITECTURE

Apache Camel is a Java library that implements Enterprise Integration Patterns (EIPs) and provides a solid foundation to develop integration systems for both legacy and new applications. Apache Camel works with different messaging systems, ranging from older mainframe-based applications, passing through the WS-* standards world, to the new HTTP API-based style of development. Camel also works with message-oriented middleware (MOM) that can be accessed using the Java Message Service (JMS) API, such as Red Hat AMQ.

Not all inputs and outputs to a Camel route need to come from an actual messaging system. Apache Camel can also process data from file systems, FTP servers, databases, and other data stores. Camel encapsulates data originating from these data stores as messages, so these data stores can act as source or destination of messages in an integration application.

Camel's architecture is based on a small number of Java classes and interfaces: CamelContext, Route, Endpoint, Component, Exchange, Message, Processor and Predicate.
The following section discusses concepts related to these classes and interfaces at a very high level, not the syntax around them. All these concepts are revisited during this course, along with coding examples.

Context, Routes, and Components

Integration applications based on Camel define a context that aggregates one or more routes and zero or more components.

A context provides the environment where running routes and components run. Apache Camel provides integration with many application frameworks and runtimes so most developers do not need to know how to initialize and start a Camel context.

A route describes an integration scenario, where a message flows from a source to one or more destination endpoints and may be transformed along the way. An endpoint is a name, usually using URI syntax, to a specific source or destination for messages.

A component provides configuration for endpoints and encapsulates the logic required to work with different sources or destinations of messages, such as FTP servers, JMS Queues, or relational databases. Multiple endpoints can reuse the same component, and multiple instances of the same component can be defined in the same context.

For example, many endpoints can use the File component, which accesses files from the local file system. Each endpoint can specify a different file system folder. Another example is the JDBC component, which can access a relational database. Multiple instances of the JDBC component can connect to different database servers using different datasources.

A context only needs to describe components that require additional, explicit configuration, such as a database server, which requires at least a server address and login credentials. Many components take all the configuration they need from an endpoint URI, such as the path for a file system folder.

Camel routes are defined using *Domain Specific Language* (DSL). The Apache Camel project provides a number of DSLs optimized for programming languages, such as Scala and Groovy. Red Hat Fuse provides production support for the following two DSLs:

Java DSL

Uses a fluent style of concatenated method calls to define routes and components. A route contains no procedural code, therefore if you need to embed complex conditional or transformation logic inside a route, you can invoke a Java Bean.

XML DSL

Uses XML elements inside a Spring bean or an OSGi Blueprint configuration file to define routes and components. Though the XML DSL is not as complete or as flexible as the Java DSL, the XML DSL does allow non-developers to create routes using a graphical tool if desired.

These two DSLs can be mixed: the same integration application can define some routes using the Java DSL, and others using the XML DSL. Components configured using the XML DSL can be used in routes defined using the Java DSL, and vice versa.

Exchanges, Messages, and Endpoints

A route connects at least two endpoints: a *consumer* and one or more *producers*. A consumer defines the origin of messages the route receives, and a producer defines a destination for messages that the route sends.
These terms can be counter-intuitive for users accustomed to messaging systems. To avoid confusion, remember they follow the point of view of the route: a route consumes messages that it receives from an endpoint, and produces messages that it sends to another endpoint.
A consumer provides a route with an *exchange*, which flows through the route until it reaches a producer. An exchange contains one *inbound* and optionally one *outbound* message. Notice that these are not input and output messages. They are request and response messages. The inbound and outbound denotation is relative to the consumer endpoint's point of view.
Depending on the component type of an endpoint, the Camel route may not produce an outbound message, that is, a response to the consumer. The message a route sends to a producer is always the inbound message of the exchange.

Processors, Predicates and Expressions

Between the consumer and producer endpoints, a number of *processors* can manipulate the exchange contents. Processors implement most of the EIPs provided by Camel. Most processors manipulate only the inbound message, as this is the message the route sends to a producer. An example processor takes a message in XML format and transforms it into a different XML format using a XSLT transformation.

Many processors make use of *predicates* and *expressions*. Predicates allow you to create conditions based on a message's body, headers, and properties. Expressions extract data from a message. Camel supports a number of expression languages, such as XPath, JSONpath, and *MVEL.*

MVEL is very similar to the Java EE *expression language* (EL) used by *Java Server Pages* (JSP) and the *Java Server Faces* (JSF) framework and provides a simple way to access properties of Java Beans.
Predicates allow a developer to define conditions, such as a message that does not have an empty body, or a message that contains a given header. Expressions are more flexible, but the expression language must match the data format of a message. For example, MVEL only works for messages that contain Java Beans, and XPath only works for XML data.

Extending and Supporting Camel

You can implement custom components, processors, and predicates to encapsulate complex logic and use them inside a route. With this functionality you can extend Camel's feature set to meet almost any requirement, adding new integration patterns and connectors to new message sources or destinations.
These custom components, processors, and predicates can be glued to routes using many approaches, for example a dependency injection framework, such as the Spring framework or Context and Dependency Injection (CDI) from Java EE.
Camel itself is agnostic to any application framework or runtime. Be aware that the Apache Camel community may provide a number of integrations with programming languages, frameworks, and information systems that are not mature enough for production usage. This is one reason why Red Hat Fuse does not include or support all of Apache Camel, but only a large subset of the components.
The parts of Camel that are included in the Red Hat Fuse product receive full production support from Red Hat. Subscription users can open support tickets and rely on Red Hat to provide a solution according to the user's service-level agreement.
Be careful to not abuse Camel's power: Camel's features are sufficient to implement many application scenarios, and you may end up implementing business logic inside a Camel route. Remember that Camel's goal is not to replace existing applications, nor to implement new applications. Camel's goal is to integrate existing and new applications, moving data between them in an easy and flexible way.

CHAPTER 2: CREATING ROUTES

READING AND WRITING FILES

CAMEL ROUTES

In Camel, a *route* describes the path of a message from one *endpoint* (the origin) to another endpoint (the destination). Routes are a critical aspect of Camel because they define integration between endpoints. With the help of components, Routes are able to move, transform, and split messages. Traditionally, integration implementation requires lots of complicated and unnecessary coding. With Camel, routes are defined in a few simple, human-readable lines of code in either Java DSL or Java XML.
A route starts with a *consumer*, which receives the data from a point of origin. The term "consumer" is slightly counter-intuitive because it is often used to refer to the destination of a message. With Camel, consider that the consumer is referring to where and how the initial message is being picked up. The origin endpoint is any Camel component, such as a location on the file system, a JMS queue, or even a tweet from Twitter. The route then directs the message to the *producer*, which sends data to a similarly configured destination. By abstracting the integration code, developers are able to implement EIPs that manipulate or transform the data within the Camel route without requiring changes to either the origin or the destination.

Figure 2.1: Route Example

In this example, a consumer receives a CSV file from a file server. The file server is the origin while the CSV file is the message. The route transforms the data into the JSON format, and the producer routes the JSON to a web system through an HTTP request.

CamelContext

To implement a Camel route, the route must be attached to a **`CamelContext`** instance. The **`CamelContext`** loads all resources like components, endpoints, and converters in the runtime system to execute the routes.
A common way to instantiate a **`CamelContext`** and attach routes to it is by using the Spring Framework. Camel provides integration with this framework, including an XML configuration dialect to use inside Spring beans configuration files.
Alternatively, you can instantiate a new **`CamelContext`** using the Java language:

```
DefaultCamelContext camelContext = new DefaultCamelContext(registry);
camelContext.setName("camelContext");
camelContext.addRoutes(new FileRouter()); camelContext.start();
```

The Camel-specific configuration inside a Spring beans configuration uses the XML DSL. A Spring beans configuration can also refer to routes defined using the Java DSL by declaring **`RouteBuilder`** objects as Spring beans.

JAVA DSL

In Java DSL routes in Camel are created by extending the **`org.apache.camel.builder.RouteBuilder`** class and overriding the **`configure`** method. A route is composed of two endpoints: a consumer and a producer. In Java DSL, this is represented by the **`from`** method for the consumer and the **`to`** method for the producer. Inside the overridden **`configure`** method, use the **`from`** and **`to`** methods to define the route.

```
public class FileRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {
from("file:orders/incoming")
.to("file:orders/outgoing");
}
}
```

In this example, the consumer uses the **`file`** component to read all files from the **`orders/ incoming`** path and the producer uses the **`file`** component to move to the **`orders/outgoing`** path.
Inside a **`RouteBuilder`** class, each route can be uniquely identified using a **`routeId`** method. Naming a route makes it easy to verify route execution in the logs, and also simplifies the process of creating unit tests. Multiple routes can be created by calling the **`from`** method many times.

```
public void configure() throws
Exception {
from("file:orders/incoming")
.routeId("route1")
.to("file:orders/outgoing");

from("file:orders/new")
.routeId("routefinancial")
.to("file:orders/financial");
}
```

Each component can specify configuration attributes. You can add attributes by appending a **?** after the origin or destination. Refer to the Camel documentation for component-specific attributes.

```
public void configure() throws Exception {

from("file:orders/incoming?include=order.*xml")
.to("file:orders/outgoing/?fileExist=Fail");

}
```

The route consumes only files with a name starting with "order", and it is an XML file.
Throws an exception if a given file already exists.

To enable a route, you need to register it as a Spring bean inside a Spring beans configuration file:

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.springframework.org/schema/beans
http://www.springframework.org/schema/beans/spring-beans.xsd
http://camel.apache.org/schema/spring
http://camel.apache.org/schema/spring/camel-spring.xsd">

<bean class="com.redhat.training.jb421.FileRouteBuilder"
id="fileRouteBuilder"/>

<camelContext id="jb421Context" xmlns="http://camel.apache.org/schema/spring">
<routeBuilder ref="fileRouteBuilder"/>

</camelContext>
```

Creates a new Spring bean.
Enables the route in the **`CamelContext`**.

XML DSL

Method names from the Java DSL map directly to XML elements in the Spring DSL in most cases. However, due to syntax differences between Java and XML, sometimes the name and the structure of elements are different in Spring DSL. Refer to Camel documentation for the correct structure of the route methods.

To use the Spring DSL, declare a **`camelContext`** element, using the custom Camel Spring namespace, inside a Spring beans configuration file. Inside the **`camelContext`** element, declare one or more **`route`** elements starting with a **`from`** element and usually ending with a **`to`** element. These **`from`** and **`to`** elements are similar to the Java DSL **`from`** and **`to`** methods.

LAB:

READING MESSAGES FROM AN FTP SERVER

MESSAGE EXCHANGE PATTERNS

The message exchange pattern describes the behavior of the communication between the producer and the consumer. Two of the primary message exchange patterns are:

Synchronous (InOut)

Consumer sends the request and consumer waits for a response.

Asynchronous (InOnly)

Consumer sends the request and does not wait for a response.

To support these patterns, Camel uses an *exchange* object. The exchange object encapsulates a received message, known as **`inMessage`**, and stores its metadata. When using the **`InOut`** pattern, the exchange also encapsulates a reply message, also known as the **`outMessage`**.

Camel supports several message exchange patterns, including **`InOnly`** and **`InOut`**. These patterns serve different purposes, and one may be more appropriate than the other, depending on the functionality of your route.
By default, many Camel components, such as jms, file, or ftp, use **`InOnly`** exchanges unless otherwise specified. However, this can vary from one component to another, so you should check the documentation for the components you are using in your route for their default exchange pattern.

THE `InOnly` EXCHANGE PATTERN

Messages in routes that use the **`InOnly`** pattern are sometimes referred to as event messages. These messages are a one-way communication and, as such, only the **`inMessage`** will ever have a value on the message exchange. The **`InOnly`** pattern is appropriate to use when the producer in your route does not need any reply information from the route consumer.
For example, a route consumes an order file from an FTP server and produces a message to the financial system. The consumer does not need to wait for a reply from the producer.

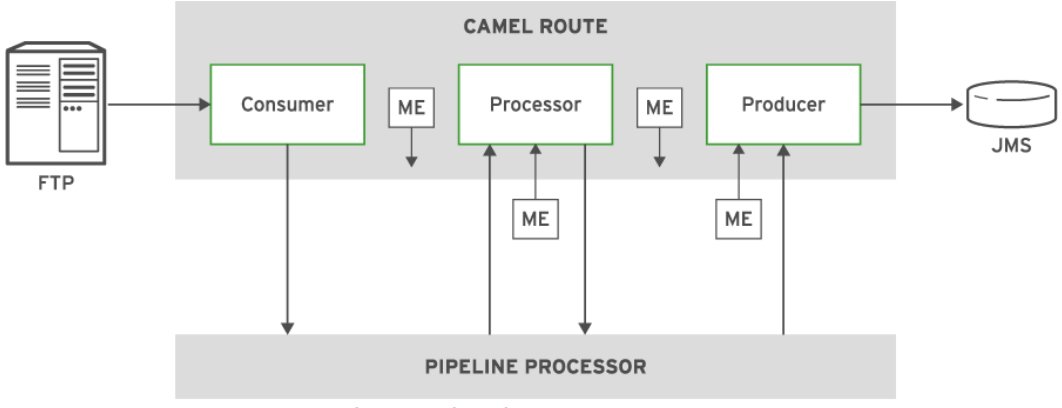


Figure 2.2: Camel route and pipeline processor

To access the **`inMessage`** object on the Camel exchange at runtime, use the **`getIn`** method provided by the **`Exchange`** interface as shown below:

```
Message inMessage = exchange.getIn();
```

You should access the **`inMessage`** object of the exchange object when you want to manipulate the original message, such as adding new headers or changing the original content.

THE `InOut` EXCHANGE PATTERN

Messages in routes using the **`InOut`** pattern are referred to as *request-reply* messages. The **`InOut`** pattern is used when a route's consumer requires a response from the producer before proceeding. This can be useful to report the results of some action that the route has taken, or to make a callback when the route is complete.

For example, the route consumes an order request from a client. The producer sends a message to the bank system to approve the transaction, and needs to wait for a reply message with the transaction status. If the transaction is approved, the route needs to produce a new message to the shipment route. If not, the route needs to produce a new message that sends an email to the client asking for a new payment transaction.

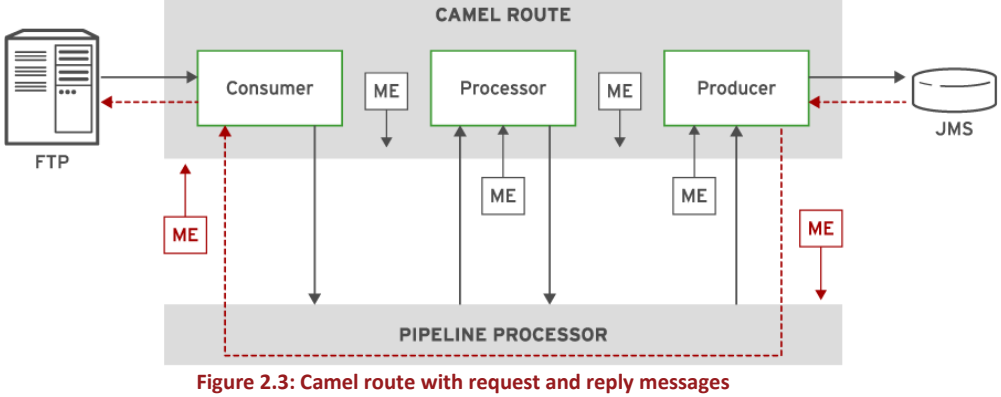


Figure 2.3: Camel route with request and reply messages

To access the **`outMessage`** object on the Camel exchange at runtime, use the **`getOut`** method provided by the **`Exchange`** interface as listed:

```
Message outMessage = exchange.getOut();
```

You should access the **`outMessage`** of the exchange object when you want to manipulate the reply message.

MESSAGES IN CAMEL

A message is a uniquely identified data structure for storing data from a producer to a consumer. The following are the primary components of messages:

Headers

The message header contains metadata such as information about the sender of the message and security details in a **`java.util.Map`** collection. Use the **`setHeader`** method to add a new header.
Placing custom metadata in a message header is a useful approach for dynamically routing messages or providing additional ways to categorize messages.

Attachments

Contain file-based contents to be transmitted to a receiver. For example, you can attach an image in the email component.

Body

The message body contains the data to be processed by the receiver or manipulated by Camel processors. This is usually JSON or XML data, but can be an **`Object`** of any type.

Fault flag

The fault flag is a property that developers can use to identify whether the message contained an error during processing.

ACCESSING COMPONENT AND EIP DOCUMENTATION

Extensive documentation for all Camel components and EIPs are available directly from `camel.apache.org`. Red Hat also maintains documentation for all supported Camel components and EIPs, which can be found in the Red Hat Fuse documentation at `https:// access.redhat.com/documentation/en-us/red_hat_fuse/7.1/`.

While some of information available from these two sources is mostly identical, be aware that:
• The Camel community documentation may contain changes that have not yet been incorporated by the Red Hat Fuse product.

• Some Camel components may not be included as part of the Red Hat Fuse product. They can be added by the developer, but its use is not supported by Red Hat. This might be an important consideration for production environments.

• The Camel community documentation does not contain details about packaging and deploying to the supported Apache Karaf, JBoss EAP, and Spring Boot containers. These containers are discussed in more detail in a later chapter in this course.

The component documentation provides useful information about component syntax and attributes. When reviewing the documentation for components, carefully observe the following information:

URI format

A component URI format specifies the format required when defining an endpoint. This typically involves a specific scheme to the URI such as `ftp:` or `file:` as well as other required and optional values to be included in the URI to control component behavior. The URI always begins with the name of the Camel component. For example, the ftp component URI format:

```
ftp://[username@]hostname[:port]/foldername[?options]
```

For the FTP component, **`hostname`** is a required options, but the **`username`** and **`port`** are optional.

URI options

The URI options are where most of the specific configuration parameters for a component are defined. These often have default values, so be sure to review the expected component behaviour.

Message Headers

Camel components frequently provide special headers that are automatically populated when that component is used. For example, in the ftp component, you have a message header containing the original file name.

Required Dependencies

Most components are not included in **`camel-core`**. This section of the documentation informs you about required dependencies for those components that need to be added to the **`pom.xml`** file.

LOGGING IN CAMEL

Camel provides two logging features: the *log component*, and the *log EIP*.

The log component is used as a producer endpoint to output log events using SLF4J logging. Logging is a important feature to debug and collect information about routes. Output is delegated to the first logging API available in the class path. For example, the Apache log4J or **`java.util.logging`** API is used, based on which API is available first in the class path.
The log component URI format is:

```
log:loggingCategory[?options]
```

For the log component, the **`loggingCategory`** option is the name of the logging category to use. Usually, this is the Java package name.
The following are examples of using the **`log`** component:

• Set the logging name and level explicitly:

```
from("activemq:input")
.to("log:com.foo?level=DEBUG")
.to("activemq:output");
```

• Format the output of the information from the exchange:

```
from("activemq:input")
.to("log:com.foo?showAll=true&multiline=true&level=DEBUG")
.to("activemq:output");
```

The log EIP, provided by the **`log`** DSL method, is another way to add logging to a Camel route. You should use the log EIP when you want to log custom messages. It also uses the SLF4J logging facade and messages are formatted using the *Simple expression language* (Simple EL), covered in detail later in this section.
Some examples of using the **`log`** DSL method are:
• Set the logging name and level explicitly using the Java DSL

```
from("activemq:input")
.log(LoggingLevel.DEBUG, "com.foo", "Got a message")
.to("activemq:output");
```

• Set the logging name using the XML DSL:

```
<from uri="activemq:input"/>
<log loggingLevel="DEBUG" loggerRef="com.foo" message="Got a message"/>
<to uri="activemq:output"/>
```

USING SIMPLE EXPRESSION LANGUAGE

Log, filter, and other EIPs can use the Camel Simple EL to get the current exchange attributes (body, headers, properties) from a message. For example:

```
from("file:in")
.log("message body:${body}")
.to("file:out")
```

Simple expressions are delimited by a dollar sign followed by braces: **`${..}`**. It is similar to the Java Server Pages (JSP) EL. Objects such as the route parent Camel context, the current exchange, the input and output messages, among other convenience objects, have names predefined by Camel. Refer to Camel Simple EL documentation for a list of all available variables.
You can use Simple EL to specify dynamic URI options for your endpoints, which refer to specific data from the exchange. For example, using the **`CamelFileHost`** header in the file name option of the file component in the following XML DSL:

```
<to uri="file:orders?fileExist=Append&amp;fileName=${header.CamelFileHost}"/>
```

RUNNING CAMEL USING MAVEN

Camel provides a plug-in for Maven to initialize the **`CamelContext`** object using the Camel Spring integration libraries. This is beneficial because you can easily test your routes without having to initialize the **`CamelContext`** in a **`main`** method.
Using the Camel Maven plug-in, the application can be started using the Maven goal **`camel:run`** that starts an instance of **`CamelContext`** inside Maven in a separate thread.
Any Camel project using Maven can use this feature by adding the following to the **`pom.xml`** file:

• The Spring Framework integration dependency.
• The plug-in reference.

The Spring Framework integration dependency can be referenced using the following statement:

```
<dependency>
<groupId>org.apache.camel</groupId>
<artifactId>camel-spring</artifactId>
</dependency>
```

The Camel Maven plug-in is activated by adding the following to the POM:

```
<plugin>
<groupId>org.apache.camel</groupId>
<artifactId>camel-maven-plugin</artifactId>
</plugin>
```

MESSAGE EXCHANGES IN CAMEL

Camel uses exchange objects to store messages processed through Camel routes. Camel exchanges also store routing information and properties. Exchange objects are composed of the following:

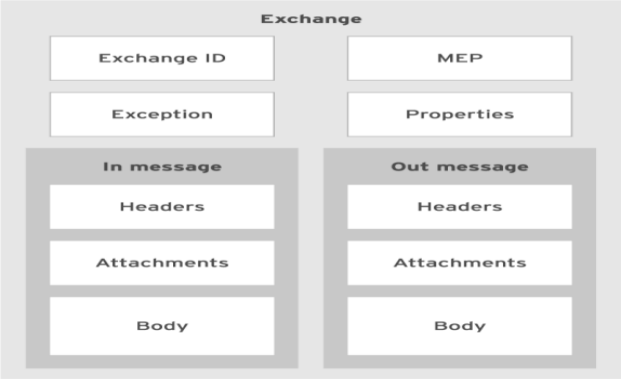
• *Exchange ID*: A unique identifier generated by Camel. • *Message Exchange Pattern (MEP)*: Describes how messages are exchanged from a sender to a receiver. The pattern can be an **`InOnly`** request (contains only one message) or an **`InOut`** request (containing two messages, one from the sender and another from the receiver).

• *Exception*: Stores any errors generated during the exchange processing.

• *Properties*: Stores metadata from the exchange processing, such as processing status. The route code can use properties to safely store information not meant to be processed by endpoints.

• *In message*: The request sent by the sender.

• *Out message*: The answer sent by the receiver.



FILTERING MESSAGES

INTRODUCING CAMELCONTEXT

The **`CamelContext`** class is the Camel runtime environment that provides important features, such as:
When using the **`camel:run`** Maven goal or a runtime environment with Camel support, such as Red Hat Fuse, the **`camelContext`** is automatically started.

• *Simple extension support*: Camel works with components that can be injected by using popular *inversion of control* (IoC) frameworks based on either XML configuration or annotations such as Spring and CDI. These frameworks allow developers to integrate various components in a loosely coupled type-safe manner. Additionally, by using these industry standard techniques, developers can leverage existing solutions in their Camel routes.

• *Life cycle*: A **`CamelContext`** instance must be started to make its routes available for execution. Sometimes the routes must be stopped for maintenance purposes, and they can be suspended and resumed. The **`CamelContext`** instances can also be stopped to shut down each route cleanly and avoid any processing problems.

• *Services*: Services can be added to the **`CamelContext`** that provide important features such as persistence, configuration, or integration with other frameworks.

The **`org.apache.camel.impl.DefaultCamelContext`** class is used to instantiate a **`CamelContext`** instance. However, the **`CamelContext`** instance needs to be started explicitly to enable processing the routes. You can start the **`CamelContext`** in the **`main`** method.

```
CamelContext context = new DefaultCamelContext();
context.start();
```

To shut down the context gracefully, invoke the **`stop`** method when the route execution is completed in the **`main`** method.

```
context.stop();
```

CREATING A ROUTEBUILDER TO BUILD ROUTES

Use the **`RouteBuilder`** abstract class provided by Camel API to develop routes. Because of the dynamic nature of routes, it has many methods that are often chained together. This results in a route that is easily read and understood by a human. In Java programming, this technique is known as a *fluent interface*; essentially creating a domain-specific language.
The fluent interface from the **`RouteBuilder`** class provides a clean and direct code to define routes and create helper objects used in your Camel routes, such as enterprise integration pattern implementations.
Normally, the starting point to create a route is to extend a **`RouteBuilder`** class and override the **`configure`** method, for example:

```
public class FileRouteBuilder extends RouteBuilder
{
@Override
public void configure() throws Exception {
...
}
}
```

Alternatively, a Spring beans configuration file can declare a route. To achieve this goal, a **`route`** element is declared, nested in the **`camelContext`** element. For example:

```
<camelContext id="demoContext" xmlns="http://camel.apache.org/schema/spring">
<route>
...
</route>
</camelContext>
```

Routes defined this way use the Camel XML domain specific language (DSL), also known as Spring DSL.

IMPORTANT
Multiple routes can be declared in the **`configure`** method of a **`RouteBuilder`** implementation.

A **`camelContext`** element can also contain references to routes defined using the Java DSL, by declaring the Java class as a Spring bean and referencing it inside the **`camelContext`** element:

```
<bean class="com.example.MyRouteBuilder" id="myRouteBuilder"/>

<camelContext id="demoContext" xmlns="http://camel.apache.org/schema/spring">

<routeBuilder ref="myRouteBuilder"/>

</camelContext>
```

You can use both XML DSL and Java DSL routes inside the same **`camelContext`** element.

DECLARING ENDPOINTS USING COMPONENTS

Data flows from a consumer to one or more producers in Camel. Each consumer or producer is an endpoint, which abstracts the end of a channel through which messages can be sent or received.

Declaring an endpoint is done using URI syntax:

<scheme>://<context/path>?<options>

For example, to connect to a file system, you must use the **`file`** component, which is associated with the **`file:`** URI prefix:

file://folder?fileExist=Append

Camel parses this URI string to instantiate an **`Endpoint`** and configure it according to the URI options. In the previous example, if the destination file already exists in the file system, it is not overwritten but appended. If multiple options are needed, the each one is separated by an ampersand (&).
A component is an endpoint factory and the main abstraction in Camel. A **`Component`** class is responsible for the following tasks:

- Connecting to the integration system
- Marshaling and unmarshaling data to Camel Message standards

Components may be explicitly configured and added to the **`CamelContext`**, injected by an IoC framework, or auto-discovered using URIs.

IMPLEMENTING THE FILTER EIP

Camel implements most of the enterprise integration patterns and provides them as methods in the **`RouteBuilder`** class or elements in the XML DSL.

Camel defines the message filter pattern to remove some messages during route execution based on the content of the Camel message.
To filter messages sent to a destination, use the following Java DSL:

```
from("<Endpoint URI>")
.filter(<filter>)
.to("<Endpoint URI>");
```

The filter must be a Camel *predicate*, which evaluates to either **`true`** or **`false`** based on the message content. The filter drops any messages that evaluate to **`false`** and the remainder of the route is not processed. Predicates can be created using expressions, which Camel evaluates at runtime.

Because of the number of data formats supported by integration systems, a set of technologies can be used to filter information. For example, in an XML-based message, XPath can be used to identify fields in an XML file.

To evaluate if a certain value is available at a specific XML element, use the following syntax:

```
filter(xpath("/body/title/text() = 'Hello World'"))
```

Likewise, the **`Simple`** expression language can be used to filter Java objects.

```
<scheme>://<context/path>?<options>
file://folder?fileExist=Append
from("<Endpoint URI>")
.filter(<filter>)
.to("<Endpoint URI>");

from("direct:a")
.filter(simple("${header.foo} == 'bar'"))
.to("direct:b")
.filter().xpath("/person[@name='James']")
.to("mock:result");
```

INTRODUCING EXPRESSIONS

Camel uses *expressions* to look for information inside messages. They support a large number of data formats, including Java-based data and common data format exchanges (XML, JSON, SQL, and so on).

An expression language used to identify Java objects is the Simple EL. It uses a syntax that resembles the Java Server Pages expression languages to search for attributes in an object. For example, in a class named **`Order`**, with an **`address`** attribute that contains a ZIP code, the Simple expression language to search for the zip code 33212 is:

${order.address.zipCode = '33212'}

IMPLEMENTING PREDICATES

Predicates in Camel are essentially expressions that must return a boolean value. This is often used to look for a certain value in an **`Exchange`** instance. Predicates can be leveraged by Camel in conjunction with expression languages to customize routes and filter data in a route. For example, to use the Simple expression language in a filter, the Simple expression must be called inside a route calling the **`simple`** method. Similarly, to use an XPath expression, there is a method named **`xpath`**.
The following XML is used as an example to explain the XPath syntax.

```
<order>
<orderId>100</orderId>
<shippingAddress>
<zipCode>22322</zipCode>
</shippingAddress>
</order>
```

To navigate in an XML file, XPath separates each element with a forward slash (/). Therefore, to get the text within the **`<orderId>`** element, use the following XPath expression:

/order/orderId/text()

To get the **`zipCode`** from the previous XML, use the following expression:

/order/orderId/shippingAddress/zipCode/text()

To get all XML contents where **`zipCode`** is *not* 23221, use the following expression:

/order/orderId/shippingAddress/[not(contains(zipCode,'23221'))]

To use the expression as a predicate in a Camel route, the **`xpath`** method parses the XPath expression and returns a boolean:

```
xpath("/order/orderId/shippingAddress/[not(contains(zipCode,'23221'))]")
```

ROUTING MESSAGES FROM JMS

THE CONTENT BASED ROUTER EIP IN CAMEL

The *Content Based Router (CBR)* EIP allows routing messages to the correct destination based on the message contents.
The Camel CBR implementation is similar to a programming language construct: the **`choice`** DSL element contains multiple **`when`** DSL elements and optionally an **`otherwise`** DSL element:

```
<route>
<from uri="schema:origin"/>
<choice>
        <when>
        <!-- predicate1 -->
        <to uri="schema:destination1"/>
        </when>
        <when>
        <!-- predicate2 -->
        <to uri="schema:destination2"/>
        </when>
        <!-- other when elements -->
        <otherwise>
        <!-- exception flow or destination -->
        </otherwise>
</choice>
</route>
```

Each **`when`** DSL element requires a predicate that, when true, triggers sending the message to its destination. If the predicate is false, the route flow moves to the next **`when`** element. The predicate can use Simple EL, XPath expressions, or any other expression language supported by Camel.
The **`otherwise`** DSL element allows having a destination for messages that fail to match any of the **`when`** predicates. The **`otherwise`** DSL element usually starts an exception flow.

CBR Using the Java DSL

The general Content Based Router (CBR) template using the Java DSL is:

```
from("schema:origin")
.choice()
.when(predicate1)
.to("schema:destination1")
.when(predicate2)
.to("schema:destination2")
...
.otherwise()
.to("schema:destinationN");
```

INTRODUCTION TO RED HAT AMQ 7

Red Hat AMQ 7 is a lightweight, flexible, and reliable messaging platform that simplifies both the integration of application components as well as workload scaling. Based on the upstream projects Apache ActiveMQ and Apache Qpid, Red Hat AMQ integrates enterprise applications by providing a standards-based platform for application components and subsystems to communicate in a loosely coupled manner regardless of language or platform.

The AMQ Broker is a Message Oriented Middleware (MOM) component based on the ActiveMQ Artemis messaging implementation that provides queuing, message persistence, and
manageability. The broker supports a variety of messaging styles such as point-to-point, publish- subscribe, store, and forward as well as multiple languages and platforms.

The main benefits of using a messaging system such as Red Hat AMQ include the fact that you can easily decouple the integrations between your systems such that their is little to no direct communication between programs. Additionally, messaging enables communications between systems to be asynchronous and event-driven. Messaging also supports additional features such as message priorities, message security, as well as data integrity and persistence.

Despite the similar characteristics this messaging system has with Camel, Camel provides more features, such as allowing integration with other components and using multiple enterprise integration patterns.

AMQ QUEUES WITH CAMEL

Using MOMs for integration purposes has been very common since the mainframe days because MOMs decouples applications from each other. The main MOM abstraction is the *queue*, which stores messages sent by a publisher until they are received by a consumer. The publisher and the consumer do not know about each other, and the publisher does not wait for a reply from the consumer. Guaranteeing message delivery is the MOM's responsibility.

The Java Message System API allows applications to connect to any MOM that provides a **`JMSConnectionFactory`**, in a similar way to connecting to relational databases using the JDBC API and a **`DataSource`**.

Camel provides a generic jms component and a specialized activemq component that share most implementation code and configuration options. Both use the JMS API to access the MOM.
The general URI syntax for the activemq component is as follows:

activemq:queue:*queue_name*

Using the Camel activemq component requires registering a **`JmsConfiguration`** with the Camel context. To do that using a Spring beans configuration file, declare an **`activemq`** bean with a **`configuration`** property.

```
<bean class="org.apache.activemq.camel.component.ActiveMQComponent" id="activemq">
       <property name="configuration" ref="jmsConfig"/>
</bean>
```

To create a **`JmsConfiguration`**, you need to register a JMS **`JMSConnectionFactory`** with the Camel context. To do that using a Spring beans configuration file, declare a **`jmsConfig`** bean with a **`connectionFactory`** property.

```
<bean class="org.apache.camel.component.jms.JmsConfiguration" id="jmsConfig">
       <property name="connectionFactory" ref="connectionFactory"/>
</bean>
```

To create a **`JMSConnectionFactory`**, you need to register a **`ActiveMQConnectionFactory`** with the Camel context. To do that using a Spring beans configuration file, declare a **`connectionFactory`** bean with a **`brokerURL`** property and a property to trust all packages.

The *activemq_server_uri* provides connection parameters and credentials to access an ActiveMQ broker.

```
<bean class="org.apache.activemq.spring.ActiveMQConnectionFactory" id="connectionFactory">
<property name="brokerURL" value="activemq_server_uri"/>
<property name="trustAllPackages" value="true"/>
</bean>
```

The *activemq_server_uri* provides connection parameters and credentials to access an ActiveMQ broker.

CAMEL MESSAGE REDELIVERY

Connecting to network resources such as MOMs, FTP servers, and other middleware, involves the risk of experiencing failures. Camel deals with this by using a *redelivery policy* component that
stores exchanges in memory and retries sending messages a number of times, usually with a delay between attempts. A redelivery policy can be attached to the entire Camel context or to a specific route, by means of an exception handling configuration, or a more powerful error handing configuration.
The Camel redelivery policy is independent of the route endpoints and can also handle transient errors from EIPs in the middle of a route.

CONFIGURING EXCHANGE HEADERS

THE DIRECT COMPONENT

The direct component connects a producer endpoint directly to a consumer endpoint in the same Camel context. This component is less of an integration feature and more of a way to break a route into small pieces. The direct component is intended to make it easier to handle large workflows in smaller chunks as well as reuse common routing logic for different consumers.

For example, you have multiple routes to consume data from many sources. All of them needs to convert the content in the JSON format and send to the database. Instead of replicating the code that converts and sends the content to the database for each route, you can create a route with the direct component that performs the conversion and sends the results to the database. Then, each route can produce a message to the new route using the direct component.

The direct URI syntax is:

```
direct:name[?options]
```

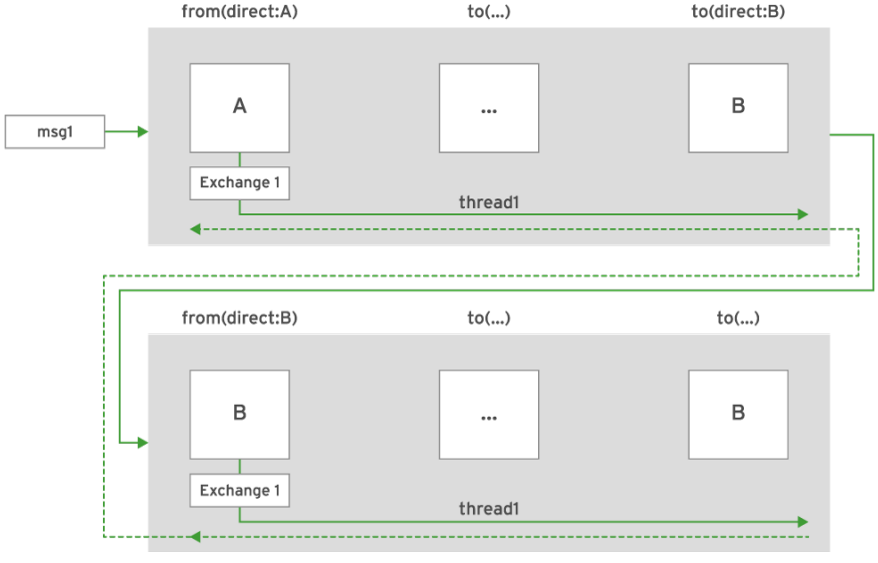
The ***name*** is a handle defined by the developer to connect producers and consumers in the same Camel context, for example:

```
<route id="route1">
        <from uri="file:input"/>
        <to uri="direct:mylogic"/>
</route>
<route id="route2">
        <from uri=""direct:mylogic""/>
        <!-- do something here -->
        <to uri=""file:output"/>
</route>
```

Produces a message exchange to a direct component called **myLogic**.

Receives a message exchange from a direct component called **myLogic**.

The direct component provides synchronous invocation of any consumers when a producer sends a message exchange. A synchronous invocation means that the producer waits for the execution of the consumer. The following diagram depicts one Camel route sending a message to another using a direct endpoint named **B**. Notice that the same thread is used to execute both routes, this is why direct components are considered synchronous.



The following example demonstrates using the direct component with Java DSL:

```
from("activemq:queue:order.in")
.to("bean:orderService?method=validate")
.to("direct:processOrder");
from("direct:processOrder")
.to("bean:orderService?method=process")
.to("activemq:queue:order.out");
```

In this example, the Camel route receives messages on an ActiveMQ queue named **`order.in`**. The first route validates those messages using a bean, and then sends the messages to a second Camel route using a direct endpoint named **`processOrder`**. Camel then uses the same thread to execute the second route, using a bean to process the message before sending the result to a second ActiveMQ queue named **`order.out`**.
The direct component has a few limitations:
• Message passing is synchronous.

• There can be only a single consumer for each direct URI.

• Producer and consumer have to be part of the same Camel context.

THE PROCESSOR INTERFACE

The **`org.apache.camel.Processor`** interface provides a generic way to write custom logic to manipulate an exchange. This can be useful for creating new headers or modifying a message body; for example, adding new content such as the date that the message was processed.
You can use processors to implement the **Message Translator** and **Event Driven Consumer** EIPs.
Implementing the **`Processor`** interface requires implementing a single method named **`process`**:

void process(Exchange exchange) throws Exception

The exchange argument allows access to both the input and output messages and the parent Camel context.
`Processor` implementation classes usually take advantage of other Camel features, such as data type converters and fluent expression builders.
To use a processor inside a route, insert the **`process`** element. For example:

```
<bean class="com.example.MyProcessor" id="myProcessor"/>
...
<route id="route1">
<from uri="file:inputFolder"/>
<process beanRef="myProcessor"/>
<to uri="activemq:outputQueue"/>
</route>
```

The same example using Java DSL:

```
.from("file:inputFolder")
.process(new com.example.MyProcessor())
.to("activemq:outputQueue");
```

Before writing your own **`Processor`** implementation, check first whether there are components, EIP, or other Camel features that might provide the same result with less custom code, for example:
• The **`transform`** DSL method allows changing a message body using any expression language supported by Camel.

• The **`setHeader`** DSL method allows changing header values.

• The **`bean`** DSL method allows calling any Java bean method from inside a route.
Compared to Java Beans, a Camel processor is preferred when there is a need to call Camel APIs from the custom Java code. A Java Bean is preferred when a transformation can reuse code that has no knowledge of Camel APIs.

DYNAMIC ENDPOINTS

An endpoint URI may include a few dynamic components, such as simple expressions to provide an optional value. Sometimes this is not sufficient if an application requires the ability to route to destinations using different components based on message contents or other runtime data.

In some application containers, Camel might cache and reuse endpoint instances in a way that the dynamic part is not re-evaluated. This could lead to messages being delivered to the wrong destination.

For those scenarios, Camel provides the **`toD`** DSL method, which stands for *dynamic to*, or *dynamic producer*. The URI is re-evaluated for each message sent and might even have different schema and components for each message.
By default, the **`toD`** method uses the Simple EL to resolve the dynamic endpoint URI. For example, to send a message to an endpoint defined by a header, you can:

```
<route>
  <from uri="direct:start"/>
  <toD uri="${header.foo}"/>
</route>
```

In Java DSL:

```
from("direct:start")
  .toD("${header.foo}");
```

You can also prefix the URI with a value because by default the URI is evaluated using the Simple EL, which supports string concatenation.

```
<route>
  <from uri="direct:start"/>
  <toD uri="mock:${header.foo}"/>
</route
```

In Java DSL:

```
from("direct:start")
  .toD("mock:${header.foo}");
```

CUSTOM AND PRE-DEFINED MESSAGE HEADERS

Most Camel components, when used as endpoints, provide metadata as message headers, and also behave differently based on received headers. Header names and their meaning depends on the component used. Carefully check the component and middleware documentation before writing routing logic that relies on a header value because they can change.
The following example uses a simple expression to access a header provided by the file component:

```
.from("file:incoming")
.log("${header.CamelFileName}")
...;
```

Camel provides the **`setHeader`** DSL method to set header values. For example:

```
...
.setHeader("CamelFileName", "destinationFile.txt")
.to("file:outgoing");
```

Headers defined by Camel components usually have the **`Camel`** prefix.

It is a common practice to create custom headers to store values for later use inside a route, or for debugging purposes. For example, you can create a header that contains an attribute from the message exchange and then route the message based on this attribute. Any header whose meaning is not known by a Camel component is ignored.

CHAPTER 3 TRANSFORMING DATA

GOAL

Convert messages between data formats using implicit and explicit transformation.

OBJECTIVES

• Invoke data transformation automatically and explicitly using a variety of different techniques.

• Transform messages using additional data formats, custom type converters, and the Message Translator pattern.

• Merge multiple messages using the Aggregator pattern and customizing the output to a traditional data format.

• Access a database with JDBC and JPA.

TRANSFORMING DATA IN A CAMEL ROUTE

One of the most common problems when integrating disparate systems is that those systems do not use a consistent data format. For example, you might receive new product information from a vendor in CSV format, but your production information system only accepts JSON data.

This difference in data format means you need to transform the data from one system before another system can correctly process it. For this reason, Camel is designed to handle these differences by providing support for dozens of different data formats, including the ability to transform data from one format to another. The data formats that Camel supports include JSON, XML, CSV, flat files, EDI, and many others.

Marshaling Data

Marshaling is the process where Camel converts the message payload from a memory-based format (for example, a Java object) to a data format suitable for storage or transmission (XML or JSON, for example). To perform marshaling, Camel uses the **`marshal`** method, which requires a **`DataFormat`** object as a parameter.

Data Formats

Data Formats in Camel are the various forms that your data can be represented, either in binary or text. The data formats that Camel supports include standard JVM serialization, XML, JSON, CSV data, and others. Each data format has a class you need to instantiate and optionally configure before you can use it in a route. For example, the **`JaxbDataFormat`** class allows you to specify the package where your XML model classes are present. Once you instantiate the **`JaxbDataFormat`** class, it uses your model classes, complete with JAXB annotations as the blueprint for how to marshal and unmarshal your XML data to your Java model classes. Additionally, data format classes support a number of custom options, such as "pretty print", or other configurations that affect the behavior of marshaling or unmarshaling. These options allow you to have more control over the marshal and unmarshal behavior such as how to handle missing elements, what type of encoding to use, namespace prefixing, and more.

Unmarshaling Data

Unmarshaling is the opposite process of marshaling, where Camel converts the message payload from a data format suitable for transmission such as XML or JSON to a memory-based format, typically a Java object. To perform unmarshaling explicitly in a Camel route, use the **`unmarshal`** method in the Java DSL. Similar to the marshaling, the method requires a **`DataFormat`** object as a parameter.

TRANSFORMING XML DATA USING JAXB

There are multiple options for working with XML data in Camel. JAXB is a very popular XML framework and is the XML marshaling library focused on throughout this course. To use JAXB with Camel, include the **`camel-jaxb`** library as a dependency of your project:

```
<dependency>
<groupId>org.apache.camel</groupId>
<artifactId>camel-jaxb</artifactId>
</dependency>
```

The **camel-jaxb** library also provides the JAXB annotations that you need to annotate your model class. These annotations are used to tell JAXB how to unmarshal the XML data into the Java objects correctly. JAXB matches fields on the model class to elements and attributes contained in the XML data using the information provided by the JAXB annotations.
Given the following XML content:

<order id="10" description="N2PENCIL" value="1.5" tax="0.15"/>

The following JAXB model class contains the necessary annotations to marshal the XML to a Java object:

```
package com.redhat.training;
 import java.io.Serializable;
 import javax.xml.bind.annotation.*;

  @XmlRootElement
  @XmlAccessorType(XmlAccessType.FIELD)
public class Order implements Serializable{

private static final long serialVersionUID = 5851038813219503043L;
@XmlAttribute
 private String id;
@XmlAttribute
 private String description;
@XmlAttribute
private double value;
 @XmlAttribute
private double tax;
}
```

Note that this model class implements the **java.io.Serializable** interface which required by JAXB to execute the marshaling and unmarshaling process.

In conjunction with the **camel-jaxb** library, you must also include JAXB annotations to instruct Camel which XML fields map to which properties in your Java model classes. In the previous example, each field in the Java class represents an attribute on the root **Order** element. By default, if no alternate name is specified in the JAXB annotation parameters, the marshaller uses the name of the field directly to map the XML data.

In the following sample route, an external system places XML data in the body of a message and then sends the message to an ActiveMQ queue named **itemInput**. The Camel route consumes the messages, and JAXB immediately unmarshals the XML data and replaces the contents of the exchange body with the corresponding Java object. The route then sends the Java object data in a message to an ActiveMQ queue named **itemOutput**.

For an XML-based route, declare the JAXB **dataFormat** and then use it to unmarshal XML data as shown in the following example:

```
<camelContext id="camel" xmlns="http://camel.apache.org/schema/spring">
<dataFormats>
  <jaxb id="jaxb" contextPath="com.mycompany.training"/>
</dataFormats>
<route>
 <from uri="activemq:queue:itemInput"/>
   <unmarshal ref="jaxb"/>
 <to uri="activemq:queue:itemOutput"/>
</route>
</camelContext>
```

The **contextPath** parameter refers to which package JAXB should scan for model classes that are annotated with JAXB annotations.
Convert the XML data in the body of the exchange into an instance of the corresponding model class and replace the exchange body with that model class instance.

Similarly, the following example demonstrates marshalling Java objects into XML using the Java DSL:

```
from("activemq:queue:itemInput)
  .marshal().jaxb( )
  .to("activemq:queue:itemOutput);
```

Notice that in the previous example Java DSL route, no JAXB data format is instantiated. This is possible because **camel-jaxb** automatically finds all classes that contain JAXB annotations if no context path is specified, and uses those annotations to unmarshal the XML data.

MARSHALING AND UNMARSHALING JSON DATA IN A CAMEL ROUTE WITH JACKSON

Similar to XML, Camel offers multiple libraries for working with JSON data. Like JAXB, Jackson is a very popular framework for working with JSON data in Java and this course focuses on
this approach for working with JSON data. To use Jackson with Camel, you need to include the **camel-jackson** library as a dependency of your project.

```
<dependency>
<groupId>org.apache.camel</groupId>
<artifactId>camel-jackson</artifactId>
</dependency>
```

Similar to JAXB, Jackson also provides a set of annotations you use to control the mapping of JSON data into your model classes.
Given the following JSON data:

```
{
"_id": "1",
"value": 5.00,
"tax": 0.50,
"description": "Sample text",
...
```

The following example is a Jackson-annotated model class which you can use to marshal the JSON data:

```
package com.redhat.training;
...
public class Order implements Serializable{
private static final long serialVersionUID = 5851038813219503043L;

@JsonProperty("_id")
private String id;
@JsonIgnore
private String description;
@JsonProperty
private double value;
 @JsonProperty
 private double tax;

}
```

Use the **@JsonProperty** annotation to explicitly declare a field in the model class, and optionally include a name for Jackson to use when marshaling and unmarshaling JSON data for that property.
Use the **@JsonIgnore** annotation to make Jackson ignore a field entirely when marshaling an instance of the model class into JSON data.

For an XML-based Camel route configuration, declare a Jackson **dataFormat** and then unmarshal JSON data, as in this example:

```
<camelContext id="camel"
xmlns="http://camel.apache.org/schema/spring">
<dataFormats>
<json id="jackson" prettyPrint="true" library="Jackson"/>
</dataFormats>
<route>
<from uri="file:inbox"/>
<unmarshal ref="jackson"/>
 <to uri="activemq:queue:itemInput"/>
</route>
</camelContext>
```

In the previous example route, JSON files are consumed from the **inbox** directory, and are unmarshaled into Java objects. Those Java objects are then sent to the **itemInput** queue.
The following is a Java DSL example of using Jackson to marshal JSON data before writing the JSON data to a file in the **outbox** directory:

```
from("queue:activemq:queue:itemInput")
.marshal().json(JsonLibrary.Jackson)
.to("file:outbox")
```

TRANSFORMING DIRECTLY BETWEEN XML AND JSON DATA USING THE CAMEL-XMLJSON MODULE

As discussed previously, Camel supports data formats to perform both XML and JSON-related conversions. However, both of these transformations require a Java model class object either as an input (marshaling) or they produce a Java object as output (unmarshaling). The **camel-xmljson** data format provides the capability to convert data from XML to JSON directly and vice versa without needing to use intermediate Java objects. Directly transforming XML to JSON is preferred as there is significant performance overhead involved in doing extra transformations.

When you use the **camel-xmljson** module, the terminology "marshaling" and "unmarshaling" are not as obvious since there is no Java objects involved. To resolve this, the module defines XML as the high-level format or the equivalent of what your Java model classes typically represent, and JSON as the low-level format more suitable for transmission or storage. This designation is mostly arbitrary for the purpose of defining the marshal and unmarshal terms.

This implies that the terms marshal and unmarshal are defined as follows:

marshaling
Converting from XML to JSON

unmarshaling
Converting from JSON to XML

To use the **XmlJsonDataFormat** class in your Camel routes you need to add the following dependencies to your POM file:

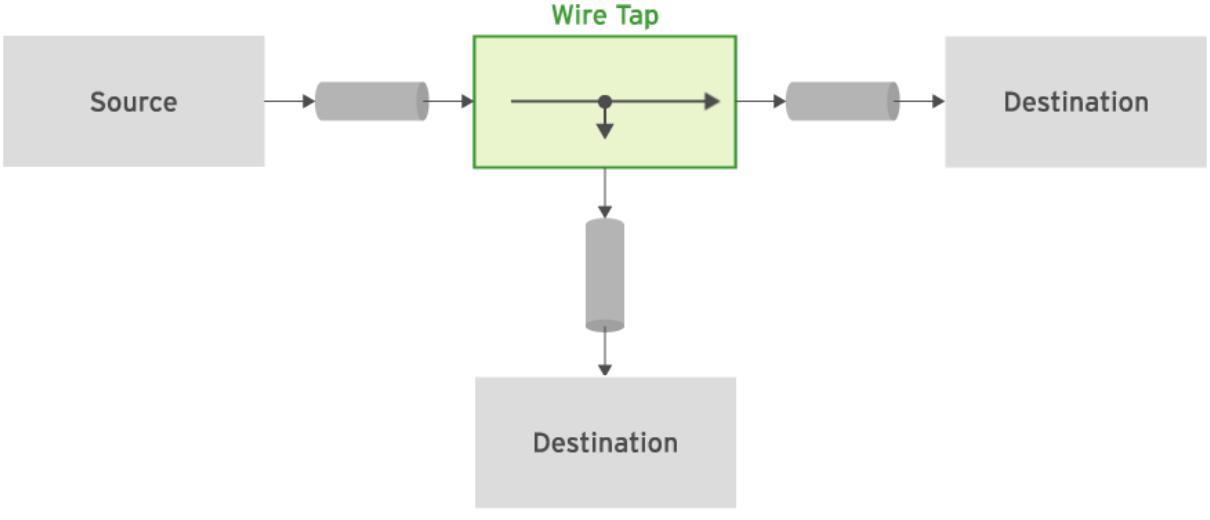
```
<dependency>
<groupId>org.apache.camel</groupId>
<artifactId>camel-xmljson</artifactId>
</dependency>

<dependency>
<groupId>xom</groupId>
<artifactId>xom</artifactId>
<version>1.2.5</version>
</dependency>
```

The following example Camel route includes the use of the **XmlJsonDataFormat**:

```
XmlJsonDataFormat xmlJsonFormat = new XmlJsonDataFormat();
// From XML to JSON from("direct:marshal")
.marshal(xmlJsonFormat)
.to("direct:json");
// From JSON to XML from("direct:unmarshal")
.unmarshal(xmlJsonFormat)
.to("direct:xml");
```

IMPLEMENTING THE WIRE TAP PATTERN IN A CAMEL ROUTE

The wire tap EIP is an integration pattern that creates a duplicate copy of each message that the route processes and then forwards the duplicate message to a second destination without
interrupting the flow from the source to the original destination. The following diagram illustrates this pattern:



This functionality is most useful for inspecting messages as they travel along a Camel route without impacting the route execution itself. Often Camel developers use wire taps to debug routes by checking the message content matches expectations mid-route. For instance, you could use a wire tap to write message body content to a file mid-route, or notify an external system with real-time updates asynchronously.
To implement this pattern, Camel provides the **`wireTap`** component, which you can use in your routes to duplicate message exchanges and send a copy of the exchange to a second destination. The following Camel route demonstrates the use of this component:

```
from("activemq:queue:orders.in")
.wireTap("file:backup")
.to("direct:start");
```

In this example, a copy of every exchange received from the **`orders.in`** queue is written to a file in the **`backup`** folder using a **`wireTap`**.

INTRODUCING MOCK ENDPOINTS IN CAMEL ROUTES

During the development of a Camel route, it is often necessary to create a mock destination to represent and behave like an external system with which you have not yet integrated. You can use a mock as a place holder any time you are integrating with other development teams in parallel, and real integration points are not ready.

To use a mock endpoint in a route definition, use the URI prefix **`mock`**, as the following Spring DSL example demonstrates:

```
<route>
  <from uri="direct:inventoryUpdate"/>
  <to uri="log:com.mycompany.inventory?level=DEBUG"/>
  <to uri="mock:fufillmentSystem"/>
</route>
```

In this example, the mock component is providing a placeholder for an integration with an external fulfillment system that has not been implemented yet.
In addition, mocks can be used when testing route functionality. The mock component provides a powerful declarative testing mechanism, which is similar to jMock or Mockito testing frameworks. Mock endpoints allow you to define expectations for any endpoint before running your unit tests. When the test executes, the Camel route processes messages that are then sent to one or more endpoints. By using a mock you can then assert the expectations defined by your test case were met to ensure the system worked as expected.
This allows you to test various things, for example:
• The correct number of messages are received by each endpoint.

• The correct payloads are received, in the right order.

• The order that the messages arrived at an endpoint using some **`Expression`** to create an order testing function.

• The messages match some kind of **`Predicate`** such as containing specific headers with certain values, or that parts of the messages like the body match some predicate, for example an XPath or XQuery expression.

IMPLEMENTING THE MESSAGE TRANSLATOR PATTERN USING TRANSFORM

The message translator pattern provides a mechanism to make updates or transformations to your Camel message exchanges to comply with requirements of the various integration endpoints used by your system. This pattern is usually used to adapt the message payload from one system to another, whether it is an entirely different data format, or just the addition of an extra field, or a tweak to the file delimiter. Message translation is often necessary for integration systems that interface between many different applications, including legacy applications, proprietary software solutions, and external vendor systems. Typically each of these systems use their own data model. This means, for instance, that each system may have a slightly different notion of the *order* entity, including fields that define an *order* and which other entities an *Order* has relationships with. For example, the accounting system may be more interested in the order's sales tax numbers while the fulfillment system stores order item SKUs and quantity.

In Camel, one method of implementing the message translator pattern is using the **`transform`** DSL method. The **`transform`** method makes inline changes to the **`Message`** instance to update its contents or format. In the following code, the route changes all of the commas (,) from a file to semicolons (;) to create a semicolon-separated file:

```
package com.redhat.training;
import org.apache.camel.builder.RouteBuilder; public
class JavaRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {

from("file:in")
  .transform(body()
  .regexReplaceAll(",", ";")
  )
  to("file:out");
}
}
```

transform method call to start the update of file content to a different format
body method call to update the contents from the message's body (the file content). A change to the header is also possible, calling the **header** method instead
Looks for all commas (,) in the file and changes each occurrence to a semicolon (;)

The **transform** method supports using Simple EL, as shown in the previous example, as well as using the **constant** method to overwrite the entire message body, as demonstrated in the following route:

```
from("direct:start")
 .log("Article name is ${body}")
 .choice()
  .when().simple("${body} contains 'Camel'")
    .transform(constant("Yes"))
  .otherwise()
    .transform(constant("No"))
 .end();
 .to("stream:out")
```

In this example, the body of the message is set to either **Yes** or **No** based on whether the message body content contains the string **Camel**.

INTRODUCING CAMEL-BINDY FOR TRANSLATING CSV FILES TO JAVA OBJECTS

Camel allows marshaling and unmarshaling to and from traditional text formats, such as a CSV or flat file, to Java objects, using the **camel-bindy** library. Bindy uses a similar approach as JAXB to map Java objects to text format and vice versa.
The following route transforms the data from a CSV format to a Java object:

```
DataFormat bindy = new
BindyCsvDataFormat("com.redhat.training");
from("file:in")
.unmarshal(bindy)
.to("jms:queue:orders");
```

Scan for classes available at **com.redhat.training** using camel-bindy annotations and unmarshal from CSV files to Java objects. This class also includes a constructor that takes a single class name instead of a package, as shown below.

DataFormat bindy = new BindyCsvDataFormat(Order.class)

The **camel-bindy** module processes the contents from a CSV file and transforms them into a **List<Map<String,Object>>**. For each position of this **List**, there will be a record in the CSV file, which is represented as a **Map**.
For each record in the **Map**, there will be a Java object retrieved from the CSV file. This allows the mapping of multiple objects from a record in the CSV file.

Mapping Java object fields to variables using **camel-bindy** is done using annotations similarly to JPA. The following code shows some important annotations.

```
package com.redhat.training;

@CsvRecord(separator=",",crlf="UNIX")
public class Order implements Serializable{

@DataField(pos=1)
private int id;
@DataField(pos=2)
private String description;
@DataField(pos=3)
private double price;
@DataField(pos=4) private double tax;
}
```

The **@CsvRecord** annotation marks the actual class as managed by Bindy. In this case, the annotation specifies that it will parse a CSV file separated by a comma (**separator** parameter) where the line breaks (**crlf** parameter) are UNIX-compliant. The separator parameter accepts one of **WINDOWS**, **MAC**, or **UNIX** as its parameter, allowing you to ensure you are parsing your files correctly based on the operating system platform where the CSV files were created.

The class implements the **java.io.Serializable** interface to allow marshaling processing.

The **DataField** annotation requires a **pos** parameter to map the position where an attribute will be read in a CSV file.

TRANSFORMING XML DATA USING THE XSLT COMPONENT

Another common mechanism for transforming XML data is XSLT (Extensible Stylesheet Language Transformations). XSLT can be used to transform XML, altering elements, values and attributes to match a different schema, or even to transform XML data to another format such as HTML.

In Camel, the xslt component provides the ability to process a message using an XSLT template. The basic URI format of the xslt component is as follows:

```
xslt:templateName[?options]
```

Here, **templateName** is the URI to an XSLT template that is available on the class path, or a complete URL to a remote XSLT template. Two examples are listed, as follows:

xslt:file:///tmp/transform.xsl # will use the file located at /tmp/transform.xsl

xslt:http://example.com/xslt/foo.xsl # will use the remote resource at the specified URL

An XSLT endpoint in a route would appear similar to the following:

```
from("activemq:myQueue").
to("xslt:file:///tmp/transform.xsl");
```

INTRODUCING CAMEL CUSTOM TYPE CONVERTERS

Camel provides a built-in type-converter system that automatically converts between well- known types. This system allows Camel components to easily work together without having type mismatches. From the Camel developer's perspective, type conversions are built into the API in many places without being invasive. When routing messages from one endpoint to another, it is often necessary for Camel to convert the body payload from one Java type to another. Common Java types that are frequently converted between include:

- File
- String
- byte[] or ByteBuffer
- InputStream or OutputStream

The **Message** interface defines **getBody** helper method to allow such automatic conversion. For example:

```
Message message = exchange.getIn();
byte[] image = message.getBody(byte[]);
```

In this example, Camel converts the body payload during the routing execution from a data format such as **File** to a Java **byte[]** array. Suppose you need to route files to a JMS queue using **javax.jmx.TextMessage** objects.

To do so, you can convert each file to a **`String`**, which forces the JMS component to use the **`TextMessage`** class. This is easy to do in Camel—you use the **`convertBodyTo`** method, as shown here:

```
from("file://orders/inbox")
.convertBodyTo(String.class)
.to("activemq:queue:inbox");
```

In some use cases, however, it is necessary to transform a known format that is not supported by Camel by default (such as a proprietary file format) to a Java class. For instance, you might work with a vendor that uses proprietary encryption technology, which requires a custom API to decrypt. This custom transformation is possible using a *custom type converter*.

To develop a type converter, use the Camel annotation **`@Converter`** in any class that implements custom conversion logic. Additionally, to allow Camel to find your type converter classes, you must include a file named **`TypeConverter`** in the **`META-INF/services/org/apache/camel/`** directory. The **`TypeConverter`** file must include any packages where you keep your custom converter implementation classes, each package on a new line, as shown in the following example:

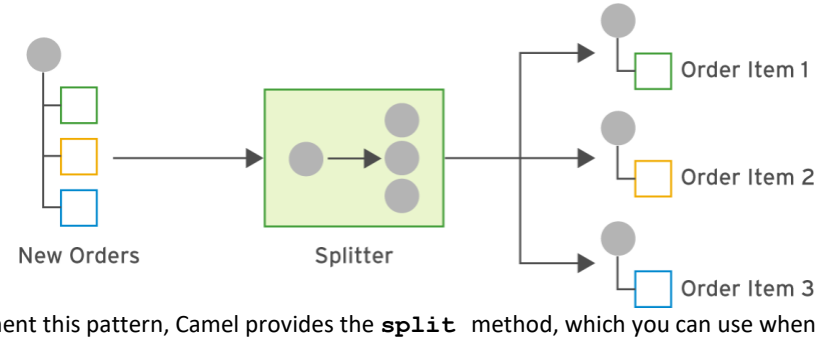
com.fuse.training.converters

In addition to the class-level annotation, a custom converter class must also have a static method (also annotated with **`@Converter`**) whose signature must meet the following requirements:

- The return value must be a type that is compatible with the resulting object.
- The first parameter must be a type that is compatible with the format you wish to convert.
- Optionally, an **`Exchange`** object can be used as a second parameter.

IMPLEMENTING THE SPLITTER PATTERN

The splitter pattern provides a way to break the contents of a message, into smaller chunks. This is especially useful when you are dealing with lists of objects, and you want to process each item in the list separately. An example where this is useful is splitting the individual items from a customer's order.



To implement this pattern, Camel provides the **`split`** method, which you can use when creating the route. The following example demonstrates using an XPath predicate to split XML data stored in the exchange body:

```
from("activemq:queue:NewOrders")
.split(body(xpath("/order/product")))
.to("activemq:queue:Orders.Items");
```

In Spring, the same pattern can be implemented using the following code:

```
<camelContext xmlns="http://camel.apache.org/schema/spring">
 <route>
  <from uri="activemq:NewOrders"/>
   <split>
```

```
    <xpath>/order/product</xpath>
    <to uri="activemq:Orders.Items"/>
   </split>
 </route>
</camelContext>
```

The **split** function also supports splitting of certain Java types by default without any predicate specified. A common use case is to split a **Collection**, **Iterator**, or array from the exchange body.

The **split** method creates separate exchanges for each part of the data that is split and then sends those exchanges along the route separately.
For example, consider a route that has unmarshaled CSV data into a **List** object. Once the data is unmarshaled, the exchange body contains a **List** of model objects, and a call to **split** creates a new exchange for each record from the CSV file.
The following examples demonstrate splitting the exchange body as well as splitting an exchange header:

```
from("direct:splitUsingBody").split(body()).to("mock:result");

from("direct:splitUsingHeader").split(header("foo")).to("mock:result");
```

The equivalent route definitions in Spring DSL appear as follows:

```
<split>
        <simple>${body}</simple>
        <to uri="mock:result"/>
</split>
<split>
        <simple>${header.foo}</simple>
        <to uri="mock:result"/>
</split>
```

This example splits the body containing an **Iterable** Java object (**List**, **Set**, **Map**, etc) into separate exchanges.

This example splits a header containing an **Iterable** Java object into separate exchanges with the same body. For example, if the exchange head a header containing a list of users, split could transform it into multiple exchanges, one per user in the list, all containing the same exchange body.

USING THE TOKENIZER WITH THE SPLITTER PATTERN

The tokenizer language is intended to *tokenize* or break up text documents, such as CSV or XML, using a specified delimiter pattern. You can use the tokenizer expression with **split** to split the exchange body using a token. This allows you to split your text content without the need to first unmarshal it into Java objects.

Because this is a common use-case, a **tokenize** XML element is provided for this in the Spring DSL, and a **tokenize** method is provided in the Java DSL. In the XML sample below, the body is split using an "at" (@) symbol as a separator. You can also use a comma, space, or even a regular expression pattern using the option **regex=true**.

```
<camelContext xmlns="http://camel.apache.org/schema/spring">
 <route>
  <from uri="direct:start"/>
  <split>
<tokenize token="@"/>
<to uri="mock:result"/>
</split>
</route>
</camelContext>
```

Additionally, if you are splitting XML data, an optimized version of the tokenizer is provided using the DSL method **tokenizeXML**. The Spring DSL tokenizer has an attribute named **xml**, which can be set to true or false to enable the XML-optimized tokenization.

Java DSL example:

```
from("file:inbox")
.split().tokenizeXML("order")
```

```
.to("activemq:queue:order");
```

Spring DSL example:

```
<route>
<from uri="file:inbox"/>
<split>
<tokenize token="order" inheritNamespaceTagName="orders" xml="true"/>
<to uri="activemq:queue:order"/>
</split>
</route>
```

ADDRESSING MEMORY USAGE ISSUES IN THE SPLITTER PATTERN WITH STREAMING

When consuming large pieces of data with Camel, the splitter pattern is often used to divide up this data into small, more manageable pieces. In addition to using the **`split`** method split the data, Camel offers an option called streaming, which can alleviate memory issues by not loading the entire piece of data into memory. If streaming is enabled, then Camel splits in a streaming fashion, which means it splits the input message in chunks, instead of attempting to read the entire body into memory at once, and then splitting it. This reduces the memory required for each invocation of the route.
For this reason, if you split messages with extremely large payloads, it is recommended that you enable streaming. However, if your data is small enough to hold in memory, streaming is probably unnecessary overhead.
You can split streams by enabling the streaming mode using the streaming builder method. The following route demonstrates streaming in Java DSL:

```
from("direct:streaming")
.split(body().tokenizeXML("order")).streaming()
.to("activemq:queue.order");
```

Create the same route In XML DSL as follows:

```
<route>
<from uri="direct:streaming"/>
<split streaming="true">
<tokenize token="order" xml="true"/>
<to uri="activemq:queue:order"/>
</split>
</route>
```

If the data you are splitting is in XML format, be sure to use the **`tokenizeXML`** instead of an XPath expression. This is because the XPath engine in Java loads the entire XML content into memory, negating the effects of streaming for very big XML payloads.

COMBINING MESSAGES THROUGH AGGREGATION

INTRODUCING THE AGGREGATOR PATTERN

The aggregator pattern is a mechanism allowing you to group fragmented data from multiple source messages into single a unique message. The aggregator pattern is suitable for use cases where fragmented data is not the best way to deliver information. For example, when you want to batch process data that you receive in fragments, such as combining individual orders that need to be fulfilled by the same vendor. Using this pattern, you can define custom aggregation behavior to control how Camel uses the source data fragments to build the final aggregated message.
To build the final message, there are three pieces of information needed:

The correlation value

You must define a correlation value which defines an expression or predicate that Camel uses to match each **`exchange`** object captured by an aggregator pattern implementation. The correlation value is a field obtained using an **`expression`** to group messages together for aggregation. A common strategy used to group messages is to use an exchange header, but it could also refer to a message body field using **`xpath`** or **`jsonpath`**.
Logic for how to compile the final message

You must provide Java code to build the final message exchange sent by the aggregator. This can be as simple as concatenating the exchange bodies together, or much more complex custom business logic. To build this, implement the **`AggregationStrategy`** interface which builds the exchange payload with the messages captured using the correlation value.

The complete condition

You must define the complete condition which uses a predicate or time condition to instruct Camel to check when the final message **`exchange`** object built from the individual incoming exchanges should be sent out of the aggregator. To use this pattern in your Camel route, use the **`aggregate`** DSL method, which requires two parameters:

```
.aggregate(correlationExpression, AggregationStrategyImpl)
```

Additionally, a completion condition is needed to define when to send the aggregated exchange. This is identified using methods from the Java domain-specific language (DSL) which will be discussed later in this section.

For example, in the following route, the messages with a matching header field named **`destination`** are aggregated using the **`MyNewStrategy AggregationStrategy`** implementation.:

```
from("file:in")
.aggregate(header("destination"),new MyNewStrategy())...
.to("file:out");
```

The AggregationStrategy Interface

The **`AggregationStrategy`** is a required implementation when merging multiple messages into a single message. It declares a single method (aggregate) and requires the following guidelines:
• The **`aggregate`** method requires two exchange parameters, but the first parameter will always be **`null`** for the first message. This is because when you receive the first message exchange you have not yet created the aggregated message. Therefore, an **`if`** clause must exist to check whether the first exchange is **`null`**, and instantiate the aggregated message and return it.

• The exchange object that is returned by the **`aggregate`** method is automatically passed into the next execution of the **`AggregationStrategy`** implementation.

In the **`AggregationStrategy`**, implementation an **`exchange`** object is expected to be returned by the method execution, with body contents that represent the aggregation of the two exchange objects passed into the **`aggregate`** method execution.

```
final class BodyAggregationStrategy implements AggregationStrategy {

 @Override
public Exchange aggregate(Exchange oldExchange , Exchange newExchange )
{
 if (oldExchange == null){
return newExchange;
}
String newBody = newExchange.getIn().getBody(String.class);
 String oldBody = oldExchange.getIn().getBody(String.class);
newBody = newBody.concat(oldBody);
 newExchange.getIn().setBody(newBody);
return newExchange;
}
}
```

CONTROLLING THE SIZE OF THE AGGREGATION

When using the aggregator pattern, Camel requires that developers identify the conditions under which the aggregated message exchange must be sent to the remainder of the route. Below are
six of the most commonly used methods that are provided by Camel to identify the complete condition:

`completionInterval(long completionInterval)`
Build the aggregated message after a certain time interval (in milliseconds).

completionPredicate(Predicate predicate)
Build the aggregated message if the predicate is true.

completionSize(int completionSize)
Build the aggregated message when the number of messages defined in the **completionSize** is reached.

completionSize(Expression completionSize)
Build the aggregated message when the number of messages processed by a Camel expression is reached.

completionTimeout(long completionTimeout)
Build the aggregated message when there are no additional messages for processing and the

completionTimeout (in milliseconds) is reached.

completionTimeout(Expression completionTimeout)

Build the aggregated message when there are no additional messages for processing and the timeout defined by a Camel expression is reached.
In the following route, the **completionSize** method is used to trigger the aggregated message creation:

```
from("file:in")
.aggregate(header("destination"),new MyNewStrategy())
.completionSize(5)
```

It is also possible to use multiple completion conditions, as shown in the following example:

```
from("file:in")
.aggregate(header("destination"),new MyNewStrategy())
.completionInterval(10000)
.completionSize(5)
.to("file:out");
```

When multiple completion conditions are defined, which ever condition is met first, will trigger the completion of the aggregation. In the previous example, for completion of the batch to occur, either five total exchanges are processed, or 10 seconds have passed, whichever occurs first.

USING A PROCESSOR TO IMPLEMENT THE MESSAGE TRANSLATOR PATTERN

Another simple way to implement the message translator pattern is to use a custom processor. With this approach you can do any modification that might be necessary to the **exchange**, and you have easy access to Java's wealth of APIs. You can invoke custom business logic or use a proprietary API to transform the message content.

To create a custom processor, Camel provides the **Processor** interface, which requires a single method, **process**, with no return type. An example processor is included below:

```
public class DateProcessor implements Processor {
        public void process(Exchange exchange) throws Exception {
        exchange.getIn().setHeader("orderDate",new Date());
 }
}
```

In this example, the **DateProcessor** adds an exchange header called **orderDate** with the current date.
After you create the processor, you can use it inside a route by declaring the bean in Spring; for example, using the XML DSL:

```
<bean id="dateProcessor" class="com.redhat.training.jb421.DateProcessor"/>
<camelContext id="jb421Context" xmlns="http://camel.apache.org/schema/spring">
 <route>
        <from uri="activemq:myQueue"/>
        <process ref="dateProcessor"/>
        <to uri="mock:myProducer"/>
 </route>
</camelContext>
```

Or by instantiating a new instance of it using the Java DSL:

```
public void configure() throws Exception {
 from("activemq:myQueue")
  .process(new DateProcessor())
  .to("mock:myProducer");
}
```

ACCESSING DATABASES WITH CAMEL ROUTES

ACCESSING DATABASES USING THE JDBC, JPA AND SQL COMPONENTS

A common use case in enterprise integration is retrieving data from a relational database such as MySQL, Oracle database, or others. Often when building an integration system you may even
need to retrieve, store or update data in multiple different databases. Camel implements multiple components that allow access to your relational database technologies:

JDBC
Provided by the **`camel-jdbc`** library. A SQL query can be executed against a database using JDBC (Java Database Connectivity). The response message contains the full result of the query.

SQL
Provided by the **`camel-sql`** library. Allows you to work with databases using JDBC queries. The difference between this component and **`jdbc`** component is that in case of SQL the query is a property of the endpoint and it uses message payload as parameters passed to the query.

Java Persistence API
Provided by the **`camel-jpa`** library. Similar to Hibernate JPA implementation, it can be used to manage database data using an ORM (Object Relational Mapping) layer. ORM tools provide an easy way to map your database tables to your model classes, and translate operations done on your model classes directly to SQL for you, drastically simplifying your application code for database communication.
These components are useful to capture data to be used by other systems, enhance message exchanges with data from a database, or to keep an external data store based on incoming message exchanges. These components simplify access to databases from your Camel routes and provide an easy-to-use mechanism to transfer data between systems.

REVIEWING THE JDBC COMPONENT

The **`jdbc`** component enables you to access databases through *Java Database Connectivity* (JDBC) using SQL queries (**`SELECT`**) or operations (**`INSERT`**, **`UPDATE`**, etc). The **`jdbc`** component expects the message body to contain SQL that it can execute against your database.
To use it in a Maven-based project, a dependency must be declared:

```
<dependency>
    <groupId>org.apache.camel</groupId>
    <artifactId>camel-jdbc</artifactId>
</dependency>
```

The URI syntax when using JPA component is: `jdbc:[dataSourceName][?options].`
The **`dataSourceName`** parameter is required and refers to a data source defined in the Spring configuration file.
An example data source configuration is:

```
<bean id="dataSource"
class="org.springframework.jdbc.datasource.DriverManagerDataSource">
<property name="driverClassName" value="${jdbc.driverClassName}"/>
<property name="url" value="${jdbc.url}"/>
<property name="username" value="${jdbc.username}"/>
<property name="password" value="${jdbc.password}"/>
</bean>
<context:property-placeholder location="jdbc.properties"/>
```

REVIEWING THE SQL COMPONENT

The **`sql`** component also enables access to databases through JDBC using native SQL queries. Unlike the **`jdbc`** component, this component does not expect the query in the body of the message, but rather it expects the query to be defined in the endpoint URI, and the message content can be used to specify parameters of the query dynamically. Additionally this component uses **`spring-jdbc`** internally instead of plain JDBC which is leveraged by the **`jdbc`** component.
To use it in a Maven-based project, a dependency must be declared:

```
<dependency>
        <groupId>org.apache.camel</groupId>
        <artifactId>camel-sql</artifactId>
</dependency>
```

The URI syntax when using the **`sql`** component is:

```
sql:select * from table where id=:#myId order by name[?options].
```

In that example URI, the query is a simple SQL **`SELECT`** query, and Camel will attempt to load the **`myId`** parameter from the message body if it is of type **`Map`** otherwise, it will look for a header on the exchange with the same name. If the named parameter cannot be resolved, an exception is thrown.

REVIEWING THE JPA COMPONENT

The Java Persistence API defines an *object relational mapping* (ORM) library that allows access to a database using a unique set of commands that the JPA library translates to SQL for you. JPA was designed with flexibility in mind and also allows low-level access under certain circumstances; for example, to use specific features (functions and procedures) from a database.
JPA is implemented by a set of providers such as Hibernate, OpenJPA, and Toplink, and it has been increasingly enhanced to improve performance and embrace database-specific functionalities.
Camel implements a component that can access a database using JPA, and then use this data in route processing. Access is provided using an entity-based approach, and data can be added to or extracted from a database.
To use the **`jpa`** component in a Maven-based project, declare the following dependency:

```
<dependency>
        <groupId>org.apache.camel</groupId>
        <artifactId>camel-jpa</artifactId>
</dependency>
```

The URI syntax when creating an endpoint which uses the JPA component is:
`jpa: [entityClassName][?options].`

The **`entityClassname`** option is required to retrieve data from a JPA producer, but is optional when inserting data with a JPA consumers. **JPA Options**

OPTION NAME	DEFAULT VALUE	DESCRIPTION
`persistenceUnit`	**`camel`**	The persistence unit name.

consumeDelete	**true**	If **true**, the entity is deleted after it is consumed.
consumeLockEntity	**true**	Specifies whether or not to set an exclusive lock on each entity bean while processing the results from polling.
maximumResults	**-1**	JPA consumer only: Set the maximum number of results to retrieve on the query.
consumer.namedQuery	N/A	To use a named query when consuming data.

For example, a JPA producer can be used to generate a serialized object from a database table for the **Order** entity. The following example route, consumes rows from the **Order** table, transforms the rows to Java objects, unmarshals those objects to XML using JAXB and writes the resulting rows to files in the **out** directory:

```
from("jpa:com.redhat.training.entity.Order")
.unmarshal().jaxb()
.to("file:out");
```

To avoid removal of rows from a table, use the **consumeDelete** option:

from("jpa:com.redhat.training.entity.Order?consumeDelete=false")...

To specify a persistence unit, other than the default, use the **persistenceUnit** option. The persistence unit is associated to a **persistence.xml** file in your Java project, and provides the connections to your database:

from("jpa:com.redhat.training.entity.Order? consumeDelete=false&**persistenceUnit=mysql**")...

SCHEDULING ROUTES WITH TIMERS AND QUARTZ

Often companies decide to defer the execution of batch processes to after regular business hours to avoid any issues of high-load taking down systems and impacting end users during their work day. Most of these batch processes are triggered by the OS or proprietary systems, but they do not provide a fine-grained mechanism to manage failures and retries.
Camel implements timer components to allow developers to trigger route processing at any time, at regular intervals, without external dependencies. This feature is implemented using two main libraries:

Java native timer features using the timer component
Implemented by the **camel-core** library, it uses basic timer features from the Java APIs.

Quartz framework features using the **camel-quartz** library
Implemented by the **camel-quartz** library, it allows advanced execution features, such as

cron-based syntax and management of the number of executions.
Both components only support being used as a producers by their nature, and cannot be called within a **to** method.

Timer Component

The timer component is provided by the camel-core library and requires the following dependency in the **pom.xml** file:

```
<dependency>
<groupId>org.apache.camel</groupId>
<artifactId>camel-core</artifactId>
</dependency>
```

The endpoint URI format is: `timer:<timerName>?options`.
This timer creates an empty **exchange** that should be filled by a developer or during the route processing. The timer customization can be achieved using the included options.

Timer Options

OPTION NAME	DEFAULT VALUE	DESCRIPTION
period	**1000**	Time in milliseconds between route executions. The time can also be specified using s (seconds), m (minutes), or h (hours). For example, an entry of 1h will be transformed by Camel to 3,600,000 ms.
delay	**0**	Length of time that Camel should wait until the first execution.

In the following URI, the route is triggered each hour, starting as soon as the Camel context is started:
from("timer:hourlyTimer?period=1h)

Quartz Component

Quartz is a timer execution framework which supports more advanced scheduling using CRON, which is an enterprise standard.
To use camel-quartz in a project, it must be imported by the **`pom.xml`** file:

```
<dependency>
        <groupId>org.apache.camel</groupId>
        <artifactId>camel-quartz</artifactId>
</dependency>
```

The endpoint URI format is: `quartz:<timerName>?options`.
Similar to the timer, it is an empty exchange that should be filled by a developer or during the route processing. Its customization can be achieved using the included options. The component uses either a **`CronTrigger`** or a **`SimpleTrigger`**. If no CRON expression is provided, the component uses a simple trigger.

OPTION NAME	DEFAULT VALUE	DESCRIPTION
`cron`	NA	Specifies a CRON expression to schedule route executions.
`trigger.repeatCount`	0	Number of times this route should be executed.
`trigger.repeatInterval`	0	The amount of time in milliseconds between repeated triggers.

For example the following quartz timer uses a CRON expression to fire a message every five minutes from 12pm to 6pm only on weekdays:

```
from("quartz://myGroup/myTimerName?cron=0+0/5+12-18+?+*+MON-FRI")

.to("activemq:startProcess");
```

CHAPTER 4

CREATING TESTS FOR ROUTES

GOAL

Develop reliable routes by developing route tests and handling errors.

OBJECTIVES

- Develop tests for Camel routes with Camel Test Kit.
- Create realistic test cases with mock components.
- Create reliable routes that handle errors gracefully.

TESTING ROUTES WITH CAMEL TEST KIT

TESTING CAMEL ROUTES

An important aspect of developing reliable integration solutions is thoroughly testing your Camel routes. One difficulty when testing integration solutions is that the routes inherently require external dependencies. To resolve this issue, Camel provides a set of classes and libraries to test routes and change endpoints during runtime to avoid starting up all services and dependencies needed by a route, such as a database or a message queue. These libraries are provided in the following modules:

• **`camel-test`** provides a number of helpers for writing JUnit tests for Camel routes.

• **`camel-test-spring`** provides additional helpers for writing JUnit tests for routes using the Spring Framework or Java fluent interface (Java DSL).

IMPLEMENTING TESTS WITH CAMEL

A Camel-enabled test is created by extending one of the Camel Test Kit supporting classes. For example:

• **`org.apache.camel.test.CamelTestSupport`**: This allows test support to Camel routes and components. A number of helper methods are provided to test an **`Endpoint`** instance state and a **`Predicate`** instance filtering capabilities and for other route testing tasks.

Normally, the **`CamelTestSupport`** class is used to test simple routes that do not depend on services that need to be externally started and configured, such as message queues or databases. When these are used, it is preferred to use a subclass that integrates with an inversion of control (IoC) framework such as Spring or CDI.

• **`org.apache.camel.test.spring.CamelSpringTestSupport`**: This is a common approach to test Camel elements. The library extends **`CamelTestSupport`** to add helper methods to read route definitions from a Spring beans configuration file.

Another way to create a Camel-enabled test is by using one of the JUnit Runner implementations provided by the Camel Test Kit, for example,
`org.apache.camel.test.spring.CamelSpringRunner`, which initializes the Camel context from a Spring beans configuration file. This approach is useful when you need to use JUnit extensions that require you to create a test subclass in addition to the **`CamelSpringTestSupport`** class.

NOTE
`CamelTestSupport` and related classes and annotations are part of the **`camel- test`** module. The subclasses featuring Spring framework integration, such as **`CamelSpringTestSupport`**, are part of the **`camel-test-spring`** module.

The following sample uses **`CamelTestSupport`** helper methods to test a route:

```
public class PredicatesTest extends CamelSpringTestSupport {
@Override
protected AbstractApplicationContext createApplicationContext() {

  return new ClassPathXmlApplicationContext("META-INF/spring/bundle-context.xml");
}

@Test
public void testRoute(){

    super.template.sendBodyAndHeader("file:in", "file", Exchange.FILE_NAME, "testFile.txt");
    GenericFile receiveBody = (GenericFile) super.consumer.receiveBody("file:out");
    String content = receiveBody.getFileNameOnly();
    assertEquals("testFile.txt",content);
```

When a test case is executed, the test execution creates a **`CamelContext`** instance and reads the XML file defined by the **`createApplicationContext`** overridden method. Also the test case instantiates attributes inherited by the **`CamelSpringTestSupport`** class, such as the template attribute that gives developers access to any endpoint that starts a route execution. After all tests are executed, the context instance stops.

DEVELOPING ROUTES WITH MOCK COMPONENTS

DEVELOPING WITH MOCK ENDPOINTS

By its nature, integration depends on multiple systems. This can be challenging when testing routes that depend on AMQ brokers or an FTP server, for example. To simulate these endpoints, Camel provides the **`mock`** component to check the output of a route execution, and to act as a placeholder for any external systems that are not yet available. To use this component in a route, include a **`mock`** URI as a producer, as shown in the following example:

```
from("file:/tmp/orders")
.to("mock:inventoryManagement")
```

In the previous route, the test may access the **`/tmp/orders`** directory and store test files. The test method can access any mock endpoint and inspect the final outcome stored in the **`mock:inventoryManagement`** endpoint. Mock endpoints also have a variety of uses when you are testing your routes. Some of the benefits of mock endpoints is that they allow for inspection of what it processes, including:

• the number of exchanges received

• the contents of an exchange

• the headers from a message

After executing the route, the mock endpoint must check if these expectations were accomplished by calling the **`assertIsSatisfied`** method.

Camel also supports mechanisms to update the route definition during test execution to avoid hard coding a mock in a route. To do this, a test must change the route prior to starting the context by using the **`adviceWith`** method.

TESTING ROUTES WITH CAMEL ANNOTATIONS

To further facilitate developing test methods for routes and capture information from endpoints in a test, Camel supports testing with annotations. Due to its power and simplicity, annotations are the preferred approach to develop tests.

Camel provides the following classes to help with sending test messages to an endpoint, and to check the messages received by an endpoint:

• **`ProducerTemplate`**: enables developers to create exchanges, specifying headers and the body contents that are sent to a route.

• **`MockEndpoint`**: provides methods to set expectations and assertions about the output from a route processing; that is, the exchanges were sent through a route to a consumer endpoint.

• **`@Produce`**: attribute-level annotation that injects a **`ProducerTemplate`** instance in a test. The ProducerTemplate instance is an endpoint that you may send custom exchange to the route without the need to manually access it using the **`CamelContext`** objects.

• **`@EndpointInject`**: attribute-level annotation that injects an endpoint managed by Camel. Usually it is useful to access **`MockEndpoint`** instances and access the information stored in the endpoint, such as the exchange received, the header values from the exchange, and the number of messages received by that endpoint.

Camel provides the following annotations to inject components:
In the following **`RouteBuilder`** definition, a file endpoint reads information from a directory and sends them to a mock endpoint:

```
public class FileRouteBuilder extends RouteBuilder{

public void configure() throws Exception{

from("file:/tmp/orders")
.routeId("process")
.to("mock:inventoryManagement");

}
}
```

In the following test case, the previous **`RouteBuilder`** instance is used by the overridden **`createRouteBuilder`** method.
Access the **`file:/tmp/orders`** and the **`mock:inventoryManagement`** endpoints with the **`ProducerTemplate`** and the **`MockEndpoint`** instances respectively:

```
public class RouteTest extends CamelTestSupport {

@Produce(uri = "file:/tmp/orders")
 private ProducerTemplate template;

@EndpointInject(uri = "mock:inventoryManagement")
private MockEndpoint mock;

@Override
protected RouteBuilder createRouteBuilder() {
return new FileRouteBuilder();
}

@Test
public void testRoute(){

template.sendBodyAndHeader("file", Exchange.FILE_NAME, "testFile.txt");
GenericFile receiveBody = (GenericFile) mock.receiveBody();
//Assertions
}
```

SUBSTITUTING ENDPOINTS IN A ROUTE FOR TESTING PURPOSES

Any route that sends messages to an external system needs to be able to be tested without the external system. To solve this problem, endpoints can be substituted with mocks during unit test execution.

Camel supports changes to an existing route by calling the **`adviceWith`** method and passing, as an argument, an **`AdviceRouteBuilder`** instance to describe the changes that must be made before a test runs.

In the following **RouteBuilder** definition, a file endpoint reads information from a directory and sends them to a direct endpoint:

```
public class DirectRouteBuilder extends RouteBuilder{
public void configure() throws Exception{
from("file:/tmp/orders")
.routeId("process")
.to("direct:transformComma");
}
}
```

In the following code, the inherited attribute **context** captures a route definition and changes the route to divert messages to a different endpoint (**mock:direct:transformComma**).

```
public class RouteTest extends CamelTestSupport {

@Produce(uri = "file:/tmp/orders")
private ProducerTemplate template;

@Override
public boolean isUseAdviceWith() {
 return true;
}
@EndpointInject(uri = "mock:direct:transformComma")
 private MockEndpoint mock;
@Override
protected RouteBuilder createRouteBuilder() {
return new DirectRouteBuilder();
}
@Test
public void testRoute(){
   context.getRouteDefinition("process")
    .adviceWith(modelCamelContext, new AdviceWithRouteBuilder() {

 @Override
public void configure() throws Exception {

 interceptSendToEndpoint("direct:transformComma")
.skipSendToOriginalEndpoint()
.to("mock:direct:transformComma");

}});
}
```

Tells Camel that you intend to use **adviceWith** in this unit test.
Intercepts calls to an endpoint named **direct:transformComma**
Skips the original endpoint
Redirects to an endpoint named **mock:direct:transformComma**

The test case using **AdviceWithRouteBuilder** instances must override the **isUseAdviceWith** returning **true** in order to manually start the Camel context.
This tells the test runner to *not* start the Camel context automatically before starting the test methods. This way, a test can change the context before starting it, and prevents the routes processing exchanges before they are changed by the test.
A state left in the Camel context by one test may interfere with other tests in the same test suite. To avoid this, you must stop the Camel context on each test method.

EXPECTING EXCHANGES WITH NOTIFYBUILDER

The exchanges sent through a route can take some time to be processed, especially when the destination is an external system such as an FTP server or a message queue. For that reason, the route processing may require waiting during the route test execution until the exchange arrives to the final endpoint.

Camel uses **NotifyBuilder** to deal with delays. **NotifyBuilder** can be used as an assert function, because it can wait for any number of conditions in the context and its routes to be true, such as the quantity of exchanges to be fully processed.
A time limit can also be specified, and if the **NotifyBuilder** conditions are not satisfied during this time, it returns false.
The following code waits for one message for 5 seconds:

```
NotifyBuilder builder = new NotifyBuilder().whenDone(1).create();

Assert.assertTrue(builder.matches(5, TimeUnit.SECONDS));
```

IMPLEMENTING TESTS

When writing a test using the Camel Test Kit, it is important to do operations in a strict order to avoid race conditions and other timing issues. The following code follows the guideline:

```
@EndpointInject(uri="mock:cdg")
private MockEndpoint mockCdg;

@Test
public void testFileCamelRoute() throws Exception {
AdviceWithRouteBuilder mockRoute = new AdviceWithRouteBuilder() {

@Override

public void configure() throws Exception {
 interceptSendToEndpoint(
"file:orders/dest/cdg").skipSendToOriginalEndpoint().to("mock:cdg");
...
}
};
//Change routes using the adviceWith method
context.getRouteDefinition("process").adviceWith(context, mockRoute);
//Start the CamelContext instance.
context.start();

//Create and configure an instance of a NotifyBuilder.
//Use NotifyBuilder to wait and assert its conditions were matched

NotifyBuilder builder = new NotifyBuilder(context).whenDone(1).create();
builder.matches(2, TimeUnit.SECONDS);
//Send test exchanges using a ProducerTemplate or any other means.
fileOrders.sendBodyAndHeader(wholeContent,Exchange.FILE_NAME,"file.xml");
//Set expectations on all mock endpoints.
mockCdg.expectedMessageCount(1);
//Check whether the mock expectations were satisfied.
assertMockEndpointsSatisfied();
```

Not all of the above operations need to be done in all test cases, but when they are, it is recommended to follow the order of operations described.

TESTING PREDICATES USING MOCKS

The **`MockEndpoint`** class has three methods that allow predicate testing:

METHOD NAME
`assertPredicate(Predicate predicate, Exchange exchange, Boolean expected)`
`assertPredicateDoesNotMatch(Predicate predicate, Exchange exchange)`
`assertPredicateMatches(Predicate predicate, Exchange exchange)`

Each method is inherited by the **`CamelTestSupport`** class and is a static method.
There is also the name of methods start with the string expected can be used to set the expectations about the number of messages, exchange content, and other valid evaluations that are useful for checking the messages exchanged. Refer to Camel API documentation.

HANDLING ERRORS IN CAMEL

UNDERSTANDING ERROR TYPES IN CAMEL

Camel routes may capture errors by nature of an external system, such as network outages, file system permissions, and services unavailability due to maintenance. Error handling is a powerful method provided by Camel to avoid data corruption or provide alternative services (such as backup databases) to solve these problems.

Errors that occur during Camel route execution can be classified into two categories:

Recoverable errors

Errors raised due to temporary problems that can be solved by retrying the request, such as network instability or a database connection timeout. Normally the failure generates a Java exception and is stored as part of the **`Exchange`** object transmitted by a route.

Irrecoverable errors

Failures without an immediate solution, such as file system failures or database corruption. These errors enable a flag from the outgoing **`Message`** in the **`Exchange`** object transmitted by a route.

Both error types should occur within the route processing and not outside, such as an endpoint. Usually failures from an endpoint are not even evaluated by Camel error handling facilities; however, some components, such as camel-file and camel-jpa, manage error handling internally.

Camel identifies recoverable errors during route processing, and manages these errors automatically, stopping the execution and propagating the error to the caller. This behavior is implemented by a Camel error handler implementation, but it can be customized to support redelivery attempts.

By default, irrecoverable errors are not handled by the Camel error handlers, but they can be enabled using a flag. This error is translated into an exception, similar to the recoverable errors. A Camel user can set this flag manually to halt the processing of an exchange and tell Camel to not attempt any redelivery or other error recovery behavior. Camel error handlers are executed within each step in a route and are part of a **`Channel`**. If a failure happens in one step of a route, the previous **`Channel`** captures the error and transmits it to the error handler that is configured.
IMPORTANT
Any modifications made to the **`Exchange`** object before the failing step are left unchanged.

CUSTOMIZING CAMEL ERROR HANDLING

You may define an error handler that can be used in all routes. By default, Camel provides a default error handler that does not redeliver exchanges, and notifies the caller about the failure.
The error handler can be customized for each route, calling the **`errorHandler`** method in the route definition:

```
public class MyRoute extends RouteBuilder{
public void configure() throws Exception{

from("file:inputDir")
.errorHandler(...)
.to(...)

}
}
```

For a Spring-based configuration:

```
<errorHandler id="myErrorHandler" type="ErrorHandlerName"/>
<route id="firstRoute" errorHandlerRef="myErrorHandler">
...
</route>
```

Alternatively, the error handler can be set for a context scope, calling the **errorHandler** method inherited by the **RouteBuilder** class:

```
public class MyRoute extends RouteBuilder{
public void configure() throws Exception{

 errorHandler(...);
 from("file:inputDir")
.to(...)

}
}
```

For a Spring-based configuration:

```
<camel:errorHandler id="myErrorHandler" type="ErrorHandlerName"/>
<camel:camelContext errorHandlerRef="myErrorHandler"
xmlns="http://camel.apache.org/schema/spring">
...
</camel:camelContext>
```

Camel implements four error handlers that you can use in your routes:

DefaultErrorHandler
Does not redeliver exchanges and notifies the caller about the failure.

LoggingErrorHandler
Logs the exception to the default output.

NoErrorHandler
Disables the error handler mechanism.

DeadLetterChannel
Implements the dead letter channel enterprise integration pattern (EIP).

DefaultErrorHandler

The **DefaultErrorHandler** class does not require any configuration or code to activate. By default, the error raised during the route execution is sent back to the caller, with the changes made during the successful step. If any other error handler is configured as the default, the route can be customized to use it, calling the **errorHandler(defaultErrorHandler())** within a route declaration.

```
from(". ..... ")
.errorHandler(defaultErrorHandler())
.to(". ..... ");
```

LoggingErrorHandler

The **LoggingErrorHandler** class is an error handler where all exceptions are sent to the logging facility. All errors are sent to a category named **org.apache.camel.processor.LoggingErrorHandler** and with an **ERROR** level. To activate it:

```
from(". ..... ")
.errorHandler(loggingErrorHandler())
.to(". ..... ");
```

NoErrorHandler

The **NoErrorHandler** class is an error handler without any error management, and is a workaround to disable the mandatory error handling imposed by Camel. To activate it:

```
from(". ..... ")
.errorHandler(noErrorHandler())
.to(". ..... ");
```

DeadLetterChannel

The **DeadLetterChannel** class is an error handler using the dead letter channel EIP. The differences from the **DefaultErrorHandler** are:

• The exchange with problems is sent to a different destination from the caller.

• The exchange does not store the generated exception.

The exchange with problems can be evaluated by another route. To activate it:

```
from(". ..... ")
.errorHandler(deadLetterChannel("destination"))
.to(". ..... ");
```

For a Spring-based route, the configuration requires the URI with the destination for exchanges with errors:

```
<camel:errorHandler id="myErrorHandler" type="DeadLetterChannel" deadLetterUri="destination"/>
<camel:route id="firstRoute" errorHandlerRef="myErrorHandler">
...
</camel:route>
```

CONTROLLING ERROR HANDLING USING THE ONEXCEPTION EXCEPTION CLAUSE

Camel error handlers represent a standard approach to handle every error thrown by the route. Unfortunately, this approach is not useful in most integration systems, since it does not allow custom error handling based on a specific condition. For example, a business rule error should not be re-executed, but a network instability error can be re-executed.
Camel implements a case-by-case exception management policy, customizing routing and redelivery policies, using the **`onException`** method call.
In the following route, if a **`LogException`** is raised, Camel sends the exchange to a different route, otherwise the default routing logic is used.

```
public class JavaRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {
 onException(LogException.class).to("file:log");
  from("file:in")
...
}
}
```

The **`onException`** method accepts alternative redelivery mechanisms:

```
public class JavaRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {
onException(LogException.class)
.to("file:log")
.maximumRedeliveries(3);

from("file:in?noop=true")
...
}
}
```

In the previous example, if a **`LogException`** is thrown during the routing execution, it attempts the redelivery three times, which is different from the default error handler.

To avoid multiple declarations, Camel allows multiple exceptions in a unique **`onException`** method call:

```
onException(LogException.class, DeliveryException.class)
.to("file:error");
```

Similarly, to use **`onExcpetion`** in a Spring XML Camel route use the **`<onException>`** XML tag as shown in the following example:

```
<camelContext xmlns="http://camel.apache.org/schema/spring">

<onException>
<exception>javax.xml.xpath.XPathException</exception>
<exception>javax.xml.transform.TransformerException</exception>
<to uri="log:xml?level=WARN"/>
</onException>

<onException>
<exception>java.io.IOException</exception>
<exception>java.sql.SQLException</exception>
<exception>javax.jms.JMSException</exception>
```

```
<redeliverPolicy maximumRedeliveries="5" redeliveryDelay="3000"/>
</onException>
</camelContext>
```

Marking an Exception as Handled

Unless you specifically mark an exception as handled, it will always be returned to the caller. In order to prevent this behavior Camel provides the **`handled`** DSL method, which supports a predicate parameter to which can be set to true explicitly or set based on a dynamic expression. The following example shows marking an exception as handled:

```
onException(Exception.class)
.handled(true)
.setHeader(Exchange.HTTP_RESPONSE_CODE, constant(500))
.setBody(simple("${exception.message}\n"));
```

Exception selection

Camel always looks for the specific exception among the **`onException`** declarations. If it is not found, Camel looks for the exception hierarchy in a similar fashion to the Java exception management. For example, in the following exception hierarchy:

```
Exception.class
+-DeliveryException.class
+-AddressNotFoundException.class
```

If an **`AddressNotFoundException`** exception is thrown and there is only exception handling to route a **`DeliveryException`** exception, Camel uses the exception handling for a **`DeliveryException`** exception.

Redelivery management

For each **`onException`** method call, Camel uses the default error handler values, even if other values were specified for the route itself. For example, in the following **`onException`** method call:

```
public class JavaRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {

onException(LogException.class)
.to("file:log");


from("file:in?noop=true")
.errorHandler(defaultErrorHandler().maximumRedeliveries(5))
...
}
}
```

Even though for the route there is a maximum of five redeliveries, the **`onException`** method call does not consider five as the maximum number of re-deliveries. It uses the default values from the default error handler management.

Finally, it is possible to mix **`onException`** definitions with more general **`errorHandler`** definitions. In this case, exceptions that are not explicitly handled by an **`onException`** block will fall to the generic **`errorHandler`** behavior. The following example shows using both in a Java DSL Camel route:

```
errorHandler(defaultErrorHandler()
.maximumRedeliveries(3)
.redeliveryDelay(2000));

onException(IOException.class)
.maximumRedeliveries(5);

from("file://orderservice")
.to("netty4:tcp://service.example.com:4444?textline=true")
.bean("orderBean", "prepareReply");
```

TRY/CATCH DSL

When a **RouteBuilder** is declared, Camel executes it only once during the route building process. For each piece of data processed by Camel, the **RouteBuilder** is not executed as ordinary Java code. Therefore, the ordinary try/catch/finally Java mechanism does not work.
However, there is an alternative way to declare the exception management, using a syntax similar to Java code: **doTry/doCatch/doFinally**:

```
public class JavaRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {
from("file:in?noop=true")
.doTry()
.process(new LogProcessor())
.doCatch(LogException.class)
.process(new FileProcessor())
.end();
...
}
}
```

The **doTry/doCatch/doFinally** approach is a useful way to implement logic to solve the problem that is not only diverting the route to another destination. In the previous example, the **FileProcessor** may update the file processed by the **file:in** endpoint to change the file name to something like ***filename*-error.xml**.

Unlike the catch clause in Java, Camel's doCatch supports two important features. First, **doCatch** allows multiple exception types to be defined in a single block as shown below:

```
from("direct:start")
.doTry()
.process(new ProcessorFail())
.to("mock:result")
.doCatch(IOException.class, IllegalStateException.class)
.to("mock:catch")
.doFinally()
.to("mock:finally")
.end();
```

Additionally, **doCatch** checks the exception hierarchy when it matches a thrown exception against the **doCatch** block. This is important because many times the original caused exception is wrapped by other wrapper exceptions, typically transposing the exception from a checked to a runtime exception.

For example, Camel itself does this by wrapping exceptions occurring during route execution into a **CamelRuntimeException** exception. Therefore, if the original exception was an **IOException** exception, then the **doCatch** defined for **IOException** still matches, even though it is wrapped by a **CamelRuntimeException** exception.

Spring DSL also supports **doTry**, **doCatch**, and **doFinally**, as in the following example:

```
<route>
<from uri="direct:start"/>
<!-- here the try starts. its a try .. catch .. finally just
as regular java code -->
<doTry>
 <process ref="processorFail"/>
 <to uri="mock:result"/>

<doCatch>
<!-- catch multiple exceptions -->

<exception>java.io.IOException</exception>
<exception>java.lang.IllegalStateException</exception>
<to uri="mock:catch"/>

</doCatch>

<doFinally>
  <to uri="mock:finally"/>

</doFinally>
</doTry>
</route>
```

ROUTING WITH JAVA BEANS

GOAL

Create dynamic routes in Camel using Java Beans

OBJECTIVES

• Create Java Beans for use in routing and transforming messages.

• Implement routes that include dynamic routing with CDI.

• Execute bean methods within DSL predicates.

DEVELOPING ROUTES WITH JAVA BEANS AND BEAN REGISTRIES

INVOKING BEANS

In many cases, developers need a way to call bean methods within a Camel route. This approach is useful for abstracting business logic required within a route, such as a method that calculates the tax for a product. By abstracting out this method, the Camel route becomes more readable and more maintainable. A Camel route can invoke a bean using multiple mechanisms, either as an endpoint or using a processor. There are two major mechanisms to invoke any bean in Camel: bean DSL and the bean component.

Bean DSL

Camel provides a method that can be used to invoke any bean. It is usually called in a route, and provides two overloaded versions that are commonly used:

• **`bean(<Class>)`** : Accepts a class as a parameter to refer to any existing class available in the class path. If multiple methods are declared in the class, Camel executes the one that can handle a Camel body.

• **`bean(String)`** : Accepts a String as a parameter to refer to a class in the bean registry.

Either method has another overload with a second String argument, which refers to the method that should be called.

Bean Component

Camel supports a call to a bean with the bean component. It provides a semantic similar to any component, and it may be called in a **`to`** method call. In the following example, the bean named "**`test`**" is invoked in the route execution.

to("bean://test");

DECLARING JAVA BEANS

As mentioned previously, Camel is able to reference beans through one of several different approaches. By not adhering to a single approach, such as just using CDI, Camel makes integration easier. As a result, it is not required for Camel developers to be able to use each of these methods, rather stick with the approach that is best suited for the existing development environment. The following are some of the approaches Camel supports for bean initialization:

ApplicationContextRegistry

This is the default approach for a bean registry when using Camel with Spring. Using the **`camelContext`** element requires no additional work to declare or initialize beans, because Spring handles the bean lookup without any configuration.

Java Import

Camel can refer to regular Java classes by using the **`bean`** method call. In the following example, the **`TransformBean`** class is used by Camel, even though it is not configured in the Spring beans configuration file.

```
from("file://originSelectMethod")
.bean(TransformBean.class)
```

CDI

When using Context Dependency Injection (CDI), Camel is able to recognize any bean annotated with one of the CDI annotations. The following is an example CDI bean:

```
@Singleton
@Named("taxBean")
public class TaxCalculator{
public String processTax(String data) throws Exception {
   return "value";
}
}
```

The **`taxBean`** is called in this route without requiring additional configuration:

```
@Singleton
public class TaxRoute extends RouteBuilder {
public void configure() throws Exception {
 from("file:in?noop=true")
.bean("taxBean")
.to("file:out")
}
}
```

Spring XML

Camel can use any bean declared in its configuration file by ID. In the following example, the configuration file refers to a bean:

```
<beans ...>
     <bean id="configFile" class="com.redhat.training.jb421.ConfigurationFile" />
</beans>
```

It may be referred by a route using the following syntax:

.to("bean://configFile")

CALLING BEAN METHODS

To invoke a Java bean in a Camel route, use the **`bean`** method. The syntax for this method is the following:

bean(beanName, "beanMethodName")

The first parameter refers to the name of the bean and the second optional parameter refers to the name of the method to call in the bean. Camel bean method invocation looks for a method that processes a compatible input. It is therefore not required to specify a method name if only a single method is available that matches the compatible input. If any conflict is found, Camel throws an **`AmbiguousMethodCallException`**. To remove this ambiguity, specify the method name within the **`bean`** method.
In the following bean, two methods are declared. Both are similar due to their parameters and return type.

```
public class TaxCalculator{

public String processTax(String data) throws Exception {

  return "value";

}
public String processTotalValue(String data) throws Exception {

 return "result";

}
}
```

Camel solves this ambiguity by using the following method call that specifically references the desired **`processTotalValue`** method:

```
public class TaxRoute extends RouteBuilder {
@Autowired
private TaxCalculator calculatorBean;

public void configure() throws Exception {
   from("file:in?noop=true")
    .bean(calculatorBean,"processTotalValue")
   .to("file:out")
} }
```

EXECUTING METHODS ON JAVA OBJECTS INSIDE A CAMEL ROUTE

Executing a bean method from a route without parameters is very limiting. Camel provides an approach that allows users to pass in a parameter to a bean method, providing further flexibility within routes. In our previous route, for example, a method is called to calculate total cost of a product. In order to do this, the bean method must be able to access the message data in order to determine the cost of the product.
The argument that is passed to the method bean must meet the following requirements:

• The parameter is compatible with the exchange processing body. • The bean's method return is compatible with Camel's transformation classes.

Be default, Camel binds the body of the message to the first parameter in the invoked bean method. This means that the **`bean`** method header must declare a parameter that is able to accept the message body, such as **`String messageBody`**.

In the following example, a single method is declared in the Java bean. Camel sends the message body as the method argument and returns the resulting processing back to the route.

```
package com.redhat.training;
```

```
public class TaxCalculator{

public String processTax(String data) throws Exception {
  double value=Double.parseDouble(data)*0.06;
  return ""+value;
}
}
```

The class is configured as a bean in Spring beans configuration file:

```
<beans... >
<bean id="taxCalculator" class="com.redhat.training.TaxCalculator" />
...
</beans>
```

The bean method is then referenced in the following XML route definition:

```
<beans ...>
<camelContext xmlns="http://camel.apache.org/schema/spring">
<route>
  <from uri="file:in"/>
  <bean ref="taxCalculator"
        method="processTax" />
  <to uri="file:out"/>
</route>
</camelContext>
</beans>
```

The following is the same route defined in the Java DSL using the bean component:

```
from("file:in?noop=true")
.to("bean://taxCalculator?method=processTotalValue")
```

PARAMETER BINDING

A method with one argument only processes the body of the **`Message`** object. If you want to either pass in an additional parameter or process other exchange information, such as message headers, you must use Camel parameter binding.
Camel automatically binds the following values that can be leveraged within a method call:

- **`Exchange`**: The exchange used to transport data in a Camel route.
- **`Message`**: The input message.
- **`CamelContext`**: The **`CamelContext`** instance.
- **`TypeConverter`**: To use a specific data converter during the route execution in Camel.
- **`Registry`**: To obtain during the route execution beans stored in the registry.
- **`Exception`**: To capture exceptions raised during the route execution.

In the following method, a message is passed as an argument:

```
public class TaxCalculator {
public String processTotalValue(Message message) throws Exception {
...
}
}
```

Camel provides annotations to extract data from a message instead of using the Camel API inside the bean class.

```
public class TaxCalculator {
public String processTotalValue(@Body String data ,
@Header("CamelFileNameOnly") String filename )
throws Exception {
...
}
}
```

The following annotations are available:

- **`@Attachments`**: Associates the method parameter to the message attachments.

• **`@Body`**: Binds the parameter to the message body.

• **`@Header(name)`** Binds the parameter to the given message header.

• **`@Headers`**: Binds the parameter to all the input headers.

• **`@OutHeaders`**: Binds the parameter to the output headers.

The **`@Attachments`**, **`@Headers`**, **`@OutHeaders`**, and **`@Properties annotated`** parameter types should be a **`java.util.Map`**.

Camel also allows for message contents to be processed using annotations.

• **`@Bean`**: Invokes a method on a bean.

• **`@Simple`**: Evaluates a Simple EL.

• **`@XPath`**: Evaluates an XPath expression.

IMPLEMENTING RECIPIENT LIST PATTERN

The recipient list EIP is an integration pattern wherein a message is routed to multiple destinations in parallel. Similar to the Content-based Router, this pattern determines the destination based on the content of the message, however that destination is a dynamic list of recipients.
A use case for this pattern is when a customer process returns, and the route needs to check with nearby warehouses for stock availability. The recipient list is generated based on the location of the customer processing the return and each warehouse is sent the return order to see if room is available for storage.

In Camel, the list of recipients is stored in the message header. The following example shows a file sent to a number of recipients, according to the contents of its header **`destination`**.

```
public class JavaRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {
  from("file:in")
  .recipientList(header("destinations"));
}
}
```

A list of recipients can be obtained directly from the header named **`destinations`**.
As mentioned previously, the list of recipients is dynamically generated based on the content of the message. A **`Processor`** class can be used to create the header contents to create this list of recipients:

```
public class DestinationBean implements Processor{
public void process(Exchange exchange) throws Exception {
Message in = exchange.getIn();
String recipientList="";
String fileName = (String)in.getHeader("CamelFileNameOnly");
String[] destination = fileName.split("-");
if ("toyota".equals(destination[0])){
recipientList = recipientList.concat("file:toyota");
} else if("gmc".equals(destination[0])){
recipientList = recipientList.concat("file:gmc");
} else {
recipientList = recipientList.concat("file:gmc,file:toyota");
}
in.getHeaders().put("destinations", recipientList);
}
}
```

The logic in the **`Processor`** class determines the destination of the file based on the initial file name. If the pattern is not found, the file is published to all destinations available.
The following code executes the route and uses the recipient list component and the **`destinations`** property on the message header to determine the list of recipients:

```
public class JavaRouteBuilder extends RouteBuilder {
@Override
public void configure() throws Exception {
 from("file:in")
```

```
 .bean(DestinationBean.class)
 .recipientList(header("destinations"));
}
}
```

DEMONSTRATION: IMPLEMENTING THE RECIPIENT LIST PATTERN

ROUTING WITH ROUTING SLIP

In a route, there are occasionally multiple steps required to complete route processing. If these intermediate steps are endpoints, the whole route is considered a *pipeline*.

One common integration problem is that this pipeline isn't static and is not always predetermined. For example, consider a pipeline that processes security checks for a credit card company. A message containing purchase information sent from the same zip code as the user does not require additional security checks, but an international purchase requires additional endpoints in the pipeline to verify that the purchase is not fraudulent.

The **Routing Slip EIP** is an integration pattern used to route a message consecutively through a series of processing steps where the sequence of steps is not known at design time and can vary for each message. The pattern calculates the pipeline in a single method call based on the message. To support this pattern, Camel has a **`routingSlip`** method. The method requires a predefined **`header`** containing a comma-separated list of endpoints that are to be used in the exchange processing:

```
from("jms:inbox").routingSlip(header("destination"));
```

In this example, the header must have a header with a key named **`destination`**. If that header has a value of "**`file://output,ftp://infrastructure/labs`**", then the routing slip processes the file endpoint first and then the FTP endpoint.

ROUTING WITH DYNAMIC ROUTER

Similar to the Routing Slip, the dynamic router EIP supports a dynamic route based on a message. A dynamic router, however, does not require this list to be predetermined, as with the routing slip.

To enable the dynamic router, create a method to calculate the route URL that returns a **`String`**. Each time the endpoint process finishes, the route is recalculated by the same method.

```
dynamicRouter(method(DestinationBeans.class,"execute"));
```

ROUTING WITH TOD() DSL

If the route needs to be dynamic for only a single destination, Camel supports an easier approach with the **`toD`** DSL. In this method, the parameter can be a **`String`** or an Simple EL expression that resolves to a destination.
For instance, the following method resolves the key named destination from the exchange header to identify the destination.

```
toD("${header.destination}");
```

This example requires that the header contains a key named **`destination`** with a value that resolves to an endpoint URL.

CHAPTER 6

IMPLEMENTING REST SERVICES

GOAL

Enabling REST support in Camel with the Java REST DSL

OBJECTIVES

• Create a route that hosts a REST Service using the REST DSL.

• Consume HTTP resources to implement the content enricher pattern.

• Document a REST service using the REST DSL integration with Swagger.

IMPLEMENTING A REST SERVICE WITH THE REST DSL

INTRODUCING THE REST DSL API

Beginning in version 2.14, Camel offers a REST DSL which can be used in Java or XML route definitions to build REST web services. The REST DSL allows end users to define REST services in Camel routes using verbs that align with the REST HTTP protocol, such as **`GET`**, **`POST`**, **`DELETE`**, and so on.

This drastically reduces the amount of development time necessary to build REST services into your Camel routes by eliminating a lot of the boilerplate networking code, and allowing you to focus on the business logic that supports the REST service.

The REST DSL is a facade supporting multiple REST component implementations, including **`camel-spark-rest`**, **`camel-undertow`**, and others. The DSL builds REST endpoints as consumers for Camel routes. The actual REST service implementation is provided by other Camel components, such as Restlet, Spark, and others that include REST integration.

The following is an example of the REST DSL in use in a Java route definition:

```
public class HelloRoute extends RouteBuilder {
public void configure() throws Exception {
 restConfiguration()
 .component("spark-rest")
 .port(8080);

rest("/speak")
  .get("/hello")
    .transform().constant("Hello World");
}
}
```

The REST DSL works as an extension to the existing Camel routing DSL, using specialized keywords to more closely resemble the underlying REST and HTTP technologies. These keywords are mapped directly into the existing Camel DSL, meaning that the REST DSL provides a simple syntax that extends Camel's existing DSL. This also means that all existing functionality of a normal Camel route is available inside of a REST DSL defined route, enabling REST developers to leverage EIPs and other Camel features to implement their service.

CONFIGURING THE REST DSL

When using the REST DSL, you need to specify which of the REST DSL capable components handle the requests made to the REST services. Each of the underlying implementations is different, but their functionality as it relates to the REST DSL is largely the same. Each component
offers slightly different options, depending on your use case, you may find one to work better than another. This course focuses on **`camel-spark-rest`**, but all of the concepts taught here should apply to the other REST DSL supported components. The following are some of the components that currently support the REST DSL:

- **`camel-jetty`**: Uses the Jetty HTTP server

- **`camel-restlet`**: Uses the Restlet library

- **`camel-spark-rest`**: Uses the Java Spark library

- **`camel-undertow`**: Uses the JBoss Undertow HTTP server

In order to specify the REST implementation used by the REST DSL, and other behavior as well, a separate DSL element, the **`restConfiguration`** DSL method is provided. Using this element, a number of options can be set to control the resulting REST service created by Camel, as shown in the following example:

```
restConfiguration()
        .component("spark-rest")
        .contextPath("/restService")
        .port(8080);
```

Or similarly in the XML DSL:

```
<restConfiguration component="spark-rest" contextPath="/restService" port="8080"/>
```

Because the REST DSL is not an implementation, only a subset of the options common to all implementations, most options are specific to the REST component used by the DSL. The following is a table of the common options across all components:

OPTION	DESCRIPTION
`component`	The Camel component to use as the HTTP server. Options include **`jetty`**, **`restlet`**, **`spark-rest`**, and **`undertow`**.
`scheme`	The HTTP scheme to use, HTTP or HTTPS. HTTP is the default.
`hostname`	The host name or IP where the HTTP server is bound.
`port`	The port number to use for the HTTP server.
`contextPath`	The base context path for the HTTP server.

You can also set options on the **`restConfiguration`** DSL element to configure the component, endpoint, and consumer specifically. Because these can vary from component to component, to set these options you need to use a generic DSL element shown in the following table:

OPTION TYPE	DSL ELEMENT
component	**`componentProperty`**
endpoint	**`endpointProperty`**
consumer	**`consumerProperty`**

To use any of these properties, you must set a key and value, where the key corresponds to the name of a property available for that component, endpoint, or consumer. An example of when this could be used is to set the minimum and maximum threads for the Jetty server as shown in the following example:

```
restConfiguration()
.component("jetty").port(8080)
.componentProperty("minThreads", "1")
.componentProperty("maxThreads", "8");
```

DEVELOPING WITH THE REST DSL

After you have configured the component for the REST DSL to use, adding a REST service definition to your Camel route is simple. First, define the set of services with the **`rest`** element, and set the context path that is specific to this set of services.

You can then define individual services using REST DSL methods such as **`get`**, **`post`**, **`put`**, and **`delete`**. You can also define path parameters using the {} syntax for each service. The following example **`RouteBuilder`** class shows a set of four services defined with the REST DSL:

```
public class OrderRoute extends RouteBuilder {
public void configure() throws Exception {
 restConfiguration()
 .component("spark-rest").port(8080);

rest("/orders")
 .get("{id}")
        .to("bean:orderService?method=getOrder(${header.id})")
 .post()
        .to("bean:orderService?method=createOrder")
 .put()
        .to("bean:orderService?method=updateOrder")
 .delete("{id}")
        .to("bean:orderService?method=cancelOrder(${header.id})");
}
}
```

Maps to any HTTP GET requests received at `http://localhost:8080/orders/id`
Maps to any HTTP POST requests received at `http://localhost:8080/orders/`
Maps to any HTTP PUT requests received at `http://localhost:8080/orders/`
Maps to any HTTP DELETE requests received at `http://localhost:8080/orders/id`

CUSTOMIZING THE REST PAYLOAD WITH DATA BINDING

The REST DSL supports automatic binding of XML and JSON data to POJOs using Camel's data formats. This means incoming JSON or XML data is automatically unmarshaled into model objects so that any processing done inside the service can use your Java model classes instead of raw JSON or XML data. For example, a service that consumes new order records in JSON format can automatically unmarshal that JSON into the **`Order`** model class for easier processing by subsequent components in the Camel route.

Binding with the REST DSL supports the modes listed in the following table and they are defined in the **`org.apache.camel.model.rest.RestBindingMode`** enumeration:

REST DSL Binding Modes

MODE	DESCRIPTION
`off`	Binding is turned off. This is the default.
`auto`	Binding is automatic, assuming the necessary data formats are available on the class path. Typically based on the **`Content-Type`** header.
`json`	Binding to and from JSON is enabled and a JSON compatible data format is required, such as camel-jackson.
`xml`	Binding to and from XML is enabled, requires camel-jaxb on the class path.
`json_xml`	Binding to and from JSON and XML are both enabled. Requires both data formats to be available on the class path.

Similar to other configurations for REST DSL, the binding mode is set on the **`restConfiguration`** element, as shown in the following example:

```
restConfiguration()
.component("spark-rest").port(8080)
.bindingMode(RestBindingMode.json)
```

```
.dataFormatProperty("prettyPrint", "true");
```

Also, similar to component or endpoint properties, data format properties specific to the data format you are using can be set generically using **`dataFormatProperty`**. In the previous example, Jackson's **`prettyPrint`** option is set to **`true`** using a data format property that formats the JSON output in a human-readable format.

IMPLEMENTING REST APIS WITH SPARK

The **`spark-rest`** component allows Camel to define REST endpoints using the Spark REST Java library using REST DSL. To use this component, include the following Maven dependency in your **`pom.xml`** file:

```
<dependency>
        <groupId>org.apache.camel</groupId>
        <artifactId>camel-spark-rest</artifactId>
</dependency>
```

To enable the spark-rest component with REST DSL, specify it in the **`component`** option on the **`restConfiguration`** DSL element as shown in the following example:

```
restConfiguration()
 .component("spark-rest")
 .port(8080);
```

MANAGING ERRORS RAISED BY REST APIS USING ONEXCEPTION

When you develop a REST API, sometimes it is necessary to catch exceptions that occur during processing and return the correct HTTP error code along with an optional message with more information.
For example, if a service supports getting a customer by ID, and an ID is passed in that does not match any of the customers in the database, an HTTP 204 code (not found) must be returned. This is simple with Camel's built-in **`onException`** DSL element. You are only required to define the error code and body to be returned for each exception you want to handle.
The following example demonstrates handling errors in a REST DSL service:

```
restConfiguration()
.component("undertow").port(8080)
.bindingMode(RestBindingMode.json)
.dataFormatProperty("prettyPrint", "true");

onException(CustomerNotFoundException.class)
 .handled(true)
 .setHeader(Exchange.HTTP_RESPONSE_CODE, constant(204))
 .setBody(constant("No customer found."));
```

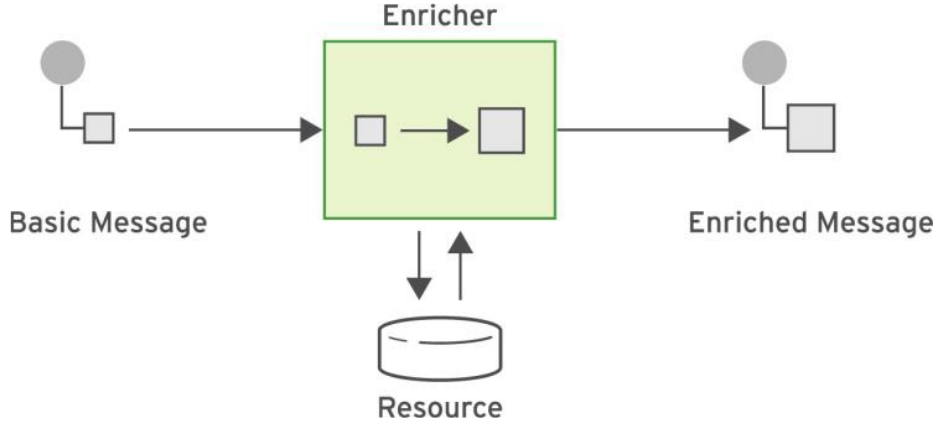
DEMONSTRATION: IMPLEMENTING A REST SERVICE WITH THE REST DSL API

CONSUMING REST SERVICES WITH THE HTTP COMPONENT

IMPLEMENTING THE CONTENT ENRICHER PATTERN

When sending messages or data from one system to another, it is common for the target or receiving system to require more information than the source or sending system can provide.

For example, the source system's data may only contain a customer ID, but the receiving system actually requires the customer's name and address. Additionally, an order message sent by the order management system may only contain an order number, but you need to find the items associated with that order, so that you can pass it to the order fulfillment system. In these situations, use the *content enricher pattern* in your Camel route to enrich or enhance your message exchange with the required additional data.



Camel supports the content enricher pattern using the **`enrich`** DSL method to enrich the message as shown in the following example:

```
from("direct:start")
  .enrich("direct:resource" , aggregationStrategy )
  .to("direct:result");

from("direct:resource")
...
```

The **`enrich`** DSL method has two parameters, the first is the URI of the producer Camel must invoke to retrieve the enrichment data.
The second parameter is an optional instance of the **`AggregationStrategy`** implementation that you must provide for Camel to use to combine the original message exchange with the enrichment data. If you do not provide an aggregation strategy, Camel uses the body obtained from the resource as the enriched message exchange.

The **`enrich`** DSL method uses a Camel producer to obtain some additional data. This producer is invoked synchronously. The **`enrich`** method retrieves additional data from a *resource endpoint* in order to enrich an incoming message (contained in the *original exchange*). The **`enrich`** method then uses an aggregation strategy to combine the original exchange and the *resource exchange*.

The first parameter of the **`aggregate`** method from the **`AggregationStrategy`** implementation corresponds to the original exchange and the second parameter to the resource exchange. Here is an example template for implementing an aggregation strategy to use with the **`enrich`** DSL method:

```
public class ExampleAggregationStrategy implements AggregationStrategy {

public Exchange aggregate(Exchange original, Exchange resource) {
```

```
Object originalBody = original.getIn().getBody();
Object resource = resource.getIn().getBody();
Object mergeResult =...// combine original body and resource response if
(original.getPattern().isOutCapable()) {
original.getOut().setBody(mergeResult);
}
else {
  original.getIn().setBody(mergeResult);
}
  return original;
}
}
```

CONSUMING WEB RESOURCES AND REST SERVICES USING THE HTTP COMPONENT

Hypertext Transfer Protocol (HTTP) is widely used by websites to distribute content. Due to its simple nature and format, it has been widely used to integrate systems, and it's use is required when connecting to remote web services. Camel provides the **`http`** component to integrate with other technologies over HTTP. This component is able to consume contents from an HTTP server, or even use **`GET`** and **`POST`** HTTP methods with a REST service to retrieve or create data.

The **`http`** component is provided by the **`camel-http`** library and its endpoint URI format is `http[s]://hostname[:port][/resourceURI][?options].`

To import the **`camel-http`** library include the following configuration in **`pom.xml`** file:

```
<dependency>
<groupId>org.apache.camel</groupId>
<artifactId>camel-http</artifactId>
</dependency>
```

Camel always uses the **`InOut`** message exchange protocol due to the HTTP protocol nature (based on a request/response paradigm). Additionally, the library supports HTTP over Secure Socket Layer (SSL) to use encryption over the HTTP protocol.
The endpoint URI format is:

http:[hostname][:port][/resourceUri][?param1=value1][&param2=value2]

Camel uses the following algorithm to determine if either the **`GET`** or **`POST`** HTTP method should be used:
1. The method provided in header field named **`Exchange.HTTP_METHOD`**.

2. **`GET`** if query string is provided in header **`Exchange.HTTP_QUERY`**.

3. **`GET`** if endpoint is configured with a query string.

4. **`POST`** if there is data to send (body is not null).

5. **`GET`** otherwise.

Therefore, by default, depending on the content contained in the body of the **`inMessage`** object on the exchange, Camel either:
• Sends an HTTP **`POST`** request to the URL using the exchange body as the body of the HTTP request and returns the HTTP response as the **`outMessage`** object on the exchange, if there is message content.

• If the body is **`null`**, sends an HTTP **`GET`** request to the URL and returns the response as the

`outMessage` object on the exchange.
URI parameters can either be set directly on the endpoint URI or as a header, as follows:

```
from("direct:start")
.to("http://example.com?order=123&detail=short");
```

```
from("direct:start")
.setHeader(Exchange.HTTP_QUERY, constant("order=123&detail=short"))
.to("http://example.com");
```

When you use the **camel-http** component, Camel can throw an exception depending on the HTTP response code returned by the external resource:
• If the response code is from 100 to 299, then Camel regards it as a success.

• If the response code is 300 or greater, then Camel regards it as a redirection response or a server failure, and throws an **HttpOperationFailedException** exception with any error messages attached to the response.

The option **throwExceptionOnFailure** can be set to **false** to prevent the **HttpOperationFailedException** exception from being thrown for failed response codes. This option allows you to get any response code from the remote server without Camel throwing an exception. The following example route demonstrates this:

```
from("direct:start")
.setHeader(Exchange.HTTP_QUERY, constant("order=123&detail=short"))
.to("http://example.com&throwExceptionOnFailure=false");
```

ENRICHING A MESSAGE EXCHANGE USING THE HTTP COMPONENT

You can easily use the **camel-http** component in conjunction with the content enricher pattern to update your message exchanges with data from an external web resource. You could use this to retrieve some relevant data from an external system exposed over HTTP. This approach is especially helpful in a microservices-based environment. The following example implements this use case:

```
from("activemq:orders")
  .enrich("direct:enrich" , new HttpAggregationStrategy())
  .log("Order sent to fulfillment: ${body}")
  .to("mock:fulfillmentSystem");

from("direct:enrich")
 .setBody(constant(null))
 .to("http://webservice.example.com");
```

The URI for the producer that the **enrich** DSL element invokes to retrieve the resource message.

The **AggregationStrategy** implementation that the **enrich** DSL element uses to combine the original message exchange and the resource message.

The URI for the consumer that the **enrich** DSL element invokes.

Set the body of the exchange to **null** so that the HTTP component sends an HTTP GET request to the resource.

The URI for the HTTP component producer is the address of the external web service.

In the Camel route from the previous example, the implementation of **HttpAggregationStrategy** that Camel uses to create the enriched message is shown in the following example:

```
public class HttpAggregationStrategy implements AggregationStrategy{
@Override
public Exchange aggregate(Exchange original, Exchange resource) {
Order originalBody = original.getIn().getBody(Order.class); String
resourceResponse = resource.getIn().getBody(String.class);
originalBody.setFulfilledBy(resourceResponse);
return original;
}
}
```

Retrieve the original message exchange body as an instance of the **Order** model class.

Retrieve the resource message exchange body as a Java **String**.

Set the response as the **fufilledBy** property on the **Order** object.