ADLINK

User Guide

Release 2.4.0

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Introduction

Mobile platforms such as Android- and iOS-based smart phones, phablets, and tablets are swiftly becoming established as the target client platforms for a large class of consumer as well as enterprise and mission/business-critical applications. Vortex Café is a pure Java *TM* DDS implementation optimised for Android and the JVM that provides effective and efficient DDS connectivity to Android based devices–as well as any JVM-enabled device.

Vortex Café is the first peer-to-peer middleware infrastructure designed for Android that allow seamless interoperability with existing DDS systems and provides a powerful infrastructure for next generation peer-to-peer Android applications.

Vortex Café's main features are:

- It is the only pure Java version of DDS for JVMs including Android.
- It has a networking stack optimized for mobility, compliant with the OMG DDSI v2.1 standard.
- It is compliant with the Java 5 PSM specification for simpler and safer programming that delivers exceptional developer productivity.

This User Guide will get you started with Vortex Café development for the JDK as well as the Android development environment.

If you have any questions, please contact us at ADLINK support.

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Configuration of your Vortex Café project

Please make sure that your environment is set up as specified in the Vortex Installation Guide.

Your Vortex Café project must include the two following steps:

- Generation of Java code from your IDL file, using the Vortex Café's **idl2j** tool.
- Compilation of your Java code using one of the Vortex Café's jars:
  - **cafe.jar** for non-Android applications
  - **cafe-android.jar** for Android applications without logging
  - **cafe-android-debug.jar** for non-Android applications with logging

The next sections describe how you can perform those steps, depending on the build system in use (with or without Apache Maven).

Without Apache Maven

idl2j usage

The idl2j tool parses your IDL file defining your DDS types and generates a set of Java classes for each type. The idl2j tool uses the Oracle JDK's `idlj` compiler, and adds specific annotations in the generated classes to identify the DDS key members.

In the `VortexCafe-2.4.0/bin` directory are two scripts to run idl2j :

`idl2j.sh` for Linux/Unix platforms

`idl2j.bat` for Windows platforms

The options accepted by idl2j are the same as for the JDK's `idlj` and are described at `http://docs.oracle.com/javase/7/docs/technotes/tools/share/idlj.html`.

module-less IDL types

Module-less IDL types are generated in the defaut unnamed package. Thus these types cannot be imported by other applications (importing a simple type without package is a compile time error).

To figure out this problem the option **-defaultPkgPrefix <package_name>** is used to make idl2j generate the code for module-less types in a named package.

Jars to use

In the `VortexCafe-2.4.0/lib` directory is the jar your project must use in its *CLASSPATH* for compilation and at runtime.

Depending on your project, you must use a specific jar:

- For a non-Android Java project:
  - `cafe.jar`
- For an Android project in debug mode, with logging activated:
  - `cafe-android-debug.jar`
- For an Android project in release mode, without logging:
  - `cafe-android.jar`

Note that these three jars contain the same core code for Vortex Café, with the same API, options and communication protocol. They differ on only two points:

- *Data marshalling/unmarshalling* : the implementation of marshalling and unmarshalling of data is based on CORBA classes which are available with the standard JVM, but not with the Android VM. The jars for Android projects contain those classes in addition.
- *Android logging back-end* : the jar for Android project in debug mode also contains a specific logging back-end for Android. This back-end adds extra load to the application. For better performance, it is strongly advised that you use the jar for release mode.

Logging activation

Vortex Café logging system is based on **SL4J** (`http://www.slf4j.org`). **SL4J** is an abstraction layer for various logging frameworks (*e.g. java.util.logging* , *Log4J*, *Logback*, *etc.*) allowing the end user to plug in the desired logging framework at deployment time.

For non-Android platforms, there is no logging by default. You need to add one of the concrete logging frameworks in *CLASSPATH* , as documented in `http://www.slf4j.org/manual.html#swapping`.

Note that for Android platforms, the `cafe-android-debug.jar` already uses the Android logging framework. If you use this jar, you don't need to add anything. If you use the `cafe-android.jar` the logging is not active.

Example with Logback framework

To use the **Logback** (`http://logback.qos.ch`) logging framework with **SLF4j**, add the logback-core-x.x.x.jar and logback-classic-x.x.x.jar to your CLASSPATH:

```
CLASSPATH=/path/to/logback-core-1.1.1.jar:/path/to/logback-classic-1.1.1.jar:$CLASSPATH
```

To configure logback, add a logback.xml file is a directory with is referred by your CLASSPATH.

Here is an example of logback.xml file :

```
<?xml version="1.0" encoding="UTF-8"?>
<configuration>

 <appender name="STDOUT" class="ch.qos.logback.core.ConsoleAppender">
  <encoder>
   <!-- Pattern for output are explain here:                    -->
   <!--      http://logback.qos.ch/manual/layouts.html          -->
   <!--   %d{ }        : time with format                       -->
   <!--   %.-1level    : level (first character only)           -->
   <!--   %18.18thread : thread name (always 18 characters)     -->
   <!--   %20.20logger : logger name (always 20 characters)     -->
   <!--   %msg         : log message                            -->
   <!--   %n           : line separator (platform dependent)    -->
   <pattern>%d{HH:mm:ss.SSS} %.-1level [%-18.18thread] %-20.20logger : %msg%n</pattern>
  </encoder>
 </appender>
```

```
 <root level="${log.level:-INFO}">
  <appender-ref ref="STDOUT" />
 </root>

</configuration>
```

With Apache Maven

Please see the Vortex Installation Guide for a description of installation in an Apache Maven environment.

idl2j usage

The idl2j tool is also a Maven plugin. You can use it in your POM as follows:

```
<plugin>
   <groupId>com.prismtech.cafe</groupId>
   <artifactId>idl2j</artifactId>
   <version>2.4.0</version>
   <executions>
      <execution>
         <id>idl-compile</id>
         <phase>generate-sources</phase>
         <goals>
            <goal>idl-compile</goal>
         </goals>
      </execution>
   </executions>
</plugin>
```

By default it searches recursively for files with an `.idl` extension in the `src/main/idl` directory, and generates Java files in the `target/generated-sources/idl` directory. Those files are automatically added to the list of Java source files to be compiled by Maven at the compile phase.

In addition, the following optional parameters can be configured:

Name	Type	Description
`outDir`	`File`	The output directory for the generated sources. Default value is: `${project.build.directory}/generated-sources/idl`
`includeDirs`	`File[]`	Additional include directories containing additional `*.idl` files required for compilation.
`idlDir`	`File`	The source directory containing `*.idl` files. The plugin will also search for files in sub-directories. Default value is: `${basedir}/src/main/idl`

Dependencies to use

If your target platform is *not* Android, you only need to add a dependency to *cafe* as follows:

```
<dependency>
   <groupId>com.prismtech.cafe</groupId>
   <artifactId>cafe</artifactId>
   <version>2.4.0</version>
</dependency>
```

If your target platform *is* Android, you need to add a dependency to either *cafe-android* or *cafe-android-debug* . Our advice is to configure different profiles for each. For example:

```
<profiles>
   <!-- default profile (with logging active for development) -->
   <profile>
      <id>default</id>
      <activation><activeByDefault>true</activeByDefault></activation>
      <dependencies>
         <!-- Vortex Cafe for Android (debug) -->
        <dependency>
           <groupId>com.prismtech.cafe</groupId>
           <artifactId>cafe-android-debug</artifactId>
           <version>2.4.0</version>
        </dependency>
      </dependencies>
   </profile>

   <!-- release profile (without logging for better performance -->
   <profile>
      <id>release</id>
      <dependencies>
         <!-- Vortex Cafe for Android -->
         <dependency>
         <groupId>com.prismtech.cafe</groupId>
         <artifactId>cafe-android</artifactId>
         <version>2.4.0</version>
         </dependency>
      </dependencies>
   </profile>
</profiles>
```

Logging activation with maven

Similarly to what's described previously in std,std-refLogging activation you have to add a dependency to a concrete logging framework to activate logging.

For non-Android platforms, you have to add a dependency to one of the logging frameworks described in `http://www.slf4j.org/manual.html#swapping` (each one is present in Maven Central Repository).

For Android platforms, the *cafe-android-debug* dependency already uses the Android logging framework. If you use this you don't need to add anything. If you use the *cafe-android* dependency the logging is not active.

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Vortex Café Usage

DDS ServiceEnvironment initialization

In your Java project, before using the Vortex Café API, the ServiceEnvironment needs to be configured to point to the Vortex Café implementation. This is done by setting the property

`ServiceEnvironment.IMPLEMENTATION_CLASS_NAME_PROPERTY`
(which is equal to `"org.omg.dds.serviceClassName"`)

with the value

`"com.prismtech.cafe.core.ServiceEnvironmentImpl"`.

For example:

```
// Set the serviceClassName property
System.setProperty(
org.omg.dds.core.ServiceEnvironment.
  IMPLEMENTATION_CLASS_NAME_PROPERTY,
  "com.prismtech.cafe.core.ServiceEnvironmentImpl");

// Instantiate a DDS ServiceEnvironment
org.omg.dds.core.ServiceEnvironment env =
  org.omg.dds.core.ServiceEnvironment.createInstance(
  this.getClass().getClassLoader());

// Get the DDS DomainParticipantFactory
org.omg.dds.domain.DomainParticipantFactory dpf =
  org.omg.dds.domain.DomainParticipantFactory.getInstance(env);

// Then you can create your DDS entities...
```

You can also set this property at runtime as any Java SystemProperty using the following command-line option:

```
-Dorg.omg.dds.serviceClassName=com.prismtech.cafe.core.ServiceEnvironmentImpl
```

DDS API

Vortex Café implements the Java 5 Language PSM for DDS standard. For more documentation, see `http://www.omg.org/spec/DDS-Java/`.

For a detailed description of this API, see the Javadoc in the product installation at: Vortex-Cafe_2.4.0/docs/apidocs/index.html

Non-standard extensions

Select data to read with a Custom Content Filter

In addition to the standard API, Vortex Café offers a way to use custom filtering for selection of data to be read *via* a DataReader.

The `org.omg.dds.sub.DataReader.Filter<T>` interface is defined as follows:

```
/**
 * Filter class is in charge to determine if a {@link Sample} content
 * is acceptable depending on internal criteria.
 *
 * @param <T> The concrete type of the data to be read.
 */
public static interface Filter<T> {
  /**
   * Operation called during each read/take operation to filter the data.
   * If this operation returns true the data will be returned to the
   * caller.
   *
   * @param data the data to be filtered or not
   * @param params optional parameters
   * @return true if the data must be returned to the read/take operation
   */
  public boolean match(T data, Object... params);
}
```

You can implement this interface as a custom filter of your data type:

```
// definition of a custom filter
public class MyDataFilter implements Filter<MyDataType> {
  @Override
  public boolean match(MyDataType data, Object... params) {
  // test the ID attribute of MyDataType
  return data.ID == ((Integer) params[0]).intValue();
  }
}
```

Or you can use the `com.prismtech.cafe.utils.JavaScriptFilter` class to define a Filter in JavaScript:

```
Filter<Msg> jsUserIDFilter =
  new JavaScriptFilter<Msg>
    ("data.ID == params[0]"); // JavaScript code
```

Then, you can use the Filter with a DataReader's Selector in a `read()` or `take()` operation. For example:

```
DataReader<DataType> reader = ... ;

// create Selector with my custom Content Filter
Selector<DataType> selector =
  reader.select().Content(new MyDataFilter(), 1);

// or with a JavaScriptFilter:
// Selector<DataType> selector =
// reader.select().Content(jsUserIDFilter, 1);
// read data with the Selector
Iterator<DataType> it = reader.read(selector);
while (it.hasNext()) {
  Sample<DataType> data = it.next();
...
}
```

Note that a safer version of the `JavaScriptFilter` constructor can be used. This constructor performs extra validation of the JavaScript code against an example of data and parameters you have to provide:

```
Filter<Msg> jsUserIDFilter =
  new JavaScriptFilter<Msg>("data.ID == params[0]"); // JavaScript code
  new DataType(1, ...),                              // validation data
  1);                                                // validation params

// Note: the 2 last arguments are used to validate the JavaScript code
// at Filter creation, avoiding runtime errors.
```

ContentFilter QoS

In addition to the standard API, Vortex Café offers a new `ContentFilter` QoS (only applicable to DataReader) allowing data at reception to be filtered.

As opposed to content filtering *via* the DataReader's Selector (See Select data to read with a Custom Content Filter previously) the data is filtered before insertion in the DataReader history cache. Therefore the rejected data is not counted in history and can never be read by user.

You can define a `ContentFilter` QoS with the same Filter class as described in Select data to read with a Custom Content Filter:

```
// definition of a custom filter
public class MyDataFilter implements Filter<MyDataType> {
  @Override
  public boolean match(MyDataType data, Object... params) {
  // test the ID attribute of MyDataType
  return data.ID == ((Integer) params[0]).intValue();
  }
}
```

```
// creation of a ContentFilter QoS
ContentFilter filter = PolicyFactory.getPolicyFactory(env)
  .ContentFilter().withFilter(new MyFilter());

// or with a JavaScriptFilter:
// ContentFilter filter =
// PolicyFactory.getPolicyFactory(env)
// .ContentFilter()
// .withFilter(
// new JavaScriptFilter<DataType>("data.ID==params[0]"));
// creation of a DataReader with ContentFilter QoS
DataReader<DataType> reader =
  sub.createDataReader(topic,
    sub.getDefaultDataReaderQos().withPolicies(filter));
```

Android permissions

Vortex Café uses a UDP multicast protocol. Your Android application using Vortex Café will therefore need the following permissions:

- `android.permission.INTERNET`
- `android.permission.CHANGE_WIFI_MULTICAST_STATE`

Also, as UDP multicast is usually only available with a WiFi connection, you may want to check if WiFi is active using the following permission:

- `android.permission.ACCESS_NETWORK_STATE`

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Vortex Café runtime configuration

Vortex Café is configured with the help of java properties.

Where to set properties

Configuration properties can be specified in 3 different ways :

- Vortex Café will first try to load properties from a default configuration file named: "**vortex_cafe.properties**". This file is searched the classpath as a Java resource. The properties loaded from this file will override default properties.
- Vortex Café will then try to load properties from a file at the location specified with the system property named: "**vortex_cafe.properties**". This property value can be a path to the configuration file, a resource name or an URL (http, https, ftp...) to this file. See "std,std-refHow Vortex Café searches for files to load" for more information on file loading. The properties loaded from this file will override previously loaded properties. Examples :

```
-Dvortex_cafe.properties=/etc/myFile.properties
```

```
-Dvortex_cafe.properties=http://10.0.0.1/myVortexCafe-properties
```

```
-Dvortex_cafe.properties=ftp://user:password@10.0.0.1/myDir/myFile.properties
```

- Vortex Café will finally try to load properties from java System Properties. These properties will override previously loaded properties.

How Vortex Café searches for files to load

For all properties defining a file location (e.g. *vortex_cafe.properties* or *ddsi.security.ssl.keystore.file*) Vortex Café will try to open the file in the following order:

- first it tries to consider the specified location as a path to a local file system:
  - using the location as an **absolute path**
  - using the location as an **relative path** starting from **"user.dir"** Java system property (i.e. the working directory)
  - using the location as an **relative path** starting from **"home.dir"** Java system property (i.e. the home directory)
- then it tries to consider the specified location as a Java resource name:
  - looking for the resource via the ContextClassLoader of the current Thread (see java.lang.Thread.getContextClassLoader())
  - looking for the resource via the ClassLoader which loaded the Vortex Café classes
  - looking for the resource via the SystemClassLoader (see java.lang.ClassLoader.getSystemResource(String))

- finally it tries to consider the specified location as an URL:
  - by default the protocols specified in the java.net.URL constructor are supported (http, https, ftp, file, and jar)
  - you can add more protocols using the java.net.URL.setURLStreamHandlerFactory() operation

Android specificities

Where to locally store files used for configuration properties ?

You can copy them to your Android project in **res/raw/** folder or in **assets** folder. When looking for a file specified via a configuration property, Vortex Café will search for the file in those 2 folders.

Vortex Café gets access to the stored files via an Android Context. You have the possibility to indicate which Context should be used calling this operation before any Participant creation:

```
// myAndroidContext could be your Application itself or any Activity object
com.prismtech.cafe.ddsi.utils.SystemUtilsAndroid.setContext(myAndroidContext);
```

If you don't call this operation, Vortex Café will try to retrieve the Android Application Context when the first Participant is created. But this requires the Participant to be created from an Activity thread.

Properties scope

Vortex Café uses a properties set per Participant. Each Participant loads its properties as seen in previous chapter.

Consequently, if you want to specify different properties for different Participants you have to set those as System Properties before each Participant creation.

Examples :

```
System.setProperty("vortex_cafe.properties", "myParticipant1.properties");

DomainParticipant dp1 =
   env.getSPI().getParticipantFactory().createParticipant(DOMAIN_ID1);


System.setProperty("vortex_cafe.properties", "myParticipant2.properties");

DomainParticipant dp2 =
   env.getSPI().getParticipantFactory().createParticipant(DOMAIN_ID2);
```

```
System.setProperty("ddsi.discovery.participant.leaseDuration", "5.0");

DomainParticipant dp1 =
   env.getSPI().getParticipantFactory().createParticipant(DOMAIN_ID1);


System.setProperty("ddsi.discovery.participant.leaseDuration", "10.0");

DomainParticipant dp2 =
   env.getSPI().getParticipantFactory().createParticipant(DOMAIN_ID2);
```

Units of duration properties

Durations are expressed in seconds with accuracy up to nanoseconds.

Example :

- 1.02 = 1 second and 20 milliseconds
- 0.001 = 1 millisecond

Configuration Properties description

ddsi.network.interface

Type String

Default "auto"

Behavior

This indicates the network interface Vortex Cafe uses for both TCP and UDP communications.
The default value "auto" will chose a default network card. In addition of "auto" the accepted values are:
- a short "Unix-like" interface name (e.g. eth0, wlan1...)
- the IP address of the interface
- on Windows platforms: a connection name (e.g. "Local Area Connection")

Note that this option can be overridden by the *ddsi.network.tcp.interface* or the *ddsi.network.udp.interface* options.

ddsi.network.tcp.interface

Type String

Default ""

Behavior

This indicates the network interface Vortex Cafe uses for TCP communications.
If both *ddsi.network.interface* and *ddsi.network.tcp.interface* options are specified, the *ddsi.network.tcp.interface* option will have precedence over the *ddsi.network.interface* option for TCP communications. The default value "auto" will chose a default network card. In addition of "auto" the accepted values are:
- a short "Unix-like" interface name (e.g. eth0, wlan1...)
- the IP address of the interface
- on Windows platforms: a connection name (e.g. "Local Area Connection")

ddsi.network.udp.interface

Type String

Default ""

Behavior

This indicates the network interface Vortex Cafe uses for UDP communications.
If both *ddsi.network.interface* and *ddsi.network.udp.interface* options are specified, the *ddsi.network.udp.interface* option will have precedence over the *ddsi.network.interface* option for UDP communications. The default value "auto" will chose a default network card. In addition of "auto" the accepted values are:

- a short “Unix-like” interface name (e.g. eth0, wlan1...)
- the IP address of the interface
- on Windows platforms: a connection name (e.g. “Local Area Connection”)

ddsi.network.transport

Type String

Default “”

Behavior

Indicates the transport Vortex Cafe should use for network communications.
Valid values are :
- “udp”
- “tcp”

@deprecated replaced by ddsi.network.tcp.enabled and ddsi.network.udp.enabled.

ddsi.network.transport=tcp is equivalent to
- *ddsi.network.tcp.enabled=true*
- *ddsi.network.udp.enabled=false*

ddsi.network.transport=udp is equivalent to
- *ddsi.network.tcp.enabled=false*
- *ddsi.network.udp.enabled=true*

Setting both this deprecated *ddsi.network.transport* option and one of the new options is considered as an invalid configuration and will throw an exception at participant creation.

ddsi.network.tcp.enabled

Type boolean

Default true

Behavior

When set to true, VortexCafe will use TCP transport (in addition to other enabled transports).

ddsi.network.udp.enabled

Type boolean

Default true

Behavior

When set to true, VortexCafe will use UDP transport (in addition to other enabled transports).

ddsi.network.endianess

Type java.nio.ByteOrder

Default BIG_ENDIAN

Behavior

Specifies in which byte order messages to be sent will be encoded. BIG_ENDIAN will require less resources for the local jvm.

ddsi.network.udp.ttl

Type int

Default 32

Behavior

Time to Live value for emitted UDP multicast packets.

ddsi.network.udp.join.interfaces

Type String

Default "single"

Behavior

Specifies which network interfaces to use when joining the UDP multicast group. Valid values are :

- **"single"** : VortexCafe will join the multicast group only via the specified network interface (configured via *ddsi.network.interface* or *ddsi.network.udp.interface* options)
- **"subnet"** : VortexCafe will join the multicast group via all active network interfaces which have an IP address on the same sub-network than the network interface configured via *ddsi.network.interface* or *ddsi.network.udp.interface* . This is the default value.

ddsi.network.ssl.handshake.timeout

Type Duration

Default 1

Behavior

Specifies the maximum amount of time Cafe should wait for a SSL handshake to finish before giving up.

ddsi.network.receiver.threadPool.size

Type int

Default 4

Behavior

Size of the thread pool used to decode messages. If the value is set to 0, then the thread pool is not created, underlying socket threads are used to decode messages. For better latency, use 0, for better throughput, use a positive value depending on the number of usable cores.

ddsi.network.receiver.transports.separateThreadPools

Type boolean

Default false

Behavior

If set to true, 2 different thread pools will be used to decode messages received from TCP transport and UDP transport. Otherwise, the same threadpool will be used.

ddsi.network.receiver.socket.buffer.size

Type int

Default 1048576

Behavior

Size of the socket receive buffer. This option directly drives the SO_RCVBUF socket option.

ddsi.network.receiver.udp.buffer.size

Type int

Default 65536

Behavior

Size of the buffers used to read incoming UDP datagrams. The default value is 65536. If a smaller value is used, some big UDP datagrams could be truncated.

ddsi.network.receiver.udp.threadPool.size

Type int

Default 4

Behavior

Size of the thread pool used to decode messages received from UDP transport. This has an impact only if *ddsi.network.receiver.transports.separateThreadPools* is explicitly set to true. Note : if *ddsi.network.receiver.transports.separateThreadPools* is set to true and this property is not set, this property will take the same value as *ddsi.network.receiver.threadPool.size*.

ddsi.network.receiver.tcp.threadPool.size

Type int

Default 4

Behavior

Size of the thread pool used to decode messages received from TCP transport. This has an impact only if *ddsi.network.receiver.transports.separateThreadPools* is explicitly set to true. Note : if *ddsi.network.receiver.transports.separateThreadPools* is set to true and this property is not set, this property will take the same value as *ddsi.network.receiver.threadPool.size*.

ddsi.network.receiver.dataProcessor.threadPool.size

Type int

Default 0

Behavior

Size of the thread pool used to treat data messages. If set to 0, then the thread pool is not created and the underlying thread (receiver thread pool or socket thread) is used to treat message. For better latency, use 0.

ddsi.network.receiver.acknackProcessor.threadPool.size

Type int

Default 0

Behavior

Size of the thread pool used to treat acknack messages. If set to 0, then the thread pool is not created and the underlying thread (receiver thread pool or socket thread) is used to treat message. For better latency, use 0.

ddsi.network.receiver.ignoreLocalPublishers

Type boolean

Default false

Behavior

When set to true, then the participant ignores all messages coming from itself. In other words, local writers will not communicate with local readers.

ddsi.network.receiver.ignoreInfoDst

Type boolean

Default false

Behavior

When set to true, then the participant ignores the INFO_DST context. So it will interpret messages that do not concern him.

ddsi.network.receiver.anyMessageAsSPDP

Type boolean

Default true

Behavior

When set to true, any message received from a given Participant will be considered as a SPDP lease renew. In other words, a participant will not be considered dead while some messages are received from it, even if no SPDP messages are received.

ddsi.network.sender.writeBuffer.highWaterMark

Type int

Default 10000000

Behavior

Specifies the maximum amount of unacked data in bytes each writer is allowed to send on the network. When a writer sent more than *highWaterMark* bytes of data on the network, it stops sending data until all the remote reliable readers positively acknowledged part of the data so that the amount of unacked sent data is less than *lowWaterMark*. The writer can then restart sending data on the network until the *highWaterMark* is eventually reached again. This allows to manage writers' data transmission rate in order to prevent a fast sender from overwhelming a slow receiver, or a slow network, or a slow Vortex Cloud/Fog service. If set to a negative value, the *highWaterMark* will be considered infinite and so the writers will never block because of it.

ddsi.network.sender.writeBuffer.lowWaterMark

Type int

Default 1000000

Behavior

Specifies the limit under which the amount of unacked sent data needs to drop down before a writer is allowed to restart sending data on the network after it stopped sending data because the *highWaterMark* has been reached. This value must be set to a lower value than the *highWaterMark*.

ddsi.network.sender.maxMessageSize

Type int

Default 60000

Behavior

The maximum size of a RTPS message that can be sent as one UDP packet. This value must be >= 512.

ddsi.network.tcp.sender.queue.enabled

Type boolean

Default true

Behavior

Specifies if the sending messages queue should be enabled or not.

- When enabled, all RTPS messages to be sent are pushed in a queue. A worker thread then pulls messages from the queue and writes them to a socket.

- When disabled, all RTPS messages to be sent are directly written to a socket. This configuration implies less thread context switches, but may lead to a situation where all threads are blocked writing to a slow TCP connection while other samples could be sent to larger connections.

ddsi.network.lossDetection

Type boolean

Default false

Behavior

When set to true, Vortex Cafe will log a WARN trace each time it detects that more than ddsi.network.lossDetection.floor messages have been lost among the last 100 messages. It will log an INFO trace when the number of lost messages get's back to less than ddsi.network.lossDetection.floor messages. Vortex Cafe will also log the amount of lost messages when it exceeds ddsi.network.lossDetection.floor .

ddsi.network.lossDetection.floor

Type int

Default 20

Behavior

This property is only used when ddsi.network.lossDetection is set to true. It indicates the minimum number of lost messages before starting to log WARN traces and lost statistics.

ddsi.network.java.io

Type String

Default "auto"

Behavior

This indicates which java IO will Cafe use.
The accepted values are:
- **"nio"** : Cafe uses NIO sockets.
- **"oio"** : Cafe uses OIO sockets.
- **"auto"** : Cafe uses NIO if multicast is available on NIO - otherwise use OIO.

ddsi.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of locators Vortex Cafe should advertise to other participants for both discovery and data communications on both TCP and UDP transports.
Valid values are :
- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an IP address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

This configuration value may be overridden by :
- ddsi.tcp.externalNetworkAddresses
- ddsi.udp.externalNetworkAddresses
- ddsi.discovery.externalNetworkAddresses
- ddsi.discovery.tcp.externalNetworkAddresses
- ddsi.discovery.udp.externalNetworkAddresses
- ddsi.data.externalNetworkAddresses
- ddsi.data.tcp.externalNetworkAddresses
- ddsi.data.udp.externalNetworkAddresses

ddsi.tcp.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of TCP locators Vortex Cafe should advertise to other participants for both discovery and data communications.
Valid values are :
- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local TCP address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of TCP locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

This configuration value may be overridden by :
- ddsi.discovery.externalNetworkAddresses
- ddsi.discovery.tcp.externalNetworkAddresses
- ddsi.data.tcp.externalNetworkAddresses

ddsi.udp.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of UDP locators Vortex Cafe should advertise to other participants for both discovery and data communications.
Valid values are :
- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local UDP address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of UDP locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

This configuration value may be overridden by :
- ddsi.discovery.externalNetworkAddresses
- ddsi.discovery.udp.externalNetworkAddresses
- ddsi.data.udp.externalNetworkAddresses

ddsi.discovery.propagation

Type boolean

Default false

Behavior

If true, when this participant discovers a new remote participant, it sends all the participants it discovered so far to the newly discovered participant. This allows a dynamic discovery in non-multicast environments.

ddsi.discovery.participant.guidPrefix

Type byte[]

Default []

Behavior

Set the GUID prefix of the Participant.

This GUID prefix **MUST** be unique in the system. It must be define here as a 12 bytes hexa string (i.e. 24 characters). For instance: *"0123456789abcdef0123456789ABCDEF"*.

If this option is not specified (this is the case by default), a GUID prefix will be generated, using hostid, process id and a counter (or random numbers if hostid or process id can't be found).

ddsi.discovery.participant.leaseDuration

Type Duration

Default 10

Behavior

Other participants should consider this participant as "dead" if they do not receive any SPDP message from it for *leaseDuration* seconds.

ddsi.discovery.participant.advertisePeriod

Type Duration

Default 2.5

Behavior

The participant will send a SPDP discovery message every *advertisePeriod* seconds. This value must be lesser than *ddsi.discovery.participant.leaseDuration* value.

ddsi.discovery.participant.discoveryWaitPeriod

Type Duration

Default 2

Behavior

At participant creation, after initialization, the create_participant() method will block for *discoveryWaitPeriod* seconds to allow discovery to complete.

ddsi.discovery.readersAdvertisementDelay

Type Duration

Default 0.05

Behavior

After discovering a remote participant, the implementation will immediately advertise it's local writers to the remote participant, but wait readersAdvertisementDelay before it advertise it's readers. This allows the local readers to set up correctly before the remote writer endpoint starts sending data on the network.

ddsi.discovery.participant.name

Type String

Default ""

Behavior

Represents the name of the participant. The default is "" which is not sent over DDSI.

ddsi.discovery.exec.name

Type String

Default ""

Behavior

Represents the name of the application. The default is "" which is replaced by the name of the class defining the `main(String[] args)` operation, or failing that, the process name.

ddsi.discovery.tcp.port

Type int

Default -1

Behavior

Indicates the port number the participant should listen on for discovery traffic when using TCP transport. If set to -1 (default value), no port will be open (i.e. the participant will acts as a TCP client only). If set to 0, an available port will be automatically chosen by the operating system.

ddsi.discovery.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of locators Vortex Cafe should advertise to other participants for discovery communications on both TCP and UDP transports.
Valid values are :
- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an IP address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

This configuration value may be overridden by :
- ddsi.discovery.tcp.externalNetworkAddresses
- ddsi.discovery.udp.externalNetworkAddresses

ddsi.discovery.tcp.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of TCP locators Vortex Cafe should advertise to other participants for discovery communications.
Valid values are :
- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local TCP address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of TCP locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

ddsi.discovery.udp.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of UDP locators Vortex Cafe should advertise to other participants for discovery communications.
Valid values are :

- **“none”** : No locators are advertised (behind a symmetric NAT)
- **“local”** : Local UDP address and ports are advertised (public address) [DEFAULT]
- **“<locator list>”** : List of UDP locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

ddsi.discovery.tcp.peers

Type String (list of list of locators)

Default []

Behavior

Indicates the list of tcp endpoints that the participant should try to contact initially when using tcp transport.

ddsi.discovery.udp.allowMulticast

Type String

Default “full”

Behavior

Indicates when multicast is allowed to be used or not. The accepted values are:
- **“full”** meaning UDP multicast is used whenever possible, for reception as well as publications. This is the default value.
- **“publications”** meaning that UDP multicast is only used for discovery (reception and publications of SPDP and SEDP) and for publications of data (not for reception).
- **“discovery”** meaning that UDP multicast is only used for discovery (reception and publications of SPDP and SEDP).
- **“minimal”** meaning UDP multicast is only used for the initial participants discovery (SPDP reception and publications). All further communications (SPDP liveliness, SEDP, user DATA) will rely on unicast. The participant will not advertise any UDP multicast locator (multicast messages may still be received but the communications does not rely on them).
- **“none”** meaning UDP multicast is never used.
- **“true”** (@deprecated) meaning the same than “full”.
- **“false”** (@deprecated) meaning the same than “none”.

ddsi.discovery.udp.peers

Type String (list of locators)

Default []

Behavior

Indicates the list of udp unicast endpoints that the participant should try to contact initially when using udp transport.

ddsi.discovery.udp.unicast.port

Type int

Default -1

Behavior

Indicates the port number the participant should listen on for discovery traffic when using UDP unicast transport. if not defined by user (-1), port rule computation will be used

ddsi.data.udp.unicast.port

Type int

Default -1

Behavior

Indicates the port number the participant should listen on for data traffic when using UDP unicast transport. if not defined by user (-1), port rule computation will be used

ddsi.discovery.udp.multicast.address

Type String (IP address)

Default "238.71.106.190"

Behavior

Indicates the multicast address used for discovery. The default value is the one specified in the RTPS standard and should be used for interoperability.

ddsi.discovery.udp.port.basenumber

Type int

Default 7400

Behavior

Port Base Number.

This value is used to calculate port numbers to listen on according to the following expressions (where PB is the Port Base Number):

- MetaTraffic-Multicast-port = PB + DG x domainId + d0
- MetaTraffic-Unicast-port = PB + DG x domainId + d1 + PG x participantId
- UserTraffic-Multicast-port = PB + DG x domainId + d2
- UserTraffic-Unicast-port = PB + DG x domainId + d3 + PG x participantId

ddsi.discovery.udp.port.dg

Type int

Default 250

Behavior

Domain Gain.

This value is used to calculate port numbers to listen on according to the following expressions (where DG is the Domain Gain):

- MetaTraffic-Multicast-port = PB + DG x domainId + d0
- MetaTraffic-Unicast-port = PB + DG x domainId + d1 + PG x participantId
- UserTraffic-Multicast-port = PB + DG x domainId + d2
- UserTraffic-Unicast-port = PB + DG x domainId + d3 + PG x participantId

ddsi.discovery.udp.port.pg

Type int

Default 2

Behavior

ParticipantId Gain.

This value is used to calculate port numbers to listen on according to the following expressions :

- MetaTraffic-Multicast-port = PB + DG x domainId + d0
- MetaTraffic-Unicast-port = PB + DG x domainId + d1 + PG x participantId
- UserTraffic-Multicast-port = PB + DG x domainId + d2
- UserTraffic-Unicast-port = PB + DG x domainId + d3 + PG x participantId

ddsi.discovery.udp.port.d0

Type int

Default 0

Behavior

Additional offset “d0”.

This value is used to calculate port numbers to listen on according to the following expressions :

- MetaTraffic-Multicast-port = PB + DG x domainId + d0
- MetaTraffic-Unicast-port = PB + DG x domainId + d1 + PG x participantId
- UserTraffic-Multicast-port = PB + DG x domainId + d2
- UserTraffic-Unicast-port = PB + DG x domainId + d3 + PG x participantId

ddsi.discovery.udp.port.d1

Type int

Default 10

Behavior

Additional offset “d1”.

This value is used to calculate port numbers to listen on according to the following expressions
:

- MetaTraffic-Multicast-port = PB + DG x domainId + d0
- MetaTraffic-Unicast-port = PB + DG x domainId + d1 + PG x participantId
- UserTraffic-Multicast-port = PB + DG x domainId + d2
- UserTraffic-Unicast-port = PB + DG x domainId + d3 + PG x participantId

ddsi.discovery.udp.port.d2

Type int

Default 1

Behavior

Additional offset "d2".

This value is used to calculate port numbers to listen on according to the following expressions
:

- MetaTraffic-Multicast-port = PB + DG x domainId + d0
- MetaTraffic-Unicast-port = PB + DG x domainId + d1 + PG x participantId
- UserTraffic-Multicast-port = PB + DG x domainId + d2
- UserTraffic-Unicast-port = PB + DG x domainId + d3 + PG x participantId

ddsi.discovery.udp.port.d3

Type int

Default 11

Behavior

Additional offset "d3".

This value is used to calculate port numbers to listen on according to the following expressions
:

- MetaTraffic-Multicast-port = PB + DG x domainId + d0
- MetaTraffic-Unicast-port = PB + DG x domainId + d1 + PG x participantId
- UserTraffic-Multicast-port = PB + DG x domainId + d2
- UserTraffic-Unicast-port = PB + DG x domainId + d3 + PG x participantId

ddsi.discovery.sedp.ignoreOrphanEntities

Type boolean

Default false

Behavior

Temporary hack for better interoperability with Twin Oaks CoreDX

ddsi.discovery.sedp.writers.heartbeat.period

Type Duration

Default 0.1

Behavior

Discovery writers (SEDP) will send a heartbeat message every *heartbeat.period* seconds until all their data messages have been acknowledged by all known associated readers.

ddsi.discovery.sedp.writers.nack.responsePeriod

Type Duration

Default 0.1

Behavior

After reception of an AckNack message, discovery writers (SEDP) will wait *nack.responsePeriod* seconds before sending a repair message.

ddsi.discovery.sedp.writers.nack.suppressionDuration

Type Duration

Default 0

Behavior

Not implemented. This value has no impact.

ddsi.discovery.sedp.readers.heartbeat.responseDelay

Type Duration

Default 0.1

Behavior

After reception of a Heartbeat message, discovery readers (SEDP) will wait *heartbeat.responseDelay* seconds before sending an AckNack message.

ddsi.discovery.sedp.udp.multicast.address

Type String (IP address)

Default "238.71.106.190"

Behavior

Indicates the multicast address used for discovery of entities (sedp protocol).

ddsi.discovery.connection.retry.number

Type int

Default 3

Behavior

Connections retry number in case of failure.

ddsi.discovery.connection.retry.period

Type Duration

Default 15

Behavior

Connections retry period. In case of connection failure the connection may be retried *period* seconds later.

ddsi.discovery.publishCMTopics

Type boolean

Default true

Behavior

SEDP writer endpoints should be created.

ddsi.discovery.subscribeCMTopics

Type boolean

Default false

Behavior

SEDP reader endpoints should be created.

ddsi.discovery.serviceType

Type String

Default "none"

Behavior

This configuration property should only be used by ADLINK. The valid values are the following:

- "none" : not a service (default value)
- "ds" : Discovery Service
- "rs" : Routing Service
- "fog" : Fog

ddsi.data.udp

Type boolean

Default true

Behavior

When set to false, no udp ports are opened to listen for user data. This property is not supposed to be used by a user application exchanging user data, but only for applications performing discovery activities only (such as the Vortex-Cloud DiscoveryService).

ddsi.data.tcp.port

Type int

Default -1

Behavior

Indicates the port number the participant should listen on for data traffic when using TCP transport. If this option is not specified, then Vortex Cafe will use the same port for both discovery and data traffic.

ddsi.data.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of locators Vortex Cafe should advertise to other participants for data communications on both TCP and UDP transports.
Valid values are :

- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an IP address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

This configuration value may be overridden by :

- ddsi.data.tcp.externalNetworkAddresses
- ddsi.data.udp.externalNetworkAddresses

ddsi.data.tcp.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of TCP locators Vortex Cafe should advertise to other participants for data communications.
Valid values are :

- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local TCP address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of TCP locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

ddsi.data.udp.externalNetworkAddresses

Type String (list of locators)

Default local

Behavior

Indicates the list of UDP locators Vortex Cafe should advertise to other participants for data communications.

Valid values are :

- **"none"** : No locators are advertised (behind a symmetric NAT)
- **"local"** : Local UDP address and ports are advertised (public address) [DEFAULT]
- **"<locator list>"** : List of UDP locators to advertise to other participants (behind a cone NAT)

Where <locator list> is a comma separated list of locators each locator being an address and port separated by a semicolon or an IP address only. Example :
1.2.3.4:7400,4.3.2.1

ddsi.data.writers.sendKeyHash

Type boolean

Default true

Behavior

If false, user writers will not send PID_KEY_HASH parameter in inlineQoS.

ddsi.data.writers.reliabilityQueue.size

Type int

Default 256

Behavior

The size of the reliability queue in RELIABLE writers. The reliability queue is used to keep messages and be able to resend them in case of transmission failure. There is one queue per associated reader.

ddsi.data.writers.heartbeat.period

Type Duration

Default 0.01

Behavior

User writers will send a heartbeat message every *heartbeat.period* seconds until all their data messages have been acknowledged by all known associated readers.

ddsi.data.writers.acknack.responseDelay

Type Duration

Default 0.01

Behavior

After reception of an AckNack message, user writers will wait *acknack.responseDelay* seconds before sending a repair message.

ddsi.data.writers.acknack.suppressionDuration

Type Duration

Default 0

Behavior

Not implemented. This value has no impact.

ddsi.data.writers.ignoreOutOfDateNacks

Type boolean

Default false

Behavior

When true, writers will ignore resend requests for samples that already have been resent since the request was made. This behavior allows to avoid useless resends (and so brings better performances) in environments with a high latency, typically WAN communications peer to peer or through Vortex Cloud and/or Vortex Fog. It should be activated in such cases. But this behavior implies more treatments and may degrade performances when the CPU resource is more constrained than network capacities which is typically the case in LAN environments, and so should be desactivated (default) in such cases.

ddsi.data.writers.tcp.initiateConnection

Type boolean

Default false

Behavior

Indicates, when using TCP transport, if writers are allowed to connect to remote readers even if they are reachable by remote readers. This value has no effect on UDP communications.

ddsi.data.readers.orderQueue.size

Type int

Default 2048

Behavior

When messages from a given writer arrive out of order, too recent messages, are kept in an order queue waiting for older messages to arrive. This is the maximum size of this order queue. When this queue is full, then messages are dropped.

ddsi.data.readers.heartbeat.responseDelay

Type Duration

Default 0.001

Behavior

After reception of a Heartbeat message, user readers will wait *heartbeat.responseDelay* seconds before sending an AckNack message.

ddsi.data.readers.heartbeat.suppressionDuration

Type Duration

Default 0

Behavior

Not implemented. This value has no impact.

ddsi.data.readers.preTimeout

Type Duration

Default 1

Behavior

Used in WaitForHistorical data algorithm : - Check if preTimeout has elapsed since the creation of the Reader - otherwise wait until this preTimout has elapsed : that is to give a chance to reader to discover remote writers *preTimeout* seconds.

ddsi.data.readers.timeout

Type Duration

Default 1

Behavior

Timeout used in WaitForHistorical *timeout* seconds.

ddsi.interop.pre611FragmentationMode

Type boolean

Default false

Behavior

OpenSpliceDDS fragments encoding changed between version V6.1.0 and V6.1.1. When this property is set to true, then fragments are encoded/decoded to be compatible with OpenSpliceDDS versions older than V6.1.1. Otherwise, fragments are encoded/decoded to be compatible with recent OpenspliceDDS versions.

ddsi.interop.twinoaksTempHack

Type boolean

Default false

Behavior

Temporary hack for better interoperability with Twin Oaks CoreDX

ddsi.security.authClassName

Type String

Default “”

Behavior

Indicates the name of the class implementing the Authentication plugin

ddsi.security.accessCtrlClassName

Type String

Default “”

Behavior

Indicates the name of the class implementing the Access Control plugin

ddsi.security.cryptoClassName

Type String

Default “”

Behavior

Indicates the name of the class implementing the Cryptographic plugin

ddsi.security.loggingClassName

Type String

Default “”

Behavior

Indicates the name of the class implementing the Logging plugin

ddsi.security.dataTagClassName

Type String

Default “”

Behavior

Indicates the name of the class implementing the Data Tagging plugin

ddsi.security.localRetryDelay

Type Duration

Default 1

Behavior

Specifies the maximum amount of time Cafe should wait before retrying local validation.

ddsi.security.randomGenerator

Type String

Default “”

Behavior

Make the random generator configurable so that the user can choose a quick generator or a more secure generator. The quick one should be used by default. The possible values are: quick (By default, using SecureRandom) secure (but slower)

ddsi.security.ssl

Type boolean

Default false

Behavior

When set to true the TCP communications will be secured via a SSL (or TLS) protocol. See all *ddsi.security.ssl...* options below to configure this.

ddsi.security.ssl.algorithm

Type String

Default “TLS”

Behavior

The standard name of the requested SSL protocol.

See the SSLContext section in the Java Cryptography Architecture Standard Algorithm Name Documentation for information about standard protocol names.

ddsi.security.ssl.keystore.file

Type String

Default “”

Behavior

The keystore file providing credential (private/public keys and certificates) to be used for encryption and authentication. See the Java Secure Socket Extension Reference Guide for more information.

This value could be:
- a path to local file system (absolute or relative)
- a Java resource name (absolute or relative)
- a URL (i.e. a string starting with a protocol scheme as “file:”, “http:” ...)

See User Guide for more information on how Cafe searches for files to load.

ddsi.security.ssl.keystore.format

Type String

Default “JKS”

Behavior

The type of the keystore file.

See the KeyStore section in the Java Cryptography Architecture Standard Algorithm Name Documentation for information about standard keystore types.

ddsi.security.ssl.keystore.password

Type char[]

Default null

Behavior

The password of the keystore file.

ddsi.security.ssl.keymanager.algorithm

Type String

Default "PKIX"

Behavior

The standard name of the requested SSL Key Manager algorithm.

See the Java Secure Socket Extension Reference Guide for information about standard algorithm names.

ddsi.security.ssl.truststore.file

Type String

Default ""

Behavior

The truststore file providing trusted certificates which are used to verify the identity of remote entities. See the Java Secure Socket Extension Reference Guide for more information.

This value could be:

- a path to local file system (absolute or relative)
- a Java resource name (absolute or relative)
- a URL (i.e. a string starting with a protocol scheme as "file:", "http:" ...)

See User Guide for more information on how Cafe searches for files to load.

ddsi.security.ssl.truststore.format

Type String

Default "JKS"

Behavior

The type of the truststore file.

See the KeyStore section in the Java Cryptography Architecture Standard Algorithm Name Documentation for information about standard keystore types (Note: a truststore is a specific keystore).

ddsi.security.ssl.truststore.password

Type char[]

Default null

Behavior

The password of the truststore file.

ddsi.security.ssl.trustmanager.algorithm

Type String

Default "PKIX"

Behavior

The standard name of the requested SSL Trust Manager algorithm.

See the Java Secure Socket Extension Reference Guide for information about standard algorithm names.

ddsi.security.ssl.crl.file

Type String

Default null

Behavior

The Certificate Revocation List (CRL) file provides a list of certificates to revoke.

ddsi.security.ssl.pkix.maxcertpathlength

Type int

Default 5

Behavior

In case the TrustManager algorithm is "PKIX", this configures the maximum number of non-self-issued intermediate certificates that can exist in a certification path. This field is used only if the Trust Algorithm field is set to PKIX. A value of 0 implies that the path can only contain a single certificate. A value of -1 implies that the path length is unconstrained (there is no maximum). Setting a value less than -1 causes an exception to be thrown.

ddsi.timer.threadPool.size

Type int

Default 1

Behavior

Size of the threadpool used for all timed actions :
- periodic actions (heartbeats, etc ...).

- delayed actions (repair, acknack, etc ...).
WARN : this value must not be set to 0.

ddsi.durability.alignment.timeout

Type Duration

Default 15

Behavior

Specifies the maximum amount of time Cafe should spend trying to retrieve historical (TRANSIENT and PERSISTENT) data for each local DataReader. Once this timeout is elapsed and if the alignment is still not yet complete, Cafe will stop the alignment process and free all local resources assigned to this alignment. In such situation, even if alignment is partially complete, no historical data will be delivered to the DataReader.

ddsi.durability.lazyStart

Type boolean

Default true

Behavior

When set to true the communication with the durability server(s) is only established when needed for the first time (when the first durable DataReader is created). Note that when set to true, this may slow down the creation of the first durable DataReader (see ddsi.durability.lazyStart.waitPeriod).

ddsi.durability.lazyStart.waitPeriod

Type Duration

Default 0.5

Behavior

When durability lazy start is activated, on the first durable DataReader creation, Cafe needs to wait for communication with the durability server(s) to establish before sending requests for historical data. This configuraion property allows to specify the amount of time Cafe should wait for the communication with the durability server(s) to establish.

5

Network transports configuration

Vortex Café supports 2 network transports for network communications : UDP (multicast and unicast) and TCP. It can use both those transports at the same time.

By default, Vortex Café will use both UDP and TCP in the following way:

- using UDP multicast for discovery protocol and to send messages to several remote participants
- using UDP unicast to send messages to a unique remote participant (previously discovered)
- establishing TCP connections with pre-configured peers (see Configuring the TCP peers)

Note that by default Vortex Café won't open any TCP port for incoming connections. This is a change since v2.3.0. In previous versions, when TCP was configured, the port 7400 was open for incoming connections, consuming unnecessary resources for applications that would never be connected from outside (e.g. devices on 3G/4G that are behind a symmetric NAT)

UDP transport configuration

DDSI standard

Vortex Café implements the DDSI protocol specified by the O.M.G.(see `http://www.omg.org/spec/DDSI/2.1/`). This protocol makes a simultaneous usage of UDP multicast and UDP unicast transports. Multicast is used for the discovery of remote participants and to send a same message to a set of discovered participants. Unicast is used when a message is intended for 1 participant only.

The DDSI specification describes some rules to automatically choose the UDP ports a DDS Participant should open. Vortex Café follows those rules by default, opening 2 UDP multicast ports and 2 UDP unicast ports:

- **Discovery Multicast Port** = PB + DG * domainId + d0
- **Discovery Unicast Port** = PB + DG * domainId + d1 + PG * participantId
- **User Multicast Port** = PB + DG * domainId + d2
- **User data Unicast Port** = PB + DG * domainId + d3 + PG * participantId

Where the *participantId* is a counter starting at 0 for the first created Participant in a process, and incremented for each successive Participants. The following table gives the default value of the constants as defined by the DDSI specification. These values can be modified by setting the corresponding configuration property in Vortex Café (see see std,std-refVortex Café runtime configuration).

Acronym	Name	Value	Café Property name
PB	Port Base Number	7400	ddsi.discovery.udp.port.basenumber
DG	Domain Id Gain	250	ddsi.discovery.udp.port.dg
PG	Participant Id Gain	2	ddsi.discovery.udp.port.pg
d0	Discovery Multicast Port Offset	0	ddsi.discovery.udp.port.d0
d1	Discovery Unicast Port Offset	10	ddsi.discovery.udp.port.d1
d2	User Data Multicast Port Offset	1	ddsi.discovery.udp.port.d2
d3	User Data Unicast Port Offset	11	ddsi.discovery.udp.port.d3

This means the first Participant created in a process on the DDS domain 0 will open those ports:

- **Discovery Multicast Port** = 7400
- **Discovery Unicast Port** = 7410
- **User Multicast Port** = 7401
- **User data Unicast Port** = 7411

In case UDP multicast is not supported or desired on the network, Vortex Café supports the usage of UDP unicast only. Using Vortex Café with UDP unicast only requires the setting of some configuration properties. The next chapter describes the main configuration steps that must be applied for this purpose.

Enabling/Disabling UDP transport

By default, Vortex Café uses both TCP and UDP transports, but UDP transport can be disabled with the help of the `ddsi.network.udp.enabled` property :

```
ddsi.network.udp.enabled=false
```

Limiting UDP multicast usage

You can make Vortex Café to limit its UDP multicast usage by setting the `ddsi.discovery.udp.allowMulticast` property. This property accepts the following values:

- `"full"`: This is the default value. This means UDP multicast is used whenever possible, for reception as well as publications.
- `"publications"`: meaning that UDP multicast is only used for discovery (reception and publications) and for publications of data (not for reception).
- `"discovery"`: meaning that UDP multicast is only used for discovery (reception and publications).
- `"minimal"`: meaning UDP multicast is only used for the initial participants discovery (SPDP reception and publications). All further communications (SPDP liveliness, SEDP, user DATA) will rely on unicast. The participant will not advertise any UDP multicast locator (multicast messages may still be received but the communications does not rely on them).
- `"none"`: meaning UDP multicast is never used.
- `"true"`: **deprecated**; equivalent to `"full"`.
- `"false"`: **deprecated**; equivalent to `"none"`.

Note that the `"minimal"` or `"discovery"` mode is advised on Android for the following reasons:

- Support of UDP multicast can be very bad on some Android devices (loss of messages at reception).
- Some WiFi environments sometime very badly handle multicast.

Configuring the UDP peers when multicast is disabled

When discovery cannot rely on multicast, each participant must be configured with some peers (in this case UDP peers) : the locators (endpoints) of the remote participants or services the configured participant should try to connect to. A locator is composed of an IP address or a host name and a port number.

There are several ways to configure remote peers :

- either all the remote participants locators are provided in the `ddsi.discovery.udp.peers` configuration property.

- either a subset only of them is provided and the discovery information propagation is enabled setting the `ddsi.discovery.propagation` property to `true` . This latter indicates to the participant to propagate its knowledge about its discovered participants. In this way, the whole participants knowledge (including their locators) will be gradually propagated to all the participants. Note that when discovery propagation is used in a system, it must be activated in all participants of the system.

Example

```
ddsi.discovery.udp.peers=192.168.1.50:7570, 192.168.1.51:7560
```

Note that in the case of a partial listing of remote participants, it is recommended that more than one locator is listed in order to avoid 'single point of failure' effects.

Setting the participant public locator

If the local address (private) of the host on which Vortex Café is running is not the address (public) that should be used to contact it (typically when the host is in a private network and behind a NAT with a public address and ports redirection) its public address must be specified in its configuration by setting the `ddsi.discovery.externalNetworkAddresses` property. This property accepts three values:

- `"none"`: This indicates that the participant host does not have a public address.
- `"local"`: This is the default value. It indicates that the local host address is the public locator of the hosted participant. This locator will be advertised to indicate the endpoint to which the other participants should connect.
- `<list of locators>` : This is a comma-separated list of public locators. This is typically the case for an internal host behind a cone NAT that hides the internal host address and exposes a different public address. Multiple locators may be provided to indicate fall-back locators and allow for an automatic failover in case of connection failure.

 Note that specifying the port of locators is optional (if not specified, the value of `ddsi.discovery.udp.unicast.port` is used).

Examples

```
ddsi.discovery.externalNetworkAddresses=192.168.1.50:7570,192.168.1.51:7560
```

```
ddsi.discovery.externalNetworkAddresses=192.168.1.50,192.168.1.51
```

Setting the participant UDP unicast ports numbers (Optional)

The discovery unicast port number is indicated by the `ddsi.discovery.udp.unicast.port` property. If this property is not set (or set to `-1`) the port rule specified by the std,std-refDDSI standard will apply.

The user unicast data port number is indicated by the `ddsi.data.udp.unicast.port` property. If this property is not set (or set to `-1`) the port rule specified by the std,std-refDDSI standard will apply.

Mixing UDP unicast-only participants and UDP multicast participants

UDP unicast-only participants interoperate with multicast participants, but they will communicate with them only via unicast.

TCP transport configuration

In addition to UDP, Vortex Café supports the TCP protocol as a transport layer for its DDSI stack. Using Vortex Café with TCP requires the setting of some configuration properties. This chapter describes the main configuration steps that must be applied to use TCP. Other configuration options available for fine-tuning of the TCP configuration are described in std,std-refConfiguration Properties description .

Enabling/Disabling TCP transport

By default, Vortex Café uses both TCP and UDP transports, but TCP transport can be disabled with the help of the `ddsi.network.tcp.enabled` property :

```
ddsi.network.tcp.enabled=false
```

Opening the TCP listening port (optional)

By default, Vortex Café does not open any listening TCP port to listen for incoming TCP connections from remote participants or services. This is suitable for most deployments when using Vortex Cloud & Fog services and avoids ports reuse problems when deploying several participants on the same host.

Anyway, if the deployment requires several participants to directly connect to each other through TCP, Vortex Café can be configured to open a specific TCP port to listen for incoming TCP connections with the help of the `ddsi.discovery.tcp.port` property.

If this property is set to 0, the operating system will chose an available TCP port automatically.

Note that if multiple DDS participants are deployed on the same host, they must be configured with different discovery port numbers.

Example

```
ddsi.discovery.tcp.port=7400
```

Configuring the TCP peers

When discovery cannot rely on multicast (which is the case when using TCP), each participant must be configured with some peers (in this case TCP peers) : the locators (endpoints) of the remote participants or services the configured participant should try to connect to. A locator is composed of an IP address or a host name and a port number.

There are several ways to configure remote peers :

- either all the remote participants locators are provided in the `ddsi.discovery.tcp.peers` configuration property.
- either a subset only of them is provided and the discovery information propagation is enabled setting the `ddsi.discovery.propagation` property to `true` . This latter indicates to the participant to propagate its knowledge about its discovered participants. In this way, the whole participants knowledge (including their locators) will be gradually propagated to all the participants. Note that when discovery propagation is used in a system, it must be activated in all participants of the system.

Example

```
ddsi.discovery.tcp.peers=192.168.1.50:7570, 192.168.1.51:7560
```

Note that in the case of a partial listing of remote participants, it is recommended that more than one locator is listed in order to avoid 'single point of failure' effects.

Setting the participant public locator

If the local address (private) of the host on which Vortex Café is running is not the address (public) that should be used to contact it (typically when the host is in a private network and behind a NAT with a public address and ports redirection) its public address must be specified in its configuration by setting the `ddsi.discovery.externalNetworkAddresses` property. This property accepts three values:

- `"none"`: This indicates that the participant host does not have a public address. This is typically the case for an internal host behind a symmetric NAT that allows only for outgoing connections. Such a participant cannot be connected by remote participants outside the LAN. It can communicate with them only *via* the TCP connections it initiates itself.

- `"local"`: This is the default value. It indicates that the local host address is the public locator of the hosted participant. This locator will be advertised to indicate the endpoint to which the other participants should connect.
- `<list of locators>` : This is a comma-separated list of public locators. This is typically the case for an internal host behind a cone NAT that hides the internal host address and exposes a different public address. Multiple locators may be provided to indicate fall-back locators and allow for an automatic failover in case of connection failure.

Note that specifying the port of locators is optional (if not specified, the value of `ddsi.discovery.udp.unicast.port` is used).

Examples

```
ddsi.discovery.externalNetworkAddresses=192.168.1.50:7570,192.168.1.51:7560
```

```
ddsi.discovery.externalNetworkAddresses=192.168.1.50,192.168.1.51
```

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Using Vortex Café with SSL

Vortex Café supports secure communications inside a DDS domain by using the SSL protocol.

Enabling SSL

SSL only works over the TCP transport and so requires TCP to be enabled (which is the case by default, unless TCP is explicitly disabled). The `ddsi.security.ssl property` must be set to true.

```
ddsi.security.ssl=true
```

By default, Vortex Café supports the TLS version of SSL. This can be changed by setting the `ddsi.security.ssl.algorithm` property.

Providing the public/private key pair

A pair of public/private keys should be provided for each SSL-enabled participant in order to authenticate itself to the other participants and encrypt the data. The same key pair may be provided to each DDS participant using two configuration properties:

- `ddsi.security.ssl.keystore.file` - Indicates the keystore file name including the private key and its associated public key (wrapped in a certificate).
- `ddsi.security.ssl.keystore.password` - Indicates the password used to protect the private key of the generated key pair.

Note that the key pair may be generated using the JDK's *keytool* utility. See `http://docs.oracle.com/javase/7/docs/technotes/tools/index.html#security` for more information about its usage.

Examples

Generating a key pair using *keytool* and importing it into a *keystore* file:

```
keytool -genkeypair -alias MyDDSDomain -keyalg RSA -validity 36500
-keypass secret -storepass secret -keystore dds_keystore.jks
```

Configuring the kestore-related configuration properties:

```
ddsi.security.ssl.keystore.file=/dds_keystore.jks
ddsi.security.ssl.keystore.password=secret
```

By default, Vortex Café supports the *JKS* format of keystores. This can be changed by setting the `ddsi.security.ssl.keystore.format` property to another format.

Providing the trusted participants certificates

As a support to participants authentication during the SSL handshake, each participant should know who to trust by acquiring its certificate. This is done by setting two configuration properties:

- `ddsi.security.ssl.truststore.file` - Indicates a truststore file name including the trusted participants certificates.
- `ddsi.security.ssl.truststore.password` - Indicates a password used to protect the truststore access and guarantee its integrity.

Examples

- Generating a certificate using the generated key pair (stored in a keystore):

  ```
  keytool -export -alias MyDDSDomain -keystore dds_keystore.jks -rfc
  -file MyDDSDomain.cert
  ```

- Importing the certificate into the truststore file:

  ```
  keytool -import -alias MyDDSDomain -file MyDDSDomain.cert -keystore
  dds_truststore.jks
  ```

- Setting the truststore-related configuration properties:

```
ddsi.security.ssl.truststore.file=/dds_truststore.jks
ddsi.security.ssl.truststore.password=secret
```

SSL with Android

Android only accepts BKS (BouncyCastle keystore) keystores. Create the "KeyManager" keystore and the "TrustManager" keystore as explained above and convert them to .bks files compatible with Android. Portecle tool can be used to do the conversion.

Converting the keystore files

- Download the latest version of portecle here `http://sourceforge.net/projects/portecle/files/latest/download`
- Run the program (`java -jar portecle.jar`)
- Open your keystore file (menu *File>Open Keystore File*)
- Convert it to BKS file : (menu *Tools>Change Keystore Type*)
  - if you use an Android API version > 16: choose *BKS*
  - otherwise: choose *BKS-V1*
- Save the Keystore as a .bks file

Using the keystore files

- To access the keystore files locally, embed them in your application .apk file:
  - copy them to the Android project in **res/raw/** folder or in **assets** folder. (when looking for a file specified via a configuration property, Vortex Café will search for the file in those 2 folders).
- To access the keystore files remotely, upload them to a server (http, https, ftp)
- Then, set those configuration properties:

```
ddsi.security.ssl=true
ddsi.security.ssl.keystore.password=secret
ddsi.security.ssl.keystore.format="BKS"
ddsi.security.ssl.keystore.file=<keystoreURL>
ddsi.security.ssl.keymanager.algorithm="X509"
ddsi.security.ssl.trustmanager.algorithm="X509"
```

- Here is an example of code that selects the correct bks file depending the android version :

```
if (Build.VERSION.SDK_INT > 16)
{
   System.setProperty("ddsi.security.ssl.keystore.file", "my_bks.bks");
}
else
{
   System.setProperty("ddsi.security.ssl.keystore.file", "my_bks_v1.bks");
}
```

SSL interoperability with OpenSplice DDS

When SSL is used to communicate between Vortex Café and OpenSplice, SSL certificates must be managed either in Java (using the *keytool* utility) or in OpenSSL (using the *openssl* utility). To share certificates between both SSL implementations the certificates must be copied from one format to another.

To convert from OpenSSL format (*pem* files) to Java key store format, the Java keytool utility can be used.

To convert Java key store format files to OpenSSL *pem* files, a number of open source utilities can be used, such as Portecle (available from `http://sourceforge.net/projects/portecle/`).

For exact details on how to transform keys and certificates please refer to the specific tool documentation.

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Durability deployment

The usage of TRANSIENT and PERSISTENT Durability QoS policies requires the durability service provided by Vortex OpenSplice.

If your Vortex Café application uses such QoS policies, at least one Vortex OpenSplice durability service must be deployed in the system. But several Vortex OpenSplice durability services can be deployed for fault tolerance purposes. Vortex OpenSplice durability services can be deployed anywhere in the system.

Note that :

- The ClientDurability functionnality needs to be activated in Vortex OpenSplice configuration to work with Vortex Café (not activated by default).
- A persistent store needs to be configured in Vortex OpenSplice to allow PERSITENT Durability QoS policy to work correctly (not configured by default).
- If you do not have any Vortex OpenSplice based applications to deploy in your system, the best way to run a durability server is to start a Vortex OpenSplice shared memory federation.

Please refer to Vortex OpenSplice deployment guide for more informations about how to configure and deploy a durability service.

Configuring the lazy clientdurability

By default, Vortex Café creates ClientDurability entities only when needed for the first time. To make the ClientDurability entities created at the domain participant"s creation set the **ddsi.durability.lazyStart** property to **false** :

```
ddsi.durability.lazyStart=false
```

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Google Protocol Buffers

About the Vortex Café Google Protocol Buffers Tutorial

It describes how to use the Vortex Café **Java 5 API** in combination with **Google Protocol Buffers** (*GPB*) data models.

Intended Audience:

This Guide is intended for anyone who wants to use **Google Protocol Buffers for DDS** in developing and running applications with Vortex Café.

Introduction

Google Protocol Buffers for DDS

Vortex Café is capable of using the **Google Protocol Buffer** (*GPB*) system for publishing and subscribing GPB messages in a DDS system. This makes it possible to use GPB as an alternative to OMG-IDL for those who prefer to use GPB rather than IDL. With the seamless integration of GPB and DDS technologies there is no need for OMG-IDL knowledge or visibility when working with GPB data models, and no OMG-DDS data-types are needed in the application (no explicit type-mapping between GPB and DDS types is required).

This results in an easy migration of GPB users to DDS(-based data-sharing) with data-centric GPB with support for keys, filters and (future) QoS-annotations (only a few DDS calls are needed). Also easy migration of DDS applications to GPB(-based data-modeling), only the field accessors change.

This chapter will describe how this is done for the language binding **Java5** by defining a GPB message layout which is compiled into proper interfaces for Vortex Café.

GPB installation and usage with Vortex Café

If you use Apache Maven as build system, there is no need to install Google Protocol Buffers and you don't have to set any environment variable. As we will detail in Compiling the datamodel with the GPB compiler chapter, Apache Maven is able to automatically download the Google Protocol Buffers libraries and executables, and to extract the DDS specific required files from Vortex Café.

IDL usage in a DDS system

In a Data Distributed System (DDS) as a Global DataSpace (GDS) for ubiquitous information-sharing in distributed systems as specified by the Object Management Group (OMG), the data is traditionally captured in the platform-and-language-independent OMG-IDL language. The relational model of DDS is supported by the notion of identifying key fields in these data structures where structure/content-awareness by the middleware allows for dynamic querying and filtering of data.

Google Protocol Buffers

Google Protocol Buffers (GPB) are a flexible, efficient, automated mechanism for serializing structured data; think XML, but smaller, faster, and simpler. One can define how data needs to be structured once, after which language-specific source code can be generated to easily write and read this structured data to and from a variety of data streams using a variety of languages. The information structure is defined in so-called *protocol buffer* message types in `.proto` files. Each protocol buffer message is a small logical record of information, containing a series of name-value pairs. This approach is quite similar to using IDL for data modeling in combination with an IDL compiler (as available in OpenSplice and DDS implementations in general).

Additionally, the GPB data structure can be updated without breaking deployed programs that are compiled against the 'old' format, similar to the *xTypes* concept as defined for DDS.

Using a GPB data-model instead of an IDL data-model

For an IDL-OMG based application, the IDL file is compiled with the IDL-PP compiler to generate the needed classes.

For Java as an example, `Address.idl` will (among others) be compiled into:

- `Address.java`
- `AddressTypesSupport.java`
- `AddressDataWriter.java`
- `AddressDataReader.java`
- ...

Using a GPB data-model, it is not necessary to create IDL files. The `protoc_gen_ddsJava` plug-in in Vortex Café will create them from the given `.proto` data-model.

For the GPB `.proto` based application, the `.proto` file is first compiled by the Google `protoc` compiler. This compiler will call the `protoc_gen_ddsjava` plug-in from Vortex Café with the `.proto` data parsed into a `CodeGeneratorRequest` protocol buffer.

The Vortex Café plug-in will generate an IDL file from this data. Any field member that is marked as key or filterable is explicitly mapped to a member in the IDL type.

The complete serialized `.proto` message is stored in the generic `ospl_protobuf_data` attribute as a sequence of bytes (making it opaque data for DDS). The mapping between data types is given in the table Mapping of GPB types to DDS types.

As the next step the **idl2j** compiler will generate the previously-named files from the idl file needed for the DDS domain. The Google `protoc` compiler will generate the classes needed for the GPB domain.

The dds options for the proto file are given in the omg/dds/descriptor.proto file listed below. This proto file shows how the different dds options on the proto file are interpreted, and gives the unique id `1016` to the dds types.

Note that the id 1016 has officially been granted to the Vortex product by Google.
This ensures these options are always unique and won't clash with any options used by users.

omg/dds/descriptor.proto

```
import "google/protobuf/descriptor.proto";

package omg.dds;

option java_package = "org.omg.dds.protobuf";
option java_outer_classname = "DescriptorProtos";
```

```
/* These options are required for any .proto message that needs to be available
 * in DDS.
 *
 * - name: An optional scoped name to allow overriding the name of the type in
 *   DDS. The dot('.') can be used as a scoping separator. In case the name
 *   starts with a dot, the name will be interpreted as an absolute scope name.
 *   If not, the name will be considered relative to the scope of the message
 *   including its 'package'.
 */
message MessageOptions {
    optional string name = 1 [default = ""];
}

extend google.protobuf.MessageOptions {
  optional omg.dds.MessageOptions type  = 1016;
}

/* These options are provided to assign specific behaviour to a member of a
 * DDS-enabled .proto message in DDS. These options will only be applied in case
 * the omg.dds.MessageOptions.type has been applied to the message in which the
 * member is modeled.
 *
 * - key: Make the member part of the key of the type in DDS. Each unique
 *   key-value will become a separate instance with its own history in DDS. Only
 *   'required' members can be made part of the key and key-definitions cannot
 *   be modified in future versions of the message. Members that are part of the
 *   key are automatically filterable as well.
 *
 * - filterable: Ensure the member is filterable in DDS using a so-called
 *   ContentFilteredTopic or QueryCondition. Only 'required' members can be made
 *   filterable and filterable definitions cannot be modified in future versions
 *   of the message.
 *
 * - name: Override the name of the member in DDS. This only applies to members
 *   that are marked as key and/or filterable.
 */
message FieldOptions {
    optional bool key = 1 [default = false];
    optional bool filterable = 2 [default = false];
    optional string name = 3 [default = ""];
}

extend google.protobuf.FieldOptions {
  optional omg.dds.FieldOptions member = 1016;
}
```

How mapping is done between the different languages is shown below in the table Mapping of GPB types to DDS types.

Mapping of GPB types to DDS types

.proto Type	Notes	Java Type	DDS IDL Type
double		double	double
float		float	float
int32	Uses variable-length encoding. Inefficient for encoding negative numbers; if your field is likely to have negative values, use sint32 instead	int	long
int64	Uses variable-length encoding. Inefficient for encoding negative numbers; if your field is likely to have negative values, use sint64 instead	long	long long
uint32	Uses variable-length encoding	int	unsigned long
uint64	Uses variable-length encoding	long	unsigned long long
sint32	Uses variable-length encoding. Signed int value. These encode negative numbers more efficiently than regular int32s.	int	long
sint64	Uses variable-length encoding. Signed int value. These encode negative numbers more efficiently than regular int64s.	long	long long
fixed32	Always four bytes. More efficient than uint32 if values are often greater than 2^28.	int	unsigned long
fixed64	Always eight bytes. More efficient than uint64 if values are often greater than 2^56.	long	unsigned long long
sfixed32	Always four bytes.	int	long
sfixed64	Always eight bytes.	long	long long
bool		boolean	bool
string	A string must always contain UTF-8 encoded or 7-bit ASCII text	String	string

Proto message for DDS system

Individual declarations in a .proto file can be annotated with a number of options. Options do not change the overall meaning of a declaration, but may affect the way it is handled in a particular context.

- File-level options: meaning they should be written at the top-level scope, not inside any message, enum, or service definition.
- Message-level options: meaning they should be written inside message definitions.
- Field-level options: meaning they should be written inside field definitions. Enum types, enum values, service types, and service methods.

Use case: Person

In this use case example, a system capable of describing the personal data of persons must be built using the GPB data-model

The layout can be:

```
string name
integer age
sequence phone-number + type
sequence friends
```

Proto file for the Person example

This use case is described in this `.proto` file:

```
import "omg/dds/descriptor.proto";
package address;

message Person {
   required string name = 1;
   required int32 age = 2;
   optional string email = 3;

   enum PhoneType {
      UNDEFINED = 0;
      MOBILE    = 1;
      HOME      = 2;
      WORK      = 3;
   }

   message PhoneNumber {
      required string number = 1;
      optional PhoneType type  = 2 [default = HOME];
   }

repeated PhoneNumber phone = 4;
repeated Person friend = 5;
}
```

GPB labels every field as either a *required* or an *optional* field. Required fields are *always* used/filled; optional fields may or may not be.

Different data models are compatible if all *required* fields are the same. Data models can be extended with extra fields; if those new fields are all *optional*, then the new model will still be compatible with older applications using the old data model.

In our example the *name* and *age* are always required. The *email* string is optional, as extra information for this person. The sequences with phone numbers and friends are allowed to be empty.

Detailed explanation for the layout of a `.proto` file can be found in the Google Protocol buffer documentation on `https://developers.google.com/protocol-buffers/docs/proto`

Annotating a proto message for use as a type in DDS

For the GPB message to be able to be handled correctly in a DDS system, some options are needed in the `.proto` file which define how the GPB message shall behave in the DDS system.

At the message level there is an extra option `.omg.dds.type`. This tells the protocol buffer compiler that this message is also a dds type message. This type option has a optional extra parameter for giving this type a dds type name. By default it has the same name in the DDS domain as it has in GPB.

The Person example with this option:

```
import "omg/dds/descriptor.proto";

package address;

message Person {
 option (.omg.dds.type) = {};
 required string name = 1;
 required int32 age = 2;

enum PhoneType {
  UNDEFINED = 0;
```

```
  MOBILE     = 1;
  HOME       = 2;
  WORK       = 3;
}

message PhoneNumber {
   required string number = 1;
  optional PhoneType type  = 2 [default = HOME];
 }
 repeated PhoneNumber phone = 4;
 repeated Person friend = 5;
}
```

Proto file with omg.dds.member.key option

For support of a key value in the datamodel, the option `key` can be given as a field-member option. One or more fields containing this option will indicate that these members make a unique key identifier in the data model. A field indicated as a key field must always be a *required* field for GPB. Also a key field is automatically a filterable field, as described below.

The Person example with *name* as a unique key (this means that each unique value of the name will lead to a separate instance in DDS with its own history):

```
import "omg/dds/descriptor.proto";

package address;

message Person {
   option (.omg.dds.type) = {};
   required string name = 1 [(.omg.dds.member).key = true];
   required int32 age = 2;
   optional string email = 3;
}
enum PhoneType {
   UNDEFINED = 0;
   MOBILE = 1;
   HOME = 2;
   WORK = 3;
}
message PhoneNumber {
   required string number = 1;
   optional PhoneType type = 2 [default = HOME];
}

repeated PhoneNumber phone = 4;
repeated Person friend = 5;
```

Proto file with omg.dds.member.filterable option

For support of filterable fields in the datamodel, the option `filterable` can be given as a field-member option.

One or more fields with this option indicates that these members are available for dynamic querying and filtering by means of a `ContentFilter` QoS on DataReader or a `Selector` with a `Content` in Vortex Café (see std,std-refSelect data to read with a Custom Content Filter).

A field marked as a filterable field must always be a *required* field in GPB. A key field is always filterable, by definition.

The Person example with *age* as a filterable attribute:

```
import "omg/dds/descriptor.proto";

package address;

message Person {
 option (.omg.dds.type) = {};
 required string name = 1 [(.omg.dds.member).key = true];
 required int32 age = 2 [(.omg.dds.member).filterable = true];
 optional string email = 3;

enum PhoneType {
  UNDEFINED = 0;
  MOBILE    = 1;
  HOME      = 2;
  WORK      = 3;
}

message PhoneNumber {
   required string number = 1;
  optional PhoneType type  = 2 [default = HOME];
 }
 repeated PhoneNumber phone = 4;
 repeated Person friend = 5;
}
```

Proto file with omg.dds.member.name option

The previous examples will result in a DDS type with the directly-mapped fields in IDL with the same name as in proto. (Key fields and filterable fields are directly mapped.)

If a different name is needed in the DDS domain for a fieldname in the generated IDL and dds type, a name can be given as an `omg.dds.member` option.

Example where the *age* field will be named `AgeInYears` in the DDS domain:

```
import "omg/dds/descriptor.proto";

package address;

message Person {
 option (.omg.dds.type) = {};
 required string name = 1 [(.omg.dds.member).key = true];
 required int32 age = 2   [(.omg.dds.member) = { name: "AgeInYears" filterable: true }];
 optional string email = 3 ;

enum PhoneType {
  UNDEFINED = 0;
  MOBILE    = 1;
  HOME      = 2;
  WORK      = 3;
}

message PhoneNumber {
   required string number = 1;
  optional PhoneType type  = 2 [default = HOME];
 }
 repeated PhoneNumber phone = 4;
 repeated Person friend = 5;
}
```

Compiling the datamodel with the GPB compiler

Once you've defined your messages, you run the protocol buffer compiler for your application's language on your `.proto` file to generate data access classes. These provide simple accessors for each field so, for instance, running the compiler on the above example will generate a class called *Person*. You can then use this class in your application to populate, serialize, and retrieve *Person* protocol buffer messages.

DDS-specific GPB-compiler plugin to generate code

The GPB compiler can be extended to support new languages *via* so-called plugins. The compiler invokes the plugin while providing the GPB type definition to it in the form of a GPB message. For DDS support the Vortex Café GPB-compiler is delivered with Vortex Café.

The Vortex Café IDL compiler is invoked by the Café GPB-compiler plugin to generate the DDS type including typed DataWriter and DataReader code. Additionally, code is generated to convert an instance of the DDS type to the GPB type and *vice versa*, which hides the DDS type from the application entirely.

Compilation example using Apache Maven

For creating the DDS specific code by the GPB compiler using Apache Maven, there is few plugins to add and configure in your pom.xml file. We will describe those in this chapter.

Note that a complete example is delivered with Vortex Café in `examples/helloworld-gpb/`. Its pom.xml file uses all the plugins we describe here.

Make Maven detect your platform characteristics

Protoc (the code generator for Google Protocl Buffer) is a binary executable. You need to use the correct binary depending your platform's OS and architecture. With the *os-maven-plugin* extension, Apache Maven is able to detect your platform characteristics and then to download the appropriate protoc binary from Maven Central.

Configure this extension adding the following XML tags in your pom.xml file within the `<build>` tag:

```
<build>
   <!-- ... -->

   <extensions>
      <extension>
         <groupId>kr.motd.maven</groupId>
         <artifactId>os-maven-plugin</artifactId>
         <version>1.5.0.Final</version>
      </extension>
   </extensions>

   <!-- ... -->
</build>
```

This extension defines at build time a **linux-x86_64** property that can be used later in the pom.xml

Make Maven to install protoc binary and the cafe-protoc plugin

Now you need the protoc binary and the cafe-protoc plugin to be installed in the build directory. For this, you have to configure the *maven-dependency-plugin* to perform 3 tasks:

1. Download and copy protoc binary into the build directory
2. Copy the cafe-protoc plugin into the build directory

3. Extract some required files from the cafe-protoc plugin. (those files are META-INF/**/*.proto, META-INF/templates/**/*.java and **/protoc-gen-ddsjava)

To do this, insert the following XML tags in your pom.xml file within the <build>/<plugins> tags:

```
<build>
   <!-- ... -->
   <plugins>
      <!-- ... -->

      <plugin>
         <groupId>org.apache.maven.plugins</groupId>
         <artifactId>maven-dependency-plugin</artifactId>
         <version>2.9</version>
         <executions>
            <execution>
               <id>copy-protoc</id>
               <phase>generate-sources</phase>
               <goals>
                  <goal>copy</goal>
               </goals>
               <configuration>
                  <artifactItems>
                     <!-- copy protoc binary into build directory -->
                     <artifactItem>
                        <groupId>com.google.protobuf</groupId>
                        <artifactId>protoc</artifactId>
                        <version>2.6.1</version>
                        <classifier>linux-x86_64</classifier>
                        <type>exe</type>
                        <overWrite>true</overWrite>
                        <outputDirectory>${project.build.directory}</outputDirectory>
                     </artifactItem>
                     <!-- copy cafe-protoc plugin for protoc into build directory -->
                     <artifactItem>
                        <groupId>com.prismtech.cafe.gpb</groupId>
                        <artifactId>cafe-protoc</artifactId>
                        <type>jar</type>
                        <overWrite>true</overWrite>
                        <outputDirectory>${project.build.directory}</outputDirectory>
                     </artifactItem>
                  </artifactItems>
               </configuration>
            </execution>

            <!-- extract some required files from cafe-protoc plugin -->
            <execution>
               <id>unpack-required-files</id>
               <phase>generate-sources</phase>
               <goals>
                  <goal>unpack</goal>
               </goals>
               <configuration>
                  <artifactItems>
                     <artifactItem>
                        <groupId>com.prismtech.cafe.gpb</groupId>
                        <artifactId>cafe-protoc</artifactId>
                        <version>2.4.0</version>
                        <type>jar</type>
                        <outputDirectory>${project.build.directory}/cafe-protoc-files</outputDire
                        <includes>META-INF/**/*.proto,
                           **/protoc-gen-ddsjava,
                           META-INF/templates/**/*.java</includes>
                     </artifactItem>
```

```
                </artifactItems>
             </configuration>
          </execution>

       </executions>
    </plugin>

    <!-- ... -->
 </plugins>
 <!-- ... -->
</build>
```

Execution of protoc with the cafe-protoc plugin

Finally, you need to make executable the protoc binary and a cafe-protoc script files, and to make Maven to execute the protoc command.

1. **Use the maven-antrun-plugin (within the `<build>/<plugins>` tags) to:**
    - grant execution rights to protoc binary
    - move protoc-gen-ddsjava script along cafe-protoc plugin
    - grant execution rights to protoc-gen-ddsjava script

```
<build>
   <!-- ... -->
   <plugins>
      <!-- ... -->

      <plugin>
         <groupId>org.apache.maven.plugins</groupId>
         <artifactId>maven-antrun-plugin</artifactId>
         <version>1.6</version>
         <executions>
            <execution>
               <id>prepare-protoc-and-plugin</id>
               <phase>process-sources</phase>
               <configuration>
                  <target>
                     <!-- grant execution rights to protoc binary -->
                     <chmod
                        file="${project.build.directory}/protoc-2.6.1-linux-x86_64.exe"
                        perm="755" />
                     <!-- move protoc-gen-ddsjava script along cafe-protoc plugin -->
                     <move
                         file="${project.build.directory}/cafe-protoc-files/META-INF/scripts/proto
                         todir="${project.build.directory}" />
                     <!-- grant execution rights to protoc-gen-ddsjava script -->
                     <chmod
                        file="${project.build.directory}/protoc-gen-ddsjava"
                        perm="755" />
                  </target>
               </configuration>
               <goals>
                  <goal>run</goal>
               </goals>
            </execution>
         </executions>
      </plugin>

      <!-- ... -->
   </plugins>
```

```
   <!-- ... -->
</build>
```

2. Use the **exec-maven-plugin** (within the <build>/<plugins> tags) to run protoc and it's cafe-protoc plugin in order to generate GPB data access code.

```
<build>
   <!-- ... -->
   <plugins>
      <!-- ... -->

      <plugin>
         <groupId>org.codehaus.mojo</groupId>
         <artifactId>exec-maven-plugin</artifactId>
         <version>1.2.1</version>
         <executions>
            <execution>
               <id>generate-protobuf-descriptor</id>
               <phase>generate-resources</phase>
               <goals>
                  <goal>exec</goal>
               </goals>
               <configuration>
                  <executable>${project.build.directory}/protoc-2.6.1-linux-x86_64.exe</executable
                  <workingDirectory>${project.build.directory}/generated-sources</workingDirectory
                  <commandlineArgs>--java_out=./
                     --ddsjava_out=./
                     --plugin=${project.build.directory}/protoc-gen-ddsjava
                     --proto_path=${project.basedir}/src/main/proto
                     --proto_path=${project.build.directory}/cafe-protoc-files/META-INF/proto/
                     ${project.basedir}/src/main/proto/address.proto
                      </commandlineArgs>
               </configuration>
            </execution>
         </executions>
      </plugin>

      <!-- ... -->
   </plugins>
   <!-- ... -->
</build>
```

Here are the meanings of used parameters:

- `--ddsjava_out` must be given to the compiler. Also the path to the plugin executable must be given.
- `--java_out` gives the path where the GDP generated code will be stored.
- `--ddsjava_out` gives the path where the DDS-specific generated code will be stored.
- `--plugin` the protoc needs the path to GPB-Compiler plugin executable, so no environment variable is needed to be set.
- first `--proto_path`: the protoc compiler needs the path where the `.proto` file is located.
- second `--proto_path`: the path where the GPB depencies are stored
- the last option is the `.proto` file to compile.

Note that the code will be generated in `<workingDirectory>`, i.e.: target/generated-sources.

Compilation of protoc generated code

For the generated code to be compiled, you just need to add its directory as a source directory using the **build-helper-maven-plugin** (within the <build>/<plugins> tags):

```
<build>
   <!-- ... -->
   <plugins>
      <!-- ... -->

      <plugin>
         <groupId>org.codehaus.mojo</groupId>
         <artifactId>build-helper-maven-plugin</artifactId>
         <version>1.7</version>
         <executions>
            <execution>
               <id>add-generated-sources</id>
               <phase>generate-sources</phase>
               <goals>
                  <goal>add-source</goal>
               </goals>
               <configuration>
                  <sources>
                     <source>${project.build.directory}/generated-sources</source>
                  </sources>
               </configuration>
            </execution>
         </executions>
      </plugin>

      <!-- ... -->
   </plugins>
   <!-- ... -->
</build>
```

Using the generated API in applications

The DDS API implementation will allow the use of GPB types for DDS transparently, and the generated underlying DDS type will be invisible to the application.

For the comming example the following proto file is used:

```
import "omg/dds/descriptor.proto";

package address;

message Organisation {
    required string name = 1 [(.omg.dds.member).key = true];
    required string address = 2 [(.omg.dds.member).filterable = true];
    optional Person.PhoneNumber phone = 3;
}

message Person {
  option (.omg.dds.type) = {name: "dds.Person"};
  required string name = 1 [(.omg.dds.member).key = true];
  required int32 age = 2 [(.omg.dds.member) = {filterable: true}];
  optional string email = 3;
  enum PhoneType {
    MOBILE = 0;
    HOME = 1;
    WORK = 2;
  }

  message PhoneNumber {
    required string number = 1;
    optional PhoneType type = 2 [default = HOME];
```

```
  }
  repeated PhoneNumber phone = 4;
  required Organisation worksFor = 5;
}
```

Java

In this example we will publish a person *Jane Doe* with one friend, *John Doe*.

The Subscriber example will read this data and print it to the `stdout`. This example is delivered with OpenSplice, and is located in `examples/helloworld-gpb`.

Publisher

Example Publisher for the generated Person data:

```
package helloworld;

import java.util.concurrent.TimeoutException;

import org.omg.dds.core.InstanceHandle;
import org.omg.dds.core.ServiceEnvironment;
import org.omg.dds.core.policy.PolicyFactory;
import org.omg.dds.core.status.PublicationMatchedStatus;
import org.omg.dds.domain.DomainParticipant;
import org.omg.dds.domain.DomainParticipantFactory;
import org.omg.dds.pub.DataWriter;
import org.omg.dds.pub.Publisher;
import org.omg.dds.topic.Topic;

import address.Address.Organisation;
import address.Address.Person;
import address.Address.Person.PhoneNumber;
import address.Address.Person.PhoneType;

public class HelloworldPublisher {
    public static void main(String[] args) {
        ServiceEnvironment env;
        DomainParticipantFactory domainParticipantFactory;
        DomainParticipant participant;
        Topic<Person> topic;
        Publisher publisher;
        DataWriter<Person> writer;
        Person.Builder janeDoeBuilder;
        PhoneNumber phone;
        Person janeDoe;
        PolicyFactory policyFactory;

        System.setProperty(
                ServiceEnvironment.IMPLEMENTATION_CLASS_NAME_PROPERTY,
                "com.prismtech.cafe.core.ServiceEnvironmentImpl");

        env = ServiceEnvironment.createInstance(HelloworldPublisher.class
                .getClassLoader());

        policyFactory = PolicyFactory.getPolicyFactory(env);
        participant = null;
        domainParticipantFactory = DomainParticipantFactory.getInstance(env);

        try {
```

```
            participant = domainParticipantFactory.createParticipant();
            // Creating a Topic for a Protobuf class
            topic = participant.createTopic("Person", Person.class);

            // Creating a Publisher and DataWriter for the Protobuf Topic
            publisher = participant.createPublisher();
            writer = publisher.createDataWriter(
                    topic,
                    publisher.getDefaultDataWriterQos().withPolicy(
                            policyFactory.Reliability().withReliable()));

            waitForSubscriber(writer);

            // Creating a builder the Protobuf data structure
            janeDoeBuilder = Person.newBuilder();

            // Creating Jane Doe
            janeDoeBuilder.setName("Jane Doe")
                    .setEmail("jane.doe@somedomain.com").setAge(23);
            phone = PhoneNumber.newBuilder().setNumber("0123456789").build();
            janeDoeBuilder.addPhone(phone);
            Organisation.Builder orgBuilder = Organisation.newBuilder();
            orgBuilder.setName("Acme Corporation");
            orgBuilder.setAddress("Wayne Manor, Gotham City");
            orgBuilder.setPhone(PhoneNumber.newBuilder()
                    .setNumber("9876543210").setType(PhoneType.WORK));
            janeDoeBuilder.setWorksFor(orgBuilder);

            janeDoe = janeDoeBuilder.build();

            System.out.println("Publisher: publishing Person: "
                    + janeDoe.getName());

            writer.write(janeDoe);
            System.out.println("Publisher: sleeping for 5 seconds...");
            Thread.sleep(5000);

            System.out.println("Publisher: disposing Jane Doe...");

            // Disposing the DDS instance
            writer.dispose(InstanceHandle.nilHandle(env), janeDoe);

        } catch (TimeoutException e) {
            System.err.println(e.getMessage());
            e.printStackTrace();
        } catch (InterruptedException e) {
            System.err.println(e.getMessage());
            e.printStackTrace();
        } finally {
            System.out.println("Publisher: terminating...");

            if (participant != null) {
                    try{
                participant.close();
                    } catch (Exception e){
                            e.printStackTrace();
                    }
            }
        }
    }

    public static void waitForSubscriber(DataWriter<Person> writer)
            throws InterruptedException {
```

```
        PublicationMatchedStatus matched;
        long millis = System.currentTimeMillis();
        long timeout = millis + (30 * 1000);
        boolean stop = false;

        System.out.println("Publisher: waiting for subscriber... ");

        do {
                matched = writer.getPublicationMatchedStatus();

            if (System.currentTimeMillis() > timeout) {
                stop = true;
            }
            if ((matched.getCurrentCount() == 0) && (!stop)) {
                Thread.sleep(500);
            }
        } while ((matched.getCurrentCount() == 0) && (!stop));

        if (matched.getCurrentCount() != 0) {
            System.out.println("Publisher: Subscriber found");
        } else {
            System.out.println("Publisher: Subscriber NOT found");
            throw new InterruptedException(
                    "Publisher: subscriber not detected within 30 seconds.");
        }
    }
}
```

Subscriber

Example Subscriber for the generated Person data:

```
package helloworld;

import java.util.concurrent.TimeUnit;
import java.util.concurrent.TimeoutException;

import org.omg.dds.core.ServiceEnvironment;
import org.omg.dds.core.WaitSet;
import org.omg.dds.core.policy.PolicyFactory;
import org.omg.dds.domain.DomainParticipant;
import org.omg.dds.domain.DomainParticipantFactory;
import org.omg.dds.sub.DataReader;
import org.omg.dds.sub.DataReader.Filter;
import org.omg.dds.sub.Sample;
import org.omg.dds.sub.Sample.Iterator;
import org.omg.dds.sub.Subscriber;
import org.omg.dds.topic.Topic;

import address.Address.Person;
import address.Address.Person.PhoneNumber;

public class HelloworldSubscriber {
    public static void main(String[] args) {
        ServiceEnvironment env;
        DomainParticipantFactory domainParticipantFactory;
        DomainParticipant participant;
        Topic<Person> topic;
        DataReader<Person> reader;
        Subscriber subscriber;
        WaitSet ws;
```

```
        PolicyFactory policyFactory;
        int expectedUpdates = 2;

        System.setProperty(
                ServiceEnvironment.IMPLEMENTATION_CLASS_NAME_PROPERTY,
                "com.prismtech.cafe.core.ServiceEnvironmentImpl");

        env = ServiceEnvironment.createInstance(HelloworldSubscriber.class
                .getClassLoader());

        policyFactory = PolicyFactory.getPolicyFactory(env);
        participant = null;
        domainParticipantFactory = DomainParticipantFactory.getInstance(env);

        try {
            participant = domainParticipantFactory.createParticipant();
            // Creating a Topic for a Protobuf class
            topic = participant.createTopic("Person", Person.class);

            // Creating a Subscriber and DataReader for the Protobuf Topic
            subscriber = participant.createSubscriber();
            reader = subscriber.createDataReader(
                    topic,
                    subscriber.getDefaultDataReaderQos().withPolicy(
                            policyFactory.Reliability().withReliable()));

            // Creating a WaitSet to block for incoming samples

            ws = env.getSPI().newWaitSet();
            ws.attachCondition(reader.createReadCondition(subscriber
                    .createDataState().withAnyViewState()
                    .withAnyInstanceState().withAnySampleState()));

            System.out.println("Subscriber: waiting for incoming samples...");

            int nbTake = 0;
            do {
                // Waiting for data to become available
                ws.waitForConditions(30, TimeUnit.SECONDS);

                // Take all data and print it to the screen
                nbTake = printAllData(reader, args);
                if(nbTake == 0)
                   break;
                expectedUpdates -= nbTake;
            } while (expectedUpdates > 0);

        } catch (RuntimeException e) {
            System.err.println(e.getMessage());
            e.printStackTrace();
        } catch (TimeoutException e) {
            System.out
                    .println("Subscriber: time-out while waiting for updates.");
        } finally {
            System.out.println("Subscriber: terminating...");

            if (participant != null) {
                participant.close();
            }
        }
    }

    public static int printAllData(DataReader<Person> reader, String[] args) {
```

```
        Iterator<Person> iter;
        Sample<Person> sample;
        Person data;
        String states;
        int sampleCount = 0;

        if(args.length > 0 && "--content-filter-query".equals(args[0]))
        {
            Filter<Person> filter = new Filter<Person>(){
                @Override
                public boolean match(Person data, Object... params)
                {
                    return data.getName().equals("Jane Doe");
                }
            };
            iter = reader.select().Content(filter).take();
        }
        else
        {
            iter = reader.take();
        }

        if(!iter.hasNext()){
            return 0;
        }

        while (iter.hasNext()) {
            sample = iter.next();
            sampleCount++;

            states = "(" + sample.getSampleState() + ", "
                    + sample.getViewState() + ", " + sample.getInstanceState()
                    + ")";

            if (sample.getData() != null) {
                System.out
                        .println("Subscriber: reading sample " + states + ":");
                printPerson(sample.getData(), "");
            } else {
                data = Person.newBuilder().buildPartial();

                //The first parameter data is immutable so the returned value is used instead
                data = reader.getKeyValue(data, sample.getInstanceHandle());
                System.out.println("Subscriber: reading invalid sample "
                        + states + ":");
                System.out.println("- Name  = " + data.getName());
            }
        }
        return sampleCount;
    }

    public static void printPerson(Person person, String tabs) {

        System.out.println(tabs + "- Name       = " + person.getName());
        System.out.println(tabs + "- Age        = " + person.getAge());
        System.out.println(tabs + "- Email      = " + person.getEmail());

        for (PhoneNumber phone : person.getPhoneList()) {
            System.out.println(tabs + "- Phone      = " + phone.getNumber()
                    + " ("
                    + phone.getType() + ")");

        }
```

```
        System.out.println(tabs + "- Company    =");
        System.out.println(tabs + "   - Name       = "
                + person.getWorksFor().getName());
        System.out.println(tabs + "   - Address    = "
                + person.getWorksFor().getAddress());

        if (person.getWorksFor().hasPhone()) {
            System.out.println(tabs + "   - Phone      = "
                    + person.getWorksFor().getPhone().getNumber() + " ("
                    + person.getWorksFor().getPhone().getType() + ")");
        } else {
            System.out.println(tabs + "   - Phone      = ");
        }
    }
}
```

Evolving data models

It is likely that over time a data model will change; for example, new fields with extra information are often added to an existing data model.

Normally all applications using that data model need to be recompiled against the new (changed) data model in order to be aware of the extra fields. However, when using a data model based on the GPB system, it is possible to add extra fields to the data model and use applications based on the original data model *and* applications based on the new data model in a mixed environment.

It is only possible to combine old and new applications with different data models as long as the required fields are the same. Remember, a key field or a filterable field is always required, so these fields can not be changed or added if it is necessary to combine old and new data models.

In our example we will make a new data model with some extra fields:

- new phonetype: *SKYPE*
- new phoneNumber property: *secret*
- new string for an alias: *facebookname*

Proto file with new options:

```
import "omg/dds/descriptor.proto";
package address;
message Person {
   option (.omg.dds.type); // default type-name will be 'Person'
   required string name = 1 [(.omg.dds.member).key = true];
   required int32 age = 2   [(.omg.dds.member).filterable = true];
   optional string email = 3;

     enum PhoneType {
       UNDEFINED = 0;
       MOBILE = 1;
       HOME = 2;
       WORK = 3;
       SKYPE = 4; // **** added SKYPE phonetype enum-value ****
     }
     message PhoneNumber {
       required string number = 1;
       optional PhoneType type = 2 [default = UNDEFINED];
       optional bool secret = 3 [default = false];
        // **** added a new phoneNumber property ****
     }
  repeated PhoneNumber phone = 4;
```

```
  repeated Person friend = 5;
  optional string facebookname = 6 [default = "NONE"];
   // **** added alias facebook name ****
}
```

Old publisher and old subscriber

Data printed by subscriber program:

```
Name  = Jane Doe
Age   = 23
Email = jane.doe@somedomain.com
Phone = 0123456789 (HOME)
Friend:
   Name  = John Doe
   Age   = 35
   Email = john.doe@somedomain.com
```

New publisher and new subscriber

Data printed by subscriber program:

```
Name     = Jane Doe
Facebook = Jane123
Age      = 23
Email    = jane.doe@somedomain.com
Phone    = 0123456789 (HOME) secret=false
Phone    = 0612345678 (MOBILE) secret=true
Phone    = splicer (SKYPE) secret=false
Friend:
   Name     = John Doe
   Facebook = NONE
   Age      = 35
   Email    = john.doe@somedomain.com
```

Old publisher and new subscriber

New subscriber gets default values for absent fields:

```
Name     = Jane Doe
Facebook = NONE
Age      = 23
Email    = jane.doe@somedomain.com
Phone    = 0123456789 (HOME) secret=false
Friend:
   Name     = John Doe
   Facebook = NONE
   Age      = 35
   Email    = john.doe@somedomain.com
```

New publisher and old subscriber

Old subscriber doesn't understand the `SKYPE` phonetype so reverts to the default `UNDEFINED` phonetype.

Read data in old subscriber:

```
Name  = Jane Doe
Age   = 23
Email = jane.doe@somedomain.com
Phone = 0123456789 (HOME)
Phone = 0612345678 (MOBILE)
Phone = splicer (UNDEFINED)
Friend:
   Name  = John Doe
   Age   = 35
   Email = john.doe@somedomain.com
```

9

Support of DDS Security

Introduction to DDS Security

Many of Internet of Things systems are being built using DDS. These systems need to secure their data exchange, especially when data is sensitive. However, prior to the DDS Security standard, there was no multi-vendor interoperable mechanism for DDS applications to communicate securely. Prior to the DDS Security

There are several existing approaches to secure communication between objects within the same network such as Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS). These approaches have some limitations for Industrial Internet applications such as :

- They work only with unicast and not with multicast.
- They encrypt all data flowing through the network.
- As mentioned above, they are not interoperable.

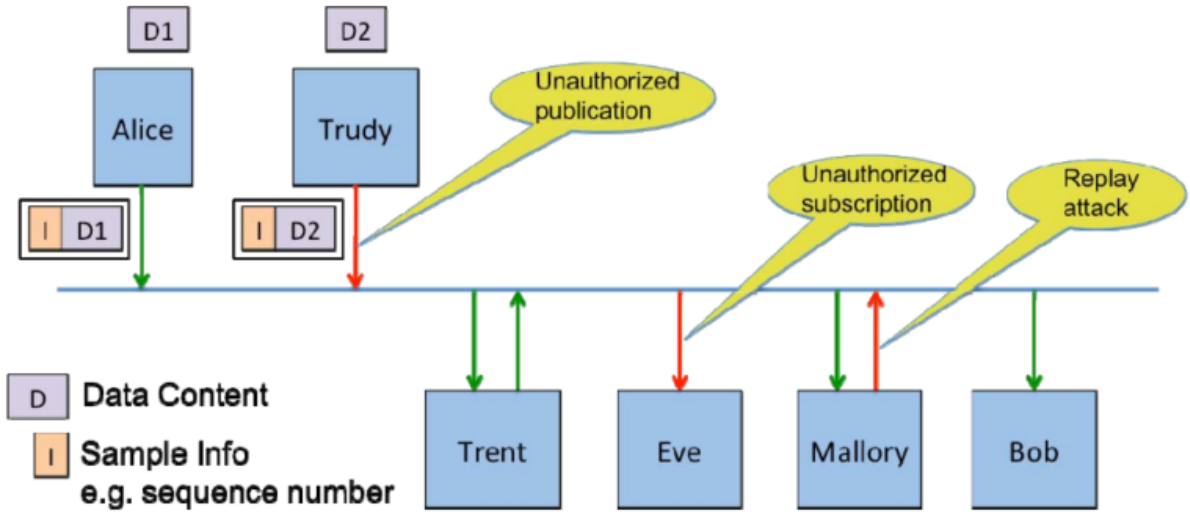
DDS Security overcomes these limitations. Most importantly, it is standard and interoperable.

Security Threats

In order to understand some of the specific threats impacting applications that use DDS and DDS Interoperability Wire Protocol (RTPS), let introduce two imaginary friends, Alice and Bob. They wish to communicate with each other and with other existing users in the network.

- **Alice**. An authorized publisher. Allowed to publish topic T
- **Bob**. An authorized subscriber. Allowed to subscribe to topic T
- **Eve**. An unauthorized subscriber (eavesdropper). Non-authorized eavesdropper
- **Trudy**. An unauthorized publisher (intruder).
- **Trent**. Trusted infrastructure service. However, he is not trusted to see the content of the information.
- **Mallory**. Malicious insider (an authorized subscriber and unauthorized publisher).

As shown in the following figure, there are several threats that can occur if there is no DDS security.



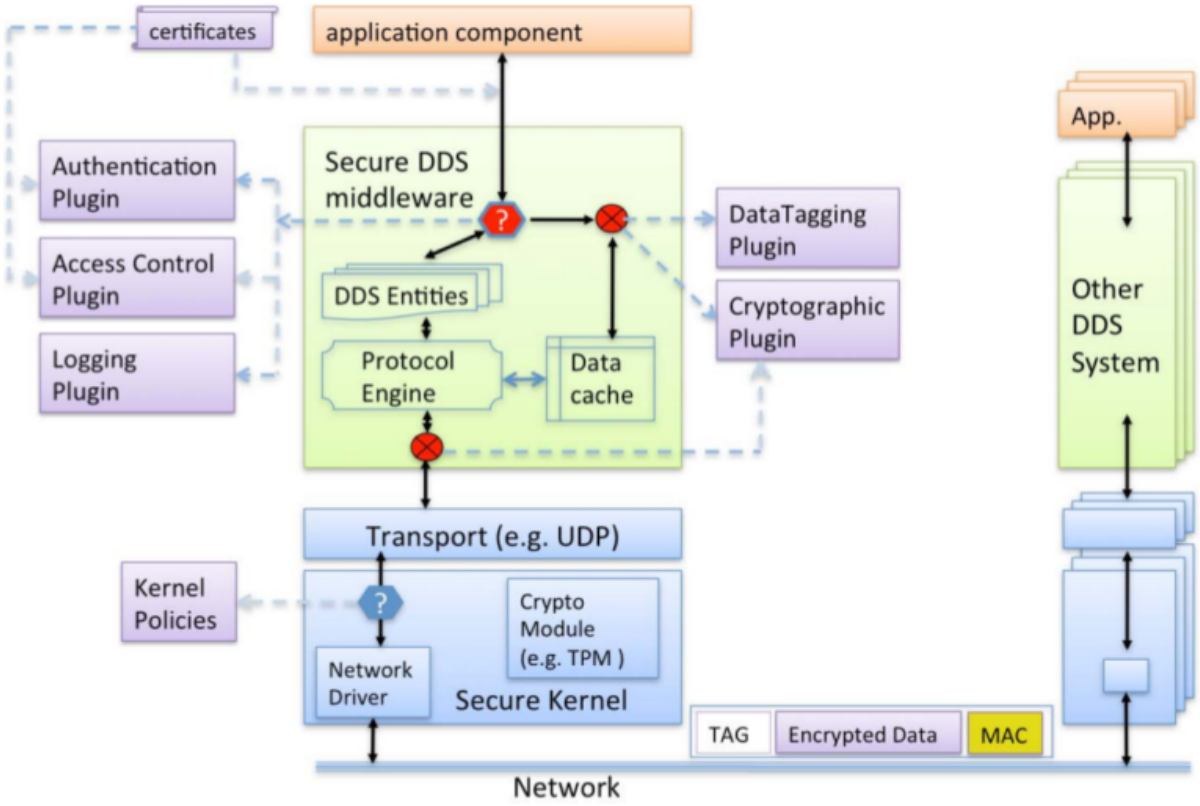
- **Unauthorized Subscription**: Eve is connected to the same network infrastructure and is able to observe the network packets. In situations where Alice and Bob are communicating over multicast, Eve could simply subscribe to the same multicast address.
- **Unauthorized Publication**: Trudy is connected to the same network infrastructure and is able to inject network packets with any data contents, headers and destination she wishes (e.g., Bob).
- **Tampering and Replay**: Mallory can use the shared secret key to create messages on the network and pretend it came from Alice. She has the secret key used to compute the Hash-based Message Authentication Code (HMACs) so she can also create a valid HMAC for the new message.
- **Unauthorized Access to Data by Infrastructure Services**: Infrastructure services are allowed to store and forward the data, but not to read the content of data. Trent is an example of such a service, he can see the headers and sample information (writer global unique identifier (GUID), sequence numbers, key hash and such) but not the message contents.
- **Constraints of the DomainParticipant BuiltinTopicKey_t (GUID)**: In addition to these threats, there is an attack based on GUID. The DomainParticipant GUID is communicated as part of DDS Discovery. An attacker with legit Identity can authenticate using the GUID of another Participant. An accepted attacker will block legitimate Participant from using its GUID because its GUID would be detected as a duplicate of the already existing one.

DDS Security Architecture

Based on the threats described above, the DDS security specification defines five Service Plugin Interfaces (SPIs) that when combined together provide Information Assurance to DDS systems:

- **Authentication**. Alice checks Bob's identity.
- **Access Control**. Alice checks Bob's permissions.
- **Cryptography**. Implements all cryptographic operations including encryption, decryption, hashing, digital signatures, etc.
- **Logging**. Log all security-relevant events.
- **Data Tagging**. Add a tag for each data sample.

DDS Security specification models these plugins in the following architecture:



DDS Security Implementation

Vortex Café partially implements the DDS Security specification.

Currently, only the Authentication, Access Control and the Cryptographic plugins are supported. However, the full DDS Security API is described in the Javadoc at: VortexCafe_2.4.0/docs/apidocs/index.html (package org.omg.dds.security)

Note that Vortex Café doesn't provide any implementation of the security plugins *data tagging* and *logging* plugins are not implemented.

DDS Security Configuration

The implementation classes of the plugins to be loaded by a Participant must be specified via configuration properties (see std,std-refVortex Café runtime configuration). Those configuration properties are:

- **Authentication plugin class**: `ddsi.security.authClassName`
- **Access Control plugin class**: `ddsi.security.accessCtrlClassName`
- **Cryptographic plugin class**: `ddsi.security.cryptoClassName`
- **Logging plugin class**: `ddsi.security.loggingClassName`
- **Data Tagging plugin class**: `ddsi.security.dataTagClassName`

To enable DDS Security, the implementation classes of Authentication, Access Control and Cryptographic plugins are mandatory. Logging and Data Tagging plugins are not yet supported.

For the need of the security implementation, we use a cryptographically strong random number generator. Initializing this number could take a time, depending on the generator class. That's why we make the usage of the random generator configurable: the user can choose a quick generator or a more secure generator which is slower. The quick one is used by default.

The configuration key is `ddsi.security.randomGenerator` and its possible values are:

- `secure` (more secure but slower)
- `quick` (default value)

Authentication plugin

Authetication is the process of determining if a DomainParticipant is who it claims to be. The authentication plugin configures the DomainParticipant to authenticate a newly discovered remote participant before initiating endpoint discovery with that participant. The authentication is implemented using a trusted Certificate Authority (CA). It performs mutual authentication between dicovered participants using the RSA Digital Signature Algorithm (i.e RSASSA-PSS-SHA256) and establishes a shared secret using Diffie-Hellman (DH) or Elliptic Curve Diffie-Hellman (ECDH) Key Agreement methods.

Vortex Café fully supports the Authentication plugin for:

- authentication a local Participant at creation
- authentication of a remote Participant at discovery
- establishment of a shared secret between 2 authentified Participants via a handshake protocol

Note: The Authentication plugin class referred by the `ddsi.security.authClassName` configuration property must implement the org.omg.dds.security.Authentication interface.

Authentication plugin configuration

Prior to a Domain Participant (DP) being enabled the Authentication plugin associated with it must be configured with three things:

- The X.509 Certificate that defines the Shared Identity CA. This certificates contains the **Public Key** of the CA.
- The **Private Key** of the Domain Participant (DP)
- An X.509 Certificate that chains up to the Shared Identity CA, that binds the Public Key of the Domain Participant to the Distinguished Name (subject name) for the Domain Participant.

The builtin authentication plugin should be configured using `PropertyQosPolicy` of the `DomainParticipantQos` with the following properties:

Property Name (all properties have "dds.sec.auth" prefix)	Property Value Description
identity_ca	Required. URI to the X509 certificate [39] of the Identity CA. Example: `identity_ca.pem`
private_key	Required. URI to access the private Private Key for the DomainParticipant. Example: `identity_ca_private_key.pem`
password	Optional. A password used to decrypt the Private Key. If the password property is not present, then the value supplied in the private_key property must contain the unencrypted private key.
identity_certificate	Required. URI to a X509 certificate signed by the IdentityCA in PEM format containing the signed public key for the DomainParticipant. Example: `participant1_identity_cert.pem`

Access Control plugin

The Access Control plugin performs two process: the governance and permissions checking. This plugin is implemented using a permission document signed by a shared Certificated Authority (CA). The shared CA could

be an existing one (including the same CA used for the Authentication plugin described before) or a new one could be created for the purpose of assigning permissions to the applications on a DDS Domain. The nature or manner in which the CA is selected is not important because the way it is used enforces a shared recognition by all particpating applications.

- **Governance checking**: is the process of configuring locally created DomainParticipants, Topics, DataWriters and DataReaders to perform the right amount of security for the right use case.
- **Permissions checking**: is the process of making sure locally create and remotely discovered entities are allowed to communicate and do what they need to to.

Both governance and permission checking are enforced by XML documents that are signed by a permission certificate authority CA. Each DomainParticipant has an associated instance of the Access Control plugin.

Access Control plugin configuration

The Access Control plugin is configured with three documents:

- The Permissions CA certificate.
- The Domain governance signed by the Permissions CA.
- The DomainParticipant permissions signed by the Permissions CA.

The Access Control plugin should be configured using the following properties:

Property Name (all properties have "dds.sec.access" prefix)	Property Value Description
permissions_ca	Required. URI to the X509 certificat for the permissions CA which is in PEM format. Example: `permissions_ca.pem`
governance	Required. URI to the signed XML goverance document Example: `governance_signed.p7s`
permissions	Required. URI to the signed XML permissions document. Example: `permissions_signed.p7s`

Vortex Café only supports the part of Access Control plugin which is related to the Participant. This implies that Vortex Café supports all operations of the org.omg.dds.security.AccessControl interface.

Note: The Access Control plugin class referred by the `ddsi.security.accessCtrlClassName` configuration property must implement the org.omg.dds.security.AccessControl interface.

Cryptography plugin

Cryptography is the process of making sure no third-party participant can manipulate or eavesdrop a communication between two authenticated participants.

Vortex Café supports keys generation and exchange, as well as encoding/decoding of payload, submessages and of whole RTPS messages.

The Cryptography plugin provides authenticated encryption using Advanced Encryption Standard (AES) in Galois Counter Mode (AES-GCM). It supports the decryption of two AES key sizes: 128 bits and 256 bits, for encryption, it is done in AES key size of 256 bits.

Notes: Temporarly, Cafe does not support the decryption of local entities (i.e. a message that was send from a local DataWriter).

The Cryptography plugin class referred by the `ddsi.security.cryptoClassName` configuration property must implement the org.omg.dds.security.Cryptography interface.

Cryptography plugin configuration

Cryptography plugin configuration is not alterable with configuration property keys.

Logging plugin

Vortex Café doesn't support the Logging plugin.

Instead, Vortex Café uses the SLF4J library (`http://www.slf4j.org/`) for all logging messages. This library is a "facade" offering a unified API over various logging libraries such as Log4J, Logback... Therefore, the usage of SLF4J allows Vortex Café to benefit lot of features from various logging library such as logging to a console, to a file or to a server.

For DDS Security logs, uses Logger objects with different names, depending the plugin related to the log:

- Authentication plugin: "**cafe.ddsi.security.auth**"
- Access Control plugin: "**cafe.ddsi.security.access**"
- Cryptographic plugin: "**cafe.ddsi.security.crypto**"
- Data Tagging plugin: "**cafe.ddsi.security.tag**"

The log levels defined by the DDS Security specification are mapped as following using SLF4J:

- **FATAL_LEVEL**: a log at ERROR level with the message prefixed by "FATAL: "
- **SEVERE_LEVEL**: a log at ERROR level with the message prefixed by "FATAL: "
- **ERROR_LEVEL**: a log at ERROR level with non-prefixed message
- **WARNING_LEVEL**: a log at WARN level with non-prefixed message
- **NOTICE_LEVEL**: a log at INFO level with the message prefixed by "NOTICE"
- **INFO_LEVEL**: a log at INFO level with non-prefixed message
- **DEBUG_LEVEL**: a log at DEBUG level with non-prefixed message
- **TRACE_LEVEL**: a log at TRACE level with non-prefixed message

Data Tagging plugin

Vortex Café doesn't support the Data Tagging plugin.

Access Control and Authentification plugin configuration example

Signing access control documents:

Let's assume we already have the non-signed XML governance document(governance.xml) and permissions document(permissions.xml). It remains to sign these files with OpenSSL. The following is the command lines in Bash.

Generation of Permissions CA private key:

```
openssl genrsa -out permissions_ca_private_key.pem 2048
```

Generation of Certificate for the Permissions CA

```
openssl x509 -req -days 3650 -in permissions_ca.csr \
    -signkey permissions_ca_private_key.pem \
    -out permissions_ca_cert.pem
```

Signing the governance document

```
openssl smime -sign -in governance.xml -text -out governance_signed.p7s \
    -signer permissions_ca_cert.pem \
    -inkey permissions_ca_private_key.pem
```

Signing the permissions documents

```
openssl smime -sign -in permissions.xml -text -out permissions_signed.p7s \
    -signer permissions_ca_cert.pem \
    -inkey permissions_ca_private_key.pem
```

Where the permissions_ca.csr comes from ?

In this example, it's the self-signed certificate request for the permissions CA, an OpenSSL Certificate Authority configuration file (cnf extension) is required to generate this csr file. Please see the OpenSSL documentation for more details about cnf files. Here is a command line example of csr generation from cnf

```
openssl req -config permissions_ca_openssl.cnf \
    -new -key permissions_ca_private_key.pem \
    -out permissions_ca.csr
```

Please see OpenSSL documentation for more details.

After running the commands above, we now have all needed documents:

- permissions_ca_cert.pem: the Permissions CA
- governance_signed.p7s: the signed XML goverance document
- permissions_signed.p7s: the signed XML goverance document

Use signed files in code:

Somewhere in your application code, you could set the properties described above like this in Java:

```
PropertyQoS propertyQoS = PolicyFactory.getPolicyFactory(environment).PropertyQoS();
Collection<Property> properties = new ArrayList<Property>();
properties.add(new Property("dds.sec.access.permissions_ca","./permissions_ca_cert.pem"));
properties.add(new Property("dds.sec.access.governance","./governance_signed.p7s"));
properties.add(new Property("dds.sec.access.permissions","./permissions_signed.p7s"));
```

At the participant creation, you could do as following:

```
return participant_factory.createParticipant(
    domain_id,
    participant_factory.getDefaultParticipantQos().withPolicy(propertyQoS),
    null,
    (Collection<Class<? extends Status>>)null);
```

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Using Vortex Café with Vortex Cloud

If Vortex Café is deployed in a LAN or a private cloud (multicast-enabled cloud) and Vortex Cloud is configured to discover user applications using UDP-multicast in the LAN/private cloud, then Vortex Café does not need to be configured with any particular configuration property. Vortex Cloud will discover and communicate with Vortex Café using the standardized multicast IP address and UDP ports. The only constraint is that both Vortex Café and Vortex Cloud are configured to participate to the same DDS domain (same domain id).

If Vortex Café is deployed in a WAN (without multicast support), then it needs to be configured to use TCP transport (which is the case by default, unless TCP is explicitly disabled). It also needs to be configured with the peers of one of the services of the Vortex Cloud & Fog system.

Example:

```
ddsi.discovery.tcp.peers=1.1.1.1:7400
```

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Vortex Café Monitor

The Vortex Café Monitor is a tool that can be executed with an application (embedded in the application's process). It enables a user to remotely connect to an application with the help of a web-browser and to display the state of all topics, local entities, and discovered entities.

See VortexCafe_2.4.0/docs/monitor.html for more information.

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Supported Features

Supported IDL types

All IDL types are supported, except *wchar* and *wstring*.

Note that as per DDS specification, the IDL types *char* and *string* can only include characters that are defined in the **ISO-8859-1** character set (see `https://en.wikipedia.org/wiki/ISO/IEC_8859-1#Codepage_layout`).

Supported DDS Profiles

Profile	Support	Limitations
Minimum profile	Partial	**Global**: • *Listeners* and *statuses* are not supported on *DomainParticipants*, *Topics*, *Publishers* and *Subscribers*. • *Statuses* are partially supported in *DataReaders* and *DataWriters*. • *QoS* are not supported on *DomainParticipants* and *Topics*. **Participant**: • *findTopic* and *lookupTopicDescription* are not supported. **Publisher**: • *waitForAcknowlegements* is not supported. **DataWriter**: • *waitForAcknowlegements* is not supported. • *getMatchedSubscriptions* and *getMatchedSubscriptionData* are not supported. • *getKeyValue* is not supported. • *cast* is not supported. **Subscriber**: • *getDataReaders* and *lookupDataReaders* are not supported. **DataReader**: • *getMatchedPublications* and *getMatchedPublicationData* are not supported. • *readNextSample* and *takeNextSample* are not supported. • *cast* is not supported. **WaitSet**: • *QueryCondition* is not supported.
Content-subscription profile	Partial	Only a non-standard custom filter is available *via* the *DataReader.Selector* (See std,std-refSelect data to read with a Custom Content Filter)
Persistence profile	*YES*	
Ownership profile	*YES*	
Object model profile	NO	

Supported QoS Policies

QoS Category	QoS Policy	Supported
Data Availability	DURABILITY	**YES**
	DURABILITY_SERVICE	**YES**
	LIFESPAN	NO
	HISTORY	**YES**
	WRITER_DATA_LIFECYCLE	**YES**
	READER_DATA_LIFECYCLE	**YES**
Data Delivery	PRESENTATION	NO
	RELIABILITY	**YES**
	PARTITION	**YES**
	DESTINATION ORDER	**YES**
	OWNERSHIP	**YES**
	OWNERSHIP_STRENGTH	**YES**
Data Timeliness	DEADLINE	**YES**
	LATENCY_BUDGET	**YES**
	TRANSPORT_PRIORITY	**YES**
Resources	TIME_BASED_FILTER	**YES**
	RESOURCE_LIMITS	**YES**
Configuration	USER_DATA	NO
	TOPIC_DATA	NO
	GROUP_DATA	NO
	ENTITY_FACTORY	**YES**
System Availability	LIVELINESS	*AUTOMATIC* only

Supported DDS Statuses

Entity	Status Name	Supported
Topic	INCONSISTENT_TOPIC	NO
Subscriber	DATA_ON_READERS	NO
DataReader	SAMPLE_REJECTED	NO
	LIVELINESS_CHANGED	**YES**
	REQUESTED_DEADLINE_MISSED	**YES**
	REQUESTED_INCOMPATIBLE_QOS	NO
	DATA_AVAILABLE	**YES**
	SAMPLE_LOST	NO
	SUBSCRIPTION_MATCHED	**YES**
DataWriter	LIVELINESS_LOST	NO
	OFFERED_DEADLINE_MISSED	**YES**
	OFFERED_INCOMPATIBLE_QOS	NO
	PUBLICATION_MATCHED	NO

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Troubleshooting

If you experience any problems with Vortex Café installation or usage then you can contact ADLINK support.

Please provide a full description of your platform, including the versions of tools you are using (such as JDK, Ant, Maven, Android SDK, *etc*...).

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