Development Guide

AlgoTrader

Version 6.0.0

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Preface

1. Document Conventions

This manual uses several conventions to highlight certain words and phrases and draw attention to specific pieces of information.

In PDF and paper editions, this manual uses typefaces drawn from the *Liberation Fonts* [1] set. The Liberation Fonts set is also used in HTML editions. If not, alternative but equivalent typefaces are displayed.

1.1. Typographic Conventions

The following **typographic** conventions are used to call attention to specific words and phrases. These conventions, and the circumstances they apply to, are as follows.

System input, including shell commands, file names and paths, and key caps and key-combinations are presented as follows.

> To see the contents of the file `my_next_bestselling_novel` in the current working directory, enter the `cat my_next_bestselling_novel` command at the shell prompt and press **Enter** to execute the command.

The above includes a file name, a shell command and a key cap, all distinguishable thanks to context.

Key-combinations can be distinguished from key caps by the symbol connecting each part of a key-combination. For example:

> Press **Enter** to execute the command.
>
> Press **Ctrl**-**Alt**-**F1** to switch to the first virtual terminal. Press **Ctrl**-**Alt**-**F7** to return to the X-Windows session.

The first sentence highlights the particular key cap to press. The second highlights two sets of three key caps, each set pressed simultaneously.

If source code is discussed, class names, methods, functions, variable names and returned values mentioned within a paragraph are presented as follows.

> File-related classes include `filesystem` for file systems, `file` for files, and `dir` for directories. Each class has its own associated set of permissions.

Words or phrases encountered on a system, including application names; dialog box text; labeled buttons; check-box and radio button labels; menu titles and sub-menu titles are presented as follows.

> Choose **System** → **Preferences** → **Mouse** from the main menu bar to launch **Mouse Preferences**. In the **Buttons** tab, click the **Left-handed mouse** check box and click **Close** to switch the primary mouse button from the left to the right (making the mouse suitable for use in the left hand).

[1] https://pagure.io/liberation-fonts

> To insert a special character into a **gedit** file, choose **Applications** → **Accessories** → **Character Map** from the main menu bar. Next, choose **Search** → **Find** from the **Character Map** menu bar, type the name of the character in the **Search** field and click **Next**. The character sought will be highlighted in the **Character Table**. Double-click this highlighted character to place it in the **Text to copy** field and then click the **Copy** button. Now switch back to the document and choose **Edit** → **Paste** from the **gedit** menu bar.

The above text includes application names; system-wide menu names and items; application-specific menu names; and buttons and text found within a GUI interface, all distinguishable by context.

Note the shorthand used to indicate traversal through a menu and its sub-menus. This is to avoid the difficult-to-follow 'Select **Mouse** from the **Preferences** sub-menu in the **System** menu of the main menu bar' approach.

Italics denotes text that does not need to be imputed literally or displayed text that changes depending on circumstance. Replaceable or variable text is presented as follows.

> To connect to a remote machine using ssh, type `ssh` *`username@ domain.name`* at a shell prompt. If the remote machine is `example.com` and the username on that machine is john, type `ssh john@example.com`.
>
> The `mount -o remount` *`file-system`* command remounts the named file system. For example, to remount the `home` file system, the command is `mount -o remount /home`.
>
> To see the version of a currently installed package, use the `rpm -q` *`package`* command. It will return a result as follows: *`package-version-release`* .

Note the words in italics above — username, domain.name, file-system, package, version and release. Each word is a placeholder, either for text entered when issuing a command or for text displayed by the system.

1.2. Pull-quote Conventions

Two commonly multi-line data types are set off visually from the surrounding text.

Output sent to a terminal is presented as follows:

```
books        Desktop   documentation  drafts  mss    photos   stuff  git
books_tests  Desktop1  downloads      images  notes  scripts  svgs
```

Source-code listings are presented and highlighted as follows:

```
package org.jboss.book.jca.ex1;

import javax.naming.InitialContext;

public class ExClient {

  public static void main(String args[]) throws Exception {
```

```
    InitialContext iniCtx = new InitialContext();
    Object ref = iniCtx.lookup("EchoBean");
    EchoHome home   = (EchoHome) ref;
    Echo echo = home.create();

    System.out.println("Created Echo");

    System.out.println("Echo.echo('Hello') = " + echo.echo("Hello"));
  }
}
```

1.3. Notes and Warnings

Finally, three visual styles are used to draw attention to information that might otherwise be overlooked.

Warning

A Warning should not be ignored. Ignoring warnings will most likely cause data loss.

Important

Important boxes detail things that are easily missed: configuration changes that only apply to the current session, or services that need restarting before an update will apply. Ignoring Important boxes won't cause data loss but may cause irritation and frustration.

Note

A note is a tip or shortcut or alternative approach to the task at hand. Ignoring a note should have no negative consequences, but might lead to a missed out on a trick that makes life easier.

Introduction

This document provides additional information on the internal implementation of AlgoTrader for cases when clients wish to make changes to the platform or extends its functionality.

Note

A source code license is required to update the internal parts of AlgoTrader

Building AlgoTrader

AlgoTrader can be built from its source either via command line or via IDE

Note

AlgoTrader based trading strategies can be developed and started without building AlgoTrader first

2.1. Command Line

To build AlgoTrader via command line please perform the following steps.

2.1.1. Git Checkout

If one hasn't installed git, please refer to git installation in the Reference Documentation (chapter 2.1.1. Prerequisites)

Perform a Git clone from the command line:

```
git clone https://gitlab.algotrader.com/main/algotrader.git
```

Note

User name and password will be provided when signing up for an AlgoTrader license

2.1.2. Maven Build

Execute the following maven command to build all maven projects

```
mvn clean install
```

Note

When running the build process for the first time, this will take a few minutes since all maven dependencies have to be downloaded.

2.1.3. Docker Build

Execute the following Docker command to build the AlgoTrader Docker image:

```
docker build -t docker.algotrader.com/algotrader/algotrader:latest .
```

2.2. IntelliJ IDEA

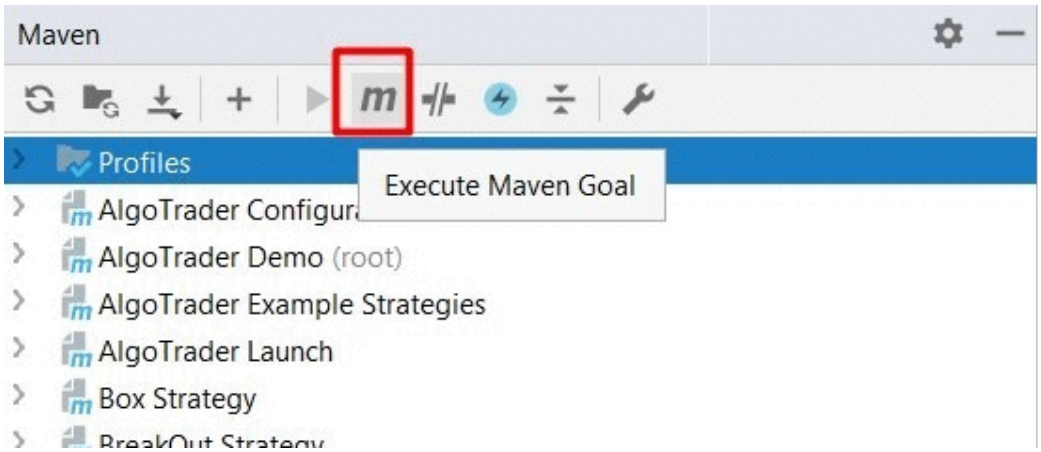
To build AlgoTrader from within IntelliJ IDEA please follow this process.

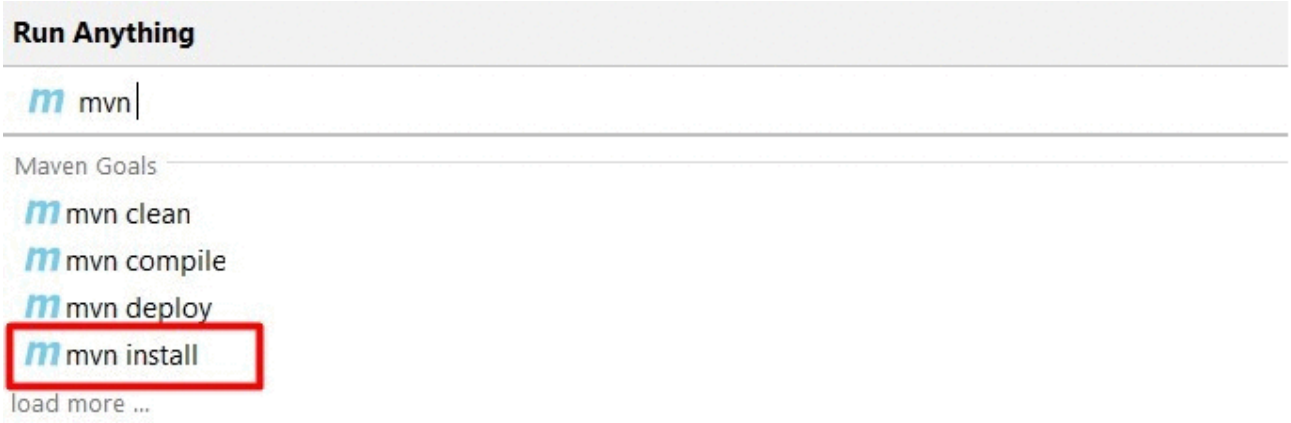
2.2.1. Git Clone

- On the main menu, select VCS / Git / Clone
- Set the following URL *https://gitlab.algotrader.com/main/algotrader.git*, configure the directory where you want the project to be stored and press clone.
- Enter User and Password (provided when licensing AlgoTrader)
- Click OK
- Confirm you want to open the project, e.g. in a new Window.
- Click on `Project` on the top of the sidebar on the left and you will see the `Bootstrap` project in the package explorer, with the sub-projects `conf` and `launch`.

2.2.2. Maven Build

To generate the code click on `Maven` on the top of the sidebar on the right to get the Maven menu, then press the `Execute Maven Goal` button at the top right and select (double-click) `Maven install`. This will download the missing libraries and compile AltoTrader





2.2.3. Docker Build

The AlgoTrader Docker Image needs to be built from the command line (see above).

2.3. AlgoTrader UI

2.3.1. Git Checkout

Perform a Git clone from the command line:

```
git clone git@gitlab.algotrader.com:main/HTML5-UI.git
```

2.3.2. Maven Build

Execute the following maven command to build UI through maven

```
mvn clean install -DALGOTRADER_NPM_NEXUS_AUTH=auth_token
```

`auth_token` is a `username:password` for AlgoTrader Nexus repository transformed by base64 function. That transformation can for example be done by using Window Powershell:

```
$Bytes = [System.Text.Encoding]::UTF8.GetBytes("username:password")
[Convert]::ToBase64String($Bytes)
```

2.3.3. Docker Build

After the Maven build of the UI, rebuild the back end Docker image (see above).

Domain Model

3.1. Security Visitors

The *Visitor Pattern* [1] is a way of separating an algorithm from an object structure on which it operates. Using this pattern it is possible to implement custom Logic per Entity without polluting the Entity code itself.

AlgoTrader provides the interface `ch.algotrader.visitor.EntityVisitor` which must be implemented by all Entity Visitors. Each Entity Visitor has two generic type parameters R and P. R is the return type (or `java.lang.Void`) returned by all visit methods and P is an arbitrary parameter object that can be added to the visit methods.

In addition there is the `ch.algotrader.visitor.PolymorphicEntityVisitor` which reflects the entire inheritance tree of all Securities. For example if there is no `visitFuture` method the `PolymorphicEntityVisitor` will automatically invoke the `visitSecurity` method.

The accept method of each Entity can be used to process an arbitrary Visitor like this:

```
entity.accept(MyVisitor.INSTANCE);
```

In AlgoTrader there are two Visitors available which are used by the AlgoTrader Server

InitializingVisitor
: Is used to make sure certain Hibernate Entity References are initialized / loaded.

ScalingVisitor
: is used to scale quantities and prices

SecurityVolumeVisitor
: Is used to determine if a particular Security is supposed to report volumes

TickValidationVisitor
: Used to validate a Tick by rules defined per Security

3.2. Data access objects (DAOs)

The AlgoTrader DAO framework of consists of several main components

BaseEntityI
: `BaseEntityI` represents an abstract serializable persistent entity with a synthetic identifier of type long.

[1] https://en.wikipedia.org/wiki/Visitor_pattern

ReadOnlyDao

`ReadOnlyDao` represents an interface for common retrieval operations for entity classes.

ReadWriteDao

`ReadWriteDao` extends `ReadOnlyDao` and represents an interface for common retrieval and mutation operations.

AbstractDao

`AbstractDao` abstract class serves as a generic base class for data access classes. It provides the most common operations to retrieve, update and delete entities as well as to build HQL and native SQL queries.

It is possible to add custom DAOs to the platform. To accomplish this one needs to create a DAO interface extending either `ReadOnlyDao` or `ReadWriteDao`, add custom operations such as entity specific finders and then create a custom DAO class extending `AbstractDao` and implementing the custom DAO interface.

```
public class MyEntity implements BaseEntityI {

    private long id;
    private String name;

    @Override
    public long getId() {
        return this.id;
    }

    protected void setId(final long id) {
        this.id = id;
    }

    @Override
    public boolean isInitialized() {
        return true;
    }

    public String getName() {
        return this.name;
    }

    public void setName(final String name) {
        this.name = name;
    }
}
```

```
public interface MyEntityDao extends ReadWriteDao<MyEntity> {

    public MyEntity findByName(String name);
```

```
}
```

```
@Repository
public class MyEntityDaoImpl extends AbstractDao<MyEntity> implements MyEntityDao {

    public MyEntityDaoImpl(final SessionFactory sessionFactory) {
        super(MyEntity.class, sessionFactory);
    }

    @Override
    public Strategy findByName(final String name) {

        return findUniqueCaching(
          "from MyEntity where name = :name", QueryType.HQL, new NamedParam("name", name));
    }

}
```

HQL and SQL queries used by AlgoTrader DAO components are externalized and stored in `Hibernate.hbm.xml` file. This allows for better management and for easier re-use of queries.

```
<query name='Strategy.findByName'>
<![CDATA[
    from StrategyImpl
    where name = :name
]]>
</query>
```

Queries can be accessed from DAO classes or custom components by their names

```
public class StrategyDaoImpl extends AbstractDao<Strategy> implements StrategyDao {
    ...
    @Override
    public Strategy findByName(final String name) {
        return findUniqueCaching(
            "Strategy.findByName", QueryType.BY_NAME, new NamedParam("name", name));
    }
}
```

3.3. Services

3.3.1. Private Services

Table 3.1. Private Services

Service	Description
`AlgoOrderService`	Order Services responsible for handling of `AlgoOrders` (delegates to `AlgoOrderExecServices`)
`AlgoOrderExecService`	Abstract Base Class for all Algo Execution Order Services
`ExternalAccountService`	Abstract Base Class for all external Account Interfaces
`ExternalMarketDataService`	Abstract Base Class for all external Market Data Interfaces
`FixSessionService`	Exposes properties of FIX sessions
`ForexService`	Responsible for the FX Hedging functionality
`GenericOrderService`	Parent Class for all Order Services
`MarketDataPersistenceService`	Responsible for persisting Market Data to the database
`OrderExecutionService`	Responsible for handling of persistence and propagation various trading events such as order status update and order fills as well as maintaining order execution status in the order book.
`OrderPersistenceService`	Responsible for persisting `Orders` and `OrderStatus` to the database
`ReconciliationService`	Responsible for reconciliation of reports provided by the broker
`ResetService`	Responsible for resetting the DB state (e.g. before the start of a simulation)
`ServerLookupService`	Provides internal data lookup operations to other server side services
`SimpleOrderService`	Order Service responsible for handling of Simple Orders (delegates to `SimpleOrderExecServices`)
`SimpleOrderExecService`	Abstract Base Class for all Simple Order Execution Services
`StrategyPersistenceService`	Handles persistence of Strategy Entities
`TransactionPersistenceService`	Responsible for the persistence of Transactions, Positions updates and Cash Balance updates to the database
`TransactionService`	Responsible for handling of incoming Fills

3.3.2. Order Services

All `OrderServices` are derived from the `GenericOrderService`. All Order Services based on Fix are derived from `FixOrderService` which in terms has subclasses for Fix versions 4.2 and 4.4.

3.3.3. Market Data Services

All `MarketDataServices` are derived from the general `ExternalMarketDataService`. All `MarketDataServices` based on Fix are derived from `FixMarketDataService` which in terms has subclasses for Fix versions 4.2 and 4.4.

3.3.4. Historical Data Services

Historical Data Services are used to download aggregated Market Data Events from the Market Data Provider.

3.3.5. Reference Data Services

Reference Data Services are used to download current option and future chains as well as information about stocks.

Java Environment

4.1. AlgoTrader Project Structure

The Framework AlgoTrader consists of the following Sub-Projects:

algotrader
: the main project

algotrader-common
: contains java code accessible to trading strategies

algotrader-core
: contains internal java code needed by the AlgoTrader Server

algotrader-dm
: contains the java code for the AlgoTrader reference and historical data management UIs

bootstrap/algotrader-conf
: contains the configuration files needed by the AlgoTrader Server

bootstrap/algotrader-launch
: contains the Run Configurations

algotrader-archetype-esper
: Maven archetype for creating new AlgoTrader Esper based strategies

algotrader-archetype-java
: Maven archetype for creating new AlgoTrader Java-only strategies

algotrader-archetype-simple
: Maven archetype for creating new AlgoTrader simple strategies

at-tests/algotrader-test-framework
: test framework for automated end-to-end UI tests

at-tests/algotrader-ui-tests
: automated UI tests

at-tests/algotrader-application-tests
: automated tests covering internal and REST-based functionalities

at-tests/algotrader-test
: contains integration tests based on *JUnit* [1]

4.1.1. common project

the AlgoTrader common project has the following structure:

[1] https://junit.org/

Table 4.1. common project

Directory	Description
`src/main/java`	manually created class files
`src/main/resouces`	manually created configuration files
`target/generated-sources/main/java`	generated class files
`src/test/java`	JUnit test cases
`src/test/resources`	test resources

4.1.2. core project

the AlgoTrader core project has the following structure:

Table 4.2. core project

Directory	Description
`src/main/java`	manually created class files
`src/main/resouces`	manually created configuration files
`src/test/java`	JUnit test cases
`src/test/resources`	test resources
`bin`	shell start scripts
`files`	files which are created/exported by the system or imported into the system
`log`	log files

4.1.3. conf project

the AlgoTrader conf project has the following structure:

Table 4.3. conf project

Directory	Description
`src/main/resources`	all the properties files

4.1.4. launch project

the AlgoTrader conf project has the following structure:

Table 4.4. launch project

Directory	Description
`/`	all the Run Configuration files

4.1.5. strategy projects

Strategy projects typically have the following structure:

Table 4.5. strategy projects

Directory	Description
`src/main/java`	java code
`src/main/resources`	config files
`bin`	Run Configuration and shell start scripts
`log`	log files

4.2. Java Packages & Classes

For a full list of java packages and classes please visit our *Javadoc* [2]

4.3. Maven Environment

AlgoTrader uses *Maven*[3] as its build management framework. Every project/module therefore has it's own pom.xml (Project Object Model) defining its structure and dependencies.

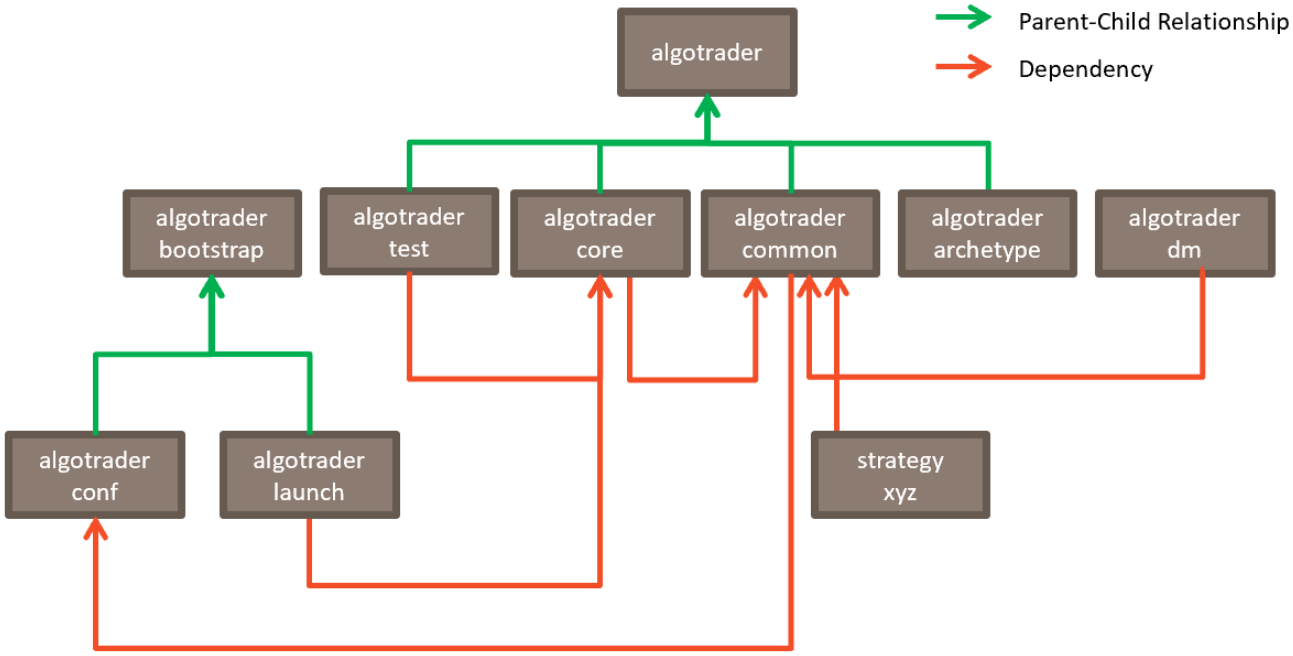


Figure 4.1. Maven Dependencies

[2] http://doc.algotrader.com/javadoc/index.html
[3] http://maven.apache.org/

4.3.1. Maven assemblies

AlgoTrader provides maven assemblies for both the AlgoTrader core module as well as for strategies. The core assembly declares all components required to run AlgoTrader server in distributed mode.

The server maven assembly definition file is located in `/algotrader-core/src/main/assembly/server-bin.xml`

The following command generates binary deployment packages from assembly descriptors.

```
mvn clean package
```

Binary deployment packages generated from Maven assemblies come in two varieties: tar.gz and zip, the former being more optimized for Unix-like operating systems while the latter being suitable for Windows platforms.

4.3.2. Packaging strategies

In addition to the AlgoTrader server assembly there is also an assembly file available that can be used to package strategies.

The strategy maven assembly definition file is located in `/algotrader-core/src/main/assembly/strategy-bin.xml`. To use the strategy assembly in your trading strategy add the following plugin to the strategy `pom.xml`:

```
<plugin>
    <artifactId>maven-assembly-plugin</artifactId>
    <version>2.5.5</version>
       <dependencies>
         <dependency>
        <groupId>algotrader</groupId>
        <artifactId>algotrader-core</artifactId>
        <version>${algotrader.version}</version>
         </dependency>
       </dependencies>
    <executions>
        <execution>
            <id>make-assembly</id>
            <phase>package</phase>
            <goals>
                <goal>single</goal>
            </goals>
            <configuration>
                <descriptorRefs>
                    <descriptorRef>strategy-bin</descriptorRef>
                </descriptorRefs>
                <tarLongFileMode>gnu</tarLongFileMode>
            </configuration>
        </execution>
```

```
    </executions>
</plugin>
```

4.3.3. Maven profiles

In addition to standard maven profile, there are Maven profiles provided to perform various side-tasks.

To enable one or more profiles one should add its names prepended by `-P` to maven command. If there is more than one profile, they should be split by a comma.

The following example will run maven clean package goals with `enunciate` and `swagger-ui` profiles enabled.

```
mvn clean package -Penunciate,swagger-ui
```

Available profiles:

enunciate
: Enables *Enunciate*[4] tool to generate HTML documentation and client-side libraries for multiple programming languages.

  Libraries are generated into `target/enunciate` directory

  Generated HTML documentation goes into `target/site/apidocs/index.html`.

swagger-ui
: Enables *Swagger UI*[5] interactive REST API docs generation.

generate-ts-domain
: Enables code generation for AlgoTrader HTML5 UI.

  The UI is written in Typescript and UI gets a lot of Algotrader's domain classes serialized in JSON. In order to have the domain of Algotrader defined in one place, the Java domain model is being transformed into Typescript types and used in UI.

vaadin-compilation
: Enables Historical Data Manager & Reference Data Manager styles compilation.

  These tools are written in *Vaadin Framework*[6] (Java) and its Sass styles need to be compiled using *Vaadin Sass Compiler*[7].

all
: Enables all of the above profiles at once

[4] http://enunciate.webcohesion.com/
[5] https://swagger.io/tools/swagger-ui/
[6] https://vaadin.com/
[7] https://vaadin.com/docs/v8/framework/themes/themes-compiling.html

Code Generation

Java Entities, Entity Interfaces and Value Objects are created by the means of the *Hibernate Tools project*[1] using the *hbm2java code exporter*[2].

AlgoTrader provides a custom maven plugin called `maven-codegen-plugin` which wraps the code generator.

```
<groupId>algotrader</groupId>
<artifactId>model-codegen-plugin</artifactId>
<name>Model code generator plugin</name>
<version>0.1.5</version>
```

The `maven-codegen-plugin` has been added to the file `/algotrader/common/pom.xml`

```
<plugin>
    <groupId>algotrader</groupId>
    <artifactId>model-codegen-plugin</artifactId>
    <version>0.1.5</version>
    <executions>
        <execution>
            <id>generate-model</id>
            <goals>
                <goal>codegen</goal>
            </goals>
            <configuration>
                <templates>
                    <template>
                        <file>pojo/Pojo.ftl</file>
                        <pattern>{package-name}/{class-name}.java</pattern>
                    </template>
                    <template>
                        <file>pojo/Interface.ftl</file>
                        <pattern>{package-name}/{class-name}I.java</pattern>
                    </template>
                    <template>
                        <file>pojo/ValueObject.ftl</file>
                        <pattern>{package-name}/{class-name}VO.java</pattern>
                    </template>
                    <template>
                        <file>pojo/ValueObjectBuilder.ftl</file>
                        <pattern>{package-name}/{class-name}VOBuilder.java</pattern>
                    </template>
                </templates>
```

[1] http://hibernate.org/tools/

[2] https://docs.jboss.org/tools/latest/en/hibernatetools/html/ant.html#d0e4821

```
            </configuration>
        </execution>
    </executions>
</plugin>
```

The above configuration generates the following artifacts for each Java Entity defined in the Hibernate mapping files:

- Entity
- Entity interface
- Value Object
- Value Object Builder

The code generator uses Hibernate mapping files which are located in `/algotrader/common/src/main/resources` in combination with *Freemarker*[3] templates which are located in `/algotrader/common/pojo` . These templates are based on the original version supplied with the Hibernate Tools project but have been augmented to produces Java code needed by AlgoTrader. For this purpose several custom attributes have been added to Hibernate mapping files:

Table 5.1. Hibernate mapping files - custom meta attributes

Tag	Description
`implements`	The interface this Entity implements
`generated-class`	Name of the main Entity class file
`class-code`	Extra class code generated into Entity classes
`interface-code`	Extra class code generated into Entity interfaces
`vo-code`	Extra class code generated into Value Objects
`class-description`	Javadoc comment for classes
`field-description`	Javadoc comment for fields
`use-in-equals`	should this property be used in the equals method
`property-type`	the class to be used for this property

Generated code is placed under the directory `/algotrader/common//target/generated-sources/main/java`.

[3] https://freemarker.apache.org/

Database

6.1. Database scripts

- `algotrader/core/src/main/scripts/db/mysql` MySql scripts
  - `create-fix-messagestore.sql` creates database tables uses for Fix message persistence
  - `datetime_milli_precision.sql` converts all `datetime` fields to usage of millisecond (requires MySql 5.6.4)
  - `reset-db.sql` reset script which resets the tables cash_balance, order, portfolio_value, subscription, transaction and position.

6.2. Transaction Handling

Using Spring Transaction Boundaries are declared on Services using the annotation *`@Transactional`*. Transaction Boundaries are handled by the `org.springframework.transaction.interceptor.TransactionInterceptor`. A typical declaration looks like this:

```
@Transactional(propagation = Propagation.SUPPORTS)
public class TransactionServiceImpl implements TransactionService {

    @Transactional(propagation = Propagation.REQUIRED)
    public void saveTransaction(final Transaction transaction) {
        ...
    }
...
}
```

In order for transactions to work services need to implement an interface (e.g. `TransactionServiceImpl` implements `TransactionService`).

Note

Transaction demarcation only works when a service method is called from another service with dependencies properly injected through Spring. For example using a scheduler inside a service to then call methods with itself will not create transactions.

Market Data

All Market Data Interfaces have a set of unique artifacts:

- Configuration Files (`conf-ib.properties` and `conf-bb.properties`)
- Adapter Classes (e.g. `IBAdapter`) responsible for management of Sessions. Adapters are available over JMX
- Session Classes (e.g. `IBSession`). Representing an individual Market Data Session
- Message Handler Classes (e.g. `BBMessageHandler`) responsible for receiving `MarketDataEvents` and propagating them into Esper
- Esper Modules (e.g. `market-data-ib`) responsible for processing and filtering of `MarketDataEvents`

Processing of Market Data is handled through the `MarketDataService`, which calls the market data provider specific `ExternalMarketDataService` implementations. Every market data service has to provide implementation of this interface e.g. (e.g. `IBMarketDataServiceImpl` or `BBMarketDataServiceImpl`).

The most important methods provided by the `MarketDataService` are `subscribe` and `unsubscribe`. Through the use of these methods new Market Data can be subscribed and unsubscribed. Subscribed securities are persisted within the DB-table *`subscription`*. The actual subscription of securities to the external broker is done through the market data provider specific `MarketDataService`.

Market data provider interfaces are responsible for receiving market data provider specific Market Data and sending them into the Esper Service Instance of the AlgoTrader Server. The Esper Service Instance will then convert these Events into generic `MarketDataEvents` (i.e. Ticks or Bars) which will be propagated to subscribed Strategies.

Adapters

8.1. Bloomberg

The Bloomberg infrastructure consists of the following classes:

Table 8.1. Bloomberg Infrastructure

Class / Interface	Description
`BBAdapter`	Management Adapter for the Bloomberg environment. Allows to start and stop Bloomberg Sessions
`BBConstants`	Bloomberg Constants used by the Bloomberg interface
`BBIdGenerator`	Generator for Bloomberg Request Id's
`BBMessageHandler`	Message Handler for incoming Bloomberg messages. Messages are either propagated into the Esper Engine or delegated back to the corresponding Service.
`BBMarketDataMessageHandler`	
`BBSession`	Represents a connection to the Bloomberg service

8.2. Currenex

The Currenex infrastructure consists of the following classes:

Table 8.2. Currenex Infrastructure

Class / Interface	Description
`CNXFixMarketDataServiceImpl`	MarketData service implementation for the Currenex environment.
`CNXFixOrderServiceImpl`	Currenex specific implementation of the generic FIX adapter for order management.

8.3. DukasCopy

The DukasCopy infrastructure consists of the following classes:

Table 8.3. DukasCopy Infrastructure

Class / Interface	Description
`DCFixMarketDataServiceImpl`	MarketData service implementation for the DukasCopy environment.
`DCFixOrderServiceImpl`	DukasCopy specific implementation of the generic FIX adapter for order management.

8.4. Exante

The Exante infrastructure consists of the following classes:

Table 8.4. Exante Infrastructure

Class / Interface	Description
`XNTFixMarketDataServiceImpl`	MarketData service implementation for the Exante environment.
`XNTFixOrderServiceImpl`	Exante specific implementation of the generic FIX adapter for order management.

8.5. EzeSoft/RealTick

The EzeSoft/RealTick infrastructure consists of the following classes:

Table 8.5. EzeSoft/RealTick Infrastructure

Class / Interface	Description
`RTFixOrderServiceImpl`	EzeSoft/RealTick specific implementation of the generic FIX adapter for order management.

8.6. Fix Interface

The Fix infrastructure consists of the following classes:

Table 8.6. Fix Infrastructure

Class / Interface	Description
`Session`	A `Session` represents a connection to a broker / exchange / market data provider
`Application`	For each `Session` an `Application` object is created. It will forward incoming messages to the corresponding `MessageHandlers`
`DefaultFixApplication`	
`FixApplicationFactory`	Is responsible for the creation of `Applications`
`DefaultFixApplicationFactory`	
`FixMultiApplicationSessionFactory`	Creates a `Session` and `Application` using the specified `FixApplicationFactory` according to the following steps: • lookup the `FixApplicationFactory` by its name • create an `Application`

Class / Interface	Description
	• create a `DefaultSessionFactory` • create a `Session`
`ExternalSessionStateHolder`	Represents the current state of a `Session` (i.e. `DISCONNECTED`, `CONNECTED`, `LOGGED_ON` and `SUBSCRIBED`)
`DefaultFixSessionStateHolder`	
`MarketDataFixSessionStateHolder`	A `ExternalSessionStateHolder` for market data sessions that will subscribe to securities as soon as the session is logged on.
`FixOrderIdGenerator`	Generator for Fix Order Ids. The default implementation reads the last Order Ids from the Fix log on start-up.
`DefaultFixOrderIdGenerator`	
`FixAdapter`	Management Adapter for the Fix environment. Allows the creation of dynamic sessions, sending Messages and managing Order Ids.
`DefaultFixAdapter`	
`ManagedFixAdapter`	Manageable implementation of a `FixAdapter` (based on JMX)
`FixEventScheduler`	QuickFix/J currently supports daily sessions (with a daily session 7 times a week) and weekly sessions (with one weekly session). However some brokers (e.g. JP Morgan) use daily sessions during workdays. To accomplish this scenario, AlgoTrader allows creation of a weekly `logon`/`logoff` event (e.g. Mo 08:00:00 and Fr 18:00:00) using Esper Statements
`DefaultFixEventScheduler`	
`EventPattern`	
`FixSocketInitiatorFactoryBean`	A Spring Factory Bean that creates the `SocketInitiator` necessary for all Fix Sessions.
`Fix42MarketDataMessageHandler`	Message Handler for incoming Fix market data messages. These classes need to be sub classed by the corresponding market data interface. Messages are propagated into the Esper Engine.
`Fix44MarketDataMessageHandler`	
`Fix42OrderMessageHandler`	Message Handler for incoming Fix Execution Reports. These classes need to be sub classed by the corresponding order interface. Messages are propagated into the Esper Engine.
`Fix44OrderMessageHandler`	

8.7. Fortex

The Fortex infrastructure consists of the following classes:

Table 8.7. Fortex Infrastructure

Class / Interface	Description
`FTXFixMarketDataServiceImpl`	MarketData service implementation for the Fortex environment.

Class / Interface	Description
FTXFixOrderServiceImpl	Fortex specific implementation of the generic FIX adapter for order management.

8.8. FXCM

The FXCM infrastructure consists of the following classes:

Table 8.8. FXCM Infrastructure

Class / Interface	Description
FXCMFixMarketDataServiceImpl	MarketData service implementation for the FXCM environment.
FXCMFixOrderServiceImpl	FXCM specific implementation of the generic FIX adapter for order management.

8.9. IB Native Interface

The IB infrastructure consists of the following classes:

Table 8.9. IB Infrastructure

Class / Interface	Description
IBSession	An IBSession represents a connection to the TWS or IB Gateway
IBSessionStateHolder DefaultIBSessionStateHolder	Represents the current state of a Session (i.e. DISCONNECTED, CONNECTED, IDLE, LOGGED_ON and SUBSCRIBED)
IBAdapter DefaultIBAdapter	Management Adapter for the IB environment. Allows to connect and disconnect IB Sessions as well as retrieval of the current ConnectionState
AbstractIBMessageHandler DefaultIBMessageHandler	Message Handler for incoming IB messages. Messages are either propagated into the Esper Engine or delegated back to the corresponding Service.
IBOrderMessageFactory DefaultIBOrderMessageFactory	Factory for order messages.
IBExection	Details of an individual order execution
IBExections	Collection (internally represented by a map) of all order executions
IBPendingRequest	Details of an individual data request such as historic data or contract details

Class / Interface	Description
`IBPendingRequests`	Collection (internally represented by a map) of all pending data requests

8.10. JP Morgan

The JP Morgan infrastructure consists of the following classes:

Table 8.10. JP Morgan Infrastructure

Class / Interface	Description
`JPMFixOrderServiceImpl`	JP Morgan specific implementation of the generic FIX adapter for order management.

8.11. LMAX

The LMAX infrastructure consists of the following classes:

Table 8.11. LMAX Infrastructure

Class / Interface	Description
`LMAXFixMarketDataServiceImpl`	MarketData service implementation for the LMAX environment.
`LMAXFixOrderServiceImpl`	LMAX specific implementation of the generic FIX adapter for order management.
`LMAXDropCopyAllocationServiceImpl`	Allocation of external fills to the right internal security and account.

8.12. Nexus Prime

The Nexus Prime infrastructure consists of the following classes:

Table 8.12. Nexus Prime Infrastructure

Class / Interface	Description
`NXSFixMarketDataServiceImpl`	MarketData service implementation for the Nexus Prime environment.
`NXSFixOrderServiceImpl`	Nexus Prime specific implementation of the generic FIX adapter for order management.

8.13. PrimeXM

The PrimeXM infrastructure consists of the following classes:

Table 8.13. PrimeXM Infrastructure

Class / Interface	Description
`PXMFixMarketDataServiceImpl`	MarketData service implementation for the PrimeXM environment.
`PXMFixOrderServiceImpl`	PrimeXM specific implementation of the generic FIX adapter for order management.

8.14. Quandl

The Quandl infrastructure consists of the following classes:

Table 8.14. Quandl Infrastructure

Class / Interface	Description
`QDLHistoricalDataServiceImpl`	Historical data service implementation for the Quandl environment.

8.15. QuantHouse

The QuantHouse infrastructure consists of the following classes:

Table 8.15. QuantHouse Infrastructure

Class / Interface	Description
`QHAdapter`	Management Adapter for the QuantHouse environment.
`QHMessageHandler`	Message Handler for incoming QuantHouse messages. Messages are either propagated into the Esper Engine or delegated back to the corresponding Service.
`QHSessionStateHolder`	Holds the current state of the QuantHouse session

8.16. SocGen

The SocGen infrastructure consists of the following classes:

Table 8.16. SocGen Infrastructure

Class / Interface	Description
`SGFixOrderServiceImpl`	SocGen specific implementation of the generic FIX adapter for order management.

8.17. Trading Technologies

The Trading Technologies infrastructure consists of the following classes:

Table 8.17. Trading Technologies Infrastructure

Class / Interface	Description
`TTFixMarketDataServiceImpl`	MarketData service implementation for the Trading Technologies environment.
`TTFixOrderServiceImpl`	Trading Technologies specific implementation of the generic FIX adapter for order management.
`TTDropCopyAllocationServiceImpl`	Allocation of external fills to the right internal security and account.
`TTFixReferenceDataServiceImpl`	Service to acquire the list of available securities from Trading Technologies.

8.18. UBS

The UBS infrastructure consists of the following classes:

Table 8.18. UBS Infrastructure

Class / Interface	Description
`UBSFixOrderService`	MarketData service implementation for the UBS environment.
`UBSFixOrderServiceImpl`	UBS specific implementation of the generic FIX adapter for order management.

8.19. Binance

Table 8.19. Main service classes

Service class name	Functionality
`BNCOrderServiceImpl`	Order submission
`BNCMarketDataServiceImpl`	Market data feed
`BNCReferenceDataServiceImpl`	Reference data - instruments
`BNCAccountServiceImpl`	Account info

Table 8.20. Main classes

Class name	Functionality
`BNCAdapter`	Main adapter class
`BNCOrderMessageHandler`, `BNCMarketDataMessageHandler`	Live market data subscription connectors
`BNCServiceWiring, BNCWiring`	Spring config files

8.20. Bitfinex

Table 8.21. Main service classes

Service class name	Functionality
`BFXOrderServiceImpl`	Order submission
`BFXMarketDataServiceImpl`	Market data feed
`BFXReferenceDataServiceImpl`	Reference data - instruments
`BFXAccountServiceImpl`	Account info retrieval

Table 8.22. Main classes

Class name	Functionality
`BFXRestAdapter`	Main adapter class
`BFXWebSocketAdapter, BFXMessageHandler`	WebSockets connectivity logic
`BFXServiceWiring, BFXWiring`	Spring config files

8.21. Bitflyer

Table 8.23. Main service classes

Service class name	Functionality
`BFLOrderServiceImpl`	Order submission
`BFLMarketDataServiceImpl`	Market data feed
`BFLReferenceDataServiceImpl`	Reference data - instruments
`BFLAccountServiceImpl`	Account info

Table 8.24. Main classes

Class name	Functionality
`BFLRestAdapter`	Main adapter class
`BFLPubNubAdapter, BFLMarketDataMessageHandler`	Live market data subscription connectors
`BFLServiceWiring, BFLWiring`	Spring config files

8.22. BitMEX

Table 8.25. Main service classes

Service class name	Functionality
`BMXOrderServiceImpl`	Order submission: Market, Limit, Stop and Stop-Limit orders with DAY, GTC, FOK or IOC Time in Force

Service class name	Functionality
`BMXMarketDataServiceImpl`	Market data feed
`BMXReferenceDataServiceImpl`	Reference data - instruments
`BMXAccountServiceImpl`	Account balances and info retrieval

Table 8.26. Main classes

Class name	Functionality
`BMXRestAdapter`	Main adapter class
`BMXWebSocketAdapter`, `BMXMarketDataMessageHandler`, `BMXOrderMessageHandler`	Live market data subscription and order status update connectors
`BMXServiceWiring`, `BMXWiring`	Spring config files

8.23. Bitstamp

Table 8.27. Main service classes

Service class name	Functionality
`BTSFixOrderServiceImpl`	Order submission
`BTSFixMarketDataServiceImpl`	Market data feed
`BTSReferenceDataServiceImpl`	Reference data - instruments
`BTSAccountServiceImpl`	Account balances and info retrieval

Table 8.28. Main classes

Class name	Functionality
`BTSRestAdapter`	Main adapter class
`BTSFixMessageHandler`	Facade class for handling Fix messages
`BTSServiceWiring`, `BTSWiring`, `BTSFixServiceWiring`, `BTSFixWiring`	Spring config files

8.24. CoinAPI

Table 8.29. Main service classes

Service class name	Functionality
`CNPHistoricalDataServiceImpl`	Historical data
`CNPMarketDataServiceImpl`	Market data feed
`CNPReferenceDataServiceImpl`	Reference data - instruments

Table 8.30. Main classes

Class name	Functionality
`CNPRestAdapter`	Main adapter class
`CNPWebSocketAdapter, CNPMessageHandler`	WebSockets connectivity logic
`CNPServiceWiring, CNPWiring`	Spring config files

8.25. Coinbase

Table 8.31. Main service classes

Service class name	Functionality
`CNBMarketDataServiceImpl`	MarketData service implementation for the Coinbase environment.
`CNBFixOrderServiceImpl`	Coinbase specific implementation of the generic FIX adapter for order management.
`CNBAccountServiceImpl`	Account specific functionalities offered by the Coinbase API.
`CNBReferenceDataServiceImpl`	Service to acquire the list of available securities from Coinbase.

8.26. Coinigy

Table 8.32. Main service classes

Service class name	Functionality
`CNGOrderServiceImpl`	Order submission
`CNGMarketDataServiceImpl`	Market data feed
`CNGReferenceDataServiceImpl`	Reference data - instruments
`CNGAccountServiceImpl`	Account info

Table 8.33. Main classes

Class name	Functionality
`CNGRestAdapter`	A REST client for the Coinigy REST API endpoint. Allows placing Limit and Stop Limit orders as well as retrieval of reference and account data.
`CNGSocketClusterAdapter, CNGMarketDataMessageHandler`	Socket Cluster client for the Coinigy WebSocket API endpoint that provides real-time market data feeds. Message Handler for incoming market data updates received through the WebSocket channels.

Class name	Functionality
`CNGServiceWiring, CNGWiring`	Spring config files

8.27. CoinMarketCap

Table 8.34. Main service classes

Service class name	Functionality
`CMCHistoricalDataServiceImpl`	Daily historical data
`CMCReferenceDataServiceImpl`	Reference data - instruments

Table 8.35. Main classes

Class name	Functionality
`CMCRestAdapter`	Main adapter class
`CMCWiring, CMCServiceWiring`	Spring config files

Execution Algos

9.1. Development of Execution Algos

Additional Execution Algos can be added to the system with relatively minimal effort. Execution Algos consist of the following artifacts

- a subclass of `AlgoOrder`. An `AlgoOrder` should be a plain old Java bean and contain no execution logic.

Note

`AlgoOrder` subclasses are persistent via hibernate, like other Order entities. Adding a new `AlgoOrder` subclass requires registering it in the hibernate mapping file: `Order.hbm.xml`. All hibernate constraints which apply to Order will apply also to `AlgoOrder` subclass. Please mind these constraints, esp. mandatory fields (e.g. security) while developing the algo logic. If any constraint is violated the algo order persistence will fail.

- an object that represents the state of an algo order execution which needs to subclass `AlgoOrderStateVO`. Please note that if state objects contains elements that are potentially threading unsafe, access to those elements must be synchronized!
- an esper module (optional). This module can optionally provide statements to cancel a child order, modify a child order, send the next child order, etc. The Esper module has to be registered in the `conf-core.properties` file by modifying the `server-engine.init` property
- an implementation of `AlgoOrderExecService` interface. It is generally recommended to subclass `AbstractAlgoOrderExecService` and implement its protected methods that represent various algo specific handling logic. The `#handleValidateOrder` method must implement algo specific order validation logic. The `#handleSendOrder`, `#handleModifyOrder` and `#handleCancelOrder` method must implement algo specific order execution, modification and cancellation logic respectively.
- a corresponding entry in the `ch.algotrader.enumeration.OrderType` class.
- a corresponding entry in the `order_preference` MySQL table. The new algo order type has to be added to the database `ORDER_TYPE` enum.
- a Spring wiring within `ch.algotrader.wiring.core.ServiceWiring`.

  Custom `AbstractAlgoOrderExecService` implementation can also tap into event streams pertaining to the algo order execution. The `#handleChildFill` and `#handleChildOrderStatus` methods can used to provide custom handling of fills and status events for child orders executed by the algo and to update its internal state. The `#handleOrderStatus` method can be used to update the internal state in response to transition of the algo order from one execution phase to another

  In addition the class can implement any additional logic needed in conjunction with custom Esper statements.

Note

It is important that `AlgoOrderExecService` implementations are built to be state-less. They must store all details pertaining to execution of algo orders in their respective state objects.

- Register the new algo in `MetaDataRestController` That will allow you to display the order properties in the UI's grids and to place that order through the UI's Advanced Order Form (the form will generate automatically, see XXXX)
- If one's going to place Execution Algos from UI, one should also provide a `AlgoOrderVOMixIn` mapper class and register it to `OjbectMapperFactory`. Also a conversion from VO to order object hast to be added to `OrderServiceImpl` in this case

The `OrderService` is aware of all `AlgoOrderExecService` instances declared in the Spring application context of the server process. Custom `AlgoOrderExecService` implementations also get automatically recognized as long as they are declared in the same application context. The `OrderService` delegates handling of individual orders to their respective algo service based on the order type. It is important for classes implementing `AlgoOrderExecService` to correctly implement its `#getAlgoOrderType` method.

9.2. Execution Algos entry form generation

The AlgoTrader UI can generate the entry form for Execution Algo automatically. To enable it one needs to register the `AlgoOrderVO` class in the `MetaDataRestController` and annotate it with `@AlgoOrderMetaData`. One needs to provide a mapping to the `OrderType` enum value there. These two steps will allow the UI to generate the entry form for that Execution Algo which will then be available in Advanced Order Form modal.

The Algo Order UI generation can be further tuned by annotating fields inside the `AlgoOrderVO` class with following annotations:

- `ch.algotrader.entity.trade.algo.UIGeneration` - allows to provide following properties:
  - `description` - adds additional information on UI for that field
  - `name` - allows to override the generated label for the field; by default the label is generated from the field's name in code
  - `required` - makes the field mandatory on UI
  - `disabled` - makes the field disabled on UI (but still visible)
  - `hidden` - hides the field on UI completely
  - `order` - allows to reorder fields. Without that annotation fields are displayed in the same order they're defined in the class. With this annotation one can provide any arbitrary order number and UI will sort all fields accordingly.

  - `toggle` - allows to hide or disable field based on a boolean value of a field (see example below)
  - `percentInput` - sets the field as a percent input, i.e. if the field is a decimal field with value ranging from 0 to 1 then it can be rendered on UI as a field with values from 0% to 100%
- `javax.validation.constraints.Pattern` - allows to define regex pattern for string values
- `javax.validation.constraints.Max` - allows to define max value for integers
- `javax.validation.constraints.Min` - allows to define min value for integers
- `javax.validation.constraints.DecimalMax` - allows to define max value for floating point numbers
- `javax.validation.constraints.DecimalMin` - allows to define min value for floating point numbers

Below code snipped shows an example for a `BigDecimal` field named `fieldA`. This field controls the visibility of `fieldB` and `fieldC`. `fieldB` is only visible if the value of `fieldA` is `true` and `fieldC` is only visible if the value of `fieldA` is `false`.

```
@UIGeneration(toggle = @FieldToggle(visibleOnTrue = "fieldB", visibleOnFalse = "fieldC"))
private BigDecimal fieldA;

@UIGeneration()
private BigDecimal fieldB;

@UIGeneration()
private BigDecimal fieldC;
```

Spring Services

AlgoTrader is built on top of the Spring Framework, which uses `BeanFactory` and `ApplicationContext` to locate Spring Beans (= AlgoTrader-Services).

The *Spring*[1] web site provides *documentation*[2] such as *'The IoC container'*[3] as an introduction.

AlgoTrader provides the class `ch.algotrader.ServiceLocator` which will instantiate the adequate `BeanFactories & ApplicationContexts` for a given operational mode depending on the specified *`BEAN_REFERENCE_LOCATION`*.

In Simulation mode the AlgoTrader Server as well as the Strategy run inside the same JVM.

In Live-Trading mode the AlgoTrader Server and strategies can be run in different JVMs. Through the use of `RmiServiceExporters` and `RmiProxyFactoryBean`, Strategies can call Services from the AlgoTrader Server. Behind the scenes this is handled transparently through RMI.

Please see *Remoting and web services using Spring*[4] for further details.

10.1. Wiring Factories

AlgoTrader provides the following Wiring Factories, which are instantiated by the `ServiceLocators`:

Table 10.1. Bean Reference Factories

Wiring Factory	Description
`LocalWiringFactory`	used when no remoting or strategy related functionality is needed (e.g. `HistoricalDataStarter`)
`EmbeddedWiringFactory`	used in Live Trading Mode when running in embedded mode
`ServerWiringFactory`	used in Live Trading Model on the server side
`ClientWiringFactory`	used by the Strategies in Live Trading Mode to connect to Services through RMI
`SimulationWiringFactory`	used in simulation

10.2. Application Context

AlgoTrader provides the following Wiring Classes and Application Context XML-Files :

[1] https://spring.io
[2] https://docs.spring.io/spring/docs/4.3.18.RELEASE/spring-framework-reference/htmlsingle/
[3] https://docs.spring.io/spring/docs/current/spring-framework-reference/core.html#beans
[4] https://docs.spring.io/spring/docs/current/spring-framework-reference/integration.html#remoting

Table 10.2. Application Context Files

ApplicationContext	Description	Examples
`CommonWiring`	contains common beans	Configuration, JMX Management, Esper Engine, Event Dispatching, Logging & Web Configuration
`ServerWiring`	contains server bean definitions	ActiveMQ, SSL & REST Controllers
`CoreWiring`		Caching, Configuration, DAOs, Data Source and Transaction Management, Hibernate, Live Cycle Manager, Server Esper Engine, Simulation & InfluxDB
`AdapterWiring`	contains adapter related beans	market data and trading adapters
`ExternalWiring`	contains external services	market data and trading services
`ClientServicesWiring`	contains all client service beans	`SubscriptionService`, `MarketDataCache`, `LiveCycleManager`, `CacheManager` & `LookupService`
`EmbeddedJMSWiring`	contains JMS embedded beans	Embedded JMS
`ClientJMSWiring`	contains JMS client beans	Remote JMS
`JMSWiring`	contains JMS server beans	Server JMS
`applicationContext-export-remoteServices.xml`	contains all `RmiServiceExporters` to make Services remotely available	
`applicationContext-import-remoteServices.xml`	contains all `RmiProxyFactoryBean` to call remote Services from the Strategies through RMI	
`applicationContext-client-*.xml`	to be provided by the Strategies	Strategy services, JMS queues
`applicationContext-env.xml`	contains environment specific bean definitions	Mail Settings, Reconciliation Dispositions

The following table shows which Wiring Classes and `ApplicationContext` is referenced by which Wiring Factory:

Table 10.3. Application Context References

ApplicationContext	Local	Embedded	Server	Client	Simulation
`CommonWiring`	x	x	x	x	x

ApplicationContext	Local	Embedded	Server	Client	Simulation
ServerWiring		x	x		
CoreWiring	x	x	x		x
AdapterWiring	x	x	x		
ExternalWiring	x	x	x		
ClientServicesWiring		x		x	
EmbeddedJMSWiring					
ClientJMSWiring				x	
JMSWiring			x		
applicationContext-export-remoteServices.xml			x		
applicationContext-import-remoteServices.xml				x	
applicationContext-client-*.xml		x		x	x
applicationContext-environment.xml	x	x	x		

10.3. Abstract Services

For many use cases abstract services are in place which can be extended for different broker interfaces.

For abstract services which have only one active implementation (through profiles), an alias can be defined for the concrete service (e.g. `iBHistoricalDataService`). A typical Spring Bean Alias definition looks like this:

```
@Profile("bBHistoricalData")
@Bean(name = {"bBHistoricalDataService", "historicalDataService"})
public HistoricalDataService createBBHistoricalDataService(
    final BBAdapter bBAdapter,
    final SecurityDao securityDao,
    final BarDao barDao) {
        return new BBHistoricalDataServiceImpl(bBAdapter, securityDao, barDao);
}
```

At runtime this service can now be accessed through its alias (e.g. *`historicalDataService`*)

For abstract services which might have more than one active implementation (through profiles), aliases are not available. In this case the following method can be used to look up all available concrete services that extend the abstract service (see `OrderService` for an example):

```
ServiceLocator.instance().getServices(OrderExecService.class)
```

10.4. Service initialization order

`InitializingServiceI` interface represents an abstract service that requires special initialization after it has been created and fully wired in the Spring application context. The life-cycle manager automatically detects such services and calls their `InitializingServiceI#init()` method before proceeding with initialization of strategy engines and deployment of strategy modules. This helps ensure that all external interfaces are fully initialized prior to strategy activation. `InitializationPriority` annotation can be used to explicitly mark a service either as a part of the platform core or as a part of an external broker interface. Core services have higher priority than all other services and get initialized before all others.

Events and Messaging

AlgoTrader provides a sophisticated event dispatching and messaging sub system. In Simulation Mode as well as Embedded Mode Event Propagation takes places within the JVM. In Distributed Live Trading Mode Event Propagation from the AlgoTrader Server to the strategies (and between strategies) happens via JMS & *ActiveMQ* [1]

11.1. Embedded ActiveMQ message broker

AlgoTrader makes use of an embedded instance of ActiveMQ message broker for message dispatch and delivery. It presently supports three transports by default:

- VM: for internal message delivery
- TCP: for message delivery to strategies running in distributed mode
- WebSockets: for message delivery to the HTML5 front-end. WebSockets transport can also be used for message delivery to any arbitrary external application that supports WebSockets transport and STOMP messaging protocols.

11.2. Embedded Jetty HTTP server

In addition to RMI transport AlgoTrader provides a RESTful interface over HTTP/S. RESTful endpoints serve only a subset of AlgoTrader functionality primarily required for HTML5 front-end. While being a subset it nonetheless represents the core functionality of the platform.

HTTP/HTTPS transport is powered by the embedded Jetty HTTP server and REST endpoints are managed by Spring Web framework.

11.3. RESTful interface

RESTful endpoints largely expose the same interface as Spring services exposed via RMI. REST controllers must follow RESTful semantic and also use immutable value objects for input / output representation.

AlgoTrader RESTful controllers serve several purposes:

- they provide request / response mapping to RESTful endpoints and enforce a contract conforming with the principles of RESTful interface;
- they de-serialize endpoint input to immutable value objects and if necessary convert them to input structures expected by the services;
- they convert service output structures to immutable value objects that can be serialized by the endpoints;
- they optionally perform additional input validation and mapping;

[1] http://activemq.apache.org/

- they map service exception to endpoint responses with an appropriate error status;

The following RESTful controller provides a list of all accounts available in the system:

```
@CrossOrigin
@RequestMapping(path                                    =                                    "/
account", method = RequestMethod.GET, produces = MediaType.APPLICATION_JSON_VALUE)
public List<AccountVO> getAccounts() {

    return lookupService.getAllAccounts().stream()
        .map(Account::convertToVO)
        .collect(Collectors.toList());
}
```

In this example the `@CrossOrigin` annotation marks endpoint as permitting cross origin requests. The `@RequestMapping` annotation defines various aspects of request / response mapping: *`path`* attribute defines path element of the request URI, *`method`* attribute defines the request method (such as GET, POST, PUT or DELETE), *`produces`* attribute defines expected media type of response body. The endpoint method implementation performs conversion of `Account` Entity objects to `AccountVO` objects, which are then serialized to JSON data stream by the framework.

For more detailed explanation of REST controllers and Web annotations please refer to Spring documentation.

AlgoTrader uses SWAGGER to document the individual REST endpoints, see:

11.4. Event Dispatcher

The `EventDispatcher` API represents a platform wide communication interface capable of submitting events to multiple `Engine` instances and event listeners both inside the same JVM as well as to separated JVMs. The `EventDispatcher` acts as an event bus for the AlgoTrader platform and individual strategies. The following Recipients are available

Table 11.1. Event Recipients

Scope	Local			Remote
	Server Engine	Strategy Engines	Event listeners	External processes
ALL	X	X	X	X
ALL_LOCAL	X	X	X	
ALL_LOCAL_STRATEGIES		X	X	
ALL_LOCAL_LISTENERS			X	
ALL_STRATEGIES		X	X	X
SERVER_LISTENERS	X		X	
SERVER_ENGINE_ONLY	X			

Scope	Local			Remote
	Server Engine	Strategy Engines	Event listeners	External processes
ALL_LISTENERS			X	X
REMOTE_ONLY				X

Note

AlgoTrader uses immutable value objects to represent events sent to strategy Engines and strategy processes.

11.5. Event Listeners

`EventListener` represents a generic communication interface to receive events from multiple event producers both in-process and remote. `EventListenerRegistry` interface represents a registry of event listeners used internally by the AlgoTrader Server process as well as individual strategy processes. One can register listeners for arbitrary event classes, which enables strategies to generate custom events either through Esper statements or in Java code and consume them internally or propagate them to other strategy processes.

The AlgoTrader platform provides a number of event listeners for common event types such as market data events, order events, external session events, life-cycle events, and a few others. Components that implement those event interfaces which are declared in the Spring application context get automatically registered with the platform upon initialization..

Table 11.2. Standard event listener classes

`BarEventListener`	receives `BarVO` events generated from tick events by individual strategies or fed from an external source
`EntityCacheEventListener`	receives `EntityCacheEvictionEventVO` generated by the cache manager
`FillEventListener`	receives `FillVO` events generated by trading interface adapters
`GenericEventListener`	receives `GenericEventVO` events generated by strategies or by the platform
`GenericTickEventListener`	receives `IBGenericTickVO` events generated by IB market data interface adapter
`LifecycleEventListener`	receives `LifecycleEventVO` generated by the life-cycle manager
`OrderCompletionEventListener`	receives `OrderCompletionVO` events generated by the Server Engine
`OrderEventListener`	receives `OrderVO` events generated by the order service
`OrderStatusEventListener`	receives `OrderStatusVO` events generated by trading interface adapters

`PositionEventListener`	receives `PositionNutationVO` events generated by the transaction service
`QueryCacheEventListener`	receives `QueryCacheEvictionEventVO` generated by the cache manager
`QuoteEventListener`	receives `QuoteVO` events (`BidVO` or `AskVO`) generated by market data interface adapters or fed from an external source
`SessionEventListener`	receives `SessionEventVO` generated by market data and trading interface adapters
`TickEventListener`	receives `TickVO` events generated by market data interface adapters or fed from an external source
`TradeEventListener`	receives `TradeVO` events generated by market data interface adapters or fed from an external source
`TransactionEventListener`	receives `TransactionVO` events generated by the transaction service
`AccountEventListener`	receives `AccountEventVO` events generated by the account service

It is possible to change event listener priority, i.e. define the order in which the listeners are invoked when reacting to an event, by applying the following annotation to the listener method:

```
@CrossOrigin
@EventHandlerPriority(value = EventHandlerType.EXECUTION, priority = 3)
public void onBar(BarVO bar) {
}
```

For `EventHandlerType` there are three options:

- MARKET_DATA_CACHE
- DEFAULT
- EXECUTION

MARKET_DATA_CACHE receives events first, and EXECUTION last.

Events for the same EventHandlerType are prioritized according the to "priority" value

- EVENT_HIGHEST_PRIORITY = 0
- EVENT_HIGH_PRIORITY = 1
- EVENT_NORMAL_PRIORITY = 2 (default value)
- EVENT_LOW_PRIORITY = 3
- EVENT_LOWEST_PRIORITY = 4

Again EVENT_HIGHEST_PRIORITY will receive events first, and EVENT_LOWEST_PRIORITY last.

Looking at a typical back test there are the following Bar consumers (in ascending order of event delivery):

- MarketDataCache (EventHandlerType = MARKET_DATA_CACHE, priority = EVENT_NORMAL_PRIORITY)
- StrategyService (your strategy) (EventHandlerType = DEFAULT, priority = EVENT_NORMAL_PRIORITY)
- Simulator (EventHandlerType = EXECUTION, priority = EVENT_NORMAL_PRIORITY)

So it is possible to change the order in which different listeners are invoked:

- To have StrategyService.onBar execute first add something like EventHandlerType = MARKET_DATA_CACHE, priority = EVENT_HIGH_PRIORITY)
- To execute StrategyService.onBar execute last add something like EventHandlerType = EXECUTION, priority = EVENT_LOW_PRIORITY)

11.6. JMS Destinations

Events are delivered to strategies via JMS. The following JMS Destinations are defined by the system

- one market data topic (`MARKETDATA.TOPIC`) defined inside `applicationContext-server.xml`: A Topic where all market data events are pushed into. On every event the *`securityId`* is set as a property, which can be used by the strategies to select market data events for securities subscribed to.
- one strategy queue per strategy (`XXX.QUEUE`) defined inside `applicationContext-client-xxx.xml`: A strategy specific Queue for messages like `OrderStatus`, `Fills` & `Transactions`. As JMS queues are persistent, messages will be delivered, even if a strategy was down, at the time of message creation.
- one generic topic (`GENERIC.TOPIC`) defined inside `applicationContext-server.xml`: A Topic for Generic Messages. Any strategy can send messages into this Topic. On every event the *`className`* of the event is set as a property, which can be used by the strategy to select event types that it is subscribed to.

Since market data events and generic events are pushed into two topics that are available to all strategies, strategies have to select appropriate messages on their own. This is the job of the `SubscriptionService`. It will modify the selectors on `MessageListenerContainer` accordingly and invoke the corresponding methods on the (server-side) `MarketDataService` (e.g. to request market data for additional securities).

Important

Strategies should never call the `MarketDataService` directly but instead call the `SubscriptionService`.

Configuration and Preferences API

12.1. Config Providers

AlgoTrader provides extensive support for configuration and customization of platform functions as well as of strategy specific settings.

The cornerstone of the configuration and preference API is the `ConfigProvider` interface that can be used to obtain arbitrary typed configuration parameters.

```
public interface ConfigProvider {

    <T> T getParameter(String name, Class<T> clazz);

    Set<String> getNames();
}
```

`DefaultSystemConfigProvider` is the default implementation of `ConfigProvider` based on Spring `ConversionService` and is internally backed by a thread safe Map. The default provider makes use of `ConversionService` conversion framework to convert the content of the internal parameter map to the desired type. One can customize the process of parameter conversion by using a custom `ConversionService` implementation.

`ConfigParams` is a utility facade for `ConfigProvider` exposing a set of getter methods for common data types such `Boolean`, `Integer`, `Long`, `Double`, `BigDecimal`, `URL` and `URI`. This class can be used by trading strategies that need to dynamically resolve configuration parameters at runtime.

`DefaultConfigLoader` is used to read configuration parameters from property files.

12.2. Config Beans

AlgoTrader also provides commonly used parameters in a form of plain Java beans referred to as Config beans. Common configuration are represented by `CommonConfig`. Core platform parameters are represented by `CoreConfig`. Instances of these classes are immutable and can be shared by multiple components and multiple threads of execution.

`ConfigBeanFactory` class can be used to create instances of Config beans based on configuration parameters using `@ConfigName` constructor parameter annotations. This factory is used to build standard `CommonConfig` and `CoreConfig` but it can also be used to build arbitrary Config beans for a trading strategy using the following convention

```
public final class StratConfig {

    private final String textParam;
```

```
    private final boolean boolParam;
    private final BigDecimal decimalParam;

    public StratConfig(
        @ConfigName(value = "my.text") final String textParam,
        @ConfigName(value = "my.bool") final boolean boolParam,
       @ConfigName(value = "my.decimal", optional = true) final BigDecimal decimalParam) {

        this.textParam = textParam;
        this.boolParam = boolParam;
        this.decimalParam = decimalParam;
    }

    public String getTextParam() {
        return textParam;
    }

    public boolean isBoolParam() {
        return boolParam;
    }

    public BigDecimal getDecimalParam() {
        return decimalParam;
    }
}
```

Each constructor parameter of a Config bean must be annotated with `@ConfigName` containing the parameter name. The config parameter type will be inferred from the constructor argument type. If a parameter is null able and might be undefined in the config property files it can be marked as `optional`.

Standard platform Config beans such as `CommonConfig` and `CoreConfig` are declared in the Spring application context and get automatically injected into all beans that require configuration. One can also add strategy specific Config beans using the following bean definition:

```
<bean id="stratConfig" class="ch.algotrader.config.spring.ConfigBeanFactoryBean">
    <constructor-arg index="0" ref="configLocator"/>
    <constructor-arg index="1" value="my.strategy.StratConfig"/>
</bean>
```

Standard as well as strategy specific Config beans can be conveniently accessed using Spring SPEL expressions to wire other beans in the same Spring application context.

```
<bean id="MyObject" class="...">
    <constructor-arg value="#{@stratConfig.requestUri}"/>
```

```
</bean>
```

In addition it is possible to reference individual beans (e.g. config beans) directly within Spring wired classes

```
private @Value("#{@configParams.accountId}") long accountId;
```

12.3. Config Locator

Even though it is preferable to dependency injection services provided by Spring application context to obtain configuration details required by custom components, in certain cases it may be necessary for unmanaged beans to get hold of Config beans. This can be done through the global `ConfigLocator`

```
ConfigParams configParams = ConfigLocator.instance().getConfigParams();
CommonConfig commonConfig = ConfigLocator.instance().getCommonConfig();
StratConfig stratConfig = ConfigLocator.instance().getConfig(StratConfig.class);
```

Processes and Networking

13.1. Processes

The following Services and Process are used by the system:

Table 13.1. Services and Processes

Service / Process	Description
AlgoTrader Server	This is the main AlgoTrader process
Strategies	In Live Trading Mode each strategy can run in its own Java process or within the same process as the AlgoTrader Server (one strategy only). In simulation mode, the strategies run within the same process as the AlgoTrader Server
MySql	Main database process.
InfluxDB	The InfluxDB database used for storage of historical data

If the AlgoTrader Server and the strategies are running within separate processes, individual strategies can be stopped / altered / restarted independent of each other and the AlgoTrader Server.

13.2. Sockets

Table 13.2. Sockets

Socket	Description	Default Ports
RMI Exporter	Remote access to Spring services	1199
ActiveMQ TCP	ActiveMQ TCP transport	61616
ActiveMQ WS	ActiveMQ WebSockets transport	61614
ActiveMQ WSS	ActiveMQ Secure WebSockets transport	61613
ActiveMQ Stomp	ActiveMQ TCP Stomp transport	61617
ActiveMQ SSL Stomp	ActiveMQ Secure TCP Stomp transport	61618
HTTP	Jetty HTTP transport	9090
HTTPS	Jetty HTTPS transport	9443
MySql	MySql database connection	3306
InfluxDB	InfluxDB connection	8086
IB Gateway	defined by IB Gateway configuration	4001
Bloomberg Terminal	BBComm.exe	8194
Fix	Fix Connections	varies

13.3. RMI

The system defines an RMI services through Spring Remoting (RMI Registry 1199): `RmiServiceExporter` (defined in `applicationContext-export-remoteServices.xml`)

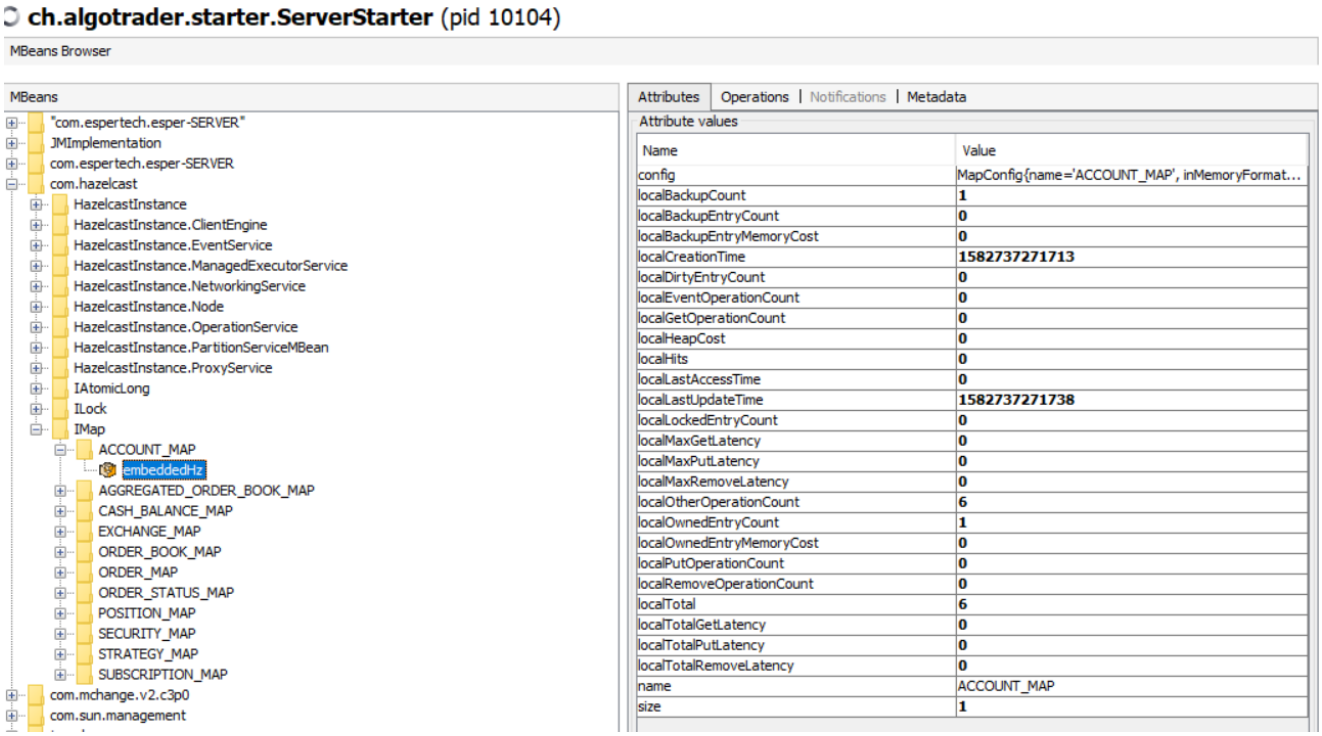
Hazelcast Caching

AlgoTrader uses Hazelcast as in-memory cache, and data access layer via internal calls through Hibernate.

You can find the documentation for the currently used version of Hazelcast *here.* [1]

14.1. MBean monitoring tool

You can connect to the Hazelcast MBean trough any a client like JConsole or Java VisualVM to monitor the current state of the instance within AlgoTrader. Hazelcast uses key-value maps to store all entities flowing through AlgoTrader during runtime. The most important map settings directly affecting the performance of the system are `timeToLiveSeconds`, the value specifying the maximum number of seconds for each entry to remain in a map before being evicted, and `mapEvictionPolicy`, that determines the eviction mode (can be `NONE`, `LRU (Least Recently Used)`, `LFU (Least Frequently Used)`).



14.2. Non-Indexed query detector

Performance Monitor is run in the background collecting usage statistics on Hazelcast maps, and logs unusual behavior. These logs can be used to spot performance bottlenecks and regressions when a map is accessed without the use of indexes. Check the logs for entries of the format

```
Non-indexed={count} queries running on map={mapName}
```

[1] https://docs.hazelcast.org/docs/3.12.4/manual/html-single/

These can and should be resolved by introducing indexes for better performance.

14.3. CacheFacade

Code-wise storage and retrieval of entities with Hazelcast are done via subclasses of `AbstractCacheFacade`. Each entity meant to be cached by its designated `CacheFacade`. For example `Account` has a corresponding `AccountCacheFacade`.

`AbstractCacheFacade` has basic methods already implemented such as `save`, `find` and their alterations. So if you are to extend `AbstractCacheFacade` to create a new cache facade, you only need to implement use-case/entity specific methods most of the time. Also, consider adding indexes (`byIndex()`) for performance critical methods you anticipate being used more often.

All entities are supplied with an identifier/key when saved to a Hazelcast map for the first time. The type of id and the way it is generated depend on the entity. Please, refer to `IdentityProvider` and `NextIdProvider` for more details.

14.4. Caveats

- There are no referential integrity constraints enforced within MySql, rather they are now implemented on the `CacheFacade` level. For more details, please refer to `ConstraintChain`.
- Hazelcast loads data from MySql at the beginning, and handles synchronization with the database, which means any changes made to the database after startup will not necessarily propagate to the cache. If you wish to change some entity values during runtime, do it through Hazelcast, to avoid data availability issues.

Logging

15.1. Custom UI Log Event Appender

This is a special customized appender which allows to send log events to the UI. The log events are sent via JMS/STOMP and log levels and loggers are configurable. For example you could define a particular logger (e.g. some specific class) or use the Root logger configured for the desired log level, e.g. INFO or WARN. In order to have multiple loggers with multiple log levels, separate appenders must be created each with it's own filter. The sample configuration below will create two UI appenders - one with level WARN (and above), another with INFO. Loggers defined in "Loggers" section reference these appenders in such a way that INFO log entries from `PortfolioServiceImpl` as well as all the entries with level WARN and above will be sent to the UI

Log entries are wrapped inside JMS message and get propagated via WebSocket STOMP protocol to the UI. In order to consume the log message the client will have to be subscribed to specific JMS topic ("/topic/log-event."). See StompAPIUtils.js in the HTML client for the subscription logic example.

```
<Appenders>
    <LogEvent name="LogEventWARN">
        <ThresholdFilter level="WARN" onMatch="ACCEPT" onMismatch="DENY"/>
    </LogEvent>
    <LogEvent name="LogEventINFO">
        <ThresholdFilter level="INFO" onMatch="ACCEPT" onMismatch="DENY"/>
    </LogEvent>
</Appenders>
<Loggers>
    <Root level="debug">
        <AppenderRef ref="LogEventWARN"/>
    </Root>
    <Logger name="ch.algotrader.service.PortfolioServiceImpl">
        <AppenderRef ref="LogEventINFO" />
    </Logger>
<Loggers>
```