

Apache Camel

Dr Phill Edwards

phill.edwards@dr-phill-edwards.eu

May 29, 2025

Apache Camel

Introduction to Apache Camel

What is Apache Camel?

Exercise

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

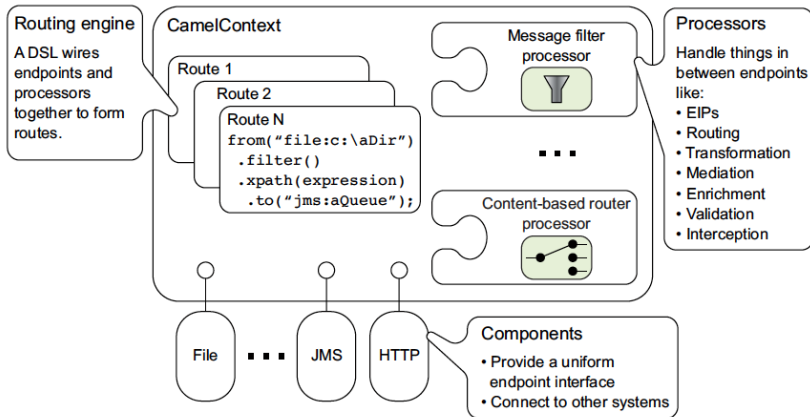
Apache Camel

- Apache Camel is an integration framework
- It implements Enterprise Integration Patterns
- Rules can be defined in Domain Specific Languages (DSL)
- DSLs are Java, XML, Groovy and YAML
- The online documentation is rather vague!

Apache Camel

- It uses URLs to work with transport or messaging models
- It has pluggable components to provide a uniform interface
- Components can connect to other systems
- It can bind to Java Beans
- It can integrate with other Java frameworks
- It has support for unit testing

Camel Architecture





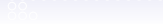
Routes

- A route is a key concept of Camel integration
- It tells Camel how to pass messages between systems
- Each route has exactly one input endpoint
- It has zero or more output endpoints



Getting Started

- A Java Development Kit (JDK) is required
- Maven will be used to manage dependencies
- We will start with a simple application
- It generates a timer event every second
- It logs a message on each event



Camel Class

- The Camel class extends the RouteBuilder
- It sets up logging
- It creates a Camel context

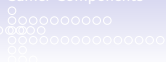
```
public class Camel extends RouteBuilder {  
    protected final Logger logger;  
    private final CamelContext context;  
  
    public Camel() {  
        logger = LoggerFactory.getLogger(getClass());  
        context = new DefaultCamelContext();  
    }  
}
```




Execute Function

- Add a function to execute Camel
- It needs to wait as Camel start is non-blocking

```
public void execute() {
    logger.info("Executing Camel");
    try {
        context.addRoutes(this);
        context.start();
        synchronized(this) {
            this.wait();
        }
    } catch (Exception e) {
        logger.error("Error on execute " + e);
    }
}
```



Entry Point

- Add a main method to instantiate the class
- It called the execute function

```
public static void main(String[] args) {  
    new Camel().execute();  
}
```



Add a Route

- Routes are added in a configure method
- The input endpoint is a timer
- The output endpoint writes a log message

```
@Override
public void configure() {
    from("timer:Hello")
        .log("Hello from Camel");
}
```

Running Camel

- There are Maven tasks to run Camel programs
- The code needs to be compiled
- The compilation is a dependent target on the run target
- There is a target to run a Camel program
- The file pom.xml has all of the dependencies required for the course

```
mvn compile
mvn camel:run
```

DaDesktop

- DaDesktop is a virtual desktop developed by NobleProg
- Instructors create a virtual machine from a Linux distribution
- The desktop is saved and all attendees get a copy
- You can request that your desktop remains available after the class
- The desktop is based on Debian Linux with Docker installed
- The desktop has a directory containing course materials

Apache Camel

Introduction to Apache Camel

What is Apache Camel?

Exercise

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Do Now! Examine the Desktop

- Connect to DaDesktop
- The Activities link on the top left lets you start and switch applications
- Start a Web browser
- Open the course notes file `Camel.pdf`
- Open a terminal window
- Open Visual Studio Code

Exercise 1: First Camel Application

- Setup if required
- Read the source files
- Compile the code
- Run the application
- Full instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Defining Routes

Unit Tests

Exercise

Message Filters

Exercise

Multicast Routes

Exercise

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components



Camel Routes

- Routes are the key feature of Camel
- They can be defined in any Domain Specific Languages (DSL)
- XML and YAML are often used
- The Java DSL makes routes more readable



Camel Class

- The RouteBuilder class implements the Java DSL
- An instance is passed to the context addRoute() method
- Route builder classes must override the configure() method

```
public class Camel extends RouteBuilder {  
    @Override  
    public void configure() {  
        // Define routes  
    }  
}
```

Endpoint URIs

- "direct:start" from a template or another route
- "file:directory?noop=true" files from/to a directory
- "stream:in?promptMessage=Enter data: " text from keyboard
- "timer://foo?fixedRate=true&delay=0&period=10000"
- "log:logger?level=INFO"
- "stream:out" output to screen

Route From

- All routes start with a call to the `RouteBuilder.from()` method
- The parameter is an endpoint URI to the message source
- It returns a `RouteDefinition` object
- Routes can also be given a unique identifier with `.routeId()`

```
@Override
public void configure() {
    from("stream:in?promptMessage=Enter data: ")
        .routeId("camel1");
}
```

Route To

- Route definitions can have zero or more calls to the `RouteDefinition.to()` method
- The parameter is an endpoint URI to the message destination
- It returns a `RouteDefinition` object for chaining
- The endpoint can be given a unique identifier with `.id()`

```
@Override
public void configure() {
    from("stream:in?promptMessage=Enter data: ")
        .routeId("camel1")
        .to("stream:out").id("out");
}
```



Processing

- Messages can be processed in a route
- There is a simple transformation it can modify the message body

```
@Override
public void configure() {
    from("stream:in?promptMessage=Enter data: ")
        .routeId("camel1")
        .transform(simple("${body.toUpperCase()}"))
        .to("stream:out").id("out");
}
```

Combining Routes

- Two or routes can be linked using direct endpoints
- The routes must be in the same context

```
from("stream:in?promptMessage=Enter data: ")  
  .to("direct:out");
```

```
from(direct:out)  
  .transform(simple("${body} from out"))  
  .to("stream:out");
```


Apache Camel

Introduction to Apache Camel

Camel Routing

Defining Routes

Unit Tests

Exercise

Message Filters

Exercise

Multicast Routes

Exercise

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components



Unit Testing

- Camel provides extensions to JUnit tests
- A test context is created automatically
- A test template CamelTest.java is available
- Tests can change the source endpoint to inject test data
- Tests can change output endpoints to mock endpoints
- Mock endpoints can verify message count and content

Test Class

- There is a test class template CamelTest.java
- It defines an instance of the class under test
- It defines mock endpoints
- It defines a producer template to inject data

```
public class CamelTest extends CamelTestSupport {  
    private Camel camel;  
    private MockEndpoint result;  
    private ProducerTemplate template;  
}
```



Test Setup

- The setup is called before every test method
- It uses the class under test to create routes
- It creates a producer template to inject data
- It creates mock endpoints

```
@BeforeEach
void setup() throws Exception {
    camel = new Camel();
    context.addRoutes(camel);
    template = context.createProducerTemplate();
    result = context.getEndpoint("mock:out", MockEndpoint.class);
}
```



Modify Routes

- Route endpoints may not be available during tests
- Unit tests should be fast and not use external resources
- The Camel Advice allows endpoints to be modified
- Weave methods add, remove or change route

```
AdviceWith.adviceWith(context.getRouteDefinition("camel1"),
    context, new AdviceWithRouteBuilder() {
    @Override
    public void configure() {
        weaveAddFirst().to("mock:first");
        replaceFromWith("direct:in");
        weaveById("out").replace().to("mock:out");
        weaveById("out").remove();
        weaveAddLast().to("mock:last");
    }
});
```

Test Method

- The test method sets expectations, injects data and verifies

```
@Test
void shouldChangeToUpperCase() throws Exception {
    AdviceWith.adviceWith(context.getRouteDefinition("camel1"),
        context, new AdviceWithRouteBuilder() {
            @Override
            public void configure() {
                replaceFromWith("direct:in");
                weaveById("out").replace().to("mock:out");
            }
        });
    context.start();
    result.expectedBodiesReceived("HELLO WORLD");
    result.expectedMessageCount(1);
    template.sendBody("direct:in", "hello world");
    result.assertIsSatisfied();
}
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Defining Routes

Unit Tests

Exercise

Message Filters

Exercise

Multicast Routes

Exercise

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Exercise 2: Camel Unit Testing

- Copy exercise1 to exercise2
- Add a transformation route to Camel.java
- Add a test method to CamelTest.java
- Run the unit tests
- Run the application
- Full instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Defining Routes

Unit Tests

Exercise

Message Filters

Exercise

Multicast Routes

Exercise

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

File Endpoint

- The file endpoint takes a directory as a parameter
- A file consumer is used in `from()`
- Consumed files are moved to a `.camel` directory
- Files will not be moved if the `noop=true` parameter is set

```
@Override
public void configure() {
    from("file:../data/input?noop=true")
      .routeId("camel1")
      .to("file:../data/output");
}
```



Unit Testing

- The unit test will replace the file output endpoint with a mock

```
@Test
void filterOnFilenameTest() throws Exception {
    AdviceWith.adviceWith(context.getRouteDefinition("camel1"),
        context, new AdviceWithRouteBuilder() {
        @Override
        public void configure() {
            weaveById("out").replace().to("mock:out");
        }
    });
    context.start();
}
```



Unit Testing

- The message body contains the content of the file
- The test will just use the file name which is in a message header
- The test will only look at the first three messages

```
result.message(0).header("CamelFileName").isEqualTo("jabberwocky.txt");  
result.message(1).header("CamelFileName").isEqualTo("jabberwocky1.txt");  
result.message(2).header("CamelFileName").isEqualTo("jabberwocky2.txt");  
result.expectedMessageCount(3);  
result.assertIsSatisfied();
```



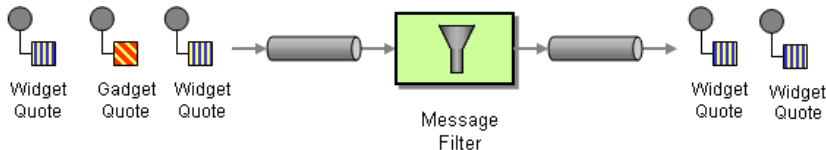
Test Failure

- The test will fail as the files will not be ordered
- The messages can be resequenced using the filename header
- The tests should now pass

```
@Override
public void configure() {
    from("file:../data/input?noop=true")
    .routeId("camel1")
    .resequence(header("CamelFileName"))
    .to("file:../data/output");
}
```

Filters

- A filter selects which messages will be processed
- Filters are often applied to message headers
- It is like an if statement
- Simple conditions compare message components to values





Filters

- The filter method has a comparison operation
- It is terminated by an end method
- Routes are only processed if the condition is true

```
.filter(simple("${headers.CamelFileName} regex '.*[235].txt'"))  
    .to("stream:out").id("out")  
.end();
```



Filter Expressions

- There are a number of filter simple expressions

```
simple("${header.foo} == 'foo'") // Match
simple("${header.foo} =~ 'foo'") // Match ignore case
simple("${header.bar} == '100'") // Integers converted to strings
simple("${header.bar} == 100")   // Integers converted to strings
simple("${header.bar} > 100")    // Integers converted to strings
simple("${header.title} contains 'Camel'")
simple("${header.number} regex '\\d{4}'")
```


Apache Camel

Introduction to Apache Camel

Camel Routing

Defining Routes

Unit Tests

Exercise

Message Filters

Exercise

Multicast Routes

Exercise

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components



Exercise 3: Route Filters

- Copy exercise1 to exercise3
- Add a filter route to Camel.java
- Add a test method to CamelTest.java
- Run the unit tests
- Run the application
- Full instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Defining Routes

Unit Tests

Exercise

Message Filters

Exercise

Multicast Routes

Exercise

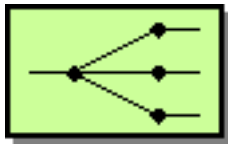
Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Multicast Routes

- Multicast routes send th same message to several endpoints
- Each endpoint can process the message differently
- Endpoints are processed sequentially
- They can be processed in parallel



Multicast

- The multicast sends the same message to several endpoints
- There can be another endpoint after the multicast

```
@Override
public void configure() {
    from("stream:in?promptMessage=Enter data: ")
        .routeId("camel1")
        .multicast()
            .to("direct:out1").id("out1")
            .to("direct:out2").id("out2")
            .to("direct:out3").id("out3")
        .end()
        .to("direct:out4").id("out4");
}
```

Multicast Processing

- Multicast uses a single thread by default
- Parallel processing uses a different thread for each endpoint
- It can also aggregate message bodies
- If an endpoint throws an exception all others are processed

```
.multicast().parallelProcessing()  
.multicast(new MyAggregationStrategy()).parallelProcessing().timeout(500)
```

Multicast Testing

- A mock endpoint is required for each multicast endpoint
- Expectations need to be set on each mock endpoint
- Each mock end point needs to assert satisfied

Apache Camel

Introduction to Apache Camel

Camel Routing

Defining Routes

Unit Tests

Exercise

Message Filters

Exercise

Multicast Routes

Exercise

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Exercise 4: Multicast Routes

- Copy exercise1 to exercise4
- Add a multicast route to Camel.java
- Add a test method to CamelTest.java
- Run the unit tests
- Run the application
- Full instructions are in CamelExercises.pdf

Message Exchanges

- Messages have a request message
- They can have a reply message
- They can have an exception message
- An Exchange is an interface used to exchange message components
- They support inbound only event messages and request and reply messages
- Endpoints have concrete implementations of Exchange
- EIP APIs use exchanges as abstractions

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator

Exercise

Splitter

Exercise

Routing Slip

Exercise

Dynamic Router

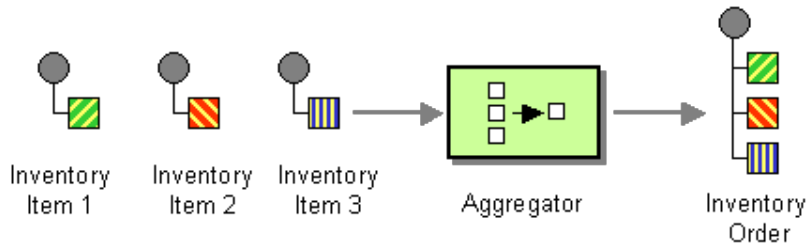
Exercise

Data Transformation

Camel Components

Aggregator Routes

- An aggregator combines the bodies of one or more messages
- Headers control how messages are combined
- An aggregator class is required to implement it





Aggregator Class

- This aggregator combines message body strings
- It defines an aggregation strategy

```
package training;

import org.apache.camel.AggregationStrategy;
import org.apache.camel.Exchange;
import org.apache.camel.Message;

public class StringAggregator implements AggregationStrategy {
}
```



Aggregate Method

- This combines pairs of message body strings
- The first exchange will be null for the first message
- Both message bodies can be null

```
@Override
public Exchange aggregate(Exchange existing, Exchange next) {
    Exchange result = next;
    if (existing != null) {
        result = next;
        String body = existing.getIn().getBody(String.class);
        Message nextIn = next.getIn();
        String nextBody = nextIn.getBody(String.class);
        nextIn.setBody(body + "," + nextBody);
    }
    return result;
}
```



Aggregator Test Class

- Create a unit test class for the aggregator
- It needs to test the aggregator class in isolation

Test class

```
package training;

import org.apache.camel.ProducerTemplate;
import org.apache.camel.builder.RouteBuilder;
import org.apache.camel.component.mock.MockEndpoint;
import org.apache.camel.test.junit5.CamelTestSupport;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;

public class AggregatorTest extends CamelTestSupport {
    private MockEndpoint result;
    private ProducerTemplate template;
}
```

Route Test Class

- Create an inner class to define the route

```
class Aggregate extends RouteBuilder {  
    @Override  
    public void configure() throws Exception {  
        from( "direct:input" )  
        .aggregate(header( "words" ), new StringAggregator())  
        .completionTimeout(3000)  
        .to("mock:out");  
    }  
}
```


Setup

- Set up the test class

```
@BeforeEach
void setup() throws Exception {
    context.addRoutes(new Aggregate());
    template = context.createProducerTemplate();
    result = context.getEndpoint("mock:out", MockEndpoint.class);
}
```



Test Method

- Create the test method
- The template sends the body, header name, and header value
- Different header names and values are aggregated separately

```
@Test
```

```
void aggregateWordsById() throws Exception {  
    context.start();  
    result.expectedMessageCount(2);  
    result.expectedBodiesReceived("the,brown", "quick,fox");  
  
    template.sendBodyAndHeader("direct:input", "the", "words", 1);  
    template.sendBodyAndHeader("direct:input", "quick", "words", 2);  
    template.sendBodyAndHeader("direct:input", "brown", "words", 1);  
    template.sendBodyAndHeader("direct:input", "fox", "words", 2);  
    result.assertIsSatisfied();  
}
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator

Exercise

Splitter

Exercise

Routing Slip

Exercise

Dynamic Router

Exercise

Data Transformation

Camel Components



Exercise 5a: Aggregator

- Copy exercise1 to exercise5
- Create StringAggregator.java
- Create AggregatorTest.java
- Run the unit tests
- Full instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator

Exercise

Splitter

Exercise

Routing Slip

Exercise

Dynamic Router

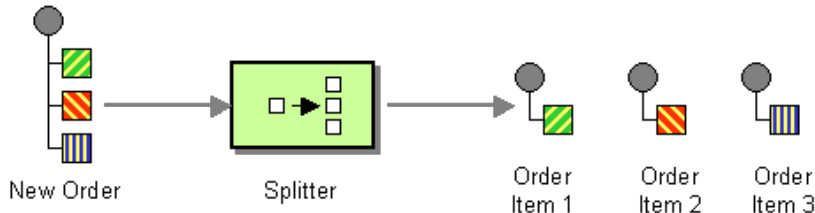
Exercise

Data Transformation

Camel Components

Splitter Routes

- Splitter splits a message body into multiple messages
- It supports simple splitting of a message body
- It can also aggregate split components
- It can split strings by a delimiter character
- It can split lists into components



Split Body

- Splits arrays, lists, maps by entry
- Splits strings by commas

```
@Override
public void configure() {
    from("direct:input")
        .split(body())
        .to("direct:out");
}
```

Tokens

- Strings can be tokenised

```
@Override
public void configure() {
    from("direct:input")
        .split(body().tokenize("\n"))
        .to("direct:output");
}
```




Test Class

- We will use a test class for split
- It will be implemented differently to show options

```
package training;

import java.util.List;
import java.util.ArrayList;
import org.apache.camel.builder.RouteBuilder;
import org.apache.camel.component.mock.MockEndpoint;
import org.apache.camel.test.junit5.CamelTestSupport;
import org.junit.jupiter.api.Test;

public class SplitterTest extends CamelTestSupport {
}
```

Route Builder

- We will create a route builder to define routes

```

@Override
protected RouteBuilder createRouteBuilder() throws Exception {
    return new RouteBuilder() {
        @Override
        public void configure() throws Exception {
            from("direct:input")
                .split(body())
                .to("mock:out") ;
        }
    } ;
}

```

Test Method

- We create a test method to send a list as a body

```
@Test
void splitList() throws Exception {
    MockEndpoint result = getMockEndpoint("mock:out");
    result.expectedMessageCount(3);
    result.expectedBodiesReceived("quick", "brown", "fox");

    List<String> body = new ArrayList<>();
    body.add("quick");
    body.add("brown");
    body.add("fox");
    template.sendBody("direct:input", body);

    result.assertIsSatisfied();
}
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator

Exercise

Splitter

Exercise

Routing Slip

Exercise

Dynamic Router

Exercise

Data Transformation

Camel Components

Exercise 5b: Splitter

- Create SplitterTest.java
- Run the unit tests
- Full instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator

Exercise

Splitter

Exercise

Routing Slip

Exercise

Dynamic Router

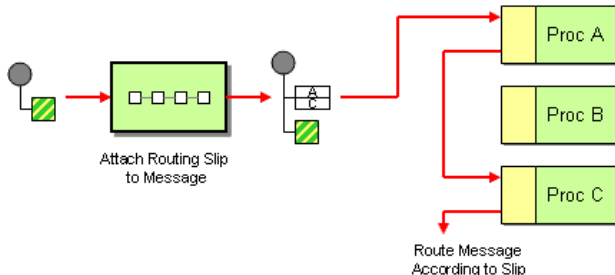
Exercise

Data Transformation

Camel Components

Routing Slip

- Messages get routed through a sequence of endpoints
- What if the sequence is not known in advance?
- What if the sequence is different for different messages?
- Routing slip gets the routing sequence from a header





Test Class

- We will use a test class for routing slip

```
package training;

import org.apache.camel.builder.RouteBuilder;
import org.apache.camel.component.mock.MockEndpoint;
import org.apache.camel.test.junit5.CamelTestSupport;
import org.junit.jupiter.api.Test;

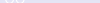
public class RoutingSlipTest extends CamelTestSupport {
}
```




Route Builder

- We will create a route builder to define routes

```
@Override
protected RouteBuilder createRouteBuilder() throws Exception {
    return new RouteBuilder() {
        @Override
        public void configure() throws Exception {
            from("direct:input")
                .routingSlip("slip")
        }
    } ;
}
```



Test Method

- We will create a test class that defines three mock endpoints

```
@Test
void routingSlip() throws Exception {
    MockEndpoint mocka = getMockEndpoint("mock:a");
    mocka.expectedMessageCount(3);
    mocka.expectedBodiesReceived("alpha", "beta", "gamma");

    MockEndpoint mockb = getMockEndpoint("mock:b");
    mockb.expectedMessageCount(1);
    mockb.expectedBodiesReceived("beta");

    MockEndpoint mockc = getMockEndpoint("mock:c");
    mockc.expectedMessageCount(1);
    mockc.expectedBodiesReceived("gamma");
}
```

Test Method

- We will send messages with routes in the slip header
- The assert is applied to all mock endpoints in the context

```
template.sendBodyAndHeader("direct:input", "alpha", "slip", "mock:a");  
template.sendBodyAndHeader("direct:input", "beta", "slip", "mock:a, mock:b");  
template.sendBodyAndHeader("direct:input", "gamma", "slip", "mock:a, mock:c");  
  
MockEndpoint.assertIsSatisfied(context);
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator
Exercise
Splitter

Exercise

Routing Slip

Exercise

Dynamic Router
Exercise

Data Transformation

Camel Components

Exercise 5c: Routing Slip

- Create RoutingSlipTest.java
- Run the unit tests
- Full instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator

Exercise

Splitter

Exercise

Routing Slip

Exercise

Dynamic Router

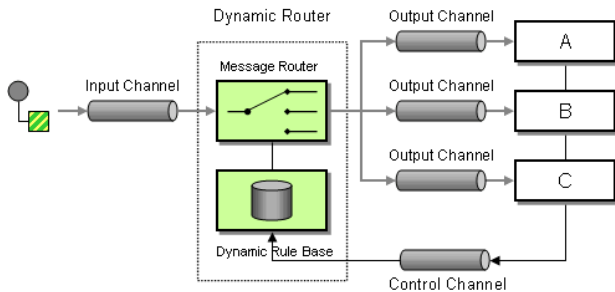
Exercise

Data Transformation

Camel Components

Dynamic Router

- A dynamic router obtains route from a Java Bean
- It can provide several routes
- A null route terminates the router



Bean Class

- Create a routing bean
- The route number is stored in properties

```
package training;
import java.util.Map;
import org.apache.camel.ExchangeProperties;

public class RouterBean {
    public String slip(String body,
        @ExchangeProperties Map<String, Object> properties) {
        int invoked = (int) properties.getOrDefault("invoked", 0) + 1;
        properties.put("invoked", invoked);
    }
}
```


Bean Class Routing

- The route is determined by the invocation number

```
String route = null;
if (invoked == 1) {
    route = "mock:a";
} else if (invoked == 2) {
    route = "mock:a,mock:b";
} else if (invoked == 3) {
    route = "mock:b";
}
return route;
```



Test Class

- We will use a test class for dynamic router

```
package training;

import org.apache.camel.builder.RouteBuilder;
import org.apache.camel.component.mock.MockEndpoint;
import org.apache.camel.test.junit5.CamelTestSupport;
import org.junit.jupiter.api.Test;

public class DynamicRouterTest extends CamelTestSupport {
}
```

Route Builder

- We will create a route builder to define routes

```

@Override
protected RouteBuilder createRouteBuilder() throws Exception {
    return new RouteBuilder() {
        @Override
        public void configure() throws Exception {
            from("direct:input")
                .dynamicRouter(method(RouterBean.class, "slip"))
                .to("mock:c");
        }
    } ;
}

```

Test Method

- We will create a test class that defines three mock endpoints

```
@Test
void routingSlip() throws Exception {
    MockEndpoint mocka = getMockEndpoint("mock:a");
    mocka.expectedMessageCount(3);
    mocka.expectedBodiesReceived("message", "message");

    MockEndpoint mockb = getMockEndpoint("mock:b");
    mockb.expectedMessageCount(1);
    mockb.expectedBodiesReceived("message", "message");

    MockEndpoint mockc = getMockEndpoint("mock:c");
    mockc.expectedMessageCount(1);
    mockc.expectedBodiesReceived("message");
}
```



Test Method

- Send a single message to the route

```
template.sendBody("direct:input", "message");
```

```
MockEndpoint.assertIsSatisfied(context);
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Aggregator

Exercise

Splitter

Exercise

Routing Slip

Exercise

Dynamic Router

Exercise

Data Transformation

Camel Components

Exercise 5d: Dynamic Router

- Create RouterBean.java
- Create DynamicRouterTest.java
- Run the unit tests
- Full instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Transforms

Exercise

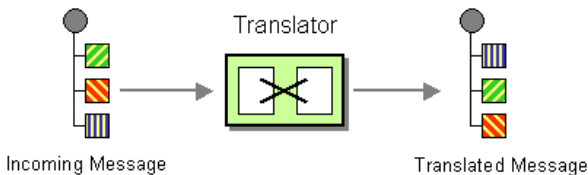
CSV, XML and JSON Files

Exercise

Camel Components

Message Translator

- Transform change the message body
- There are several ways of doing this
- A null route terminates the router





Transforms

- Simple transformations can modify the message body

```
@Override
public void configure() {
    from("stream:in?promptMessage=Enter data: ")
        .routeId("camel1")
        .transform(simple("Transformed ${body.toUpperCase()}"))
        .to("stream:out").id("out");
}
```

Transforms

- Data format transformers are provided

```
@Override
public void configure() {
    transformer().name("base64")
        .withDataFormat(dataFormat().base64().end());
    DataType base64 = new DataType("base64");
    from("direct:input")
        .transform(base64)
        .to("mock:out");
}
```

Transforms

- Test method for base64 encoding

```
@Test
void transformation() throws Exception {
    MockEndpoint mocka = getMockEndpoint("mock:out");
    mocka.expectedMessageCount(1);
    mocka.expectedBodiesReceived("YWJj\r\n");

    template.sendBody("direct:input", "abc");
    MockEndpoint.assertIsSatisfied(context);
}
```



Bean Transformer

- A Java Bean can be a transformer class

```
package training;

import org.apache.camel.Message;
import org.apache.camel.spi.DataType;
import org.apache.camel.spi.DataTypeTransformer;
import org.apache.camel.spi.Transformer;

@DataTypeTransformer(name = "wordcase")
public class CaseTransformer extends Transformer{
}
```

Bean Transformer

- A transform method can rewrite a message body
- It capitalises the first letter of each word

```
@Override
```

```
public void transform(Message message, DataType from, DataType to)
```

```
    throws Exception {
```

```
        char[] chars = message.getBody(String.class).toCharArray();
```

```
        boolean inword = false;
```

```
        for (int i = 0; i < chars.length; i++) {
```

```
            if (!inword && Character.isLetter(chars[i])) {
```

```
                chars[i] = Character.toUpperCase(chars[i]);
```

```
                inword = true;
```

```
            } else if (Character.isWhitespace(chars[i])) {
```

```
                inword = false;
```

```
            }
```

```
        }
```

```
        message.setBody(String.valueOf(chars));
```

```
    }
```



Test Route Builder

- The route defines the bean as a transformer

```
@Override
protected RouteBuilder createRouteBuilder() throws Exception {
    return new RouteBuilder() {
        @Override
        public void configure() throws Exception {
            transformer().name("wordcase")
                .withJava(CaseTransformer.class);
            from("direct:input")
                .transform(new DataType("wordcase"))
                .to("mock:out");
        }
    };
}
```



Test Method

- The test method for the transformer bean

```
@Test
void transformation() throws Exception {
    MockEndpoint mocka = getMockEndpoint("mock:out");
    mocka.expectedMessageCount(1);
    mocka.expectedBodiesReceived("The Quick Brown Fox");

    template.sendBody("direct:input", "the quick brown fox");
    MockEndpoint.assertIsSatisfied(context);
}
```


Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Transforms

Exercise

CSV, XML and JSON Files

Exercise

Camel Components

Exercise 5e: Bean Transformer

- Use a Java Bean Transformer to reverse the characters of the message body string
- Create ReverserBean.java
- Create ReverserBeanTest.java
- Run the unit tests
- Instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Transforms

Exercise

CSV, XML and JSON Files

Exercise

Camel Components

CSV, XML and JSON

- Camel has support for different file types
- It can marshal Java objects into file formats
- It can unmarshal file content into Java objects
- Annotations are used to identify fields to be translated
- Java classes can be annotated for more than one format



Animal Class

- Start with a class Animal.java
- Each animal has a name, body mass, and brain mass

```
package training;

public class Animal {
    private String name;
    private double body;
    private double brain;

    // Define getter and setter methods

    public String toString() {
        return String.format("%s body %.2fkg brain %.2fg", name, body, brain);
    }
}
```

Camel Bindy

- Animal data is in data/csv/animals.csv
- Camel Bindy can marshal and unmarshal CSV
- Annotations are required on the java class

```
import org.apache.camel.dataformat.bindy.annotation.CsvRecord;  
import org.apache.camel.dataformat.bindy.annotation.DataField;
```

```
@CsvRecord(separator = ",", skipFirstLine = true)  
public class Animal {  
    @DataField(pos = 1)  
    private String name;  
    @DataField(pos = 2)  
    private double body;  
    @DataField(pos = 3)  
    private double brain;  
}
```

Router

- Create a route in Camel.java

```
@Override
public void configure() throws Exception {
    DataFormat bindy = new BindyCsvDataFormat(Animal.class);

    from("file:../data/csv?fileName=animals.csv&noop=true")
        .unmarshal(bindy)
        .to("direct:toString");
}
```

Router

- Create a second route to display the animals

```
from("direct:toString")
  .split(body())
    .transform(simple("${body.toString()}"))
    .to("stream:out")
  .end();
```




Run Camel

- Run the program to see the list of animals
- Type control-C to terminate the wait

```
mvn camel:run
```

XML Files

- XML files can be processed using JAXB
- It used to be part of JEE but is now in Jakarta
- The package javax.xml became jakarta.xml
- It provides annotations
- It provides a Camel DataFormat



Wrapper Class

- The CSV file contains a list of animals
- It requires a wrapper class Animals.java for the XML root
- The annotation defones the XML root

```
package training;

import java.util.List;
import java.util.ArrayList;
import jakarta.xml.bind.annotation.XmlRootElement;

@XmlRootElement(name = "animals")
public class Animals {
    private List<Animal> animals = new ArrayList<>();
}
```

Wrapper Class

- Define getter, setter and add methods

```
public List<Animal> getAnimals() {  
    return animals;  
}  
  
public void addAnimal(Animal animal) {  
    animals.add(animal);  
}  
  
public void setAnimals(List<Animal> animals) {  
    this.animals.addAll(animals);  
}
```



Annotations

- Add XML annotations to Animal.java

```
import jakarta.xml.bind.annotation.XmlAccessType;  
import jakarta.xml.bind.annotation.XmlAccessorType;  
import jakarta.xml.bind.annotation.XmlRootElement;  
  
@XmlRootElement(name = "animal")  
@XmlAccessorType(XmlAccessType.FIELD)  
@CsvRecord(separator = ",", skipFirstLine = true)  
public class Animal {  
}
```

Processors

- A Camel Processor is a Java class called from a route
- It must have a `process()` method
- It has an `Exchange` parameter which contains the message
- It replaces the message body

Animal List Processor

- Write the class `AnimalListProcessor.java`
- The input message is an array of `Animal`

```
package training;

import org.apache.camel.Exchange;
import org.apache.camel.Processor;

public class AnimalListProcessor implements Processor {
    @Override
    public void process(Exchange exchange) throws Exception {
        Animals animals = new Animals();
        for (Animal animal : exchange.getIn().getBody(Animal[].class)) {
            animals.addAnimal(animal);
        }
        exchange.getIn().setBody(animals);
    }
}
```



Add Route

- Add an XML data format
- Change the route target

```
import jakarta.xml.bind.JAXBContext;
import org.apache.camel.converter.jaxb.JaxbDataFormat;

JaxbDataFormat xmlDataFormat = new JaxbDataFormat();
JAXBContext con = JAXBContext.newInstance(Animals.class);
xmlDataFormat.setContext(con);

//.to("direct:toString");
.to("direct:toXml");
```




Add Route

- Add a to XML route
- Run Camel

```
from("direct:toXml")  
  .process(new AnimalListProcessor())  
  .marshal(xmlDataFormat)  
  .to("stream:out");
```

JSON Files

- JSON files can be processed using Jackson
- It can use XML annotations
- It has a few quirks that can result in empty JSON
- It provides annotations
- It provides a Camel DataFormat



Annotations

- Add JSON annotations to Animal.java
- All getter methods need annotating

```
import com.fasterxml.jackson.annotation.JsonGetter;
```

```
@JsonGetter
public String getName() {
    return name;
}
```

Global Options

- Enable Jackson conversion in Camel constructor

```
public Camel() {  
    logger = LogManager.getLogger(getClass());  
    context = new DefaultCamelContext();  
    context.getGlobalOptions().put("CamelJacksonEnableTypeConverter", "true");  
    context.getGlobalOptions().put("CamelJacksonTypeConverterToPojo", "true");  
}
```

Add Route

- Change the route target
- Add JSON route and run Camel

```
import org.apache.camel.model.dataformat.JsonLibrary;

//.to("direct:toString");
//.to("direct:toXml");
.to("direct:toJson");

from("direct:toJson")
.marshall().json(JsonLibrary.Jackson)
.to("stream:out");
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Transforms

Exercise

CSV, XML and JSON Files

Exercise

Camel Components

Exercise 6: CSV, XML and JSON

- Copy exercise1 to exercise6
- Create Animal.java annotated for CSV
- Create a route in Camel.java
- Run the program
- Add the code to output the animal list as XML
- Run the program
- Add the code to output the animal list as JSON
- Run the program
- Instructions are in CamelExercises.pdf

Camel Components

- Camel components are endpoints to external services
- They have URIs for `from()` and `to()`
- We have already seen the file, stream, and timer endpoints
- We have used mock endpoints for testing
- Others are provided by adding dependencies to the POM
- Custom endpoints can be written

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


Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Camel MINA

Exercise

Camel JDBC

Exercise

Project

Apache MINA

- Multipurpose Infrastructure for Network Applications
- Java network application framework
- APIs for TCP and UDP
- It also supports direct transport in the same JVM
- Provides low level APIs
- Has mocks for unit testing
- The online documentation is very vague!
- It requires the `camel-mina` dependency

String Processor

- Create a class StringProcessor.java

```
package training;

import org.apache.camel.Exchange;
import org.apache.camel.Processor;

public class StringProcessor implements Processor {
    @Override
    public void process(Exchange exchange) throws Exception {
        String body = exchange.getIn().getBody(String.class);
        exchange.getIn().setBody("Processed " + body);
    }
}
```



Test Class

- Create a test class MINATest.java
- Define an endpoint URI

```
package training;

import org.apache.camel.builder.RouteBuilder;
import org.apache.camel.component.mock.MockEndpoint;
import org.apache.camel.test.junit5.CamelTestSupport;
import org.junit.jupiter.api.Assertions;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;

public class MINATest extends CamelTestSupport {
    private static final String stringURI =
        "mina:tcp://localhost:6200?textline=true&sync=true";
    private MockEndpoint result;
}
```



Route Builder Class

- Create a MINIRoute inner class defining a route
- Add route to context and create mock endpoint

```
class MINIRoute extends RouteBuilder {
    @Override
    public void configure() throws Exception {
        from(stringURI)
        .process(new StringProcessor())
        .to("mock:result");
    }
}

@BeforeEach
void setup() throws Exception {
    context.addRoutes(new MINIRoute());
    result = context.getEndpoint("mock:result", MockEndpoint.class);
}
```

Test Method

- Create a MINASendMessage test class and run the tests

```
@Test
```

```
void MINASendMessage() throws Exception {
```

```
    result.expectedMessageCount(1);
```

```
    result.expectedBodiesReceived("Processed message");
```

```
    String response = (String)template.requestBody(stringURI, "message");
```

```
    Assertions.assertEquals("Processed message", response);
```

```
    result.assertIsSatisfied();
```

```
}
```



POJO

- Create a POJO Creature.java
- Add getters and setters and a toString() method

```
public class Creature implements Serializable{
    private String name;
    private int legs;
    private boolean flies;

    public Creature(String name, int legs, boolean flies) {
        this.name = name;
        this.legs = legs;
        this.flies = flies;
    }
}
```

Creature Processor

- Create a processor to look up a creature by name

```
public class CreatureProcessor implements Processor {  
    private static Map<String, Creature> creatures;  
  
    static {  
        creatures = new HashMap<>();  
        creatures.put("bat", new Creature("Bat", 2, true));  
        creatures.put("penguin", new Creature("Penguin", 2, false));  
    }  
  
    @Override  
    public void process(Exchange exchange) throws Exception {  
        String name = exchange.getIn().getBody(String.class);  
        exchange.getIn().setBody(creatures.get(name));  
    }  
}
```




Add Route

- Define a URI for the route
- Warning, the POJO class name pattern is required here!
- Add a route

```
private static final String objectURI =
    "mina:tcp://localhost:6201?sync=true&objectCodecPattern=*";

    from(objectURI)
    .process(new CreatureProcessor());
```



Add test Cases

- Add test cases for the POJO
- Run the tests

```
Creature creature = (Creature)template.requestBody(objectURI, "bat");  
Assertions.assertEquals("Bat 2 legs flies", creature.toString());
```

```
creature = (Creature)template.requestBody(objectURI, "penguin");  
Assertions.assertEquals("Penguin 2 legs", creature.toString());
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Camel MINA

Exercise

Camel JDBC

Exercise

Project

Exercise 7a: Components

- Copy exercise1 to exercise7
- Create StringProcessor.java
- Create MINATest.java
- Run the tests
- Add a POJO of your choosing
- Create a processor to return a POJO object by name
- Add tests for the POJO
- Run the tests
- Instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Camel MINA

Exercise

Camel JDBC

Exercise

Project

Camel JDBC

- Camel JDBC and Camel SQL provide database component endpoints
- This requires more plumbing code to work
- It requires a database data source
- SQL statements are route parameters
- The online documentation is very very vague!
- It requires the `camel-mina` `camel-sql` and database driver dependencies



Postgres Database

- A Postgres database can be run in a Docker container
- The `initdb` script sets up the database
- The `rundb` script starts or restarts the database
- The Posgress CLI has been installed
- A table needs to be created

```
docker ps
```

```
./rundb
```

```
psql -h localhost -U camel cameldb
```

```
cameldb# \i animal.sql
```

```
cameldb# \d animal
```

```
cameldb# \q
```



Test Class

- Create JdbcTest.java
- It needs a database URL and data source

```
import org.apache.commons.dbcp2.BasicDataSource;

public class JdbcTest extends CamelTestSupport {
    private static final String dburi =
        "jdbc:postgresql://localhost:5432/cameldb";
    private static BasicDataSource dataSource;
    private ProducerTemplate template;
    private MockEndpoint result;
}
```




Initial Setup

- Create a data source to connect to the database

```
@BeforeAll
static void initialSetup() throws Exception {
    dataSource = new BasicDataSource();
    dataSource.setDriverClassName("org.postgresql.Driver");
    dataSource.setUsername("camel");
    dataSource.setPassword("camel");
    dataSource.setUrl(dburi);
}
```

Pretest Setup

- Create a pre-test setup that registers the data source

```
@BeforeEach
void setup() throws Exception {
    context.getRegistry().bind("PostgresDataSource", dataSource);
    context.addRoutes(new JdbcRoute());
    template = context.createProducerTemplate();
    result = getMockEndpoint("mock:result");
    context.start();
}
```

Insert Processor

- Create a processor `CreatureInsertProcessor.java` to insert an object

```
public class CreatureInsertProcessor implements Processor {
    private String format;

    CreatureInsertProcessor() {
        format = "insert into animal (name, legs, flies) " +
            "values ('%s', %d, %b)";
    }

    @Override
    public void process(Exchange exchange) throws Exception {
        Creature creature = exchange.getIn().getBody(Creature.class);
        exchange.getIn().setBody(String.format(format,
            creature.getName(), creature.getLegs(), creature.isFlies()));
    }
}
```

Route Class

- Create an inner class to define a route
- The end point is a data source that expects SQL

```
class JdbcRoute extends RouteBuilder {
    @Override
    public void configure() throws Exception {
        from("direct:insert")
        .process(new CreatureInsertProcessor())
        .to("jdbc:PostgresDataSource")
        .log("${body}");
    }
}
```

Test Method

- Create test method
- Exception handling is required as exceptions can be cryptic!

```
@Test
void animalDatabase() throws Exception {
    Creature bat = new Creature("Bat", 2, true);
    Creature penguin = new Creature("Penguin", 2, false);
    try {
        template.sendBody("direct:insert", bat);
        template.sendBody("direct:insert", penguin);
    } catch (Exception e) {
        System.err.println(e);
        e.printStackTrace(System.err);
    }
}
```

Test Method

- Run the tests
- If an exception occurs look for the caused by exception trace
- Verify that the objects have been inserted

```
psql -h localhost -U camel cameldb  
select * from animal;  
\q
```



Delete Route

- The tests will fail if run again due to database constraints
- Add a route to delete the database records

```
from("direct:delete")  
  .to("jdbc:PostgresDataSource");
```

Test Delete

- Add a template send to the delete route and run tests

```
template.sendBody("direct:delete", "delete from animal");  
template.sendBody("direct:insert", bat);  
template.sendBody("direct:insert", penguin);
```




Select Processor

- Create CreatureSelectProcessor.java
- Java generics were very badly designed!

```
public class CreatureSelectProcessor implements Processor {
    @Override
    public void process(Exchange exchange) throws Exception {
        @SuppressWarnings("unchecked")
        Map<String, Object> creatureMap =
            (Map<String, Object>)exchange.getIn().getBody();
        Creature creature = new Creature((String)creatureMap.get("name"),
            (Integer)creatureMap.get("legs"),
            (Boolean)creatureMap.get("flies"));
        exchange.getIn().setBody(creature.toString());
    }
}
```

Select Route

- Add a route to select from the database

```
from("direct:select")
.to("jdbc:PostgresDataSource")
.split(body())
    .process(new CreatureSelectProcessor())
    .log("${body}")
    .to("mock:result")
.end();
```

Test Route

- Add expectations and send for select and run test

```
result.expectedBodiesReceived("Bat 2 legs flies","Penguin 2 legs");
result.expectedMessageCount(2);
// At end of try
template.sendBody("direct:select", "select name,legs,flies from animal");
// At end of method
result.assertIsSatisfied();
```

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Camel MINA

Exercise

Camel JDBC

Exercise

Project

Exercise 7b: Database

- Create StringProcessor.java
- Create MINATest.java
- Run the tests
- Add a POJO of your choosing
- Create a processor to return a POJO object by name
- Add tests for the POJO
- Run the tests
- Instructions are in CamelExercises.pdf

Apache Camel

Introduction to Apache Camel

Camel Routing

Enterprise Integration Patterns
(EIP)

Data Transformation

Camel Components

Camel MINA

Exercise

Camel JDBC

Exercise

Project

Project

- This is the end of the course material
- Any questions?
- We will now do a project either individually or pairs
- There is some data on over 300 penguins used for training AI models
- Penguin species can be identified by body mass, flipper length and beak dimensions!
- Use Camel features to process the CSV file, store in a database, and query penguin data
- Instructions are in CamelExercises.pdf

Thank you for attending
Any Questions?