Spring for Apache Kafka

2.2.1.RELEASE

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1. Preface

The Spring for Apache Kafka project applies core Spring concepts to the development of Kafka-based messaging solutions. We provide a "template" as a high-level abstraction for sending messages. We also provide support for Message-driven POJOs.

2. What's new?

2.1 What's new in 2.2 Since 2.1

Kafka Client Version

This version requires the 2.0.0 `kafka-clients` or higher.

Class/Package Changes

The class `ContainerProperties` has been moved from `org.springframework.kafka.listener.config` to `org.springframework.kafka.listener`.

The enum `AckMode` has been moved from `AbstractMessageListenerContainer` to `ContainerProperties`.

`setBatchErrorHandler()` and `setErrorHandler()` methods have been moved from `ContainerProperties` to `AbstractMessageListenerContainer` (and `AbstractKafkaListenerContainerFactory`).

After rollback processing

A new `AfterRollbackProcessor` strategy is provided - see the section called "After Rollback Processor" for more information.

ConcurrentKafkaListenerContainerFactory changes

The `ConcurrentKafkaListenerContainerFactory` can now be used to create/configure any `ConcurrentMessageListenerContainer`, not just those for `@KafkaListener` annotations. See the section called "Container factory" for more information.

Listener Container Changes

A new container property `missingTopicsFatal` has been added.

See the section called "KafkaMessageListenerContainer" for more information.

A `ConsumerStoppedEvent` is now emitted when a consumer terminates.

See the section called "Thread Safety" for more information.

Batch listeners can optionally receive the complete `ConsumerRecords<?, ?>` object instead of a `List<ConsumerRecord<?, ?>>`.

See the section called "Batch listeners" for more information.

The `DefaultAfterRollbackProcessor` and `SeekToCurrentErrorHandler` can now recover (skip) records that keep failing, and will do so after 10 failures, by default. They can be configured to publish failed records to a dead-letter topic.

See the section called "After Rollback Processor", the section called "Seek To Current Container Error Handlers" and the section called "Publishing Dead-Letter Records" for more information.

The `ConsumerStoppingEvent` has been added. See the section called “Events” for more information.

@KafkaListener Changes

You can now override the `concurrency` and `autoStartup` properties of the listener container factory by setting properties on the annotation. You can now add configuration to determine which headers (if any) are copied to a reply message.

See the section called “@KafkaListener Annotation” for more information.

You can now use `@KafkaListener` as a meta-annotation on your own annotations.

See the section called “@KafkaListener as a Meta Annotation” for more information.

It is now easier to configure a `Validator` for `@Payload` validation. See the section called “@KafkaListener @Payload Validation” for more information.

Header Mapping Changes

Headers of type `MimeType` and `MediaType` are now mapped as simple strings in the `RecordHeader` value. Previously, they were mapped as JSON and only `MimeType` was decoded, `MediaType` could not be decoded. They are now simple strings for interoperability.

Also, the `DefaultKafkaHeaderMapper` has a new method `addToStringClasses` allowing the specification of types that should be mapped using `toString()` instead of JSON.

See the section called “Message Headers” for more information.

Embedded Kafka Changes

The `KafkaEmbedded` class and its `KafkaRule` interface have need deprecated in favor of the `EmbeddedKafkaBroker` and its JUnit 4 `EmbeddedKafkaRule` wrapper. The `@EmbeddedKafka` annotation now populates an `EmbeddedKafkaBroker` bean instead of the deprecated `KafkaEmbedded`. This allows the use of `@EmbeddedKafka` in JUnit 5 tests.

See Section 4.3, “Testing Applications” for more information.

JsonSerializer/Deserializer Enhancements

You can now provide type mapping information using producer/consumer properties.

New constructors are available on the deserializer to allow overriding the type header information with the supplied target type.

The JsonDeserializer will now remove any type information headers by default.

See the section called “Serialization/Deserialization and Message Conversion” for more information.

Kafka Streams Changes

The streams configuration bean must now be a `KafkaStreamsConfiguration` object instead of a `StreamsConfig`.

The `StreamsBuilderFactoryBean` has been moved from package `...core` to `...config`.

See Section 4.2, “Kafka Streams Support” and the section called “Configuration” for more information.

Transactional Id

When a transaction is started by the listener container, the `transactional.id` is now the `transactionIdPrefix` appended with `<group.id>.<topic>.<partition>`. This is to allow proper fencing of zombies as described here.

3. Introduction

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

3.1 Quick Tour for the Impatient

Introduction

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

Prerequisites: install and run Apache Kafka Then grab the spring-kafka JAR and all of its dependencies - the easiest way to do that is to declare a dependency in your build tool, e.g. for Maven:

```
<dependency>
  <groupId>org.springframework.kafka</groupId>
  <artifactId>spring-kafka</artifactId>
  <version>2.2.1.RELEASE</version>
</dependency>
```

And for Gradle:

```
compile 'org.springframework.kafka:spring-kafka:2.2.1.RELEASE'
```

Compatibility

- Apache Kafka Clients 2.0.0
- Spring Framework 5.1.x
- Minimum Java version: 8

Very, Very Quick

Using plain Java to send and receive a message:

```
@Test
public void testAutoCommit() throws Exception {
    logger.info("Start auto");
    ContainerProperties containerProps = new ContainerProperties("topic1", "topic2");
    final CountDownLatch latch = new CountDownLatch(4);
    containerProps.setMessageListener(new MessageListener<Integer, String>() {

        @Override
        public void onMessage(ConsumerRecord<Integer, String> message) {
            logger.info("received: " + message);
            latch.countDown();
        }

    });
    KafkaMessageListenerContainer<Integer, String> container = createContainer(containerProps);
    container.setBeanName("testAuto");
    container.start();
    Thread.sleep(1000); // wait a bit for the container to start
    KafkaTemplate<Integer, String> template = createTemplate();
    template.setDefaultTopic(topic1);
    template.sendDefault(0, "foo");
    template.sendDefault(2, "bar");
    template.sendDefault(0, "baz");
    template.sendDefault(2, "qux");
    template.flush();
    assertTrue(latch.await(60, TimeUnit.SECONDS));
    container.stop();
    logger.info("Stop auto");

}
```

```java
private KafkaMessageListenerContainer<Integer, String> createContainer(
                        ContainerProperties containerProps) {
    Map<String, Object> props = consumerProps();
    DefaultKafkaConsumerFactory<Integer, String> cf =
                            new DefaultKafkaConsumerFactory<Integer, String>(props);
    KafkaMessageListenerContainer<Integer, String> container =
                            new KafkaMessageListenerContainer<>(cf, containerProps);
    return container;
}

private KafkaTemplate<Integer, String> createTemplate() {
    Map<String, Object> senderProps = senderProps();
    ProducerFactory<Integer, String> pf =
              new DefaultKafkaProducerFactory<Integer, String>(senderProps);
    KafkaTemplate<Integer, String> template = new KafkaTemplate<>(pf);
    return template;
}

private Map<String, Object> consumerProps() {
    Map<String, Object> props = new HashMap<>();
    props.put(ConsumerConfig.BOOTSTRAP_SERVERS_CONFIG, "localhost:9092");
    props.put(ConsumerConfig.GROUP_ID_CONFIG, group);
    props.put(ConsumerConfig.ENABLE_AUTO_COMMIT_CONFIG, true);
    props.put(ConsumerConfig.AUTO_COMMIT_INTERVAL_MS_CONFIG, "100");
    props.put(ConsumerConfig.SESSION_TIMEOUT_MS_CONFIG, "15000");
    props.put(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG, IntegerDeserializer.class);
    props.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, StringDeserializer.class);
    return props;
}

private Map<String, Object> senderProps() {
    Map<String, Object> props = new HashMap<>();
    props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, "localhost:9092");
    props.put(ProducerConfig.RETRIES_CONFIG, 0);
    props.put(ProducerConfig.BATCH_SIZE_CONFIG, 16384);
    props.put(ProducerConfig.LINGER_MS_CONFIG, 1);
    props.put(ProducerConfig.BUFFER_MEMORY_CONFIG, 33554432);
    props.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, IntegerSerializer.class);
    props.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, StringSerializer.class);
    return props;
}
```

With Java Configuration

A similar example but with Spring configuration in Java:

```
@Autowired
private Listener listener;

@Autowired
private KafkaTemplate<Integer, String> template;

@Test
public void testSimple() throws Exception {
    template.send("annotated1", 0, "foo");
    template.flush();
    assertTrue(this.listener.latch1.await(10, TimeUnit.SECONDS));
}

@Configuration
@EnableKafka
public class Config {

    @Bean
    ConcurrentKafkaListenerContainerFactory<Integer, String>
                        kafkaListenerContainerFactory() {
        ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
                                new ConcurrentKafkaListenerContainerFactory<>();
        factory.setConsumerFactory(consumerFactory());
        return factory;
    }

    @Bean
    public ConsumerFactory<Integer, String> consumerFactory() {
        return new DefaultKafkaConsumerFactory<>(consumerConfigs());
    }

    @Bean
    public Map<String, Object> consumerConfigs() {
        Map<String, Object> props = new HashMap<>();
        props.put(ConsumerConfig.BOOTSTRAP_SERVERS_CONFIG, embeddedKafka.getBrokersAsString());
        ...
        return props;
    }

    @Bean
    public Listener listener() {
        return new Listener();
    }

    @Bean
    public ProducerFactory<Integer, String> producerFactory() {
        return new DefaultKafkaProducerFactory<>(producerConfigs());
    }

    @Bean
    public Map<String, Object> producerConfigs() {
        Map<String, Object> props = new HashMap<>();
        props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, embeddedKafka.getBrokersAsString());
        ...
        return props;
    }

    @Bean
    public KafkaTemplate<Integer, String> kafkaTemplate() {
        return new KafkaTemplate<Integer, String>(producerFactory());
    }

}
```

```java
public class Listener {

    private final CountDownLatch latch1 = new CountDownLatch(1);

    @KafkaListener(id = "foo", topics = "annotated1")
    public void listen1(String foo) {
        this.latch1.countDown();
    }

}
```

Even Quicker, with Spring Boot

The following Spring Boot application sends 3 messages to a topic, receives them, and stops.

Application.

```java
@SpringBootApplication
public class Application implements CommandLineRunner {

    public static Logger logger = LoggerFactory.getLogger(Application.class);

    public static void main(String[] args) {
        SpringApplication.run(Application.class, args).close();
    }

    @Autowired
    private KafkaTemplate<String, String> template;

    private final CountDownLatch latch = new CountDownLatch(3);

    @Override
    public void run(String... args) throws Exception {
        this.template.send("myTopic", "foo1");
        this.template.send("myTopic", "foo2");
        this.template.send("myTopic", "foo3");
        latch.await(60, TimeUnit.SECONDS);
        logger.info("All received");
    }

    @KafkaListener(topics = "myTopic")
    public void listen(ConsumerRecord<?, ?> cr) throws Exception {
        logger.info(cr.toString());
        latch.countDown();
    }

}
```

Boot takes care of most of the configuration; when using a local broker, the only properties we need are:

application.properties.

```
spring.kafka.consumer.group-id=foo
spring.kafka.consumer.auto-offset-reset=earliest
```

The first because we are using group management to assign topic partitions to consumers so we need a group, the second to ensure the new consumer group will get the messages we just sent, because the container might start after the sends have completed.

4. Reference

This part of the reference documentation details the various components that comprise Spring for Apache Kafka. The main chapter covers the core classes to develop a Kafka application with Spring.

4.1 Using Spring for Apache Kafka

Configuring Topics

If you define a `KafkaAdmin` bean in your application context, it can automatically add topics to the broker. Simply add a `NewTopic` `@Bean` for each topic to the application context.

```
@Bean
public KafkaAdmin admin() {
    Map<String, Object> configs = new HashMap<>();
    configs.put(AdminClientConfig.BOOTSTRAP_SERVERS_CONFIG,
            StringUtils.arrayToCommaDelimitedString(embeddedKafka().getBrokerAddresses()));
    return new KafkaAdmin(configs);
}

@Bean
public NewTopic topic1() {
    return new NewTopic("foo", 10, (short) 2);
}

@Bean
public NewTopic topic2() {
    return new NewTopic("bar", 10, (short) 2);
}
```

By default, if the broker is not available, a message will be logged, but the context will continue to load. You can programmatically invoke the admin's `initialize()` method to try again later. If you wish this condition to be considered fatal, set the admin's `fatalIfBrokerNotAvailable` property to `true` and the context will fail to initialize.

> **Note**
>
> If the broker supports it (1.0.0 or higher), the admin will increase the number of partitions if it is found that an existing topic has fewer partitions than the `NewTopic.numPartitions`.

For more advanced features, such as assigning partitions to replicas, you can use the `AdminClient` directly:

```
@Autowired
private KafkaAdmin admin;

...

    AdminClient client = AdminClient.create(admin.getConfig());
    ...
    client.close();
```

Sending Messages

KafkaTemplate

Overview

The `KafkaTemplate` wraps a producer and provides convenience methods to send data to kafka topics.

```
ListenableFuture<SendResult<K, V>> sendDefault(V data);

ListenableFuture<SendResult<K, V>> sendDefault(K key, V data);

ListenableFuture<SendResult<K, V>> sendDefault(Integer partition, K key, V data);

ListenableFuture<SendResult<K, V>> sendDefault(Integer partition, Long timestamp, K key, V data);

ListenableFuture<SendResult<K, V>> send(String topic, V data);

ListenableFuture<SendResult<K, V>> send(String topic, K key, V data);

ListenableFuture<SendResult<K, V>> send(String topic, Integer partition, K key, V data);

ListenableFuture<SendResult<K, V>> send(String topic, Integer partition, Long timestamp, K key, V data);

ListenableFuture<SendResult<K, V>> send(ProducerRecord<K, V> record);

ListenableFuture<SendResult<K, V>> send(Message<?> message);

Map<MetricName, ? extends Metric> metrics();

List<PartitionInfo> partitionsFor(String topic);

<T> T execute(ProducerCallback<K, V, T> callback);

// Flush the producer.

void flush();

interface ProducerCallback<K, V, T> {

    T doInKafka(Producer<K, V> producer);

}
```

The `sendDefault` API requires that a default topic has been provided to the template.

The API which take in a `timestamp` as a parameter will store this timestamp in the record. The behavior of the user provided timestamp is stored is dependent on the timestamp type configured on the Kafka topic. If the topic is configured to use `CREATE_TIME` then the user specified timestamp will be recorded or generated if not specified. If the topic is configured to use `LOG_APPEND_TIME` then the user specified timestamp will be ignored and broker will add in the local broker time.

The `metrics` and `partitionsFor` methods simply delegate to the same methods on the underlying `Producer`. The `execute` method provides direct access to the underlying `Producer`.

To use the template, configure a producer factory and provide it in the template's constructor:

```
@Bean
public ProducerFactory<Integer, String> producerFactory() {
    return new DefaultKafkaProducerFactory<>(producerConfigs());
}

@Bean
public Map<String, Object> producerConfigs() {
    Map<String, Object> props = new HashMap<>();
    props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, "localhost:9092");
    props.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, StringSerializer.class);
    props.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, StringSerializer.class);
    // See https://kafka.apache.org/documentation/#producerconfigs for more properties
    return props;
}

@Bean
public KafkaTemplate<Integer, String> kafkaTemplate() {
    return new KafkaTemplate<Integer, String>(producerFactory());
}
```

The template can also be configured using standard `<bean/>` definitions.

Then, to use the template, simply invoke one of its methods.

When using the methods with a `Message<?>` parameter, topic, partition and key information is provided in a message header:

- `KafkaHeaders.TOPIC`
- `KafkaHeaders.PARTITION_ID`
- `KafkaHeaders.MESSAGE_KEY`
- `KafkaHeaders.TIMESTAMP`

with the message payload being the data.

Optionally, you can configure the `KafkaTemplate` with a `ProducerListener` to get an async callback with the results of the send (success or failure) instead of waiting for the `Future` to complete.

```
public interface ProducerListener<K, V> {

    void onSuccess(String topic, Integer partition, K key, V value, RecordMetadata recordMetadata);

    void onError(String topic, Integer partition, K key, V value, Exception exception);

    boolean isInterestedInSuccess();

}
```

By default, the template is configured with a `LoggingProducerListener` which logs errors and does nothing when the send is successful.

`onSuccess` is only called if `isInterestedInSuccess` returns `true`.

For convenience, the abstract `ProducerListenerAdapter` is provided in case you only want to implement one of the methods. It returns `false` for `isInterestedInSuccess`.

Notice that the send methods return a `ListenableFuture<SendResult>`. You can register a callback with the listener to receive the result of the send asynchronously.

```
ListenableFuture<SendResult<Integer, String>> future = template.send("foo");
future.addCallback(new ListenableFutureCallback<SendResult<Integer, String>>() {

    @Override
    public void onSuccess(SendResult<Integer, String> result) {
        ...
    }

    @Override
    public void onFailure(Throwable ex) {
        ...
    }

});
```

The `SendResult` has two properties, a `ProducerRecord` and `RecordMetadata`; refer to the Kafka API documentation for information about those objects.

If you wish to block the sending thread, to await the result, you can invoke the future's `get()` method. You may wish to invoke `flush()` before waiting or, for convenience, the template has a constructor with an `autoFlush` parameter which will cause the template to `flush()` on each send. Note, however that flushing will likely significantly reduce performance.

Examples

Non Blocking (Async).

```
public void sendToKafka(final MyOutputData data) {
    final ProducerRecord<String, String> record = createRecord(data);

    ListenableFuture<SendResult<Integer, String>> future = template.send(record);
    future.addCallback(new ListenableFutureCallback<SendResult<Integer, String>>() {

        @Override
        public void onSuccess(SendResult<Integer, String> result) {
            handleSuccess(data);
        }

        @Override
        public void onFailure(Throwable ex) {
            handleFailure(data, record, ex);
        }

    });
}
```

Blocking (Sync).

```
public void sendToKafka(final MyOutputData data) {
    final ProducerRecord<String, String> record = createRecord(data);

    try {
        template.send(record).get(10, TimeUnit.SECONDS);
        handleSuccess(data);
    }
    catch (ExecutionException e) {
        handleFailure(data, record, e.getCause());
    }
    catch (TimeoutException | InterruptedException e) {
        handleFailure(data, record, e);
    }
}
```

Transactions

Overview

The 0.11.0.0 client library added support for transactions. Spring for Apache Kafka adds support in several ways.

- `KafkaTransactionManager` - used with normal Spring transaction support (`@Transactional`, `TransactionTemplate` etc).
- Transactional `KafkaMessageListenerContainer`
- Local transactions with `KafkaTemplate`

Transactions are enabled by providing the `DefaultKafkaProducerFactory` with a `transactionIdPrefix`. In that case, instead of managing a single shared `Producer`, the factory maintains a cache of transactional producers. When the user `close()` s a producer, it is returned to the cache for reuse instead of actually being closed. The `transactional.id` property of each producer is `transactionIdPrefix + n`, where `n` starts with `0` and is incremented for each new producer, unless the transaction is started by a listener container with a record-based listener. In that case, the `transactional.id` is `<transactionIdPrefix>.<group.id>.<topic>.<partition>`; this is to properly support fencing zombies as described here. This new behavior was added in versions 1.3.7, 2.0.6, 2.1.10, and 2.2.0. If you wish to revert to the previous behavior, set the `producerPerConsumerPartition` property on the `DefaultKafkaProducerFactory` to `false`.

> **Note**
>
> While transactions are supported with batch listeners, zombie fencing cannot be supported because a batch may contain records from multiple topics/partitions.

KafkaTransactionManager

The `KafkaTransactionManager` is an implementation of Spring Framework's `PlatformTransactionManager`; it is provided with a reference to the producer factory in its constructor. If you provide a custom producer factory, it must support transactions - see `ProducerFactory.transactionCapable()`.

You can use the `KafkaTransactionManager` with normal Spring transaction support (`@Transactional`, `TransactionTemplate` etc). If a transaction is active, any `KafkaTemplate` operations performed within the scope of the transaction will use the transaction's `Producer`. The manager will commit or rollback the transaction depending on success or failure. The `KafkaTemplate` must be configured to use the same `ProducerFactory` as the transaction manager.

Transactional Listener Container and Exactly Once Processing

You can provide a listener container with a `KafkaAwareTransactionManager` instance; when so configured, the container will start a transaction before invoking the listener. Any `KafkaTemplate` operations performed by the listener will participate in the transaction. If the listener successfully processes the record (or records when using a `BatchMessageListener`), the container will send the offset(s) to the transaction using `producer.sendOffsetsToTransaction()`), before the transaction manager commits the transaction. If the listener throws an exception, the transaction is rolled back and the consumer is repositioned so that the rolled-back record(s) will be retrieved on the next poll. See the section called "After Rollback Processor" for more information and for handling records that repeatedly fail.

Transaction Synchronization

If you need to synchronize a Kafka transaction with some other transaction; simply configure the listener container with the appropriate transaction manager (one that supports synchronization, such as the `DataSourceTransactionManager`). Any operations performed on a **transactional** `KafkaTemplate` from the listener will participate in a single transaction. The Kafka transaction will be committed (or rolled back) immediately after the controlling transaction. Before exiting the listener, you should invoke one of the template's `sendOffsetsToTransaction` methods (unless you use a [`ChainedKafkaTransactionManager` - see below]). For convenience, the listener container binds its consumer group id to the thread so, generally, you can use the first method:

```
void sendOffsetsToTransaction(Map<TopicPartition, OffsetAndMetadata> offsets);

void sendOffsetsToTransaction(Map<TopicPartition, OffsetAndMetadata> offsets, String consumerGroupId);
```

For example:

```
@Bean
KafkaMessageListenerContainer container(ConsumerFactory<String, String> cf,
            final KafkaTemplate template) {
    ContainerProperties props = new ContainerProperties("foo");
    props.setGroupId("group");
    props.setTransactionManager(new SomeOtherTransactionManager());
    ...
    props.setMessageListener((MessageListener<String, String>) m -> {
        template.send("foo", "bar");
        template.send("baz", "qux");
        template.sendOffsetsToTransaction(
            Collections.singletonMap(new TopicPartition(m.topic(), m.partition()),
                new OffsetAndMetadata(m.offset() + 1)));
    });
    return new KafkaMessageListenerContainer<>(cf, props);
}
```

> **Note**
>
> The offset to be committed is one greater than the offset of the record(s) processed by the listener.

> **Important**
>
> This should only be called when using transaction synchronization. When a listener container is configured to use a `KafkaTransactionManager`, it will take care of sending the offsets to the transaction.

ChainedKafkaTransactionManager

The `ChainedKafkaTransactionManager` was introduced in *version 2.1.3*. This is a subclass of `ChainedTransactionManager` that can have exactly one `KafkaTransactionManager`. Since it is a `KafkaAwareTransactionManager`, the container can send the offsets to the transaction in the same way as when the container is configured with a simple `KafkaTransactionManager`. This provides another mechanism for synchronizing transactions without having to send the offsets to the transaction in the listener code. Chain your transaction managers in the desired order and provide the `ChainedTransactionManager` in the `ContainerProperties`.

KafkaTemplate Local Transactions

You can use the `KafkaTemplate` to execute a series of operations within a local transaction.

```
boolean result = template.executeInTransaction(t -> {
    t.sendDefault("foo", "bar");
    t.sendDefault("baz", "qux");
    return true;
});
```

The argument in the callback is the template itself (`this`). If the callback exits normally, the transaction is committed; if an exception is thrown, the transaction is rolled-back.

> **Note**
>
> If there is a `KafkaTransactionManager` (or synchronized) transaction in process, it will not be used; a new "nested" transaction is used.

ReplyingKafkaTemplate

Version 2.1.3 introduced a subclass of `KafkaTemplate` to provide request/reply semantics; the class is named `ReplyingKafkaTemplate` and has one method (in addition to those in the superclass):

```
RequestReplyFuture<K, V, R> sendAndReceive(ProducerRecord<K, V> record);
```

The result is a `ListenableFuture` that will asynchronously be populated with the result (or an exception, for a timeout). The result also has a property `sendFuture` which is the result of calling `KafkaTemplate.send()`; you can use this future to determine the result of the send operation.

The following Spring Boot application is an example of how to use the feature:

```
@SpringBootApplication
public class KRequestingApplication {

    public static void main(String[] args) {
        SpringApplication.run(KRequestingApplication.class, args).close();
    }

    @Bean
    public ApplicationRunner runner(ReplyingKafkaTemplate<String, String, String> template) {
        return args -> {
            ProducerRecord<String, String> record = new ProducerRecord<>("kRequests", "foo");
            RequestReplyFuture<String, String, String> replyFuture = template.sendAndReceive(record);
            SendResult<String, String> sendResult = replyFuture.getSendFuture().get();
            System.out.println("Sent ok: " + sendResult.getRecordMetadata());
            ConsumerRecord<String, String> consumerRecord = replyFuture.get();
            System.out.println("Return value: " + consumerRecord.value());
        };
    }

    @Bean
    public ReplyingKafkaTemplate<String, String, String> kafkaTemplate(
            ProducerFactory<String, String> pf,
            KafkaMessageListenerContainer<String, String> replyContainer) {

        return new ReplyingKafkaTemplate<>(pf, replyContainer);
    }

    @Bean
    public KafkaMessageListenerContainer<String, String> replyContainer(
            ConsumerFactory<String, String> cf) {

        ContainerProperties containerProperties = new ContainerProperties("kReplies");
        return new KafkaMessageListenerContainer<>(cf, containerProperties);
    }

    @Bean
    public NewTopic kRequests() {
        return new NewTopic("kRequests", 10, (short) 2);
    }

    @Bean
    public NewTopic kReplies() {
        return new NewTopic("kReplies", 10, (short) 2);
    }

}
```

The template sets a header `KafkaHeaders.CORRELATION_ID` which must be echoed back by the server side.

In this case, simple `@KafkaListener` application responds:

```
@SpringBootApplication
public class KReplyingApplication {

    public static void main(String[] args) {
        SpringApplication.run(KReplyingApplication.class, args);
    }

    @KafkaListener(id="server", topics = "kRequests")
    @SendTo // use default replyTo expression
    public String listen(String in) {
        System.out.println("Server received: " + in);
        return in.toUpperCase();
    }

    @Bean
    public NewTopic kRequests() {
        return new NewTopic("kRequests", 10, (short) 2);
    }

    @Bean // not required if Jackson is on the classpath
    public MessagingMessageConverter simpleMapperConverter() {
        MessagingMessageConverter messagingMessageConverter = new MessagingMessageConverter();
        messagingMessageConverter.setHeaderMapper(new SimpleKafkaHeaderMapper());
        return messagingMessageConverter;
    }

}
```

The `@KafkaListener` infrastructure echoes the correlation id and determines the reply topic.

See the section called “Forwarding Listener Results using @SendTo” for more information about sending replies; the template uses the default header `KafKaHeaders.REPLY_TOPIC` to indicate which topic the reply goes to.

Starting with version 2.2, the template will attempt to detect the reply topic/partition from the configured reply container. If the container is configured to listen to a single topic or a single `TopicPartitionInitialOffset`, it will be used to set the reply headers. If the container is configured otherwise, the user must set up the reply header(s); in this case, an INFO log is written during initialization.

```
record.headers().add(new RecordHeader(KafkaHeaders.REPLY_TOPIC, "kReplies".getBytes()));
```

When configuring with a single reply `TopicPartitionInitialOffset`, you can use the same reply topic for multiple templates, as long as each instance listens on a different partition. When configuring with a single reply topic, each instance must use a different `group.id` - in this case, all instances will receive each reply, but only the instance that sent the request will find the correlation id. This may be useful for auto-scaling, but with the overhead of additional network traffic and the small cost of discarding each unwanted reply. When using this setting, it is recommended that you set the template's `sharedReplyTopic` to true, which will reduce the logging level of unexpected replies to DEBUG instead of the default ERROR.

> **Important**
>
> If you have multiple client instances, and you don't configure them as discussed in the paragraphe above, each instance will need a dedicated reply topic. An alternative is to set the `KafkaHeaders.REPLY_PARTITION` and use a dedicated partition for each instance; the `Header` contains a 4 byte int (Big-endian). The server must use this header to route the reply to the correct topic (`@KafkaListener` does this). In this case, though, the reply container must

> not use Kafka’s group management feature and must be configured to listen on a fixed partition (using a `TopicPartitionInitialOffset` in its `ContainerProperties` constructor).

> **Note**
>
> The `DefaultKafkaHeaderMapper` requires Jackson to be on the classpath (for the `@KafkaListener`). If it is not available, the message converter has no header mapper, so you must configure a `MessagingMessageConverter` with a `SimpleKafkaHeaderMapper` as shown above.

Receiving Messages

Messages can be received by configuring a `MessageListenerContainer` and providing a Message Listener, or by using the `@KafkaListener` annotation.

Message Listeners

When using a Message Listener Container you must provide a listener to receive data. There are currently eight supported interfaces for message listeners:

```
public interface MessageListener<K, V> { ❶

    void onMessage(ConsumerRecord<K, V> data);

}

public interface AcknowledgingMessageListener<K, V> { ❷

    void onMessage(ConsumerRecord<K, V> data, Acknowledgment acknowledgment);

}

public interface ConsumerAwareMessageListener<K, V> extends MessageListener<K, V> { ❸

    void onMessage(ConsumerRecord<K, V> data, Consumer<?, ?> consumer);

}

public interface AcknowledgingConsumerAwareMessageListener<K, V> extends MessageListener<K, V> { ❹

    void onMessage(ConsumerRecord<K, V> data, Acknowledgment acknowledgment, Consumer<?, ?> consumer);

}

public interface BatchMessageListener<K, V> { ❺

    void onMessage(List<ConsumerRecord<K, V>> data);

}

public interface BatchAcknowledgingMessageListener<K, V> { ❻

    void onMessage(List<ConsumerRecord<K, V>> data, Acknowledgment acknowledgment);

}

public interface BatchConsumerAwareMessageListener<K, V> extends BatchMessageListener<K, V> { ❼

    void onMessage(List<ConsumerRecord<K, V>> data, Consumer<?, ?> consumer);

}

public interface BatchAcknowledgingConsumerAwareMessageListener<K, V> extends BatchMessageListener<K, V>
 { ❽

    void onMessage(List<ConsumerRecord<K, V>> data, Acknowledgment acknowledgment, Consumer<?, ?>
 consumer);

}
```

❶ Use this for processing individual `ConsumerRecord` s received from the kafka consumer `poll()` operation when using auto-commit, or one of the container-managed commit methods.

❷ Use this for processing individual `ConsumerRecord` s received from the kafka consumer `poll()` operation when using one of the manual commit methods.

❸ Use this for processing individual `ConsumerRecord` s received from the kafka consumer `poll()` operation when using auto-commit, or one of the container-managed commit methods. Access to the `Consumer` object is provided.

❹ Use this for processing individual `ConsumerRecord` s received from the kafka consumer `poll()` operation when using one of the manual commit methods. Access to the `Consumer` object is provided.

❺ Use this for processing all `ConsumerRecord` s received from the kafka consumer `poll()` operation when using auto-commit, or one of the container-managed commit methods.

`AckMode.RECORD` is not supported when using this interface since the listener is given the complete batch.

❻ Use this for processing all `ConsumerRecord` s received from the kafka consumer `poll()` operation when using one of the manual commit methods.

❼ Use this for processing all `ConsumerRecord` s received from the kafka consumer `poll()` operation when using auto-commit, or one of the container-managed commit methods. `AckMode.RECORD` is not supported when using this interface since the listener is given the complete batch. Access to the `Consumer` object is provided.

❽ Use this for processing all `ConsumerRecord` s received from the kafka consumer `poll()` operation when using one of the manual commit methods. Access to the `Consumer` object is provided.

> **Important**
>
> The `Consumer` object is not thread-safe; you must only invoke its methods on the thread that calls the listener.

Message Listener Containers

Two `MessageListenerContainer` implementations are provided:

- `KafkaMessageListenerContainer`
- `ConcurrentMessageListenerContainer`

The `KafkaMessageListenerContainer` receives all message from all topics/partitions on a single thread. The `ConcurrentMessageListenerContainer` delegates to `1` or more `KafkaMessageListenerContainer` s to provide multi-threaded consumption.

KafkaMessageListenerContainer

The following constructors are available.

```
public KafkaMessageListenerContainer(ConsumerFactory<K, V> consumerFactory,
                    ContainerProperties containerProperties)

public KafkaMessageListenerContainer(ConsumerFactory<K, V> consumerFactory,
                    ContainerProperties containerProperties,
                    TopicPartitionInitialOffset... topicPartitions)
```

Each takes a `ConsumerFactory` and information about topics and partitions, as well as other configuration in a `ContainerProperties` object. The second constructor is used by the `ConcurrentMessageListenerContainer` (see below) to distribute `TopicPartitionInitialOffset` across the consumer instances. `ContainerProperties` has the following constructors:

```
public ContainerProperties(TopicPartitionInitialOffset... topicPartitions)

public ContainerProperties(String... topics)

public ContainerProperties(Pattern topicPattern)
```

The first takes an array of `TopicPartitionInitialOffset` arguments to explicitly instruct the container which partitions to use (using the consumer `assign()` method), and with an optional initial offset: a positive value is an absolute offset by default; a negative value is relative to the current last offset within a partition by default. A constructor for `TopicPartitionInitialOffset` is provided that takes an additional `boolean` argument. If this is `true`, the initial offsets (positive or negative) are relative to the current position for this consumer. The offsets are applied when the container is started. The second takes an array of topics and Kafka allocates the partitions based on the `group.id` property - distributing partitions across the group. The third uses a regex `Pattern` to select the topics.

To assign a `MessageListener` to a container, use the `ContainerProps.setMessageListener` method when creating the Container:

```
ContainerProperties containerProps = new ContainerProperties("topic1", "topic2");
containerProps.setMessageListener(new MessageListener<Integer, String>() {
    ...
});
DefaultKafkaConsumerFactory<Integer, String> cf =
                        new DefaultKafkaConsumerFactory<Integer, String>(consumerProps());
KafkaMessageListenerContainer<Integer, String> container =
                        new KafkaMessageListenerContainer<>(cf, containerProps);
return container;
```

Refer to the JavaDocs for `ContainerProperties` for more information about the various properties that can be set.

Since *version 2.1.1*, a new property `logContainerConfig` is available; when true, and INFO logging is enabled, each listener container will write a log message summarizing its configuration properties.

By default, logging of topic offset commits is performed with the DEBUG logging level. Starting with *version 2.1.2*, there is a new property in `ContainerProperties` called `commitLogLevel` which allows you to specify the log level for these messages. For example, to change the log level to INFO, use `containerProperties.setCommitLogLevel(LogIfLevelEnabled.Level.INFO);`.

Starting with *version 2.2*, a new container property `missingTopicsFatal` has been added (default `true`). This prevents the container from starting if any of the configured topics are not present on the broker; it does not apply if the container is configured to listen to a topic pattern (regex). Previously, the container threads looped within the `consumer.poll()` method waiting for the topic to appear, while logging many messages; aside from the logs, there was no indication that there was a problem. To restore the previous behavior, set the property to `false`.

ConcurrentMessageListenerContainer

The single constructor is similar to the first `KafkaListenerContainer` constructor:

```
public ConcurrentMessageListenerContainer(ConsumerFactory<K, V> consumerFactory,
                            ContainerProperties containerProperties)
```

It also has a property `concurrency`, e.g. `container.setConcurrency(3)` will create 3 `KafkaMessageListenerContainer` s.

For the first constructor, kafka will distribute the partitions across the consumers using its group management capabilities.

> **Important**
>
> When listening to multiple topics, the default partition distribution may not be what you expect. For example, if you have 3 topics with 5 partitions each and you want to use `concurrency=15` you will only see 5 active consumers, each assigned one partition from

> each topic, with the other 10 consumers being idle. This is because the default Kafka `PartitionAssignor` is the `RangeAssignor` (see its javadocs). For this scenario, you may want to consider using the `RoundRobinAssignor` instead, which will distribute the partitions across all of the consumers. Then, each consumer will be assigned one topic/partition. To change the `PartitionAssignor`, set the `partition.assignment.strategy` consumer property (`ConsumerConfigs.PARTITION_ASSIGNMENT_STRATEGY_CONFIG`) in the properties provided to the `DefaultKafkaConsumerFactory`.
>
> When using Spring Boot:
>
> ```
> spring.kafka.consumer.properties.partition.assignment.strategy=\
> org.apache.kafka.clients.consumer.RoundRobinAssignor
> ```

For the second constructor, the `ConcurrentMessageListenerContainer` distributes the `TopicPartition` s across the delegate `KafkaMessageListenerContainer` s.

If, say, 6 `TopicPartition` s are provided and the `concurrency` is 3; each container will get 2 partitions. For 5 `TopicPartition` s, 2 containers will get 2 partitions and the third will get 1. If the `concurrency` is greater than the number of `TopicPartitions`, the `concurrency` will be adjusted down such that each container will get one partition.

> **Note**
>
> The `client.id` property (if set) will be appended with `-n` where `n` is the consumer instance according to the concurrency. This is required to provide unique names for MBeans when JMX is enabled.

Starting with *version 1.3*, the `MessageListenerContainer` provides an access to the metrics of the underlying `KafkaConsumer`. In case of `ConcurrentMessageListenerContainer` the `metrics()` method returns the metrics for all the target `KafkaMessageListenerContainer` instances. The metrics are grouped into the `Map<MetricName, ? extends Metric>` by the `client-id` provided for the underlying `KafkaConsumer`.

Committing Offsets

Several options are provided for committing offsets. If the `enable.auto.commit` consumer property is true, kafka will auto-commit the offsets according to its configuration. If it is false, the containers support the following `AckMode` s.

The consumer `poll()` method will return one or more `ConsumerRecords`; the `MessageListener` is called for each record; the following describes the action taken by the container for each `AckMode` :

- RECORD - commit the offset when the listener returns after processing the record.
- BATCH - commit the offset when all the records returned by the `poll()` have been processed.
- TIME - commit the offset when all the records returned by the `poll()` have been processed as long as the `ackTime` since the last commit has been exceeded.
- COUNT - commit the offset when all the records returned by the `poll()` have been processed as long as `ackCount` records have been received since the last commit.
- COUNT_TIME - similar to TIME and COUNT but the commit is performed if either condition is true.

- MANUAL - the message listener is responsible to `acknowledge()` the `Acknowledgment`; after which, the same semantics as `BATCH` are applied.
- MANUAL_IMMEDIATE - commit the offset immediately when the `Acknowledgment.acknowledge()` method is called by the listener.

> **Note**
>
> `MANUAL`, and `MANUAL_IMMEDIATE` require the listener to be an `AcknowledgingMessageListener` or a `BatchAcknowledgingMessageListener`; see Message Listeners.

The `commitSync()` or `commitAsync()` method on the consumer is used, depending on the `syncCommits` container property.

The `Acknowledgment` has this method:

```
public interface Acknowledgment {

    void acknowledge();

}
```

This gives the listener control over when offsets are committed.

Listener Container Auto Startup

The listener containers implement `SmartLifecycle` and `autoStartup` is `true` by default; the containers are started in a late phase (`Integer.MAX-VALUE - 100`). Other components that implement `SmartLifecycle`, that handle data from listeners, should be started in an earlier phase. The `- 100` leaves room for later phases to enable components to be auto-started after the containers.

@KafkaListener Annotation

Record Listeners

The `@KafkaListener` annotation provides a mechanism for simple POJO listeners:

```
public class Listener {

    @KafkaListener(id = "foo", topics = "myTopic", clientIdPrefix = "myClientId")
    public void listen(String data) {
        ...
    }

}
```

This mechanism requires an `@EnableKafka` annotation on one of your `@Configuration` classes and a listener container factory, which is used to configure the underlying `ConcurrentMessageListenerContainer`: by default, a bean with name `kafkaListenerContainerFactory` is expected.

```
@Configuration
@EnableKafka
public class KafkaConfig {

    @Bean
    KafkaListenerContainerFactory<ConcurrentMessageListenerContainer<Integer, String>>
                        kafkaListenerContainerFactory() {
        ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
                                new ConcurrentKafkaListenerContainerFactory<>();
        factory.setConsumerFactory(consumerFactory());
        factory.setConcurrency(3);
        factory.getContainerProperties().setPollTimeout(3000);
        return factory;
    }

    @Bean
    public ConsumerFactory<Integer, String> consumerFactory() {
        return new DefaultKafkaConsumerFactory<>(consumerConfigs());
    }

    @Bean
    public Map<String, Object> consumerConfigs() {
        Map<String, Object> props = new HashMap<>();
        props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, embeddedKafka.getBrokersAsString());
        ...
        return props;
    }
}
```

Notice that to set container properties, you must use the `getContainerProperties()` method on the factory. It is used as a template for the actual properties injected into the container.

Starting with version 2.1.1, it is now possible to set the `client.id` property for consumers created by the annotation. The `clientIdPrefix` is suffixed with `-n` where `n` is an integer representing the container number when using concurrency.

Starting with version 2.2, you can now override the container factory's `concurrency` and `autoStartup` properties using properties on the annotation itself. The properties can be simple values, property placeholders or SpEL expressions.

```
@KafkaListener(id = "myListener", topics = "myTopic",
        autoStartup = "${listen.auto.start:true}", concurrency = "${listen.concurrency:3}")
public void listen(String data) {
    ...
}
```

You can also configure POJO listeners with explicit topics and partitions (and, optionally, their initial offsets):

```
@KafkaListener(id = "bar", topicPartitions =
        { @TopicPartition(topic = "topic1", partitions = { "0", "1" }),
          @TopicPartition(topic = "topic2", partitions = "0",
             partitionOffsets = @PartitionOffset(partition = "1", initialOffset = "100"))
        })
public void listen(ConsumerRecord<?, ?> record) {
    ...
}
```

Each partition can be specified in the `partitions` or `partitionOffsets` attribute, but not both.

When using manual `AckMode`, the listener can also be provided with the `Acknowledgment`; this example also shows how to use a different container factory.

```
@KafkaListener(id = "baz", topics = "myTopic",
          containerFactory = "kafkaManualAckListenerContainerFactory")
public void listen(String data, Acknowledgment ack) {
    ...
    ack.acknowledge();
}
```

Finally, metadata about the message is available from message headers, the following header names can be used for retrieving the headers of the message:

- `KafkaHeaders.RECEIVED_MESSAGE_KEY`
- `KafkaHeaders.RECEIVED_TOPIC`
- `KafkaHeaders.RECEIVED_PARTITION_ID`
- `KafkaHeaders.RECEIVED_TIMESTAMP`
- `KafkaHeaders.TIMESTAMP_TYPE`

```
@KafkaListener(id = "qux", topicPattern = "myTopic1")
public void listen(@Payload String foo,
        @Header(KafkaHeaders.RECEIVED_MESSAGE_KEY) Integer key,
        @Header(KafkaHeaders.RECEIVED_PARTITION_ID) int partition,
        @Header(KafkaHeaders.RECEIVED_TOPIC) String topic,
        @Header(KafkaHeaders.RECEIVED_TIMESTAMP) long ts
        ) {
    ...
}
```

Batch listeners

Starting with *version 1.1*, `@KafkaListener` methods can be configured to receive the entire batch of consumer records received from the consumer poll. To configure the listener container factory to create batch listeners, set the `batchListener` property:

```
@Bean
public KafkaListenerContainerFactory<?> batchFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
            new ConcurrentKafkaListenerContainerFactory<>();
    factory.setConsumerFactory(consumerFactory());
    factory.setBatchListener(true);  // <<<<<<<<<<<<<<<<<<<<<<<<<
    return factory;
}
```

To receive a simple list of payloads:

```
@KafkaListener(id = "list", topics = "myTopic", containerFactory = "batchFactory")
public void listen(List<String> list) {
    ...
}
```

The topic, partition, offset etc are available in headers which parallel the payloads:

```
@KafkaListener(id = "list", topics = "myTopic", containerFactory = "batchFactory")
public void listen(List<String> list,
        @Header(KafkaHeaders.RECEIVED_MESSAGE_KEY) List<Integer> keys,
        @Header(KafkaHeaders.RECEIVED_PARTITION_ID) List<Integer> partitions,
        @Header(KafkaHeaders.RECEIVED_TOPIC) List<String> topics,
        @Header(KafkaHeaders.OFFSET) List<Long> offsets) {
    ...
}
```

Alternatively you can receive a List of `Message<?>` objects with each offset, etc in each message, but it must be the only parameter (aside from optional `Acknowledgment`, when using manual commits, and/or `Consumer<?, ?>` parameters) defined on the method:

```
@KafkaListener(id = "listMsg", topics = "myTopic", containerFactory = "batchFactory")
public void listen14(List<Message<?>> list) {
    ...
}

@KafkaListener(id = "listMsgAck", topics = "myTopic", containerFactory = "batchFactory")
public void listen15(List<Message<?>> list, Acknowledgment ack) {
    ...
}

@KafkaListener(id = "listMsgAckConsumer", topics = "myTopic", containerFactory = "batchFactory")
public void listen16(List<Message<?>> list, Acknowledgment ack, Consumer<?, ?> consumer) {
    ...
}
```

No conversion is performed on the payloads in this case.

If the `BatchMessagingMessageConverter` is configured with a `RecordMessageConverter`, you can also add a generic type to the `Message` parameter and the payloads will be converted. See the section called “Payload Conversion with Batch Listeners” for more information.

You can also receive a list of `ConsumerRecord<?, ?>` objects but it must be the only parameter (aside from optional `Acknowledgment`, when using manual commits, and/or `Consumer<?, ?>` parameters) defined on the method:

```
@KafkaListener(id = "listCRs", topics = "myTopic", containerFactory = "batchFactory")
public void listen(List<ConsumerRecord<Integer, String>> list) {
    ...
}

@KafkaListener(id = "listCRsAck", topics = "myTopic", containerFactory = "batchFactory")
public void listen(List<ConsumerRecord<Integer, String>> list, Acknowledgment ack) {
    ...
}
```

Starting with *version 2.2*, the listener can receive the complete `ConsumerRecords<?, ?>` object returned by the `poll()` method, allowing the listener to access additional methods such as `partitions()` which returns the `TopicPartition` s in the list and `records(TopicPartition)` to get selective records. Again, this must be the only parameter (aside from optional `Acknowledgment`, when using manual commits, and/or `Consumer<?, ?>` parameters) on the method:

```
@KafkaListener(id = "pollResults", topics = "myTopic", containerFactory = "batchFactory")
public void pollResults(ConsumerRecords<?, ?> records) {
    ...
}
```

> **Important**
>
> If the container factory has a `RecordFilterStrategy` configured, it will be ignored for `ConsumerRecords<?, ?>` listeners, with a WARNing log emitted. Records can only be filtered with a batch listener if the `<List<?>>` form of listener is used.

Starting with *version 2.0*, the `id` attribute (if present) is used as the Kafka `group.id` property, overriding the configured property in the consumer factory, if present. You can also set `groupId` explicitly, or set `idIsGroup` to false, to restore the previous behavior of using the consumer factory `group.id`.

You can use property placeholders or SpEL expressions within annotation properties, for example…

```
@KafkaListener(topics = "${some.property}")

@KafkaListener(topics = "#{someBean.someProperty}",
    groupId = "#{someBean.someProperty}.group")
```

Starting with *version 2.1.2*, the SpEL expressions support a special token `__listener` which is a pseudo bean name which represents the current bean instance within which this annotation exists.

For example, given…

```
@Bean
public Listener listener1() {
    return new Listener("topic1");
}

@Bean
public Listener listener2() {
    return new Listener("topic2");
}
```

…we can use…

```
public class Listener {

    private final String topic;

    public Listener(String topic) {
        this.topic = topic;
    }

    @KafkaListener(topics = "#{__listener.topic}",
        groupId = "#{__listener.topic}.group")
    public void listen(...) {
        ...
    }

    public String getTopic() {
        return this.topic;
    }

}
```

If, in the unlikely event that you have an actual bean called `__listener`, you can change the expression token using the `beanRef` attribute…

```
@KafkaListener(beanRef = "__x", topics = "#{__x.topic}",
    groupId = "#{__x.topic}.group")
```

Container Thread Naming

Listener containers currently use two task executors, one to invoke the consumer and another which will be used to invoke the listener, when the kafka consumer property `enable.auto.commit` is `false`. You can provide custom executors by setting the `consumerExecutor` and `listenerExecutor` properties of the container's `ContainerProperties`. When using pooled executors, be sure that enough threads are available to handle the concurrency across all the containers in which they are used. When using the `ConcurrentMessageListenerContainer`, a thread from each is used for each consumer (`concurrency`).

If you don't provide a consumer executor, a `SimpleAsyncTaskExecutor` is used; this executor creates threads with names `<beanName>-C-1` (consumer thread). For the

`ConcurrentMessageListenerContainer`, the `<beanName>` part of the thread name becomes `<beanName>-m`, where `m` represents the consumer instance. n increments each time the container is started. So, with a bean name of `container`, threads in this container will be named `container-0-C-1`, `container-1-C-1` etc., after the container is started the first time; `container-0-C-2`, `container-1-C-2` etc., after a stop/start.

@KafkaListener as a Meta Annotation

Starting with version 2.2, you can now use `@KafkaListener` as a meta annotation. For example:

```
@Target(ElementType.METHOD)
@Retention(RetentionPolicy.RUNTIME)
@KafkaListener
public @interface MyThreeConsumersListener {

    @AliasFor(annotation = KafkaListener.class, attribute = "id")
    String id();

    @AliasFor(annotation = KafkaListener.class, attribute = "topics")
    String[] topics();

    @AliasFor(annotation = KafkaListener.class, attribute = "concurrency")
    String concurrency() default "3";

}
```

You must alias at least one of `topics`, `topicPattern`, or `topicPartitions` (and, usually, `id` or `groupId` unless you have specified a `group.id` in the consumer factory configuration).

```
@MyThreeConsumersListener(id = "my.group", topics = "my.topic")
public void listen1(String in) {
    ...
}
```

@KafkaListener on a Class

When using `@KafkaListener` at the class-level, you specify `@KafkaHandler` at the method level. When messages are delivered, the converted message payload type is used to determine which method to call.

```
@KafkaListener(id = "multi", topics = "myTopic")
static class MultiListenerBean {

    @KafkaHandler
    public void listen(String foo) {
        ...
    }

    @KafkaHandler
    public void listen(Integer bar) {
        ...
    }

    @KafkaHandler(isDefault = true`)
    public void listenDefault(Object object) {
        ...
    }

}
```

Starting with *version 2.1.3*, a `@KafkaHandler` method can be designated as the default method which is invoked if there is no match on other methods. At most one method can be so designated. When using

`@KafkaHandler` methods, the payload must have already been converted to the domain object (so the match can be performed). Use a custom deserializer, the `JsonDeserializer` or the `(String|Bytes)JsonMessageConverter` with its `TypePrecedence` set to `TYPE_ID` - see the section called “Serialization/Deserialization and Message Conversion” for more information.

@KafkaListener Lifecycle Management

The listener containers created for `@KafkaListener` annotations are not beans in the application context. Instead, they are registered with an infrastructure bean of type `KafkaListenerEndpointRegistry`. This bean is automatically declared by the framework and manages the containers' lifecycles; it will auto-start any containers that have `autoStartup` set to `true`. All containers created by all container factories must be in the same `phase` - see the section called “Listener Container Auto Startup” for more information. You can manage the lifecycle programmatically using the registry; starting/stopping the registry will start/stop all the registered containers. Or, you can get a reference to an individual container using its `id` attribute; you can set `autoStartup` on the annotation, which will override the default setting configured into the container factory. Simply get a reference to the bean from the application context, such as auto wiring, to manage its registered containers:

```
@KafkaListener(id = "myContainer", topics = "myTopic", autoStartup = "false")
public void listen(...) { ... }
```

```
@Autowired
private KafkaListenerEndpointRegistry registry;

...

    this.registry.getListenerContainer("myContainer").start();

...
```

@KafkaListener @Payload Validation

Starting with version 2.2, it is now easier to add a `Validator` to validate `@KafkaListener` `@Payload` arguments. Previously, you had to configure a custom `DefaultMessageHandlerMethodFactory` and add it to the registrar. Now, you can simply add the validator to the registrar itself.

```
@Configuration
@EnableKafka
public class Config implements KafkaListenerConfigurer {

    ...

    @Override
    public void configureKafkaListeners(KafkaListenerEndpointRegistrar registrar) {
      registrar.setValidator(new MyValidator());
    }
}
```

> **Note**
>
> When using Spring Boot with the validation starter, a `LocalValidatorFactoryBean` is auto-configured:

```
@Configuration
@EnableKafka
public class Config implements KafkaListenerConfigurer {

    @Autowired
    private LocalValidatorFactoryBean validator;
    ...

    @Override
    public void configureKafkaListeners(KafkaListenerEndpointRegistrar registrar) {
      registrar.setValidator(this.validator);
    }
}
```

To validate:

```
public static class ValidatedClass {

  @Max(10)
  private int bar;

  public int getBar() {
    return this.bar;
  }

  public void setBar(int bar) {
    this.bar = bar;
  }

}
```

and

```
@KafkaListener(id="validated", topics = "annotated35", errorHandler = "validationErrorHandler",
      containerFactory = "kafkaJsonListenerContainerFactory")
public void validatedListener(@Payload @Valid ValidatedClass val) {
    ...
}

@Bean
public KafkaListenerErrorHandler validationErrorHandler() {
    return (m, e) -> {
        ...
    };
}
```

Rebalance Listeners

`ContainerProperties` has a property `consumerRebalanceListener` which takes an implementation of the Kafka client's `ConsumerRebalanceListener` interface. If this property is not provided, the container will configure a simple logging listener that logs rebalance events under the `INFO` level. The framework also adds a sub-interface `ConsumerAwareRebalanceListener`:

```
public interface ConsumerAwareRebalanceListener extends ConsumerRebalanceListener {

    void onPartitionsRevokedBeforeCommit(Consumer<?, ?> consumer, Collection<TopicPartition>
 partitions);

    void onPartitionsRevokedAfterCommit(Consumer<?, ?> consumer, Collection<TopicPartition> partitions);

    void onPartitionsAssigned(Consumer<?, ?> consumer, Collection<TopicPartition> partitions);

}
```

Notice that there are two callbacks when partitions are revoked: the first is called immediately; the second is called after any pending offsets are committed. This is useful if you wish to maintain offsets in some external repository; for example:

```
containerProperties.setConsumerRebalanceListener(new ConsumerAwareRebalanceListener() {

    @Override
    public void onPartitionsRevokedBeforeCommit(Consumer<?, ?> consumer, Collection<TopicPartition>
 partitions) {
        // acknowledge any pending Acknowledgments (if using manual acks)
    }

    @Override
    public void onPartitionsRevokedAfterCommit(Consumer<?, ?> consumer, Collection<TopicPartition>
 partitions) {
        // ...
            store(consumer.position(partition));
        // ...
    }

    @Override
    public void onPartitionsAssigned(Collection<TopicPartition> partitions) {
        // ...
            consumer.seek(partition, offsetTracker.getOffset() + 1);
        // ...
    }
});
```

Forwarding Listener Results using @SendTo

Starting with *version 2.0*, if you also annotate a `@KafkaListener` with a `@SendTo` annotation and the method invocation returns a result, the result will be forwarded to the topic specified by the `@SendTo`.

The `@SendTo` value can have several forms:

- `@SendTo("someTopic")` routes to the literal topic
- `@SendTo("#{someExpression}")` routes to the topic determined by evaluating the expression once during application context initialization.
- `@SendTo("!{someExpression}")` routes to the topic determined by evaluating the expression at runtime. The `#root` object for the evaluation has 3 properties:
- request - the inbound `ConsumerRecord` (or `ConsumerRecords` object for a batch listener))
- source - the `org.springframework.messaging.Message<?>` converted from the `request`.
- result - the method return result.
- `@SendTo` (no properties) - this is treated as `!{source.headers['kafka_replyTopic']}` (since version 2.1.3).

Starting with versions 2.1.11, 2.2.1, property placeholders are resolved within `@SendTo` values.

The result of the expression evaluation must be a `String` representing the topic name.

```
@KafkaListener(topics = "annotated21")
@SendTo("!{request.value()}") // runtime SpEL
public String replyingListener(String in) {
    ...
}

@KafkaListener(topics = "${some.property:annotated22}")
@SendTo("#{myBean.replyTopic}") // config time SpEL
public Collection<String> replyingBatchListener(List<String> in) {
    ...
}

@KafkaListener(topics = "annotated23", errorHandler = "replyErrorHandler")
@SendTo("annotated23reply") // static reply topic definition
public String replyingListenerWithErrorHandler(String in) {
    ...
}
...
@KafkaListener(topics = "annotated25")
@SendTo("annotated25reply1")
public class MultiListenerSendTo {

    @KafkaHandler
    public String foo(String in) {
        ...
    }

    @KafkaHandler
    @SendTo("!{'annotated25reply2'}")
    public String bar(@Payload(required = false) KafkaNull nul,
            @Header(KafkaHeaders.RECEIVED_MESSAGE_KEY) int key) {
        ...
    }

}
```

Starting with version 2.2, you can add a `ReplyHeadersConfigurer` to the listener container factory. This is consulted to determine which headers you want to set in the reply message.

```
@Bean
public ConcurrentKafkaListenerContainerFactory<Integer, String> kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
        new ConcurrentKafkaListenerContainerFactory<>();
    factory.setConsumerFactory(cf());
    factory.setReplyTemplate(template());
    factory.setReplyHeadersConfigurer((k, v) -> k.equals("baz"));
    return factory;
}
```

You can also add more headers if you wish

```
@Bean
public ConcurrentKafkaListenerContainerFactory<Integer, String> kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
        new ConcurrentKafkaListenerContainerFactory<>();
    factory.setConsumerFactory(cf());
    factory.setReplyTemplate(template());
    factory.setReplyHeadersConfigurer(new ReplyHeadersConfigurer() {

      @Override
      public boolean shouldCopy(String headerName, Object headerValue) {
        return false;
      }

      @Override
      public Map<String, Object> additionalHeaders() {
        return Collections.singletonMap("qux", "fiz");
      }

    });
    return factory;
}
```

When using `@SendTo`, the `ConcurrentKafkaListenerContainerFactory` must be configured with a `KafkaTemplate` in its `replyTemplate` property, to perform the send. NOTE: unless you are using request/reply semantics only the simple `send(topic, value)` method is used, so you may wish to create a subclass to generate the partition and/or key:

```
@Bean
public KafkaTemplate<String, String> myReplyingTemplate() {
    return new KafkaTemplate<Integer, String>(producerFactory()) {

        @Override
        public ListenableFuture<SendResult<String, String>> send(String topic, String data) {
            return super.send(topic, partitionForData(data), keyForData(data), data);
        }

        ...

    };
}
```

Important

If the listener method returns `Message<?>` or `Collection<Message<?>>`, the listener method is responsible for setting up the message headers for the reply; for example, when handling a request from a `ReplyingKafkaTemplate`, you might do the following:

```
@KafkaListener(id = "messageReturned", topics = "someTopic")
public Message<?> listen(String in, @Header(KafkaHeaders.REPLY_TOPIC) byte[] replyTo,
        @Header(KafkaHeaders.CORRELATION_ID) byte[] correlation) {
    return MessageBuilder.withPayload(in.toUpperCase())
            .setHeader(KafkaHeaders.TOPIC, replyTo)
            .setHeader(KafkaHeaders.MESSAGE_KEY, 42)
            .setHeader(KafkaHeaders.CORRELATION_ID, correlation)
            .setHeader("someOtherHeader", "someValue")
            .build();
}
```

When using request/reply semantics, the target partition can be requested by the sender.

> **Note**
>
> You can annotate a `@KafkaListener` method with `@SendTo` even if no result is returned. This is to allow the configuration of an `errorHandler` that can forward information about a failed message delivery to some topic.

```
@KafkaListener(id = "voidListenerWithReplyingErrorHandler", topics = "someTopic",
        errorHandler = "voidSendToErrorHandler")
@SendTo("failures")
public void voidListenerWithReplyingErrorHandler(String in) {
    throw new RuntimeException("fail");
}

@Bean
public KafkaListenerErrorHandler voidSendToErrorHandler() {
    return (m, e) -> {
        return ... // some information about the failure and input data
    };
}
```

See the section called “Handling Exceptions” for more information.

Filtering Messages

In certain scenarios, such as rebalancing, a message may be redelivered that has already been processed. The framework cannot know whether such a message has been processed or not, that is an application-level function. This is known as the Idempotent Receiver pattern and Spring Integration provides an implementation thereof.

The Spring for Apache Kafka project also provides some assistance by means of the `FilteringMessageListenerAdapter` class, which can wrap your `MessageListener`. This class takes an implementation of `RecordFilterStrategy` where you implement the `filter` method to signal that a message is a duplicate and should be discarded. This has an additional property `ackDiscarded` which indicates whether the adapter should acknowledge the discarded record; it is `false` by default.

When using `@KafkaListener`, set the `RecordFilterStrategy` (and optionally `ackDiscarded`) on the container factory and the listener will be wrapped in the appropriate filtering adapter.

In addition, a `FilteringBatchMessageListenerAdapter` is provided, for when using a batch message listener.

> **Important**
>
> The `FilteringBatchMessageListenerAdapter` is ignored if your `@KafkaListener` receives a `ConsumerRecords<?, ?>` instead of `List<ConsumerRecord<?, ?>` because `ConsumerRecords` is immutable.

Retrying Deliveries

If your listener throws an exception, the default behavior is to invoke the `ErrorHandler`, if configured, or logged otherwise.

> **Note**
>
> Two error handler interfaces are provided `ErrorHandler` and `BatchErrorHandler`; the appropriate type must be configured to match the Message Listener.

To retry deliveries, a convenient listener adapter `RetryingMessageListenerAdapter` is provided.

It can be configured with a `RetryTemplate` and `RecoveryCallback<Void>` - see the spring-retry project for information about these components. If a recovery callback is not provided, the exception is thrown to the container after retries are exhausted. In that case, the `ErrorHandler` will be invoked, if configured, or logged otherwise.

When using `@KafkaListener`, set the `RetryTemplate` (and optionally `recoveryCallback`) on the container factory and the listener will be wrapped in the appropriate retrying adapter.

The contents of the `RetryContext` passed into the `RecoveryCallback` will depend on the type of listener. The context will always have an attribute `record` which is the record for which the failure occurred. If your listener is acknowledging and/or consumer aware, additional attributes `acknowledgment` and/or `consumer` will be available. For convenience, the `RetryingMessageListenerAdapter` provides static constants for these keys. See its javadocs for more information.

A retry adapter is not provided for any of the batch message listeners because the framework has no knowledge of where, in a batch, the failure occurred. Users wishing retry capabilities, when using a batch listener, are advised to use a `RetryTemplate` within the listener itself.

Stateful Retry

It is important to understand that the retry discussed above suspends the consumer thread (if a `BackOffPolicy` is used); there are no calls to `Consumer.poll()` during the retries. Kafka has two properties to determine consumer health; the `session.timeout.ms` is used to determine if the consumer is active. Since version `0.10.1.0` heartbeats are sent on a background thread so a slow consumer no longer affects that. `max.poll.interval.ms` (default 5 minutes) is used to determine if a consumer appears to be hung (taking too long to process records from the last poll). If the time between `poll()` s exceeds this, the broker will revoke the assigned partitions and perform a rebalance. For lengthy retry sequences, with back off, this can easily happen.

Since *version 2.1.3*, you can avoid this problem by using stateful retry in conjunction with a `SeekToCurrentErrorHandler`. In this case, each delivery attempt will throw the exception back to the container and the error handler will re-seek the unprocessed offsets and the same message will be redelivered by the next `poll()`. This avoids the problem of exceeding the `max.poll.interval.ms` property (as long as an individual delay between attempts does not exceed it). So, when using an `ExponentialBackOffPolicy`, it's important to ensure that the `maxInterval` is rather less than the `max.poll.interval.ms` property. To enable stateful retry, use the `RetryingMessageListenerAdapter` constructor that takes a `stateful` `boolean` argument (set it to `true`). When configuring using the listener container factory (for `@KafkaListener` s), set the factory's `statefulRetry` property to `true`.

Detecting Idle and Non-Responsive Consumers

While efficient, one problem with asynchronous consumers is detecting when they are idle - users might want to take some action if no messages arrive for some period of time.

You can configure the listener container to publish a `ListenerContainerIdleEvent` when some time passes with no message delivery. While the container is idle, an event will be published every `idleEventInterval` milliseconds.

To configure this feature, set the `idleEventInterval` on the container:

```
@Bean
public KafkaMessageListenerContainer(ConsumerFactory<String, String> consumerFactory) {
    ContainerProperties containerProps = new ContainerProperties("topic1", "topic2");
    ...
    containerProps.setIdleEventInterval(60000L);
    ...
    KafkaMessageListenerContainer<String, String> container = new KafKaMessageListenerContainer<>(...);
    return container;
}
```

Or, for a `@KafkaListener`…

```
@Bean
public ConcurrentKafkaListenerContainerFactory kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<String, String> factory =
                new ConcurrentKafkaListenerContainerFactory<>();
    ...
    factory.getContainerProperties().setIdleEventInterval(60000L);
    ...
    return factory;
}
```

In each of these cases, an event will be published once per minute while the container is idle.

In addition, if the broker is unreachable (at the time of writing), the consumer `poll()` method does not exit, so no messages are received, and idle events can't be generated. To solve this issue, the container will publish a `NonResponsiveConsumerEvent` if a poll does not return within 3x the `pollInterval` property. By default, this check is performed once every 30 seconds in each container. You can modify the behavior by setting the `monitorInterval` and `noPollThreshold` properties in the `ContainerProperties` when configuring the listener container. Receiving such an event will allow you to stop the container(s), thus waking the consumer so it can terminate.

Event Consumption

You can capture these events by implementing `ApplicationListener` - either a general listener, or one narrowed to only receive this specific event. You can also use `@EventListener`, introduced in Spring Framework 4.2.

The following example combines the `@KafkaListener` and `@EventListener` into a single class. It's important to understand that the application listener will get events for all containers so you may need to check the listener id if you want to take specific action based on which container is idle. You can also use the `@EventListener condition` for this purpose.

See the section called "Events" for information about event properties.

The event is normally published on the consumer thread, so it is safe to interact with the `Consumer` object.

```
public class Listener {

    @KafkaListener(id = "qux", topics = "annotated")
    public void listen4(@Payload String foo, Acknowledgment ack) {
        ...
    }

    @EventListener(condition = "event.listenerId.startsWith('qux-')")
    public void eventHandler(ListenerContainerIdleEvent event) {
        ...
    }

}
```

Important

Event listeners will see events for all containers; so, in the example above, we narrow the events received based on the listener ID. Since containers created for the `@KafkaListener` support concurrency, the actual containers are named `id-n` where the `n` is a unique value for each instance to support the concurrency. Hence we use `startsWith` in the condition.

Caution

If you wish to use the idle event to stop the lister container, you should not call `container.stop()` on the thread that calls the listener - it will cause delays and unnecessary log messages. Instead, you should hand off the event to a different thread that can then stop the container. Also, you should not `stop()` the container instance in the event if it is a child container, you should stop the concurrent container instead.

Current Positions when Idle

Note that you can obtain the current positions when idle is detected by implementing `ConsumerSeekAware` in your listener; see `onIdleContainer()` in `the section called “Seeking to a Specific Offset”.

Topic/Partition Initial Offset

There are several ways to set the initial offset for a partition.

When manually assigning partitions, simply set the initial offset (if desired) in the configured `TopicPartitionInitialOffset` arguments (see the section called “Message Listener Containers”). You can also seek to a specific offset at any time.

When using group management where the broker assigns partitions:

- For a new `group.id`, the initial offset is determined by the `auto.offset.reset` consumer property (`earliest` or `latest`).
- For an existing group id, the initial offset is the current offset for that group id. You can, however, seek to a specific offset during initialization (or at any time thereafter).

Seeking to a Specific Offset

In order to seek, your listener must implement `ConsumerSeekAware` which has the following methods:

```
void registerSeekCallback(ConsumerSeekCallback callback);

void onPartitionsAssigned(Map<TopicPartition, Long> assignments, ConsumerSeekCallback callback);

void onIdleContainer(Map<TopicPartition, Long> assignments, ConsumerSeekCallback callback);
```

The first is called when the container is started; this callback should be used when seeking at some arbitrary time after initialization. You should save a reference to the callback; if you are using the same listener in multiple containers (or in a `ConcurrentMessageListenerContainer`) you should store the callback in a `ThreadLocal` or some other structure keyed by the listener `Thread`.

When using group management, the second method is called when assignments change. You can use this method, for example, for setting initial offsets for the partitions, by calling the callback; you must use the callback argument, not the one passed into `registerSeekCallback`. This method will never be called if you explicitly assign partitions yourself; use the `TopicPartitionInitialOffset` in that case.

The callback has these methods:

```
void seek(String topic, int partition, long offset);

void seekToBeginning(String topic, int partition);

void seekToEnd(String topic, int partition);
```

You can also perform seek operations from `onIdleContainer()` when an idle container is detected; see the section called “Detecting Idle and Non-Responsive Consumers” for how to enable idle container detection.

To arbitrarily seek at runtime, use the callback reference from the `registerSeekCallback` for the appropriate thread.

Container factory

As discussed in the section called “@KafkaListener Annotation” a `ConcurrentKafkaListenerContainerFactory` is used to create containers for annotated methods.

Starting with *version 2.2*, the same factory can be used to create any `ConcurrentMessageListenerContainer`. This might be useful if you want to create several containers with similar properties, or you wish to use some externally configured factory, such as the one provided by Spring Boot auto configuration. Once the container is created, you can further modify its properties, many of which are set by using `container.getContainerProperties()`.

```
@Bean
public ConcurrentMessageListenerContainer<String, String>(
        ConcurrentKafkaListenerContainerFactory<String, String> factory) {

    ConcurrentMessageListenerContainer<String, String> container =
        factory.createContainer("topic1", "topci2");
    container.setMessageListener(m -> { ... } );
    return container;
}
```

> **Important**
>
> Containers created this way are not added to the endpoint registry. They should be created as `@Bean` s so that they will be registered with the application context.

Thread Safety

When using a concurrent message listener container, a single listener instance is invoked on all consumer threads. Listeners, therefore, need to be thread-safe; and it is preferable to use stateless listeners. If it is not possible to make your listener thread-safe, or adding synchronization would significantly reduce the benefit of adding concurreny, there are several techniques you can use.

1. Use n containers with `concurrency=1` with a prototype scoped `MessageListener` bean so each container gets its own instance (this is not possible when using `@KafkaListener`).

2. Keep the state in `ThreadLocal<?>` s.

3. Have the singleton listener delegate to a bean that is declared in `SimpleThreadScope` or similar.

To facilitate cleaning up thread state (for 2 and 3), starting with version 2.2, the listener container will publish `ConsumerStoppedEvent` s when each thread exits. Consume these events with an `ApplicationListener` or `@EventListener` method to remove `ThreadLocal<?>` s, or `remove()` thread-scoped beans from the scope. Note that `SimpleThreadScope` does not destroy beans that have a destruction interface (e.g. `DisposableBean`) so you should `destroy()` the instance yourself.

> **Important**
>
> By default, the application context's event multicaster invokes event listeners on the calling thread. If you change the multicaster to use an async executor, thread cleanup will not be effective.

Pausing/Resuming Listener Containers

Version 2.1.3 added `pause()` and `resume()` methods to listener containers. Previously, you could pause a consumer within a `ConsumerAwareMessageListener` and resume it by listening for `ListenerContainerIdleEvent` s, which provide access to the `Consumer` object. While you could pause a consumer in an idle container via an event listener, in some cases this was not thread-safe since there is no guarantee that the event listener is invoked on the consumer thread. To safely pause/resume consumers, you should use the methods on the listener containers. `pause()` takes effect just before the next `poll()`; `resume` takes effect, just after the current `poll()` returns. When a container is paused, it continues to `poll()` the consumer, avoiding a rebalance if group management is being used, but will not retrieve any records; refer to the Kafka documentation for more information.

Starting with *version 2.1.5*, you can call `isPauseRequested()` to see if `pause()` has been called. However, the consumers might not have actually paused yet; `isConsumerPaused()` will return true if all `Consumer` s have actually paused.

In addition, also since *2.1.5*, `ConsumerPausedEvent` s and `ConsumerResumedEvent` s are published with the container as the `source` property and the `TopicPartition` s involved in the `partitions` s property.

This simple Spring Boot application demonstrates using the container registry to get a reference to a `@KafkaListener` method's container and pausing/resuming its consumers, as well as receiving the corresponding events.

```java
@SpringBootApplication
public class Application implements ApplicationListener<KafkaEvent> {

    public static void main(String[] args) {
        SpringApplication.run(Application.class, args).close();
    }

    @Override
    public void onApplicationEvent(KafkaEvent event) {
        System.out.println(event);
    }

    @Bean
    public ApplicationRunner runner(KafkaListenerEndpointRegistry registry,
            KafkaTemplate<String, String> template) {
        return args -> {
            template.send("pause.resume.topic", "foo");
            Thread.sleep(10_000);
            System.out.println("pausing");
            registry.getListenerContainer("pause.resume").pause();
            Thread.sleep(10_000);
            template.send("pause.resume.topic", "bar");
            Thread.sleep(10_000);
            System.out.println("resuming");
            registry.getListenerContainer("pause.resume").resume();
            Thread.sleep(10_000);
        };
    }

    @KafkaListener(id = "pause.resume", topics = "pause.resume.topic")
    public void listen(String in) {
        System.out.println(in);
    }

    @Bean
    public NewTopic topic() {
        return new NewTopic("pause.resume.topic", 2, (short) 1);
    }

}
```

With results:

```
partitions assigned: [pause.resume.topic-1, pause.resume.topic-0]
foo
pausing
ConsumerPausedEvent [partitions=[pause.resume.topic-1, pause.resume.topic-0]]
resuming
ConsumerResumedEvent [partitions=[pause.resume.topic-1, pause.resume.topic-0]]
bar
```

Events

The following events are published by listener containers and their consumers:

- `ContainerIdleEvent` - when no messages have been received in `idleInterval` (if configured)
- `NonResponsiveConsumerEvent` - when the consumer appears to be blocked in the `poll` method
- `ConsumerPausedEvent` - issued by each consumer when the container is paused
- `ConsumerResumedEvent` - issued by each consumer when the container is resumed
- `ConsumerStoppingEvent` - issued by each consumer just before stopping
- `ConsumerStoppedEvent` - issued after the consumer is closed; see the section called “Thread Safety”

- `ContainerStoppedEvent` - when all consumers have terminated

> **Important**
>
> By default, the application context's event multicaster invokes event listeners on the calling thread. If you change the multicaster to use an async executor, you must not invoke any `Consumer` methods when the event contains a reference to the consumer.

The `ContainerIdleEvent` has 6 properties:

- `source` - the listener container instance that published the event.
- `container` - the listener container or the parent listener container if the source container is a child.
- `id` - the listener id (or container bean name).
- `idleTime` - the time the container had been idle when the event was published.
- `topicPartitions` - the topics/partitions that the container was assigned at the time the event was generated.
- `consumer` - a reference to the kafka `Consumer` object; for example, if the consumer was previously `pause()` d, it can be `resume()` d when the event is received.
- `paused` if the container is currently paused; see the section called "Pausing/Resuming Listener Containers" for more information.

The `NonResponsiveConsumerEvent` has the following properties:

- `source` - the listener container instance that published the event.
- `container` - the listener container or the parent listener container if the source container is a child.
- `id` - the listener id (or container bean name).
- `timeSinceLastPoll` - the time just before the container last called `poll()`.
- `topicPartitions` - the topics/partitions that the container was assigned at the time the event was generated.
- `consumer` - a reference to the kafka `Consumer` object; for example, if the consumer was previously `pause()` d, it can be `resume()` d when the event is received.
- `paused` if the container is currently paused; see the section called "Pausing/Resuming Listener Containers" for more information.

The `ConsumerPausedEvent`, `ConsumerResumedEvent` and `ConsumerStopping` events have the following properties:

- `source` - the listener container instance that published the event.
- `container` - the listener container or the parent listener container if the source container is a child.
- `partitions` - the `TopicPartition` s involved.

The `ConsumerStoppedEvent` and `ContainerStoppedEvent` have the following properties:

- `source` - the listener container instance that published the event.
- `container` - the listener container or the parent listener container if the source container is a child.

The `ContainerStoppedEvent` is published by all containers (regardless of whether it is a child or parent). For a parent container, the source and container properties are identical.

Serialization/Deserialization and Message Conversion

Overview

Apache Kafka provides a high-level API for serializing/deserializing record values as well as their keys. It is present with the `org.apache.kafka.common.serialization.Serializer<T>` and `org.apache.kafka.common.serialization.Deserializer<T>` abstractions with some built-in implementations. Meanwhile we can specify simple (de)serializer classes using Producer and/or Consumer configuration properties, e.g.:

```
props.put(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG, IntegerDeserializer.class);
props.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, StringDeserializer.class);
...
props.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, IntegerSerializer.class);
props.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, StringSerializer.class);
```

For more complex or particular cases, the `KafkaConsumer`, and therefore `KafkaProducer`, provides overloaded constructors to accept `(De)Serializer` instances for `keys` and/or `values`, respectively.

Using this API, the `DefaultKafkaProducerFactory` and `DefaultKafkaConsumerFactory` also provide properties (via constructors or setter methods) to inject custom `(De)Serializer` s to the target `Producer`/`Consumer`.

Spring for Apache Kafka also provides `JsonSerializer`/`JsonDeserializer` implementations based on the Jackson JSON object mapper. The `JsonSerializer` is quite simple and just allows writing any Java object as a JSON `byte[]`, the `JsonDeserializer` requires an additional `Class<?> targetType` argument to allow the deserialization of a consumed `byte[]` to the proper target object.

```
JsonDeserializer<Bar> barDeserializer = new JsonDeserializer<>(Bar.class);
```

Both `JsonSerializer` and `JsonDeserializer` can be customized with an `ObjectMapper`. You can also extend them to implement some particular configuration logic in the `configure(Map<String, ?> configs, boolean isKey)` method.

Starting with *version 2.1*, type information can be conveyed in record `Headers`, allowing the handling of multiple types. In addition, the serializer/deserializer can be configured using Kafka properties.

- `JsonSerializer.ADD_TYPE_INFO_HEADERS` (default `true`); set to `false` to disable this feature on the `JsonSerializer` (sets the `addTypeInfo` property).
- `JsonSerializer.TYPE_MAPPINGS` (default `empty`); see below.
- `JsonDeserializer.REMOVE_TYPE_INFO_HEADERS` (default `true`); set to `false` to retain headers set by the serializer.
- `JsonDeserializer.KEY_DEFAULT_TYPE`; fallback type for deserialization of keys if no header information is present.
- `JsonDeserializer.VALUE_DEFAULT_TYPE`; fallback type for deserialization of values if no header information is present.

- `JsonDeserializer.TRUSTED_PACKAGES` (default `java.util`, `java.lang`); comma-delimited list of package patterns allowed for deserialization; `*` means deserialize all.
- `JsonDeserializer.TYPE_MAPPINGS` (default `empty`); see below.

Starting with version 2.2, the type information headers (if added by the serializer) will be removed by the deserializer. You can revert to the previous behavior by setting the `removeTypeHeaders` property to false, either directly on the deserializer, or with the configuration property described above.

Mapping Types

Starting with version 2.2, you can now provide type mappings using the properties in the above list; previously you had to customize the type mapper within the serializer, deserializer. Mappings consist of a comma-delimited list of `token:className` pairs; on outbound, the payload's class name is mapped to the corresponding token and, on inbound, the token in the type header is mapped to the corresponding class name.

For example:

```
senderProps.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, JsonSerializer.class);
senderProps.put(JsonSerializer.TYPE_MAPPINGS, "foo:com.myfoo.Foo, bar:com.mybar.bar");
...
consumerProps.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, JsonDeserializer.class);
consumerProps.put(JsonDeSerializer.TYPE_MAPPINGS, "foo:com.yourfoo.Foo, bar:com.yourbar.bar");
```

Of course, the corresponding objects must be compatible.

Spring Boot, these properties can be provided in the `application.properties` (or yaml) file:

```
spring.kafka.producer.value-serializer=org.springframework.kafka.support.serializer.JsonSerializer
spring.kafka.producer.properties.spring.json.type.mapping=foo:com.myfoo.Foo,bar:com.mybar.Bar
```

> **Important**
>
> Only simple configuration can be performed with properties; for more advanced configuration (such as using a custom `ObjectMapper` in the serializer/deserializer), you should use the producer/consumer factory constructors that accept a pre-built serializer and deserializer. For example, with Spring Boot, to override the default factories:

```
@Bean
public ConsumerFactory<Foo, Bar> kafkaConsumerFactory(KafkaProperties properties,
    JsonDeserializer customDeserializer) {

    return new DefaultKafkaConsumerFactory<>(properties.buildConsumerProperties(),
        customDeserializer, customDeserializer);
}

@Bean
public ProducererFactory<Foo, Bar> kafkaProducerFactory(KafkaProperties properties,
    JsonSserializer customSerializer) {

    return new DefaultKafkaConsumerFactory<>(properties.buildProducerProperties(),
        customSerializer, customSerializer);
}
```

Setters are also provided, as an alternative to using these constructors.

Starting with version 2.2, you can explicitly configure the deserializer to use the supplied target type and ignore type information in headers, using one of the overloaded constructors that have a boolean `useHeadersIfPresent` (which is `true` by default):

```
DefaultKafkaConsumerFactory<Integer, Foo1> cf = new DefaultKafkaConsumerFactory<>(props,
        new IntegerDeserializer(), new JsonDeserializer<>(Foo1.class, false));
```

Spring Messaging Message Conversion

Although the `Serializer/Deserializer` API is quite simple and flexible from the low-level Kafka `Consumer` and `Producer` perspective, you might need more flexibility at the Spring Messaging level, either when using `@KafkaListener` or [Spring Integration](). To easily convert to/from `org.springframework.messaging.Message`, Spring for Apache Kafka provides a `MessageConverter` abstraction with the `MessagingMessageConverter` implementation and its `StringJsonMessageConverter` and `BytesJsonMessageConverter` customization. The `MessageConverter` can be injected into `KafkaTemplate` instance directly and via `AbstractKafkaListenerContainerFactory` bean definition for the `@KafkaListener.containerFactory()` property:

```
@Bean
public KafkaListenerContainerFactory<?> kafkaJsonListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
        new ConcurrentKafkaListenerContainerFactory<>();
    factory.setConsumerFactory(consumerFactory());
    factory.setMessageConverter(new StringJsonMessageConverter());
    return factory;
}
...
@KafkaListener(topics = "jsonData",
                containerFactory = "kafkaJsonListenerContainerFactory")
public void jsonListener(Foo foo) {
...
}
```

When using a `@KafkaListener`, the parameter type is provided to the message converter to assist with the conversion.

> **Note**
>
> This type inference can only be achieved when the `@KafkaListener` annotation is declared at the method level. With a class-level `@KafkaListener`, the payload type is used to select which `@KafkaHandler` method to invoke so it must already have been converted before the method can be chosen.

> **Note**
>
> When using the `StringJsonMessageConverter`, you should use a `StringDeserializer` in the kafka consumer configuration and `StringSerializer` in the kafka producer configuration, when using Spring Integration or the `KafkaTemplate.send(Message<?> message)` method. When using the `BytesJsonMessageConverter`, you should use a `BytesDeserializer` in the kafka consumer configuration and `BytesSerializer` in the kafka producer configuration, when using Spring Integration or the `KafkaTemplate.send(Message<?> message)` method (see the section called “KafkaTemplate”). Generally, the `BytesJsonMessageConverter` is more efficient because it avoids a `String` to/from `byte[]` conversion.

ErrorHandlingDeserializer

When a deserializer fails to deserialize a message, Spring has no way to handle the problem because it occurs before the `poll()` returns. To solve this problem, version 2.2 introduced the `ErrorHandlingDeserializer2`. This deserializer delegates to a real deserializer (key or value). If the delegate fails to deserialize the record content, the `ErrorHandlingDeserializer2` returns a `null` value and a `DeserializationException` in a header, containing the cause and raw bytes. When using a record-level `MessageListener`, if either the key or value contains a `DeserializationException` header, the container's `ErrorHandler` is called with the failed `ConsumerRecord`; the record is not passed to the listener.

Alternatively, you can configure a `failedDeserializationFunction` which is a `BiConsumer<byte[], Headers, T>`. This function is invoked to create an instance of `T` which is passed to the listener, as normal. The raw record value and headers are provided to the function. The `DeserializationException` can be found (as a serialized Java object) in headers; see the javadocs for the `ErrorHandlingDeserializer2` for more information.

When using a `BatchMessageListener`, you **must** provide a `failedDeserializationFunction`, otherwise, the batch of records will not be type safe.

You can use the `DefaultKafkaConsumerFactory` constructor that takes key and value `Deserializer` objects and wire in appropriate `ErrorHandlingDeserializer2` configured with the proper delegates. Alternatively, you can use consumer configuration properties which are used by the `ErrorHandlingDeserializer` to instantiate the delegates. The property names are `ErrorHandlingDeserializer2.KEY_DESERIALIZER_CLASS` and `ErrorHandlingDeserializer2.VALUE_DESERIALIZER_CLASS`; the property value can be a class or class name. For example:

```
... // other props
props.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, ErrorHandlingDeserializer2.class);
props.put(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG, ErrorHandlingDeserializer2.class);
props.put(ErrorHandlingDeserializer.KEY_DESERIALIZER_CLASS, JsonDeserializer.class);
props.put(JsonDeserializer.KEY_DEFAULT_TYPE, "com.example.MyKey")
props.put(ErrorHandlingDeserializer.VALUE_DESERIALIZER_CLASS, JsonDeserializer.class.getName());
props.put(JsonDeserializer.VALUE_DEFAULT_TYPE, "com.example.MyValue")
props.put(JsonDeserializer.TRUSTED_PACKAGES, "com.example")
return new DefaultKafkaConsumerFactory<>(props);
```

The following is an example of using a `failedDeserializationFunction`.

```
public class BadFoo extends Foo {

  private final byte[] failedDecode;

  public BadFoo(byte[] failedDecode) {
    this.failedDecode = failedDecode;
  }

  public byte[] getFailedDecode() {
    return this.failedDecode;
  }

}

public class FailedFooProvider implements BiFunction<byte[], Headers, Foo> {

  @Override
  public Foo apply(byte[] t, Headers u) {
    return new BadFoo(t);
  }

}
```

and config

```
...
consumerProps.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, ErrorHandlingDeserializer2.class);
consumerProps.put(ErrorHandlingDeserializer2.VALUE_DESERIALIZER_CLASS, JsonDeserializer.class);
consumerProps.put(ErrorHandlingDeserializer2.VALUE_FUNCTION, FailedFooProvider.class);
...
```

Payload Conversion with Batch Listeners

Starting with *version 1.3.2*, you can also use a `StringJsonMessageConverter` or `BytesJsonMessageConverter` within a `BatchMessagingMessageConverter` for converting batch messages, when using a batch listener container factory. See the section called “Serialization/Deserialization and Message Conversion” for more information.

By default, the type for the conversion is inferred from the listener argument. If you configure the `(Bytes|String)JsonMessageConverter` with a `DefaultJackson2TypeMapper` that has its `TypePrecedence` set to `TYPE_ID` (instead of the default `INFERRED`), then the converter will use type information in headers (if present) instead. This allows, for example, listener methods to be declared with interfaces instead of concrete classes. Also, the type converter supports mapping so the deserialization can be to a different type than the source (as long as the data is compatible). This is also useful when using class-level `@KafkaListener` s where the payload must have already been converted, to determine which method to invoke.

```
@Bean
public KafkaListenerContainerFactory<?> kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
            new ConcurrentKafkaListenerContainerFactory<>();
    factory.setConsumerFactory(consumerFactory());
    factory.setBatchListener(true);
    factory.setMessageConverter(new BatchMessagingMessageConverter(converter()));
    return factory;
}

@Bean
public StringJsonMessageConverter converter() {
    return new StringJsonMessageConverter();
}
```

Note that for this to work, the method signature for the conversion target must be a container object with a single generic parameter type, such as:

```
@KafkaListener(topics = "blc1")
public void listen(List<Foo> foos, @Header(KafkaHeaders.OFFSET) List<Long> offsets) {
    ...
}
```

Notice that you can still access the batch headers too.

If the batch converter has a record converter that supports it, you can also receive a list of messages where the payloads are converted according to the generic type:

```
@KafkaListener(topics = "blc3", groupId = "blc3")
public void listen1(List<Message<Foo>> fooMessages) {
    ...
}
```

ConversionService Customization

Starting with *version 2.1.1*, the `org.springframework.core.convert.ConversionService` used by the default `o.s.messaging.handler.annotation.support.MessageHandlerMethodFactory` to resolve parameters for the invocation of a listener method is supplied with all beans implementing any of the following interfaces:

- `org.springframework.core.convert.converter.Converter`
- `org.springframework.core.convert.converter.GenericConverter`
- `org.springframework.format.Formatter`

This allows you to further customize listener deserialization without changing the default configuration for `ConsumerFactory` and `KafkaListenerContainerFactory`.

> **Important**
>
> Setting a custom `MessageHandlerMethodFactory` on the `KafkaListenerEndpointRegistrar` through a `KafkaListenerConfigurer` bean will disable this feature.

Message Headers

The 0.11.0.0 client introduced support for headers in messages. Spring for Apache Kafka *version 2.0* now supports mapping these headers to/from `spring-messaging MessageHeaders`.

> **Note**
>
> Previous versions mapped `ConsumerRecord` and `ProducerRecord` to spring-messaging `Message<?>` where the value property is mapped to/from the `payload` and other properties (`topic`, `partition`, etc) were mapped to headers. This is still the case but additional, arbitrary, headers can now be mapped.

Apache Kafka headers have a simple API:

```
public interface Header {

    String key();

    byte[] value();

}
```

The `KafkaHeaderMapper` strategy is provided to map header entries between Kafka `Headers` and `MessageHeaders`:

```
public interface KafkaHeaderMapper {

    void fromHeaders(MessageHeaders headers, Headers target);

    void toHeaders(Headers source, Map<String, Object> target);

}
```

The `DefaultKafkaHeaderMapper` maps the key to the `MessageHeaders` header name and, in order to support rich header types, for outbound messages, JSON conversion is performed. A "special" header, with key, `spring_json_header_types` contains a JSON map of `<key>:<type>`. This header is used on the inbound side to provide appropriate conversion of each header value to the original type.

On the inbound side, all Kafka `Header` s are mapped to `MessageHeaders`. On the outbound side, by default, all `MessageHeaders` are mapped except `id`, `timestamp`, and the headers that map to `ConsumerRecord` properties.

You can specify which headers are to be mapped for outbound messages, by providing patterns to the mapper.

```
public DefaultKafkaHeaderMapper() {
    ...
}

public DefaultKafkaHeaderMapper(ObjectMapper objectMapper) {
    ...
}

public DefaultKafkaHeaderMapper(String... patterns) {
    ...
}

public DefaultKafkaHeaderMapper(ObjectMapper objectMapper, String... patterns) {
    ...
}
```

The first constructor will use a default Jackson `ObjectMapper` and map most headers, as discussed above. The second constructor will use the provided Jackson `ObjectMapper` and map most headers, as discussed above. The third constructor will use a default Jackson `ObjectMapper` and map headers according to the provided patterns. The third constructor will use the provided Jackson `ObjectMapper` and map headers according to the provided patterns.

Patterns are rather simple and can contain either a leading or trailing wildcard `*`, or both, e.g. `*.foo.*`. Patterns can be negated with a leading `!`. The first pattern that matches a header name wins (positive or negative).

When providing your own patterns, it is recommended to include `!id` and `!timestamp` since these headers are read-only on the inbound side.

> **Important**
>
> By default, the mapper will only deserialize classes in `java.lang` and `java.util`. You can trust other (or all) packages by adding trusted packages using the `addTrustedPackages` method. If you are receiving messages from untrusted sources, you may wish to add just those packages that you trust. To trust all packages use `mapper.addTrustedPackages("*")`.

The `DefaultKafkaHeaderMapper` is used in the `MessagingMessageConverter` and `BatchMessagingMessageConverter` by default, as long as Jackson is on the class path.

With the batch converter, the converted headers are available in the `KafkaHeaders.BATCH_CONVERTED_HEADERS` as a `List<Map<String, Object>>` where the map in a position of the list corresponds to the data position in the payload.

If the converter has no converter (either because Jackson is not present, or it is explicitly set to `null`), the headers from the consumer record are provided unconverted in the `KafkaHeaders.NATIVE_HEADERS` header (a `Headers` object, or a `List<Headers>` in the case of the batch converter, where the position in the list corresponds to the data position in the payload).

> **Important**
>
> Certain types are not suitable for JSON serialization and a simple `toString()` serialization might be preferred for these types. The `DefaultKafkaHeaderMapper` has a method `addToStringClasses()` where you can supply names of classes that should be treated this way for outbound mapping. During inbound mapping, they will be mapped as `String`. By default, just `org.springframework.util.MimeType` and `org.springframework.http.MediaType` are mapped this way.

Null Payloads and Log Compaction *Tombstone* Records

When using Log Compaction, it is possible to send and receive messages with `null` payloads which identifies the deletion of a key.

It is also possible to receive `null` values for other reasons - such as a `Deserializer` that might return `null` when it can't deserialize a value.

To send a `null` payload using the `KafkaTemplate` simply pass null into the value argument of the `send()` methods. One exception to this is the `send(Message<?> message)` variant. Since `spring-messaging` `Message<?>` cannot have a `null` payload, a special payload type `KafkaNull` is used and the framework will send `null`. For convenience, the static `KafkaNull.INSTANCE` is provided.

When using a message listener container, the received `ConsumerRecord` will have a `null` `value()`.

To configure the `@KafkaListener` to handle `null` payloads, you must use the `@Payload` annotation with `required = false`; if it's a tombstone message for a compacted log, you will usually also need the key so your application can determine which key was "deleted":

```
@KafkaListener(id = "deletableListener", topics = "myTopic")
public void listen(@Payload(required = false) String value, @Header(KafkaHeaders.RECEIVED_MESSAGE_KEY)
 String key) {
    // value == null represents key deletion
}
```

When using a class-level `@KafkaListener` with multiple `@KafkaHandler` methods, some additional configuration is needed - a `@KafkaHandler` method with a `KafkaNull` payload:

```
@KafkaListener(id = "multi", topics = "myTopic")
static class MultiListenerBean {

    @KafkaHandler
    public void listen(String foo) {
        ...
    }

    @KafkaHandler
    public void listen(Integer bar) {
        ...
    }

    @KafkaHandler
    public void delete(@Payload(required = false) KafkaNull
 nul, @Header(KafkaHeaders.RECEIVED_MESSAGE_KEY) int key) {
        ...
    }

}
```

Note that the argument will be `null` not a `KafkaNull`.

Handling Exceptions

Listener Error Handlers

Starting with *version 2.0*, the `@KafkaListener` annotation has a new attribute: `errorHandler`.

This attribute is not configured by default.

Use the `errorHandler` to provide the bean name of a `KafkaListenerErrorHandler` implementation. This functional interface has one method:

```
@FunctionalInterface
public interface KafkaListenerErrorHandler {

    Object handleError(Message<?> message, ListenerExecutionFailedException exception) throws Exception;

}
```

As you can see, you have access to the spring-messaging `Message<?>` object produced by the message converter and the exception that was thrown by the listener, wrapped in a `ListenerExecutionFailedException`. The error handler can throw the original or a new exception which will be thrown to the container. Anything returned by the error handler is ignored.

It has a sub-interface `ConsumerAwareListenerErrorHandler` that has access to the consumer object, via the method:

```
Object handleError(Message<?> message, ListenerExecutionFailedException exception, Consumer<?, ?>
 consumer);
```

If your error handler implements this interface you can, for example, adjust the offsets accordingly. For example, to reset the offset to replay the failed message, you could do something like the following; note however, these are simplistic implementations and you would probably want more checking in the error handler.

```
@Bean
public ConsumerAwareListenerErrorHandler listen3ErrorHandler() {
    return (m, e, c) -> {
        this.listen3Exception = e;
        MessageHeaders headers = m.getHeaders();
        c.seek(new org.apache.kafka.common.TopicPartition(
                headers.get(KafkaHeaders.RECEIVED_TOPIC, String.class),
                headers.get(KafkaHeaders.RECEIVED_PARTITION_ID, Integer.class)),
                headers.get(KafkaHeaders.OFFSET, Long.class));
        return null;
    };
}
```

And for a batch listener:

```
@Bean
public ConsumerAwareListenerErrorHandler listen10ErrorHandler() {
    return (m, e, c) -> {
        this.listen10Exception = e;
        MessageHeaders headers = m.getHeaders();
        List<String> topics = headers.get(KafkaHeaders.RECEIVED_TOPIC, List.class);
        List<Integer> partitions = headers.get(KafkaHeaders.RECEIVED_PARTITION_ID, List.class);
        List<Long> offsets = headers.get(KafkaHeaders.OFFSET, List.class);
        Map<TopicPartition, Long> offsetsToReset = new HashMap<>();
        for (int i = 0; i < topics.size(); i++) {
            int index = i;
            offsetsToReset.compute(new TopicPartition(topics.get(i), partitions.get(i)),
                    (k, v) -> v == null ? offsets.get(index) : Math.min(v, offsets.get(index)));
        }
        offsetsToReset.forEach((k, v) -> c.seek(k, v));
        return null;
    };
}
```

This resets each topic/partition in the batch to the lowest offset in the batch.

Container Error Handlers

You can specify a global error handler used for all listeners in the container factory.

```
@Bean
public KafkaListenerContainerFactory<ConcurrentMessageListenerContainer<Integer, String>>
        kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
            new ConcurrentKafkaListenerContainerFactory<>();
    ...
    factory.setErrorHandler(myErrorHandler);
    ...
    return factory;
}
```

or

```
@Bean
public KafkaListenerContainerFactory<ConcurrentMessageListenerContainer<Integer, String>>
        kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
            new ConcurrentKafkaListenerContainerFactory<>();
    ...
    factory.getContainerProperties().setBatchErrorHandler(myBatchErrorHandler);
    ...
    return factory;
}
```

By default, if an annotated listener method throws an exception, it is thrown to the container, and the message will be handled according to the container configuration.

Consumer-Aware Container Error Handlers

The container-level error handlers (`ErrorHandler` and `BatchErrorHandler`) have sub-interfaces `ConsumerAwareErrorHandler` and `ConsumerAwareBatchErrorHandler` with method signatures:

```
void handle(Exception thrownException, ConsumerRecord<?, ?> data, Consumer<?, ?> consumer);

void handle(Exception thrownException, ConsumerRecords<?, ?> data, Consumer<?, ?> consumer);
```

respectively.

Similar to the `@KafkaListener` error handlers, you can reset the offsets as needed based on the data that failed.

> **Note**
>
> Unlike the listener-level error handlers, however, you should set the container property `ackOnError` to false when making adjustments; otherwise any pending acks will be applied after your repositioning.

Seek To Current Container Error Handlers

If an `ErrorHandler` implements `RemainingRecordsErrorHandler`, the error handler is provided with the failed record and any unprocessed records retrieved by the previous `poll()`. Those records will not be passed to the listener after the handler exits.

```
@FunctionalInterface
public interface RemainingRecordsErrorHandler extends ConsumerAwareErrorHandler {

    void handle(Exception thrownException, List<ConsumerRecord<?, ?>> records, Consumer<?, ?> consumer);

}
```

This allows implementations to seek all unprocessed topic/partitions so the current record (and the others remaining) will be retrieved by the next poll. The `SeekToCurrentErrorHandler` does exactly this.

The container will commit any pending offset commits before calling the error handler.

To configure the listener container with this handler, add it to the `ContainerProperties`.

For example, with the `@KafkaListener` container factory:

```
@Bean
public ConcurrentKafkaListenerContainerFactory<String, String> kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<String, String> factory = new
 ConcurrentKafkaListenerContainerFactory();
    factory.setConsumerFactory(consumerFactory());
    factory.getContainerProperties().setAckOnError(false);
    factory.getContainerProperties().setAckMode(AckMode.RECORD);
    factory.setErrorHandler(new SeekToCurrentErrorHandler());
    return factory;
}
```

As an example; if the `poll` returns 6 records (2 from each partition 0, 1, 2) and the listener throws an exception on the fourth record, the container will have acknowledged the first 3 by committing their offsets. The `SeekToCurrentErrorHandler` will seek to offset 1 for partition 1 and offset 0 for partition 2. The next `poll()` will return the 3 unprocessed records.

If the `AckMode` was `BATCH`, the container commits the offsets for the first 2 partitions before calling the error handler.

Starting with version 2.2, the `SeekToCurrentErrorHandler` can now recover (skip) a record that keeps failing. By default, after 10 failures, the failed record will be logged (ERROR). You can configure the handler with a custom recoverer (`BiConsumer`) and/or max failures. Setting the `maxFailures` property to a negative number will cause infinite retries.

```
SeekToCurrentErrorHandler errorHandler =
    new SeekToCurrentErrorHandler((record, exception) -> {
        // recover after 3 failures - e.g. send to a dead-letter topic
    }, 3);
```

Also see the section called “Publishing Dead-Letter Records”.

When using transactions, similar functionality is provided by the `DefaultAfterRollbackProcessor`; see the section called “After Rollback Processor”.

The `SeekToCurrentBatchErrorHandler` seeks each partition to the first record in each partition in the batch so the whole batch is replayed. This error handler does not support recovery because the framework cannot know which message in the batch is failing.

After seeking, an exception wrapping the `ListenerExecutionFailedException` is thrown. This is to cause the transaction to roll back (if transactions are enabled).

Container Stopping Error Handlers

The `ContainerStoppingErrorHandler` (used with record listeners) will stop the container if the listener throws an exception. When the `AckMode` is `RECORD`, offsets for already processed records will be committed. When the `AckMode` is any manual, offsets for already acknowledged records will be committed. When the `AckMode` is `BATCH`, the entire batch will be replayed when the container is restarted, unless transactions are enabled in which case only the unprocessed records will be re-fetched.

The `ContainerStoppingBatchErrorHandler` (used with batch listeners) will stop the container and the entire batch will be replayed when the container is restarted.

After the container stops, an exception wrapping the `ListenerExecutionFailedException` is thrown. This is to cause the transaction to roll back (if transactions are enabled).

After Rollback Processor

When using transactions, if the listener throws an exception (and an error handler, if present, throws an exception), the transaction is rolled back. By default, any unprocessed records (including the failed record) will be re-fetched on the next poll. This is achieved by performing `seek` operations in the `DefaultAfterRollbackProcessor`. With a batch listener, the entire batch of records will be reprocessed (the container has no knowledge of which record in the batch failed). To modify this behavior, configure the listener container with a custom `AfterRollbackProcessor`. For example, with a record-based listener, you might want to keep track of the failed record and give up after some number of attempts - perhaps by publishing it to a dead-letter topic.

Starting with version 2.2, the `DefaultAfterRollbackProcessor` can now recover (skip) a record that keeps failing. By default, after 10 failures, the failed record will be logged (ERROR). You can configure the processor with a custom recoverer (`BiConsumer`) and/or max failures. Setting the `maxFailures` property to a negative number will cause infinite retries.

```
AfterRollbackProcessor<String, String> processor =
    new DefaultAfterRollbackProcessor((record, exception) -> {
        // recover after 3 failures - e.g. send to a dead-letter topic
    }, 3);
```

When not using transactions, similar functionality can be achieved by configuring a `SeekToCurrentErrorHandler`; see the section called “Seek To Current Container Error Handlers”.

> **Important**
>
> Recovery is not possible with a batch listener since the framework has no knowledge about which record in the batch keeps failing. In such cases, the application listener must handle a record that keeps failing.

Also see the section called “Publishing Dead-Letter Records”.

Publishing Dead-Letter Records

As discussed above, the `SeekToCurrentErrorHandler` and `DefaultAfterRollbackProcessor` can be configured with a record recoverer when the maximum number of failures is reached for a record. The framework provides the `DeadLetterPublishingRecoverer` which will publish the failed message to another topic. The recoverer requires a `KafkaTemplate<Object, Object>` which is used to send the record. It also, optionally, can be configured with a `BiFunction<ConsumerRecord<?, ?>, Exception, TopicPartition>` which is called to resolve the destination topic and partition. By default, the dead-letter record is sent to a topic named `<originalTopic>.DLT` (the original topic name suffixed with `.DLT`) and to the same partition as the original record. Therefore, when using the default resolver, the dead-letter topic must have at least as many partitions as the original topic. If the returned `TopicPartition` has a negative partition, the partition is not set in the `ProducerRecord` and so the partition will be selected by Kafka. The following is an example of wiring a custom destination resolver.

```
DeadLetterPublishingRecoverer recoverer = new DeadLetterPublishingRecoverer(template,
        (r, e) -> {
            if (e instanceof FooException) {
                return new TopicPartition(r.topic() + ".Foo.failures", r.partition());
            }
            else {
                return new TopicPartition(r.topic() + ".other.failures", r.partition());
            }
        });
ErrorHandler errorHandler = new SeekToCurrentErrorHandler(recoverer, 3);
```

The record sent to the dead-letter topic is enhanced with the following headers:

- `KafkaHeaders.DLT_EXCEPTION_FQCN` - Exception class name.
- `KafkaHeaders.DLT_EXCEPTION_STACKTRACE` - Exception stack trace.
- `KafkaHeaders.DLT_EXCEPTION_MESSAGE` - Exception message.
- `KafkaHeaders.DLT_ORIGINAL_TOPIC` - Original topic.
- `KafkaHeaders.DLT_ORIGINAL_PARTITION` Original partition.
- `KafkaHeaders.DLT_ORIGINAL_OFFSET` - Original offset.
- `KafkaHeaders.DLT_ORIGINAL_TIMESTAMP` - Original timestamp.
- `KafkaHeaders.DLT_ORIGINAL_TIMESTAMP_TYPE` - Original timestamp type.

Kerberos

Starting with version 2.0 a `KafkaJaasLoginModuleInitializer` class has been added to assist with Kerberos configuration. Simply add this bean, with the desired configuration, to your application context.

```
@Bean
public KafkaJaasLoginModuleInitializer jaasConfig() throws IOException {
    KafkaJaasLoginModuleInitializer jaasConfig = new KafkaJaasLoginModuleInitializer();
    jaasConfig.setControlFlag("REQUIRED");
    Map<String, String> options = new HashMap<>();
    options.put("useKeyTab", "true");
    options.put("storeKey", "true");
    options.put("keyTab", "/etc/security/keytabs/kafka_client.keytab");
    options.put("principal", "kafka-client-1@EXAMPLE.COM");
    jaasConfig.setOptions(options);
    return jaasConfig;
}
```

4.2 Kafka Streams Support

Introduction

Starting with *version 1.1.4*, Spring for Apache Kafka provides first class support for Kafka Streams. For using it from a Spring application, the `kafka-streams` jar must be present on classpath. It is an optional dependency of the `spring-kafka` project and isn't downloaded transitively.

Basics

The reference Apache Kafka Streams documentation suggests this way of using the API:

```
// Use the builders to define the actual processing topology, e.g. to specify
// from which input topics to read, which stream operations (filter, map, etc.)
// should be called, and so on.

StreamsBuilder builder = ...;  // when using the Kafka Streams DSL

// Use the configuration to tell your application where the Kafka cluster is,
// which serializers/deserializers to use by default, to specify security settings,
// and so on.
StreamsConfig config = ...;

KafkaStreams streams = new KafkaStreams(builder, config);

// Start the Kafka Streams instance
streams.start();

// Stop the Kafka Streams instance
streams.close();
```

So, we have two main components: `StreamsBuilder` with an API to build `KStream` (or `KTable`) instances and `KafkaStreams` to manage their lifecycle. Note: all `KStream` instances exposed to a `KafkaStreams` instance by a single `StreamsBuilder` will be started and stopped at the same time, even if they have a fully different logic. In other words all our streams defined by a `StreamsBuilder` are tied with a single lifecycle control. Once a `KafkaStreams` instance has been closed via `streams.close()` it cannot be restarted, and a new `KafkaStreams` instance to restart stream processing must be created instead.

Spring Management

To simplify the usage of Kafka Streams from the Spring application context perspective and utilize the lifecycle management via container, the Spring for Apache Kafka introduces `StreamsBuilderFactoryBean`. This is an `AbstractFactoryBean` implementation to expose a `StreamsBuilder` singleton instance as a bean:

```
@Bean
public FactoryBean<StreamsBuilderFactoryBean> myKStreamBuilder(KafkaStreamsConfiguration streamsConfig)
 {
    return new StreamsBuilderFactoryBean(streamsConfig);
}
```

> **Important**
>
> Starting with version 2.2, the stream configuration is now provided as a `KafkaStreamsConfiguration` object, rather than a `StreamsConfig`.

The `StreamsBuilderFactoryBean` also implements `SmartLifecycle` to manage lifecycle of an internal `KafkaStreams` instance. Similar to the Kafka Streams API, the `KStream` instances must be defined before starting the `KafkaStreams`, and that also applies for the Spring API for Kafka Streams. Therefore we have to declare `KStream` s on the `StreamsBuilder` before the application context is refreshed, when we use default `autoStartup = true` on the `StreamsBuilderFactoryBean`. For example, `KStream` can be just as a regular bean definition, meanwhile the Kafka Streams API is used without any impacts:

```
@Bean
public KStream<?, ?> kStream(StreamsBuilder kStreamBuilder) {
    KStream<Integer, String> stream = kStreamBuilder.stream(STREAMING_TOPIC1);
    // Fluent KStream API
    return stream;
}
```

If you would like to control lifecycle manually (e.g. stop and start by some condition), you can reference the `StreamsBuilderFactoryBean` bean directly using factory bean (&) prefix. Since `StreamsBuilderFactoryBean` utilize its internal `KafkaStreams` instance, it is safe to stop and restart it again - a new `KafkaStreams` is created on each `start()`. Also consider using different `StreamsBuilderFactoryBean` s, if you would like to control lifecycles for `KStream` instances separately.

You also can specify `KafkaStreams.StateListener`, `Thread.UncaughtExceptionHandler` and `StateRestoreListener` options on the `StreamsBuilderFactoryBean` which are delegated to the internal `KafkaStreams` instance. Also apart from setting those options indirectly on `StreamsBuilderFactoryBean`, starting with *version 2.1.5*, a `KafkaStreamsCustomizer` callback interface can be used to configure inner `KafkaStreams` instance. Note that `KafkaStreamsCustomizer` will override the options which are given via `StreamsBuilderFactoryBean`. That internal `KafkaStreams` instance can be accessed via `StreamsBuilderFactoryBean.getKafkaStreams()` if you need to perform some `KafkaStreams` operations directly. You can autowire `StreamsBuilderFactoryBean` bean by type, but you should be sure that you use full type in the bean definition, for example:

```
@Bean
public StreamsBuilderFactoryBean myKStreamBuilder(KafkaStreamsConfiguration streamsConfig) {
    return new StreamsBuilderFactoryBean(streamsConfig);
}
...
@Autowired
private StreamsBuilderFactoryBean myKStreamBuilderFactoryBean;
```

Or add `@Qualifier` for injection by name if you use interface bean definition:

```
@Bean
public FactoryBean<StreamsBuilder> myKStreamBuilder(KafkaStreamsConfiguration streamsConfig) {
    return new StreamsBuilderFactoryBean(streamsConfig);
}
...
@Autowired
@Qualifier("&myKStreamBuilder")
private StreamsBuilderFactoryBean myKStreamBuilderFactoryBean;
```

JSON Serdes

For serializing and deserializing data when reading or writing to topics or state stores in JSON format, Spring Kafka provides a `JsonSerde` implementation using JSON, delegating to the `JsonSerializer` and `JsonDeserializer` described in [the serialization/deserialization section](). The `JsonSerde` provides the same configuration options via its constructor (target type and/or `ObjectMapper`). In the following example we use the `JsonSerde` to serialize and deserialize the `Foo` payload of a Kafka stream - the `JsonSerde` can be used in a similar fashion wherever an instance is required.

```
stream.through(Serdes.Integer(), new JsonSerde<>(Foo.class), "foos");
```

> **Important**
>
> Since Kafka Streams do not support headers, the `addTypeInfo` property on the `JsonSerializer` is ignored.

Configuration

To configure the Kafka Streams environment, the `StreamsBuilderFactoryBean` requires a `KafkaStreamsConfiguration` instance. See Apache Kafka [documentation]() for all possible options.

> **Important**
>
> Starting with version 2.2, the stream configuration is now provided as a `KafkaStreamsConfiguration` object, rather than a `StreamsConfig`.

To avoid boilerplate code for most cases, especially when you develop micro services, Spring for Apache Kafka provides the `@EnableKafkaStreams` annotation, which should be placed on a `@Configuration` class. All you need is to declare a `KafkaStreamsConfiguration` bean with the name `defaultKafkaStreamsConfig`. A `StreamsBuilder` bean, with the name `defaultKafkaStreamsBuilder`, will be declared in the application context automatically. Any additional `StreamsBuilderFactoryBean` beans can be declared and used as well.

By default, when the factory bean is stopped, the `KafkaStreams.cleanUp()` method is called. Starting with *version 2.1.2*, the factory bean has additional constructors, taking a `CleanupConfig` object that has properties to allow you to control whether the `cleanUp()` method is called during `start()`, `stop()`, or neither.

Kafka Streams Example

Putting it all together:

```
@Configuration
@EnableKafka
@EnableKafkaStreams
public static class KafkaStreamsConfig {

    @Bean(name = KafkaStreamsDefaultConfiguration.DEFAULT_STREAMS_CONFIG_BEAN_NAME)
    public KafkaStreamsConfiguration kStreamsConfigs() {
        Map<String, Object> props = new HashMap<>();
        props.put(StreamsConfig.APPLICATION_ID_CONFIG, "testStreams");
        props.put(StreamsConfig.KEY_SERDE_CLASS_CONFIG, Serdes.Integer().getClass().getName());
        props.put(StreamsConfig.VALUE_SERDE_CLASS_CONFIG, Serdes.String().getClass().getName());
        props.put(StreamsConfig.TIMESTAMP_EXTRACTOR_CLASS_CONFIG,
 WallclockTimestampExtractor.class.getName());
        return new KafkaStreamsConfiguration(props);
    }

    @Bean
    public KStream<Integer, String> kStream(StreamsBuilder kStreamBuilder) {
        KStream<Integer, String> stream = kStreamBuilder.stream("streamingTopic1");
        stream
                .mapValues(String::toUpperCase)
                .groupByKey()
                .reduce((String value1, String value2) -> value1 + value2,
                  TimeWindows.of(1000),
                  "windowStore")
                .toStream()
                .map((windowedId, value) -> new KeyValue<>(windowedId.key(), value))
                .filter((i, s) -> s.length() > 40)
                .to("streamingTopic2");

        stream.print();

        return stream;
    }

}
```

4.3 Testing Applications

Introduction

The `spring-kafka-test` jar contains some useful utilities to assist with testing your applications.

JUnit

`o.s.kafka.test.utils.KafkaTestUtils` provides some static methods to set up producer and consumer properties:

```
/**
 * Set up test properties for an {@code <Integer, String>} consumer.
 * @param group the group id.
 * @param autoCommit the auto commit.
 * @param embeddedKafka a {@link EmbeddedKafkaBroker} instance.
 * @return the properties.
 */
public static Map<String, Object> consumerProps(String group, String autoCommit,
                                       EmbeddedKafkaBroker embeddedKafka) { ... }

/**
 * Set up test properties for an {@code <Integer, String>} producer.
 * @param embeddedKafka a {@link EmbeddedKafkaBroker} instance.
 * @return the properties.
 */
public static Map<String, Object> senderProps(EmbeddedKafkaBroker embeddedKafka) { ... }
```

A JUnit 4 `@Rule` wrapper for the `EmbeddedKafkaBroker` is provided that creates an embedded Kafka and an embedded Zookeeper server. (See the section called “@EmbeddedKafka Annotation” about using `@EmbeddedKafka` with JUnit 5).

```
/**
 * Create embedded Kafka brokers.
 * @param count the number of brokers.
 * @param controlledShutdown passed into TestUtils.createBrokerConfig.
 * @param topics the topics to create (2 partitions per).
 */
public EmbeddedKafkaRule(int count, boolean controlledShutdown, String... topics) { ... }

/**
 *
 * Create embedded Kafka brokers.
 * @param count the number of brokers.
 * @param controlledShutdown passed into TestUtils.createBrokerConfig.
 * @param partitions partitions per topic.
 * @param topics the topics to create.
 */
public EmbeddedKafkaRule(int count, boolean controlledShutdown, int partitions, String... topics)
 { ... }
```

The `EmbeddedKafkaBroker` class has a utility method allowing you to consume for all the topics it created:

```
Map<String, Object> consumerProps = KafkaTestUtils.consumerProps("testT", "false", embeddedKafka);
DefaultKafkaConsumerFactory<Integer, String> cf = new DefaultKafkaConsumerFactory<Integer, String>(
        consumerProps);
Consumer<Integer, String> consumer = cf.createConsumer();
embeddedKafka.consumeFromAllEmbeddedTopics(consumer);
```

The `KafkaTestUtils` has some utility methods to fetch results from the consumer:

```
/**
 * Poll the consumer, expecting a single record for the specified topic.
 * @param consumer the consumer.
 * @param topic the topic.
 * @return the record.
 * @throws org.junit.ComparisonFailure if exactly one record is not received.
 */
public static <K, V> ConsumerRecord<K, V> getSingleRecord(Consumer<K, V> consumer, String topic) { ... }

/**
 * Poll the consumer for records.
 * @param consumer the consumer.
 * @return the records.
 */
public static <K, V> ConsumerRecords<K, V> getRecords(Consumer<K, V> consumer) { ... }
```

Usage:

```
...
template.sendDefault(0, 2, "bar");
ConsumerRecord<Integer, String> received = KafkaTestUtils.getSingleRecord(consumer, "topic");
...
```

When the embedded Kafka and embedded Zookeeper server are started by by the `EmbeddedKafkaBroker`, a system property `spring.embedded.kafka.brokers` is set to the address of the Kafka broker(s) and a system property `spring.embedded.zookeeper.connect` is set to the address of Zookeeper. Convenient constants `EmbeddedKafkaBroker.SPRING_EMBEDDED_KAFKA_BROKERS` and `EmbeddedKafkaBroker.SPRING_EMBEDDED_ZOOKEEPER_CONNECT` are provided for this property.

With the `EmbeddedKafkaBroker.brokerProperties(Map<String, String>)` you can provide additional properties for the Kafka server(s). See Kafka Config for more information about possible broker properties.

Configuring Topics

```
public class MyTests {

    @ClassRule
    private static EmbeddedKafkaRule embeddedKafka = new EmbeddedKafkaRule(1, false, 5, "foo", "bar");

    @Test
    public void test() {
        embeddedKafkaRule.getEmbeddedKafka()
              .addTopics(new NewTopic("baz", 10, (short) 1), new NewTopic("qux", 15, (short) 1));
        ...
      }

}
```

The above configuration will create topics `foo` and `bar` with 5 partitions, `baz` with 10 and `qux` with 15.

Using the Same Broker(s) for Multiple Test Classes

There is no built-in support for this, but it can be achieved with something similar to the following:

```
public final class EmbeddedKafkaHolder {

    private static EmbeddedKafkaRule embeddedKafka = new EmbeddedKafkaRule(1, false);

    private static boolean started;

    public static EmbeddedKafkaRule getEmbeddedKafka() {
        if (!started) {
            try {
                embeddedKafka.before();
            }
            catch (Exception e) {
                throw new KafkaException(e);
            }
            started = true;
        }
        return embeddedKafka;
    }

    private EmbeddedKafkaHolder() {
        super();
    }

}
```

And then, in each test class:

```
static {
    EmbeddedKafkaHolder.getEmbeddedKafka().addTopics(topic1, topic2);
}

private static EmbeddedKafkaRule embeddedKafka = EmbeddedKafkaHolder.getEmbeddedKafka();
```

> **Important**
>
> This example provides no mechanism for shutting down the broker(s) when all tests are complete. This could be a problem if, say, you run your tests in a Gradle daemon. You

> should not use this technique in such a situation, or use something to call `destroy()` on the `EmbeddedKafkaBroker` when your tests are complete.

@EmbeddedKafka Annotation

It is generally recommended to use the rule as a `@ClassRule` to avoid starting/stopping the broker between tests (and use a different topic for each test). Starting with *version 2.0*, if you are using Spring's test application context caching, you can also declare a `EmbeddedKafkaBroker` bean, so a single broker can be used across multiple test classes. For convenience a test class level `@EmbeddedKafka` annotation is provided with the purpose to register `EmbeddedKafkaBroker` bean:

```
@RunWith(SpringRunner.class)
@DirtiesContext
@EmbeddedKafka(partitions = 1,
         topics = {
                 KafkaStreamsTests.STREAMING_TOPIC1,
                 KafkaStreamsTests.STREAMING_TOPIC2 })
public class KafkaStreamsTests {

    @Autowired
    private EmbeddedKafkaBroker embeddedKafka;

    @Test
    public void someTest() {
        Map<String, Object> consumerProps =
 KafkaTestUtils.consumerProps("testGroup", "true", this.embeddedKafka);
        consumerProps.put(ConsumerConfig.AUTO_OFFSET_RESET_CONFIG, "earliest");
        ConsumerFactory<Integer, String> cf = new DefaultKafkaConsumerFactory<>(consumerProps);
        Consumer<Integer, String> consumer = cf.createConsumer();
        this.embeddedKafka.consumeFromAnEmbeddedTopic(consumer, KafkaStreamsTests.STREAMING_TOPIC2);
        ConsumerRecords<Integer, String> replies = KafkaTestUtils.getRecords(consumer);
        assertThat(replies.count()).isGreaterThanOrEqualTo(1);
    }

    @Configuration
    @EnableKafkaStreams
    public static class KafkaStreamsConfiguration {

        @Value("${" + EmbeddedKafkaBroker.SPRING_EMBEDDED_KAFKA_BROKERS + "}")
        private String brokerAddresses;

        @Bean(name = KafkaStreamsDefaultConfiguration.DEFAULT_STREAMS_CONFIG_BEAN_NAME)
        public StreamsConfig kStreamsConfigs() {
            Map<String, Object> props = new HashMap<>();
            props.put(StreamsConfig.APPLICATION_ID_CONFIG, "testStreams");
            props.put(StreamsConfig.BOOTSTRAP_SERVERS_CONFIG, this.brokerAddresses);
            return new StreamsConfig(props);
        }

    }

}
```

The `topics`, `brokerProperties`, and `brokerPropertiesLocation` attributes of `@EmbeddedKafka` support property placeholder resolutions:

```
@TestPropertySource(locations = "classpath:/test.properties")
@EmbeddedKafka(topics = { "any-topic", "${kafka.topics.another-topic}" },
        brokerProperties = { "log.dir=${kafka.broker.logs-dir}",
                            "listeners=PLAINTEXT://localhost:${kafka.broker.port}",
                            "auto.create.topics.enable=${kafka.broker.topics-enable:true}" }
        brokerPropertiesLocation = "classpath:/broker.properties")
```

In the example above, the property placeholders `${kafka.topics.another-topic}`, `${kafka.broker.logs-dir}`, and `${kafka.broker.port}` are resolved from the Spring

`Environment`. In addition the broker properties are loaded from the `broker.properties` classpath resource specified by the `brokerPropertiesLocation`. Property placeholders are resolved for the `brokerPropertiesLocation` URL and for any property placeholders found in the resource. Properties defined by `brokerProperties` override properties found in `brokerPropertiesLocation`.

The `@EmbeddedKafka` annotation can be used with JUnit 4 or JUnit 5.

Embedded Broker in `@SpringBootTest` s

Spring Initializr now automatically adds the `spring-kafka-test` dependency in test scope to the project configuration.

> **Important**
>
> If your application is using the Kafka binder in `spring-cloud-stream`, if you want to use an embedded broker for tests, you must remove the `spring-cloud-stream-test-support` dependency because it replaces the real binder with a test binder for test casess. If you wish some tests to use the test binder and some to use the embedded broker, tests using the real binder need to disable the test binder by excluding the binder auto configuration in the test class.

```
@RunWith(SpringRunner.class)
@SpringBootTest(properties = "spring.autoconfigure.exclude="
    + "org.springframework.cloud.stream.test.binder.TestSupportBinderAutoConfiguration")
public class MyApplicationTests {
    ...
}
```

There are several ways to use an embedded broker in a Spring Boot application test.

JUnit4 Class Rule

```
@RunWith(SpringRunner.class)
@SpringBootTest
public class MyApplicationTests {

    @ClassRule
    public static EmbeddedKafkaRule broker = new EmbeddedKafkaRule(1,
        false, "someTopic");

    @BeforeClass
    public static void setup() {
        System.setProperty("spring.kafka.bootstrap-servers",
                    broker.getEmbeddedKafka().getBrokersAsString());
    }

    @Autowired
    private KafkaTemplate<String, String> template;

    @Test
    public void test() {
        ...
    }

}
```

`@EmbeddedKafka` Annotation or `EmbeddedKafkaBroker` Bean

```
@RunWith(SpringRunner.class)
@EmbeddedKafka(topics = "someTopic")
public class MyApplicationTests {

    static {
        System.setProperty(EmbeddedKafkaBroker.BROKER_LIST_PROPERTY,
                "spring.kafka.bootstrap-servers");
    }

    @Autowired
    private KafkaTemplate<String, String> template;

    @Test
    public void test() {
        ...
    }

}
```

Hamcrest Matchers

The `o.s.kafka.test.hamcrest.KafkaMatchers` provides the following matchers:

```
/**
 * @param key the key
 * @param <K> the type.
 * @return a Matcher that matches the key in a consumer record.
 */
public static <K> Matcher<ConsumerRecord<K, ?>> hasKey(K key) { ... }

/**
 * @param value the value.
 * @param <V> the type.
 * @return a Matcher that matches the value in a consumer record.
 */
public static <V> Matcher<ConsumerRecord<?, V>> hasValue(V value) { ... }

/**
 * @param partition the partition.
 * @return a Matcher that matches the partition in a consumer record.
 */
public static Matcher<ConsumerRecord<?, ?>> hasPartition(int partition) { ... }

/**
 * Matcher testing the timestamp of a {@link ConsumerRecord} asssuming the topic has been set with
 * {@link org.apache.kafka.common.record.TimestampType#CREATE_TIME CreateTime}.
 *
 * @param ts timestamp of the consumer record.
 * @return a Matcher that matches the timestamp in a consumer record.
 */
public static Matcher<ConsumerRecord<?, ?>> hasTimestamp(long ts) {
  return hasTimestamp(TimestampType.CREATE_TIME, ts);
}

/**
 * Matcher testing the timestamp of a {@link ConsumerRecord}
 * @param type timestamp type of the record
 * @param ts timestamp of the consumer record.
 * @return a Matcher that matches the timestamp in a consumer record.
 */
public static Matcher<ConsumerRecord<?, ?>> hasTimestamp(TimestampType type, long ts) {
  return new ConsumerRecordTimestampMatcher(type, ts);
}
```

AssertJ Conditions

```
/**
 * @param key the key
 * @param <K> the type.
 * @return a Condition that matches the key in a consumer record.
 */
public static <K> Condition<ConsumerRecord<K, ?>> key(K key) { ... }

/**
 * @param value the value.
 * @param <V> the type.
 * @return a Condition that matches the value in a consumer record.
 */
public static <V> Condition<ConsumerRecord<?, V>> value(V value) { ... }

/**
 * @param partition the partition.
 * @return a Condition that matches the partition in a consumer record.
 */
public static Condition<ConsumerRecord<?, ?>> partition(int partition) { ... }

/**
 * @param value the timestamp.
 * @return a Condition that matches the timestamp value in a consumer record.
 */
public static Condition<ConsumerRecord<?, ?>> timestamp(long value) {
  return new ConsumerRecordTimestampCondition(TimestampType.CREATE_TIME, value);
}

/**
 * @param type the type of timestamp
 * @param value the timestamp.
 * @return a Condition that matches the timestamp value in a consumer record.
 */
public static Condition<ConsumerRecord<?, ?>> timestamp(TimestampType type, long value) {
  return new ConsumerRecordTimestampCondition(type, value);
}
```

Example

Putting it all together:

```
public class KafkaTemplateTests {

    private static final String TEMPLATE_TOPIC = "templateTopic";

    @ClassRule
    public static EmbeddedKafkaRule embeddedKafka = new EmbeddedKafkaRule(1, true, TEMPLATE_TOPIC);

    @Test
    public void testTemplate() throws Exception {
        Map<String, Object> consumerProps = KafkaTestUtils.consumerProps("testT", "false",
            embeddedKafka);
        DefaultKafkaConsumerFactory<Integer, String> cf =
                            new DefaultKafkaConsumerFactory<Integer, String>(consumerProps);
        ContainerProperties containerProperties = new ContainerProperties(TEMPLATE_TOPIC);
        KafkaMessageListenerContainer<Integer, String> container =
                            new KafkaMessageListenerContainer<>(cf, containerProperties);
        final BlockingQueue<ConsumerRecord<Integer, String>> records = new LinkedBlockingQueue<>();
        container.setupMessageListener(new MessageListener<Integer, String>() {

            @Override
            public void onMessage(ConsumerRecord<Integer, String> record) {
                System.out.println(record);
                records.add(record);
            }

        });
        container.setBeanName("templateTests");
        container.start();
        ContainerTestUtils.waitForAssignment(container,
 embeddedKafka.getEmbeddedKafka().getPartitionsPerTopic());
        Map<String, Object> senderProps =

 KafkaTestUtils.senderProps(embeddedKafka.getEmbeddedKafka().getBrokersAsString());
        ProducerFactory<Integer, String> pf =
                            new DefaultKafkaProducerFactory<Integer, String>(senderProps);
        KafkaTemplate<Integer, String> template = new KafkaTemplate<>(pf);
        template.setDefaultTopic(TEMPLATE_TOPIC);
        template.sendDefault("foo");
        assertThat(records.poll(10, TimeUnit.SECONDS), hasValue("foo"));
        template.sendDefault(0, 2, "bar");
        ConsumerRecord<Integer, String> received = records.poll(10, TimeUnit.SECONDS);
        assertThat(received, hasKey(2));
        assertThat(received, hasPartition(0));
        assertThat(received, hasValue("bar"));
        template.send(TEMPLATE_TOPIC, 0, 2, "baz");
        received = records.poll(10, TimeUnit.SECONDS);
        assertThat(received, hasKey(2));
        assertThat(received, hasPartition(0));
        assertThat(received, hasValue("baz"));
    }

}
```

The above uses the hamcrest matchers; with `AssertJ`, the final part looks like this…

```
assertThat(records.poll(10, TimeUnit.SECONDS)).has(value("foo"));
template.sendDefault(0, 2, "bar");
ConsumerRecord<Integer, String> received = records.poll(10, TimeUnit.SECONDS);
assertThat(received).has(key(2));
assertThat(received).has(partition(0));
assertThat(received).has(value("bar"));
template.send(TEMPLATE_TOPIC, 0, 2, "baz");
received = records.poll(10, TimeUnit.SECONDS);
assertThat(received).has(key(2));
assertThat(received).has(partition(0));
assertThat(received).has(value("baz"));
```

5. Spring Integration

This part of the reference shows how to use the `spring-integration-kafka` module of Spring Integration.

5.1 Spring Integration for Apache Kafka

Introduction

This documentation pertains to versions 2.0.0 and above; for documentation for earlier releases, see the 1.3.x README.

Spring Integration Kafka is now based on the Spring for Apache Kafka project. It provides the following components:

- Outbound Channel Adapter
- Message-Driven Channel Adapter

These are discussed in the following sections.

Outbound Channel Adapter

The Outbound channel adapter is used to publish messages from a Spring Integration channel to Kafka topics. The channel is defined in the application context and then wired into the application that sends messages to Kafka. Sender applications can publish to Kafka via Spring Integration messages, which are internally converted to Kafka messages by the outbound channel adapter, as follows: the payload of the Spring Integration message will be used to populate the payload of the Kafka message, and (by default) the `kafka_messageKey` header of the Spring Integration message will be used to populate the key of the Kafka message.

The target topic and partition for publishing the message can be customized through the `kafka_topic` and `kafka_partitionId` headers, respectively.

In addition, the `<int-kafka:outbound-channel-adapter>` provides the ability to extract the key, target topic, and target partition by applying SpEL expressions on the outbound message. To that end, it supports the mutually exclusive pairs of attributes `topic`/`topic-expression`, `message-key`/`message-key-expression`, and `partition-id`/`partition-id-expression`, to allow the specification of `topic`,`message-key` and `partition-id` respectively as static values on the adapter, or to dynamically evaluate their values at runtime against the request message.

> **Important**
>
> The `KafkaHeaders` interface (provided by `spring-kafka`) contains constants used for interacting with headers. The `messageKey` and `topic` default headers now require a `kafka_` prefix. When migrating from an earlier version that used the old headers, you need to specify `message-key-expression="headers['messageKey']"` and `topic-expression="headers['topic']"` on the `<int-kafka:outbound-channel-adapter>`, or simply change the headers upstream to the new headers from `KafkaHeaders` using a `<header-enricher>` or `MessageBuilder`. Or, of course, configure them on the adapter using `topic` and `message-key` if you are using constant values.

NOTE : If the adapter is configured with a topic or message key (either with a constant or expression), those are used and the corresponding header is ignored. If you wish the header to override the configuration, you need to configure it in an expression, such as:

`topic-expression="headers['topic'] != null ? headers['topic'] : 'myTopic'"`.

The adapter requires a `KafkaTemplate`.

Here is an example of how the Kafka outbound channel adapter is configured with XML:

```
<int-kafka:outbound-channel-adapter id="kafkaOutboundChannelAdapter"
                                    kafka-template="template"
                                    auto-startup="false"
                                    channel="inputToKafka"
                                    topic="foo"
                                    sync="false"
                                    message-key-expression="'bar'"
                                    send-failure-channel="failures"
                                    send-success-channel="successes"
                                    error-message-strategy="ems"
                                    partition-id-expression="2">
</int-kafka:outbound-channel-adapter>

<bean id="template" class="org.springframework.kafka.core.KafkaTemplate">
    <constructor-arg>
        <bean class="org.springframework.kafka.core.DefaultKafkaProducerFactory">
            <constructor-arg>
                <map>
                    <entry key="bootstrap.servers" value="localhost:9092" />
                    ... <!-- more producer properties -->
                </map>
            </constructor-arg>
        </bean>
    </constructor-arg>
</bean>
```

As you can see, the adapter requires a `KafkaTemplate` which, in turn, requires a suitably configured `KafkaProducerFactory`.

When using Java Configuration:

```
@Bean
@ServiceActivator(inputChannel = "toKafka")
public MessageHandler handler() throws Exception {
    KafkaProducerMessageHandler<String, String> handler =
            new KafkaProducerMessageHandler<>(kafkaTemplate());
    handler.setTopicExpression(new LiteralExpression("someTopic"));
    handler.setMessageKeyExpression(new LiteralExpression("someKey"));
    handler.setFailureChannel(failures());
    return handler;
}

@Bean
public KafkaTemplate<String, String> kafkaTemplate() {
    return new KafkaTemplate<>(producerFactory());
}

@Bean
public ProducerFactory<String, String> producerFactory() {
    Map<String, Object> props = new HashMap<>();
    props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, this.brokerAddress);
    // set more properties
    return new DefaultKafkaProducerFactory<>(props);
}
```

When using Spring Integration Java DSL:

```
@Bean
public ProducerFactory<Integer, String> producerFactory() {
    return new DefaultKafkaProducerFactory<>(KafkaTestUtils.producerProps(embeddedKafka));
}

@Bean
public IntegrationFlow sendToKafkaFlow() {
    return f -> f
            .<String>split(p -> Stream.generate(() -> p).limit(101).iterator(), null)
            .publishSubscribeChannel(c -> c
                    .subscribe(sf -> sf.handle(
                            kafkaMessageHandler(producerFactory(), TEST_TOPIC1)
                                    .timestampExpression("T(Long).valueOf('1487694048633')"),
                            e -> e.id("kafkaProducer1")))
                    .subscribe(sf -> sf.handle(
                            kafkaMessageHandler(producerFactory(), TEST_TOPIC2)
                                   .timestamp(m -> 1487694048644L),
                            e -> e.id("kafkaProducer2")))
            );
}

@Bean
public DefaultKafkaHeaderMapper mapper() {
    return new DefaultKafkaHeaderMapper();
}

private KafkaProducerMessageHandlerSpec<Integer, String, ?> kafkaMessageHandler(
        ProducerFactory<Integer, String> producerFactory, String topic) {
    return Kafka
            .outboundChannelAdapter(producerFactory)
            .messageKey(m -> m
                    .getHeaders()
                    .get(IntegrationMessageHeaderAccessor.SEQUENCE_NUMBER))
            .headerMapper(mapper())
            .partitionId(m -> 10)
            .topicExpression("headers[kafka_topic] ?: '" + topic + "'")
            .configureKafkaTemplate(t -> t.id("kafkaTemplate:" + topic));
}
```

If a `send-failure-channel` is provided, if a send failure is received (sync or async), an `ErrorMessage` is sent to the channel. The payload is a `KafkaSendFailureException` with properties `failedMessage`, `record` (the `ProducerRecord`) and `cause`. The `DefaultErrorMessageStrategy` can be overridden via the `error-message-strategy` property.

If a `send-success-channel` is provided, a message with a payload of type `org.apache.kafka.clients.producer.RecordMetadata` will be sent after a successful send. When using Java configuration, use `setOutputChannel` for this purpose.

Message Driven Channel Adapter

The `KafkaMessageDrivenChannelAdapter` (`<int-kafka:message-driven-channel-adapter>`) uses a `spring-kafka` `KafkaMessageListenerContainer` or `ConcurrentListenerContainer`.

Starting with *spring-integration-kafka version 2.1*, the `mode` attribute is available (`record` or `batch`, default `record`). For `record` mode, each message payload is converted from a single `ConsumerRecord`; for mode `batch` the payload is a list of objects which are converted from all the `ConsumerRecord` s returned by the consumer poll. As with the batched `@KafkaListener`, the `KafkaHeaders.RECEIVED_MESSAGE_KEY`, `KafkaHeaders.RECEIVED_PARTITION_ID`, `KafkaHeaders.RECEIVED_TOPIC` and `KafkaHeaders.OFFSET` headers are also lists with, positions corresponding to the position in the payload.

An example of xml configuration variant is shown here:

```xml
<int-kafka:message-driven-channel-adapter
        id="kafkaListener"
        listener-container="container1"
        auto-startup="false"
        phase="100"
        send-timeout="5000"
        mode="record"
        retry-template="template"
        recovery-callback="callback"
        error-message-strategy="ems"
        channel="someChannel"
        error-channel="errorChannel" />

<bean id="container1" class="org.springframework.kafka.listener.KafkaMessageListenerContainer">
    <constructor-arg>
        <bean class="org.springframework.kafka.core.DefaultKafkaConsumerFactory">
            <constructor-arg>
                <map>
                <entry key="bootstrap.servers" value="localhost:9092" />
                ...
                </map>
            </constructor-arg>
        </bean>
    </constructor-arg>
    <constructor-arg>
        <bean class="org.springframework.kafka.listener.config.ContainerProperties">
            <constructor-arg name="topics" value="foo" />
        </bean>
    </constructor-arg>

</bean>
```

When using Java Configuration:

```java
@Bean
public KafkaMessageDrivenChannelAdapter<String, String>
            adapter(KafkaMessageListenerContainer<String, String> container) {
    KafkaMessageDrivenChannelAdapter<String, String> kafkaMessageDrivenChannelAdapter =
            new KafkaMessageDrivenChannelAdapter<>(container, ListenerMode.record);
    kafkaMessageDrivenChannelAdapter.setOutputChannel(received());
    return kafkaMessageDrivenChannelAdapter;
}

@Bean
public KafkaMessageListenerContainer<String, String> container() throws Exception {
    ContainerProperties properties = new ContainerProperties(this.topic);
    // set more properties
    return new KafkaMessageListenerContainer<>(consumerFactory(), properties);
}

@Bean
public ConsumerFactory<String, String> consumerFactory() {
    Map<String, Object> props = new HashMap<>();
    props.put(ConsumerConfig.BOOTSTRAP_SERVERS_CONFIG, this.brokerAddress);
    // set more properties
    return new DefaultKafkaConsumerFactory<>(props);
}
```

When using Spring Integration Java DSL:

```
@Bean
public IntegrationFlow topic1ListenerFromKafkaFlow() {
    return IntegrationFlows
            .from(Kafka.messageDrivenChannelAdapter(consumerFactory(),
                    KafkaMessageDrivenChannelAdapter.ListenerMode.record, TEST_TOPIC1)
                    .configureListenerContainer(c ->
                            c.ackMode(AbstractMessageListenerContainer.AckMode.MANUAL)
                                    .id("topic1ListenerContainer"))
                    .recoveryCallback(new ErrorMessageSendingRecoverer(errorChannel(),
                            new RawRecordHeaderErrorMessageStrategy()))
                    .retryTemplate(new RetryTemplate())
                    .filterInRetry(true))
            .filter(Message.class, m ->
                            m.getHeaders().get(KafkaHeaders.RECEIVED_MESSAGE_KEY, Integer.class) < 101,
                    f -> f.throwExceptionOnRejection(true))
            .<String, String>transform(String::toUpperCase)
            .channel(c -> c.queue("listeningFromKafkaResults1"))
            .get();
}
```

Received messages will have certain headers populated. Refer to the `KafkaHeaders` class for more information.

> **Important**
>
> The `Consumer` object (in the `kafka_consumer` header) is not thread-safe; you must only invoke its methods on the thread that calls the listener within the adapter; if you hand off the message to another thread, you must not call its methods.

When a `retry-template` is provided, delivery failures will be retried according to its retry policy. An `error-channel` is not allowed in this case. The `recovery-callback` can be used to handle the error when retries are exhausted. In most cases, this will be an `ErrorMessageSendingRecoverer` which will send the `ErrorMessage` to a channel.

When building `ErrorMessage` (for use in the `error-channel` or `recovery-callback`), you can customize the error message using the `error-message-strategy` property. By default, a `RawRecordHeaderErrorMessageStrategy` is used; providing access to the converted message as well as the raw `ConsumerRecord`.

Starting with *Spring for Apache Kafka version 2.2* (*Spring Integration Kafka 3.1*), the container factory used for `@KafkaListener` annotations can also be used to create `ConcurrentMessageListenerContainer` s for other purposes. See the section called “Container factory” for an example.

With the Java DSL, the container does not have to be configured as a `@Bean` because the DSL will register the container as a bean.

```
@Bean
public IntegrationFlow topic2ListenerFromKafkaFlow() {
    return IntegrationFlows

 .from(Kafka.messageDrivenChannelAdapter(kafkaListenerContainerFactory().createContainer(TEST_TOPIC2),
            KafkaMessageDrivenChannelAdapter.ListenerMode.record)
                .id("topic2Adapter"))
            ...
            get();
}
```

Notice that, in this case, the adapter is given an `id` ("topic2Adapter"); the container will be registered in the application context with the name `topic2Adapter.container`. If the adapter does not have an id property, the container's bean name will be the container's fully qualified class name + #n where n is incremented for each container.

Outbound Gateway

The outbound gateway is for request/reply operations; it is different to most Spring Integration gateways in that the sending thread does not block in the gateway, the reply is processed on the reply listener container thread. Of course, if user code invokes the gateway behind a synchronous Messaging Gateway, the user thread will block there until the reply is received (or a timeout occurs).

> **Important**
>
> the gateway will not accept requests until the reply container has been assigned its topics and partitions. It is suggested that you add a `ConsumerRebalanceListener` to the template's reply container properties and wait for the `onPartitionsAssigned` call before sending messages to the gateway.

Here is an example of configuring a gateway, with Java Configuration:

```
@Bean
@ServiceActivator(inputChannel = "kafkaRequests", outputChannel = "kafkaReplies")
public KafkaProducerMessageHandler<String, String> outGateway(
        ReplyingKafkaTemplate<String, String, String> kafkaTemplate) {
    return new KafkaProducerMessageHandler<>(kafkaTemplate);
}
```

Notice that the same class as the outbound channel adapter is used, the only difference being that the kafka template passed into the constructor is a `ReplyingKafkaTemplate` - see the section called "ReplyingKafkaTemplate" for more information.

The outbound topic, partition, key etc, are determined the same way as the outbound adapter. The reply topic is determined as follows:

1. A message header `KafkaHeaders.REPLY_TOPIC`, if present (must have a `String` or `byte[]` value) - validated against the template's reply container subscribed topics.

2. If the template's `replyContainer` is subscribed to just one topic, it will be used.

You can also specify a `KafkaHeaders.REPLY_PARTITION` header to determine a specific partition to be used for replies. Again, this is validated against the template's reply container subscriptions.

Configuring with the Java DSL:

```
@Bean
public IntegrationFlow outboundGateFlow(
        ReplyingKafkaTemplate<String, String, String> kafkaTemplate) {
    return IntegrationFlows.from("kafkaRequests")
            .handle(Kafka.outboundGateway(kafkaTemplate))
            .channel("kafkaReplies")
            .get();
}
```

Or:

```
@Bean
public IntegrationFlow outboundGateFlow() {
    return IntegrationFlows.from("kafkaRequests")
            .handle(Kafka.outboundGateway(producerFactory(), replyContainer())
                .configureKafkaTemplate(t -> t.replyTimeout(30_000)))
            .channel("kafkaReplies")
            .get();
}
```

XML configuration is not currently available for this component.

Inbound Gateway

The inbound gateway is for request/reply operations.

Configuring an inbound gateway with Java Configuration:

```
@Bean
public KafkaInboundGateway<Integer, String, String> inboundGateway(
        AbstractMessageListenerContainer<Integer, String>container,
        KafkaTemplate<Integer, String> replyTemplate) {

    KafkaInboundGateway<Integer, String, String> gateway =
        new KafkaInboundGateway<>(container, replyTemplate);
    gateway.setRequestChannel(requests);
    gateway.setReplyChannel(replies);
    gateway.setReplyTimeout(30_000);
    return gateway;
}
```

Configuring a simple upper case converter with the Java DSL:

```
@Bean
public IntegrationFlow serverGateway(
        ConcurrentMessageListenerContainer<Integer, String> container,
        KafkaTemplate<Integer, String> replyTemplate) {
    return IntegrationFlows
            .from(Kafka.inboundGateway(container, template)
                .replyTimeout(30_000))
            .<String, String>transform(String::toUpperCase)
            .get();
}
```

Or:

```
@Bean
public IntegrationFlow serverGateway() {
    return IntegrationFlows
            .from(Kafka.inboundGateway(consumerFactory(), containerProperties(),
                    producerFactory())
                .replyTimeout(30_000))
            .<String, String>transform(String::toUpperCase)
            .get();
}
```

XML configuration is not currently available for this component.

Starting with *Spring for Apache Kafka version 2.2* (*Spring Integration Kafka 3.1*), the container factory used for `@KafkaListener` annotations can also be used to create `ConcurrentMessageListenerContainer` s for other purposes. See the section called “Container factory” and the section called “Message Driven Channel Adapter” for examples.

Message Conversion

A `StringJsonMessageConverter` is provided, see the section called “Serialization/Deserialization and Message Conversion” for more information.

When using this converter with a message-driven channel adapter, you can specify the type to which you want the incoming payload to be converted. This is achieved by setting the `payload-type` attribute (`payloadType` property) on the adapter.

```
<int-kafka:message-driven-channel-adapter
        id="kafkaListener"
        listener-container="container1"
        auto-startup="false"
        phase="100"
        send-timeout="5000"
        channel="nullChannel"
        message-converter="messageConverter"
        payload-type="com.example.Foo"
        error-channel="errorChannel" />

<bean id="messageConverter"
    class="org.springframework.kafka.support.converter.MessagingMessageConverter"/>
```

```
@Bean
public KafkaMessageDrivenChannelAdapter<String, String>
            adapter(KafkaMessageListenerContainer<String, String> container) {
    KafkaMessageDrivenChannelAdapter<String, String> kafkaMessageDrivenChannelAdapter =
            new KafkaMessageDrivenChannelAdapter<>(container, ListenerMode.record);
    kafkaMessageDrivenChannelAdapter.setOutputChannel(received());
    kafkaMessageDrivenChannelAdapter.setMessageConverter(converter());
    kafkaMessageDrivenChannelAdapter.setPayloadType(Foo.class);
    return kafkaMessageDrivenChannelAdapter;
}
```

Null Payloads and Log Compaction *Tombstone* Records

Spring Messaging `Message<?>` objects cannot have `null` payloads; when using the Kafka endpoints, `null` payloads (also known as tombstone records) are represented by a payload of type `KafkaNull`. See the section called “Null Payloads and Log Compaction *Tombstone* Records” for more information.

Starting with version 3.1 of Spring Integration Kafka, such records can now be received by Spring Integration POJO methods with a true `null` value instead. Simply mark the parameter with `@Payload(required = false)`.

```
@ServiceActivator(inputChannel = "fromSomeKafkaInboundEndpoint")
public void in(@Header(KafkaHeaders.RECEIVED_MESSAGE_KEY) String key,
               @Payload(required = false) Customer customer) {
    // customer is null if a tombstone record
    ...
}
```

What’s New in Spring Integration for Apache Kafka

See the [Spring for Apache Kafka Project Page] for a matrix of compatible `spring-kafka` and `kafka-clients` versions.

2.1.x

The 2.1.x branch introduced the following changes:

- Update to `spring-kafka` 1.1.x; including support of batch payloads

- Support `sync` outbound requests via XML configuration
- Support `payload-type` for inbound channel adapters
- Support for Enhanced Error handling for the inbound channel adapter (2.1.1)
- Support for send success/failure messages (2.1.2)

2.2.x

The 2.2.x branch introduced the following changes:

- Update to `spring-kafka` 1.2.x

2.3.x

The 2.3.x branch introduced the following changes:

- Update to `spring-kafka` 1.3.x; including support for transactions and header mapping provided by `kafka-clients` 0.11.0.0
- Support for record timestamps

3.0.x

- Update to `spring-kafka` 2.1.x and `kafka-clients` 1.0.0
- Support `ConsumerAwareMessageListener` (`Consumer` is available in a message header)
- Update to Spring Integration 5.0 and Java 8
- Moved Java DSL to main project
- Added inbound and outbound gateways (3.0.2)

3.1.x

- Update to `spring-kafka` 2.2.x and `kafka-clients` 2.0.0
- Support tombstones in EIP POJO Methods

6. Other Resources

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

- Apache Kafka Project Home Page
- Spring for Apache Kafka Home Page
- Spring for Apache Kafka GitHub Repository
- Spring Integration Kafka Extension GitHub Repository

Appendix A. Override Dependencies to use the 2.1.x kafka-clients with an Embedded Broker

When using `spring-kafka-test` (version 2.2.x) with the 2.1.x `kafka-clients` jar, you will need to override certain transitive dependencies as follows:

```
<dependency>
    <groupId>org.springframework.kafka</groupId>
    <artifactId>spring-kafka</artifactId>
    <version>${spring.kafka.version}</version>
</dependency>

<dependency>
    <groupId>org.springframework.kafka</groupId>
    <artifactId>spring-kafka-test</artifactId>
    <version>${spring.kafka.version}</version>
    <scope>test</scope>
</dependency>

<dependency>
    <groupId>org.apache.kafka</groupId>
    <artifactId>kafka-clients</artifactId>
    <version>2.1.0</version>
</dependency>

<dependency>
    <groupId>org.apache.kafka</groupId>
    <artifactId>kafka-clients</artifactId>
    <version>2.1.0</version>
    <classifier>test</classifier>
</dependency>

<dependency>
    <groupId>org.apache.kafka</groupId>
    <artifactId>kafka_2.11</artifactId>
    <version>2.1.0</version>
    <scope>test</scope>
</dependency>

<dependency>
    <groupId>org.apache.kafka</groupId>
    <artifactId>kafka_2.11</artifactId>
    <version>2.1.0</version>
    <classifier>test</classifier>
    <scope>test</scope>
</dependency>
```

Appendix B. Change History

B.1 Changes between 2.0 and 2.1

Kafka Client Version

This version requires the 1.0.0 `kafka-clients` or higher.

> **Note**
>
> The 1.1.x client is supported, with *version 2.1.5*, but you will need to override dependencies as described in ???. The 1.1.x client will be supported natively in *version 2.2*.

JSON Improvements

The `StringJsonMessageConverter` and `JsonSerializer` now add type information in `Headers`, allowing the converter and `JsonDeserializer` to create specific types on reception, based on the message itself rather than a fixed configured type. See the section called “Serialization/Deserialization and Message Conversion” for more information.

Container Stopping Error Handlers

Container Error handlers are now provided for both record and batch listeners that treat any exceptions thrown by the listener as fatal; they stop the container. See the section called “Handling Exceptions” for more information.

Pausing/Resuming Containers

The listener containers now have `pause()` and `resume()` methods (since *version 2.1.3*). See the section called “Pausing/Resuming Listener Containers” for more information.

Stateful Retry

Starting with *version 2.1.3*, stateful retry can be configured; see the section called “Stateful Retry” for more information.

Client ID

Starting with *version 2.1.1*, it is now possible to set the `client.id` prefix on `@KafkaListener`. Previously, to customize the client id, you would need a separate consumer factory (and container factory) per listener. The prefix is suffixed with `-n` to provide unique client ids when using concurrency.

Logging Offset Commits

By default, logging of topic offset commits is performed with the DEBUG logging level. Starting with *version 2.1.2*, there is a new property in `ContainerProperties` called `commitLogLevel` which allows you to specify the log level for these messages. See the section called “KafkaMessageListenerContainer” for more information.

Default @KafkaHandler

Starting with *version 2.1.3*, one of the `@KafkaHandler` s on a class-level `@KafkaListener` can be designated as the default. See the section called “@KafkaListener on a Class” for more information.

ReplyingKafkaTemplate

Starting with *version 2.1.3*, a subclass of `KafkaTemplate` is provided to support request/reply semantics. See the section called “ReplyingKafkaTemplate” for more information.

ChainedKafkaTransactionManager

version 2.1.3 introduced the `ChainedKafkaTransactionManager` see the section called “ChainedKafkaTransactionManager” for more information.

Migration Guide from 2.0

2.0 to 2.1 Migration.

B.2 Changes Between 1.3 and 2.0

Spring Framework and Java Versions

The Spring for Apache Kafka project now requires Spring Framework 5.0 and Java 8.

@KafkaListener Changes

You can now annotate `@KafkaListener` methods (and classes, and `@KafkaHandler` methods) with `@SendTo`. If the method returns a result, it is forwarded to the specified topic. See the section called “Forwarding Listener Results using @SendTo” for more information.

Message Listeners

Message listeners can now be aware of the `Consumer` object. See the section called “Message Listeners” for more information.

ConsumerAwareRebalanceListener

Rebalance listeners can now access the `Consumer` object during rebalance notifications. See the section called “Rebalance Listeners” for more information.

B.3 Changes Between 1.2 and 1.3

Support for Transactions

The 0.11.0.0 client library added support for transactions; the `KafkaTransactionManager` and other support for transactions has been added. See the section called “Transactions” for more information.

Support for Headers

The 0.11.0.0 client library added support for message headers; these can now be mapped to/from `spring-messaging MessageHeaders`. See the section called “Message Headers” for more information.

Creating Topics

The 0.11.0.0 client library provides an `AdminClient` which can be used to create topics. The `KafkaAdmin` uses this client to automatically add topics defined as `@Bean` s.

Support for Kafka timestamps

`KafkaTemplate` now supports API to add records with timestamps. New `KafkaHeaders` have been introduced regarding `timestamp` support. Also new `KafkaConditions.timestamp()` and `KafkaMatchers.hasTimestamp()` testing utilities have been added. See the section called "KafkaTemplate", the section called "@KafkaListener Annotation" and Section 4.3, "Testing Applications" for more details.

@KafkaListener Changes

You can now configure a `KafkaListenerErrorHandler` to handle exceptions. See the section called "Handling Exceptions" for more information.

By default, the `@KafkaListener id` property is now used as the `group.id` property, overriding the property configured in the consumer factory (if present). Further, you can explicitly configure the `groupId` on the annotation. Previously, you would have needed a separate container factory (and consumer factory) to use different `group.id` s for listeners. To restore the previous behavior of using the factory configured `group.id`, set the `idIsGroup` property on the annotation to `false`.

@EmbeddedKafka Annotation

For convenience a test class level `@EmbeddedKafka` annotation is provided with the purpose to register `KafkaEmbedded` as a bean. See Section 4.3, "Testing Applications" for more information.

Kerberos Configuration

Support for configuring Kerberos is now provided. See the section called "Kerberos" for more information.

B.4 Changes between 1.1 and 1.2

This version uses the 0.10.2.x client.

B.5 Changes between 1.0 and 1.1

Kafka Client

This version uses the Apache Kafka 0.10.x.x client.

Batch Listeners

Listeners can be configured to receive the entire batch of messages returned by the `consumer.poll()` operation, rather than one at a time.

Null Payloads

Null payloads are used to "delete" keys when using log compaction.

Initial Offset

When explicitly assigning partitions, you can now configure the initial offset relative to the current position for the consumer group, rather than absolute or relative to the current end.

Seek

You can now seek the position of each topic/partition. This can be used to set the initial position during initialization when group management is in use and Kafka assigns the partitions. You can also seek when an idle container is detected, or at any arbitrary point in your application’s execution. See the section called “Seeking to a Specific Offset” for more information.