Spring for Apache Kafka

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Version 3.0.0-SNAPSHOT
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Chapter 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.
Chapter 2. What’s new?

2.1. What’s New in 2.8 Since 2.7

This section covers the changes made from version 2.7 to version 2.8. For changes in earlier version, see Change History.

2.1.1. Kafka Client Version

This version requires the 3.1.0 kafka-clients

⚠️ When using transactions, the minimum broker version is 2.5.

See Exactly Once Semantics and KIP-447 for more information.

2.1.2. Package Changes

Classes and interfaces related to type mapping have been moved from …support.converter to …support.mapping.

- AbstractJavaTypeMapper
- ClassMapper
- DefaultJackson2JavaTypeMapper
- Jackson2JavaTypeMapper

2.1.3. Out of Order Manual Commits

The listener container can now be configured to accept manual offset commits out of order (usually asynchronously). The container will defer the commit until the missing offset is acknowledged. See Manually Committing Offsets for more information.

2.1.4. @KafkaListener Changes

It is now possible to specify whether the listener method is a batch listener on the method itself. This allows the same container factory to be used for both record and batch listeners.

See Batch Listeners for more information.

Batch listeners can now handle conversion exceptions.

See Conversion Errors with Batch Error Handlers for more information.

RecordFilterStrategy, when used with batch listeners, can now filter the entire batch in one call. See the note at the end of Batch Listeners for more information.
2.1.5. **KafkaTemplate Changes**

You can now receive a single record, given the topic, partition and offset. See [Using KafkaTemplate to Receive](#) for more information.

2.1.6. **CommonErrorHandler Added**

The legacy `GenericErrorHandler` and its sub-interface hierarchies for record an batch listeners have been replaced by a new single interface `CommonErrorHandler` with implementations corresponding to most legacy implementations of `GenericErrorHandler`. See [Container Error Handlers](#) and [Migrating Custom Legacy Error Handler Implementations to CommonErrorHandler](#) for more information.

2.1.7. **Listener Container Changes**

The `interceptBeforeTx` container property is now `true` by default.

The `authorizationExceptionRetryInterval` property has been renamed to `authExceptionRetryInterval` and now applies to `AuthenticationException`s in addition to `AuthorizationException`s previously. Both exceptions are considered fatal and the container will stop by default, unless this property is set.

See [Using KafkaMessageListenerContainer](#) and [Listener Container Properties](#) for more information.

2.1.8. **Serializer/Deserializer Changes**

The `DelegatingByTopicSerializer` and `DelegatingByTopicDeserializer` are now provided. See [Delegating Serializer and Deserializer](#) for more information.

2.1.9. **DeadLetterPublishingRecover Changes**

The property `stripPreviousExceptionHeaders` is now `true` by default.

See [Managing Dead Letter Record Headers](#) for more information.

2.1.10. **Retryable Topics Changes**

Now you can use the same factory for retryable and non-retryable topics. See [Specifying a ListenerContainerFactory](#) for more information.

There’s now a manageable global list of fatal exceptions that will make the failed record go straight to the DLT. Refer to [Exception Classifier](#) to see how to manage it.

You can now use blocking and non-blocking retries in conjunction. See [Combining blocking and non-blocking retries](#) for more information.

The `KafkaBackOffException` thrown when using the retryable topics feature is now logged at DEBUG level. See [Changing KafkaBackOffException Logging Level](#) if you need to change the logging level back to WARN or set it to any other level.
Chapter 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 can help you get up and running as quickly as possible.

3.1. Quick Tour

Prerequisites: You must install and run Apache Kafka. Then you must put the Spring for Apache Kafka (`spring-kafka`) JAR and all of its dependencies on your class path. The easiest way to do that is to declare a dependency in your build tool.

If you are not using Spring Boot, declare the `spring-kafka` jar as a dependency in your project.

Maven

```xml
<dependency>
    <groupId>org.springframework.kafka</groupId>
    <artifactId>spring-kafka</artifactId>
    <version>3.0.0-SNAPSHOT</version>
</dependency>
```

Gradle

```
compile 'org.springframework.kafka:spring-kafka:3.0.0-SNAPSHOT'
```

When using Spring Boot, (and you haven't used start.spring.io to create your project), omit the version and Boot will automatically bring in the correct version that is compatible with your Boot version:

Maven

```xml
<dependency>
    <groupId>org.springframework.kafka</groupId>
    <artifactId>spring-kafka</artifactId>
</dependency>
```

Gradle

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

However, the quickest way to get started is to use `start.spring.io` (or the wizards in Spring Tool Suits and Intellij IDEA) and create a project, selecting 'Spring for Apache Kafka' as a dependency.
3.1.1. Compatibility

This quick tour works with the following versions:

- Apache Kafka Clients 3.0.0
- Spring Framework 5.3.x
- Minimum Java version: 8

3.1.2. Getting Started

The simplest way to get started is to use start.spring.io (or the wizards in Spring Tool Suits and IntelliJ IDEA) and create a project, selecting 'Spring for Apache Kafka' as a dependency. Refer to the Spring Boot documentation for more information about its opinionated auto configuration of the infrastructure beans.

Here is a minimal consumer application.

Spring Boot Consumer App
Example 1. Application

Java

```java
@SpringBootApplication
public class Application {

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

    @Bean
    public NewTopic topic() {
        return TopicBuilder.name("topic1")
            .partitions(10)
            .replicas(1)
            .build();
    }

    @KafkaListener(id = "myId", topics = "topic1")
    public void listen(String in) {
        System.out.println(in);
    }
}
```

Kotlin

```kotlin
@SpringBootApplication
class Application {

    @Bean
    fun topic() = NewTopic("topic1", 10, 1)

    @KafkaListener(id = "myId", topics = ["topic1"])
    fun listen(value: String?) {
        println(value)
    }
}

fun main(args: Array<String>) = runApplication<Application>(*args)
```

Example 2. application.properties

```properties
spring.kafka.consumer.auto-offset-reset=earliest
```
The `NewTopic` bean causes the topic to be created on the broker; it is not needed if the topic already exists.

**Spring Boot Producer App**
Example 3. Application

Java

```java
@SpringBootApplication
public class Application {

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

    @Bean
    public NewTopic topic() {
        return TopicBuilder.name("topic1")
            .partitions(10)
            .replicas(1)
            .build();
    }

    @Bean
    public ApplicationRunner runner(KafkaTemplate<String, String> template) {
        return args -> {
            template.send("topic1", "test");
        };
    }
}
```

Kotlin

```kotlin
@SpringBootApplication
class Application {

    @Bean
    fun topic() = NewTopic("topic1", 10, 1)

    @Bean
    fun runner(template: KafkaTemplate<String?, String?>) = 
        ApplicationRunner { template.send("topic1", "test") }

    companion object {
        @JvmStatic
        fun main(args: Array<String>) = runApplication<Application>(*args)
    }
}
```
Spring for Apache Kafka is designed to be used in a Spring Application Context. For example, if you create the listener container yourself outside of a Spring context, not all functions will work unless you satisfy all of the ...Aware interfaces that the container implements.

Here is an example of an application that does not use Spring Boot; it has both a Consumer and Producer.
public class Sender {

    public static void main(String[] args) {
        AnnotationConfigApplicationContext context = new AnnotationConfigApplicationContext(Config.class);
        context.getBean(Sender.class).send("test", 42);
    }

    private final KafkaTemplate<Integer, String> template;

    public Sender(KafkaTemplate<Integer, String> template) {
        this.template = template;
    }

    public void send(String toSend, int key) {
        this.template.send("topic1", key, toSend);
    }
}

public class Listener {

    @KafkaListener(id = "listen1", topics = "topic1")
    public void listen1(String in) {
        System.out.println(in);
    }
}

@Configuration
@EnableKafka
public class Config {

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

    @Bean
    public ConsumerFactory<Integer, String> consumerFactory() {
        return new DefaultKafkaConsumerFactory<>(consumerProps());
    }
}
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.KEY_DESERIALIZER_CLASS_CONFIG, IntegerDeserializer.class);
    props.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, StringDeserializer.class);
    props.put(ConsumerConfig.AUTO_OFFSET_RESET_CONFIG, "earliest");
    // ...
    return props;
}

@Bean
public Sender sender(KafkaTemplate<Integer, String> template) {
    return new Sender(template);
}

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

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

private Map<String, Object> senderProps() {
    Map<String, Object> props = new HashMap<>();
    props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, "localhost:9092");
    props.put(ProducerConfig.LINGER_MS_CONFIG, 10);
    props.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, IntegerSerializer.class);
    props.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, StringSerializer.class);
    // ...
    return props;
}

@Bean
public KafkaTemplate<Integer, String> kafkaTemplate(ProducerFactory<Integer, String> producerFactory) {
    return new KafkaTemplate<Integer, String>(producerFactory);
}
import java.util.HashMap

### class Sender

```kotlin
class Sender(private val template: KafkaTemplate<Int, String>) {
    fun send(toSend: String, key: Int) {
        template.send("topic1", key, toSend)
    }
}
```

### class Listener

```kotlin
class Listener {
    @KafkaListener(id = "listen1", topics = ["topic1"])
    fun listen1(`in`: String) {
        println(`in`)
    }
}
```

### @Configuration

```kotlin
@Configuration
@EnableKafka
class Config {

    @Bean
    fun kafkaListenerContainerFactory(consumerFactory: ConsumerFactory<Int, String>) =
        ConcurrentKafkaListenerContainerFactory<Int, String>().also {
            it.consumerFactory = consumerFactory
        }

    @Bean
    fun consumerFactory() = DefaultKafkaConsumerFactory<Int, String>(consumerProps)

    val consumerProps = mapOf(
        ConsumerConfig.BOOTSTRAP_SERVERS_CONFIG to "localhost:9092",
        ConsumerConfig.GROUP_ID_CONFIG to "group",
        ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG to IntegerDeserializer::class.java,
        ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG to StringDeserializer::class.java,
        ConsumerConfig.AUTO_OFFSET_RESET_CONFIG to "earliest"
    )

    @Bean
    fun sender(template: KafkaTemplate<Int, String>) = Sender(template)

    @Bean
    fun listener() = Listener()

    @Bean
    fun producerFactory() = DefaultKafkaProducerFactory<Int, String>(senderProps)
```
As you can see, you have to define several infrastructure beans when not using Spring Boot.
Chapter 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

This section offers detailed explanations of the various concerns that impact using Spring for Apache Kafka. For a quick but less detailed introduction, see Quick Tour.

4.1.1. Connecting to Kafka

- KafkaAdmin - see Configuring Topics
- ProducerFactory - see Sending Messages
- ConsumerFactory - see Receiving Messages

Starting with version 2.5, each of these extends KafkaResourceFactory. This allows changing the bootstrap servers at runtime by adding a Supplier<String> to their configuration: setBootstrapServersSupplier(() -> …). This will be called for all new connections to get the list of servers. Consumers and Producers are generally long-lived. To close existing Producers, call reset() on the DefaultKafkaProducerFactory. To close existing Consumers, call stop() (and then start()) on the KafkaListenerEndpointRegistry and/or stop() and start() on any other listener container beans.

For convenience, the framework also provides an ABSwitchCluster which supports two sets of bootstrap servers; one of which is active at any time. Configure the ABSwitchCluster and add it to the producer and consumer factories, and the KafkaAdmin, by calling setBootstrapServersSupplier(). When you want to switch, call primary() or secondary() and call reset() on the producer factory to establish new connection(s); for consumers, stop() and start() all listener containers. When using @KafkaListener s, stop() and start() the KafkaListenerEndpointRegistry bean.

See the Javadocs for more information.

Factory Listeners

Starting with version 2.5, the DefaultKafkaProducerFactory and DefaultKafkaConsumerFactory can be configured with a Listener to receive notifications whenever a producer or consumer is created or closed.
In each case, the id is created by appending the client-id property (obtained from the metrics() after creation) to the factory beanName property, separated by ..

These listeners can be used, for example, to create and bind a Micrometer KafkaClientMetrics instance when a new client is created (and close it when the client is closed).

The framework provides listeners that do exactly that; see Micrometer Native Metrics.

### 4.1.2. Configuring Topics

If you define a KafkaAdmin bean in your application context, it can automatically add topics to the broker. To do so, you can add a NewTopic @Bean for each topic to the application context. Version 2.3 introduced a new class TopicBuilder to make creation of such beans more convenient. The following example shows how to do so:
@Bean
public KafkaAdmin admin() {
    Map<String, Object> configs = new HashMap<>();
    configs.put(AdminClientConfig.BOOTSTRAP_SERVERS_CONFIG, "localhost:9092");
    return new KafkaAdmin(configs);
}

@Bean
public NewTopic topic1() {
    return TopicBuilder.name("thing1")
        .partitions(10)
        .replicas(3)
        .compact()
        .build();
}

@Bean
public NewTopic topic2() {
    return TopicBuilder.name("thing2")
        .partitions(10)
        .replicas(3)
        .config(TopicConfig.COMPRESSION_TYPE_CONFIG, "zstd")
        .build();
}

@Bean
public NewTopic topic3() {
    return TopicBuilder.name("thing3")
        .assignReplicas(0, Arrays.asList(0, 1))
        .assignReplicas(1, Arrays.asList(1, 2))
        .assignReplicas(2, Arrays.asList(2, 0))
        .config(TopicConfig.COMPRESSION_TYPE_CONFIG, "zstd")
        .build();
}
Kotlin

@Bean
fun admin() = KafkaAdmin(mapOf(AdminClientConfig.BOOTSTRAP_SERVERS_CONFIG to
"localhost:9092"))

@Bean
fun topic1() =
    TopicBuilder.name("thing1")
    .partitions(10)
    .replicas(3)
    .compact()
    .build()

@Bean
fun topic2() =
    TopicBuilder.name("thing2")
    .partitions(10)
    .replicas(3)
    .config(TopicConfig.COMPRESSION_TYPE_CONFIG, "zstd")
    .build()

@Bean
fun topic3() =
    TopicBuilder.name("thing3")
    .assignReplicas(0, Arrays.asList(0, 1))
    .assignReplicas(1, Arrays.asList(1, 2))
    .assignReplicas(2, Arrays.asList(2, 0))
    .config(TopicConfig.COMPRESSION_TYPE_CONFIG, "zstd")
    .build()

Starting with version 2.6, you can omit .partitions() and/or replicas() and the broker defaults will be applied to those properties. The broker version must be at least 2.4.0 to support this feature - see KIP-464.
Starting with version 2.7, you can declare multiple `NewTopic` s in a single `KafkaAdmin.NewTopics` bean definition:
When using Spring Boot, a `KafkaAdmin` bean is automatically registered so you only need the `NewTopic` (and/or `NewTopics`) `@Bean` s.

By default, if the broker is not available, a message is logged, but the context continues 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`. The context then fails to initialize.

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

Starting with version 2.7, the `KafkaAdmin` provides methods to create and examine topics at runtime.

- `createOrModifyTopics`
- `describeTopics`

For more advanced features, you can use the `AdminClient` directly. The following example shows
how to do so:

```java
@Autowired
class KafkaAdmin admin;
...
AdminClient client = AdminClient.create(admin.getConfigurationProperties());
...
client.close();
```

### 4.1.3. Sending Messages

This section covers how to send messages.

**Using KafkaTemplate**

This section covers how to use KafkaTemplate to send messages.

**Overview**

The KafkaTemplate wraps a producer and provides convenience methods to send data to Kafka topics. The following listing shows the relevant methods from KafkaTemplate:
See the [Javadoc](#) for more detail.

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

The API takes in a `timestamp` as a parameter and stores this timestamp in the record. How the user-provided timestamp is stored depends on the timestamp type configured on the Kafka topic. If the topic is configured to use `CREATE_TIME`, the user-specified timestamp is recorded (or generated if not specified). If the topic is configured to use `LOG_APPEND_TIME`, the user-specified timestamp is ignored and the broker adds in the local broker time.
The `metrics` and `partitionsFor` methods delegate to the same methods on the underlying `Producer`. The `execute` method provides direct access to the underlying `Producer`.

To use the template, you can configure a producer factory and provide it in the template's constructor. The following example shows how to do so:

```java
@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<>(producerFactory());
}
```

Starting with version 2.5, you can now override the factory's `ProducerConfig` properties to create templates with different producer configurations from the same factory:

```java
@Bean
public KafkaTemplate<String, String> stringTemplate(ProducerFactory<String, String> pf) {
    return new KafkaTemplate<>(pf);
}

@Bean
public KafkaTemplate<String, byte[]> bytesTemplate(ProducerFactory<String, byte[]> pf) {
    return new KafkaTemplate<>(pf, Collections.singletonMap(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, ByteArraySerializer.class));
}
```
Note that a bean of type `ProducerFactory<?, ?>` (such as the one auto-configured by Spring Boot) can be referenced with different narrowed generic types.

You can also configure the template by using standard `<bean/>` definitions.

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

When you use the methods with a `Message<?>` parameter, the topic, partition, and key information is provided in a message header that includes the following items:

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

The message payload is the data.

Optionally, you can configure the `KafkaTemplate` with a `ProducerListener` to get an asynchronous callback with the results of the send (success or failure) instead of waiting for the `Future` to complete. The following listing shows the definition of the `ProducerListener` interface:

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

    void onSuccess(ProducerRecord<K, V> producerRecord, RecordMetadata recordMetadata);

    void onError(ProducerRecord<K, V> producerRecord, RecordMetadata recordMetadata,
                 Exception exception);
}
```

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

For convenience, default method implementations are provided in case you want to implement only one of the methods.

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. The following example shows how to do so:
ListenableFuture<SendResult<Integer, String>> future = template.send("myTopic", "something");
future.addCallback(new ListenableFutureCallback<SendResult<Integer, String>>() {
    @Override
    public void onSuccess(SendResult<Integer, String> result) {
        ...
    }
    @Override
    public void onFailure(Throwable ex) {
        ...
    }
});

SendResult has two properties, a ProducerRecord and RecordMetadata. See the Kafka API documentation for information about those objects.

The Throwable in onFailure can be cast to a KafkaProducerException; its failedProducerRecord property contains the failed record.

Starting with version 2.5, you can use a KafkaSendCallback instead of a ListenableFutureCallback, making it easier to extract the failed ProducerRecord, avoiding the need to cast the Throwable:

ListenableFuture<SendResult<Integer, String>> future = template.send("topic", 1, "thing");
future.addCallback(new KafkaSendCallback<Integer, String>() {
    @Override
    public void onSuccess(SendResult<Integer, String> result) {
        ...
    }
    @Override
    public void onFailure(KafkaProducerException ex) {
        ProducerRecord<Integer, String> failed = ex.getFailedProducerRecord();
        ...
    }
});

You can also use a pair of lambdas:
ListenableFuture<SendResult<Integer, String>> future = template.send("topic", 1, "thing");
future.addCallback(result -> {
    ...
    }, (KafkaFailureCallback<Integer, String>) ex -> {
        ProducerRecord<Integer, String> failed = ex.getFailedProducerRecord();
        ...
    });

If you wish to block the sending thread to await the result, you can invoke the future's get() method; using the method with a timeout is recommended. You may wish to invoke flush() before waiting or, for convenience, the template has a constructor with an autoFlush parameter that causes the template to flush() on each send. Flushing is only needed if you have set the linger.ms producer property and want to immediately send a partial batch.

Examples

This section shows examples of sending messages to Kafka:
Example 5. Non Blocking (Async)

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

    ListenableFuture<SendResult<Integer, String>> future = template.send(record);
    future.addCallback(new KafkaSendCallback<Integer, String>() {
        @Override
        public void onSuccess(SendResult<Integer, String> result) {
            handleSuccess(data);
        }

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

Blocking (Sync)

```java
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);
    }
}
```

Note that the cause of the `ExecutionException` is `KafkaProducerException` with the `failedProducerRecord` property.

Using `RoutingKafkaTemplate`

Starting with version 2.5, you can use a `RoutingKafkaTemplate` to select the producer at runtime, based on the destination `topic` name.
The routing template does not support transactions, execute, flush, or metrics operations because the topic is not known for those operations.

The template requires a map of java.util.regex.Pattern to ProducerFactory<Object, Object> instances. This map should be ordered (e.g. a LinkedHashMap) because it is traversed in order; you should add more specific patterns at the beginning.

The following simple Spring Boot application provides an example of how to use the same template to send to different topics, each using a different value serializer.

```java
@SpringBootApplication
public class Application {

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

    @Bean
    public RoutingKafkaTemplate routingTemplate(GenericApplicationContext context, ProducerFactory<Object, Object> pf) {
        // Clone the PF with a different Serializer, register with Spring for shutdown
        Map<String, Object> configs = new HashMap<>(pf.getConfigurationProperties());
        configs.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, ByteArraySerializer.class);
        DefaultKafkaProducerFactory<Object, Object> bytesPF = new DefaultKafkaProducerFactory<>(configs);
        context.registerBean(DefaultKafkaProducerFactory.class, "bytesPF", bytesPF);

        Map<Pattern, ProducerFactory<Object, Object>> map = new LinkedHashMap<>();
        map.put(Pattern.compile("two"), bytesPF);
        map.put(Pattern.compile(".+"), pf); // Default PF with StringSerializer
        return new RoutingKafkaTemplate(map);
    }

    @Bean
    public ApplicationRunner runner(RoutingKafkaTemplate routingTemplate) {
        return args -> {
            routingTemplate.send("one", "thing1");
            routingTemplate.send("two", "thing2".getBytes());
        };
    }
}
```
The corresponding @KafkaListener s for this example are shown in Annotation Properties.

For another technique to achieve similar results, but with the additional capability of sending different types to the same topic, see Delegating Serializer and Deserializer.

Using DefaultKafkaProducerFactory

As seen in Using KafkaTemplate, a ProducerFactory is used to create the producer.

When not using Transactions, by default, the DefaultKafkaProducerFactory creates a singleton producer used by all clients, as recommended in the KafkaProducer javadocs. However, if you call flush() on the template, this can cause delays for other threads using the same producer. Starting with version 2.3, the DefaultKafkaProducerFactory has a new property producerPerThread. When set to true, the factory will create (and cache) a separate producer for each thread, to avoid this issue.

When producerPerThread is true, user code must call closeThreadBoundProducer() on the factory when the producer is no longer needed. This will physically close the producer and remove it from the ThreadLocal. Calling reset() or destroy() will not clean up these producers.

Also see KafkaTemplate Transactional and non-Transactional Publishing.

When creating a DefaultKafkaProducerFactory, key and/or value Serializer classes can be picked up from configuration by calling the constructor that only takes in a Map of properties (see example in Using KafkaTemplate), or Serializer instances may be passed to the DefaultKafkaProducerFactory constructor (in which case all Producer s share the same instances). Alternatively you can provide Supplier<Serializer> s (starting with version 2.3) that will be used to obtain separate Serializer instances for each Producer:

```java
@Bean
public ProducerFactory<Integer, CustomValue> producerFactory() {
    return new DefaultKafkaProducerFactory<CodecKey(), CustomValueSerializer>();
}

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

Starting with version 2.5.10, you can now update the producer properties after the factory is created. This might be useful, for example, if you have to update SSL key/trust store locations after a credentials change. The changes will not affect existing producer instances; call reset() to close any existing producers so that new producers will be created using the new properties. NOTE: You cannot change a transactional producer factory to non-transactional, and vice-versa.

Two new methods are now provided:
Starting with version 2.8, if you provide serializers as objects (in the constructor or via the setters), the factory will invoke the `configure()` method to configure them with the configuration properties.

**Using `ReplyingKafkaTemplate`**

Version 2.1.3 introduced a subclass of `KafkaTemplate` to provide request/reply semantics. The class is named `ReplyingKafkaTemplate` and has two additional methods; the following shows the method signatures:

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

(Also see **Request/Reply with `Message<?>` s**).

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

If the first method is used, or the `replyTimeout` argument is `null`, the template’s `defaultReplyTimeout` property is used (5 seconds by default).

The following Spring Boot application shows 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(10, TimeUnit.SECONDS);
            System.out.println("Sent ok: " + sendResult.getRecordMetadata());
            ConsumerRecord<String, String> consumerRecord = replyFuture.get(10,
                    TimeUnit.SECONDS);
            System.out.println("Return value: " + consumerRecord.value());
        }
    }

    @Bean
    public ReplyingKafkaTemplate<String, String, String> replyingTemplate(ProducerFactory<String, String> pf,
            ConcurrentMessageListenerContainer<String, String> repliesContainer) {
        return new ReplyingKafkaTemplate<>(pf, repliesContainer);
    }

    @Bean
    public ConcurrentMessageListenerContainer<String, String> repliesContainer(ConcurrentKafkaListenerContainerFactory<String, String> containerFactory) {
        ConcurrentMessageListenerContainer<String, String> repliesContainer =
                containerFactory.createContainer("kReplies");
        repliesContainer.getContainerProperties().setGroupId("repliesGroup");
        repliesContainer.setAutoStartup(false);
        return repliesContainer;
    }

    @Bean
    public NewTopic kRequests() {
        return TopicBuilder.name("kRequests")
                .partitions(10)
                .replicas(2)
                .build();
    }
}
Note that we can use Boot's auto-configured container factory to create the reply container.

If a non-trivial deserializer is being used for replies, consider using an `ErrorHandlingDeserializer` that delegates to your configured deserializer. When so configured, the `RequestReplyFuture` will be completed exceptionally and you can catch the `ExecutionException`, with the `DeserializationException` in its `cause` property.

Starting with version 2.6.7, in addition to detecting `DeserializationException` s, the template will call the `replyErrorChecker` function, if provided. If it returns an exception, the future will be completed exceptionally.

Here is an example:
The template sets a header (named `KafkaHeaders.CORRELATION_ID` by default), which must be echoed back by the server side.

In this case, the following @KafkaListener application responds:
The `@KafkaListener` infrastructure echoes the correlation ID and determines the reply topic.

See [Forwarding Listener Results using `@SendTo`](#) for more information about sending replies. The template uses the default header `KafkaHeaders.REPLY_TOPIC` to indicate the topic to which the reply goes.

Starting with version 2.2, the template tries to detect the reply topic or partition from the configured reply container. If the container is configured to listen to a single topic or a single `TopicPartitionOffset`, it is used to set the reply headers. If the container is configured otherwise, the user must set up the reply headers. In this case, an `INFO` log message is written during initialization. The following example uses `KafkaHeaders.REPLY_TOPIC`: 
When you configure with a single reply `TopicPartitionOffset`, 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 receive each reply, but only the instance that sent the request finds 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 you use this setting, we recommend that you set the template’s `sharedReplyTopic` to `true`, which reduces the logging level of unexpected replies to `DEBUG` instead of the default `ERROR`.

The following is an example of configuring the reply container to use the same shared reply topic:

```java
@Bean
public ConcurrentMessageListenerContainer<String, String> replyContainer(
    ConcurrentKafkaListenerContainerFactory<String, String> containerFactory)
{
    ConcurrentMessageListenerContainer<String, String> container =
        containerFactory.createContainer("topic2");
    container.getContainerProperties().setGroupId(UUID.randomUUID().toString());
    // unique
    Properties props = new Properties();
    props.setProperty(ConsumerConfig.AUTO_OFFSET_RESET_CONFIG, "latest"); // so
    the new group doesn't get old replies
    container.getContainerProperties().setKafkaConsumerProperties(props);
    return container;
}
```

If you have multiple client instances and you do not configure them as discussed in the preceding paragraph, each instance needs 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 four-byte int (big-endian). The server must use this header to route the reply to the correct partition (@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 (by using a `TopicPartitionOffset` in its `ContainerProperties` constructor).

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 earlier.
By default, 3 headers are used:

- **KafkaHeaders.CORRELATION_ID** - used to correlate the reply to a request
- **KafkaHeaders.REPLY_TOPIC** - used to tell the server where to reply
- **KafkaHeaders.REPLY_PARTITION** - (optional) used to tell the server which partition to reply to

These header names are used by the `@KafkaListener` infrastructure to route the reply.

Starting with version 2.3, you can customize the header names - the template has 3 properties `correlationHeaderName`, `replyTopicHeaderName`, and `replyPartitionHeaderName`. This is useful if your server is not a Spring application (or does not use the `@KafkaListener`).

**Request/Reply with Message<?> s**

Version 2.7 added methods to the `ReplyingKafkaTemplate` to send and receive `spring-messaging`'s `Message<?>` abstraction:

```java
RequestReplyMessageFuture<K, V> sendAndReceive(Message<?> message);
RequestReplyTypedMessageFuture<K, V, P> sendAndReceive(Message<?> message,
                                                          ParameterizedTypeReference<P> returnType);
```

These will use the template’s default `replyTimeout`, there are also overloaded versions that can take a timeout in the method call.

Use the first method if the consumer’s `Deserializer` or the template’s `MessageConverter` can convert the payload without any additional information, either via configuration or type metadata in the reply message.

Use the second method if you need to provide type information for the return type, to assist the message converter. This also allows the same template to receive different types, even if there is no type metadata in the replies, such as when the server side is not a Spring application. The following is an example of the latter:
Example 6. Template Bean

Java

```java
@Bean
ReplyingKafkaTemplate<String, String, String> template(
    ProducerFactory<String, String> pf,
    ConcurrentKafkaListenerContainerFactory<String, String> factory) {

    ConcurrentMessageListenerContainer<String, String> replyContainer =
        factory.createContainer("replies");
    replyContainer.getContainerProperties().setGroupId("request.replies");
    ReplyingKafkaTemplate<String, String, String> template =
        new ReplyingKafkaTemplate<>(pf, replyContainer);
    template.setMessageConverter(new ByteArrayJsonMessageConverter());
    template.setDefaultTopic("requests");
    return template;
}
```

Kotlin

```kotlin
@<Bean
fun template(    pf: ProducerFactory<String?, String>?,
    factory: ConcurrentKafkaListenerContainerFactory<String?, String?>
): ReplyingKafkaTemplate<String?, String, String?> { val replyContainer = factory.createContainer("replies")
    replyContainer.containerProperties.groupId = "request.replies"
    val template = ReplyingKafkaTemplate(pf, replyContainer)
    template.messageConverter = ByteArrayJsonMessageConverter()
    template.defaultTopic = "requests"
    return template
}
```
Example 7. Using the template

**Java**

```java
RequestReplyTypedMessageFuture<String, String, Thing> future1 =
    template.sendAndReceive(MessageBuilder.withPayload("getAThing").build(),
    new ParameterizedTypeReference<Thing>() { });
log.info(future1.getSendFuture().get(10, TimeUnit.SECONDS).getRecordMetadata().toString());
Thing thing = future1.get(10, TimeUnit.SECONDS).getPayload();
log.info(thing.toString());
```

```java
RequestReplyTypedMessageFuture<String, String, List<Thing>> future2 =
    template.sendAndReceive(MessageBuilder.withPayload("getThings").build(),
    new ParameterizedTypeReference<List<Thing>>() { });
log.info(future2.getSendFuture().get(10, TimeUnit.SECONDS).getRecordMetadata().toString());
List<Thing> things = future2.get(10, TimeUnit.SECONDS).getPayload();
things.forEach(Consumer { thing1: Thing -> log.info(thing1.toString()) });
```

**Kotlin**

```kotlin
val future1: RequestReplyTypedMessageFuture<String?, String?, Thing?>? =
    template.sendAndReceive(MessageBuilder.withPayload("getAThing").build(),
    object : ParameterizedTypeReference<Thing?>() { });
log.info(future1?.sendFuture?.get(10, TimeUnit.SECONDS)?.recordMetadata?.toString())
val thing = future1?.get(10, TimeUnit.SECONDS)?.payload
log.info(thing.toString())
```

```kotlin
    template.sendAndReceive(MessageBuilder.withPayload("getThings").build(),
    object : ParameterizedTypeReference<List<Thing?>?>() { });
log.info(future2?.sendFuture?.get(10, TimeUnit.SECONDS)?.recordMetadata.toString())
val things = future2?.get(10, TimeUnit.SECONDS)?.payload
things?.forEach(Consumer { thing1: Thing? -> log.info(thing1.toString()) });
```

**Reply Type Message<?>**

When the `@KafkaListener` returns a `Message<?>`, with versions before 2.5, it was necessary to populate the reply topic and correlation id headers. In this example, we use the reply topic header from the request:
@KafkaListener(id = "requestor", topics = "request")
@SendTo
public Message<?> messageReturn(String in) {
    return MessageBuilder.withPayload(in.toUpperCase())
        .setHeader(KafkaHeaders.TOPIC, replyTo)
        .setHeader(KafkaHeaders.MESSAGE_KEY, 42)
        .setHeader(KafkaHeaders.CORRELATION_ID, correlation)
        .build();
}

This also shows how to set a key on the reply record.

Starting with version 2.5, the framework will detect if these headers are missing and populate them with the topic - either the topic determined from the @SendTo value or the incoming KafkaHeaders.REPLY_TOPIC header (if present). It will also echo the incoming KafkaHeaders.CORRELATION_ID and KafkaHeaders.REPLY_PARTITION, if present.

@KafkaListener(id = "requestor", topics = "request")
@SendTo // default REPLY_TOPIC header
public Message<?> messageReturn(String in) {
    return MessageBuilder.withPayload(in.toUpperCase())
        .setHeader(KafkaHeaders.MESSAGE_KEY, 42)
        .build();
}

### Aggregating Multiple Replies

The template in UsingReplyingKafkaTemplate is strictly for a single request/reply scenario. For cases where multiple receivers of a single message return a reply, you can use the AggregatingReplyingKafkaTemplate. This is an implementation of the client-side of the Scatter-Gather Enterprise Integration Pattern.

Like the ReplyingKafkaTemplate, the AggregatingReplyingKafkaTemplate constructor takes a producer factory and a listener container to receive the replies; it has a third parameter BiPredicate<List<ConsumerRecord<K, R>>, Boolean> releaseStrategy which is consulted each time a reply is received; when the predicate returns true, the collection of ConsumerRecord s is used to complete the Future returned by the sendAndReceive method.

There is an additional property returnPartialOnTimeout (default false). When this is set to true, instead of completing the future with a KafkaReplyTimeoutException, a partial result completes the future normally (as long as at least one reply record has been received).

Starting with version 2.3.5, the predicate is also called after a timeout (if returnPartialOnTimeout is true). The first argument is the current list of records; the second is true if this call is due to a timeout. The predicate can modify the list of records.
AggregatingReplyingKafkaTemplate<Integer, String, String> template =
        new AggregatingReplyingKafkaTemplate<>((producerFactory, container, coll -> coll.size() == releaseSize);

RequestReplyFuture<Integer, String, Collection<ConsumerRecord<Integer, String>>> future =
        template.sendAndReceive(record);
future.getSendFuture().get(10, TimeUnit.SECONDS); // send ok
ConsumerRecord<Integer, Collection<ConsumerRecord<Integer, String>>> consumerRecord =
        future.get(30, TimeUnit.SECONDS);

Notice that the return type is a ConsumerRecord with a value that is a collection of ConsumerRecord s. The "outer" ConsumerRecord is not a "real" record, it is synthesized by the template, as a holder for the actual reply records received for the request. When a normal release occurs (release strategy returns true), the topic is set to aggregatedResults; if returnPartialOnTimeout is true, and timeout occurs (and at least one reply record has been received), the topic is set to partialResultsAfterTimeout. The template provides constant static variables for these "topic" names:

```java
/**
 * Pseudo topic name for the "outer" @link ConsumerRecords} that has the aggregated
 * results in its value after a normal release by the release strategy.
 */
public static final String AGGREGATED_RESULTS_TOPIC = "aggregatedResults";

/**
 * Pseudo topic name for the "outer" @link ConsumerRecords} that has the aggregated
 * results in its value after a timeout.
 */
public static final String PARTIAL_RESULTS_AFTER_TIMEOUT_TOPIC =
        "partialResultsAfterTimeout";
```

The real ConsumerRecord s in the Collection contain the actual topic(s) from which the replies are received.
The listener container for the replies MUST be configured with `AckMode.MANUAL` or `AckMode.MANUAL_IMMEDIATE`; the consumer property `enable.auto.commit` must be `false` (the default since version 2.3). To avoid any possibility of losing messages, the template only commits offsets when there are zero requests outstanding, i.e. when the last outstanding request is released by the release strategy. After a rebalance, it is possible for duplicate reply deliveries; these will be ignored for any in-flight requests; you may see error log messages when duplicate replies are received for already released replies.

If you use an `ErrorHandlingDeserializer` with this aggregating template, the framework will not automatically detect `DeserializationException` s. Instead, the record (with a `null` value) will be returned intact, with the deserialization exception(s) in headers. It is recommended that applications call the utility method `RepyingKafkaTemplate.checkDeserialization()` method to determine if a deserialization exception occurred. See its javadocs for more information. The `replyErrorChecker` is also not called for this aggregating template; you should perform the checks on each element of the reply.

### 4.1.4. Receiving Messages

You can receive messages by configuring a `MessageListenerContainer` and providing a message listener or by using the `@KafkaListener` annotation.

**Message Listeners**

When you use a message listener container, you must provide a listener to receive data. There are currently eight supported interfaces for message listeners. The following listing shows these interfaces:
public interface MessageListener<K, V> { ①
    void onMessage(ConsumerRecord<K, V> data);
}

public interface AcknowledgingMessageListener<K, V> { ②
    void onMessage(ConsumerRecord<K, V> data, Acknowledgment acknowledgment);
}

public interface ConsumerAwareMessageListener<K, V> extends MessageListener<K, V> { ③
    void onMessage(ConsumerRecord<K, V> data, Consumer<?, ?> consumer);
}

public interface AcknowledgingConsumerAwareMessageListener<K, V> extends MessageListener<K, V> { ④
    void onMessage(ConsumerRecord<K, V> data, Acknowledgment acknowledgment, Consumer<?, ?> consumer);
}

public interface BatchMessageListener<K, V> { ⑤
    void onMessage(List<ConsumerRecord<K, V>> data);
}

public interface BatchAcknowledgingMessageListener<K, V> { ⑥
    void onMessage(List<ConsumerRecord<K, V>> data, Acknowledgment acknowledgment);
}

public interface BatchConsumerAwareMessageListener<K, V> extends BatchMessageListener<K, V> { ⑦
    void onMessage(List<ConsumerRecord<K, V>> data, Consumer<?, ?> consumer);
}

public interface BatchAcknowledgingConsumerAwareMessageListener<K, V> extends BatchMessageListener<K, V> { ⑧
```java
void onMessage(List<ConsumerRecord<K, V>> data, Acknowledgment acknowledgment, Consumer<?, ?> consumer);
```

① Use this interface for processing individual `ConsumerRecord` instances received from the Kafka consumer `poll()` operation when using auto-commit or one of the container-managed commit methods.

② Use this interface for processing individual `ConsumerRecord` instances received from the Kafka consumer `poll()` operation when using one of the manual commit methods.

③ Use this interface for processing individual `ConsumerRecord` instances 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.

④ Use this interface for processing individual `ConsumerRecord` instances received from the Kafka consumer `poll()` operation when using one of the manual commit methods. Access to the `Consumer` object is provided.

⑤ Use this interface for processing all `ConsumerRecord` instances 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 you use this interface, since the listener is given the complete batch.

⑥ Use this interface for processing all `ConsumerRecord` instances received from the Kafka consumer `poll()` operation when using one of the manual commit methods.

⑦ Use this interface for processing all `ConsumerRecord` instances 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 you use this interface, since the listener is given the complete batch. Access to the `Consumer` object is provided.

⑧ Use this interface for processing all `ConsumerRecord` instances received from the Kafka consumer `poll()` operation when using one of the manual commit methods. Access to the `Consumer` object is provided.

⚠️ The `Consumer` object is not thread-safe. You must only invoke its methods on the thread that calls the listener.

⚠️ You should not execute any `Consumer<?, ?>` methods that affect the consumer's positions and or committed offsets in your listener; the container needs to manage such information.

**Message Listener Containers**

Two `MessageListenerContainer` implementations are provided:

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

Starting with version 2.2.7, you can add a RecordInterceptor to the listener container; it will be invoked before calling the listener allowing inspection or modification of the record. If the interceptor returns null, the listener is not called. Starting with version 2.7, it has additional methods which are called after the listener exits (normally, or by throwing an exception). Also, starting with version 2.7, there is now a BatchInterceptor, providing similar functionality for Batch Listeners. In addition, the ConsumerAwareRecordInterceptor (and BatchInterceptor) provide access to the Consumer<?, ?>. This might be used, for example, to access the consumer metrics in the interceptor.

⚠️ You should not execute any methods that affect the consumer’s positions and or committed offsets in these interceptors; the container needs to manage such information.

The CompositeRecordInterceptor and CompositeBatchInterceptor can be used to invoke multiple interceptors.

By default, starting with version 2.8, when using transactions, the interceptor is invoked before the transaction has started. You can set the listener container’s interceptBeforeTx property to false to invoke the interceptor after the transaction has started instead.

Starting with versions 2.3.8, 2.4.6, the ConcurrentMessageListenerContainer now supports Static Membership when the concurrency is greater than one. The group.instance.id is suffixed with -n with n starting at 1. This, together with an increased session.timeout.ms, can be used to reduce rebalance events, for example, when application instances are restarted.

Using KafkaMessageListenerContainer

The following constructor is available:

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

It receives a ConsumerFactory and information about topics and partitions, as well as other configuration, in a ContainerProperties object. ContainerProperties has the following constructors:

```java
public ContainerProperties(TopicPartitionOffset... topicPartitions)
public ContainerProperties(String... topics)
public ContainerProperties(Pattern topicPattern)
```
The first constructor takes an array of `TopicPartitionOffset` arguments to explicitly instruct the container about 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 `TopicPartitionOffset` that takes an additional `boolean` argument is provided. 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, you can use the `ContainerProps.setMessageListener` method when creating the Container. The following example shows how to do so:

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

Note that when creating a `DefaultKafkaConsumerFactory`, using the constructor that just takes in the properties as above means that key and value `Deserializer` classes are picked up from configuration. Alternatively, `Deserializer` instances may be passed to the `DefaultKafkaConsumerFactory` constructor for key and/or value, in which case all Consumers share the same instances. Another option is to provide `Supplier<Deserializer>`s (starting with version 2.3) that will be used to obtain separate `Deserializer` instances for each `Consumer`:

```java
DefaultKafkaConsumerFactory<Integer, CustomValue> cf =
    new DefaultKafkaConsumerFactory<>(consumerProps(), null,
    () -> new CustomValueDeserializer());
KafkaMessageListenerContainer<Integer, String> container =
    new KafkaMessageListenerContainer<>(cf, containerProps);
return container;
```

Refer to the Javadoc for `ContainerProperties` for more information about the various properties that you can set.

Since version 2.1.1, a new property called `logContainerConfig` is available. When `true` and `INFO` logging is enabled each listener container writes a log message summarizing its configuration properties.
By default, logging of topic offset commits is performed at the DEBUG logging level. Starting with version 2.1.2, a property in ContainerProperties called commitLogLevel lets you specify the log level for these messages. For example, to change the log level to INFO, you can use containerProperties.setCommitLogLevel(LogIfLevelEnabled.Level.INFO);

Starting with version 2.2, a new container property called missingTopicsFatal has been added (default: false since 2.3.4). 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.

As of version 2.8, a new container property authExceptionRetryInterval has been introduced. This causes the container to retry fetching messages after getting any AuthenticationException or AuthorizationException from the KafkaConsumer. This can happen when, for example, the configured user is denied access to read a certain topic or credentials are incorrect. Defining authExceptionRetryInterval allows the container to recover when proper permissions are granted.

By default, no interval is configured - authentication and authorization errors are considered fatal, which causes the container to stop.

Starting with version 2.8, when creating the consumer factory, if you provide deserializers as objects (in the constructor or via the setters), the factory will invoke the configure() method to configure them with the configuration properties.

Using ConcurrentMessageListenerContainer

The single constructor is similar to the KafkaListenerContainer constructor. The following listing shows the constructor's signature:

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

It also has a concurrency property. For example, container.setConcurrency(3) creates three KafkaMessageListenerContainer instances.

For the first constructor, Kafka distributes the partitions across the consumers using its group management capabilities.
When listening to multiple topics, the default partition distribution may not be what you expect. For example, if you have three topics with five partitions each and you want to use `concurrency=15`, you see only five 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 Javadoc). For this scenario, you may want to consider using the `RoundRobinAssignor` instead, which distributes the partitions across all of the consumers. Then, each consumer is assigned one topic or partition. To change the `PartitionAssignor`, you can set the `partition.assignment.strategy` consumer property (`ConsumerConfigs.PARTITION_ASSIGNMENT_STRATEGY_CONFIG`) in the properties provided to the `DefaultKafkaConsumerFactory`.

When using Spring Boot, you can assign set the strategy as follows:

```java
spring.kafka.consumer.properties.partition.assignment.strategy=
  org.apache.kafka.clients.consumer.RoundRobinAssignor
```

When the container properties are configured with `TopicPartitionOffset` s, the `ConcurrentMessageListenerContainer` distributes the `TopicPartitionOffset` instances across the delegate `KafkaMessageListenerContainer` instances.

If, say, six `TopicPartitionOffset` instances are provided and the `concurrency` is 3; each container gets two partitions. For five `TopicPartitionOffset` instances, two containers get two partitions, and the third gets one. If the `concurrency` is greater than the number of `TopicPartitions`, the `concurrency` is adjusted down such that each container gets one partition.

The `client.id` property (if set) is appended with `-n` where `n` is the consumer instance that corresponds to the concurrency. This is required to provide unique names for MBeans when JMX is enabled.

Starting with version 1.3, the `MessageListenerContainer` provides access to the metrics of the underlying `KafkaConsumer`. In the 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`.

Starting with version 2.3, the `ContainerProperties` provides an `idleBetweenPolls` option to let the main loop in the listener container to sleep between `KafkaConsumer.poll()` calls. An actual sleep interval is selected as the minimum from the provided option and difference between the `max.poll.interval.ms` consumer config and the current records batch processing time.

**Committing Offsets**

Several options are provided for committing offsets. If the `enable.auto.commit` consumer property is `true`, Kafka auto-commits the offsets according to its configuration. If it is `false`, the containers support several `AckMode` settings (described in the next list). The default `AckMode` is `BATCH`. Starting
with version 2.3, the framework sets `enable.auto.commit` to `false` unless explicitly set in the configuration. Previously, the Kafka default (`true`) was used if the property was not set.

The consumer `poll()` method returns one or more `ConsumerRecords`. The `MessageListener` is called for each record. The following lists describes the action taken by the container for each `AckMode` (when transactions are not being used):

- **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 that, the same semantics as `BATCH` are applied.
- **MANUAL_IMMEDIATE**: Commit the offset immediately when the `Acknowledgment.acknowledge()` method is called by the listener.

When using `transactions`, the offset(s) are sent to the transaction and the semantics are equivalent to `RECORD` or `BATCH`, depending on the listener type (record or batch).

```
MANUAL, and MANUAL_IMMEDIATE require the listener to be an
AcknowledgingMessageListener or a BatchAcknowledgingMessageListener. See Message
Listners.
```

Depending on the `syncCommits` container property, the `commitSync()` or `commitAsync()` method on the consumer is used. `syncCommits` is `true` by default; also see `setSyncCommitTimeout`. See `setCommitCallback` to get the results of asynchronous commits; the default callback is the `LoggingCommitCallback` which logs errors (and successes at debug level).

Because the listener container has its own mechanism for committing offsets, it prefers the Kafka `ConsumerConfig.ENABLE_AUTO_COMMIT_CONFIG` to be `false`. Starting with version 2.3, it unconditionally sets it to `false` unless specifically set in the consumer factory or the container’s consumer property overrides.

The `Acknowledgment` has the following method:

```java
public interface Acknowledgment {
    void acknowledge();
}
```
This method gives the listener control over when offsets are committed.

Starting with version 2.3, the **Acknowledgment** interface has two additional methods `nack(long sleep)` and `nack(int index, long sleep)`. The first one is used with a record listener, the second with a batch listener. Calling the wrong method for your listener type will throw an `IllegalStateException`.

If you want to commit a partial batch, using `nack()`, When using transactions, set the `AckMode` to `MANUAL`; invoking `nack()` will send the offsets of the successfully processed records to the transaction.

`nack()` can only be called on the consumer thread that invokes your listener.

With a record listener, when `nack()` is called, any pending offsets are committed, the remaining records from the last poll are discarded, and seeks are performed on their partitions so that the failed record and unprocessed records are redelivered on the next `poll()`.

The consumer thread can be paused before redelivery by setting the `sleep` argument. This is similar functionality to throwing an exception when the container is configured with a `DefaultErrorHandler`.

When using a batch listener, you can specify the index within the batch where the failure occurred. When `nack()` is called, offsets will be committed for records before the index and seeks are performed on the partitions for the failed and discarded records so that they will be redelivered on the next `poll()`.

See [Container Error Handlers](#) for more information.

When using partition assignment via group management, it is important to ensure the `sleep` argument (plus the time spent processing records from the previous poll) is less than the consumer `max.poll.interval.ms` property.

**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`, to 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.

**Manually Committing Offsets**

Normally, when using `AckMode.MANUAL` or `AckMode.MANUAL_IMMEDIATE`, the acknowledgments must be acknowledged in order, because Kafka does not maintain state for each record, only a committed offset for each group/partition. Starting with version 2.8, you can now set the container property `asyncAcks`, which allows the acknowledgments for records returned by the poll to be acknowledged in any order. The listener container will defer the out-of-order commits until the missing acknowledgments are received. The consumer will be paused (no new records delivered) until all the offsets for the previous poll have been committed.
While this feature allows applications to process records asynchronously, it should be understood that it increases the possibility of duplicate deliveries after a failure.

**@KafkaListener Annotation**

The `@KafkaListener` annotation is used to designate a bean method as a listener for a listener container. The bean is wrapped in a `MessagingMessageListenerAdapter` configured with various features, such as converters to convert the data, if necessary, to match the method parameters.

You can configure most attributes on the annotation with SpEL by using `{…}` or property placeholders (`${…}`). See the javadoc for more information.

**Record Listeners**

The `@KafkaListener` annotation provides a mechanism for simple POJO listeners. The following example shows how to use it:

```java
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. The following example shows how to use `ConcurrentMessageListenerContainer`:
@Configuration
@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, you can now 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 by using properties on the annotation itself. The properties can be simple values, property placeholders, or SpEL expressions. The following example shows how to do so:
Explicit Partition Assignment

You can also configure POJO listeners with explicit topics and partitions (and, optionally, their initial offsets). The following example shows how to do so:

```java
@KafkaListener(id = "thing2", topicPartitions =
    { @TopicPartition(topic = "topic1", partitions = { "0", "1" }),
      @TopicPartition(topic = "topic2", partitions = {"0"},
                     partitionOffsets = @PartitionOffset(partition = "1", initialOffset = "100"))
    }
) public void listen(ConsumerRecord<?, ?> record) {
    ...
}
```

You can specify each partition in the `partitions` or `partitionOffsets` attribute but not both.

As with most annotation properties, you can use SpEL expressions; for an example of how to generate a large list of partitions, see Manually Assigning All Partitions.

Starting with version 2.5.5, you can apply an initial offset to all assigned partitions:

```java
@KafkaListener(id = "thing3", topicPartitions =
    { @TopicPartition(topic = "topic1", partitions = { "0", "1" },
      partitionOffsets = @PartitionOffset(partition = "*", initialOffset = "0")
    })
) public void listen(ConsumerRecord<?, ?> record) {
    ...
}
```

The * wildcard represents all partitions in the `partitions` attribute. There must only be one `@PartitionOffset` with the wildcard in each `@TopicPartition`.

In addition, when the listener implements `ConsumerSeekAware`, `onPartitionsAssigned` is now called,
even when using manual assignment. This allows, for example, any arbitrary seek operations at that time.

Starting with version 2.6.4, you can specify a comma-delimited list of partitions, or partition ranges:

```java
@KafkaListener(id = "pp", autoStartup = "false",
   topicPartitions = @TopicPartition(topic = "topic1",
         partitions = "0-5, 7, 10-15"))
public void process(String in) {
   ...
}
```

The range is inclusive; the example above will assign partitions 0, 1, 2, 3, 4, 5, 7, 10, 11, 12, 13, 14, 15.

The same technique can be used when specifying initial offsets:

```java
@KafkaListener(id = "thing3", topicPartitions =
   { @TopicPartition(topic = "topic1",
         partitionOffsets = @PartitionOffset(partition = "0-5", initialOffset = "0")) })
public void listen(ConsumerRecord<?, ?> record) {
   ...
}
```

The initial offset will be applied to all 6 partitions.

**Manual Acknowledgment**

When using manual AckMode, you can also provide the listener with the Acknowledgment. The following example also shows how to use a different container factory.

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

**Consumer Record Metadata**

Finally, metadata about the record is available from message headers. You can use the following
header names to retrieve the headers of the message:

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

Starting with version 2.5 the RECEIVED_MESSAGE_KEY is not present if the incoming record has a null key; previously the header was populated with a null value. This change is to make the framework consistent with spring-messaging conventions where null valued headers are not present.

The following example shows how to use the headers:

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

Starting with version 2.5, instead of using discrete headers, you can receive record metadata in a ConsumerRecordMetadata parameter.

```java
@KafkaListener(...)
public void listen(String str, ConsumerRecordMetadata meta) {
    ...
}
```

This contains all the data from the ConsumerRecord except the key and value.

**Batch Listeners**

Starting with version 1.1, you can configure @KafkaListener methods to receive the entire batch of consumer records received from the consumer poll. To configure the listener container factory to create batch listeners, you can set the batchListener property. The following example shows how to do so:
@Bean
public KafkaListenerContainerFactory<?, ?> batchFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
        new ConcurrentKafkaListenerContainerFactory<>();
    factory.setConsumerFactory(consumerFactory());
    factory.setBatchListener(true); // <<<<<<<<<<<<<<<<<<<<<<<<
    return factory;
}

Starting with version 2.8, you can override the factory's `batchListener` property using the `batch` property on the `@KafkaListener` annotation. This, together with the changes to Container Error Handlers allows the same factory to be used for both record and batch listeners.

The following example shows how to receive a list of payloads:

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

The topic, partition, offset, and so on are available in headers that parallel the payloads. The following example shows how to use the headers:

```
@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 and other details 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. The following example shows how to do so:
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 are converted. See 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 Consumer<?, ?> parameters) defined on the method. The following example shows how to do so:

Starting with version 2.2, the listener can receive the complete ConsumerRecords<?, ?> object returned by the poll() method, letting the listener access additional methods, such as partitions() (which returns the TopicPartition instances in the list) and records(TopicPartition) (which gets
selective records). Again, this must be the only parameter (aside from optional Acknowledgment, when using manual commits or Consumer<?, ?> parameters) on the method. The following example shows how to do so:

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

If the container factory has a RecordFilterStrategy configured, it is ignored for ConsumerRecords<?, ?> listeners, with a WARN log message emitted. Records can only be filtered with a batch listener if the <List<?>> form of listener is used. By default, records are filtered one-at-a-time; starting with version 2.8, you can override filterBatch to filter the entire batch in one call.

Annotation Properties

Starting with version 2.0, the id property (if present) is used as the Kafka consumer 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 most annotation properties, as the following example shows:

```java
@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. It is a pseudo bean name that represents the current bean instance within which this annotation exists.

Consider the following example:
@Bean
public Listener listener1() {
    return new Listener("topic1");
}

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

Given the beans in the previous example, we can then use the following:

```java
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 by using the `beanRef` attribute. The following example shows how to do so:

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

Starting with version 2.2.4, you can specify Kafka consumer properties directly on the annotation, these will override any properties with the same name configured in the consumer factory. You **cannot** specify the `groupId` and `client.id` properties this way; they will be ignored; use the `groupId` and `clientIdPrefix` annotation properties for those.
The properties are specified as individual strings with the normal Java `Properties` file format: `foo:bar`, `foo=bar`, or `foo bar`.

```java
@KafkaListener(topics = "myTopic", groupId = "group", properties = {
    "max.poll.interval.ms:60000",
    ConsumerConfig.MAX_POLL_RECORDS_CONFIG + "=100"
})
```

The following is an example of the corresponding listeners for the example in Using `RoutingKafkaTemplate`.

```java
@KafkaListener(id = "one", topics = "one")
public void listen1(String in) {
    System.out.println("1: " + in);
}

@KafkaListener(id = "two", topics = "two",
    properties = 
    "value.deserializer:org.apache.kafka.common.serialization.ByteArrayDeserializer")
public void listen2(byte[] in) {
    System.out.println("2: " + new String(in));
}
```

### Obtaining the Consumer `groupId`

When running the same listener code in multiple containers, it may be useful to be able to determine which container (identified by its `groupId` consumer property) that a record came from.

You can call `KafkaUtils.getConsumerGroupId()` on the listener thread to do this. Alternatively, you can access the group id in a method parameter.

```java
@KafkaListener(id = "bar", topicPattern = "${topicTwo:annotated2}", exposeGroupId = "${always:true}")
public void listener(@Payload String foo, 
    @Header(KafkaHeaders.GROUP_ID) String groupId) {
    ...
}
```

This is available in record listeners and batch listeners that receive a `List<?>` of records. It is **not** available in a batch listener that receives a `ConsumerRecords<?, ?>` argument. Use the `KafkaUtils` mechanism in that case.
Container Thread Naming

Listener containers currently use two task executors, one to invoke the consumer and another that is 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 do not provide a consumer executor, a `SimpleAsyncTaskExecutor` is used. This executor creates threads with names similar to `<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 and subsequent start.

@KafkaListener as a Meta Annotation

Starting with version 2.2, you can now use `@KafkaListener` as a meta annotation. The following example shows how to do so:

```java
@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). The following example shows how to do so:
@MyThreeConsumersListener(id = "my.group", topics = "my.topic")
public void listen1(String in) {
    ...
}

@KafkaListener on a Class

When you use @KafkaListener at the class-level, you must specify @KafkaHandler at the method level. When messages are delivered, the converted message payload type is used to determine which method to call. The following example shows how to do so:

@KafkaListener(id = "multi", topics = "myTopic")
static class MultilistenBean {
    @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, you can designate a @KafkaHandler method as the default method that 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 JsonMessageConverter with its TypePrecedence set to TYPE_ID. See Serialization, Deserialization, and Message Conversion for more information.

Due to some limitations in the way Spring resolves method arguments, a default @KafkaHandler cannot receive discrete headers; it must use the ConsumerRecordMetadata as discussed in Consumer Record Metadata.

For example:
@KafkaHandler(isDefault = true)
public void listenDefault(Object object, @Header(KafkaHeaders.RECEIVED_TOPIC) String topic) {
    
}

This won't work if the object is a String; the topic parameter will also get a reference to object.

If you need metadata about the record in a default method, use this:

@KafkaHandler(isDefault = true)
void listen(Object in, @Header(KafkaHeaders.RECORD_METADATA) ConsumerRecordMetadata meta) {
    String topic = meta.topic();
    
}

@KafkaListener Attribute Modification

Starting with version 2.7.2, you can now programmatically modify annotation attributes before the container is created. To do so, add one or more KafkaListenerAnnotationBeanPostProcessor.AnnotationEnhancer to the application context. AnnotationEnhancer is a BiFunction<Map<String, Object>, AnnotatedElement, Map<String, Object>> and must return a map of attributes. The attribute values can contain SpEL and/or property placeholders; the enhancer is called before any resolution is performed. If more than one enhancer is present, and they implement Ordered, they will be invoked in order.

AnnotationEnhancer bean definitions must be declared static because they are required very early in the application context's lifecycle.

An example follows:
@Bean
public static AnnotationEnhancer groupIdEnhancer() {
    return attrs, element) -> {
        attrs.put("groupId", attrs.get("id") + "." + (element instanceof Class
                ? ((Class<?>) element).getSimpleClassName()
                : ((Method) element).getDeclaringClass().getSimpleName()
                        + "." + ((Method) element).getName()));
        return attrs;
    };
}

@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 Listener Container Auto Startup for more information. You can manage the lifecycle programmatically by using the registry. Starting or stopping the registry will start or stop all the registered containers. Alternatively, you can get a reference to an individual container by using its id attribute. You can set autoStartup on the annotation, which overrides the default setting configured into the container factory. You can get a reference to the bean from the application context, such as auto-wiring, to manage its registered containers. The following examples show how to do so:

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

@Autowired
private KafkaListenerEndpointRegistry registry;

...

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

...
```

The registry only maintains the life cycle of containers it manages; containers declared as beans are not managed by the registry and can be obtained from the application context. A collection of managed containers can be obtained by calling the registry's getListenerContainers() method. Version 2.2.5 added a convenience method getAllListenerContainers(), which returns a collection of all containers, including those managed by the registry and those declared as beans. The collection returned will include any prototype beans that have been initialized, but it will not
initialize any lazy bean declarations.

[@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 add the validator to the registrar itself. The following code shows how to do so:

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

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

When you use Spring Boot with the validation starter, a LocalValidatorFactoryBean is auto-configured, as the following example shows:

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

    @Autowired
    private LocalValidatorFactoryBean validator;

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

The following examples show how 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;
    }
}

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

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

Starting with version 2.5.11, validation now works on payloads for @KafkaHandler methods in a class-level listener. See @KafkaListener on a Class.

Rebalancing Listeners

ContainerProperties has a property called consumerRebalanceListener, which takes an implementation of the Kafka client's ConsumerRebalanceListener interface. If this property is not provided, the container configures a logging listener that logs rebalance events at the INFO level. The framework also adds a sub-interface ConsumerAwareRebalanceListener. The following listing shows the ConsumerAwareRebalanceListener interface definition:
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);
    void onPartitionsLost(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, as the following example shows:

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);
        // ...
    }
});
Starting with version 2.4, a new method `onPartitionsLost()` has been added (similar to a method with the same name in `ConsumerRebalanceLister`). The default implementation on `ConsumerRebalanceLister` simply calls `onPartitionsRevoked`. The default implementation on `ConsumerAwareRebalanceListener` does nothing. When supplying the listener container with a custom listener (of either type), it is important that your implementation not call `onPartitionsRevoked` from `onPartitionsLost`. If you implement `ConsumerRebalanceListener` you should override the default method. This is because the listener container will call its own `onPartitionsRevoked` from its implementation of `onPartitionsLost` after calling the method on your implementation. If you implementation delegates to the default behavior, `onPartitionsRevoked` will be called twice each time the `Consumer` calls that method on the container's listener.

**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 is 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 three properties:
  - `request`: The inbound `ConsumerRecord` (or `ConsumerRecords` object for a batch listener))
  - `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 and 2.2.1, property placeholders are resolved within `@SendTo` values.

The result of the expression evaluation must be a `String` that represents the topic name. The following examples show the various ways to use `@SendTo`:
In order to support @SendTo, the listener container factory must be provided with a KafkaTemplate (in its replyTemplate property), which is used to send the reply. This should be a KafkaTemplate and not a ReplyingKafkaTemplate which is used on the client-side for request/reply processing. When using Spring Boot, boot will auto-configure the template into the factory; when configuring your own factory, it must be set as shown in the examples below.

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. The following example shows how to add a ReplyHeadersConfigurer:
@Bean
public ConcurrentKafkaListenerContainerFactory<Integer, String> kafkaListenerContainerFactory()
{
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
        new ConcurrentKafkaListenerContainerFactory<>();
    factory.setConsumerFactory(cf());
    factory.setReplyTemplate(template());
    factory.setReplyHeadersConfigurer((k, v) -> k.equals("cat"));
    return factory;
}

You can also add more headers if you wish. The following example shows how to do so:

@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 you use @SendTo, you must configure the ConcurrentKafkaListenerContainerFactory with a KafkaTemplate in its replyTemplate property to perform the send.

Unless you use request/reply semantics only the simple send(topic, value) method is used, so you may wish to create a subclass to generate the partition or key. The following example shows how to do so:
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:

```java
@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.
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. The following example shows how to do so:

```java
@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 [Handling Exceptions](#) for more information.

If a listener method returns an `Iterable`, by default a record for each element as the value is sent. Starting with version 2.3.5, set the `splitIterables` property on `@KafkaListener` to `false` and the entire result will be sent as the value of a single `ProducerRecord`. This requires a suitable serializer in the reply template's producer configuration. However, if the reply is `Iterable<Message<?>>` the property is ignored and each message is sent separately.

### Filtering Messages

In certain scenarios, such as rebalancing, a message that has already been processed may be redelivered. 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 of it.

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` in which you implement the `filter` method to signal that a message is a duplicate and should be discarded. This has an additional property called `ackDiscarded`, which indicates whether the adapter should acknowledge the discarded record. It is `false` by default.

When you use `@KafkaListener`, set the `RecordFilterStrategy` (and optionally `ackDiscarded`) on the container factory so that the listener is wrapped in the appropriate filtering adapter.
In addition, a `FilteringBatchMessageListenerAdapter` is provided, for when you use a batch message listener.

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

Retrying Deliveries

See the `DefaultErrorHandler` in Handling Exceptions.

Starting `@KafkaListener` s in Sequence

A common use case is to start a listener after another listener has consumed all the records in a topic. For example, you may want to load the contents of one or more compacted topics into memory before processing records from other topics. Starting with version 2.7.3, a new component `ContainerGroupSequencer` has been introduced. It uses the `@KafkaListener containerGroup` property to group containers together and start the containers in the next group, when all the containers in the current group have gone idle.

It is best illustrated with an example.

```java
@KafkaListener(id = "listen1", topics = "topic1", containerGroup = "g1", concurrency = "2")
public void listen1(String in) {
}

@KafkaListener(id = "listen2", topics = "topic2", containerGroup = "g1", concurrency = "2")
public void listen2(String in) {
}

@KafkaListener(id = "listen3", topics = "topic3", containerGroup = "g2", concurrency = "2")
public void listen3(String in) {
}

@KafkaListener(id = "listen4", topics = "topic4", containerGroup = "g2", concurrency = "2")
public void listen4(String in) {
}

@Bean
ContainerGroupSequencer sequencer(KafkaListenerEndpointRegistry registry) {
    return new ContainerGroupSequencer(registry, 5000, "g1", "g2");
}
```
Here, we have 4 listeners in two groups, \textit{g1} and \textit{g2}.

During application context initialization, the sequencer, sets the \textit{autoStartup} property of all the containers in the provided groups to \textit{false}. It also sets the \textit{idleEventInterval} for any containers (that do not already have one set) to the supplied value (5000ms in this case). Then, when the sequencer is started by the application context, the containers in the first group are started. As \texttt{ListenerContainerIdleEvent}s are received, each individual child container in each container is stopped. When all child containers in a \texttt{ConcurrentMessageListenerContainer} are stopped, the parent container is stopped. When all containers in a group have been stopped, the containers in the next group are started. There is no limit to the number of groups or containers in a group.

By default, the containers in the final group (\textit{g2} above) are not stopped when they go idle. To modify that behavior, set \textit{stopLastGroupWhenIdle} to \textit{true} on the sequencer.

As an aside; previously, containers in each group were added to a bean of type \texttt{Collection<MessageListenerContainer>} with the bean name being the \texttt{containerGroup}. These collections are now deprecated in favor of beans of type \texttt{ContainerGroup} with a bean name that is the group name, suffixed with \texttt{.group}; in the example above, there would be 2 beans \texttt{g1.group} and \texttt{g2.group}. The \texttt{Collection} beans will be removed in a future release.

\textbf{Using KafkaTemplate to Receive}

This section covers how to use \texttt{KafkaTemplate} to receive messages.

Starting with version 2.8, the template has four \texttt{receive()} methods:

\begin{verbatim}
ConsumerRecord<K, V> receive(String topic, int partition, long offset);
ConsumerRecord<K, V> receive(String topic, int partition, long offset, Duration pollTimeout);
ConsumerRecords<K, V> receive(Collection<TopicPartitionOffset> requested);
ConsumerRecords<K, V> receive(Collection<TopicPartitionOffset> requested, Duration pollTimeout);
\end{verbatim}

As you can see, you need to know the partition and offset of the record(s) you need to retrieve; a new \texttt{Consumer} is created (and closed) for each operation.

With the last two methods, each record is retrieved individually and the results assembled into a \texttt{ConsumerRecords} object. When creating the \texttt{TopicPartitionOffset}s for the request, only positive, absolute offsets are supported.

\textbf{4.1.5. Listener Container Properties}

\textit{Table 1. ContainerProperties Properties}
<table>
<thead>
<tr>
<th>Property</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ackCount</td>
<td>1</td>
<td>The number of records before committing pending offsets when the ackMode is COUNT or COUNT_TIME.</td>
</tr>
<tr>
<td>adviceChain</td>
<td>null</td>
<td>A chain of Advice objects (e.g. MethodInterceptor around advice) wrapping the message listener, invoked in order.</td>
</tr>
<tr>
<td>ackMode</td>
<td>BATCH</td>
<td>Controls how often offsets are committed - see Committing Offsets.</td>
</tr>
<tr>
<td>ackOnError</td>
<td>false</td>
<td>[DEPRECATED in favor of ErrorHandler.isAckAfterHandle()]</td>
</tr>
<tr>
<td>ackTime</td>
<td>5000</td>
<td>The time in milliseconds after which pending offsets are committed when the ackMode is TIME or COUNT_TIME.</td>
</tr>
<tr>
<td>assignmentCommitOption</td>
<td>LATESTONLY_NO_TX</td>
<td>Whether or not to commit the initial position on assignment; by default, the initial offset will only be committed if the ConsumerConfig.AUTO_OFFSET_RESET_CONFIG is latest and it won’t run in a transaction even if there is a transaction manager present. See the javadocs for ContainerProperties.AssignmentCommitOption for more information about the available options.</td>
</tr>
<tr>
<td>authExceptionRetryInterval</td>
<td>null</td>
<td>When not null, a Duration to sleep between polls when an AuthenticationException or AuthorizationException is thrown by the Kafka client. When null, such exceptions are considered fatal and the container will stop.</td>
</tr>
<tr>
<td>clientId</td>
<td>(empty string)</td>
<td>A prefix for the client.id consumer property. Overrides the consumer factory client.id property; in a concurrent container, -n is added as a suffix for each consumer instance.</td>
</tr>
<tr>
<td>Property</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>checkDeserExWhenKeyNull</td>
<td>false</td>
<td>Set to <code>true</code> to always check for a <code>DeserializationException</code> header when a null key is received. Useful when the consumer code cannot determine that an <code>ErrorHandlingDeserializer</code> has been configured, such as when using a delegating deserializer.</td>
</tr>
<tr>
<td>checkDeserExWhenValueNull</td>
<td>false</td>
<td>Set to <code>true</code> to always check for a <code>DeserializationException</code> header when a null value is received. Useful when the consumer code cannot determine that an <code>ErrorHandlingDeserializer</code> has been configured, such as when using a delegating deserializer.</td>
</tr>
<tr>
<td>commitCallback</td>
<td>null</td>
<td>When present and <code>syncCommits</code> is <code>false</code> a callback invoked after the commit completes.</td>
</tr>
<tr>
<td>commitLogLevel</td>
<td>DEBUG</td>
<td>The logging level for logs pertaining to committing offsets.</td>
</tr>
<tr>
<td>consumerRebalanceListener</td>
<td>null</td>
<td>A rebalance listener; see <code>Rebalancing Listeners</code>.</td>
</tr>
<tr>
<td>consumerStartTimeout</td>
<td>30s</td>
<td>The time to wait for the consumer to start before logging an error; this might happen if, say, you use a task executor with insufficient threads.</td>
</tr>
<tr>
<td>consumerTaskExecutor</td>
<td>SimpleAsyncTaskExecutor</td>
<td>A task executor to run the consumer threads. The default executor creates threads named <code>&lt;name&gt;-C-n</code>; with the <code>KafkaMessageListenerContainer</code>, the name is the bean name; with the <code>ConcurrentMessageListenerContainer</code> the name is the bean name suffixed with <code>-n</code> where n is incremented for each child container.</td>
</tr>
<tr>
<td>deliveryAttemptHeader</td>
<td>false</td>
<td>See <code>Delivery Attempts Header</code>.</td>
</tr>
<tr>
<td>eosMode</td>
<td>V2</td>
<td>Exactly Once Semantics mode; see <code>Exactly Once Semantics</code>.</td>
</tr>
<tr>
<td>Property</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>fixTxOffsets</td>
<td>false</td>
<td>When consuming records produced by a transactional producer, and the consumer is positioned at the end of a partition, the lag can incorrectly be reported as greater than zero, due to the pseudo record used to indicate transaction commit/rollback and, possibly, the presence of rolled-back records. This does not functionally affect the consumer but some users have expressed concern that the &quot;lag&quot; is non-zero. Set this property to true and the container will correct such mis-reported offsets. The check is performed before the next poll to avoid adding significant complexity to the commit processing. At the time of writing, the lag will only be corrected if the consumer is configured with isolation.level=read_committed and max.poll.records is greater than 1. See KAFKA-10683 for more information.</td>
</tr>
<tr>
<td>groupId</td>
<td>null</td>
<td>Overrides the consumer group.id property; automatically set by the @KafkaListener id or groupId property.</td>
</tr>
<tr>
<td>idleBeforeDataMultiplier</td>
<td>5.0</td>
<td>Multiplier for idleEventInterval that is applied before any records are received. After a record is received, the multiplier is no longer applied. Available since version 2.8.</td>
</tr>
<tr>
<td>idleBetweenPolls</td>
<td>0</td>
<td>Used to slow down deliveries by sleeping the thread between polls. The time to process a batch of records plus this value must be less than the max.poll.interval.ms consumer property.</td>
</tr>
<tr>
<td>idleEventInterval</td>
<td>null</td>
<td>When set, enables publication of ListenerContainerIdleEvent s, see Application Events and Detecting Idle and Non-Responsive Consumers. Also see idleBeforeDataMultiplier.</td>
</tr>
<tr>
<td>idlePartitionEventInterval</td>
<td>null</td>
<td>When set, enables publication of ListenerContainerIdlePartitionEvent s, see Application Events and Detecting Idle and Non-Responsive Consumers.</td>
</tr>
<tr>
<td>Property</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>kafkaConsumerProperties</td>
<td>None</td>
<td>Used to override any arbitrary consumer properties configured on the consumer factory.</td>
</tr>
<tr>
<td>logContainerConfig</td>
<td>false</td>
<td>Set to true to log at INFO level all container properties.</td>
</tr>
<tr>
<td>messageListener</td>
<td>null</td>
<td>The message listener.</td>
</tr>
<tr>
<td>micrometerEnabled</td>
<td>true</td>
<td>Whether or not to maintain Micrometer timers for the consumer threads.</td>
</tr>
<tr>
<td>missingTopicsFatal</td>
<td>false</td>
<td>When true prevents the container from starting if the configured topic(s) are not present on the broker.</td>
</tr>
<tr>
<td>monitorInterval</td>
<td>30s</td>
<td>How often to check the state of the consumer threads for NonResponsiveConsumerEvents. See noPollThreshold and pollTimeout.</td>
</tr>
<tr>
<td>noPollThreshold</td>
<td>3.0</td>
<td>Multiplied by pollTimeout to determine whether to publish a NonResponsiveConsumerEvent. See monitorInterval.</td>
</tr>
<tr>
<td>onlyLogRecordMetadata</td>
<td>false</td>
<td>Set to false to log the complete consumer record (in error, debug logs etc) instead of just topic-partition@offset.</td>
</tr>
<tr>
<td>pollTimeout</td>
<td>5000</td>
<td>The timeout passed into Consumer.poll().</td>
</tr>
<tr>
<td>scheduler</td>
<td>ThreadPoolTaskScheduler</td>
<td>A scheduler on which to run the consumer monitor task.</td>
</tr>
<tr>
<td>shutdownTimeout</td>
<td>10000</td>
<td>The maximum time in ms to block the stop() method until all consumers stop and before publishing the container stopped event.</td>
</tr>
<tr>
<td>stopContainerWhenFenced</td>
<td>false</td>
<td>Stop the listener container if a ProducerFencedException is thrown. See After-rollback Processor for more information.</td>
</tr>
<tr>
<td>stopImmediate</td>
<td>false</td>
<td>When the container is stopped, stop processing after the current record instead of after processing all the records from the previous poll.</td>
</tr>
</tbody>
</table>
### AbstractListenerContainer Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>subBatchPerPartition</td>
<td>See desc.</td>
<td>When using a batch listener, if this is true, the listener is called with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the results of the poll split into sub batches, one per partition. Default</td>
</tr>
<tr>
<td></td>
<td></td>
<td>false except when using transactions with EOSMode.ALPHA - see Exactly Once</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Semantics.</td>
</tr>
<tr>
<td>syncCommitTimeout</td>
<td>null</td>
<td>The timeout to use when syncCommits is true. When not set, the container</td>
</tr>
<tr>
<td></td>
<td></td>
<td>will attempt to determine the default.api.timeout.ms consumer property and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>use that; otherwise it will use 60 seconds.</td>
</tr>
<tr>
<td>syncCommits</td>
<td>true</td>
<td>Whether to use sync or async commits for offsets; see commitCallback.</td>
</tr>
<tr>
<td>topics topicPattern</td>
<td>n/a</td>
<td>The configured topics, topic pattern or explicitly assigned topics/partitions.</td>
</tr>
<tr>
<td>topicPartitions</td>
<td></td>
<td>Mutually exclusive; at least one must be provided; enforced by ContainerProperties constructors.</td>
</tr>
<tr>
<td>transactionManager</td>
<td>null</td>
<td>See Transactions.</td>
</tr>
</tbody>
</table>

### Table 2. AbstractListenerContainer Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>afterRollbackProcessor</td>
<td></td>
<td>An AfterRollbackProcessor to invoke after a transaction is rolled back.</td>
</tr>
<tr>
<td>applicationEventPublisher</td>
<td></td>
<td>The event publisher.</td>
</tr>
<tr>
<td>batchErrorHandler</td>
<td></td>
<td>Deprecated - see commonErrorHandler.</td>
</tr>
<tr>
<td>batchInterceptor</td>
<td>null</td>
<td>Set a BatchInterceptor to call before invoking the batch listener; does not apply to record listeners. Also see interceptBeforeTx.</td>
</tr>
<tr>
<td>beanName</td>
<td>bean name</td>
<td>The bean name of the container; suffixed with -n for child containers.</td>
</tr>
<tr>
<td>commonErrorProcessor</td>
<td></td>
<td>DefaultErrorHandler or null when a transactionManager is provided when a DefaultAfterRollbackProcessor is used. See Container Error Handlers.</td>
</tr>
<tr>
<td>containerProperties</td>
<td>ContainerProperties</td>
<td>The container properties instance.</td>
</tr>
<tr>
<td>errorHandler</td>
<td></td>
<td>Deprecated - see commonErrorHandler.</td>
</tr>
<tr>
<td>Property</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>genericErrorHandler</td>
<td>See desc.</td>
<td>Deprecated - see <code>commonErrorHandler</code>.</td>
</tr>
<tr>
<td>groupId</td>
<td>See desc.</td>
<td>The <code>containerProperties.groupId</code>, if present, otherwise the <code>groupId</code> property from the consumer factory.</td>
</tr>
<tr>
<td>interceptBeforeTx</td>
<td>true</td>
<td>Determines whether the <code>recordInterceptor</code> is called before or after a transaction starts.</td>
</tr>
<tr>
<td>listenerId</td>
<td>See desc.</td>
<td>The bean name for user-configured containers or the <code>id</code> attribute of <code>@KafkaListener</code> s.</td>
</tr>
<tr>
<td>pauseRequested</td>
<td>(read only)</td>
<td>True if a consumer pause has been requested.</td>
</tr>
<tr>
<td>recordInterceptor</td>
<td>null</td>
<td>Set a <code>RecordInterceptor</code> to call before invoking the record listener; does not apply to batch listeners. Also see <code>interceptBeforeTx</code>.</td>
</tr>
<tr>
<td>topicCheckTimeout</td>
<td>30s</td>
<td>When the <code>missingTopicsFatal</code> container property is <code>true</code>, how long to wait, in seconds, for the <code>describeTopics</code> operation to complete.</td>
</tr>
</tbody>
</table>

Table 3. KafkaMessageListenerContainer Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>assignedPartitions</td>
<td>(read only)</td>
<td>The partitions currently assigned to this container (explicitly or not).</td>
</tr>
<tr>
<td>assignedPartitionsByClientId</td>
<td>(read only)</td>
<td>The partitions currently assigned to this container (explicitly or not).</td>
</tr>
<tr>
<td>clientIdSuffix</td>
<td>null</td>
<td>Used by the concurrent container to give each child container's consumer a unique <code>client.id</code>.</td>
</tr>
<tr>
<td>containerPaused</td>
<td>n/a</td>
<td>True if pause has been requested and the consumer has actually paused.</td>
</tr>
</tbody>
</table>

Table 4. ConcurrentMessageListenerContainer Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>alwaysClientIdSuffix</td>
<td>true</td>
<td>Set to false to suppress adding a suffix to the <code>client.id</code> consumer property, when the <code>concurrency</code> is only 1.</td>
</tr>
<tr>
<td>assignedPartitions</td>
<td>(read only)</td>
<td>The aggregate of partitions currently assigned to this container's child KafkaMessageListenerContainer s (explicitly or not).</td>
</tr>
<tr>
<td>Property</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>assignedPartitionsById</td>
<td>(read only)</td>
<td>The partitions currently assigned to this container's child KafkaMessageListenerContainer s (explicitly or not), keyed by the child container's consumer's client.id property.</td>
</tr>
<tr>
<td>concurrency</td>
<td>1</td>
<td>The number of child KafkaMessageListenerContainer s to manage.</td>
</tr>
<tr>
<td>containerPaused</td>
<td>n/a</td>
<td>True if pause has been requested and all child containers' consumer has actually paused.</td>
</tr>
<tr>
<td>containers</td>
<td>n/a</td>
<td>A reference to all child KafkaMessageListenerContainer s.</td>
</tr>
</tbody>
</table>

### 4.1.6. Application Events

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

- **ConsumerStartingEvent** - published when a consumer thread is first started, before it starts polling.
- **ConsumerStartedEvent** - published when a consumer is about to start polling.
- **ConsumerFailedToStartEvent** - published if no ConsumerStartingEvent is published within the consumerStartTimeout container property. This event might signal that the configured task executor has insufficient threads to support the containers it is used in and their concurrency. An error message is also logged when this condition occurs.
- **ListenerContainerIdleEvent**: published when no messages have been received in idleInterval (if configured).
- **ListenerContainerNo Longer IdleEvent**: published when a record is consumed after previously publishing a ListenerContainerIdleEvent.
- **ListenerContainerPartitionIdleEvent**: published when no messages have been received from that partition in idlePartitionEventInterval (if configured).
- **ListenerContainerPartitionNo Longer IdleEvent**: published when a record is consumed from a partition that has previously published a ListenerContainerPartitionIdleEvent.
- **NonResponsiveConsumerEvent**: published when the consumer appears to be blocked in the poll method.
- **ConsumerPartitionPausedEvent**: published by each consumer when a partition is paused.
- **ConsumerPartitionResumedEvent**: published by each consumer when a partition is resumed.
- **ConsumerPausedEvent**: published by each consumer when the container is paused.
- **ConsumerResumedEvent**: published by each consumer when the container is resumed.
- **ConsumerStoppingEvent**: published by each consumer just before stopping.
- **ConsumerStoppedEvent**: published after the consumer is closed. See Thread Safety.
- **ContainerStoppedEvent**: published when all consumers have stopped.
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 `ListenerContainerIdleEvent` 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).
- **idleTime**: The time the container had been idle when the event was published.
- **topicPartitions**: The topics and 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’s `pause()` method was previously called, it can `resume()` when the event is received.
- **paused**: Whether the container is currently paused. See Pausing and Resuming Listener Containers for more information.

The `ListenerContainerNo LongerIdleEvent` has the same properties, except `idleTime` and `paused`.

The `ListenerContainerPartitionIdleEvent` 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).
- **idleTime**: The time partition consumption had been idle when the event was published.
- **topicPartition**: The topic and partition that triggered the event.
- **consumer**: A reference to the Kafka `Consumer` object. For example, if the consumer’s `pause()` method was previously called, it can `resume()` when the event is received.
- **paused**: Whether that partition consumption is currently paused for that consumer. See Pausing and Resuming Listener Containers for more information.

The `ListenerContainerPartitionNo LongerIdleEvent` has the same properties, except `idleTime` and `paused`.

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 and 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's `pause()` method was previously called, it can `resume()` when the event is received.

• **paused**: Whether the container is currently paused. See Pausing and 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` instances involved.

The `ConsumerPartitionPausedEvent`, `ConsumerPartitionResumedEvent` 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.
- **partition**: The `TopicPartition` instance involved.

The `ConsumerStartingEvent`, `ConsumerStartingEvent`, `ConsumerFailedToStartEvent`, `ConsumerStoppedEvent` and `ContainerStoppedEvent` 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.

All containers (whether a child or a parent) publish `ContainerStoppedEvent`. For a parent container, the source and container properties are identical.

In addition, the `ConsumerStoppedEvent` has the following additional property:

- **reason**
  - **NORMAL** - the consumer stopped normally (container was stopped).
  - **ERROR** - a `java.lang.Error` was thrown.
  - **FENCED** - the transactional producer was fenced and the `stopContainerWhenFenced` container property is `true`.
  - **AUTH** - an `AuthenticationException` or `AuthorizationException` was thrown and the `authExceptionRetryInterval` is not configured.
  - **NO_OFFSET** - there is no offset for a partition and the `auto.offset.reset` policy is `none`. 
You can use this event to restart the container after such a condition:

```java
if (event.getReason.equals(Reason.FENCED)) {
    event.getSource(MessageListenerContainer.class).start();
}
```

Detecting Idle and Non-Responsive Consumers

While efficient, one problem with asynchronous consumers is detecting when they are idle. You 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 is published every `idleEventInterval` milliseconds.

To configure this feature, set the `idleEventInterval` on the container. The following example shows how to do so:

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

The following example shows how to set the `idleEventInterval` for a `@KafkaListener`:

```java
@Bean
public ConcurrentKafkaListenerContainerFactory kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<String, String> factory = new ConcurrentKafkaListenerContainerFactory<>();
    ... factory.getContainerProperties().setIdleEventInterval(60000L);
    ... return factory;
}
```
In each of these cases, an event is published once per minute while the container is idle.

If, for some reason, the consumer `poll()` method does not exit, no messages are received and idle events cannot be generated (this was a problem with early versions of the `kafka-clients` when the broker wasn’t reachable). In this case, the container publishes a `NonResponsiveConsumerEvent` if a poll does not return within $3 \times$ the `pollTimeout` property. By default, this check is performed once every 30 seconds in each container. You can modify this behavior by setting the `monitorInterval` (default 30 seconds) and `noPollThreshold` (default 3.0) properties in the `ContainerProperties` when configuring the listener container. The `noPollThreshold` should be greater than 1.0 to avoid getting spurious events due to a race condition. Receiving such an event lets you stop the containers, thus waking the consumer so that it can stop.

Starting with version 2.6.2, if a container has published a `ListenerContainerIdleEvent`, it will publish a `ListenerContainerNo LongerIdleEvent` when a record is subsequently received.

**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 next example combines `@KafkaListener` and `@EventListener` into a single class. You should understand that the application listener gets 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 [Application 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.

The following example uses both `@KafkaListener` and `@EventListener`:

```java
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) {
        ...
    }
}
```
Event listeners see events for all containers. Consequently, in the preceding example, 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. That is why we use `startsWith` in the condition.

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. Doing so causes 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 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 Seeking to a Specific Offset.

4.1.7. Topic/Partition Initial Offset

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

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

When you use 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).

4.1.8. Seeking to a Specific Offset

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

```java
void registerSeekCallback(ConsumerSeekCallback callback);

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

void onPartitionsRevoked(Collection<TopicPartition> partitions);

void onIdleContainer(Map<TopicPartition, Long> assignments, ConsumerSeekCallback callback);
```
The `registerSeekCallback` is called when the container is started and whenever partitions are assigned. You should use this callback when seeking at some arbitrary time after initialization. You should save a reference to the callback. If you use 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, `onPartitionsAssigned` is called when partitions are assigned. You can use this method, for example, for setting initial offsets for the partitions, by calling the callback. You can also use this method to associate this thread's callback with the assigned partitions (see the example below). You must use the callback argument, not the one passed into `registerSeekCallback`. Starting with version 2.5.5, this method is called, even when using manual partition assignment.

`onPartitionsRevoked` is called when the container is stopped or Kafka revokes assignments. You should discard this thread's callback and remove any associations to the revoked partitions.

The callback has the following methods:

```java
void seek(String topic, int partition, long offset);
void seekToBeginning(String topic, int partition);
void seekToBeginning(Collection<TopicPartitions> partitions);
void seekToEnd(String topic, int partition);
void seekToEnd(Collection<TopicPartitions> partitions);
void seekRelative(String topic, int partition, long offset, boolean toCurrent);
void seekToTimestamp(String topic, int partition, long timestamp);
void seekToTimestamp(Collection<TopicPartition> topicPartitions, long timestamp);
```

`seekRelative` was added in version 2.3, to perform relative seeks.

- `offset` negative and `toCurrent` false - seek relative to the end of the partition.
- `offset` positive and `toCurrent` false - seek relative to the beginning of the partition.
- `offset` negative and `toCurrent` true - seek relative to the current position (rewind).
- `offset` positive and `toCurrent` true - seek relative to the current position (fast forward).

The `seekToTimestamp` methods were also added in version 2.3.
When seeking to the same timestamp for multiple partitions in the `onIdleContainer` or `onPartitionsAssigned` methods, the second method is preferred because it is more efficient to find the offsets for the timestamps in a single call to the consumer's `offsetsForTimes` method. When called from other locations, the container will gather all timestamp seek requests and make one call to `offsetsForTimes`.

You can also perform seek operations from `onIdleContainer()` when an idle container is detected. See Detecting Idle and Non-Responsive Consumers for how to enable idle container detection.

The `seekToBeginning` method that accepts a collection is useful, for example, when processing a compacted topic and you wish to seek to the beginning every time the application is started:

```java
public class MyListener implements ConsumerSeekAware {

    ... 

    @Override
    public void onPartitionsAssigned(Map<TopicPartition, Long> assignments, ConsumerSeekCallback callback) {
        callback.seekToBeginning(assignments.keySet());
    }
}
```

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

Here is a trivial Spring Boot application that demonstrates how to use the callback; it sends 10 records to the topic; hitting `<Enter>` in the console causes all partitions to seek to the beginning.
@SpringBootApplication
public class SeekExampleApplication {

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

    @Bean
    public ApplicationRunner runner(Listener listener, KafkaTemplate<String, String> template) {
        return args -> {
            IntStream.range(0, 10).forEach(i -> template.send(
                new ProducerRecord<>("seekExample", i % 3, "foo", "bar")));
            while (true) {
                System.in.read();
                listener.seekToStart();
            }
        };
    }

    @Bean
    public NewTopic topic() {
        return new NewTopic("seekExample", 3, (short) 1);
    }
}

@Component
class Listener implements ConsumerSeekAware {

    private static final Logger logger = LoggerFactory.getLogger(Listener.class);

    private final ThreadLocal<ConsumerSeekCallback> callbackForThread = new ThreadLocal<>();

    private final Map<TopicPartition, ConsumerSeekCallback> callbacks = new ConcurrentHashMap<>();

    @Override
    public void registerSeekCallback(ConsumerSeekCallback callback) {
        this.callbackForThread.set(callback);
    }

    @Override
    public void onPartitionsAssigned(Map<TopicPartition, Long> assignments, ConsumerSeekCallback callback) {
        assignments.keySet().forEach(tp -> this.callbacks.put(tp, this.callbackForThread.get()));
    }
}
To make things simpler, version 2.3 added the `AbstractConsumerSeekAware` class, which keeps track of which callback is to be used for a topic/partition. The following example shows how to seek to the last record processed, in each partition, each time the container goes idle. It also has methods that allow arbitrary external calls to rewind partitions by one record.
public class SeekToLastOnIdleListener extends AbstractConsumerSeekAware {
    @KafkaListener(id = "seekOnIdle", topics = "seekOnIdle")
    public void listen(String in) {
        ...
    }

    @Override
    public void onIdleContainer(Map<org.apache.kafka.common.TopicPartition, Long> assignments,
                                 ConsumerSeekCallback callback) {
        assignments.keySet().forEach(tp -> callback.seekRelative(tp.topic(), tp.partition(), -1, true));
    }

    /**
     * Rewind all partitions one record.
     */
    public void rewindAllOneRecord() {
        getSeekCallbacks()
            .forEach((tp, callback) ->
                callback.seekRelative(tp.topic(), tp.partition(), -1, true));
    }

    /**
     * Rewind one partition one record.
     */
    public void rewindOnePartitionOneRecord(String topic, int partition) {
        getSeekCallbackFor(new org.apache.kafka.common.TopicPartition(topic, partition))
            .seekRelative(topic, partition, -1, true);
    }
}

Version 2.6 added convenience methods to the abstract class:

- `seekToBeginning()` - seeks all assigned partitions to the beginning
- `seekToEnd()` - seeks all assigned partitions to the end
- `seekToTimestamp(long time)` - seeks all assigned partitions to the offset represented by that timestamp.

Example:
public class MyListener extends AbstractConsumerSeekAware {

    @KafkaListener(...)
    void listn(...) {
        ...
    }
}

public class SomeOtherBean {

    MyListener listener;

    ...

    void someMethod() {
        this.listener.seekToTimestamp(System.currentTimeMillis - 60_000);
    }
}

4.1.9. Container factory

As discussed in @KafkaListener Annotation, a ConcurrentKafkaListenerContainerFactory is used to create containers for annotated methods.

Starting with version 2.2, you can use the same factory 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(). The following example configures a ConcurrentMessageListenerContainer:

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

    ConcurrentMessageListenerContainer<String, String> container =
    factory.createContainer("topic1", "topic2");
    container.setMessageListener(m -> { ... });
    return container;
}
Containers created this way are not added to the endpoint registry. They should be created as `@Bean` definitions so that they are registered with the application context.

Starting with version 2.3.4, you can add a `ContainerCustomizer` to the factory to further configure each container after it has been created and configured.

```java
@Bean
public KafkaListenerContainerFactory<?, ?> kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
        new ConcurrentKafkaListenerContainerFactory<>();
    ...
    factory.setContainerCustomizer((container -> { /* customize the container */ }));
    return factory;
}
```

### 4.1.10. 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 concurrency, you can use one of a few techniques:

- Use \( n \) containers with `concurrency=1` with a prototype scoped `MessageListener` bean so that each container gets its own instance (this is not possible when using `@KafkaListener`).
- Keep the state in `ThreadLocal<?>` instances.
- Have the singleton listener delegate to a bean that is declared in `SimpleThreadScope` (or a similar scope).

To facilitate cleaning up thread state (for the second and third items in the preceding list), starting with version 2.2, the listener container publishes a `ConsumerStoppedEvent` when each thread exits. You can consume these events with an `ApplicationListener` or `@EventListener` method to remove `ThreadLocal<?>` instances or `remove()` thread-scoped beans from the scope. Note that `SimpleThreadScope` does not destroy beans that have a destruction interface (such as `DisposableBean`), so you should `destroy()` the instance yourself.

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 is not effective.

### 4.1.11. Monitoring
Monitoring Listener Performance

Starting with version 2.3, the listener container will automatically create and update Micrometer Timer s for the listener, if Micrometer is detected on the class path, and a single MeterRegistry is present in the application context. The timers can be disabled by setting the ContainerProperty micrometerEnabled to false.

Two timers are maintained - one for successful calls to the listener and one for failures.

The timers are named spring.kafka.listener and have the following tags:

- **name**: (container bean name)
- **result**: success or failure
- **exception**: none or ListenerExecutionFailedException

You can add additional tags using the ContainerProperties micrometerTags property.

With the concurrent container, timers are created for each thread and the **name** tag is suffixed with -n where n is 0 to concurrency-1.

Monitoring KafkaTemplate Performance

Starting with version 2.5, the template will automatically create and update Micrometer Timer s for send operations, if Micrometer is detected on the class path, and a single MeterRegistry is present in the application context. The timers can be disabled by setting the template's micrometerEnabled property to false.

Two timers are maintained - one for successful calls to the listener and one for failures.

The timers are named spring.kafka.template and have the following tags:

- **name**: (template bean name)
- **result**: success or failure
- **exception**: none or the exception class name for failures

You can add additional tags using the template's micrometerTags property.

Micrometer Native Metrics

Starting with version 2.5, the framework provides Factory Listeners to manage a Micrometer KafkaClientMetrics instance whenever producers and consumers are created and closed.

To enable this feature, simply add the listeners to your producer and consumer factories:
```java
@Bean
public ConsumerFactory<String, String> myConsumerFactory() {
    Map<String, Object> configs = consumerConfigs();
    DefaultKafkaConsumerFactory<String, String> cf = new DefaultKafkaConsumerFactory<>(configs);
    cf.addListener(new MicrometerConsumerListener<String, String>(meterRegistry(),
        Collections.singletonList(new ImmutableTag("customTag",
            "customTagValue"))));
    return cf;
}

@Bean
public ProducerFactory<String, String> myProducerFactory() {
    Map<String, Object> configs = producerConfigs();
    configs.put(ProducerConfig.CLIENT_ID_CONFIG, "myClientId");
    DefaultKafkaProducerFactory<String, String> pf = new DefaultKafkaProducerFactory<>(configs);
    pf.addListener(new MicrometerProducerListener<String, String>(meterRegistry(),
        Collections.singletonList(new ImmutableTag("customTag",
            "customTagValue"))));
    return pf;
}
```

The consumer/producer id passed to the listener is added to the meter's tags with tag name `spring.id`.

An example of obtaining one of the Kafka metrics

```java
double count = this.meterRegistry.get("kafka.producer.node.incoming.byte.total")
    .tag("customTag", "customTagValue")
    .tag("spring.id", "myProducerFactory.myClientId-1")
    .functionCounter()
    .count()
```

A similar listener is provided for the StreamsBuilderFactoryBean - see KafkaStreams Micrometer Support.
### 4.1.12. Transactions

This section describes how Spring for Apache Kafka supports transactions.

#### Overview

The 0.11.0.0 client library added support for transactions. Spring for Apache Kafka adds support in the following ways:

- **KafkaTransactionManager**: Used with normal Spring transaction support (@Transactional, TransactionTemplate etc).
- **Transactional KafkaMessageListenerContainer**
- **Local transactions with KafkaTemplate**
- **Transaction synchronization with other transaction managers**

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 calls `close()` on 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, you can set the `producerPerConsumerPartition` property on the DefaultKafkaProducerFactory to `false`.

While transactions are supported with batch listeners, by default, zombie fencing is not supported because a batch may contain records from multiple topics or partitions. However, starting with version 2.3.2, zombie fencing is supported if you set the container property `subBatchPerPartition` to `true`. In that case, the batch listener is invoked once per partition received from the last poll, as if each poll only returned records for a single partition. This is `true` by default since version 2.5 when transactions are enabled with `EOSMode.ALPHA`; set it to `false` if you are using transactions but are not concerned about zombie fencing. Also see Exactly Once Semantics.

Also see `transactionIdPrefix`.

With Spring Boot, it is only necessary to set the `spring.kafka.producer.transaction-id-prefix` property - Boot will automatically configure a `KafkaTransactionManager` bean and wire it into the listener container.
Starting with version 2.5.8, you can now configure the `maxAge` property on the producer factory. This is useful when using transactional producers that might lay idle for the broker's `transactional.id.expiration.ms`. With current `kafka-clients`, this can cause a `ProducerFencedException` without a rebalance. By setting the `maxAge` to less than `transactional.id.expiration.ms`, the factory will refresh the producer if it is past its max age.

**Using 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`, and others). If a transaction is active, any `KafkaTemplate` operations performed within the scope of the transaction use the transaction's `Producer`. The manager commits or rolls back the transaction, depending on success or failure. You must configure the `KafkaTemplate` to use the same `ProducerFactory` as the transaction manager.

**Transaction Synchronization**

This section refers to producer-only transactions (transactions not started by a listener container); see **Using Consumer-Initiated Transactions** for information about chaining transactions when the container starts the transaction.

If you want to send records to kafka and perform some database updates, you can use normal Spring transaction management with, say, a `DataSourceTransactionManager`.

```java
@Transactional
public void process(List<Thing> things) {
    things.forEach(thing -> this.kafkaTemplate.send("topic", thing));
    updateDb(things);
}
```

The interceptor for the `@Transactional` annotation starts the transaction and the `KafkaTemplate` will synchronize a transaction with that transaction manager; each send will participate in that transaction. When the method exits, the database transaction will commit followed by the Kafka transaction. If you wish the commits to be performed in the reverse order (Kafka first), use nested `@Transactional` methods, with the outer method configured to use the `DataSourceTransactionManager`, and the inner method configured to use the `KafkaTransactionManager`.

See **Examples of Kafka Transactions with Other Transaction Managers** for examples of an application that synchronizes JDBC and Kafka transactions in Kafka-first or DB-first configurations.
Starting with versions 2.5.17, 2.6.12, 2.7.9 and 2.8.0, if the commit fails on the synchronized transaction (after the primary transaction has committed), the exception will be thrown to the caller. Previously, this was silently ignored (logged at debug). Applications should take remedial action, if necessary, to compensate for the committed primary transaction.

Using Consumer-Initiated Transactions

The ChainedKafkaTransactionManager is now deprecated, since version 2.7; see the javadocs for its super class ChainedTransactionManager for more information. Instead, use a KafkaTransactionManager in the container to start the Kafka transaction and annotate the listener method with @Transactional to start the other transaction.

See Examples of Kafka Transactions with Other Transaction Managers for an example application that chains JDBC and Kafka transactions.

KafkaTemplate Local Transactions

You can use the KafkaTemplate to execute a series of operations within a local transaction. The following example shows how to do so:

```java
boolean result = template.executeInTransaction(t -> {
    t.sendDefault("thing1", "thing2");
    t.sendDefault("cat", "hat");
    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.

If there is a KafkaTransactionManager (or synchronized) transaction in process, it is not used. Instead, a new "nested" transaction is used.

transactionIdPrefix

As mentioned in the overview, the producer factory is configured with this property to build the producer transactional.id property. There is a dichotomy when specifying this property in that, when running multiple instances of the application with EOSMode.ALPHA, it must be the same on all instances to satisfy fencing zombies (also mentioned in the overview) when producing records on a listener container thread. However, when producing records using transactions that are not started by a listener container, the prefix has to be different on each instance. Version 2.3, makes this simpler to configure, especially in a Spring Boot application. In previous versions, you had to create two producer factories and KafkaTemplate s - one for producing records on a listener container thread and one for stand-alone transactions started by kafkaTemplate.executeInTransaction() or by a transaction interceptor on a @Transactional method.
Now, you can override the factory's `transactionalIdPrefix` on the `KafkaTemplate` and the `KafkaTransactionManager`.

When using a transaction manager and template for a listener container, you would normally leave this to default to the producer factory's property. This value should be the same for all application instances when using `EOSMode.ALPHA`. With `EOSMode.BETA` it is no longer necessary to use the same `transactional.id`, even for consumer-initiated transactions; in fact, it must be unique on each instance the same as producer-initiated transactions. For transactions started by the template (or the transaction manager for `@Transaction`) you should set the property on the template and transaction manager respectively. This property must have a different value on each application instance.

This problem (different rules for `transactional.id`) has been eliminated when `EOSMode.BETA` is being used (with broker versions >= 2.5); see `Exactly Once Semantics`.

**KafkaTemplate Transactional and non-Transactional Publishing**

Normally, when a `KafkaTemplate` is transactional (configured with a transaction-capable producer factory), transactions are required. The transaction can be started by a `TransactionTemplate`, a `@Transactional` method, calling `executeInTransaction`, or by a listener container, when configured with a `KafkaTransactionManager`. Any attempt to use the template outside the scope of a transaction results in the template throwing an `IllegalStateException`. Starting with version 2.4.3, you can set the template's `allowNonTransactional` property to `true`. In that case, the template will allow the operation to run without a transaction, by calling the `ProducerFactory`'s `createNonTransactionalProducer()` method; the producer will be cached, or thread-bound, as normal for reuse. See `Using DefaultKafkaProducerFactory`.

**Transactions with Batch Listeners**

When a listener fails while transactions are being used, the `AfterRollbackProcessor` is invoked to take some action after the rollback occurs. When using the default `AfterRollbackProcessor` with a record listener, seeks are performed so that the failed record will be redelivered. With a batch listener, however, the whole batch will be redelivered because the framework doesn't know which record in the batch failed. See `After-rollback Processor` for more information.

When using a batch listener, version 2.4.2 introduced an alternative mechanism to deal with failures while processing a batch; the `BatchToRecordAdapter`. When a container factory with `batchListener` set to `true` is configured with a `BatchToRecordAdapter`, the listener is invoked with one record at a time. This enables error handling within the batch, while still making it possible to stop processing the entire batch, depending on the exception type. A default `BatchToRecordAdapter` is provided, that can be configured with a standard `ConsumerRecordRecoverer` such as the `DeadLetterPublishingRecoverer`. The following test case configuration snippet illustrates how to use this feature:
public static class TestListener {

    final List<String> values = new ArrayList<>();

    @KafkaListener(id = "batchRecordAdapter", topics = "test")
    public void listen(String data) {
        values.add(data);
        if ("bar".equals(data)) {
            throw new RuntimeException("reject partial");
        }
    }
}

@Configuration
@EnableKafka
public static class Config {

    ConsumerRecord<?, ?> failed;

    @Bean
    public TestListener test() {
        return new TestListener();
    }

    @Bean
    public ConsumerFactory<?, ?> consumerFactory() {
        return mock(ConsumerFactory.class);
    }

    @Bean
    public ConcurrentKafkaListenerContainerFactory<String, String> kafkaListenerContainerFactory() {
        ConcurrentKafkaListenerContainerFactory factory = new ConcurrentKafkaListenerContainerFactory();
        factory.setConsumerFactory(consumerFactory());
        factory.setBatchListener(true);
        factory.setBatchToRecordAdapter(new DefaultBatchToRecordAdapter<>((record, ex) -> {
            this.failed = record;
        }));
        return factory;
    }
}
4.1.13. Exactly Once Semantics

You can provide a listener container with a KafkaAwareTransactionManager instance. When so configured, the container starts a transaction before invoking the listener. Any KafkaTemplate operations performed by the listener participate in the transaction. If the listener successfully processes the record (or multiple records, when using a BatchMessageListener), the container sends the offset(s) to the transaction by 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) can be retrieved on the next poll. See After-rollback Processor for more information and for handling records that repeatedly fail.

Using transactions enables Exactly Once Semantics (EOS).

This means that, for a read→process→write sequence, it is guaranteed that the sequence is completed exactly once. (The read and process are have at least once semantics).

Spring for Apache Kafka version 2.5 and later supports two EOS modes:

- ALPHA - alias for V1 (deprecated)
- BETA - alias for V2 (deprecated)
- V1 - aka transactional.id fencing (since version 0.11.0.0)
- V2 - aka fetch-offset-request fencing (since version 2.5)

With mode V1, the producer is “fenced” if another instance with the same transactional.id is started. Spring manages this by using a Producer for each group.id/topic/partition; when a rebalance occurs a new instance will use the same transactional.id and the old producer is fenced.

With mode V2, it is not necessary to have a producer for each group.id/topic/partition because consumer metadata is sent along with the offsets to the transaction and the broker can determine if the producer is fenced using that information instead.

Starting with version 2.6, the default EOSMode is V2.

To configure the container to use mode ALPHA, set the container property EOSMode to ALPHA, to revert to the previous behavior.

With V2 (default), your brokers must be version 2.5 or later; kafka-clients version 3.0, the producer will no longer fall back to V1; if the broker does not support V2, an exception is thrown. If your brokers are earlier than 2.5, you must set the EOSMode to V1, leave the DefaultKafkaProducerFactory producerPerConsumerPartition set to true and, if you are using a batch listener, you should set subBatchPerPartition to true.

When your brokers are upgraded to 2.5 or later, you should switch the mode to V2, but the number of producers will remain as before. You can then do a rolling upgrade of your application with producerPerConsumerPartition set to false to reduce the number of producers; you should also no longer set the subBatchPerPartition container property.
If your brokers are already 2.5 or newer, you should set the `DefaultKafkaProducerFactory.producerPerConsumerPartition` property to `false`, to reduce the number of producers needed.

When using `EOSMode.V2` with `producerPerConsumerPartition=false` the `transactional.id` must be unique across all application instances.

When using `V2` mode, it is no longer necessary to set the `subBatchPerPartition` to `true`; it will default to `false` when the `EOSMode` is `V2`.

Refer to [KIP-447](#) for more information.

`V1` and `V2` were previously `ALPHA` and `BETA`; they have been changed to align the framework with [KIP-732](#).

### 4.1.14. Wiring Spring Beans into Producer/Consumer Interceptors

Apache Kafka provides a mechanism to add interceptors to producers and consumers. These objects are managed by Kafka, not Spring, and so normal Spring dependency injection won't work for wiring in dependent Spring Beans. However, you can manually wire in those dependencies using the interceptor `config()` method. The following Spring Boot application shows how to do this by overriding boot's default factories to add some dependent bean into the configuration properties.
@SpringBootApplication
public class Application {

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

    @Bean
    public ConsumerFactory<?, ?> kafkaConsumerFactory(SomeBean someBean) {
        Map<String, Object> consumerProperties = new HashMap<>();
        // consumerProperties.put(..., ...)
        // ...
        consumerProperties.put(ConsumerConfig.INTERCEPTOR_CLASSES_CONFIG, MyConsumerInterceptor.class.getName());
        consumerProperties.put("some.bean", someBean);
        return new DefaultKafkaConsumerFactory<>(consumerProperties);
    }

    @Bean
    public ProducerFactory<?, ?> kafkaProducerFactory(SomeBean someBean) {
        Map<String, Object> producerProperties = new HashMap<>();
        // producerProperties.put(..., ...)
        // ...
        Map<String, Object> producerProperties = properties.buildProducerProperties();
        producerProperties.put(ProducerConfig.INTERCEPTOR_CLASSES_CONFIG, MyProducerInterceptor.class.getName());
        producerProperties.put("some.bean", someBean);
        DefaultKafkaProducerFactory<?, ?> factory = new DefaultKafkaProducerFactory<>(producerProperties);
        return factory;
    }

    @Bean
    public SomeBean someBean() {
        return new SomeBean();
    }

    @KafkaListener(id = "kgk897", topics = "kgh897")
    public void listen(String in) {
        System.out.println("Received " + in);
    }

    @Bean
    public ApplicationRunner runner(KafkaTemplate<String, String> template) {
        return args -> template.send("kgh897", "test");
    }

    @Bean
public NewTopic kRequests() {
    return TopicBuilder.name("kgh897")
        .partitions(1)
        .replicas(1)
        .build();
}

public class SomeBean {
    public void someMethod(String what) {
        System.out.println(what + " in my foo bean");
    }
}

public class MyProducerInterceptor implements ProducerInterceptor<String, String> {
    private SomeBean bean;

    @Override
    public void configure(Map<String, ?> configs) {
        this.bean = (SomeBean) configs.get("some.bean");
    }

    @Override
    public ProducerRecord<String, String> onSend(ProducerRecord<String, String> record) {
        this.bean.someMethod("producer interceptor");
        return record;
    }

    @Override
    public void onAcknowledgement(RecordMetadata metadata, Exception exception) {
    }

    @Override
    public void close() {
    }
}
public class MyConsumerInterceptor implements ConsumerInterceptor<String, String> {

    private SomeBean bean;

    @Override
    public void configure(Map<String, ?> configs) {
        this.bean = (SomeBean) configs.get("some.bean");
    }

    @Override
    public ConsumerRecords<String, String> consume(ConsumerRecords<String, String> records) {
        this.bean.someMethod("consumer interceptor");
        return records;
    }

    @Override
    public void onCommit(Map<TopicPartition, OffsetAndMetadata> offsets) {
    }

    @Override
    public void close() {
    }
}

Result:

producer interceptor in my foo bean
consumer interceptor in my foo bean
Received test

4.1.15. Producer Interceptor Managed in Spring

Starting with version 3.0.0, when it comes to a producer interceptor, you can let Spring manage it directly as a bean instead of providing the class name of the interceptor to the Apache Kafka producer configuration. If you go with this approach, then you need to set this producer interceptor on KafkaTemplate. Following is an example using the same MyProducerInterceptor from above, but changed to not use the internal config property.
Right before the records are sent, the `onSend` method of the producer interceptor is invoked. Once
the server sends an acknowledgement on publishing the data, then the `onAcknowledgement` method is invoked. The `onAcknowledgement` is called right before the producer invokes any user callbacks.

If you have multiple such producer interceptors managed through Spring that need to be applied on the `KafkaTemplate`, you need to use `CompositeProducerInterceptor` instead. `CompositeProducerInterceptor` allows individual producer interceptors to be added in order. The methods from the underlying `ProducerInterceptor` implementations are invoked in the order as they were added to the `CompositeProducerInterceptor`.

4.1.16. Pausing and 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 a `ListenerContainerIdleEvent`, which provides access to the `Consumer` object. While you could pause a consumer in an idle container by using 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 and resume consumers, you should use the `pause` and `resume` methods on the listener containers. A `pause()` takes effect just before the next `poll()`; a `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 it does not retrieve any records. See 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()` returns true if all `Consumer` instances have actually paused.

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

The following simple Spring Boot application demonstrates by using the container registry to get a reference to a `@KafkaListener` method's container and pausing or resuming its consumers as well as receiving the corresponding events:
@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", "thing1");
            Thread.sleep(10_000);
            System.out.println("pausing");
            registry.getListenerContainer("pause.resume").pause();
            Thread.sleep(10_000);
            template.send("pause.resume.topic", "thing2");
            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 TopicBuilder.name("pause.resume.topic")
                .partitions(2)
                .replicas(1)
                .build();
    }
}

The following listing shows the results of the preceding example:
4.1.17. Pausing and Resuming Partitions on Listener Containers

Since version 2.7 you can pause and resume the consumption of specific partitions assigned to that consumer by using the `pausePartition(TopicPartition topicPartition)` and `resumePartition(TopicPartition topicPartition)` methods in the listener containers. The pausing and resuming takes place respectively before and after the `poll()` similar to the `pause()` and `resume()` methods. The `isPartitionPauseRequested()` method returns true if pause for that partition has been requested. The `isPartitionPaused()` method returns true if that partition has effectively been paused.

Also since version 2.7 `ConsumerPartitionPausedEvent` and `ConsumerPartitionResumedEvent` instances are published with the container as the source property and the `TopicPartition` instance.

4.1.18. Serialization, Deserialization, and Message Conversion

Overview

Apache Kafka provides a high-level API for serializing and 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 serializer and deserializer classes by using `Producer` or `Consumer` configuration properties. The following example shows how to do so:

```java
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 `Serializer` and `Deserializer` instances for keys and values, respectively.

When you use this API, the `DefaultKafkaProducerFactory` and `DefaultKafkaConsumerFactory` also
provide properties (through constructors or setter methods) to inject custom Serializer and Deserializer instances into the target Producer or Consumer. Also, you can pass in Supplier<Serializer> or Supplier<Deserializer> instances through constructors - these Supplier's are called on creation of each Producer or Consumer.

**String serialization**

Since version 2.5, Spring for Apache Kafka provides ToStringSerializer and ParseStringDeserializer classes that use String representation of entities. They rely on methods toString and some Function<String> or BiFunction<String, Headers> to parse the String and populate properties of an instance. Usually, this would invoke some static method on the class, such as parse:

```java
ToStringSerializer<Thing> thingSerializer = new ToStringSerializer<>();
//...
ParseStringDeserializer<Thing> deserializer = new ParseStringDeserializer<>((Thing str) -> {
    byte[] header = headers.lastHeader(ToStringSerializer.VALUE_TYPE).value();
    String entityType = new String(header);
    if (entityType.contains("Thing")) {
        return Thing.parse(str);
    } else {
        // ...parsing logic
    }
});
```

By default, the ToStringSerializer is configured to convey type information about the serialized entity in the record Headers. You can disable this by setting the addTypeInfo property to false. This information can be used by ParseStringDeserializer on the receiving side.

- **ToStringSerializer.ADD_TYPE_INFO_HEADERS** (default true): You can set it to false to disable this feature on the ToStringSerializer (sets the addTypeInfo property).

```java
ParseStringDeserializer<Object> deserializer = new ParseStringDeserializer<>((str, headers) -> {
    byte[] header = headers.lastHeader(ToStringSerializer.VALUE_TYPE).value();
    String entityType = new String(header);
    if (entityType.contains("Thing")) {
        return Thing.parse(str);
    } else {
        // ...parsing logic
    }
});
```

You can configure the Charset used to convert String to/from byte[] with the default being UTF-8.

You can configure the deserializer with the name of the parser method using ConsumerConfig properties:

- ParseStringDeserializer.KEY_PARSER
The properties must contain the fully qualified name of the class followed by the method name, separated by a period. The method must be static and have a signature of either `(String, Headers)` or `(String)`.

A `ToFromCharSerde` is also provided, for use with Kafka Streams.

### JSON

Spring for Apache Kafka also provides `JsonSerializer` and `JsonDeserializer` implementations that are based on the Jackson JSON object mapper. The `JsonSerializer` 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. The following example shows how to create a `JsonDeserializer`:

```java
JsonDeserializer<Thing> thingDeserializer = new JsonDeserializer<>(Thing.class);
```

You can customize both `JsonSerializer` and `JsonDeserializer` 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 2.3, all the JSON-aware components are configured by default with a `JacksonUtils.enhancedObjectMapper()` instance, which comes with the `MapperFeature.DEFAULT_VIEW_INCLUSION` and `DeserializationFeature.FAIL_ON_UNKNOWN_PROPERTIES` features disabled. Also such an instance is supplied with well-known modules for custom data types, such as a Java time and Kotlin support. See `JacksonUtils.enhancedObjectMapper()` JavaDocs for more information. This method also registers a `org.springframework.kafka.support.JacksonMimeTypeModule` for `org.springframework.util.MimeType` objects serialization into the plain string for inter-platform compatibility over the network. A `JacksonMimeTypeModule` can be registered as a bean in the application context and it will be auto-configured into `Spring Boot ObjectMapper` instance.

Also starting with version 2.3, the `JsonDeserializer` provides `TypeReference`-based constructors for better handling of target generic container types.

Starting with version 2.1, you can convey type information in record `Headers`, allowing the handling of multiple types. In addition, you can configure the serializer and deserializer by using the following Kafka properties. They have no effect if you have provided `Serializer` and `Deserializer` instances for `KafkaConsumer` and `KafkaProducer`, respectively.

#### Configuration Properties

- `JsonSerializer.ADD_TYPE_INFO_HEADERS` (default `true`): You can set it to `false` to disable this feature on the `JsonSerializer` (sets the `addTypeInfo` property).
- `JsonSerializer.TYPE_MAPPINGS` (default empty): See Mapping Types.
- `JsonDeserializer.USE_TYPE_INFO_HEADERS` (default `true`): You can set it to `false` to ignore headers
set by the serializer.

- **JsonDeserializer.REMOVE_TYPE_INFO_HEADERS** (default `true`): You can set it 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 Mapping Types.

- **JsonDeserializer.KEY_TYPE_METHOD** (default `empty`): See Using Methods to Determine Types.

- **JsonDeserializer.VALUE_TYPE_METHOD** (default `empty`): See Using Methods to Determine Types.

Starting with version 2.2, the type information headers (if added by the serializer) are 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 earlier.

See also Customizing the JsonSerializer and JsonDeserializer.

Starting with version 2.8, if you construct the serializer or deserializer programmatically as shown in Programmatic Construction, the above properties will be applied by the factories, as long as you have not set any properties explicitly (using `set*()` methods or using the fluent API). Previously, when creating programmatically, the configuration properties were never applied; this is still the case if you explicitly set properties on the object directly.

**Mapping Types**

Starting with version 2.2, when using JSON, you can now provide type mappings by using the properties in the preceding list. Previously, you had to customize the type mapper within the serializer and 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. On inbound, the token in the type header is mapped to the corresponding class name.

The following example creates a set of mappings:
senderProps.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, JsonSerializer.class);
senderProps.put(JsonSerializer.TYPE_MAPPINGS, "cat:com.mycat.Cat, hat:com.myhat.hat");
...
consumerProps.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, JsonDeserializer.class);
consumerProps.put(JsonDeSerializer.TYPE_MAPPINGS, "cat:com.yourcat.Cat, hat:com.yourhat.hat");

⚠️ The corresponding objects must be compatible.

If you use Spring Boot, you can provide these properties in the application.properties (or yaml) file. The following example shows how to do so:

```
spring.kafka.producer.value-serializer=org.springframework.kafka.support.serializer.JsonSerializer
```
You can perform only simple configuration with properties. For more advanced configuration (such as using a custom ObjectMapper in the serializer and deserializer), you should use the producer and consumer factory constructors that accept a pre-built serializer and deserializer. The following Spring Boot example overrides the default factories:

```java
@Bean
public ConsumerFactory<String, Thing> kafkaConsumerFactory(
    JsonDeserializer customValueDeserializer)
{
    Map<String, Object> properties = new HashMap<>();
    // properties.put(..., ...)
    // ...
    return new DefaultKafkaConsumerFactory<
        String, Thing>
        (properties,
         new StringDeserializer(),
         customValueDeserializer);
}

@Bean
public ProducerFactory<String, Thing> kafkaProducerFactory(
    JsonSerializer customValueSerializer)
{
    return new DefaultKafkaProducerFactory<
        String, Thing>
        (properties.
         buildProducerProperties(),
         new StringSerializer(),
         customValueSerializer);
}
```

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 by using one of the overloaded constructors that have a boolean useHeadersIfPresent (which is true by default). The following example shows how to do so:

```java
DefaultKafkaConsumerFactory<Integer, Cat1> cf = new DefaultKafkaConsumerFactory<>
    (props,
     new IntegerDeserializer(), new JsonDeserializer<>(Cat1.class, false));
```

### Using Methods to Determine Types

Starting with version 2.5, you can now configure the deserializer, via properties, to invoke a method to determine the target type. If present, this will override any of the other techniques discussed above. This can be useful if the data is published by an application that does not use the Spring serializer and you need to deserialize to different types depending on the data, or other headers. Set these properties to the method name - a fully qualified class name followed by the method name, separated by a period.. The method must be declared as public static, have one of
three signatures \((\text{String topic, byte[] data, Headers headers}), (\text{byte[] data, Headers headers})\) or \((\text{byte[] data})\) and return a Jackson \text{JavaType}.

- \text{JsonDeserializer.KEY\_TYPE\_METHOD}: spring.json.key.type.method
- \text{JsonDeserializer.VALUE\_TYPE\_METHOD}: spring.json.value.type.method

You can use arbitrary headers or inspect the data to determine the type.

\begin{example}
\begin{verbatim}
JavaType thing1Type = TypeFactory.defaultInstance().constructType(Thing1.class);
JavaType thing2Type = TypeFactory.defaultInstance().constructType(Thing2.class);

public static JavaType thingOneOrThingTwo(byte[] data, Headers headers) {
    // {"thisIsAFieldInThing1":"value", ...}
    if (data[21] == '1') {
        return thing1Type;
    } else {
        return thing2Type;
    }
}
\end{verbatim}
\end{example}

For more sophisticated data inspection consider using \text{JsonPath} or similar but, the simpler the test to determine the type, the more efficient the process will be.

The following is an example of creating the deserializer programmatically (when providing the consumer factory with the deserializer in the constructor):

\begin{verbatim}
JsonDeserializer<
Object> deser = new JsonDeserializer<>()
    .trustedPackages("*")
    .typeResolver(SomeClass::thing1Thing2JavaTypeForTopic);
...

public static JavaType thing1Thing2JavaTypeForTopic(String topic, byte[] data, Headers headers) {
    ...
}
\end{verbatim}

\textbf{Programmatic Construction}

When constructing the serializer/deserializer programmatically for use in the producer/consumer factory, since version 2.3, you can use the fluent API, which simplifies configuration.
@Bean
public ProducerFactory<MyKeyType, MyValueType> pf() {
    Map<String, Object> props = new HashMap<>();
    // props.put(..., ...)
    // ...
    DefaultKafkaProducerFactory<MyKeyType, MyValueType> pf = new
    DefaultKafkaProducerFactory<>(props,
        new JsonSerializer<MyKeyType>()
            .forKeys()
            .noTypeInfo(),
        new JsonSerializer<MyValueType>()
            .noTypeInfo());
    return pf;
}

@Bean
public ConsumerFactory<MyKeyType, MyValueType> cf() {
    Map<String, Object> props = new HashMap<>();
    // props.put(..., ...)
    // ...
    DefaultKafkaConsumerFactory<MyKeyType, MyValueType> cf = new
    DefaultKafkaConsumerFactory<>(props,
        new JsonDeserializer<MyKeyType>(MyKeyType.class)
            .forKeys()
            .ignoreTypeHeaders(),
        new JsonDeserializer<MyValueType>(MyValueType.class)
            .ignoreTypeHeaders());
    return cf;
}

To provide type mapping programmatically, similar to Using Methods to Determine Types, use the typeFunction property.

Example

JsonDeserializer<Object> deser = new JsonDeserializer<>()
    .trustedPackages("*")
    .typeFunction(MyUtils::thingOneOrThingTwo);

Alternatively, as long as you don't use the fluent API to configure properties, or set them using set*() methods, the factories will configure the serializer/deserializer using the configuration properties; see Configuration Properties.

Delegating Serializer and Deserializer
Using Headers

Version 2.3 introduced the `DelegatingSerializer` and `DelegatingDeserializer`, which allow producing and consuming records with different key and/or value types. Producers must set a header `DelegatingSerializer.VALUE_SERIALIZATION_SELECTOR` to a selector value that is used to select which serializer to use for the value and `DelegatingSerializer.KEY_SERIALIZATION_SELECTOR` for the key; if a match is not found, an `IllegalStateException` is thrown.

For incoming records, the deserializer uses the same headers to select the deserializer to use; if a match is not found or the header is not present, the raw `byte[]` is returned.

You can configure the map of selector to `Serializer` / `Deserializer` via a constructor, or you can configure it via Kafka producer/consumer properties with the keys `DelegatingSerializer.VALUE_SERIALIZATION_SELECTOR_CONFIG` and `DelegatingSerializer.KEY_SERIALIZATION_SELECTOR_CONFIG`. For the serializer, the producer property can be a `Map<String, Object>` where the key is the selector and the value is a `Serializer` instance, a `serializer Class` or the class name. The property can also be a String of comma-delimited map entries, as shown below.

For the deserializer, the consumer property can be a `Map<String, Object>` where the key is the selector and the value is a `Deserializer` instance, a `Deserializer Class` or the class name. The property can also be a String of comma-delimited map entries, as shown below.

To configure using properties, use the following syntax:

```java
producerProps.put(DelegatingSerializer.VALUE_SERIALIZATION_SELECTOR_CONFIG,
                 "thing1:com.example.MyThing1Serializer, thing2:com.example.MyThing2Serializer")

consumerProps.put(DelegatingDeserializer.VALUE_SERIALIZATION_SELECTOR_CONFIG,
                 "thing1:com.example.MyThing1Deserializer,
                 thing2:com.example.MyThing2Deserializer")
```

Producers would then set the `DelegatingSerializer.VALUE_SERIALIZATION_SELECTOR` header to `thing1` or `thing2`.

This technique supports sending different types to the same topic (or different topics).

Starting with version 2.5.1, it is not necessary to set the selector header, if the type (key or value) is one of the standard types supported by `Serdes` (`Long`, `Integer`, etc). Instead, the serializer will set the header to the class name of the type. It is not necessary to configure serializers or deserializers for these types, they will be created (once) dynamically.

For another technique to send different types to different topics, see Using `RoutingKafkaTemplate`. 
By Type

Version 2.8 introduced the `DelegatingByTypeSerializer`.

```java
@Bean
public ProducerFactory<Integer, Object> producerFactory(Map<String, Object> config) {
    return new DefaultKafkaProducerFactory<>(config,
        null, new DelegatingByTypeSerializer(Map.of(
            byte[].class, new ByteArraySerializer(),
            Bytes.class, new BytesSerializer(),
            String.class, new StringSerializer())));
}
```

Starting with version 2.8.3, you can configure the serializer to check if the map key is assignable from the target object, useful when a delegate serializer can serialize sub classes. In this case, if there are amiguous matches, an ordered `Map`, such as a `LinkedHashMap` should be provided.

By Topic

Starting with version 2.8, the `DelegatingByTopicSerializer` and `DelegatingByTopicDeserializer` allow selection of a serializer/deserializer based on the topic name. Regex `Pattern`s are used to lookup the instance to use. The map can be configured using a constructor, or via properties (a comma delimited list of `pattern:serializer`).

```java
producerConfigs.put(DelegatingByTopicSerializer.VALUE_SERIALIZATION_TOPIC_CONFIG,
    "topic[0-4]:" + ByteArraySerializer.class.getName() + ", topic[5-9]:" + StringSerializer.class.getName());
...
ConsumerConfigs.put(DelegatingByTopicDeserializer.VALUE_SERIALIZATION_TOPIC_CONFIG
    "topic[0-4]:" + ByteArrayDeserializer.class.getName() + ", topic[5-9]:" + StringDeserializer.class.getName());
```

Use `KEY_SERIALIZATION_TOPIC_CONFIG` when using this for keys.
@Bean
public ProducerFactory<Integer, Object> producerFactory(Map<String, Object> config) {
    return new DefaultKafkaProducerFactory<>(config,
            null,
            new DelegatingByTopicSerializer<Map.of(
                    Pattern.compile("topic[0-4]"), new ByteArraySerializer(),
                    Pattern.compile("topic[5-9]"), new StringSerializer()),
                    new JsonSerializer<Object>())); // default
}

You can specify a default serializer/deserializer to use when there is no pattern match using DelegatingByTopicSerialization.KEY_SERIALIZATION_TOPIC_DEFAULT and DelegatingByTopicSerialization.VALUE_SERIALIZATION_TOPIC_DEFAULT.

An additional property DelegatingByTopicSerialization.CASE_SENSITIVE (default true), when set to false makes the topic lookup case insensitive.

Retrying Deserializer

The RetryingDeserializer uses a delegate Deserializer and RetryTemplate to retry deserialization when the delegate might have transient errors, such a network issues, during deserialization.

ConsumerFactory cf = new DefaultKafkaConsumerFactory(myConsumerConfigs,
        new RetryingDeserializer(myUnreliableKeyDeserializer, retryTemplate),
        new RetryingDeserializer(myUnreliableValueDeserializer, retryTemplate));

Refer to the spring-retry project for configuration of the RetryTemplate with a retry policy, back off policy, etc.

Spring Messaging Message Conversion

Although the Serializer and 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, when using either @KafkaListener or Spring Integration’s Apache Kafka Support. To let you easily convert to and from org.springframework.messaging.Message, Spring for Apache Kafka provides a MessageConverter abstraction with the MessagingMessageConverter implementation and its JsonMessageConverter (and subclasses) customization. You can inject the MessageConverter into a KafkaTemplate instance directly and by using AbstractKafkaListenerContainerFactory bean definition for the @KafkaListener.containerFactory() property. The following example shows how to do so:
When using Spring Boot, simply define the converter as a `@Bean` and Spring Boot auto configuration will wire it into the auto-configured template and container factory.

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

This type inference can be achieved only 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.
On the consumer side, you can configure a `JsonMessageConverter`; it can handle `ConsumerRecord` values of type `byte[]`, `Bytes` and `String` so should be used in conjunction with a `ByteArrayDeserializer`, `BytesDeserializer` or `StringDeserializer`. (`byte[]` and `Bytes` are more efficient because they avoid an unnecessary `byte[]` to `String` conversion). You can also configure the specific subclass of `JsonMessageConverter` corresponding to the deserializer, if you so wish.

On the producer side, when you use Spring Integration or the `KafkaTemplate.send(Message<?> message)` method (see Using KafkaTemplate), you must configure a message converter that is compatible with the configured Kafka Serializer.

- `StringJsonMessageConverter` with `StringSerializer`  
- `BytesJsonMessageConverter` with `BytesSerializer`  
- `ByteArrayJsonMessageConverter` with `ByteArraySerializer`

Again, using `byte[]` or `Bytes` is more efficient because they avoid a `String` to `byte[]` conversion.

For convenience, starting with version 2.3, the framework also provides a `StringOrBytesSerializer` which can serialize all three value types so it can be used with any of the message converters.

Starting with version 2.7.1, message payload conversion can be delegated to a `spring-messaging SmartMessageConverter`; this enables conversion, for example, to be based on the `MessageHeaders.CONTENT_TYPE` header.

The `KafkaMessageConverter.fromMessage()` method is called for outbound conversion to a `ProducerRecord` with the message payload in the `ProducerRecord.value()` property. The `KafkaMessageConverter.toMessage()` method is called for inbound conversion from `ConsumerRecord` with the payload being the `ConsumerRecord.value()` property. The `SmartMessageConverter.toMessage()` method is called to create a new outbound `Message<?>` from the `Message` passed to `fromMessage()` (usually by `KafkaTemplate.send(Message<?> msg)`). Similarly, in the `KafkaMessageConverter.toMessage()` method, after the converter has created a new `Message<?>` from the `ConsumerRecord`, the `SmartMessageConverter.fromMessage()` method is called and then the final inbound message is created with the newly converted payload. In either case, if the `SmartMessageConverter` returns `null`, the original message is used.

When the default converter is used in the `KafkaTemplate` and listener container factory, you configure the `SmartMessageConverter` by calling `setMessagingConverter()` on the template and via the `contentMessageConverter` property on `@KafkaListener` methods.

Examples:
template.setMessagingConverter(mySmartConverter);

@KafkaListener(id = "withSmartConverter", topics = "someTopic",
   contentTypeConverter = "mySmartConverter")
public void smart(Thing thing) {
    ...
}

Using Spring Data Projection Interfaces

Starting with version 2.1.1, you can convert JSON to a Spring Data Projection interface instead of a concrete type. This allows very selective, and low-coupled bindings to data, including the lookup of values from multiple places inside the JSON document. For example the following interface can be defined as message payload type:

```java
interface SomeSample {
    @JsonPath({ "$username", "$user.name" })
    String getUsername();
}
```

Accessor methods will be used to lookup the property name as field in the received JSON document by default. The @JsonPath expression allows customization of the value lookup, and even to define multiple JSON Path expressions, to lookup values from multiple places until an expression returns an actual value.

To enable this feature, use a ProjectingMessageConverter configured with an appropriate delegate converter (used for outbound conversion and converting non-projection interfaces). You must also add spring-data:spring-data-commons and com.jayway.jsonpath:json-path to the class path.

When used as the parameter to a @KafkaListener method, the interface type is automatically passed to the converter as normal.
Using 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, the ErrorHandlingDeserializer has been introduced. This deserializer delegates to a real deserializer (key or value). If the delegate fails to deserialize the record content, the ErrorHandlingDeserializer returns a null value and a DeserializationException in a header that contains the cause and the raw bytes. When you use a record-level MessageListener, if the ConsumerRecord contains a DeserializationException header for either the key or value, the container's ErrorHandler is called with the failed ConsumerRecord. The record is not passed to the listener.

Alternatively, you can configure the ErrorHandlingDeserializer to create a custom value by providing a failedDeserializationFunction, which is a Function<FailedDeserializationInfo, T>. This function is invoked to create an instance of T, which is passed to the listener in the usual fashion. An object of type FailedDeserializationInfo, which contains all the contextual information is provided to the function. You can find the DeserializationException (as a serialized Java object) in headers. See the Javadoc for the ErrorHandlingDeserializer for more information.

You can use the DefaultKafkaConsumerFactory constructor that takes key and value Deserializer objects and wire in appropriate ErrorHandlingDeserializer instances that you have 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 ErrorHandlingDeserializer.KEY_DESERIALIZER_CLASS and ErrorHandlingDeserializer.VALUE_DESERIALIZER_CLASS. The property value can be a class or class name. The following example shows how to set these properties:

```java
// other props
props.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, ErrorHandlingDeserializer.class);
props.put(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG, ErrorHandlingDeserializer.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 example uses a failedDeserializationFunction.
public class BadFoo extends Foo {

    private final FailedDeserializationInfo failedDeserializationInfo;

    public BadFoo(FailedDeserializationInfo failedDeserializationInfo) {
        this.failedDeserializationInfo = failedDeserializationInfo;
    }

    public FailedDeserializationInfo getFailedDeserializationInfo() {
        return this.failedDeserializationInfo;
    }
}

public class FailedFooProvider implements Function<FailedDeserializationInfo, Foo> {

    @Override
    public Foo apply(FailedDeserializationInfo info) {
        return new BadFoo(info);
    }
}

The preceding example uses the following configuration:

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

If the consumer is configured with an ErrorHandlingDeserializer it is important to configure the KafkaTemplate and its producer with a serializer that can handle normal objects as well as raw byte[] values, which result from deserialization exceptions. The generic value type of the template should be Object. One technique is to use the DelegatingByTypeSerializer; an example follows:
@Bean
public ProducerFactory<String, Object> producerFactory() {
    return new DefaultKafkaProducerFactory<>(
        producerConfiguration(),
        new DelegatingByTypeSerializer(Map.of(byte[].class, new ByteArraySerializer(),
            MyNormalObject.class, new JsonSerializer<Object>()));
}

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

When using an ErrorHandlingDeserializer with a batch listener, you must check for the deserialization exceptions in message headers. When used with a DefaultBatchErrorHandler, you can use that header to determine which record the exception failed on and communicate to the error handler via a BatchListenerFailedException.

@KafkaListener(id = "test", topics = "test")
void listen(List<Thing> in, @Header(KafkaHeaders.BATCH_CONVERTED_HEADERS) List<Map<String, Object>> headers) {
    for (int i = 0; i < in.size(); i++) {
        Thing thing = in.get(i);
        if (thing == null && headers.get(i).get(SerializationUtils.VALUE_DESERIALIZER_EXCEPTION_HEADER) != null) {
            DeserializationException deserEx = ListenerUtils.byteArrayToDeserializationException(this.logger,
                (byte[]) headers.get(i).get(SerializationUtils.VALUE_DESERIALIZER_EXCEPTION_HEADER));
            if (deserEx != null) {
                logger.error(deserEx, "Record at index " + i + " could not be deserialized");
            }
            throw new BatchListenerFailedException("Deserialization", deserEx, i);
        }
        process(thing);
    }
}

ListenerUtils.byteArrayToDeserializationException() can be used to convert the header to a DeserializationException.

When consuming List<ConsumerRecord<?, ?>>, ListenerUtils.getExceptionFromHeader() is used instead:
@KafkaListener(id = "kgh2036", topics = "kgh2036")
void listen(List<ConsumerRecord<String, Thing>> in) {
    for (int i = 0; i < in.size(); i++) {
        ConsumerRecord<String, Thing> rec = in.get(i);
        if (rec.value() == null) {
            DeserializationException deserEx = ListenerUtils
                .getExceptionFromHeader(rec,
                SerializationUtils.VALUE_DESERIALIZER_EXCEPTION_HEADER, this
                .logger);
            if (deserEx != null) {
                logger.error(deserEx, "Record at offset " + rec.offset() + " could not be deserialized");
                throw new BatchListenerFailedException("Deserialization", deserEx, i);
            }
        }
        process(rec.value());
    }
}

Payload Conversion with Batch Listeners

You can also use a JsonMessageConverter within a BatchMessagingMessageConverter to convert batch messages when you use a batch listener container factory. See Serialization, Deserialization, and Message Conversion and Spring Messaging Message Conversion for more information.

By default, the type for the conversion is inferred from the listener argument. If you configure the JsonMessageConverter with a DefaultJackson2TypeMapper that has its TypePrecedence set to TYPE_ID (instead of the default INFERRED), the converter uses the 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 you use class-level @KafkaListener instances where the payload must have already been converted to determine which method to invoke. The following example creates beans that use this method:
@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 JsonMessageConverter converter() {
    return new JsonMessageConverter();
}

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 the following:

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

Note that you can still access the batch headers.

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. The following example shows how to do so:

@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 that implement any of the following interfaces:
This lets you further customize listener deserialization without changing the default configuration for `ConsumerFactory` and `KafkaListenerContainerFactory`.

Setting a custom `MessageHandlerMethodFactory` on the `KafkaListenerEndpointRegistrar` through a `KafkaListenerConfigurer` bean disables this feature.

Adding custom `HandlerMethodArgumentResolver` to `@KafkaListener`

Starting with version 2.4.2 you are able to add your own `HandlerMethodArgumentResolver` and resolve custom method parameters. All you need is to implement `KafkaListenerConfigurer` and use method `setCustomMethodArgumentResolvers()` from class `KafkaListenerEndpointRegistrar`.

```java
@Configuration
class CustomKafkaConfig implements KafkaListenerConfigurer {

    @Override
    public void configureKafkaListeners(KafkaListenerEndpointRegistrar registrar) {
        registrar.setCustomMethodArgumentResolvers(
            new HandlerMethodArgumentResolver() {
                @Override
                public boolean supportsParameter(MethodParameter parameter) {
                    return CustomMethodArgument.class.isAssignableFrom(parameter.getParameterType());
                }

                @Override
                public Object resolveArgument(MethodParameter parameter, Message<? extends ? super ?> message) {
                    return new CustomMethodArgument(message.getHeaders().get(KafkaHeaders.RECEIVED_TOPIC, String.class));
                }
            });
    }
}
```

You can also completely replace the framework’s argument resolution by adding a custom
**MessageHandlerMethodFactory** to the **KafkaListenerEndpointRegistrar** bean. If you do this, and your application needs to handle tombstone records, with a **null value()** (e.g. from a compacted topic), you should add a **KafkaNullAwarePayloadArgumentResolver** to the factory; it must be the last resolver because it supports all types and can match arguments without a @Payload annotation. If you are using a **DefaultMessageHandlerMethodFactory**, set this resolver as the last custom resolver; the factory will ensure that this resolver will be used before the standard **PayloadMethodArgumentResolver**, which has no knowledge of **KafkaNull** payloads.

See also **Null Payloads and Log Compaction of 'Tombstone' Records**.

### 4.1.19. Message Headers

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

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

Apache Kafka headers have a simple API, shown in the following interface definition:

```java
public interface Header {
    String key();
    byte[] value();
}
```

The **KafkaHeaderMapper** strategy is provided to map header entries between Kafka **Headers** and **MessageHeaders**. Its interface definition is as follows:

```java
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 a key of **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` instances 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. The following listing shows a number of example mappings:

```java
public DefaultKafkaHeaderMapper() { ①
  ...
}

public DefaultKafkaHeaderMapper(ObjectMapper objectMapper) { ②
  ...
}

public DefaultKafkaHeaderMapper(String... patterns) { ③
  ...
}

public DefaultKafkaHeaderMapper(ObjectMapper objectMapper, String... patterns) { ④
  ...
}
```

① Uses a default Jackson `ObjectMapper` and maps most headers, as discussed before the example.

② Uses the provided Jackson `ObjectMapper` and maps most headers, as discussed before the example.

③ Uses a default Jackson `ObjectMapper` and maps headers according to the provided patterns.

④ Uses the provided Jackson `ObjectMapper` and maps headers according to the provided patterns.

Patterns are rather simple and can contain a leading wildcard (`.`), a trailing wildcard, or both (for example, `.cat.*`). You can negate patterns with a leading `!`. The first pattern that matches a header name (whether positive or negative) wins.

When you provide your own patterns, we recommend including `!id` and `!timestamp`, since these headers are read-only on the inbound side.
By default, the mapper deserializes only classes in `java.lang` and `java.util`. You can trust other (or all) packages by adding trusted packages with the `addTrustedPackages` method. If you receive messages from untrusted sources, you may wish to add only those packages you trust. To trust all packages, you can use `mapper.addTrustedPackages("*").

Mapping `String` header values in a raw form is useful when communicating with systems that are not aware of the mapper’s JSON format.

Starting with version 2.2.5, you can specify that certain string-valued headers should not be mapped using JSON, but to/from a raw `byte[]`. The `AbstractKafkaHeaderMapper` has new properties; `mapAllStringsOut` when set to true, all string-valued headers will be converted to `byte[]` using the `charset` property (default UTF-8). In addition, there is a property `rawMappedHeaders`, which is a map of header name : boolean; if the map contains a header name, and the header contains a `String` value, it will be mapped as a raw `byte[]` using the charset. This map is also used to map raw incoming `byte[]` headers to `String` using the charset if, and only if, the boolean in the map value is `true`. If the boolean is `false`, or the header name is not in the map with a `true` value, the incoming header is simply mapped as the raw unmapped header.

The following test case illustrates this mechanism.

```java
@Test
public void testSpecificStringConvert() {
    DefaultKafkaHeaderMapper mapper = new DefaultKafkaHeaderMapper();
    Map<String, Boolean> rawMappedHeaders = new HashMap<>();
    rawMappedHeaders.put("thisOnesAString", true);
    rawMappedHeaders.put("thisOnesBytes", false);
    mapper.setRawMappedHeaders(rawMappedHeaders);
    Map<String, Object> headersMap = new HashMap<>();
    headersMap.put("thisOnesAString", "thing1");
    headersMap.put("thisOnesBytes", "thing2");
    headersMap.put("alwaysRaw", "thing3".getBytes());
    MessageHeaders headers = new MessageHeaders(headersMap);
    Headers target = new RecordHeaders();
    mapper.fromHeaders(headers, target);
    assertThat(target).containsExactlyInAnyOrder(
        new RecordHeader("thisOnesAString", "thing1".getBytes()),
        new RecordHeader("thisOnesBytes", "thing2".getBytes()),
        new RecordHeader("alwaysRaw", "thing3".getBytes()));
    headersMap.clear();
    mapper.toHeaders(target, headersMap);
    assertThat(headersMap).contains(
        entry("thisOnesAString", "thing1"),
        entry("thisOnesBytes", "thing2".getBytes()),
        entry("alwaysRaw", "thing3".getBytes()));
}
```
By default, the DefaultKafkaHeaderMapper is used in the MessagingMessageConverter and BatchMessagingMessageConverter, 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 there is 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. This header is 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.

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

Starting with version 2.3, handling of String-valued headers is simplified. Such headers are no longer JSON encoded, by default (i.e. they do not have enclosing "...
" added). The type is still added to the JSONTYPES header so the receiving system can convert back to a String (from byte[]). The mapper can handle (decode) headers produced by older versions (it checks for a leading ""); in this way an application using 2.3 can consume records from older versions.

To be compatible with earlier versions, set encodeStrings to true, if records produced by a version using 2.3 might be consumed by applications using earlier versions. When all applications are using 2.3 or higher, you can leave the property at its default value of false.

```java
@Bean
MessagingMessageConverter converter() {
    MessagingMessageConverter converter = new MessagingMessageConverter();
    DefaultKafkaHeaderMapper mapper = new DefaultKafkaHeaderMapper();
    mapper.setEncodeStrings(true);
    converter.setHeaderMapper(mapper);
    return converter;
}
```

If using Spring Boot, it will auto configure this converter bean into the auto-configured KafkaTemplate; otherwise you should add this converter to the template.
4.1.20. Null Payloads and Log Compaction of 'Tombstone' Records

When you use Log Compaction, you can send and receive messages with null payloads to identify the deletion of a key.

You can also receive null values for other reasons, such as a Deserializer that might return null when it cannot deserialize a value.

To send a null payload by using the KafkaTemplate, you can 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, you can use a special payload type called KafkaNull, and the framework sends null. For convenience, the static KafkaNull.INSTANCE is provided.

When you use a message listener container, the received ConsumerRecord has a null value().

To configure the @KafkaListener to handle null payloads, you must use the @Payload annotation with required = false. If it is a tombstone message for a compacted log, you usually also need the key so that your application can determine which key was “deleted”. The following example shows such a configuration:

```java
@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 you use a class-level @KafkaListener with multiple @KafkaHandler methods, some additional configuration is needed. Specifically, you need a @KafkaHandler method with a KafkaNull payload. The following example shows how to configure one:
Note that the argument is null, not KafkaNull.

This feature requires the use of a KafkaNullAwarePayloadArgumentResolver which the framework will configure when using the default MessageHandlerMethodFactory. When using a custom MessageHandlerMethodFactory, see Adding custom HandlerMethodArgumentResolver to @KafkaListener.

### 4.1.21. Handling Exceptions

This section describes how to handle various exceptions that may arise when you use Spring for Apache Kafka.

**Listener Error Handlers**

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

You can use the errorHandler to provide the bean name of a KafkaListenerErrorHandler implementation. This functional interface has one method, as the following listing shows:
@FunctionalInterface
public interface KafkaListenerErrorHandler {
    Object handleError(Message<?> message, ListenerExecutionFailedException exception) throws Exception;
}

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

Starting with version 2.7, you can set the `rawRecordHeader` property on the `MessagingMessageConverter` and `BatchMessagingMessageConverter` which causes the raw `ConsumerRecord` to be added to the converted `Message<?>` in the `KafkaHeaders.RAW_DATA` header. This is useful, for example, if you wish to use a `DeadLetterPublishingRecoverer` in a listener error handler. It might be used in a request/reply scenario where you wish to send a failure result to the sender, after some number of retries, after capturing the failed record in a dead letter topic.

```java
@Bean
KafkaListenerErrorHandler eh(DeadLetterPublishingRecoverer recoverer) {
    return (msg, ex) -> {
        if (msg.getHeaders().get(KafkaHeaders.DELIVERY_ATTEMPT, Integer.class) > 9) {
            recoverer.accept(msg.getHeaders().get(KafkaHeaders.RAW_DATA, ConsumerRecord.class), ex);
            return "FAILED";
        }
        throw ex;
    };
}
```

It has a sub-interface (ConsumerAwareListenerErrorHandler) that has access to the consumer object, through the following method:

```java
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:
@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;
  }
}

Similarly, you could do something like the following 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.

The preceding two examples are simplistic implementations, and you would probably want more checking in the error handler.
Container Error Handlers

Starting with version 2.8, the legacy `ErrorHandler` and `BatchErrorHandler` interfaces have been superseded by a new `CommonErrorHandler`. These error handlers can handle errors for both record and batch listeners, allowing a single listener container factory to create containers for both types of listener. `CommonErrorHandler` implementations to replace most legacy framework error handler implementations are provided and the legacy error handlers deprecated. The legacy interfaces are still supported by listener containers and listener container factories; they will be deprecated in a future release.

See [Migrating Custom Legacy Error Handler Implementations to `CommonErrorHandler` for information to migrate custom error handlers to `CommonErrorHandler`.

When transactions are being used, no error handlers are configured, by default, so that the exception will roll back the transaction. Error handling for transactional containers are handled by the `AfterRollbackProcessor`. If you provide a custom error handler when using transactions, it must throw an exception if you want the transaction rolled back.

This interface has a default method `isAckAfterHandle()` which is called by the container to determine whether the offset(s) should be committed if the error handler returns without throwing an exception; it returns true by default.

Typically, the error handlers provided by the framework will throw an exception when the error is not "handled" (e.g. after performing a seek operation). By default, such exceptions are logged by the container at `ERROR` level. All of the framework error handlers extend `KafkaExceptionLogLevelAware` which allows you to control the level at which these exceptions are logged.

```java
/**
 * Set the level at which the exception thrown by this handler is logged.
 * @param logLevel the level (default ERROR).
 */
public void setLogLevel(KafkaException.Level logLevel) {
    ...
}
```

You can specify a global error handler to be used for all listeners in the container factory. The following example shows how to do so:
@Bean
public KafkaListenerContainerFactory<ConcurrentMessageListenerContainer<Integer, String>>
    kafkaListenerContainerFactory() {
    ConcurrentKafkaListenerContainerFactory<Integer, String> factory =
        new ConcurrentKafkaListenerContainerFactory<>();
    ...
    factory.setCommonErrorHandler(myErrorHandler);
    ...
    return factory;
}

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

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

If you are using Spring Boot, you simply need to add the error handler as a @Bean and Boot will add
it to the auto-configured factory.

**DefaultErrorHandler**

This new error handler replaces the SeekToCurrentErrorHandler and RecoveringBatchErrorHandler,
which have been the default error handlers for several releases now. One difference is that the
fallback behavior for batch listeners (when an exception other than a BatchListenerFailedException
is thrown) is the equivalent of the Retrying Complete Batches.

The error handler can recover (skip) a record that keeps failing. By default, after ten failures, the
failed record is logged (at the ERROR level). You can configure the handler with a custom recoverer
(BiConsumer) and a BackOff that controls the delivery attempts and delays between each. Using a
FixedBackOff with FixedBackOff.UNLIMITED_ATTEMPTS causes (effectively) infinite retries. The
following example configures recovery after three tries:

```java
DefaultErrorHandler errorHandler =
    new DefaultErrorHandler((record, exception) -> {
        // recover after 3 failures, with no back off - e.g. send to a dead-letter
topic
    }), new FixedBackOff(0L, 2L));
```

To configure the listener container with a customized instance of this handler, add it to the
container factory.

For example, with the @KafkaListener container factory, you can add DefaultErrorHandler as follows:
For a record listener, this will retry a delivery up to 2 times (3 delivery attempts) with a back off of 1 second, instead of the default configuration (`FixedBackOff(0L, 9)`). Failures are simply logged after retries are exhausted.

As an example; if the `poll` returns six records (two from each partition 0, 1, 2) and the listener throws an exception on the fourth record, the container acknowledges the first three messages by committing their offsets. The `DefaultErrorHandler` seeks to offset 1 for partition 1 and offset 0 for partition 2. The next `poll()` returns the three unprocessed records.

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

For a batch listener, the listener must throw a `BatchListenerFailedException` indicating which records in the batch failed.

The sequence of events is:

- Commit the offsets of the records before the index.
- If retries are not exhausted, perform seeks so that all the remaining records (including the failed record) will be redelivered.
- If retries are exhausted, attempt recovery of the failed record (default log only) and perform seeks so that the remaining records (excluding the failed record) will be redelivered. The recovered record’s offset is committed
- If retries are exhausted and recovery fails, seeks are performed as if retries are not exhausted.

The default recoverer logs the failed record after retries are exhausted. You can use a custom recoverer, or one provided by the framework such as the `DeadLetterPublishingRecoverer`.

When using a POJO batch listener (e.g. `List<Thing>`), and you don’t have the full consumer record to add to the exception, you can just add the index of the record that failed:
When the container is configured with `AckMode.MANUAL_IMMEDIATE`, the error handler can be configured to commit the offset of recovered records; set the `commitRecovered` property to `true`.

See also Publishing Dead-letter Records.

When using transactions, similar functionality is provided by the `DefaultAfterRollbackProcessor`. See After-rollback Processor.

The `DefaultErrorHandler` considers certain exceptions to be fatal, and retries are skipped for such exceptions; the recoverer is invoked on the first failure. The exceptions that are considered fatal, by default, are:

- `DeserializationException`
- `MessageConversionException`
- `ConversionException`
- `MethodArgumentResolutionException`
- `NoSuchMethodException`
- `ClassCastException`

since these exceptions are unlikely to be resolved on a retried delivery.

You can add more exception types to the not-retryable category, or completely replace the map of classified exceptions. See the Javadocs for `DefaultErrorHandler.addNotRetryableException()` and `DefaultErrorHandler.setClassifications()` for more information, as well as those for the spring-retry `BinaryExceptionClassifier`.

Here is an example that adds `IllegalArgumentException` to the not-retryable exceptions:
@Bean
defaultErrorHandler errorHandler(ConsumerRecordRecoverer recoverer) {
    DefaultErrorHandler handler = new DefaultErrorHandler(recoverer);
    handler.addNotRetryableExceptions(IllegalArgumentException.class);
    return handler;
}

The error handler can be configured with one or more RetryListener s, receiving notifications of retry and recovery progress.

@FunctionalInterface
public interface RetryListener {
    void failedDelivery(ConsumerRecord<?, ?> record, Exception ex, int deliveryAttempt);
    default void recovered(ConsumerRecord<?, ?> record, Exception ex) {
    }
    default void recoveryFailed(ConsumerRecord<?, ?> record, Exception original, Exception failure) {
    }
}

See the javadocs for more information.

If the recoverer fails (throws an exception), the failed record will be included in the seeks. If the recoverer fails, the BackOff will be reset by default and redeliveries will again go through the back offs before recovery is attempted again. To skip retries after a recovery failure, set the error handler's resetStateOnRecoveryFailure to false.

You can provide the error handler with a BiFunction<ConsumerRecord<?, ?>, Exception, BackOff> to determine the BackOff to use, based on the failed record and/or the exception:

    handler.setBackOffFunction((record, ex) -> { ... });

If the function returns null, the handler's default BackOff will be used.

Set resetStateOnExceptionChange to true and the retry sequence will be restarted (including the selection of a new BackOff, if so configured) if the exception type changes between failures. By
default, the exception type is not considered.

Also see Delivery Attempts Header.

Conversion Errors with Batch Error Handlers

Starting with version 2.8, batch listeners can now properly handle conversion errors, when using a MessageConverter with a ByteArrayDeserializer, a BytesDeserializer or a StringDeserializer, as well as a DefaultErrorHandler. When a conversion error occurs, the payload is set to null and a deserialization exception is added to the record headers, similar to the ErrorHandlingDeserializer. A list of ConversionException s is available in the listener so the listener can throw a BatchListenerFailedException indicating the first index at which a conversion exception occurred.

Example:

```java
@KafkaListener(id = "test", topics = "topic")
void listen(List<Thing> in, @Header(KafkaHeaders.CONVERSION_FAILURES) List<ConversionException> exceptions) {
    for (int i = 0; i < in.size(); i++) {
        Foo foo = in.get(i);
        if (foo == null && exceptions.get(i) != null) {
            throw new BatchListenerFailedException("Conversion error", exceptions.get(i), i);
        }
        process(foo);
    }
}
```

Retrying Complete Batches

This is now the fallback behavior of the DefaultErrorHandler for a batch listener where the listener throws an exception other than a BatchListenerFailedException.

There is no guarantee that, when a batch is redelivered, the batch has the same number of records and/or the redelivered records are in the same order. It is impossible, therefore, to easily maintain retry state for a batch. The FallbackBatchErrorHandler takes a the following approach. If a batch listener throws an exception that is not a BatchListenerFailedException, the retries are performed from the in-memory batch of records. In order to avoid a rebalance during an extended retry sequence, the error handler pauses the consumer, polls it before sleeping for the back off, for each retry, and calls the listener again. If/when retries are exhausted, the ConsumerRecordRecoverer is called for each record in the batch. If the recoverer throws an exception, or the thread is interrupted during its sleep, the batch of records will be redelivered on the next poll. Before exiting, regardless of the outcome, the consumer is resumed.

⚠️ This mechanism cannot be used with transactions.

While waiting for a BackOff interval, the error handler will loop with a short sleep until the desired
delay is reached, while checking to see if the container has been stopped, allowing the sleep to exit soon after the `stop()` rather than causing a delay.

**Container Stopping Error Handlers**

The `CommonContainerStoppingErrorHandler` stops the container if the listener throws an exception. For record listeners, when the `AckMode` is `RECORD`, offsets for already processed records are committed. For record listeners, when the `AckMode` is any manual value, offsets for already acknowledged records are committed. For record listeners, when the `AckMode` is `BATCH`, or for batch listeners, the entire batch is replayed when the container is restarted.

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

**Delegating Error Handler**

The `CommonDelegatingErrorHandler` can delegate to different error handlers, depending on the exception type. For example, you may wish to invoke a `DefaultErrorHandler` for most exceptions, or a `CommonContainerStoppingErrorHandler` for others.

**Logging Error Handler**

The `CommonLoggingErrorHandler` simply logs the exception; with a record listener, the remaining records from the previous poll are passed to the listener. For a batch listener, all the records in the batch are logged.

**Using Different Common Error Handlers for Record and Batch Listeners**

If you wish to use a different error handling strategy for record and batch listeners, the `CommonMixedErrorHandler` is provided allowing the configuration of a specific error handler for each listener type.

**Common Error Handler Summery**

- `DefaultErrorHandler`
- `CommonContainerStoppingErrorHandler`
- `CommonDelegatingErrorHandler`
- `CommonLoggingErrorHandler`
- `CommonMixedErrorHandler`

**Legacy Error Handlers and Their Replacements**

<table>
<thead>
<tr>
<th>Legacy Error Handler</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>LoggingErrorHandler</code></td>
<td><code>CommonLoggingErrorHandler</code></td>
</tr>
<tr>
<td><code>BatchLoggingErrorHandler</code></td>
<td><code>CommonLoggingErrorHandler</code></td>
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<tr>
<td><code>ConditionalDelegatingErrorHandler</code></td>
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<td><code>ConditionalDelegatingBatchErrorHandler</code></td>
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</tr>
<tr>
<td>Legacy Error Handler</td>
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<tr>
<td>----------------------------------------------------------</td>
<td>-----------------------------</td>
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<tr>
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<tr>
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<td>CommonContainerStoppingErrorHandler</td>
</tr>
<tr>
<td>SeekToCurrentErrorHandler</td>
<td>DefaultErrorHandler</td>
</tr>
<tr>
<td>SeekToCurrentBatchErrorHandler</td>
<td>No replacement, use DefaultErrorHandler with an infinite BackOff.</td>
</tr>
<tr>
<td>RecoveringBatchErrorHandler</td>
<td>DefaultErrorHandler</td>
</tr>
<tr>
<td>RetryingBatchErrorHandler</td>
<td>No replacements - use DefaultErrorHandler and throw an exception other than BatchListenerFailedException.</td>
</tr>
</tbody>
</table>

### Migrating Custom Legacy Error Handler Implementations to CommonErrorHandler

Refer to the javadocs in `CommonErrorHandler`.

To replace an `ErrorHandler` or `ConsumerAwareErrorHandler` implementation, you should implement `handleRecord()` and leave `remainingRecords()` to return `false` (default). You should also implement `handleOtherException()` - to handle exceptions that occur outside the scope of record processing (e.g. consumer errors).

To replace a `RemainingRecordsErrorHandler` implementation, you should implement `handleRemaining()` and override `remainingRecords()` to return `true`. You should also implement `handleOtherException()` - to handle exceptions that occur outside the scope of record processing (e.g. consumer errors).

To replace any `BatchErrorHandler` implementation, you should implement `handleBatch()` You should also implement `handleOtherException()` - to handle exceptions that occur outside the scope of record processing (e.g. consumer errors).

### 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) are 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 is reprocessed (the container has no knowledge of which record in the batch failed). To modify this behavior, you can 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 ten failures, the failed record is logged (at the `ERROR` level). You can configure the processor with a custom recoverer (`BiConsumer`) and maximum failures. Setting the `maxFailures` property to a negative number causes infinite retries. The following example configures recovery after three tries:
AfterRollbackProcessor<String, String> processor =
    new DefaultAfterRollbackProcessor((record, exception) -> {
        // recover after 3 failures, with no back off - e.g. send to a dead-letter topic
        }, new FixedBackOff(0L, 2L));

When you do not use transactions, you can achieve similar functionality by configuring a DefaultErrorHandler. See Container Error Handlers.

⚠️ 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.

See also Publishing Dead-letter Records.

Starting with version 2.2.5, the DefaultAfterRollbackProcessor can be invoked in a new transaction (started after the failed transaction rolls back). Then, if you are using the DeadLetterPublishingRecoverer to publish a failed record, the processor will send the recovered record's offset in the original topic/partition to the transaction. To enable this feature, set the commitRecovered and kafkaTemplate properties on the DefaultAfterRollbackProcessor.

⚠️ If the recoverer fails (throws an exception), the failed record will be included in the seeks. Starting with version 2.5.5, if the recoverer fails, the BackOff will be reset by default and redeliveries will again go through the back offs before recovery is attempted again. With earlier versions, the BackOff was not reset and recovery was re-attempted on the next failure. To revert to the previous behavior, set the processor's resetStateOnRecoveryFailure property to false.

Starting with version 2.6, you can now provide the processor with a BiFunction<ConsumerRecord<?>, Exception, BackOff> to determine the BackOff to use, based on the failed record and/or the exception:

```
handler.setBackOffFunction((record, ex) -> { ... });
```

If the function returns null, the processor's default BackOff will be used.

Starting with version 2.6.3, set resetStateOnExceptionChange to true and the retry sequence will be restarted (including the selection of a new BackOff, if so configured) if the exception type changes between failures. By default, the exception type is not considered.

Starting with version 2.3.1, similar to the DefaultErrorHandler, the DefaultAfterRollbackProcessor considers certain exceptions to be fatal, and retries are skipped for such exceptions; the recoverer is invoked on the first failure. The exceptions that are considered fatal, by default, are:
• DeserializationException
• MessageConversionException
• ConversionException
• MethodArgumentResolutionException
• NoSuchMethodException
• ClassCastException

since these exceptions are unlikely to be resolved on a retried delivery.

You can add more exception types to the not-retryable category, or completely replace the map of classified exceptions. See the Javadocs for DefaultAfterRollbackProcessor.setClassifications() for more information, as well as those for the spring-retry BinaryExceptionClassifier.

Here is an example that adds IllegalArgumentException to the not-retryable exceptions:

```java
@Bean
public DefaultAfterRollbackProcessor errorHandler(BiConsumer<ConsumerRecord<?, ?>, Exception> recoverer) {
    DefaultAfterRollbackProcessor processor = new DefaultAfterRollbackProcessor(recoverer);
    processor.addNotRetryableException(IllegalArgumentException.class);
    return processor;
}
```

Also see Delivery Attempts Header.

With current kafka-clients, the container cannot detect whether a ProducerFencedException is caused by a rebalance or if the producer's transactional.id has been revoked due to a timeout or expiry. Because, in most cases, it is caused by a rebalance, the container does not call the AfterRollbackProcessor (because it's not appropriate to seek the partitions because we no longer are assigned them). If you ensure the timeout is large enough to process each transaction and periodically perform an "empty" transaction (e.g. via a ListenerContainerIdleEvent) you can avoid fencing due to timeout and expiry. Or, you can set the stopContainerWhenFenced container property to true and the container will stop, avoiding the loss of records. You can consume a ConsumerStoppedEvent and check the Reason property for FENCED to detect this condition. Since the event also has a reference to the container, you can restart the container using this event.

Starting with version 2.7, while waiting for a BackOff interval, the error handler will loop with a short sleep until the desired delay is reached, while checking to see if the container has been stopped, allowing the sleep to exit soon after the stop() rather than causing a delay.

Starting with version 2.7, the processor can be configured with one or more RetryListener s,
receiving notifications of retry and recovery progress.

```java
@FunctionalInterface
public interface RetryListener {
    void failedDelivery(ConsumerRecord<?, ?> record, Exception ex, int deliveryAttempt);

    default void recovered(ConsumerRecord<?, ?> record, Exception ex) {
    }

    default void recoveryFailed(ConsumerRecord<?, ?> record, Exception original, Exception failure) {
    }
}
```

See the javadocs for more information.

**Delivery Attempts Header**

The following applies to record listeners only, not batch listeners.

Starting with version 2.5, when using an `ErrorHandler` or `AfterRollbackProcessor` that implements `DeliveryAttemptAware`, it is possible to enable the addition of the `KafkaHeaders.DELIVERY_ATTEMPT` header (`kafka_deliveryAttempt`) to the record. The value of this header is an incrementing integer starting at 1. When receiving a raw `ConsumerRecord<?, ?>` the integer is in a `byte[4].

```java
int delivery = ByteBuffer.wrap(record.headers().
    .lastHeader(KafkaHeaders.DELIVERY_ATTEMPT).value()).
    getInt()
```

When using `@KafkaListener` with the `DefaultKafkaHeaderMapper` or `SimpleKafkaHeaderMapper`, it can be obtained by adding `@Header(KafkaHeaders.DELIVERY_ATTEMPT) int delivery` as a parameter to the listener method.

To enable population of this header, set the container property `deliveryAttemptHeader` to `true`. It is disabled by default to avoid the (small) overhead of looking up the state for each record and adding the header.

The `DefaultErrorHandler` and `DefaultAfterRollbackProcessor` support this feature.

**Publishing Dead-letter Records**

You can configure the `DefaultErrorHandler` and `DefaultAfterRollbackProcessor` with a record
recoverer when the maximum number of failures is reached for a record. The framework provides the DeadLetterPublishingRecoverer, which publishes the failed message to another topic. The recoverer requires a KafkaTemplate<Object, Object>, which is used to send the record. You can also, optionally, configure it 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 you use 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, so the partition is selected by Kafka. Starting with version 2.2.4, any ListenerExecutionFailedException (thrown, for example, when an exception is detected in a @KafkaListener method) is enhanced with the groupId property. This allows the destination resolver to use this, in addition to the information in the ConsumerRecord to select the dead letter topic.

The following example shows how to wire a custom destination resolver:

```java
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 DefaultErrorHandler(recoverer, new FixedBackOff (0L, 2L));
```

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

- **KafkaHeaders.DLT_EXCEPTION_FQCN**: The Exception class name (generally a ListenerExecutionFailedException, but can be others).
- **KafkaHeaders.DLT_EXCEPTION_CAUSE_FQCN**: The Exception cause class name, if present (since version 2.8).
- **KafkaHeaders.DLT_EXCEPTION_STACKTRACE**: The Exception stack trace.
- **KafkaHeaders.DLT_EXCEPTION_MESSAGE**: The Exception message.
- **KafkaHeaders.DLT_KEY_EXCEPTION_FQCN**: The Exception class name (key deserialization errors only).
- **KafkaHeaders.DLT_KEY_EXCEPTION_STACKTRACE**: The Exception stack trace (key deserialization errors only).
Key exceptions are only caused by `DeserializationException` so there is no `DLT_KEY_EXCEPTION_CAUSE_FQCN`.

There are two mechanisms to add more headers.

1. Subclass the recoverer and override `createProducerRecord()` - call `super.createProducerRecord()` and add more headers.

2. Provide a `BiFunction` to receive the consumer record and exception, returning a `Headers` object; headers from there will be copied to the final producer record. Use `setHeadersFunction()` to set the `BiFunction`.

The second is simpler to implement but the first has more information available, including the already assembled standard headers.

Starting with version 2.3, when used in conjunction with an `ErrorHandlingDeserializer`, the publisher will restore the record `value()`, in the dead-letter producer record, to the original value that failed to be deserialized. Previously, the `value()` was null and user code had to decode the `DeserializationException` from the message headers. In addition, you can provide multiple `KafkaTemplate`s to the publisher; this might be needed, for example, if you want to publish the `byte[]` from a `DeserializationException`, as well as values using a different serializer from records that were deserialized successfully. Here is an example of configuring the publisher with `KafkaTemplate`s that use a `String` and `byte[]` serializer:

```java
@Bean
public DeadLetterPublishingRecoverer publisher(KafkaTemplate<?, ?> stringTemplate,
                                               KafkaTemplate<?, ?> bytesTemplate) {

    Map<Class<?>, KafkaTemplate<?, ?>> templates = new LinkedHashMap<>();
    templates.put(String.class, stringTemplate);
    templates.put(byte[].class, bytesTemplate);
    return new DeadLetterPublishingRecoverer(templates);
}
```
The publisher uses the map keys to locate a template that is suitable for the value() about to be published. A LinkedHashMap is recommended so that the keys are examined in order.

When publishing null values, when there are multiple templates, the recoverer will look for a template for the Void class; if none is present, the first template from the values().iterator() will be used.

Since 2.7 you can use the setFailIfSendResultIsError method so that an exception is thrown when message publishing fails. You can also set a timeout for the verification of the sender success with setWaitForSendResultTimeout.

If the recoverer fails (throws an exception), the failed record will be included in the seeks. Starting with version 2.5.5, if the recoverer fails, the BackOff will be reset by default and redeliveries will again go through the back offs before recovery is attempted again. With earlier versions, the BackOff was not reset and recovery was re-attempted on the next failure. To revert to the previous behavior, set the error handler's resetStateOnRecoveryFailure property to false.

Starting with version 2.6.3, set resetStateOnExceptionChange to true and the retry sequence will be restarted (including the selection of a new BackOff, if so configured) if the exception type changes between failures. By default, the exception type is not considered.

Starting with version 2.3, the recoverer can also be used with Kafka Streams - see Recovery from Deserialization Exceptions for more information.

The ErrorHandlingDeserializer adds the deserialization exception(s) in headers ErrorHandlingDeserializer.VALUE_DESERIALIZER_EXCEPTION_HEADER and ErrorHandlingDeserializer.KEY_DESERIALIZER_EXCEPTION_HEADER (using java serialization). By default, these headers are not retained in the message published to the dead letter topic. Starting with version 2.7, if both the key and value fail deserialization, the original values of both are populated in the record sent to the DLT.

If incoming records are dependent on each other, but may arrive out of order, it may be useful to republish a failed record to the tail of the original topic (for some number of times), instead of sending it directly to the dead letter topic. See this Stack Overflow Question for an example.

The following error handler configuration will do exactly that:
@Bean
public ErrorHandler eh(KafkaOperations<String, String> template) {
    return new DefaultErrorHandler(new DeadLetterPublishingRecoverer(template,
        (rec, ex) -> {
            org.apache.kafka.common.header.Header retries = rec.headers().
                lastHeader("retries");
            if (retries == null) {
                retries = new RecordHeader("retries", new byte[] \{ 1 \});
                rec.headers().add(retries);
            } else {
                retries.value()[0]++;
            }
            return retries.value()[0] > 5
                ? new TopicPartition("topic.DLT", rec.partition())
                : new TopicPartition("topic", rec.partition());
        })), new FixedBackOff(0L, 0L));
}

Starting with version 2.7, the recoverer checks that the partition selected by the destination resolver actually exists. If the partition is not present, the partition in the ProducerRecord is set to null, allowing the KafkaProducer to select the partition. You can disable this check by setting the verifyPartition property to false.

Managing Dead Letter Record Headers

Referring to Publishing Dead-letter Records above, the DeadLetterPublishingRecoverer has two properties used to manage headers when those headers already exist (such as when reprocessing a dead letter record that failed, including when using Non-Blocking Retries).

• appendOriginalHeaders (default true)
• stripPreviousExceptionHeaders (default true since version 2.8)

Apache Kafka supports multiple headers with the same name; to obtain the "latest" value, you can use headers.lastHeader(headerName); to get an iterator over multiple headers, use headers.headers(headerName).iterator().

When repeatedly republishing a failed record, these headers can grow (and eventually cause publication to fail due to a RecordTooLargeException); this is especially true for the exception headers and particularly for the stack trace headers.

The reason for the two properties is because, while you might want to retain only the last exception information, you might want to retain the history of which topic(s) the record passed through for each failure.

appendOriginalHeaders is applied to all headers named ORIGINAL while stripPreviousExceptionHeaders is applied to all headers named EXCEPTION.
Also see Failure Header Management with Non-Blocking Retries.

**ExponentialBackOffWithMaxRetries Implementation**

Spring Framework provides a number of BackOff implementations. By default, the `ExponentialBackOff` will retry indefinitely; to give up after some number of retry attempts requires calculating the `maxElapsedTime`. Since version 2.7.3, Spring for Apache Kafka provides the `ExponentialBackOffWithMaxRetries` which is a subclass that receives the `maxRetries` property and automatically calculates the `maxElapsedTime`, which is a little more convenient.

```java
@Bean
DefaultErrorHandler handler() {
    ExponentialBackOffWithMaxRetries bo = new ExponentialBackOffWithMaxRetries(6);
    bo.setInitialInterval(1_000L);
    bo.setMultiplier(2.0);
    bo.setMaxInterval(10_000L);
    return new DefaultErrorHandler(myRecoverer, bo);
}
```

This will retry after 1, 2, 4, 8, 10, 10 seconds, before calling the recoverer.

### 4.1.22. JAAS and Kerberos

Starting with version 2.0, a `KafkaJaasLoginModuleInitializer` class has been added to assist with Kerberos configuration. You can add this bean, with the desired configuration, to your application context. The following example configures such a bean:

```java
@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. Apache Kafka Streams Support

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

### 4.2.1. Basics

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

```java
// 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.
- **KafkaStreams**: To manage the lifecycle of those instances.

All `KStream` instances exposed to a `KafkaStreams` instance by a single `StreamsBuilder` are started and stopped at the same time, even if they have different logic. In other words, all streams defined by a `StreamsBuilder` are tied with a single lifecycle control. Once a `KafkaStreams` instance has been closed by `streams.close()`, it cannot be restarted. Instead, a new `KafkaStreams` instance to restart stream processing must be created.

### 4.2.2. Spring Management

To simplify using Kafka Streams from the Spring application context perspective and use the lifecycle management through a container, the Spring for Apache Kafka introduces `StreamsBuilderFactoryBean`. This is an `AbstractFactoryBean` implementation to expose a `StreamsBuilder` singleton instance as a bean. The following example creates such a bean:
@Bean
public FactoryBean<StreamsBuilder> myKStreamBuilder(KafkaStreamsConfiguration streamsConfig) {
    return new StreamsBuilderFactoryBean(streamsConfig);
}

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 the lifecycle of an internal KafkaStreams instance. Similar to the Kafka Streams API, you must define the KStream instances before you start the KafkaStreams. That also applies for the Spring API for Kafka Streams. Therefore, when you use default autoStartup = true on the StreamsBuilderFactoryBean, you must declare KStream instances on the StreamsBuilder before the application context is refreshed. For example, KStream can be a regular bean definition, while the Kafka Streams API is used without any impacts. The following example shows how to do so:

@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 the lifecycle manually (for example, stopping and starting by some condition), you can reference the StreamsBuilderFactoryBean bean directly by using the factory bean prefix. Since StreamsBuilderFactoryBean use its internal KafkaStreams instance, it is safe to stop and restart it again. A new KafkaStreams is created on each start(). You might also consider using different StreamsBuilderFactoryBean instances, if you would like to control the 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, you can use a KafkaStreamsCustomizer callback interface to configure an inner KafkaStreams instance. Note that KafkaStreamsCustomizer overrides the options provided by StreamsBuilderFactoryBean. If you need to perform some KafkaStreams operations directly, you can access that internal KafkaStreams instance by using StreamsBuilderFactoryBean.getKafkaStreams(). You can autowire StreamsBuilderFactoryBean bean by type, but you should be sure to use the full type in the bean definition, as the following example shows:
@Bean
public StreamsBuilderFactoryBean myKStreamBuilder(KafkaStreamsConfiguration streamsConfig) {
    return new StreamsBuilderFactoryBean(streamsConfig);
}

@Autowired
private StreamsBuilderFactoryBean myKStreamBuilderFactoryBean;

Alternatively, you can add @Qualifier for injection by name if you use interface bean definition. The following example shows how to do so:

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

@Autowired
@Qualifier("&myKStreamBuilder")
private StreamsBuilderFactoryBean myKStreamBuilderFactoryBean;

Starting with version 2.4.1, the factory bean has a new property infrastructureCustomizer with type KafkaStreamsInfrastructureCustomizer; this allows customization of the StreamsBuilder (e.g. to add a state store) and/or the Topology before the stream is created.

public interface KafkaStreamsInfrastructureCustomizer {
    void configureBuilder(StreamsBuilder builder);
    void configureTopology(Topology topology);
}

Default no-op implementations are provided to avoid having to implement both methods if one is not required.

A CompositeKafkaStreamsInfrastructureCustomizer is provided, for when you need to apply multiple customizers.
4.2.3. KafkaStreams Micrometer Support

Introduced in version 2.5.3, you can configure a KafkaStreamsMicrometerListener to automatically register micrometer meters for the KafkaStreams object managed by the factory bean:

```java
streamsBuilderFactoryBean.addListener(new KafkaStreamsMicrometerListener(meterRegistry, Collections.singletonList(new ImmutableTag("customTag", "customTagValue"))));
```

4.2.4. Streams JSON Serialization and Deserialization

For serializing and deserializing data when reading or writing to topics or state stores in JSON format, Spring for Apache Kafka provides a JsonSerde implementation that uses JSON, delegating to the JsonSerializer and JsonDeserializer described in Serialization, Deserialization, and Message Conversion. The JsonSerde implementation provides the same configuration options through its constructor (target type or ObjectMapper). In the following example, we use the JsonSerde to serialize and deserialize the Cat payload of a Kafka stream (the JsonSerde can be used in a similar fashion wherever an instance is required):

```java
stream
  .through(Serdes.Integer(), new JsonSerde<Cat.class>, "cats");
```

When constructing the serializer/deserializer programmatically for use in the producer/consumer factory, since version 2.3, you can use the fluent API, which simplifies configuration.

```java
stream
  .through(new JsonSerde<MyKeyType.class>
    .forKeys()
    .noTypeInfo(),
    new JsonSerde<MyValueType.class>
    .noTypeInfo(),
    "myTypes")
  .through(Serdes.Integer(), new JsonSerde<Cat.class>, "cats");
```

4.2.5. Using KafkaStreamBrancher

The KafkaStreamBrancher class introduces a more convenient way to build conditional branches on top of KStream.

Consider the following example that does not use KafkaStreamBrancher:
KStream<String, String>[] branches = builder.stream("source").branch(
    (key, value) -> value.contains("A"),
    (key, value) -> value.contains("B"),
    (key, value) -> true
);
branches[0].to("A");
branches[1].to("B");
branches[2].to("C");

The following example uses KafkaStreamBrancher:

```java
new KafkaStreamBrancher<String, String>()
    .branch((key, value) -> value.contains("A"), ks -> ks.to("A"))
    .branch((key, value) -> value.contains("B"), ks -> ks.to("B"))
    //default branch should not necessarily be defined in the end of the chain!
    .defaultBranch(ks -> ks.to("C"))
    .onTopOf(builder.stream("source"));
    //onTopOf method returns the provided stream so we can continue with method chaining
```

4.2.6. Configuration

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

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

To avoid boilerplate code for most cases, especially when you develop microservices, Spring for Apache Kafka provides the @EnableKafkaStreams annotation, which you should place on a @Configuration class. All you need is to declare a KafkaStreamsConfiguration bean named defaultKafkaStreamsConfig. A StreamsBuilderFactoryBean bean, named defaultKafkaStreamsBuilder, is automatically declared in the application context. You can declare and use any additional StreamsBuilderFactoryBean beans as well. You can perform additional customization of that bean, by providing a bean that implements StreamsBuilderFactoryBeanConfigurer. If there are multiple such beans, they will be applied according to their Ordered.order property.

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 let you control whether the cleanup() method is called during start() or stop() or neither. Starting with version 2.7, the default is to never clean up local state.
4.2.7. Header Enricher

Version 2.3 added the HeaderEnricher implementation of Transformer. This can be used to add headers within the stream processing; the header values are SpEL expressions; the root object of the expression evaluation has 3 properties:

- context - the ProcessorContext, allowing access to the current record metadata
- key - the key of the current record
- value - the value of the current record

The expressions must return a byte[] or a String (which will be converted to byte[] using UTF-8).

To use the enricher within a stream:

```
.stream().transform(() -> enricher)
```

The transformer does not change the key or value; it simply adds headers.

⚠️ If your stream is multi-threaded, you need a new instance for each record.

```
.stream().transform(() -> new HeaderEnricher..., ...)(expressionMap))
```

Here is a simple example, adding one literal header and one variable:

```
Map<String, Expression> headers = new HashMap<>();
headers.put("header1", new LiteralExpression("value1"));
SpelExpressionParser parser = new SpelExpressionParser();
headers.put("header2", parser.parseExpression("context.timestamp() + '@' +
context.offset()"));
HeaderEnricher<String, String> enricher = new HeaderEnricher<>(headers);
KStream<String, String> stream = builder.stream(INPUT);
stream
  .transform(() -> enricher)
  .to(OUTPUT);
```

4.2.8. MessagingTransformer

Version 2.3 added the MessagingTransformer this allows a Kafka Streams topology to interact with a Spring Messaging component, such as a Spring Integration flow. The transformer requires an implementation of MessagingFunction.
@FunctionalInterface
public interface MessagingFunction {
    Message<?> exchange(Message<?> message);
}

Spring Integration automatically provides an implementation using its GatewayProxyFactoryBean. It also requires a MessagingMessageConverter to convert the key, value and metadata (including headers) to/from a Spring Messaging Message<?>.

### 4.2.9. Recovery from Deserialization Exceptions

Version 2.3 introduced the RecoveringDeserializationExceptionHandler which can take some action when a deserialization exception occurs. Refer to the Kafka documentation about DeserializationExceptionHandler, of which the RecoveringDeserializationExceptionHandler is an implementation. The RecoveringDeserializationExceptionHandler is configured with a ConsumerRecordRecoverer implementation. The framework provides the DeadLetterPublishingRecoverer which sends the failed record to a dead-letter topic. See Publishing Dead-letter Records for more information about this recoverer.

To configure the recoverer, add the following properties to your streams configuration:

```java
@Bean(name = KafkaStreamsDefaultConfiguration.DEFAULT_STREAMS_CONFIG_BEAN_NAME)
public KafkaStreamsConfiguration kStreamsConfigs() {
    Map<String, Object> props = new HashMap<>();
    ...  
    props.put(StreamsConfig.DEFAULT_DESERIALIZATION_EXCEPTION_HANDLER_CLASS_CONFIG,
              RecoveringDeserializationExceptionHandler.class);
    props.put(RecoveringDeserializationExceptionHandler.KSTREAM_DESERIALIZATION_RECOVERER, recoverer());
    ...
    return new KafkaStreamsConfiguration(props);
}

@Bean
public DeadLetterPublishingRecoverer recoverer() {
    return new DeadLetterPublishingRecoverer(kafkaTemplate(),
                                              (record, ex) -> new TopicPartition("recovererDLQ", -1));
}
```

Of course, the recoverer() bean can be your own implementation of ConsumerRecordRecoverer.
4.2.10. Kafka Streams Example

The following example combines all the topics we have covered in this chapter:
@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.BOOTSTRAP_SERVERS_CONFIG, "localhost:9092");
        props.put(StreamsConfig.DEFAULT_KEY_SERDE_CLASS_CONFIG, Serdes.Integer().getClass().getName());
        props.put(StreamsConfig.DEFAULT_VALUE_SERDE_CLASS_CONFIG, Serdes.String().getClass().getName());
        props.put(StreamsConfig.DEFAULT_TIMESTAMP_EXTRACTOR_CLASS_CONFIG, WallclockTimestampExtractor.class.getName());
        return new KafkaStreamsConfiguration(props);
    }

    @Bean
    public StreamsBuilderFactoryBeanConfigurer configurer() {
        return fb -> fb.setStateListener((newState, oldState) -> {
            System.out.println("State transition from " + oldState + " to " + newState);
        });
    }

    @Bean
    public KStream<Integer, String> kStream(StreamsBuilder kStreamBuilder) {
        KStream<Integer, String> stream = kStreamBuilder.stream("streamingTopic1");
        stream
            .mapValues(((ValueMapper<String, String>) String::toUpperCase)
                .groupByKey()
                .windowedBy(TimeWindows.of(Duration.ofMillis(1000)))
                .reduce((String value1, String value2) -> value1 + value2,
                    Named.as("windowStore"))
                .toStream()
                .map((windowedId, value) -> new KeyValue<>(windowedId.key(),
                    value))
            .filter((i, s) -> s.length() > 40)
            .to("streamingTopic2");
        stream.print(Printed.toSysOut());
        return stream;
    }
}
4.3. Testing Applications

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

4.3.1. KafkaTestUtils

`o.s.kafka.test.utils.KafkaTestUtils` provides a number of static helper methods to consume records, retrieve various record offsets, and others. Refer to its Javadocs for complete details.

4.3.2. JUnit

`o.s.kafka.test.utils.KafkaTestUtils` also provides some static methods to set up producer and consumer properties. The following listing shows those method signatures:

```java
/**
 * 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> producerProps(EmbeddedKafkaBroker embeddedKafka)
    { ...
}
```

Starting with version 2.5, the `consumerProps` method sets the `ConsumerConfig.AUTO_OFFSET_RESET_CONFIG` to `earliest`. This is because, in most cases, you want the consumer to consume any messages sent in a test case. The `ConsumerConfig` default is `latest` which means that messages already sent by a test, before the consumer starts, will not receive those records. To revert to the previous behavior, set the property to `latest` after calling the method.

When using the embedded broker, it is generally best practice to use a different topic for each test, to prevent cross-talk. If this is not possible for some reason, note that the `consumeFromEmbeddedTopics` method's default behavior is to seek the assigned partitions to the beginning after assignment. Since it does not have access to the consumer properties, you must use the overloaded method that takes a `seekToEnd` boolean parameter to seek to the end instead of the beginning.
A JUnit 4 `@Rule` wrapper for the `EmbeddedKafkaBroker` is provided to create an embedded Kafka and an embedded Zookeeper server. (See `@EmbeddedKafka` Annotation for information about using `@EmbeddedKafka` with JUnit 5). The following listing shows the signatures of those methods:

```java
/**
 * 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 that lets you consume for all the topics it created. The following example shows how to use it:

```java
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. The following listing shows those method signatures:
/**
 * 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) {
    ...
}

The following example shows how to use KafkaTestUtils:

```java
... 

template.sendDefault(0, 2, "bar");

ConsumerRecord<Integer, String> received = KafkaTestUtils.getSingleRecord(
    consumer, "topic");

... 
```

When the embedded Kafka and embedded Zookeeper server are started by the EmbeddedKafkaBroker, a system property named `spring.embedded.kafka.brokers` is set to the address of the Kafka brokers and a system property named `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 servers. See Kafka Config for more information about possible broker properties.

### 4.3.3. Configuring Topics

The following example configuration creates topics called `cat` and `hat` with five partitions, a topic called `thing1` with 10 partitions, and a topic called `thing2` with 15 partitions:
public class MyTests {

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

    @Test
    public void test() {
        embeddedKafkaRule.getEmbeddedKafka()
            .addTopics(new NewTopic("thing1", 10, (short) 1), new NewTopic("thing2", 15, (short) 1));
        ...
    }
}

By default, addTopics will throw an exception when problems arise (such as adding a topic that already exists). Version 2.6 added a new version of that method that returns a Map<String, Exception>; the key is the topic name and the value is null for success, or an Exception for a failure.

4.3.4. Using the Same Broker(s) for Multiple Test Classes

There is no built-in support for doing so, but you can use the same broker for multiple test classes with something similar to the following:
public final class EmbeddedKafkaHolder {

    private static EmbeddedKafkaBroker embeddedKafka = new EmbeddedKafkaBroker(1, false)
            .brokerListProperty("spring.kafka.bootstrap-servers");

    private static boolean started;

    public static EmbeddedKafkaBroker getEmbeddedKafka() {
        if (!started) {
            try {
                embeddedKafka.afterPropertiesSet();
            } catch (Exception e) {
                throw new KafkaException("Embedded broker failed to start", e);
            }
            started = true;
        }
        return embeddedKafka;
    }

    private EmbeddedKafkaHolder() {
        super();
    }
}

This assumes a Spring Boot environment and the embedded broker replaces the bootstrap servers property.

Then, in each test class, you can use something similar to the following:

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

   private static final EmbeddedKafkaBroker broker = EmbeddedKafkaHolder.getEmbeddedKafka();

If you are not using Spring Boot, you can obtain the bootstrap servers using broker.getBrokersAsString().
The preceding 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 you should use something to call `destroy()` on the `EmbeddedKafkaBroker` when your tests are complete.

### 4.3.5. @EmbeddedKafka Annotation

We generally recommend that you use the rule as a `@ClassRule` to avoid starting and stopping the broker between tests (and use a different topic for each test). Starting with version 2.0, if you use 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, we provide a test class-level annotation called `@EmbeddedKafka` to register the `EmbeddedKafkaBroker` bean. The following example shows how to use it:
@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 KafkaStreamsConfiguration kStreamsConfigs() {
            Map<String, Object> props = new HashMap<>();
            props.put(StreamsConfig.APPLICATION_ID_CONFIG, "testStreams");
            props.put(StreamsConfig.BOOTSTRAP_SERVERS_CONFIG, this.
                brokerAddresses);
            return new KafkaStreamsConfiguration(props);
        }
    }
}

Starting with version 2.2.4, you can also use the @EmbeddedKafka annotation to specify the Kafka
The following example sets the topics, brokerProperties, and brokerPropertiesLocation attributes of @EmbeddedKafka support property placeholder resolutions:

```java
@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 preceding example, 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` URL. 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`.

You can use the @EmbeddedKafka annotation with JUnit 4 or JUnit 5.

### 4.3.6. @EmbeddedKafka Annotation with JUnit5

Starting with version 2.3, there are two ways to use the @EmbeddedKafka annotation with JUnit5. When used with the @SpringJUnitConfig annotation, the embedded broker is added to the test application context. You can auto wire the broker into your test, at the class or method level, to get the broker address list.

When not using the spring test context, the EmbeddedKafkaCondition creates a broker; the condition includes a parameter resolver so you can access the broker in your test method...

```java
@EmbeddedKafka
public class EmbeddedKafkaConditionTests {

    @Test
    public void test(EmbeddedKafkaBroker broker) {
        String brokerList = broker.getBrokersAsString();
        ...
    }
}
```

A stand-alone (not Spring test context) broker will be created if the class annotated with
@EmbeddedBroker is not also annotated (or meta annotated) with `ExtendedWith(SpringExtension.class)`. `@SpringJUnitConfig` and `@SpringBootTest` are so meta annotated and the context-based broker will be used when either of those annotations are also present.

When there is a Spring test application context available, the topics and broker properties can contain property placeholders, which will be resolved as long as the property is defined somewhere. If there is no Spring context available, these placeholders won’t be resolved.

### 4.3.7. Embedded Broker in `@SpringBootTest` Annotations

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

If your application uses the Kafka binder in `spring-cloud-stream` and 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 cases. If you wish some tests to use the test binder and some to use the embedded broker, tests that use the real binder need to disable the test binder by excluding the binder auto configuration in the test class. The following example shows how to do so:

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

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

They include:

- JUnit4 Class Rule
- `@EmbeddedKafka` Annotation or `EmbeddedKafkaBroker` Bean

### JUnit4 Class Rule

The following example shows how to use a JUnit4 class rule to create an embedded broker:
@RunWith(SpringRunner.class)
@SpringBootTest
public class MyApplicationTests {

    @ClassRule
    public static EmbeddedKafkaRule broker = new EmbeddedKafkaRule(1,
        false, "someTopic")
        .brokerListProperty("spring.kafka.bootstrap-servers");

    @Autowired
    private KafkaTemplate<String, String> template;

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

Notice that, since this is a Spring Boot application, we override the broker list property to set Boot’s property.

@EmbeddedKafka Annotation or EmbeddedKafkaBroker Bean

The following example shows how to use an @EmbeddedKafka Annotation to create an embedded broker:

@RunWith(SpringRunner.class)
@EmbeddedKafka(topics = "someTopic",
    bootstrapServersProperty = "spring.kafka.bootstrap-servers")
public class MyApplicationTests {

    @Autowired
    private KafkaTemplate<String, String> template;

    @Test
    public void test() {
        ...
    }
}
4.3.8. Hamcrest Matchers

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

```java
/**
 * @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 ConsumerRecord assuming 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 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);
}
```
4.3.9. AssertJ Conditions

You can use the following 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 key the key.
 * @param value the value.
 * @param <K> the key type.
 * @param <V> the value type.
 * @return a Condition that matches the key in a consumer record.
 * @since 2.2.12
 */
public static <K, V> Condition<ConsumerRecord<K, V>> keyValue(K key, 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);
}
4.3.10. Example

The following example brings together most of the topics covered in this chapter:
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.getEmbeddedKafka());
        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.setMessageListener(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> producerProps = KafkaTestUtils.producerProps(embeddedKafka
                .getEmbeddedKafka());
        ProducerFactory<Integer, String> pf = new DefaultKafkaProducerFactory<Integer, String>
                (producerProps);
        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);
    }
}
The preceding example uses the Hamcrest matchers. With AssertJ, the final part looks like the following code:

```java
assertThat(records.poll(10, TimeUnit.SECONDS)).has(value("foo"));
template.sendDefault(0, 2, "bar");
ConsumerRecord<Integer, String> received = records.poll(10, TimeUnit.SECONDS);
// using individual assertions
assertThat(received).has(key(2));
assertThat(received).has(value("bar"));
assertThat(received).has(partition(0));
template.send(Template, 0, 2, "baz");
received = records.poll(10, TimeUnit.SECONDS);
// using allOf()
assertThat(received).has(allOf(keyValue(2, "baz"), partition(0)));
```

### 4.4. Non-Blocking Retries

This is an experimental feature and the usual rule of no breaking API changes does not apply to this feature until the experimental designation is removed. Users are encouraged to try out the feature and provide feedback via GitHub Issues or GitHub discussions. This is regarding the API only; the feature is considered to be complete, and robust.

Achieving non-blocking retry / dlt functionality with Kafka usually requires setting up extra topics and creating and configuring the corresponding listeners. Since 2.7 Spring for Apache Kafka offers support for that via the @RetryableTopic annotation and RetryTopicConfiguration class to simplify that bootstrapping.

#### 4.4.1. How The Pattern Works

If message processing fails, the message is forwarded to a retry topic with a back off timestamp. The retry topic consumer then checks the timestamp and if it’s not due it pauses the consumption
for that topic's partition. When it is due the partition consumption is resumed, and the message is consumed again. If the message processing fails again the message will be forwarded to the next retry topic, and the pattern is repeated until a successful processing occurs, or the attempts are exhausted, and the message is sent to the Dead Letter Topic (if configured).

To illustrate, if you have a "main-topic" topic, and want to setup non-blocking retry with an exponential backoff of 1000ms with a multiplier of 2 and 4 max attempts, it will create the main-topic-retry-1000, main-topic-retry-2000, main-topic-retry-4000 and main-topic-dlt topics and configure the respective consumers. The framework also takes care of creating the topics and setting up and configuring the listeners.

- By using this strategy you lose Kafka's ordering guarantees for that topic.
- You can set the AckMode mode you prefer, but RECORD is suggested.
- At this time this functionality doesn't support class level @KafkaListener annotations

### 4.4.2. Back Off Delay Precision

#### Overview and Guarantees

All message processing and backing off is handled by the consumer thread, and, as such, delay precision is guaranteed on a best-effort basis. If one message's processing takes longer than the next message's back off period for that consumer, the next message's delay will be higher than expected. Also, for short delays (about 1s or less), the maintenance work the thread has to do, such as committing offsets, may delay the message processing execution. The precision can also be affected if the retry topic's consumer is handling more than one partition, because we rely on waking up the consumer from polling and having full pollTimeouts to make timing adjustments.

That being said, for consumers handling a single partition the message's processing should happen under 100ms after it's exact due time for most situations.

- It is guaranteed that a message will never be processed before its due time.

#### Tuning the Delay Precision

The message's processing delay precision relies on two ContainerProperties: `ContainerProperties.pollTimeout` and `ContainerProperties.idlePartitionEventInterval`. Both properties will be automatically set in the retry topic and dlt's `ListenerContainerFactory` to one quarter of the smallest delay value for that topic, with a minimum value of 250ms and a maximum value of 5000ms. These values will only be set if the property has its default values - if you change either value yourself your change will not be overridden. This way you can tune the precision and performance for the retry topics if you need to.
You can have separate ListenerContainerFactory instances for the main and retry topics - this way you can have different settings to better suit your needs, such as having a higher polling timeout setting for the main topics and a lower one for the retry topics.

### 4.4.3. Configuration

#### Using the @RetryableTopic annotation

To configure the retry topic and dlt for a @KafkaListener annotated method, you just have to add the @RetryableTopic annotation to it and Spring for Apache Kafka will bootstrap all the necessary topics and consumers with the default configurations.

```java
@RetryableTopic(kafkaTemplate = "myRetryableTopicKafkaTemplate")
@KafkaListener(topics = "my-annotated-topic", groupId = "myGroupId")
public void processMessage(MyPojo message) {
    // ... message processing
}
```

You can specify a method in the same class to process the dlt messages by annotating it with the @DltHandler annotation. If no DltHandler method is provided a default consumer is created which only logs the consumption.

```java
@DltHandler
public void processMessage(MyPojo message) {
    // ... message processing, persistence, etc
}
```

If you don't specify a kafkaTemplate name a bean with name retryTopicDefaultKafkaTemplate will be looked up. If no bean is found an exception is thrown.

#### Using RetryTopicConfiguration beans

You can also configure the non-blocking retry support by creating RetryTopicConfiguration beans in a @Configuration annotated class.
```java
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, Object> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .create(template);
}
```

This will create retry topics and a dlt, as well as the corresponding consumers, for all topics in methods annotated with `@KafkaListener` using the default configurations. The `KafkaTemplate` instance is required for message forwarding.

To achieve more fine-grained control over how to handle non-blocking retrials for each topic, more than one `RetryTopicConfiguration` bean can be provided.

```java
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, MyPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .fixedBackoff(3000)
        .maxAttempts(5)
        .includeTopics("my-topic", "my-other-topic")
        .create(template);
}
```

```java
@Bean
public RetryTopicConfiguration myOtherRetryTopic(KafkaTemplate<String, MyOtherPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .exponentialBackoff(1000, 2, 5000)
        .maxAttempts(4)
        .excludeTopics("my-topic", "my-other-topic")
        .retryOn(MyException.class)
        .create(template);
}
```

The retry topics' and dlt's consumers will be assigned to a consumer group with a group id that is the combination of the one with you provide in the `groupId` parameter of the `@KafkaListener` annotation with the topic's suffix. If you don't provide any they'll all belong to the same group, and rebalance on a retry topic will cause an unnecessary rebalance on the main topic.
If the consumer is configured with an `ErrorHandlingDeserializer`, to handle deserialization exceptions, it is important to configure the `KafkaTemplate` and its producer with a serializer that can handle normal objects as well as raw `byte[]` values, which result from deserialization exceptions. The generic value type of the template should be `Object`. One technique is to use the `DelegatingByTypeSerializer`; an example follows:

```java
@Bean
public ProducerFactory<String, Object> producerFactory() {
    return new DefaultKafkaProducerFactory<>(producerConfiguration(), new StringSerializer(),
        new DelegatingByTypeSerializer(Map.of(byte[].class, new ByteArraySerializer(),
            MyNormalObject.class, new JsonSerializer<Object>()));
}

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

### 4.4.4. Features

Most of the features are available both for the `@RetryableTopic` annotation and the `RetryTopicConfiguration` beans.

#### BackOff Configuration

The BackOff configuration relies on the `BackOffPolicy` interface from the `Spring Retry` project.

It includes:

- Fixed Back Off
- Exponential Back Off
- Random Exponential Back Off
- Uniform Random Back Off
- No Back Off
- Custom Back Off
@RetryableTopic(attempts = 5, 
    backoff = @Backoff(delay = 1000, multiplier = 2, maxDelay = 5000))
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}

@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, MyPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .fixedBackoff(3000)
        .maxAttempts(4)
        .build();
}

You can also provide a custom implementation of Spring Retry’s `SleepingBackOffPolicy` interface:

@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, MyPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .customBackOff(new MyCustomBackOffPolicy())
        .maxAttempts(5)
        .build();
}

The default backoff policy is `FixedBackOffPolicy` with a maximum of 3 attempts and 1000ms intervals.

There is a 30-second default maximum delay for the `ExponentialBackOffPolicy`. If your back off policy requires delays with values bigger than that, adjust the `maxDelay` property accordingly.

The first attempt counts against `maxAttempts`, so if you provide a `maxAttempts` value of 4 there’ll be the original attempt plus 3 retries.

**Single Topic Fixed Delay Retries**

If you’re using fixed delay policies such as `FixedBackOffPolicy` or `NoBackOffPolicy` you can use a
single topic to accomplish the non-blocking retries. This topic will be suffixed with the provided or default suffix, and will not have either the index or the delay values appended.

```java
@RetryableTopic(backoff = @Backoff(2000), fixedDelayTopicStrategy = FixedDelayStrategy.SINGLE_TOPIC)
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}
```

```java
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, MyPojo> template) {
    return RetryTopicConfigurationBuilder.newInstance()
        .fixedBackoff(3000)
        .maxAttempts(5)
        .useSingleTopicForFixedDelays()
        .build();
}
```

The default behavior is creating separate retry topics for each attempt, appended with their index value: retry-0, retry-1, ...

**Global timeout**

You can set the global timeout for the retrying process. If that time is reached, the next time the consumer throws an exception the message goes straight to the DLT, or just ends the processing if no DLT is available.

```java
@RetryableTopic(backoff = @Backoff(2000), timeout = 5000)
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}
```
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, MyPojo> template) {
  return RetryTopicConfigurationBuilder
    .newInstance()  
    .fixedBackoff(2000)  
    .timeoutAfter(5000)  
    .build();
}

The default is having no timeout set, which can also be achieved by providing -1 as the timeout value.

**Exception Classifier**

You can specify which exceptions you want to retry on and which not to. You can also set it to traverse the causes to lookup nested exceptions.

@RetryableTopic(include = {MyRetryException.class, MyOtherRetryException.class}, traversingCauses = true)
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
  throw new RuntimeException(new MyRetryException());  // Will retry
}

@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, MyOtherPojo> template) {
  return RetryTopicConfigurationBuilder  
    .newInstance()  
    .notRetryOn(MyDontRetryException.class)  
    .create(template);
}

The default behavior is retrying on all exceptions and not traversing causes.

Since 2.8.3 there’s a global list of fatal exceptions which will cause the record to be sent to the DLT without any retries. See DefaultErrorHandler for the default list of fatal exceptions. You can add or remove exceptions to and from this list with:
@Bean(name = RetryTopicInternalBeanNames.DESTINATION_TOPIC_CONTAINER_NAME)
public DefaultDestinationTopicResolver topicResolver(ApplicationContext applicationContext,
        @Qualifier(RetryTopicInternalBeanNames
        .INTERNAL_BACKOFF_CLOCK_BEAN_NAME) Clock clock) {
    DefaultDestinationTopicResolver ddtr = new DefaultDestinationTopicResolver
            (clock, applicationContext);
    ddtr.addNotRetryableExceptions(MyFatalException.class);
    ddtr.removeNotRetryableException(ConversionException.class);
    return ddtr;
}

To disable fatal exceptions' classification, clear the default list using the
setClassifications method in DefaultDestinationTopicResolver.

Include and Exclude Topics

You can decide which topics will and will not be handled by a RetryTopicConfiguration bean via the
.includeTopic(String topic), .includeTopics(Collection<String> topics) .excludeTopic(String topic) and
.excludeTopics(Collection<String> topics) methods.

@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<Integer, MyPojo>
        template) {
    return RetryTopicConfigurationBuilder
            .newInstance()
            .includeTopics(List.of("my-included-topic", "my-other-included-topic"
            ))
            .create(template);
}

@Bean
public RetryTopicConfiguration myOtherRetryTopic(KafkaTemplate<Integer, MyPojo>
        template) {
    return RetryTopicConfigurationBuilder
            .newInstance()
            .excludeTopic("my-excluded-topic")
            .create(template);
}

The default behavior is to include all topics.
Topics AutoCreation

Unless otherwise specified the framework will auto create the required topics using `NewTopic` beans that are consumed by the `KafkaAdmin` bean. You can specify the number of partitions and the replication factor with which the topics will be created, and you can turn this feature off.

Note that if you’re not using Spring Boot you’ll have to provide a KafkaAdmin bean in order to use this feature.

```java
@RetryableTopic(numPartitions = 2, replicationFactor = 3)
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}

@RetryableTopic(autoCreateTopics = false)
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}
```

```java
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<Integer, MyPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .autoCreateTopicsWith(2, 3)
        .create(template);
}

@Bean
public RetryTopicConfiguration myOtherRetryTopic(KafkaTemplate<Integer, MyPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .doNotAutoCreateRetryTopics()
        .create(template);
}
```

By default the topics are autocreated with one partition and a replication factor of one.

Failure Header Management

When considering how to manage failure headers (original headers and exception headers), the framework delegates to the `DeadLetterPublishingRecover` to decide whether to append or replace the
headers.

By default, it explicitly sets `appendOriginalHeaders` to `false` and leaves `stripPreviousExceptionHeaders` to the default used by the `DeadLetterPublishingRecover`.

This means that only the first "original" and last exception headers are retained with the default configuration. This is to avoid creation of excessively large messages (due to the stack trace header, for example) when many retry steps are involved.

See Managing Dead Letter Record Headers for more information.

To reconfigure the framework to use different settings for these properties, replace the standard `DeadLetterPublishingRecovererFactory` bean by adding a `recovererCustomizer`:

```java
@Bean(RetryTopicInternalBeanNames.DEAD_LETTER_PUBLISHING_RECOVERER_FACTORY_BEAN_NAME)
DeadLetterPublishingRecovererFactory factory(DestinationTopicResolver resolver) {
    DeadLetterPublishingRecovererFactory factory = new DeadLetterPublishingRecovererFactory(resolver);
    factory.setDeadLetterPublishingRecovererCustomizer(dlpr -> {
        dlpr.appendOriginalHeaders(true);
        dlpr.setStripPreviousExceptionHeaders(false);
    });
    return factory;
}
```

### 4.4.5. Combining blocking and non-blocking retries

Starting in 2.8.4 you can configure the framework to use both blocking and non-blocking retries in conjunction. For example, you can have a set of exceptions that would likely trigger errors on the next records as well, such as `DatabaseAccessException`, so you can retry the same record a few times before sending it to the retry topic, or straight to the DLT.

To configure blocking retries you just need to add the exceptions you want to retry through the `addRetryableExceptions` method in the `ListenerContainerFactoryConfigurer` bean as follows. The default policy is `FixedBackOff`, with nine retries and no delay between them. Optionally, you can provide your own back off policy.
```java
@Bean(name = RetryTopicInternalBeanNames.LISTENER_CONTAINER_FACTORY_CONFIGURER_NAME)
public ListenerContainerFactoryConfigurer lcfc(KafkaConsumerBackoffManager kafkaConsumerBackoffManager,
                                           DeadLetterPublishingRecovererFactory deadLetterPublishingRecovererFactory,
                                           @Qualifier(RetryTopicInternalBeanNames.INTERNAL_BACKOFF_CLOCK_BEAN_NAME) Clock clock) {

    ListenerContainerFactoryConfigurer lcfc = new ListenerContainerFactoryConfigurer(kafkaConsumerBackoffManager,
                                                                                     deadLetterPublishingRecovererFactory, clock);
    lcfc.setBlockingRetryableExceptions(MyBlockingRetryException.class,
                                         MyOtherBlockingRetryException.class);
    lcfc.setBlockingRetriesBackOff(new FixedBackOff(500, 5)); // Optional
    return lcfc;
}
```

If you need to further tune the exception classification, you can set your own Map of classifications through the `ListenerContainerFactoryConfigurer.setErrorHandlerCustomizer()` method, such as:

```java
lcfc.setErrorHandlerCustomizer(ceh -> ((DefaultErrorHandler) ceh)
                               .setClassifications(myClassificationsMap, myDefaultValue));
```

In combination with the global retryable topic's fatal exceptions classification, you can configure the framework for any behavior you'd like, such as having some exceptions trigger both blocking and non-blocking retries, trigger only one kind or the other, or go straight to the DLT without retries of any kind.

Here's an example with both configurations working together:
In this example:

- `ShouldRetryOnlyBlockingException.class` would retry only via blocking and, if all retries fail, would go straight to the DLT.

- `ShouldRetryViaBothException.class` would retry via blocking, and if all blocking retries fail would be forwarded to the next retry topic for another set of attempts.

- `ShouldSkipBothRetriesException.class` would never be retried in any way and would go straight to the DLT if the first processing attempt failed.

Note that the blocking retries behavior is allowlist - you add the exceptions you do want to retry that way; while the non-blocking retries classification is geared towards FATAL exceptions and as such is denylist - you add the exceptions you don’t want to do non-blocking retries, but to send directly to the DLT instead.

The non-blocking exception classification behavior also depends on the specific topic’s configuration.
4.4.6. Topic Naming

Retry topics and DLT are named by suffixing the main topic with a provided or default value, appended by either the delay or index for that topic.

Examples:

"my-topic" → "my-topic-retry-0", "my-topic-retry-1", ..., "my-topic-dlt"

"my-other-topic" → "my-topic-myRetrySuffix-1000", "my-topic-myRetrySuffix-2000", ..., "my-topic-myDltSuffix".

Retry Topics and Dlt Suffixes

You can specify the suffixes that will be used by the retry and dlt topics.

```java
@RetryableTopic(retryTopicSuffix = "-my-retry-suffix", dltTopicSuffix = "-my-dlt-suffix")
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}
```

```java
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<String, MyOtherPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .retryTopicSuffix("-my-retry-suffix")
        .dltTopicSuffix("-my-dlt-suffix")
        .create(template);
}
```

The default suffixes are "-retry" and "-dlt", for retry topics and dlt respectively.

Appending the Topic's Index or Delay

You can either append the topic's index or delay values after the suffix.
The default behavior is to suffix with the delay values, except for fixed delay configurations with multiple topics, in which case the topics are suffixed with the topic's index.

Custom naming strategies

More complex naming strategies can be accomplished by registering a bean that implements RetryTopicNamesProviderFactory. The default implementation is SuffixingRetryTopicNamesProviderFactory and a different implementation can be registered in the following way:

```java
@Bean
public RetryTopicNamesProviderFactory myRetryNamingProviderFactory() {
    return new CustomRetryTopicNamesProviderFactory();
}
```

As an example the following implementation, in addition to the standard suffix, adds a prefix to retry/dl topics names:
public class CustomRetryTopicNamesProviderFactory implements RetryTopicNamesProviderFactory {

    @Override
    public RetryTopicNamesProvider createRetryTopicNamesProvider(
            DestinationTopic.Properties properties) {

        if(properties.isMainEndpoint()) {
            return new SuffixingRetryTopicNamesProvider(properties);
        } else {
            return new SuffixingRetryTopicNamesProvider(properties) {

                @Override
                public String getTopicName(String topic) {
                    return "my-prefix-" + super.getTopicName(topic);
                }

            };
        }
    }
}

4.4.7. Dlt Strategies

The framework provides a few strategies for working with DLTs. You can provide a method for DLT processing, use the default logging method, or have no DLT at all. Also you can choose what happens if DLT processing fails.

Dlt Processing Method

You can specify the method used to process the Dlt for the topic, as well as the behavior if that processing fails.

To do that you can use the @DltHandler annotation in a method of the class with the @RetryableTopic annotation(s). Note that the same method will be used for all the @RetryableTopic annotated methods within that class.
The DLT handler method can also be provided through the `RetryTopicConfigurationBuilder.dltHandlerMethod(String, String)` method, passing as arguments the bean name and method name that should process the DLT’s messages.

```
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<Integer, MyPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .dltProcessor("myCustomDltProcessor", "processDltMessage")
        .create(template);
}

@Component
public class MyCustomDltProcessor {

    private final MyDependency myDependency;

    public MyCustomDltProcessor(MyDependency myDependency) {
        this.myDependency = myDependency;
    }

    public void processDltMessage(MyPojo message) {
        // ... message processing, persistence, etc
    }
}
```

If no DLT handler is provided, the default `RetryTopicConfigurer.LoggingDltListenerHandlerMethod` is used.

Starting with version 2.8, if you don’t want to consume from the DLT in this application at all, including by the default handler (or you wish to defer consumption), you can control whether or not the DLT container starts, independent of the container factory’s `autoStartup` property.
When using the `@RetryableTopic` annotation, set the `autoStartDltHandler` property to `false`; when using the configuration builder, use `.autoStartDltHandler(false)`.

You can later start the DLT handler via the `KafkaListenerEndpointRegistry`.

**DLT Failure Behavior**

Should the DLT processing fail, there are two possible behaviors available: `ALWAYS_RETRY_ON_ERROR` and `FAIL_ON_ERROR`.

In the former the record is forwarded back to the DLT topic so it doesn’t block other DLT records’ processing. In the latter the consumer ends the execution without forwarding the message.

```java
@RetryableTopic(dltProcessingFailureStrategy = DltStrategy.FAIL_ON_ERROR)
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}
```

```java
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<Integer, MyPojo> template) {
    return RetryTopicConfigurationBuilder
        .newInstance()
        .dltProcessor(MyCustomDltProcessor.class, "processDltMessage")
        .doNotRetryOnDltFailure()
        .create(template);
}
```

The default behavior is to `ALWAYS_RETRY_ON_ERROR`.

Starting with version 2.8.3, `ALWAYS_RETRY_ON_ERROR` will NOT route a record back to the DLT if the record causes a fatal exception to be thrown, such as a `DeserializationException` because, generally, such exceptions will always be thrown.

Exceptions that are considered fatal are:

- `DeserializationException`
- `MessageConversionException`
- `ConversionException`
- `MethodArgumentResolutionException`
- `NoSuchMethodException`
You can add exceptions to and remove exceptions from this list using methods on the DestinationTopicResolver bean.

See Exception Classifier for more information.

Configuring No DLT

The framework also provides the possibility of not configuring a DLT for the topic. In this case after retrials are exhausted the processing simply ends.

```java
@RetryableTopic(dltProcessingFailureStrategy = DltStrategy.NO_DLT)
@KafkaListener(topics = "my-annotated-topic")
public void processMessage(MyPojo message) {
    // ... message processing
}
```

```java
@Bean
public RetryTopicConfiguration myRetryTopic(KafkaTemplate<Integer, MyPojo> template) {
    return RetryTopicConfigurationBuilder.newInstance()
        .doNotConfigureDlt()
        .create(template);
}
```

4.4.8. Specifying a ListenerContainerFactory

By default the RetryTopic configuration will use the provided factory from the @KafkaListener annotation, but you can specify a different one to be used to create the retry topic and dlt listener containers.

For the @RetryableTopic annotation you can provide the factory's bean name, and using the RetryTopicConfiguration bean you can either provide the bean name or the instance itself.
Since 2.8.3 you can use the same factory for retryable and non-retryable topics.

If you need to revert the factory configuration behavior to prior 2.8.3, you can replace the standard `RetryTopicConfigurer` bean and set `useLegacyFactoryConfigurer` to `true`, such as:
4.4.9. Changing KafkaBackOffException Logging Level

When a message in the retry topic is not due for consumption, a KafkaBackOffException is thrown. Such exceptions are logged by default at DEBUG level, but you can change this behavior by setting an error handler customizer in the ListenerContainerFactoryConfigurer in a @Configuration class.

For example, to change the logging level to WARN you might add:

```java
@Bean(name = RetryTopicInternalBeanNames.RETRY_TOPIC_CONFIGURER)
public RetryTopicConfigurer retryTopicConfigurer(DestinationTopicProcessor
destinationTopicProcessor, ListenerContainerFactoryResolver
containerFactoryResolver, ListenerContainerFactoryConfigurer
listenerContainerFactoryConfigurer, BeanFactory beanFactory,
RetryTopicNamesProviderFactory retryTopicNamesProviderFactory) {
    RetryTopicConfigurer retryTopicConfigurer = new RetryTopicConfigurer
    (destinationTopicProcessor, containerFactoryResolver,
     listenerContainerFactoryConfigurer, beanFactory, retryTopicNamesProviderFactory);
    retryTopicConfigurer.useLegacyFactoryConfigurer(true);
    return retryTopicConfigurer;
}
```
Chapter 5. Tips, Tricks and Examples

5.1. Manually Assigning All Partitions

Let’s say you want to always read all records from all partitions (such as when using a compacted topic to load a distributed cache), it can be useful to manually assign the partitions and not use Kafka’s group management. Doing so can be unwieldy when there are many partitions, because you have to list the partitions. It’s also an issue if the number of partitions changes over time, because you would have to recompile your application each time the partition count changes.

The following is an example of how to use the power of a SpEL expression to create the partition list dynamically when the application starts:

```java
@KafkaListener(topicPartitions = @TopicPartition(topic = "compacted",
partitions = "#{finder.partitions('compacted')}"),
partitionOffsets = @PartitionOffset(partition = "*", initialOffset = "0"))
public void listen(@Header(KafkaHeaders.RECEIVED_MESSAGE_KEY) String key, String payload) {
...
}

@Bean
public PartitionFinder finder(ConsumerFactory<String, String> consumerFactory) {
    return new PartitionFinder(consumerFactory);
}

class PartitionFinder {
    private final ConsumerFactory<String, String> consumerFactory;

    public PartitionFinder(ConsumerFactory<String, String> consumerFactory) {
        this.consumerFactory = consumerFactory;
    }

    public String[] partitions(String topic) {
        try (Consumer<String, String> consumer = consumerFactory.createConsumer()) {
            return consumer.partitionsFor(topic).stream()
                .map(pi -> "" + pi.partition())
                .toArray(String[]::new);
        }
    }
}
```
Using this in conjunction with `ConsumerConfig.AUTO_OFFSET_RESET_CONFIG=earliest` will load all records each time the application is started. You should also set the container's `AckMode` to `MANUAL` to prevent the container from committing offsets for a `null` consumer group. However, starting with version 2.5.5, as shown above, you can apply an initial offset to all partitions; see Explicit Partition Assignment for more information.

### 5.2. Examples of Kafka Transactions with Other Transaction Managers

The following Spring Boot application is an example of chaining database and Kafka transactions. The listener container starts the Kafka transaction and the `@Transactional` annotation starts the DB transaction. The DB transaction is committed first; if the Kafka transaction fails to commit, the record will be redelivered so the DB update should be idempotent.
@SpringBootApplication
public class Application {

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

    @Bean
    public ApplicationRunner runner(KafkaTemplate<String, String> template) {
        return args -> template.executeInTransaction(t -> t.send("topic1", "test"));
    }

    @Bean
    public DataSourceTransactionManager dstm(DataSource dataSource) {
        return new DataSourceTransactionManager(dataSource);
    }

    @Component
    public static class Listener {

        private final JdbcTemplate jdbcTemplate;
        private final KafkaTemplate<String, String> kafkaTemplate;

        public Listener(JdbcTemplate jdbcTemplate, KafkaTemplate<String, String> kafkaTemplate) {
            this.jdbcTemplate = jdbcTemplate;
            this.kafkaTemplate = kafkaTemplate;
        }

        @KafkaListener(id = "group1", topics = "topic1")
        @Transactional("dstm")
        public void listen1(String in) {
            this.kafkaTemplate.send("topic2", in.toUpperCase());
            this.jdbcTemplate.execute("insert into mytable (data) values (" + in + ")");
        }

        @KafkaListener(id = "group2", topics = "topic2")
        public void listen2(String in) {
            System.out.println(in);
        }
    }

    @Bean
    public NewTopic topic1() {
        return TopicBuilder.name("topic1").build();
    }
}
```java
@Bean
public NewTopic topic2() {
    return TopicBuilder.name("topic2").build();
}
```

```java
public void someMethod(String in) {
    this.kafkaTemplate.send("topic2", in.toUpperCase());
    this.jdbcTemplate.execute("insert into mytable (data) values ('" + in + ")");
}
```

The `KafkaTemplate` will synchronize its transaction with the DB transaction and the commit/rollback occurs after the database.

If you wish to commit the Kafka transaction first, and only commit the DB transaction if the Kafka transaction is successful, use nested `@Transactional` methods:
@Transactional("dstm")
public void someMethod(String in) {
    this.jdbcTemplate.execute("insert into mytable (data) values ('" + in + ")'"));
    sendToKafka(in);
}

@Transactional("kafkaTransactionManager")
public void sendToKafka(String in) {
    this.kafkaTemplate.send("topic2", in.toUpperCase());
}

5.3. Customizing the JsonSerializer and JsonDeserializer

The serializer and deserializer support a number of customizations using properties, see JSON for more information. The kafka-clients code, not Spring, instantiates these objects, unless you inject them directly into the consumer and producer factories. If you wish to configure the (de)serializer using properties, but wish to use, say, a custom ObjectMapper, simply create a subclass and pass the custom mapper into the super constructor. For example:

```java
public class CustomJsonSerializer extends JsonSerializer<Object> {
    public CustomJsonSerializer() {
        super(customizedObjectMapper());
    }

    private static ObjectMapper customizedObjectMapper() {
        ObjectMapper mapper = JacksonUtils.enhancedObjectMapper();
        mapper.disable(SerializationFeature.WRITE_DATES_AS_TIMESTAMPS);
        return mapper;
    }
}
```
Chapter 6. Other Resources

In addition to this reference documentation, we recommend 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 GitHub Repository (Apache Kafka Module)
Appendix A: Override Spring Boot Dependencies

When using Spring for Apache Kafka in a Spring Boot application, the Apache Kafka dependency versions are determined by Spring Boot's dependency management. If you wish to use a different version of `kafka-clients` or `kafka-streams`, and use the embedded kafka broker for testing, you need to override their version used by Spring Boot dependency management and add two test artifacts for Apache Kafka.

There is a bug in Apache Kafka 3.0.0 when running the embedded broker on Microsoft Windows KAFKA-13391. To use the embedded broker on Windows, you need to downgrade the Apache Kafka version to 2.8.1 until 3.0.1 is available. When using 2.8.1, you also need to exclude `zookeeper` dependency from `spring-kafka-test`.
<properties>
    <kafka.version>2.8.1</kafka.version>
</properties>

<dependency>
    <groupId>org.springframework.kafka</groupId>
    <artifactId>spring-kafka</artifactId>
</dependency>
<!-- optional - only needed when using kafka-streams -->
<dependency>
    <groupId>org.apache.kafka</groupId>
    <artifactId>kafka-streams</artifactId>
</dependency>

<dependency>
    <groupId>org.springframework.kafka</groupId>
    <artifactId>spring-kafka-test</artifactId>
    <scope>test</scope>
    <!-- needed if downgrading to Apache Kafka 2.8.1 -->
    <exclusions>
        <exclusion>
            <groupId>org.apache.zookeeper</groupId>
            <artifactId>zookeeper</artifactId>
        </exclusion>
    </exclusions>
</dependency>

<dependency>
    <groupId>org.apache.kafka</groupId>
    <artifactId>kafka-clients</artifactId>
    <classifier>test</classifier>
    <scope>test</scope>
    <version>${kafka.version}</version>
</dependency>

<dependency>
    <groupId>org.apache.kafka</groupId>
    <artifactId>kafka_2.13</artifactId>
    <classifier>test</classifier>
    <scope>test</scope>
    <version>${kafka.version}</version>
</dependency>
ext['kafka.version'] = '2.8.1'

dependencies {
    implementation 'org.springframework.kafka:spring-kafka'
    implementation "org.apache.kafka:kafka-streams"  // optional - only needed when using kafka-streams
    testImplementation ('org.springframework.kafka:spring-kafka-test') {
        // needed if downgrading to Apache Kafka 2.8.1
        exclude group: 'org.apache.zookeeper', module: 'zookeeper'
    }
    testImplementation "org.apache.kafka:kafka-clients:${kafka.version}:test"
    testImplementation "org.apache.kafka:kafka_2.13:${kafka.version}:test"
}

The test scope dependencies are only needed if you are using the embedded Kafka broker in tests.
Appendix B: Change History

B.1. Changes between 2.6 and 2.7

B.1.1. Kafka Client Version

This version requires the 2.7.0 kafka-clients. It is also compatible with the 2.8.0 clients, since version 2.7.1; see Override Spring Boot Dependencies.

B.1.2. Non-Blocking Delayed Retries Using Topics

This significant new feature is added in this release. When strict ordering is not important, failed deliveries can be sent to another topic to be consumed later. A series of such retry topics can be configured, with increasing delays. See Non-Blocking Retries for more information.

B.1.3. Listener Container Changes

The onlyLogRecordMetadata container property is now true by default.

A new container property stopImmediate is now available.

See Listener Container Properties for more information.

Error handlers that use a BackOff between delivery attempts (e.g. SeekToCurrentErrorHandler and DefaultAfterRollbackProcessor) will now exit the back off interval soon after the container is stopped, rather than delaying the stop. See After-rollback Processor and [seek-to-current] for more information.

Error handlers and after rollback processors that extend FailedRecordProcessor can now be configured with one or more RetryListener s to receive information about retry and recovery progress.

See See After-rollback Processor, [seek-to-current], and [recovering-batch-eh] for more information.

The RecordInterceptor now has additional methods called after the listener returns (normally, or by throwing an exception). It also has a sub-interface ConsumerAwareRecordInterceptor. In addition, there is now a BatchInterceptor for batch listeners. See Message Listener Containers for more information.

B.1.4. @KafkaListener Changes

You can now validate the payload parameter of @KafkaHandler methods (class-level listeners). See @KafkaListener @Payload Validation for more information.

You can now set the rawRecordHeader property on the MessagingMessageConverter and BatchMessagingMessageConverter which causes the raw ConsumerRecord to be added to the converted Message<?>. This is useful, for example, if you wish to use a DeadLetterPublishingRecoverer in a listener error handler. See Listener Error Handlers for more information.
You can now modify `@KafkaListener` annotations during application initialization. See `@KafkaListener` Attribute Modification for more information.

### B.1.5. DeadLetterPublishingRecover Changes

Now, if both the key and value fail deserialization, the original values are published to the DLT. Previously, the value was populated but the key `DeserializationException` remained in the headers. There is a breaking API change, if you subclassed the recoverer and overrode the `createProducerRecord` method.

In addition, the recoverer verifies that the partition selected by the destination resolver actually exists before publishing to it.

See Publishing Dead-letter Records for more information.

### B.1.6. ChainedKafkaTransactionManager is Deprecated

See Transactions for more information.

### B.1.7.ReplyingKafkaTemplate Changes

There is now a mechanism to examine a reply and fail the future exceptionally if some condition exists.

Support for sending and receiving `spring-messaging Message<?>` s has been added.

See Using `ReplyingKafkaTemplate` for more information.

### B.1.8. Kafka Streams Changes

By default, the `StreamsBuilderFactoryBean` is now configured to not clean up local state. See Configuration for more information.

### B.1.9. KafkaAdmin Changes

New methods `createOrModifyTopics` and `describeTopics` have been added. `KafkaAdmin.NewTopics` has been added to facilitate configuring multiple topics in a single bean. See Configuring Topics for more information.

### B.1.10. MessageConverter Changes

It is now possible to add a `spring-messaging SmartMessageConverter` to the `MessagingMessageConverter`, allowing content negotiation based on the `contentType` header. See Spring Messaging Message Conversion for more information.

### B.1.11. Sequencing `@KafkaListener` s

See Starting `@KafkaListener` s in Sequence for more information.
B.1.12. ExponentialBackOffWithMaxRetries

A new BackOff implementation is provided, making it more convenient to configure the max retries. See ExponentialBackOffWithMaxRetries Implementation for more information.

B.1.13. Conditional Delegating Error Handlers

These new error handlers can be configured to delegate to different error handlers, depending on the exception type. See Delegating Error Handler for more information.

B.2. Changes between 2.5 and 2.6

B.2.1. Kafka Client Version

This version requires the 2.6.0 kafka-clients.

B.2.2. Listener Container Changes

The default EOSMode is now BETA. See Exactly Once Semantics for more information.

Various error handlers (that extend FailedRecordProcessor) and the DefaultAfterRollbackProcessor now reset the BackOff if recovery fails. In addition, you can now select the BackOff to use based on the failed record and/or exception. See [seek-to-current], [recovering-batch-eh], Publishing Dead-letter Records and After-rollback Processor for more information.

You can now configure an adviceChain in the container properties. See Listener Container Properties for more information.

When the container is configured to publish ListenerContainerIdleEvent s, it now publishes a ListenerContainerNoLongerIdleEvent when a record is received after publishing an idle event. See Application Events and Detecting Idle and Non-Responsive Consumers for more information.

B.2.3. @KafkaListener Changes

When using manual partition assignment, you can now specify a wildcard for determining which partitions should be reset to the initial offset. In addition, if the listener implements ConsumerSeekAware, onPartitionsAssigned() is called after the manual assignment. (Also added in version 2.5.5). See Explicit Partition Assignment for more information.

Convenience methods have been added to AbstractConsumerSeekAware to make seeking easier. See Seeking to a Specific Offset for more information.

B.2.4. ErrorHandler Changes

Subclasses of FailedRecordProcessor (e.g. SeekToCurrentErrorHandler, DefaultAfterRollbackProcessor, RecoveringBatchErrorHandler) can now be configured to reset the retry state if the exception is a different type to that which occurred previously with this record. See [seek-to-current], After-rollback Processor, [recovering-batch-eh] for more information.
B.2.5. Producer Factory Changes

You can now set a maximum age for producers after which they will be closed and recreated. See Transactions for more information.

You can now update the configuration map after the DefaultKafkaProducerFactory has been created. This might be useful, for example, if you have to update SSL key/trust store locations after a credentials change. See Using DefaultKafkaProducerFactory for more information.

B.3. Changes between 2.4 and 2.5

This section covers the changes made from version 2.4 to version 2.5. For changes in earlier version, see Change History.

B.3.1. Consumer/Producer Factory Changes

The default consumer and producer factories can now invoke a callback whenever a consumer or producer is created or closed. Implementations for native Micrometer metrics are provided. See Factory Listeners for more information.

You can now change bootstrap server properties at runtime, enabling failover to another Kafka cluster. See Connecting to Kafka for more information.

B.3.2. StreamsBuilderFactoryBean Changes

The factory bean can now invoke a callback whenever a KafkaStreams created or destroyed. An Implementation for native Micrometer metrics is provided. See KafkaStreams Micrometer Support for more information.

B.3.3. Kafka Client Version

This version requires the 2.5.0 kafka-clients.

B.3.4. Class/Package Changes

SeekUtils has been moved from the o.s.k.support package to o.s.k.listener.

B.3.5. Delivery Attempts Header

There is now an option to add a header which tracks delivery attempts when using certain error handlers and after rollback processors. See Delivery Attempts Header for more information.

B.3.6. @KafkaListener Changes

Default reply headers will now be populated automatically if needed when a @KafkaListener return type is Message<?>. See Reply Type Message<?> for more information.

The KafkaHeaders.RECEIVED_MESSAGE_KEY is no longer populated with a null value when the incoming record has a null key; the header is omitted altogether.
@KafkaListener methods can now specify a ConsumerRecordMetadata parameter instead of using discrete headers for metadata such as topic, partition, etc. See Consumer Record Metadata for more information.

B.3.7. Listener Container Changes

The assignmentCommitOption container property is now LATEST_ONLY_NO_TX by default. See Listener Container Properties for more information.

The subBatchPerPartition container property is now true by default when using transactions. See Transactions for more information.

A new RecoveringBatchErrorHandler is now provided. See [recovering-batch-eh] for more information.

Static group membership is now supported. See Message Listener Containers for more information.

When incremental/cooperative rebalancing is configured, if offsets fail to commit with a non-fatal RebalanceInProgressException, the container will attempt to re-commit the offsets for the partitions that remain assigned to this instance after the rebalance is completed.

The default error handler is now the SeekToCurrentErrorHandler for record listeners and RecoveringBatchErrorHandler for batch listeners. See Container Error Handlers for more information.

You can now control the level at which exceptions intentionally thrown by standard error handlers are logged. See Container Error Handlers for more information.

The getAssignmentsByClientId() method has been added, making it easier to determine which consumers in a concurrent container are assigned which partition(s). See Listener Container Properties for more information.

You can now suppress logging entire ConsumerRecord s in error, debug logs etc. See onlyLogRecordMetadata in Listener Container Properties.

B.3.8. KafkaTemplate Changes

The KafkaTemplate can now maintain micrometer timers. See Monitoring for more information.

The KafkaTemplate can now be configured with ProducerConfig properties to override those in the producer factory. See Using KafkaTemplate for more information.

A RoutingKafkaTemplate has now been provided. See Using RoutingKafkaTemplate for more information.

You can now use KafkaSendCallback instead of ListenerFutureCallback to get a narrower exception, making it easier to extract the failed ProducerRecord. See Using KafkaTemplate for more information.
B.3.9. Kafka String Serializer/Deserializer

New **ToStringSerializer/StringDeserializer** s as well as an associated **SerDe** are now provided. See **String serialization** for more information.

B.3.10. JsonDeserializer

The **JsonDeserializer** now has more flexibility to determine the deserialization type. See **Using Methods to Determine Types** for more information.

B.3.11. Delegating Serializer/Deserializer

The **DelegatingSerializer** can now handle "standard" types, when the outbound record has no header. See **Delegating Serializer and Deserializer** for more information.

B.3.12. Testing Changes

The **KafkaTestUtils.consumerProps()** helper record now sets **ConsumerConfig.AUTO_OFFSET_RESET_CONFIG** to **earliest** by default. See **JUnit** for more information.

B.4. Changes between 2.3 and 2.4

B.4.1. Kafka Client Version

This version requires the 2.4.0 **kafka-clients** or higher and supports the new incremental rebalancing feature.

B.4.2. ConsumerAwareRebalanceListener

Like **ConsumerRebalanceListener**, this interface now has an additional method **onPartitionsLost**. Refer to the Apache Kafka documentation for more information.

Unlike the **ConsumerRebalanceListener**, The default implementation does not call **onPartitionsRevoked**. Instead, the listener container will call that method after it has called **onPartitionsLost**; you should not, therefore, do the same when implementing **ConsumerAwareRebalanceListener**.

See the IMPORTANT note at the end of **Rebalancing Listeners** for more information.

B.4.3. GenericErrorHandler

The **isAckAfterHandle()** default implementation now returns true by default.

B.4.4. KafkaTemplate

The **KafkaTemplate** now supports non-transactional publishing alongside transactional. See **KafkaTemplate Transactional and non-Transactional Publishing** for more information.
B.4.5. AggregatingReplyingKafkaTemplate

The releaseStrategy is now a BiConsumer. It is now called after a timeout (as well as when records arrive); the second parameter is true in the case of a call after a timeout.

See Aggregating Multiple Replies for more information.

B.4.6. Listener Container

The ContainerProperties provides an authorizationExceptionRetryInterval option to let the listener container to retry after any AuthorizationException is thrown by the KafkaConsumer. See its JavaDocs and Using KafkaMessageListenerContainer for more information.

B.4.7. @KafkaListener

The @KafkaListener annotation has a new property splitIterables; default true. When a replying listener returns an Iterable this property controls whether the return result is sent as a single record or a record for each element is sent. See Forwarding Listener Results using @SendTo for more information.

Batch listeners can now be configured with a BatchToRecordAdapter; this allows, for example, the batch to be processed in a transaction while the listener gets one record at a time. With the default implementation, a ConsumerRecordRecoverer can be used to handle errors within the batch, without stopping the processing of the entire batch - this might be useful when using transactions. See Transactions with Batch Listeners for more information.

B.4.8. Kafka Streams

The StreamsBuilderFactoryBean accepts a new property KafkaStreamsInfrastructureCustomizer. This allows configuration of the builder and/or topology before the stream is created. See Spring Management for more information.

B.5. Changes Between 2.2 and 2.3

This section covers the changes made from version 2.2 to version 2.3.

B.5.1. Tips, Tricks and Examples

A new chapter Tips, Tricks and Examples has been added. Please submit GitHub issues and/or pull requests for additional entries in that chapter.

B.5.2. Kafka Client Version

This version requires the 2.3.0 kafka-clients or higher.

B.5.3. Class/Package Changes

TopicPartitionInitialOffset is deprecated in favor of TopicPartitionOffset.
B.5.4. Configuration Changes

Starting with version 2.3.4, the `missingTopicsFatal` container property is false by default. When this is true, the application fails to start if the broker is down; many users were affected by this change; given that Kafka is a high-availability platform, we did not anticipate that starting an application with no active brokers would be a common use case.

B.5.5. Producer and Consumer Factory Changes

The `DefaultKafkaProducerFactory` can now be configured to create a producer per thread. You can also provide `Supplier<Serializer>` instances in the constructor as an alternative to either configured classes (which require no-arg constructors), or constructing with `Serializer` instances, which are then shared between all Producers. See Using `DefaultKafkaProducerFactory` for more information.

The same option is available with `Supplier<Deserializer>` instances in `DefaultKafkaConsumerFactory`. See Using KafkaMessageListenerContainer for more information.

B.5.6. Listener Container Changes

Previously, error handlers received `ListenerExecutionFailedException` (with the actual listener exception as the `cause`) when the listener was invoked using a listener adapter (such as `@KafkaListener`). Exceptions thrown by native `GenericMessageListener`s were passed to the error handler unchanged. Now a `ListenerExecutionFailedException` is always the argument (with the actual listener exception as the `cause`), which provides access to the container's `group.id` property.

Because the listener container has its own mechanism for committing offsets, it prefers the Kafka `ConsumerConfig.ENABLE_AUTO_COMMIT_CONFIG` to be `false`. It now sets it to false automatically unless specifically set in the consumer factory or the container's consumer property overrides.

The `ackOnError` property is now `false` by default. See [seek-to-current] for more information.

It is now possible to obtain the consumer's `group.id` property in the listener method. See Obtaining the Consumer `group.id` for more information.

The container has a new property `recordInterceptor` allowing records to be inspected or modified before invoking the listener. A `CompositeRecordInterceptor` is also provided in case you need to invoke multiple interceptors. See Message Listener Containers for more information.

The `ConsumerSeekAware` has new methods allowing you to perform seeks relative to the beginning, end, or current position and to seek to the first offset greater than or equal to a time stamp. See Seeking to a Specific Offset for more information.

A convenience class `AbstractConsumerSeekAware` is now provided to simplify seeking. See Seeking to a Specific Offset for more information.

The `ContainerProperties` provides an `idleBetweenPolls` option to let the main loop in the listener container to sleep between `KafkaConsumer.poll()` calls. See its JavaDocs and Using KafkaMessageListenerContainer for more information.
When using AckMode.MANUAL (or MANUAL_IMMEDIATE) you can now cause a redelivery by calling `nack` on the Acknowledgment. See Committing Offsets for more information.

Listener performance can now be monitored using Micrometer Timer s. See Monitoring for more information.

The containers now publish additional consumer lifecycle events relating to startup. See Application Events for more information.

Transactional batch listeners can now support zombie fencing. See Transactions for more information.

The listener container factory can now be configured with a ContainerCustomizer to further configure each container after it has been created and configured. See Container factory for more information.

**B.5.7. ErrorHandler Changes**

The SeekToCurrentErrorHandler now treats certain exceptions as fatal and disables retry for those, invoking the recoverer on first failure.

The SeekToCurrentErrorHandler and SeekToCurrentBatchErrorHandler can now be configured to apply a BackOff (thread sleep) between delivery attempts.

Starting with version 2.3.2, recovered records’ offsets will be committed when the error handler returns after recovering a failed record.

See [seek-to-current] for more information.

The DeadLetterPublishingRecoverer, when used in conjunction with an ErrorHandlingDeserializer, now sets the payload of the message sent to the dead-letter topic, to the original value that could not be deserialized. Previously, it was `null` and user code needed to extract the DeserializationException from the message headers. See Publishing Dead-letter Records for more information.

**B.5.8. TopicBuilder**

A new class TopicBuilder is provided for more convenient creation of NewTopic @Bean s for automatic topic provisioning. See Configuring Topics for more information.

**B.5.9. Kafka Streams Changes**

You can now perform additional configuration of the StreamsBuilderFactoryBean created by @EnableKafkaStreams. See Streams Configuration for more information.

A RecoveringDeserializationExceptionHandler is now provided which allows records with deserialization errors to be recovered. It can be used in conjunction with a DeadLetterPublishingRecoverer to send these records to a dead-letter topic. See Recovery from Deserialization Exceptions for more information.
The HeaderEnricher transformer has been provided, using SpEL to generate the header values. See Header Enricher for more information.

The MessagingTransformer has been provided. This allows a Kafka streams topology to interact with a spring-messaging component, such as a Spring Integration flow. See MessagingTransformer and See [Calling a Spring Integration Flow from a KStream] for more information.

**B.5.10. JSON Component Changes**

Now all the JSON-aware components are configured by default with a Jackson ObjectMapper produced by the JacksonUtils.enhancedObjectMapper(). The JsonDeserializer now provides TypeReference-based constructors for better handling of target generic container types. Also a JacksonMimeTypeModule has been introduced for serialization of org.springframework.util.MimeType to plain string. See its JavaDocs and Serialization, Deserialization, and Message Conversion for more information.

A ByteArrayJsonMessageConverter has been provided as well as a new super class for all Json converters, JsonMessageConverter. Also, a StringOrBytesSerializer is now available; it can serialize byte[], Bytes and String values in ProducerRecord s. See Spring Messaging Message Conversion for more information.

The JsonSerializer, JsonDeserializer and JsonSerde now have fluent APIs to make programmatic configuration simpler. See the javadocs, Serialization, Deserialization, and Message Conversion, and Streams JSON Serialization and Deserialization for more information.

**B.5.11. ReplyingKafkaTemplate**

When a reply times out, the future is completed exceptionally with a KafkaReplyTimeoutException instead of a KafkaException.

Also, an overloaded sendAndReceive method is now provided that allows specifying the reply timeout on a per message basis.

**B.5.12. AggregatingReplyingKafkaTemplate**

Extends the ReplyingKafkaTemplate by aggregating replies from multiple receivers. See Aggregating Multiple Replies for more information.

**B.5.13. Transaction Changes**

You can now override the producer factory's transactionIdPrefix on the KafkaTemplate and KafkaTransactionManager. See transactionIdPrefix for more information.

**B.5.14. New Delegating Serializer/Deserializer**

The framework now provides a delegating Serializer and Deserializer, utilizing a header to enable producing and consuming records with multiple key/value types. See Delegating Serializer and Deserializer for more information.
B.5.15. New Retrying Deserializer

The framework now provides a delegating RetryingDeserializer, to retry serialization when transient errors such as network problems might occur. See Retrying Deserializer for more information.

B.6. Changes Between 2.1 and 2.2

B.6.1. Kafka Client Version

This version requires the 2.0.0 kafka-clients or higher.

B.6.2. Class and Package Changes

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

The AckMode enum has been moved from AbstractMessageListenerContainer to ContainerProperties.

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

B.6.3. After Rollback Processing

A new AfterRollbackProcessor strategy is provided. See After-rollback Processor for more information.

B.6.4. ConcurrentKafkaListenerContainerFactory Changes

You can now use the ConcurrentKafkaListenerContainerFactory to create and configure any ConcurrentMessageListenerContainer, not only those for @KafkaListener annotations. See Container factory for more information.

B.6.5. Listener Container Changes

A new container property (missingTopicsFatal) has been added. See Using KafkaMessageListenerContainer for more information.

A ConsumerStoppedEvent is now emitted when a consumer stops. See Thread Safety for more information.

Batch listeners can optionally receive the complete ConsumerRecords<?, ?> object instead of a List<ConsumerRecord<?, ?>> object. See Batch Listeners for more information.

The DefaultAfterRollbackProcessor and SeekToCurrentErrorHandler can now recover (skip) records that keep failing, and, by default, does so after 10 failures. They can be configured to publish failed records to a dead-letter topic.
Starting with version 2.2.4, the consumer's group ID can be used while selecting the dead letter topic name.

See After-rollback Processor, [seek-to-current], and Publishing Dead-letter Records for more information.

The ConsumerStoppingEvent has been added. See Application Events for more information.

The SeekToCurrentErrorHandler can now be configured to commit the offset of a recovered record when the container is configured with AckMode.MANUAL_IMMEDIATE (since 2.2.4). See [seek-to-current] for more information.

### B.6.6. @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 @KafkaListener Annotation for more information.

You can now use @KafkaListener as a meta-annotation on your own annotations. See @KafkaListener as a Meta Annotation for more information.

It is now easier to configure a Validator for @Payload validation. See @KafkaListener @Payload Validation for more information.

You can now specify kafka consumer properties directly on the annotation; these will override any properties with the same name defined in the consumer factory (since version 2.2.4). See Annotation Properties for more information.

### B.6.7. 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 addToStringClasses method, allowing the specification of types that should be mapped by using toString() instead of JSON. See Message Headers for more information.

### B.6.8. Embedded Kafka Changes

The KafkaEmbedded class and its KafkaRule interface have been 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 change allows the use of @EmbeddedKafka in JUnit 5 tests. The @EmbeddedKafka annotation now has the attribute ports to specify the port that populates the EmbeddedKafkaBroker. See Testing Applications for more information.

### B.6.9. JsonSerializer/Deserializer Enhancements

You can now provide type mapping information by using producer and consumer properties.
New constructors are available on the deserializer to allow overriding the type header information with the supplied target type.

The `JsonDeserializer` now removes any type information headers by default.

You can now configure the `JsonDeserializer` to ignore type information headers by using a Kafka property (since 2.2.3).

See [Serialization, Deserialization, and Message Conversion](#) for more information.

**B.6.10. Kafka Streams Changes**

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

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

The `KafkaStreamBrancher` has been introduced for better end-user experience when conditional branches are built on top of `KStream` instance.

See [Apache Kafka Streams Support](#) and [Configuration](#) for more information.

**B.6.11. 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 change allows proper fencing of zombies, as described [here](#).

**B.7. Changes Between 2.0 and 2.1**

**B.7.1. Kafka Client Version**

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

The 1.1.x client is supported natively in version 2.2.

**B.7.2. JSON Improvements**

The `StringJsonMessageConverter` and `JsonSerializer` now add type information in `Headers`, letting the converter and `JsonDeserializer` create specific types on reception, based on the message itself rather than a fixed configured type. See [Serialization, Deserialization, and Message Conversion](#) for more information.

**B.7.3. 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 [Handling Exceptions](#) for more information.
B.7.4. Pausing and Resuming Containers

The listener containers now have `pause()` and `resume()` methods (since version 2.1.3). See Pausing and Resuming Listener Containers for more information.

B.7.5. Stateful Retry

Starting with version 2.1.3, you can configure stateful retry. See Stateful Retry for more information.

B.7.6. Client ID

Starting with version 2.1.1, you can now set the `client.id` prefix on `@KafkaListener`. Previously, to customize the client ID, you needed a separate consumer factory (and container factory) per listener. The prefix is suffixed with `-n` to provide unique client IDs when you use concurrency.

B.7.7. Logging Offset Commits

By default, logging of topic offset commits is performed with the DEBUG logging level. Starting with version 2.1.2, a new property in `ContainerProperties` called `commitLogLevel` lets you specify the log level for these messages. See Using KafkaMessageListenerContainer for more information.

B.7.8. Default @KafkaHandler

Starting with version 2.1.3, you can designate one of the `@KafkaHandler` annotations on a class-level `@KafkaListener` as the default. See @KafkaListener on a Class for more information.

B.7.9. ReplyingKafkaTemplate

Starting with version 2.1.3, a subclass of KafkaTemplate is provided to support request/reply semantics. See Using ReplyingKafkaTemplate for more information.

B.7.10. ChainedKafkaTransactionManager

Version 2.1.3 introduced the ChainedKafkaTransactionManager. (It is now deprecated).

B.7.11. Migration Guide from 2.0

See the 2.0 to 2.1 Migration guide.

B.8. Changes Between 1.3 and 2.0

B.8.1. Spring Framework and Java Versions

The Spring for Apache Kafka project now requires Spring Framework 5.0 and Java 8.
B.8.2. @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 Forwarding Listener Results using @SendTo for more information.

B.8.3. Message Listeners

Message listeners can now be aware of the Consumer object. See Message Listeners for more information.

B.8.4. Using ConsumerAwareRebalanceListener

Rebalance listeners can now access the Consumer object during rebalance notifications. See Rebalancing Listeners for more information.

B.9. Changes Between 1.2 and 1.3

B.9.1. Support for Transactions

The 0.11.0.0 client library added support for transactions. The KafkaTransactionManager and other support for transactions have been added. See Transactions for more information.

B.9.2. Support for Headers

The 0.11.0.0 client library added support for message headers. These can now be mapped to and from spring-messaging MessageHeaders. See Message Headers for more information.

B.9.3. Creating Topics

The 0.11.0.0 client library provides an AdminClient, which you can use to create topics. The KafkaAdmin uses this client to automatically add topics defined as @Bean instances.

B.9.4. Support for Kafka Timestamps

KafkaTemplate now supports an 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 Using KafkaTemplate, @KafkaListener Annotation, and Testing Applications for more details.

B.9.5. @KafkaListener Changes

You can now configure a KafkaListenerErrorHandler to handle exceptions. See Handling Exceptions for more information.

By default, the @KafkaListener id property is now used as the groupId 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` values for listeners. To restore the previous behavior of using the factory configured `group.id`, set the `idIsGroup` property on the annotation to `false`.

**B.9.6. @EmbeddedKafka Annotation**

For convenience, a test class-level `@EmbeddedKafka` annotation is provided, to register `KafkaEmbedded` as a bean. See Testing Applications for more information.

**B.9.7. Kerberos Configuration**

Support for configuring Kerberos is now provided. See JAAS and Kerberos for more information.

**B.10. Changes Between 1.1 and 1.2**

This version uses the 0.10.2.x client.

**B.11. Changes Between 1.0 and 1.1**

**B.11.1. Kafka Client**

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

**B.11.2. 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.

**B.11.3. Null Payloads**

Null payloads are used to “delete” keys when you use log compaction.

**B.11.4. 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.

**B.11.5. Seek**

You can now seek the position of each topic or partition. You can use this 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 Seeking to a Specific Offset for more information.