



What is Quarkus?

Quarkus is a Kubernetes Native Java stack tailored for GraalVM & OpenJDK HotSpot, crafted from the best of breed Java libraries and standards. Also focused on developer experience, making things just work with little to no configuration and allowing to do live coding.

Cheat-sheet tested with **Quarkus 0.26.1**.

Getting Started

Quarkus comes with a Maven archetype to scaffold a very simple starting project.

```
mvn io.quarkus:quarkus-maven-plugin:0.26.1:create \
  -DprojectId=org.acme \
  -DprojectArtifactId=getting-started \
  -DclassName="org.acme.quickstart.GreetingResource" \
  -Dpath="/hello"
```

This creates a simple JAX-RS resource called `GreetingResource`.

```
@Path("/hello")
public class GreetingResource {

    @GET
    @Produces(MediaType.TEXT_PLAIN)
    public String hello() {
        return "hello";
    }
}
```

Gradle

There is no way to scaffold a project in Gradle but you only need to do:

```
plugins {
    id 'java'
    id 'io.quarkus' version '0.26.1'
}

repositories {
    mavenCentral()
}

dependencies {
    implementation enforcedPlatform('io.quarkus:quarkus-bom:0.26.1')
    implementation 'io.quarkus:quarkus-resteasy'
}
```

Or in Kotlin:

```
plugins {
    java
}
apply(plugin = "io.quarkus")

repositories {
    mavenCentral()
}

dependencies {
    implementation(enforcedPlatform("io.quarkus:quarkus-bom:0.26.1"))
    implementation("io.quarkus:quarkus-resteasy")
}
```

Extensions

Quarkus comes with extensions to integrate with some libraries such as JSON-B, Camel or MicroProfile spec. To list all available extensions just run:

```
./mvnw quarkus:list-extensions
```

Tip You can use `-DsearchPattern=panache` to filter out all extensions except the ones matching the expression.

And to register the extensions into build tool:

```
./mvnw quarkus:add-extension -Dextensions=""
```

Tip `extensions` property supports CSV format to register more than one extension at once.

Application Lifecycle

You can be notified when the application starts/stops by observing `StartupEvent` and `ShutdownEvent` events.

```
@ApplicationScoped
public class ApplicationLifecycle {
    void onStart(@Observes StartupEvent event) {}
    void onStop(@Observes ShutdownEvent event) {}
}
```

Adding Configuration Parameters

To add configuration to your application, Quarkus relies on MicroProfile Config spec.

```
@ConfigProperty(name = "greetings.message")
String message;

@ConfigProperty(name = "greetings.message",
    defaultValue = "Hello")
String messageWithDefault;

@ConfigProperty(name = "greetings.message")
Optional<String> optionalMessage;
```

Properties can be set as:

- Environment variables (`GREETINGS_MESSAGE`).
- System properties (`-Dgreetings.message`).
- Resources
`src/main/resources/application.properties`.
- External config directory under the current working directory:
`config/application.properties`.

```
greetings.message = Hello World
```

Tip Array, List and Set are supported. The delimiter is comma `(,)` char and `\` is the escape char.

Configuration Profiles

Quarkus allow you to have multiple configuration in the same file (`application.properties`).

The syntax for this is `%{profile}.config.key=value`.

```
quarkus.http.port=9090
%dev.quarkus.http.port=8181
```

HTTP port will be 9090, unless the 'dev' profile is active.

Default profiles are:

- dev: Activated when in development mode (`quarkus:dev`).
- test: Activated when running tests.
- prod: The default profile when not running in development or test mode

You can create custom profile names by enabling the profile either setting `quarkus.profile` system property or `QUARKUS_PROFILE` environment variable.

```
quarkus.http.port=9090
%staging.quarkus.http.port=9999
```

And enable it `quarkus.profile=staging`.

You can also set it in the build tool:

```
<groupId>org.apache.maven.plugins</groupId>
<artifactId>maven-surefire-plugin</artifactId>
<version>${surefire-plugin.version}</version>
<configuration>
  <systemPropertyVariables>
    <quarkus.test.profile>foo</quarkus.test.profile>
    <buildDirectory>${project.build.directory}
  </buildDirectory>
  </systemPropertyVariables>
</configuration>
```

Tip Same for `maven-failsafe-plugin`.

```
test {
    useJUnitPlatform()
    systemProperty "quarkus.test.profile", "foo"
}
```

@ConfigProperties

As an alternative to injecting multiple related configuration values, you can also use the `@io.quarkus.arc.config.ConfigProperties` annotation to group properties.

```
@ConfigProperties(prefix = "greeting")
public class GreetingConfiguration {
    private String message;
    // getter/setter
}
```

This class maps `greeting.message` property defined in `application.properties`.

You can inject this class by using CDI `@Inject` `GreetingConfiguration` `greeting`;

Also you can use an interface approach:

```
@ConfigProperties(prefix = "greeting")
public interface GreetingConfiguration {

    @ConfigProperty(name = "message")
    String message();
    String getSuffix();
}
```

If property does not follow getter/setter naming convention you need to use `org.eclipse.microprofile.config.inject.ConfigProperty` to set it.

Nested objects are also supporte:

```
@ConfigProperties(prefix = "greeting")
public class GreetingConfiguration {
    public String message;
    public HiddenConfig hidden;

    public static class HiddenConfig {
        public List<String> recipients;
    }
}
```

And an `application.properties` mapping previous class:

```
greeting.message = hello
greeting.hidden.recipients=Jane,John
```

Bean Validation is also supported so properties are validated at startup time, for example `@Size(min = 20)` `public String message;`.

TIP: `prefix` attribute is not mandatory. If not provided, attribute is determined by class name (ie `GreetingConfiguration` is translated to `greeting` or `GreetingExtraConfiguration` to `greeting-extra`). The suffix of the class is always removed.

Custom Loader

You can implement your own `ConfigSource` to load configuration from different places than the default ones provided by Quarkus. For example, database, custom XML, REST Endpoints, ...

You need to create a new class and implement `ConfigSource` interface:

```
package com.acme.config;

public class InMemoryConfig implements ConfigSource {

    private Map<String, String> prop = new HashMap<>();

    public InMemoryConfig() {
        // Init properties
    }

    @Override
    public int getOrdinal() {
        // The highest ordinal takes precedence
        return 900;
    }

    @Override
    public Map<String, String> getProperties() {
        return prop;
    }

    @Override
    public String getValue(String propertyName) {
        return prop.get(propertyName);
    }

    @Override
    public String getName() {
        return "MemoryConfigSource";
    }
}
```

Then you need to register the `ConfigSource` as Java service. Create a file `/META-INF/services/org.eclipse.microprofile.config.spi.ConfigSource` with next content:

```
com.acme.config.InMemoryConfig
```

Custom Converters

You can implement your own conversion types from String. Implement `org.eclipse.microprofile.config.spi.Converter` interface:

```
@Priority(DEFAULT_QUARKUS_CONVERTER_PRIORITY + 100)
public class CustomInstantConverter
    implements Converter<Instant> {

    @Override
    public Instant convert(String value) {
        if ("now".equals(value.trim())) {
            return Instant.now();
        }
        return Instant.parse(value);
    }
}
```

@Priority annotation is used to override the default InstantConverter.

Then you need to register the Converter as Java service. Create a file `/META-INF/services/org.eclipse.microprofile.config.spi.Converter` with next content:

```
com.acme.config.CustomInstantConverter
```

Custom Context Path

By default Undertow will serve content from under the root context. If you want to change this you can use the `quarkus.servlet.context-path` config key to set the context path.

Injection

Quarkus is based on CDI 2.0 to implement injection of code. It is not fully supported and only a subset of the specification is implemented.

```
@ApplicationScoped
public class GreetingService {

    public String message(String message) {
        return message.toUpperCase();
    }
}
```

Scope annotation is mandatory to make the bean discoverable.

```
@Inject
GreetingService greetingService;
```

Quarkus is designed with Substrate VM in mind. For **Important** this reason, we encourage you to use *package-private* scope instead of *private*.

Produces

You can also create a factory of an object by using @javax.enterprise.inject.Produces annotation.

```
@Produces
@ApplicationScoped
Message message() {
    Message m = new Message();
    m.setMsn("Hello");
    return m;
}

@Inject
Message msg;
```

Qualifiers

You can use qualifiers to return different implementations of the same interface or to customize the configuration of the bean.

```
@Qualifier
@Retention(RUNTIME)
@Target({TYPE, METHOD, FIELD, PARAMETER})
public @interface Quote {
    @Nonbinding String value();
}

@Produces
@Quote("")
Message message(InjectionPoint msg) {
    Message m = new Message();
    m.setMsn(
        msg.getAnnotated()
            .getAnnotation(Quote.class)
            .value()
    );

    return m;
}

@Inject
@Quote("Aloha Beach")
Message message;
```

TIP

Quarkus breaks the CDI spec by allowing you to inject qualified beans without using @Inject annotation.

```
@Quote("Aloha Beach")
Message message;
```

JSON Marshalling/Unmarshalling

To work with JSON-B you need to add a dependency:

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-resteasy-jsonb"
```

Any POJO is marshaled/unmarshalled automatically.

```
public class Sauce {
    private String name;
    private long scovilleHeatUnits;

    // getter/setters
}
```

JSON equivalent:

```
{
    "name": "Blair's Ultra Death",
    "scovilleHeatUnits": 1100000
}
```

In a POST endpoint example:

```
@POST
@Consumes(MediaType.APPLICATION_JSON)
public Response create(Sauce sauce) {
    // Create Sauce
    return Response.created(URI.create(sauce.getId()))
        .build();
}
```

To work with Jackson you need to add:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-resteasy-jackson"
```

If you don't want to use the default ObjectMapper you can customize it by:

```
@ApplicationScoped
public class CustomObjectMapperConfig {
    @Singleton
    @Produces
    public ObjectMapper objectMapper() {
        ObjectMapper objectMapper = new ObjectMapper();
        // perform configuration
        return objectMapper;
    }
}
```

XML Marshalling/Unmarshalling

To work with JAX-B you need to add a dependency:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-resteasy-jaxb"
```

Then annotated POJOs are converted to XML.

```
@XmlRootElement
public class Message {
}

@GET
@Produces(MediaType.APPLICATION_XML)
public Message hello() {
    return message;
}
```

Validator

Quarkus uses **Hibernate Validator** to validate input/output of REST services and business services using Bean validation spec.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-hibernate-validator"
```

Annotate POJO objects with validator annotations such as: @NotNull, @Digits, @NotBlank, @Min, @Max, ...

```
public class Sauce {

    @NotBlank(message = "Name may not be blank")
    private String name;
    @Min(0)
    private long scovilleHeatUnits;

    // getter/setters
}
```

To validate an object use @Valid annotation:

```
public Response create(@Valid Sauce sauce) {}
```

Tip If a validation error is triggered, a violation report is generated and serialized as JSON. If you want to manipulate the output, you need to catch in the code the `ConstraintViolationException` exception.

Create Your Custom Constraints

First you need to create the custom annotation:

```
@Target({ METHOD, FIELD, ANNOTATION_TYPE, CONSTRUCTOR,
          PARAMETER, TYPE_USE })
@Retention(RUNTIME)
@Documented
@Constraint(validatedBy = { NotExpiredValidator.class})
public @interface NotExpired {

    String message() default "Sauce must not be expired";
    Class<?>[] groups() default { };
    Class<? extends Payload>[] payload() default { };

}
```

You need to implement the validator logic in a class that implements `ConstraintValidator`.

```
public class NotExpiredValidator
    implements ConstraintValidator<NotExpired, LocalDate>
{

    @Override
    public boolean isValid(LocalDate value,
                          ConstraintValidatorContext ctx) {
        if ( value == null ) return true;
        LocalDate today = LocalDate.now();
        return ChronoUnit.YEARS.between(today, value) > 0;
    }
}
```

And use it normally:

```
@NotExpired
@JsonbDateFormat(value = "yyyy-MM-dd")
private LocalDate expired;
```

Manual Validation

You can call the validation process manually instead of relaying to @Valid by injecting `Validator` class.

```
@Inject
Validator validator;
```

And use it:

```
Set<ConstraintViolation<Sauce>> violations =
    validator.validate(sauce);
```

Logging

You can configure how Quarkus logs:

```
quarkus.log.console.enable=true
quarkus.log.console.level=DEBUG
quarkus.log.console.color=false
quarkus.log.category."com.lordofthejars".level=DEBUG
```

Prefix is `quarkus.log`.

Property	Default	Description
category."<category-name>".level	INFO	Minimum level category.
level	INFO	Default minimum level.

console.enable	true	Console logging enabled.
console.format	%d{yyyy-MM-dd HH:mm:ss,SSS} %-5p [%c{3.}] (%t) %s%n	Format pattern to use for logging.
console.level	INFO	Minimum log level.
console.color	INFO	Allow color rendering.
file.enable	false	File logging enabled.
file.format	%d{yyyy-MM-dd HH:mm:ss,SSS} %h %N[%i] %-5p [%c{3.}] (%t) %s%n	Format pattern to use for logging.
file.level	ALL	Minimum log level.
file.path	quarkus.log	The path to log file.
file.rotation.max-file-size		The maximum file size of the log file.
file.rotation.max-backup-index	1	The maximum number of backups to keep.
file.rotation.file-suffix		Rotating log file suffix.
file.rotation.rotate-on-boot	true	Indicates rotate logs at bootup.
file.async	false	Log asynchronously.
file.async.queue-length	512	The queue length to use before flushing writing.

		queue is full.
syslog.enable	false	syslog logging is enabled.
syslog.format	%d{yyyy-MM-dd HH:mm:ss,SSS} %h %N[%i] %-5p [%c{3.}] (%t) %s%e%n	The format pattern to use for logging to syslog.
syslog.level	ALL	The minimum log level to write to syslog.
syslog.endpoint	localhost:514	The IP address and port of the syslog server.
syslog.app-name	Current process name.	The app name used when formatting the message in RFC5424 format.
syslog.hostname	Current hostname.	The name of the host the messages are being sent from.
syslog.facility	USER_LEVEL	Priority of the message as defined by RFC-5424 and RFC-3164.
syslog.syslog-type	RFC5424	The syslog type of format message.
syslog.protocol	TCP	Protocol used.
syslog.use-counting-framing	false	Message prefixed with the size of the message.
syslog.truncate	true	Message should be truncated.
syslog.block-on-reconnect	true	Block when attempting to

syslog.async	false	Log asynchronously.
syslog.async.queue-length	512	The queue length to use before flushing writing.
syslog.async.overflow	BLOCK	Action when queue is full.

Rest Client

Quarkus implements MicroProfile Rest Client spec:

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-rest-client"
```

To get content from <http://worldclockapi.com/api/json/cet/now> you need to create a service interface:

```
@Path("/api")
@RegisterRestClient
public interface WorldClockService {

    @GET @Path("/json/cet/now")
    @Produces(MediaType.APPLICATION_JSON)
    WorldClock getNow();

    @GET
    @Path("/json/{where}/now")
    @Produces(MediaType.APPLICATION_JSON)
    WorldClock getSauce(@BeanParam
                        WorldClockOptions worldClockOptions);

}
```

```
public class WorldClockOptions {
    @HeaderParam("Authorization")
    String auth;

    @PathParam("where")
    String where;
}
```

And configure the hostname at `application.properties`:

```
org.acme.quickstart.WorldClockService/mp-rest/url=
http://worldclockapi.com
```

Injecting the client:

```
@RestClient
WorldClockService worldClockService;
```

If invocation happens within JAX-RS, you can propagate headers from incoming to outgoing by using `next` property.

```
org.eclipse.microprofile.rest.client.propagateHeaders=
Authorization,MyCustomHeader
```

Tip You can still use the JAX-RS client without any problem `ClientBuilder.newClient().target(...)`

Adding headers

You can customize the headers passed by implementing `MicroProfile ClientHeadersFactory` annotation:

```
@RegisterForReflection
public class BaggageHeadersFactory
    implements ClientHeadersFactory {

    @Override
    public MultivaluedMap<String, String> update(
        MultivaluedMap<String, String> incomingHeaders,
        MultivaluedMap<String, String> outgoingHeaders) {}

}
```

And registering it in the client using `RegisterClientHeaders` annotation.

```
@RegisterClientHeaders(BaggageHeadersFactory.class)
@RegisterRestClient
public interface WorldClockService {}
```

Or statically set:

```
@GET
@ClientHeaderParam(name="X-Log-Level", value="ERROR")
Response getNow();
```

Asynchronous

A method on client interface can return a `CompletionStage` class to be executed asynchronously.

```
@GET @Path("/json/cet/now")
@Produces(MediaType.APPLICATION_JSON)
CompletionStage<WorldClock> getNow();
```

Multipart

It is really easy to send multipart form-data with Rest Client.

```
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-multipart-provider</artifactId>
</dependency>
```

The model object:

```
import java.io.InputStream;

import javax.ws.rs.FormParam;
import javax.ws.rs.core.MediaType;

import
    org.jboss.resteasy.annotations.providers.multipart.PartType;

public class MultipartBody {

    @FormParam("file")
    @PartType(MediaType.APPLICATION_OCTET_STREAM)
    private InputStream file;

    @FormParam("fileName")
    @PartType(MediaType.TEXT_PLAIN)
    private String name;

    // getter/setters

}
```

And the Rest client interface:

```
import
    org.jboss.resteasy.annotations.providers.multipart.MultipartForm;

@Path("/echo")
@RegisterRestClient
public interface MultipartService {

    @POST
    @Consumes(MediaType.MULTIPART_FORM_DATA)
    @Produces(MediaType.TEXT_PLAIN)
    String sendMultipartData(@MultipartForm
                             MultipartBody data);

}
```

Testing

Quarkus archetype adds test dependencies with JUnit 5 and Rest-Assured library to test REST endpoints.

```
@QuarkusTest
public class GreetingResourceTest {

    @Test
    public void testHelloEndpoint() {
        given()
            .when().get("/hello")
            .then()
                .statusCode(200)
                .body(is("hello"));
    }

}
```

Test port can be set in `quarkus.http.test-port` property.

You can also inject the URL where Quarkus is started:

```
@TestHTTPResource("index.html")
URL url;
```

Quarkus Test Resource

You can execute some logic before the first test run (start) and execute some logic at the end of the test suite (stop).

You need to create a class implementing `QuarkusTestResourceLifecycleManager` interface and register it in the test via `@QuarkusTestResource` annotation.

```
public class MyCustomTestResource
    implements QuarkusTestResourceLifecycleManager {

    @Override
    public Map<String, String> start() {
        // return system properties that
        // should be set for the running test
        return Collections.emptyMap();
    }

    @Override
    public void stop() {
    }

    // optional
    @Override
    public void inject(Object testInstance) {
    }

    // optional
    @Override
    public int order() {
        return 0;
    }

}
```

And the usage:

```
@QuarkusTestResource(MyCustomTestResource.class)
public class MyTest {
}
```

Mocking

If you need to provide an alternative implementation of a service (for testing purposes) you can do it by using CDI `@Alternative` annotation using it in the test service placed at `src/test/java`:

```
@Alternative
@Priority(1)
@ApplicationScoped
public class MockExternalService extends ExternalService {}
```

Important This does not work when using native image testing.

A stereotype annotation `io.quarkus.test.Mock` is provided declaring `@Alternative`, `@Priority(1)` and `@Dependent`.

Interceptors

Tests are actually full CDI beans, so you can apply CDI interceptors:

```
@QuarkusTest
@Stereotype
@Transactional
@Retention(RetentionPolicy.RUNTIME)
@Target(ElementType.TYPE)
public @interface TransactionalQuarkusTest {
}

@TransactionalQuarkusTest
public class TestStereotypeTestCase {}
```

Test Coverage Due the nature of Quarkus to calculate correctly the coverage information with JaCoCo, you might need offline instrumentation. I recommend reading [this document](#) to understand how JaCoCo and Quarkus works and how you can configure JaCoCo to get correct data.

Native Testing

To test native executables annotate the test with `@SubstrateTest`.

Important Returning new system properties implies running parallel tests in different JVMs.

Persistence

Quarkus works with JPA(Hibernate) as persistence solution. But also provides an Active Record pattern implementation under Panache project.

To use database access you need to add Quarkus JDBC drivers instead of the original ones. At this time Apache Derby, H2, MariaDB, MySQL, MSSQL and PostgreSQL drivers are supported.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-hibernate-orm-panache,
            io.quarkus:quarkus-jdbc-mariadb"
```

```
@Entity
public class Developer extends PanacheEntity {

    // id field is implicit

    public String name;
}
```

And configuration in src/main/resources/application.properties:

```
quarkus.datasource.url=jdbc:mariadb://localhost:3306/mydb
quarkus.datasource.driver=org.mariadb.jdbc.Driver
quarkus.datasource.username=developer
quarkus.datasource.password=developer
quarkus.hibernate-orm.database.generation=update
```

List of datasource parameters.

quarkus.datasource as prefix is skipped in the next table.

Parameter	Type
driver	String
url	String
username	String
password	String
min-size	Integer
max-size	Integer

Parameter	Type
initial-size	Integer
background-validation-interval	java.time.Duration
acquisition-timeout	java.time.Duration
leak-detection-interval	java.time.Duration
idle-removal-interval	java.time.Duration
transaction-isolation-level	io.quarkus.agroal.runtime.TransactionIsolationLevel
enable-metrics	Boolean
xa	Boolean

Hibernate configuration properties. Prefix quarkus.hibernate-orm is skipped.

Parameter	Description	Values[Default]
dialect	Class name of the Not necessary Hibernate to set. ORM dialect.	
dialect.storage-engine	The storage engine when the dialect supports multiple storage engines.	Not necessary to set.
sql-load-script	Name of the file containing the SQL statements to execute when starts. no-file force Hibernate to skip SQL import.	import.sql

Parameter	Description	Values[Default]
batch-fetch-size	The size of the batches.	-1 disabled.
query.query-plan-cache-max-size	The maximum size of the query plan cache.	
query.default-null-ordering	Default precedence of null values in ORDER BY.	[none], first, last.
database.generation	Database schema is generation.	[none], create, drop-and-create, drop, update.
database.generation.halt-on-error	Stop on the first error when applying the schema.	[false], true
database.default-catalog	Default catalog.	
database.default-schema	Default Schema.	
database.charset	Charset.	
jdbc.timezone	Time Zone JDBC driver.	
jdbc.statement-fetch-size	Number of rows fetched at a time.	
jdbc.statement-batch-size	Number of updates sent at a time.	
log.sql	Show SQL logs	[false], true

Multiple datasources

You can register more than one datasource.

```
# default
quarkus.datasource.driver=org.h2.Driver
quarkus.datasource.url=jdbc:h2:tcp://localhost/mem:default
....
# users datasource
quarkus.datasource.users.driver=org.h2.Driver
quarkus.datasource.users.url=jdbc:h2:tcp://localhost/mem:users
```

Notice that after `datasource` you set the `datasource` name, in previous case `users`.

You can inject then `AgroalDataSource` with `io.quarkus.agroal.DataSource`.

```
@DataSource("users")
AgroalDataSource dataSource1;
```

Flushing

You can force flush operation by calling `.flush()` or `.persistAndFlush()` to make it in a single call.

Important This flush is less efficient and you still need to commit transaction.

Testing

There is a Quarkus Test Resource that starts and stops H2 server before and after test suite.

Register dependency `io.quarkus:quarkus-test-h2:test`.

And annotate the test:

```
@QuarkusTestResource(H2DatabaseTestResource.class)
public class FlywayTestResources {
}
```

Transactions

The easiest way to define your transaction boundaries is to use the `@Transactional` annotation.

Transactions are mandatory in case of none idempotent operations.

```
@Transactional
public void createDeveloper() {}
```

You can control the transaction scope:

- `@Transactional(REQUIRED)` (default): starts a transaction if none was started, stays with the existing one otherwise.
- `@Transactional(REQUIRES_NEW)`: starts a transaction if none was started; if an existing one was started, suspends it and starts a new one for the boundary of that method.
- `@Transactional(MANDATORY)`: fails if no transaction was started ; works within the existing transaction otherwise.
- `@Transactional(SUPPORTS)`: if a transaction was started, joins it ; otherwise works with no transaction.
- `@Transactional(NOT_SUPPORTED)`: if a transaction was started, suspends it and works with no transaction for the boundary of the method; otherwise works with no transaction.
- `@Transactional(NEVER)`: if a transaction was started, raises an exception; otherwise works with no transaction.

You can configure the default transaction timeout using `quarkus.transaction-manager.default-transaction-timeout` configuration property. By default it is set to 60 seconds.

You can set a timeout property, in seconds, that applies to transactions created within the annotated method by using `@TransactionConfiguration` annotation.

```
@Transactional
@TransactionConfiguration(timeout=40)
public void createDeveloper() {}
```

If you want more control over transactions you can inject `UserTransaction` and use a programmatic way.

```
@Inject UserTransaction transaction

transaction.begin();
transaction.commit();
transaction.rollback();
```

Infinispan

Quarkus integrates with Infinispan:

```
./mvnw quarkus:add-extension
-Dextensions="infinispan-client"
```

Serialization uses a library called `Protostream`.

Annotation based

```
@ProtoFactory
public Author(String name, String surname) {
    this.name = name;
    this.surname = surname;
}

@ProtoField(number = 1)
public String getName() {
    return name;
}

@ProtoField(number = 2)
public String getSurname() {
    return surname;
}
```

Initializer to set configuration settings.

```
@AutoProtoSchemaBuilder(includeClasses =
    { Book.class, Author.class },
    schemaPackageName = "book_sample")
interface BookContextInitializer
    extends SerializationContextInitializer {
}
```

User written based

There are three ways to create your schema:

Protofile

Creates a `.proto` file in the `META-INF` directory.

```
package book_sample;

message Author {
    required string name = 1;
    required string surname = 2;
}
```

In case of having a `Collection` field you need to use the repeated key (ie repeated `Author` `authors = 4`).

In code

Setting `proto` schema directly in a produced bean.

```
@Produces
FileDescriptorSource bookProtoDefinition() {
    return FileDescriptorSource
        .fromString("library.proto",
            "package book_sample;\n" +
            "message Author {\n" +
            "    required string name = 1;\n" +
            "    required string surname = 2;\n" +
            "}");
}
```

Marshaller

Using `org.infinispan.protostream.MessageMarshaller` interface.

```
public class AuthorMarshaller
    implements MessageMarshaller<Author> {

    @Override
    public String getTypeName() {
        return "book_sample.Author";
    }

    @Override
    public Class<? extends Author> getJavaClass() {
        return Author.class;
    }

    @Override
    public void writeTo(ProtoStreamWriter writer,
        Author author) throws IOException {
        writer.writeString("name", author.getName());
        writer.writeString("surname", author.getSurname());
    }

    @Override
    public Author readFrom(ProtoStreamReader reader)
        throws IOException {
        String name = reader.readString("name");
        String surname = reader.readString("surname");
        return new Author(name, surname);
    }
}
```

And producing the marshaller:

```
@Produces
MessageMarshaller authorMarshaller() {
    return new AuthorMarshaller();
}
```

Infinispan Embedded

```
./mvnw quarkus:add-extension
-Dextensions="infinispan-embeddedy"
```

Configuration in `infinispan.xml`:

```
<local-cache name="quarkus-transaction">
  <transaction
    transaction-manager-lookup=
      "org.infinispan.transaction.lookup.JBossStandaloneJTAManagerLookup"/>
</local-cache>
```

```
quarkus.infinispan-embedded.xml-config=infinispan.xml
```

And you can inject the main entry point for the cache:

```
@Inject
org.infinispan.manager.EmbeddedCacheManager cacheManager;
```

Flyway

Quarkus integrates with Flyway to help you on database schema migrations.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-flyway"
```

Then place migration files to the migrations folder (classpath:db/migration).

You can inject `org.flywaydb.core.Flyway` to programmatically execute the migration.

```
@Inject
Flyway flyway;

flyway.migrate();
```

Or can be automatically executed by setting `migrate-at-start` property to `true`.

```
quarkus.flyway.migrate-at-start=true
```

List of Flyway parameters.

`quarkus.` as prefix is skipped in the next table.

Parameter	Default	Description
flyway.migrate-at-start	false	Flyway migration automatically.
flyway.locations	classpath:db/migration	CSV locations to scan recursively for migrations. Supported prefixes classpath and filesystem.

Parameter	Default	Description
flyway.connect-retries	0	The maximum number of retries when attempting to connect.
flyway.schemas	none	CSV case-sensitive list of schemas managed.
flyway.table	flyway_schema_history	The name of Flyway's schema history table.
flyway.sql-migration-prefix	V	Prefix for versioned SQL migrations.
flyway.repeatable-sql-migration-prefix	R	Prefix for repeatable SQL migrations.
flyway.baseline-on-migrate		Only migrations above baseline-version will then be applied.

flyway.baseline-version	Version to tag an existing schema with when executing 1 baseline.	
flyway.baseline-description	Flyway Baseline	Description to tag an existing schema with when executing baseline

Hibernate Search

Quarkus integrates with Elasticsearch to provide a full-featured full-text search using Hibernate Search API.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-hibernate-search-elasticsearch"
```

You need to annotate your model with Hibernate Search API to index it:

```
@Entity
@Indexed
public class Author extends PanacheEntity {

    @FullTextField(analyzer = "english")
    public String bio;

    @FullTextField(analyzer = "name")
    @KeywordField(name = "firstName_sort",
        sortable = Sortable.YES,
        normalizer = "sort")
    public String firstName;

    @OneToMany
    @IndexedEmbedded
    public List<Book> books;

}
```

Important It is not mandatory to use Panache.

You need to define the analyzers and normalizers defined in annotations. You only need to implement ElasticsearchAnalysisConfigurer interface and configure it.

```
public class MyQuarkusAnalysisConfigurer
    implements ElasticsearchAnalysisConfigurer {

    @Override
    public void configure(
        ElasticsearchAnalysisDefinitionContainerContext ctx)
    {
        ctx.analyzer("english").custom()
            .withTokenizer("standard")
            .withTokenFilters("asciifolding",
                "lowercase", "porter_stem");

        ctx.normalizer("sort").custom()
            .withTokenFilters("asciifolding", "lowercase");
    }
}
```

Use Hibernate Search in REST service:

```
public class LibraryResource {

    @Inject
    EntityManager em;

    @Transactional
    public List<Author> searchAuthors(
        @QueryParam("pattern") String pattern) {
        return Search.getSearchSession(em)
            .search(Author.class)
            .predicate(f ->
                pattern == null || pattern.isEmpty() ?
                    f.matchAll() :
                    f.simpleQueryString()
                        .onFields("firstName",
                            "lastName", "books.title")
                        .matching(pattern)
                    )
            .sort(f -> f.byField("lastName_sort")
                .then().byField("firstName_sort"))
            .fetchHits();
    }
}
```

IMPORTANT When not using Hibernate ORM, index data using Search.getSearchSession(em).createIndexer().startAndWait() at startup time.

Configure the extension in application.properties:

```
quarkus.hibernate-search-elasticsearch.version=7
quarkus.hibernate-search-elasticsearch.
    analysis-configurer=MyQuarkusAnalysisConfigurer
quarkus.hibernate-search-elasticsearch.
    automatic-indexing.synchronization-strategy=searchable
quarkus.hibernate-search-elasticsearch.
    index-defaults.lifecycle.strategy=drop-and-create
quarkus.hibernate-search-elasticsearch.
    index-defaults.lifecycle.required-status=yellow
```

List of Hibernate-Elasticsearch properties prefixed with quarkus.hibernate-search-elasticsearch:

Parameter	Description
backends	Map of configuration of additional backends.
version	Version of Elasticsearch
analysis-configurer	Class or name of the neab used to configure.
hosts	List of Elasticsearch servers hosts.

Parameter	Description
password	Password for auth.
connection-timeout	Duration of connection timeout.
max-connections	Max number of connections to servers.
max-connections-per-route	Max number of connections to server.
indexes	Per-index specific configuration.
discovery.enabled	Enables automatic discovery.
discovery.refresh-interval	Refresh interval of node list.
discovery.default-scheme	Scheme to be used for the new nodes.
automatic-indexing.synchronization-strategy	Status for which you wait before considering the operation completed (queued,committed or searchable).
automatic-indexing.enable-dirty-check	When enabled, re-indexing of is skipped if the changes are on properties that are not used when indexing.
index-defaults.lifecycle.strategy	Index lifecycle (none, validate, update, create, drop-and-create, drop-abd-create-drop)
index-defaults.lifecycle.required-status	Minimal cluster status (green,yellow,red)
index-defaults.lifecycle.required-status-wait-timeout	Waiting time before failing the bootstrap.

Parameter	Description
<code>index-defaults.refresh-after-write</code>	Set if index should be refreshed after writes.

Possible annotations:

Parameter	Description
<code>@Indexed</code>	Register entity as full text index
<code>@FullTextField</code>	Full text search. Need to set an analyzer to split tokens.
<code>@KeywordField</code>	The string is kept as one single token but can be normalized.
<code>IndexedEmbedded</code>	Include the Book fields into the Author index.
<code>@ContainerExtraction</code>	Sets how to extract a value from container, e.g from a Map.
<code>@DocumentId</code>	Map an unusual entity identifier to a document identifier.
<code>@GenericField</code>	Full text index for any supported type.
<code>@IdentifierBridgeRef</code>	Reference to the identifier bridge to use for a <code>@DocumentId</code> .
<code>@IndexingDependency</code>	How a dependency of the indexing process to a property should affect automatic reindexing.
<code>@ObjectPath</code>	
<code>@ScaledNumberField</code>	For <code>java.math.BigDecimal</code> or <code>java.math.BigInteger</code> that you need higher precision.

Amazon DynamoDB

Quarkus integrates with Amazon DynamoDB:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-amazon-dynamodb"
```

```
@Inject
DynamoDbClient dynamoDB;

@Inject
DynamoDbAsyncClient dynamoDB;
```

To use it as a local DynamoDB instance:

```
quarkus.dynamodb.region=
eu-central-1
quarkus.dynamodb.endpoint-override=
http://localhost:8000
quarkus.dynamodb.credentials.type=STATIC
quarkus.dynamodb.credentials.static-provider
.access-key-id=test-key
quarkus.dynamodb.credentials.static-provider
.secret-access-key=test-secret
```

If you want to work with an AWS account, you’d need to set it with:

```
quarkus.dynamodb.region=<YOUR_REGION>
quarkus.dynamodb.credentials.type=DEFAULT
```

DEFAULT credentials provider chain:

- **System properties** `aws.accessKeyId`, `aws.secretKey`
- **Env. Variables** `AWS_ACCESS_KEY_ID`, `AWS_SECRET_ACCESS_KEY`
- **Credentials profile** `~/.aws/credentials`
- **Credentials through the Amazon EC2 container service** if the `AWS_CONTAINER_CREDENTIALS_RELATIVE_URI` set
- **Credentials through Amazon EC2 metadata service.**

Configuration parameters prefixed with `quarkus.dynamodb`:

Parameter	Default	Description
<code>enable-endpoint-discovery</code>	<code>false</code>	Endpoint discovery for a service API that supports endpoint discovery.
<code>endpoint-override</code>		Configure the endpoint with which the SDK should communicate.
<code>api-call-timeout</code>		Time to complete an execution.

interceptors		List of class interceptors.
Configuration parameters		prefixed with
<code>quarkus.dynamodb.aws:</code>		
Parameter	Default	Description
region		Region that hosts DynamoDB.
credentials.type	DEFAULT	Credentials that should be used DEFAULT, STATIC, SYSTEM_PROPERTY, ENV_VARIABLE, PROFILE, CONTAINER, INSTANCE_PROFILE, PROCESS, ANONYMOUS

Credentials specific parameters prefixed with `quarkus.dynamodb.aws.credentials`:

Parameter	Default	Description
<code>DEFAULT</code>		
<code>default-provider.async-credential-update-enabled</code>	<code>false</code>	Should fetch credentials async.
<code>default-provider.reuse-last-provider-enabled</code>	<code>true</code>	Should reuse the last successful credentials.
<code>STATIC</code>		
<code>static-provider.access-key-id</code>		AWS access key id.
<code>static-provider.secret-access-key</code>		AWS secret access key.
<code>PROFILE</code>		
<code>profile-provider.profile-name</code>	<code>default</code>	The name of the profile to use.

Parameter	Default	Description	Parameter	Default	Description	Parameter	Default	Description
PROCESS			use-idle-connection-reaper	true	Connections in pool should be closed asynchronously.	connection-acquisition-timeout	10S	Connection acquisition timeout.
process-provider.command		Command to execute to retrieve credentials.	proxy.endpoint		Endpoint of the proxy server.	connection-max-idle-time	60S	Max time to connection to be opened.
process-provider.process-output-limit	1024	Max bytes to retrieve from process.	proxy.enabled	false	Enables HTTP proxy.	connection-timeout		Connection timeout.
process-provider.credential-refresh-threshold	PT15S	The amount of time between credentials expire and credentials refreshed.	proxy.username		Proxy username.	connection-time-to-live	0	Max time connection to be open.
process-provider.async-credential-update-enabled	false	Should fetch credentials async.	proxy.ntlm-domain		For NTLM, domain name.	max-concurrency	50	Max number of concurrent connections.
In case of synchronous client, the next parameters can be configured prefixed by <code>quarkus.dynamodb.sync-client</code> :			proxy.ntlm-workstation		For NTLM, workstation name.	use-idle-connection-reaper	true	Connections in pool should be closed asynchronously.
Parameter	Default	Description	proxy.preemptive-basic-authentication-enabled		Authenticate preemptively.	read-timeout	30S	Read timeout.
connection-acquisition-timeout	10S	Connection acquisition timeout.	proxy.non-proxy-hosts		List of non proxy hosts.	write-timeout	30S	Write timeout.
connection-max-idle-time	60S	Max time to connection to be opened.	tls-managers-provider.type	system-property	TLS manager: none, system-property, file-store	proxy.endpoint		Endpoint of the proxy server.
connection-timeout		Connection timeout.	tls-managers-provider.file-store.path		Path to key store.	proxy.enabled	false	Enables HTTP proxy.
connection-time-to-live	0	Max time connection to be open.	tls-managers-provider.file-store.type		Key store type.	proxy.non-proxy-hosts		List of non proxy hosts.
socket-timeout	30S	Time to wait for data.	tls-managers-provider.file-store.password		Key store password.	tls-managers-provider.type	system-property	TLS manager: none, system-property, file-store
max-connections	50	Max connections.				tls-managers-provider.file-store.path		Path to key store.
expect-continue-enabled	true	Client send an HTTP expect-continue handshake.	In case of asynchronous client, the next parameters can be configured prefixed by <code>quarkus.dynamodb.async-client</code> :			tls-managers-provider.file-store.type		Key store type.
Parameter	Default	Description	Parameter	Default	Description	Parameter	Default	Description

Parameter	Default	Description
tls-managers-provider.file-store.password		Key store password.
ssl-provider		SSL Provider (jdk, openssl, openssl-refcnt).
protocol	HTTP_1_1	Sets the HTTP protocol.
max-http2-streams		Max number of concurrent streams.
event-loop.override	false	Enable custom event loop conf.
event-loop.number-of-threads		Number of threads to use in event loop.
event-loop.thread-name-prefix	aws-java-sdk-NettyEventLoop	Prefix of thread names.

Neo4j

Quarkus integrates with Neo4j:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-neo4j"

@Inject
org.neo4j.driver.Driver driver;
```

Configuration properties:

quarkus.neo4j as prefix is skipped in the next table.

Parameter	Default	Description
uri	localhost:7687	URI of Neo4j.
authentication.username	neo4j	Username.
authentication.password	neo4j	Password.

Parameter	Default	Description
authentication.disabled	false	Disable authentication.
pool.metrics-enabled	false	Enable metrics.
pool.log-leaked-sessions	false	Enable leaked sessions logging.
pool.max-connection-pool-size	100	Max amount of connections.
pool.max-connection-lifetime	1H	Pooled connections older will be closed and removed from the pool.
pool.connection-acquisition-timeout	1M	Timeout for connection adquisition.
pool.idle-time-before-connection-test	-1	Pooled connections idled in the pool for longer than this timeout will be tested before they are used.

As Neo4j uses SSL communication by default, to create a native executable you need to compile with next options GraalVM options:

```
-H:EnableURLProtocols=http,https --enable-all-security-services -H:+JNI
```

And Quarkus Maven Plugin with next configuration:

```
<artifactId>quarkus-maven-plugin</artifactId>
<executions>
  <execution>
    <id>native-image</id>
    <goals>
      <goal>native-image</goal>
    </goals>
    <configuration>
      <enableHttpUrlHandler>true
    </enableHttpUrlHandler>
      <enableHttpsUrlHandler>true
    </enableHttpsUrlHandler>
      <enableAllSecurityServices>true
    </enableAllSecurityServices>
      <enableJni>true</enableJni>
    </configuration>
  </execution>
</executions>
```

Alternatively, and as a not recommended way in production, you can disable SSL and Quarkus will disable Bolt SSL as well. quarkus.ssl.native=false.

If you are using Neo4j 4.0, you can use fully reactive. Add next depenency management io.projectreactor:reactor-bom:Californium-SR4:pom:import and dependency: io.projectreactor:reactor-core.

```
public Publisher<String> get() {
    return Flux.using(driver::rxSession, ...);
}
```

MongoDB Client

Quarkus integrates with MongoDB:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-mongodb-client"

@Inject
com.mongodb.client.MongoClient client;

@Inject
io.quarkus.mongodb.ReactiveMongoClient client;

quarkus.mongodb.connection-string=mongodb://localhost:27018
quarkus.mongodb.write-concern.journal=false
```

quarkus.mongodb as prefix is skipped in the next table.

Parameter	Type	Description
-----------	------	-------------

Parameter	Type	Description	Parameter	Type	Description	Parameter	Type	Description
connection-string	String	MongoDB connection URI.	connection-timeout	Duration		write-concern.retry-writes	boolean [false]	Retry writes if network fails.
			socket-timeout	Duration				
hosts	List<String>	Addresses passed as host:port.	tls-insecure	boolean [false]	Insecure TLS.	write-concern.w-timeout	Duration	Timeout to all write commands.
			tls	boolean [false]	Enable TLS	credentials.username	String	Username.
application-name	String	Application name.	replica-set-name	String	Implies hosts given are a seed list.	credentials.password	String	Password.
max-pool-size	Int	Maximum number of connections.	server-selection-timeout	Duration	Time to wait for server selection.	credentials.auth-mechanism	MONGO-CR, GSSAPI, PLAIN, MONGODB-X509	
min-pool-size	Int	Minimum number of connections.				credentials.auth-source	String	Source of the authentication credentials.
max-connection-idle-time	Duration	Idle time of a pooled connection.	local-threshold	Duration	Minimum ping time to make a server eligible.	credentials.auth-mechanism-properties	Map<String, String>	Authentication mechanism properties.
max-connection-life-time	Duration	Life time of pooled connection.	heartbeat-frequency	Duration	Frequency to determine the state of servers.			
wait-queue-timeout	Duration	Maximum wait time for new connection.	read-preference	primary, primaryPreferred, secondary, secondaryPreferred, nearest	Read preferences.			
maintenance-frequency	Duration	Time period between runs of maintenance job.	max-wait-queue-size	Int	Max number of concurrent operations allowed to wait.			
maintenance-initial-delay	Duration	Time to wait before running the first maintenance job.	write-concern.safe	boolean [true]	Ensures are writes are ack.			
wait-queue-multiple	Int	Multiplied with max-pool-size gives max number of threads waiting.	write-concern.journal	boolean [true]	Journal writing aspect.			
			write-concern.w	String	Value to all write commands.			

MongoDB Panache

You can also use the Panache framework to write persistence part when using MongoDB.

```
./mvnw quarkus:add-extension
-Dextensions="mongodb-panache"
```

MongoDB configuration comes from MongoDB Client section.

```
@MongoEntity(collection="ThePerson")
public class Person extends PanacheMongoEntity {
    public String name;

    @BsonProperty("birth")
    public LocalDate birthDate;

    public Status status;
}
```

Possible annotations in fields: @BsonId (for custom ID), @BsonProperty and @BsonIgnore.

Important: @MongoEntity is optional.

Methods provided are similar of the ones shown in Persistence section.

MongoDB Panache

You can also use the Panache framework to write persistence part when using MongoDB.

```
./mvnw quarkus:add-extension
-Dextensions="mongodb-panache"
```

MongoDB configuration comes from MongoDB Client section.

```
@MongoEntity(collection="ThePerson")
public class Person extends PanacheMongoEntity {
    public String name;

    @BsonProperty("birth")
    public LocalDate birthDate;

    public Status status;
}
```

Possible annotations in fields: @BsonId (for custom ID), @BsonProperty and @BsonIgnore.

Important: @MongoEntity is optional.

Methods provided are similar of the ones shown in Persistence section.

```
person.persist();
person.update();
person.delete();

List<Person> allPersons = Person.listAll();
person = Person.findById(personId);
List<Person> livingPersons = Person.list("status", Status.Alive);
List<Person> persons = Person.list(Sort.by("name").and("birth"));

long countAll = Person.count();

Person.delete("status", Status.Alive);
```

All list methods have equivalent stream versions.

Pagination

You can also use pagination:

```
PanacheQuery<Person> livingPersons =
    Person.find("status", Status.Alive);
livingPersons.page(Page.ofSize(25));

// get the first page
List<Person> firstPage = livingPersons.list();
// get the second page
List<Person> secondPage = livingPersons.nextPage().list();
```

Queries

Native MongoDB queries are supported (if they start with { or org.bson.Document instance) as well as Panache Queries. Panache Queries equivalence in MongoDB:

- `firstname = ?1 and status = ?2 → {'firstname': ?1, 'status': ?2}`
- `amount > ?1 and firstname != ?2 → {'amount': {'$gt': ?1}, 'firstname': {'$ne': ?2}}`
- `lastname like ?1 → {'lastname': {'$regex': ?1}}`
- `lastname is not null → {'lastname': {'$exists': true}}`

WARNING: PanacheQL refers to the Object parameter name but native queries refer to MongoDB field names.

DAO pattern

```
@ApplicationScoped
public class PersonRepository
    implements PanacheMongoRepository<Person> {
}
```

If entities are defined in external JAR, you need to enable in these proiects the Jandex plugin in proiect.

```
<plugin>
  <groupId>org.jboss.jandex</groupId>
  <artifactId>jandex-maven-plugin</artifactId>
  <version>1.0.3</version>
  <executions>
    <execution>
      <id>make-index</id>
      <goals>
        <goal>jandex</goal>
      </goals>
    </execution>
  </executions>
</dependencies>
<dependencies>
  <dependency>
    <groupId>org.jboss</groupId>
    <artifactId>jandex</artifactId>
    <version>2.1.1.Final</version>
  </dependency>
</dependencies>
</plugin>
```

Reactive Programming

Quarkus implements MicroProfile Reactive spec and uses RXJava2 to provide reactive programming model.

```
./mvnw quarkus:add-extension
-Dextensions="
  io.quarkus:quarkus-smallrye-reactive-streams-operators"
```

Asynchronous HTTP endpoint is implemented by returning Java CompletionStage. You can create this class either manually or using MicroProfile Reactive Streams spec:

```
@GET
@Path("/reactive")
@Produces(MediaType.TEXT_PLAIN)
public CompletionStage<String> getHello() {
    return ReactiveStreams.of("h", "e", "l", "l", "o")
        .map(String::toUpperCase)
        .toList()
        .run()
        .thenApply(list -> list.toString());
}
```

Creating streams is also easy, you just need to return Publisher object.

```
@GET
@Path("/stream")
@Produces(MediaType.SERVER_SENT_EVENTS)
public Publisher<String> publishers() {
    return Flowable
        .interval(500, TimeUnit.MILLISECONDS)
        .map(s -> atomicInteger.getAndIncrement())
        .map(i -> Integer.toString(i));
}
```

Reactive Messaging

Quarkus relies on MicroProfile Reactive Messaging spec to implement reactive messaging streams.

```
mvn quarkus:add-extension
-Dextensions="
  io.quarkus:quarkus-smallrye-reactive-messaging"
```

You can just start using in-memory streams by using @Incoming to produce data and @Outgoing to consume data.

Produce every 5 seconds one piece of data.


```
@ApplicationScoped
public class ProducerData {

    @Outgoing("my-in-memory")
    public Flowable<Integer> generate() {
        return Flowable.interval(5, TimeUnit.SECONDS)
            .map(tick -> random.nextInt(100));
    }
}
```

If you want to dispatch to all subscribers you can annotate the method with `@Broadcast`.

Consumes generated data from my-in-memory stream.

```
@ApplicationScoped
public class ConsumerData {
    @Incoming("my-in-memory")
    public void randomNumber(int randomNumber) {
        System.out.println("Received " + randomNumber);
    }
}
```

You can also inject an stream as a field:

```
@Inject
@Stream("my-in-memory") Publisher<Integer> randomNumbers;
```

```
@Inject @Stream("generated-price")
Emitter<String> emitter;
```

Patterns

REST API → Message

```
@Inject @Stream("in")
Emitter<String> emitter;

emitter.send(message);
```

Message → Message

```
@Incoming("in")
@Outgoing("out")
public String process(String in) {
}
```

Message → SSE

```
@Inject @Stream("out")
Publisher<String> result;

@GET
@Produces(SERVER_SENT_EVENTS)
public Publisher<String> stream() {
    return result;
}
```

Message → Business Logic

```
@ApplicationScoped
public class ReceiverMessages {
    @Incoming("prices")
    public void print(String price) {
    }
}
```

Possible implementations are:

In-Memory

If the stream is not configured then it is assumed to be an in-memory stream, if not then stream type is defined by connector field.

Kafka

To integrate with Kafka you need to add next extensions:

```
mvn quarkus:add-extension
-Dextensions="
io.quarkus:quarkus-smallrye-reactive-messaging-kafka"
```

Then `@Outgoing`, `@Incoming` or `@Stream` can be used.

Kafka configuration schema: `mp.messaging.[outgoing|incoming].{stream-name}.<property>=<value>`.

The connector type is `smallrye-kafka`.

```
mp.messaging.outgoing.generated-price.connector=
smallrye-kafka
mp.messaging.outgoing.generated-price.topic=
prices
mp.messaging.outgoing.generated-price.bootstrap.servers=
localhost:9092
mp.messaging.outgoing.generated-price.value.serializer=
org.apache.kafka.common.serialization.IntegerSerializer

mp.messaging.incoming.prices.connector=
smallrye-kafka
mp.messaging.incoming.prices.value.deserializer=
org.apache.kafka.common.serialization.IntegerDeserializer
```

A complete list of supported properties are in Kafka site. For the producer and for consumer

JSON-B Serializer/Deserializer

You can use JSON-B to serialize/deserialize objects.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-kafka-client"
```

To serialize you can use `io.quarkus.kafka.client.serialization.JsonbSerializer`.

To deserialize you need to extend `io.quarkus.kafka.client.serialization.JsonbDeserializer` and provide a type.

```
public class BeerDeserializer
    extends JsonbDeserializer<Beer> {

    public BeerDeserializer() {
        super(Beer.class);
    }

}
```

AMQP

To integrate with AMQP you need to add next extensions:

```
./mvnw quarkus:add-extension
-Dextensions="reactive-messaging-amqp"
```

Then `@Outgoing`, `@Incoming` or `@Stream` can be used.

AMQP configuration schema: `mp.messaging.[outgoing|incoming].{stream-name}.<property>=<value>`. Special properties `amqp-username` and `amqp-password` are used to configure AMQP broker credentials.

The connector type is `smallrye-amqp`.

```
amqp-username=quarkus
amqp-password=quarkus
# write
mp.messaging.outgoing.generated-price.connector=
smallrye-amqp
mp.messaging.outgoing.generated-price.address=
prices
mp.messaging.outgoing.generated-price.durable=
true
# read
mp.messaging.incoming.prices.connector=
smallrye-amqp
mp.messaging.incoming.prices.durable=
true
```

A complete list of supported properties for AMQP.

MQTT

To integrate with MQTT you need to add next extensions:

```
./mvnw quarkus:add-extension
-Dextensions="vertx, smallrye-reactive-streams-operators
smallrye-reactive-messaging"
```

And add io.smallrye.reactive:smallrye-reactive-messaging-mqtt-1.0:0.0.10 dependency in your build tool.

Then @Outgoing, @Incoming or @Stream can be used.

MQTT configuration schema: mp.messaging.[outgoing|incoming].{stream-name}.<property>=<value>.

The connector type is smallrye-mqtt.

```
mp.messaging.outgoing.topic-price.type=
smallrye-mqtt
mp.messaging.outgoing.topic-price.topic=
prices
mp.messaging.outgoing.topic-price.host=
localhost
mp.messaging.outgoing.topic-price.port=
1883
mp.messaging.outgoing.topic-price.auto-generated-client-id=
true

mp.messaging.incoming.prices.type=
smallrye-mqtt
mp.messaging.incoming.prices.topic=
prices
mp.messaging.incoming.prices.host=
localhost
mp.messaging.incoming.prices.port=
1883
mp.messaging.incoming.prices.auto-generated-client-id=
true
```

Kafka Streams

Create streaming queries with the Kafka Streams API.

```
./mvnw quarkus:add-extension
-Dextensions="kafka-streams"
```

All we need to do for that is to declare a CDI producer method which returns the Kafka Streams org.apache.kafka.streams.Topology:

```
@ApplicationScoped
public class TopologyProducer {
    @Produces
    public Topology buildTopology() {
        org.apache.kafka.streams.StreamsBuilder.StreamsBuilder
        builder = new StreamsBuilder();
        // ...
        builder.stream()
            .join()
            // ...
            .toStream()
            .to();
        return builder.build();
    }
}
```

Previous example produces content to another stream. If you want to write interactive queries, you can use Kafka streams.

```
@Inject
KafkaStreams streams;

return streams
    .store("stream", QueryableStoreTypes.keyValueStore());
```

The Kafka Streams extension is configured via the Quarkus configuration file application.properties.

```
quarkus.kafka-streams.bootstrap-servers=localhost:9092
quarkus.kafka-streams.application-id=temperature-aggregator
quarkus.kafka-streams.application-server=${hostname}:8080
quarkus.kafka-streams.topics=weather-stations,temperature-values

kafka-streams.cache.max.bytes.buffering=10240
kafka-streams.commit.interval.ms=1000
```

IMPORTANT: All the properties within the kafka-streams namespace are passed through as-is to the Kafka Streams engine. Changing their values requires a rebuild of the application.

Reactive PostgreSQL Client

You can use Reactive PostgreSQL to execute queries to PostgreSQL database in a reactive way, instead of using JDBC way.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-reactive-pg-client"
```

Database configuration is the same as shown in Persistence section, but URL is different as it is not a *jdbc*.

```
quarkus.datasource.url=
vertx-reactive:postgresql://host:5431/db
```

Then you can inject io.vertx.axle.pgclient.PgPool class.

```
@Inject
PgPool client;

CompletionStage<JsonArray> =
    client.query("SELECT * FROM table")
        .thenApply(rowSet -> {
            JsonArray jsonArray = new JsonArray();
            PgIterator iterator = rowSet.iterator();
            return jsonArray;
        })
```

Reactive MySQL Client

You can use Reactive MySQL to execute queries to MySQL database in a reactive way, instead of using JDBC way.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-reactive-mysql-client"
```

Database configuration is the same as shown in Persistence section, but URL is different as it is not a *jdbc*.

```
quarkus.datasource.url=
vertx-reactive:mysql://localhost:3306/db
```

Then you can inject io.vertx.axle.mysqlclient.MySQLPool class.

```
@Inject
MySQLPool client;

public static CompletionStage<Fruit> findById(
    MySQLPool c, Long id) {
    return c.preparedQuery("SELECT name FROM fruits WHERE id =
        Tuple.of(id))
        .thenApply(RowSet::iterator)
        .thenApply(iterator -> iterator.hasNext() ?
            from(iterator.next()) : null);
}
```

ActiveMQ Artemis

Quarkus uses Reactive Messaging to integrate with messaging systems, but in case you need deeper control when using Apache ActiveMQ Artemis there is also an extension:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-artemis-core"
```

And then you can inject `org.apache.activemq.artemis.api.core.client.ServerLocator` instance.

```
@ApplicationScoped
public class ArtemisConsumerManager {

    @Inject
    ServerLocator serverLocator;

    private ClientSessionFactory connection;

    @PostConstruct
    public void init() throws Exception {
        connection = serverLocator.createSessionFactory();
    }
}
```

And configure `ServerLocator` in `application.properties`:

```
quarkus.artemis.url=tcp://localhost:61616
```

You can configure ActiveMQ Artemis in `application.properties` file by using next properties prefixed with `quarkus`:

Parameter	Default	Description
artemis.url		Connection URL
artemis.username		Username for authentication.
artemis.password		Password for authentication.

Artemis JMS

If you want to use JMS with Artemis, you can do it by using its extension:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-artemis-jms"
```

And then you can inject `javax.jms.ConnectionFactory`:

```
@ApplicationScoped
public class ArtemisConsumerManager {

    @Inject
    ConnectionFactory connectionFactory;

    private Connection connection;

    @PostConstruct
    public void init() throws JMSEException {
        connection = connectionFactory.createConnection();
        connection.start();
    }
}
```

INFO: Configuration options are the same as Artemis core.

RBAC

You can set RBAC using annotations or in `application.properties`.

Annotations

You can define roles by using `javax.annotation.security.RolesAllowed` annotation.

```
@RolesAllowed("Subscriber")
```

You can use `io.quarkus.security.Authenticated` as a shortcut of `@RolesAllowed("*")`.

File Configuration

Defining RBAC in `application.properties` instead of using annotations.

```
quarkus.http.auth.policy.role-policy1.roles-allowed=
    user,admin
quarkus.http.auth.permission.roles1.paths=
    /roles-secured/*,/other/*,/api/*
quarkus.http.auth.permission.roles1.policy=
    role-policy1

quarkus.http.auth.permission.permit1.paths=
    /public/*
quarkus.http.auth.permission.permit1.policy=
    permit
quarkus.http.auth.permission.permit1.methods=
    GET

quarkus.http.auth.permission.deny1.paths=
    /forbidden
quarkus.http.auth.permission.deny1.policy=
    deny
```

You need to provide permissions set by using the `roles-allowed` property or use the built-in ones `deny`, `permit` or `authenticated`.

JWT

Quarkus implements MicroProfile JWT RBAC spec.

```
mvn quarkus:add-extension
-Dextensions="io.quarkus:quarkus-smallrye-jwt"
```

Minimum JWT required claims: `typ`, `alg`, `kid`, `iss`, `sub`, `exp`, `iat`, `jti`, `upn`, `groups`.

You can inject token by using `JsonWebToken` or a claim individually by using `@Claim`.

```
@Inject
JsonWebToken jwt;

@Inject
@Claim(standard = Claims.preferred_username)
String name;

@Inject
@Claim("groups")
Set<String> groups;
```

Set of supported types: String, Set<String>, Long, Boolean, `javax.json.JsonValue`, Optional, org.eclipse.microprofile.jwt.ClaimValue.

And configuration in src/main/resources/application.properties:

```
mp.jwt.verify.publickey.location=
META-INF/resources/publicKey.pem
mp.jwt.verify.issuer=
https://quarkus.io/using-jwt-rbac
```

Configuration options:

Parameter	Default	Description
quarkus.smallrye-jwt.enabled	true	Determine if the jwt extension is enabled.
quarkus.smallrye-jwt.realm-name	Quarkus-JWT	Name to use for security realm.
quarkus.smallrye-jwt.auth-mechanism	MP-JWT	Authentication mechanism.
mp.jwt.verify.publickey	none	Public Key text itself to be supplied as a string.
mp.jwt.verify.publickey.location	none	Relative path or URL of a public key.
mp.jwt.verify.issuer	none	iss accepted as valid.

Supported public key formats:

- PKCS#8 PEM

- JWK
- JWKS
- JWK Base64 URL
- JWKS Base64 URL

To send a token to server-side you should use Authorization header: curl -H "Authorization: Bearer eyJraWQiOi...".

To inject claim values, the bean must be @RequestScoped CDI scoped. If you need to inject claim values in scope with a lifetime greater than @RequestScoped then you need to use javax.enterprise.inject.Instance interface.

```
@Inject
@Claim(standard = Claims.iat)
private Instance<Long> providerIAT;
```

RBAC

JWT groups claim is directly mapped to roles to be used in security annotations.

```
@RolesAllowed("Subscriber")
```

OpenId Connect

Quarkus can use OpenId Connect or OAuth 2.0 authorization servers such as Keycloak to protect resources using bearer token issued by Keycloak server.

```
mvn quarkus:add-extension
-Dextensions="using-openid-connect"
```

You can also protect resources with security annotations.

```
@GET
@RolesAllowed("admin")
```

Configure application to Keycloak service in application.properties file.

```
quarkus.oidc.realm=quarkus
quarkus.oidc.auth-server-url=http://localhost:8180/auth
quarkus.oidc.resource=backend-service
quarkus.oidc.bearer-only=true
quarkus.oidc.credentials.secret=secret
```

Configuration options with quarkus.oidc prefix:

Parameter	Default	Description
auth-server-url		The base URL of the OpenID Connect (OIDC) server
introspection-path		Relative path of the RFC7662 introspection service
jwtks-path		Relative path of the OIDC service returning a JWK set
public-key		Public key for the local JWT token verification
client-id		The client-id of the application.
credentials.secret		The client secret

NOTE: With Keycloak OIDC server https://host:port/auth/realms/{realm} where {realm} has to be replaced by the name of the Keycloak realm.

TIP: You can use quarkus.http.cors property to enable consuming form different domain.

OAuth2

Quarkus integrates with OAuth2 to be used in case of opaque tokens (none JWT) and its validation against an introspection endpoint.

```
mvn quarkus:add-extension
-Dextensions="security-oauth2"
```

And configuration in src/main/resources/application.properties:

```
quarkus.oauth2.client-id=client_id
quarkus.oauth2.client-secret=secret
quarkus.oauth2.introspection-url=http://oauth-server/introspect
```

And you can map roles to be used in security annotations.

```
@RolesAllowed("Subscriber")
```


Parameter	Default	Description
quarkus.oauth2.enabled	true	Determine if the OAuth2 extension is enabled.
quarkus.oauth2.client-id		The OAuth2 client id used to validate the token.
quarkus.oauth2.client-secret		The OAuth2 client secret used to validate the token.
quarkus.oauth2.introspection-url		URL used to validate the token and gather the authentication claims.
quarkus.oauth2.role-claim	scope	The claim that is used in the endpoint response to load the roles

HTTP basic auth

HTTP basic auth is now enabled by the `quarkus.http-auth.basic=true` property. Then you need to add `elytron-security-properties-file` or `elytron-security-jdbc`.

Security with Properties File

You can also protect endpoints and store identities (user, roles) in the file system.

```
mvn quarkus:add-extension
-Dextensions="elytron-security-properties-file"
```

You need to configure the extension with users and roles files:

And `configuration` in `src/main/resources/application.properties`:

```
quarkus.security.users.file.enabled=true
quarkus.security.users.file.users=test-users.properties
quarkus.security.users.file.roles=test-roles.properties
quarkus.security.users.file.auth-mechanism=BASIC
quarkus.security.users.file.realm-name=MyRealm
```

Then `users.properties` and `roles.properties`:

```
scott=jb0ss
jdoe=p4ssw0rd

scott=Admin,admin,Tester,user
jdoe=NoRolesUser
```

IMPORTANT: If `plain-text` is set to `false` (or omitted) then passwords must be stored in the form MD5 (`username:realm:`password``).

Elytron File Properties configuration properties. Prefix `quarkus.security.users` is skipped.

Parameter	Default	Description
file.enabled	false	The file realm is enabled
file.auth-mechanism	BASIC	The authentication mechanism
file.realm-name	Quarkus	The authentication realm name
file.plain-text	false	If passwords are in plain or in MD5
file.users	users.properties	Classpath resource of user/password
file.roles	roles.properties	Classpath resource of user/role

Embedded Realm

You can embed user/password/role in the same `application.properties`:

```
quarkus.security.users.embedded.enabled=true
quarkus.security.users.embedded.plain-text=true
quarkus.security.users.embedded.users.scott=jb0ss
quarkus.security.users.embedded.roles.scott=admin,tester,user
quarkus.security.users.embedded.auth-mechanism=BASIC
```

IMPORTANT: If `plain-text` is set to `false` (or omitted) then passwords must be stored in the form MD5 (`username:realm:`password``).

Prefix `quarkus.security.users.embedded` is skipped.

Parameter	Default	Description
file.enabled	false	The file realm is enabled
file.auth-mechanism	BASIC	The authentication mechanism
file.realm-name	Quarkus	The authentication realm name
file.plain-text	false	If passwords are in plain or in MD5
file.users.*		* is user and value is password
file.roles.*		* is user and value is role

Security with a JDBC Realm

You can also protect endpoints and store identities in a database.

```
mvn quarkus:add-extension
-Dextensions="elytron-security-jdbc"
```

You still need to add the database driver (ie `jdbc-h2`).

You need to configure JDBC and Elytron JDBC Realm:

```
quarkus.datasource.url=
quarkus.datasource.driver=org.h2.Driver
quarkus.datasource.username=sa
quarkus.datasource.password=sa

quarkus.security.jdbc.enabled=true
quarkus.security.jdbc.principal-query.sql=
SELECT u.password, u.role FROM test_user u WHERE u.user=?
quarkus.security.jdbc.principal-query
.clear-password-mapper.enabled=true
quarkus.security.jdbc.principal-query
.clear-password-mapper.password-index=1
quarkus.security.jdbc.principal-query
.attribute-mappings.0.index=2
quarkus.security.jdbc.principal-query
.attribute-mappings.0.to=groups
```

You need to set the index (1-based) of password and role.

Elytron JDBC Realm configuration properties. Prefix `quarkus.security.jdbc` is skipped.

Parameter	Default	Description
auth-mechanism	BASIC	The authentication mechanism
realm-name	Quarkus	The authentication realm name
enabled	false	If the properties store is enabled
principal-query.sql		The sql query to find the password
principal-query.datasource		The data source to use
principal-query.clear-password-mapper.enabled	false	If the clear-password-mapper is enabled
principal-query.clear-password-mapper.password-index	1	The index of column containing clear password
principal-query.bcrypt-password-mapper.enabled	false	If the bcrypt-password-mapper is enabled
principal-query.bcrypt-password-mapper.password-index	0	The index of column containing password hash
principal-query.bcrypt-password-mapper.hash-encoding	BASE64	A string referencing the password hash encoding (BASE64 or HEX)
principal-query.bcrypt-password-mapper.salt-index	0	The index column containing the Bcrypt salt

Parameter	Default	Description
principal-query.bcrypt-password-mapper.salt-encoding	BASE64	A string referencing the salt encoding (BASE64 or HEX)
principal-query.bcrypt-password-mapper.iteration-count-index	0	The index column containing the Bcrypt iteration count

For multiple datasources you can use the datasource name in the properties:

```
quarkus.datasource.url=
quarkus.security.jdbc.principal-query.sql=

quarkus.datasource.permissions.url=
quarkus.security.jdbc.principal-query.permissions.sql=
```

Vault

Quarkus integrates with Vault to manage secrets or protecting sensitive data.

```
mvn quarkus:add-extension
-Dextensions="vault"
```

And configuring Vault in application.properties:

```
# vault url
quarkus.vault.url=http://localhost:8200

quarkus.vault.authentication.userpass.username=
    bob
quarkus.vault.authentication.userpass.password=
    sinclair

# path within the kv secret engine
quarkus.vault.secret-config-kv-path=
    myapps/vault-quickstart/config
```

Then you can inject the value configured at secret/myapps/vault-quickstart/a-private-key.

```
@ConfigProperty(name = "a-private-key")
String privateKey;
```

You can access the KV engine programmatically:

```
@Inject
VaultKVSecretEngine kvSecretEngine;

kvSecretEngine.readSecret("myapps/vault-quickstart/" + vaultPa
```

Fetching credentials DB

With the next *kv* vault kv put secret/myapps/vault-quickstart/db password=connor

```
quarkus.vault.credentials-provider.mydatabase.kv-path=
    myapps/vault-quickstart/db
quarkus.datasource.credentials-provider=
    mydatabase

quarkus.datasource.url=
    jdbc:postgresql://localhost:5432/mydatabase
quarkus.datasource.driver=
    org.postgresql.Driver
quarkus.datasource.username=
    sarah
```

No password is set as it is fetched from Vault.

INFO: dynamic database credentials through the database-credentials-role property.

Elytron JDBC Realm configuration properties. Prefix quarkus.vault is skipped.

Parameter	Default	Description
url		Vault server U
authentication.client-token		Vault token access
authentication.app-role.role-id		Role Id AppRole auth
authentication.app-role.secret-id		Secret Id AppRole auth
authentication.userpass.username		Username userpass autr
authentication.userpass.password		Password userpass autr
authentication.kubernetes.role		Kubernetes authenticator role

Parameter	Default	Description	Parameter	Default	Description
authentication.kubernetes.jwt-token-path		Location of the file containing the Kubernetes JWT token	credentials-provider."credentials-provider".database-credentials-role		Database credentials role
renew-grace-period	1H	Renew grace period duration.	credentials-provider."credentials-provider".kv-path		A path in vault kv store, where we will find the kv-key
secret-config-cache-period	10M	Vault config source cache period	credentials-provider."credentials-provider".kv-key	password	Key name to search in vault path kv-path
secret-config-kv-path		Vault path in kv store			
log-confidentiality-level	medium	Used to hide confidential infos. low, medium, high			
kv-secret-engine-version	1	Kv secret engine version			
kv-secret-engine-mount-path	secret	Kv secret engine path			
tls.skip-verify	false	Allows to bypass certificate validation on TLS communications			
tls.ca-cert		Certificate bundle used to validate TLS communications			
tls.use-kubernetes-ca-cert	true	TLS will be active			
connect-timeout	5S	Tiemout to establish a connection			
read-timeout	1S	Request timeout			

JAX-RS

Quarkus uses JAX-RS to define REST-ful web APIs. Under the covers, Rest-EASY is working with Vert.X directly without using any Servlet.

It is **important** to know that if you want to use any feature that implies a Servlet (ie Servlet Filters) then you need to add the quarkus-undertow extension to switch back to the Servlet ecosystem but generally speaking, you don't need to add it as everything else is well-supported.

```
@Path("/book")
public class BookResource {

    @GET
    @Produces(MediaType.APPLICATION_JSON)
    public List<Book> getAllBooks() {}

    @POST
    @Produces(MediaType.APPLICATION_JSON)
    public Response createBook(Book book) {}

    @DELETE
    @Path("/{isbn}")
    @Produces(MediaType.APPLICATION_JSON)
    public Response deleteBook(
        @PathParam("isbn") String isbn) {}

    @GET
    @Produces(MediaType.APPLICATION_JSON)
    @Path("search")
    public Response searchBook(
        @QueryParam("description") String description) {}
}
```

To get information from request:

Property	Description	Example
@PathParam	Gets content from request URI.	/book/{id} @PathParam("id")
@QueryParam	Gets query parameter.	/book?desc="" @QueryParam("des
@FormParam	Gets form parameter.	
@MatrixParam	Get URI matrix parameter.	/book;author=mkyong;country=ma

Property	Description	Example
<code>@CookieParam</code>	Gets cookie param by name.	
<code>@HeaderParam</code>	Gets header parameter by name.	

Valid HTTP method annotations provided by the spec are: `@GET`, `@POST`, `@PUT`, `@DELETE`, `@PATCH`, `@HEAD` and `@OPTIONS`.

You can create new annotations that bind to HTTP methods not defined by the spec.

```
@Target({ElementType.METHOD})
@Retention(RetentionPolicy.RUNTIME)
@HttpMethod("LOCK")
public @interface LOCK {
}

@LOCK
public void lockIt() {}
}
```

Injecting

Using `@Context` annotation to inject JAX-RS and Servlet information.

```
@GET
public String getBase(@Context UriInfo uriInfo) {
    return uriInfo.getBaseUri();
}
```

Possible injectable objects: `SecurityContext`, `Request`, `Application`, `Configuration`, `Providers`, `ResourceContext`, `ServletConfig`, `ServletContext`, `HttpServletRequest`, `HttpServletResponse`, `HttpHeaders`, `UriInfo`, `SseEventSink` and `Sse`.

HTTP Filters

HTTP request and response can be intercepted to manipulate the metadata (ie headers, parameters, media type, ...) or abort a request. You only need to implement the `next` `ContainerRequestFilter` and `ContainerResponseFilter` JAX-RS interfaces respectively.

```
@Provider
public class LoggingFilter
    implements ContainerRequestFilter {

    @Context
    UriInfo info;

    @Context
    HttpServletRequest request;

    @Override
    public void filter(ContainerRequestContext context) {
        final String method = context.getMethod();
        final String path = info.getPath();
        final String address = request.getRemoteAddr();
        System.out.println("Request %s %s from IP %s",
            method, path, address);
    }
}
```

Exception Mapper

You can map exceptions to produce a custom output by implementing `ExceptionMapper` interface:

```
@Provider
public class ErrorMapper
    implements ExceptionMapper<Exception> {

    @Override
    public Response toResponse(Exception exception) {
        int code = 500;
        if (exception instanceof WebApplicationException) {
            code = ((WebApplicationException) exception)
                .getResponse().getStatus();
        }
        return Response.status(code)
            .entity(
                Json.createObjectBuilder()
                    .add("error", exception.getMessage())
                    .add("code", code)
                    .build()
            )
            .build();
    }
}
```

Vert.X Filters and Routes

Programmatically

You can also register Vert.X Filters and Router programmatically inside a CDI bean:

```
import io.quarkus.vertx.http.runtime.filters.Filters;
import io.vertx.ext.web.Router;
import javax.enterprise.context.ApplicationScoped;
import javax.enterprise.event.Observes;

@ApplicationScoped
public class MyBean {

    public void filters(
        @Observes Filters filters) {
        filters
            .register(
                rc -> {
                    rc.response()
                        .putHeader("X-Filter", "filter 1");
                    rc.next();
                },
                10);
    }

    public void routes(
        @Observes Router router) {
        router
            .get("/")
            .handler(rc -> rc.response().end("OK"));
    }
}
```

Declarative

You can use `@Route` annotation to use reactive routes in a declarative way:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-vertx-web"
```

```
@ApplicationScoped
public class MyDeclarativeRoutes {

    @Route(path = "/hello", methods = HttpMethod.GET)
    public void greetings(RoutingContext rc) {
        String name = rc.request().getParam("name");
        if (name == null) {
            name = "world";
        }
        rc.response().end("hello " + name);
    }
}
```

GZip Support

You can configure Quarkus to use GZip in the `application.properties` file using the next properties with `quarkus.resteasy` suffix:

Parameter	Default	Description
-----------	---------	-------------

Parameter	Default	Description
gzip.enabled	false	EnableGZip.
gzip.max-input	10M	Configure the upper limit on deflated request body.

CORS Filter

Quarkus comes with a CORS filter that can be enabled via configuration:

```
quarkus.http.cors=true
```

Prefix is quarkus.http.

Property	Default	Description
cors	false	Enable CORS.
cors.origins	Any request valid.	CSV of origins allowed.
cors.methods	Any method valid.	CSV of methods valid.
cors.headers	Any requested header valid.	CSV of valid allowed headers.
cors.exposed-headers		CSV of valid exposed headers.

Fault Tolerance

Quarkus uses MicroProfile Fault Tolerance spec:

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-smallrye-fault-tolerance"
```

MicroProfile Fault Tolerance spec uses CDI interceptor and it can be used in several elements such as CDI bean, JAX-RS resource or MicroProfile Rest Client.

To do automatic **retries** on a method:

```
@Path("/api")
@RegisterRestClient
public interface WorldClockService {
    @GET @Path("/json/cet/now")
    @Produces(MediaType.APPLICATION_JSON)
    @Retry(maxRetries = 2)
    WorldClock getNow();
}
```

You can set fallback code in case of an error by using `@Fallback` annotation:

```
@Retry(maxRetries = 1)
@Fallback(fallbackMethod = "fallbackMethod")
WorldClock getNow(){

    public WorldClock fallbackMethod() {
        return new WorldClock();
    }
}
```

`fallbackMethod` must have the same parameters and return type as the annotated method.

You can also set logic into a class that implements `FallbackHandler` interface:

```
public class RecoverFallback
    implements FallbackHandler<WorldClock> {
    @Override
    public WorldClock handle(ExecutionContext context) {
    }
}
```

And set it in the annotation as value `@Fallback(RecoverFallback.class)`.

In case you want to use **circuit breaker** pattern:

```
@CircuitBreaker(requestVolumeThreshold = 4,
                failureRatio=0.75,
                delay = 1000)
WorldClock getNow(){}
```

If 3 (4 x 0.75) failures occur among the rolling window of 4 consecutive invocations then the circuit is opened for 1000 ms and then be back to half open. If the invocation succeeds then the circuit is back to closed again.

You can use **bulkahead** pattern to limit the number of concurrent access to the same resource. If the operation is synchronous it uses a semaphore approach, if it is asynchronous a thread-pool one. When a request cannot be processed `BulkheadException` is thrown. It can be used together with any other fault tolerance annotation.

```
@Bulkhead(5)
@Retry(maxRetries = 4,
      delay = 1000,
      retryOn = BulkheadException.class)
WorldClock getNow(){}
```

Fault tolerance annotations:

Annotation	Properties
@Timeout	unit
@Retry	maxRetries, delay, delayUnit, maxDuration, durationUnit, jitter, jitterDelayUnit, retryOn, abortOn
@Fallback	fallbackMethod
@Bulkhead	waitingTaskQueue (only valid in asynchronous)
@CircuitBreaker	failOn, delay, delayUnit, requestVolumeThreshold, failureRatio, successThreshold
@Asynchronous	

You can override annotation parameters via configuration file using `[classname/methodname/]annotation/parameter:` property

```
org.acme.quickstart.WorldClock/getNow/Retry/maxDuration=30
# Class scope
org.acme.quickstart.WorldClock/Retry/maxDuration=3000
# Global
Retry/maxDuration=3000
```

You can also enable/disable policies using special parameter enabled.

```
org.acme.quickstart.WorldClock/getNow/Retry/enabled=false
# Disable everything except fallback
MP_Fault_Tolerance_NonFallback_Enabled=false
```

MicroProfile Fault Tolerance integrates with MicroProfile **Tip Metrics** spec. You can disable it by setting `MP_Fault_Tolerance_Metrics_Enabled` to false.

Observability

Health Checks

Quarkus relies on MicroProfile Health spec to provide health checks.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-smallrye-health"
```

By just adding this extension, an endpoint is registered to /health providing a default health check.

```
{
  "status": "UP",
  "checks": [
  ]
}
```

To create a custom health check you need to implement the `HealthCheck` interface and annotate either with `@Readiness` (ready to process requests) or `@Liveness` (is running) annotations.

```
@Readiness
public class DatabaseHealthCheck implements HealthCheck {
    @Override
    public HealthCheckResponse call() {
        HealthCheckResponseBuilder responseBuilder =
            HealthCheckResponse.named("Database conn");

        try {
            checkDatabaseConnection();
            responseBuilder.withData("connection", true);
            responseBuilder.up();
        } catch (IOException e) {
            // cannot access the database
            responseBuilder.down()
                .withData("error", e.getMessage());
        }
        return responseBuilder.build();
    }
}
```

Builds the next output:

```
{
  "status": "UP",
  "checks": [
    {
      "name": "Database conn",
      "status": "UP",
      "data": {
        "connection": true
      }
    }
  ]
}
```

Since health checks are CDI beans, you can do:

```
@ApplicationScoped
public class DatabaseHealthCheck {

    @Produces
    @Liveness
    HealthCheck check1() {
        return io.smallrye.health.HealthStatus
            .up("successful-live");
    }

    @Produces
    @Readiness
    HealthCheck check2() {
        return HealthStatus
            .state("successful-read", this::isReady)
    }

    private boolean isReady() {}
}
```

You can ping liveness or readiness health checks individually by querying /health/live or /health/ready.

Quarkus comes with some `HealthCheck` implementations for checking service status.

- **SocketHealthCheck:** checks if host is reachable using a socket.
- **UrlHealthCheck:** checks if host is reachable using a Http URL connection.
- **InetAddressHealthCheck:** checks if host is reachable using `InetAddress.isReachable` method.

```
@Produces
@Liveness
HealthCheck check1() {
    return new UrlHealthCheck("https://www.google.com")
        .name("Google-Check");
}
```

If you want to override or set manually readiness/liveness probes

```
quarkus.smallrye-health.root-path=/hello
quarkus.smallrye-health.liveness-path=/customlive
quarkus.smallrye-health.readiness-path=/customready
```

Metrics

Quarkus can utilize the MicroProfile Metrics spec to provide metrics support.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-smallrye-metrics"
```

The metrics can be read with JSON or the OpenMetrics format. An endpoint is registered automatically at /metrics providing default metrics.

MicroProfile Metrics annotations:

Annotation	Description
@Timed	Tracks the duration.
@Metered	Tracks the frequency of invocations.
@Counted	Counts number of invocations.
@Gauge	Samples the value of the annotated object.
@ConcurrentGauge	Gauge to count parallel invocations.
@Metric	Used to inject a metric. Valid types <code>Meter</code> , <code>Timer</code> , <code>Counter</code> , <code>Histogram</code> . Gauge only on producer methods/fields.

```
@GET
//...
@Timed(name = "checksTimer",
description = "A measure of how long it takes
                to perform a hello.",
unit = MetricUnits.MILLISECONDS)
public String hello() {}

@Counted(name = "countWelcome",
description = "How many welcome have been performed.")
public String hello() {}
```

@Gauge annotation returning a measure as a gauge.

```
@Gauge(name = "hottestSauce", unit = MetricUnits.NONE,
description = "Hottest Sauce so far.")
public Long hottestSauce() {}
```

Injecting a histogram using @Metric.

```
@Inject
@Metric(name = "histogram")
Histogram histogram;
```

Tracing

Quarkus can utilize the MicroProfile OpenTracing spec.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-smallrye-opentracing"
```

Requests sent to any endpoint are traced automatically.

This extension includes OpenTracing support and Jaeger tracer.

Jaeger tracer configuration:

```
quarkus.jaeger.service-name=myservice
quarkus.jaeger.sampler-type=const
quarkus.jaeger.sampler-param=1
quarkus.jaeger.endpoint=http://localhost:14268/api/traces
```

@Traced annotation can be set to disable tracing at class or method level.

Tracer class can be injected into the class.

```
@Inject
Tracer tracer;

tracer.activeSpan().setBaggageItem("key", "value");
```

You can disable Jaeger extension by using quarkus.jaeger.enabled property.

Additional tracers

JDBC Tracer

Adds a span for each JDBC queries.

```
<dependency>
  <groupId>io.opentracing.contrib</groupId>
  <artifactId>opentracing-jdbc</artifactId>
</dependency>
```

```
# add ':tracing' to your database URL
quarkus.datasource.url=
  jdbc:tracing:postgresql://localhost:5432/mydatabase
quarkus.datasource.driver=
  io.opentracing.contrib.jdbc.TracingDriver
quarkus.hibernate-orm.dialect=
  org.hibernate.dialect.PostgreSQLDialect
```

Cloud

Native

You can build a native image by using GraalVM. The common use case is creating a Docker image so you can execute the next commands:

```
./mvnw package -Pnative -Dnative-image.docker-build=true

docker build -f src/main/docker/Dockerfile.native
               -t quarkus/getting-started .
docker run -i --rm -p 8080:8080 quarkus/getting-started
```

To configure native application, you can create a config directory at the same place as the native file and place an application.properties file inside. config/application.properties.

Kubernetes

Quarks can use Dekorater to generate Kubernetes resources.

```
./mvnw quarkus:add-extensions
-Dextensions="io.quarkus:quarkus-kubernetes"
```

Running ./mvnw package the Kubernetes resources are created at target/wiring-classes/META-INF/kubernetes/ directory.

Property	Default	Description
quarkus.kubernetes.group	Current username	Set Docker Username.
quarkus.application.name	Current project name	Project name

Generated resource is integrated with MicroProfile Health annotations.

Kubernetes Client

Quarkus integrates with Fabric8 Kubernetes Client.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-kubernetes-client"
```

List of Kubernetes client parameters.

quarkus.kubernetes-client as prefix is skipped in the next table.

Property	Default	Description
----------	---------	-------------

Property	Default	Description
trust-certs	false	Trust self-signed certificates.
master-url		URL of Kubernetes API server.
namesapce		Default namespace.
ca-cert-file		CA certificate data.
client-cert-file		Client certificate file.
client-cert-data		Client certificate data.
client-key-data		Client key data.
client-key-algorithm		Client key algorithm.
client-key-passphrase		Client key passphrase.
username		Username.
password		Password.
watch-reconnect-interval	PT1S	Watch reconnect interval.
watch-reconnect-limit	-1	Maximum reconnect attempts.
connection-timeout	PT10S	Maximum amount of time to wait for a connection.
request-timeout	PT10S	Maximum amount of time to wait for a request.
rolling-timeout	PT15M	Maximum amount of time to wait for a rollout.

Property	Default	Description
http-proxy		HTTP proxy used to access the Kubernetes.
https-proxy	""	HTTPS proxy used to access the Kubernetes.
proxy-username		Proxy username.
proxy-password		Proxy password.
no-proxy		IP addresses or hosts to exclude from proxying

Or programmatically:

```
@Dependent
public class KubernetesClientProducer {

    @Produces
    public KubernetesClient kubernetesClient() {
        Config config = new ConfigBuilder()
            .withMasterUrl("https://mymaster.com")
            .build();
        return new DefaultKubernetesClient(config);
    }
}
```

And inject it on code:

```
@Inject
KubernetesClient client;

ServiceList myServices = client.services().list();

Service myservice = client.services()
    .inNamespace("default")
    .withName("myservice")
    .get();

CustomResourceDefinitionList crds = client
    .customResourceDefinitions()
    .list();

dummyCRD = new CustomResourceDefinitionBuilder()
    ...
    .build()
client.customResourceDefinitions()
    .create(dummyCRD);
```

Testing

Quarkus provides a Kubernetes Mock test resource that starts a mock of Kubernetes API server and sets the proper environment variables needed by Kubernetes Client.

Register next dependency: `io.quarkus:quarkus-test-kubernetes-client:test`.

```
@QuarkusTestResource(KubernetesMockServerTestResource.class)
@QuarkusTest
public class KubernetesClientTest {

    @MockServer
    private KubernetesMockServer mockServer;

    @Test
    public void test() {
        final Pod pod1 = ...
        mockServer
            .expect()
            .get()
            .withPath("/api/v1/namespaces/test/pods")
            .andReturn(200,
                new PodListBuilder()
                    .withNewMetadata()
                    .withResourceVersion("1")
                    .endMetadata()
                    .withItems(pod1, pod2)
                    .build())
            .always();
    }
}
```

Amazon Lambda

Quarkus integrates with Amazon Lambda.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-amazon-lambda"
```

And then implement `com.amazonaws.services.lambda.runtime.RequestHandler` interface.

```
public class TestLambda
    implements RequestHandler<MyInput, MyOutput> {
    @Override
    public MyOutput handleRequest(MyInput input,
                                   Context context) {
    }
}
```

You can set the handler name by using `quarkus.lambda.handler` property.

You can write tests for Amazon lambdas:

```
<dependency>
  <groupId>io.quarkus</groupId>
  <artifactId>quarkus-test-amazon-lambda</artifactId>
  <scope>test</scope>
</dependency>
```

```
@Test
public void testLambda() {
    MyInput in = new MyInput();
    in.setGreeting("Hello");
    in.setName("Stu");
    MyOutput out = LambdaClient.invoke(MyOutput.class, in);
}
```

Azure Functions

Quarkus can make a microservice be deployable to the Azure Functions.

To scaffold a deployable microservice to the Azure Functions run:

```
mvn archetype:generate \
  -DarchetypeGroupId=io.quarkus \
  -DarchetypeArtifactId=quarkus-azure-functions-http-archetype \
  -DarchetypeVersion={version}
```

Apache Camel

Apache Camel Quarkus has its own site:
<https://github.com/apache/camel-quarkus>

WebSockets

Quarkus can be used to handling web sockets.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-undertow-websockets"
```

And web sockets classes can be used:

```
@ServerEndpoint("/chat/{username}")
@ApplicationScoped
public class ChatSocket {

    @OnOpen
    public void onOpen(Session session,
        @PathParam("username") String username) {}

    @OnClose
    public void onClose(..) {}

    @OnError
    public void onError(..., Throwable throwable) {}

    @OnMessage
    public void onMessage(...) {}

}
```

OpenAPI

Quarkus can expose its API description as OpenAPI spec and test it using Swagger UI.

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-smallrye-openapi"
```

Then you only need to access to `/openapi` to get OpenAPI v3 spec of services.

You can update the OpenApi path by setting `quarkus.smallrye-openapi.path` property.

Also, in case of starting Quarkus application in dev or test mode, Swagger UI is accessible at `/swagger-ui`. If you want to use it in production mode you need to set `quarkus.swagger-ui.always-include` property to `true`.

You can update the Swagger UI path by setting `quarkus.swagger-ui.path` property.

```
quarkus.swagger-ui.path=/my-custom-path
```

You can customize the output by using Open API v3 annotations.

```
@Schema(name="Developers",
        description="POJO that represents a developer.")
public class Developer {
    @Schema(required = true, example = "Alex")
    private String name;
}

@POST
@Path("/developer")
@Operation(summary = "Create deeloper",
        description = "Only be done by admin.")
public Response createDeveloper(
    @RequestBody(description = "Developer object",
        required = true,
        content = @Content(schema =
            @Schema(implementation = Developer.class)))
        Developer developer)
```

All possible annotations can be seen at org.eclipse.microprofile.openapi.annotations package.

You can also serve OpenAPI Schema from static files instead of dynamically generated from annotation scanning.

You need to put OpenAPIdocumentation under `META-INF` directory (ie: `META-INF/openapi.yaml`).

A request to `/openapi` will serve the combined OpenAPI document from the static file and the generated from annotations. You can disable the scanning documents by adding the next configuration property:
`mp.openapi.scan.disable=true`.

Other valid document paths are: `META-INF/openapi.yml`, `META-INF/openapi.json`, `WEB-INF/classes/META-INF/openapi.yml`, `WEB-INF/classes/META-INF/openapi.yaml`, `WEB-INF/classes/META-INF/openapi.json`.

Mail Sender

You can send emails by using Quarkus Mailer extension:

```
./mvnw quarkus:add-extension
-Dextensions="io.quarkus:quarkus-mailer"
```

You can inject two possible classes `io.quarkus.mailer.Mailer` for synchronous API or `io.quarkus.mailer.ReactiveMailer` for asynchronous API.

```
@Inject
Mailer mailer;

@Inject
ReactiveMailer reactiveMailer;
```

And then you can use them to send an email:

```
mailer.send(
    Mail.withText("to@acme.org", "Subject", "Body")
);

CompletionStage<Void> stage =
    reactiveMailer.send(
        Mail.withText("to@acme.org", "Subject", "Body")
    );
```

Mail class contains methods to add cc, bcc, headers, bounce address, reply to, attachments, inline attachments and html body.

```
mailer.send(Mail.withHtml("to@acme.org", "Subject", body)
    .addInlineAttachment("quarkus.png",
        new File("quarkus.png"),
        "image/png", "<my-image@quarkus.io>"));
```

Tip If you need deep control you can inject Vert.x mail client
`@Inject MailClient client;`

You need to configure SMTP properties to be able to send an email:

```
quarkus.mailer.from=test@quarkus.io
quarkus.mailer.host=smtp.sendgrid.net
quarkus.mailer.port=465
quarkus.mailer.ssl=true
quarkus.mailer.username=...
quarkus.mailer.password=...
```

List of Mailer parameters. `quarkus.` as a prefix is skipped in the next table.

Parameter	Default	Description
mailer.from		Default address.
mailer.mock	false in prod, true in dev and test.	Emails not sent, just printed and stored in a MockMailbox.
mailer.bounce-address		Default address.
mailer.host	mandatory	SMTP host.
mailer.port	25	SMTP port.
mailer.username		The username.
mailer.password		The password.
mailer.ssl	false	Enables SSL.
mailer.trust-all	false	Trust all certificates.
mailer.max-pool-size	10	Max connections . open
mailer.own-host-name		Hostname HELO/EHLO Message-ID for and
mailer.keep-alive	true	Connection pool enabled.
mailer.disable-esmtp	false	Disable ESMTP.
mailer.start-tls	OPTIONAL	TLS security mode. DISABLED, OPTIONAL, REQUIRED.
mailer.login	NONE	Login mode. NONE, OPTIONAL, REQUIRED.
mailer.auth-methods	All methods.	Space-separated list.

Parameter	Default	Description
mailer.key-store		Path of the key store.
mailer.key-store-password		Key store password.

IMPORTANT: if you enable SSL for the mailer and you want to build a native executable, you will need to enable the SSL support `quarkus.ssl.native=true`.

Testing

If `quarkus.mailer.mock` is set to `true`, which is the default value in dev and test mode, you can inject `MockMailbox` to get the sent messages.

```
@Inject
MockMailbox mailbox;

@BeforeEach
void init() {
    mailbox.clear();
}

List<Mail> sent = mailbox
    .getMessagesSentTo("to@acme.org");
```

Scheduled Tasks

You can schedule periodic tasks with Quarkus.

```
@ApplicationScoped
public class CounterBean {

    @Scheduled(every="10s")
    void increment() {}

    @Scheduled(cron="0 15 10 * * ?")
    void morningTask() {}
}
```

`every` and `cron` parameters can be surrounded with `{ }` and the value is used as config property to get the value.

```
@Scheduled(cron = "{morning.check.cron.expr}")
void morningTask() {}
```

And configure the property into `application.properties`:

```
morning.check.cron.expr=0 15 10 * * ?
```

Kogito

Quarkus integrates with Kogito, a next-generation business automation toolkit from Drools and jBPM projects for adding business automation capabilities.

To start using it you only need to add the next extension:

```
./mvnw quarkus:add-extension
-Dextensions="kogito"
```

Apache Tika

Quarkus integrets with Apache Tika to detect and extract metadata/text from different file types:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-tika"
```

```
@Inject
io.quarkus.tika.TikaParser parser;

@POST
@Path("/text")
@Consumes({ "text/plain", "application/pdf",
            "application/vnd.oasis.opendocument.text" })
@Produces(MediaType.TEXT_PLAIN)
public String extractText(InputStream stream) {
    return parser.parse(stream).getText();
}
```

You can configure Apache Tika in application.properties file by using next properties prefixed with quarkus:

Parameter	Default	Description
tika.tika-config-path	tika-config.xml	Path to the Tika configuration resource.
quarkus.tika.parsers		CSV of the abbreviated or full parser class to be loaded by the extension.
tika.append-embedded-content	true	The document may have other embedded documents. Set if autmatically append.

JGit

Quarkus integrets with JGit to integrate with Git repositories:

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-jgit"
```

And then you can start using JGit:

```
try (Git git = Git.cloneRepository()
    .setDirectory(tmpDir)
    .setURI(url)
    .call()) {
    return tmpDir.toString();
}
```

IMPORTANT: When running in native mode, make sure to configure SSL access correctly quarkus.ssl.native=true (Native and SSL).

Web Resources

You can serve web resources with Quarkus. You need to place web resources at src/main/resources/META-INF/resources and then they are accessible (ie http://localhost:8080/index.html)

By default static resources as served under the root context. You can change this by using quarkus.http.root-path property.

Transactional Memory

Quarkus integrates with the Software Transactional Memory (STM) implementation provided by the Narayana project.

```
./mvnw quarkus:add-extension
-Dextensions="narayana-stm"
```

Transactional objects must be interfaces and annotated with org.jboss.stm.annotations.Transactional.

```
@Transactional
@NestedTopLevel
public interface FlightService {
    int getNumberOfBookings();
    void makeBooking(String details);
}
```

The pessimistic strategy is the default one, you can change to optimistic by using @Optimistic.

Then you need to create the object inside org.jboss.stm.Container.

```
Container<FlightService> container = new Container<>();
FlightServiceImpl instance = new FlightServiceImpl();
FlightService flightServiceProxy = container.create(instance);
```

The implementation of the service sets the locking and what needs to be saved/restored:

```
import org.jboss.stm.annotations.ReadLock;
import org.jboss.stm.annotations.State;
import org.jboss.stm.annotations.WriteLock;

public class FlightServiceImpl
    implements FlightService {
    @State
    private int numberOfBookings;

    @ReadLock
    public int getNumberOfBookings() {
        return numberOfBookings;
    }

    @WriteLock
    public void makeBooking(String details) {
        numberOfBookings += 1;
    }
}
```

Any member is saved/restored automatically (@State is not mandatory). You can use @NotState to avoid behaviour.

Transaction boundaries

Declarative

- @NestedTopLevel: Defines that the container will create a new top-level transaction for each method invocation.
- @Nested: Defines that the container will create a new top-level or nested transaction for each method invocation.

Programmatically

```
AtomicAction aa = new AtomicAction();

aa.begin();
{
    try {
        flightService.makeBooking("BA123 ...");
        taxiService.makeBooking("East Coast Taxis ...");

        aa.commit();
    } catch (Exception e) {
        aa.abort();
    }
}
```


Spring DI

Quarkus provides a compatibility layer for Spring dependency injection.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-spring-di"
```

Some examples of what you can do. Notice that annotations are the Spring original ones.

```
@Configuration
public class AppConfig {

    @Bean(name = "capitalizeFunction")
    public StringFunction capitalizer() {
        return String::toUpperCase;
    }
}
```

Or as a component:

```
@Component("noopFunction")
public class NoOpSingleStringFunction
    implements StringFunction {

}
```

Also as a service and injection properties from application.properties.

```
@Service
public class MessageProducer {

    @Value("${greeting.message}")
    String message;

}
```

And you can inject using Autowired or constructor in a component and in a JAX-RS resource too.

```
@Component
public class GreeterBean {

    private final MessageProducer messageProducer;

    @Autowired @Qualifier("noopFunction")
    StringFunction noopStringFunction;

    public GreeterBean(MessageProducer messageProducer) {
        this.messageProducer = messageProducer;
    }
}
```

Spring Web

Quarkus provides a compatibility layer for Spring Web.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-spring-web"
```

Specifically supports the REST related features. Notice that infrastructure things like BeanPostProcessor will not be executed.

```
@RestController
@RequestMapping("/greeting")
public class GreetingController {

    private final GreetingBean greetingBean;

    public GreetingController(GreetingBean greetingBean) {
        this.greetingBean = greetingBean;
    }

    @GetMapping("/{name}")
    public Greeting hello(@PathVariable(name = "name")
        String name) {
        return new Greeting(greetingBean.greet(name));
    }
}
```

Supported annotations are: RestController, RequestMapping, GetMapping, PostMapping, PutMapping, DeleteMapping, PatchMapping, RequestParam, `RequestHeader, MatrixVariable, PathVariable, CookieValue, RequestBody, ResponseStatus, ExceptionHandler and RestControllerAdvice.

TIP: If you scaffold the project with spring-web extension, then Spring Web annotations are sed in the generated project. mvn io.quarkus:quarkus-maven-plugin:0.26.1:create ... -Dextensions="spring-web".

Spring Data JPA

While users are encouraged to use Hibernate ORM with Panache for Relational Database access, Quarkus provides a compatibility layer for Spring Data JPA repositories.

```
./mvnw quarkus:add-extension
-Dextensions="quarkus-spring-data-jpa"
```

INFO: Of course you still need to add the JDBC driver, and configure it in application.properties.

```
public interface FruitRepository
    extends CrudRepository<Fruit, Long> {
    List<Fruit> findByColor(String color);
}
```

And then you can inject it either as shown in Spring DI or in Spring Web.

Interfaces supported:

- org.springframework.data.repository.Repository
- org.springframework.data.repository.CrudRepository
- org.springframework.data.repository.PagingAndSortingRepository
- org.springframework.data.jpa.repository.JpaRepository

INFO: Generated repositories are automatically annotated with @Transactional.

Repository fragments is also supported:

```
public interface PersonRepository
    extends JpaRepository<Person, Long>, PersonFragment {

    void makeNameUpperCase(Person person);
}
```

User defined queries:

```
@Query("select m from Movie m where m.rating = ?1")
Iterator<Movie> findByRating(String rating);

@Modifying
@Query("delete from Movie where rating = :rating")
void deleteByRating(@Param("rating") String rating);
```

What is currently unsupported:

- Methods of org.springframework.data.repository.query.QueryByExampleExecutor
- QueryDSL support
- Customizing the base repository
- java.util.concurrent.Future as return type
- Native and named queries when using @Query

Resources

- <https://quarkus.io/guides/>

- <https://www.youtube.com/user/lordofthejars>

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