OpenSplice RMI over DDS

Version 6.x

Getting Started Guide

PrismTech

OpenSplice RMI over DDS

GETTING STARTED GUIDE

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Preface

About the Getting Started Guide

The OpenSplice RMI over DDS *Getting Started Guide* is intended to explain the steps required to take advantage of the client/server interaction paradigm provided by OpenSplice RMI layered over the publish/subscribe paradigm of OpenSplice DDS.

Intended Audience

This OpenSplice RMI over DDS *Getting Started Guide* is for developers using remote invocations in DDS applications.

Organisation

The first two chapters give a general introduction to RMI over DDS.

Chapter 3, *Building an RMI Application*, describes the steps involved in building applications using RMI over DDS.

Chapter 4, *Language mapping for OpenSplice RMI*, gives the C++ and Java mapping of the IDL types that can be declared in the RMI services description file.

Chapter 5, *RMI Interface to DDS topics mapping rules*, shows how IDL declarations of RMI interfaces are mapped into IDL declarations of the implied DDS topics.

Chapter 6, *RMI Runtime Configuration Options*, describes the command-line options available when starting the RMI runtime.

Appendix A, *QoS policies XML schema*, contains the XML schema for reference.

Conventions

The conventions listed below are used to guide and assist the reader in understanding this *Getting Started Guide*.

⚠	Item of special significance or where caution needs to be taken.
i	Item contains helpful hint or special information.
WIN	Information applies to Windows (*e.g.* XP, 2003, Windows 7) only.
UNIX	Information applies to Unix-based systems (*e.g.* Solaris) only.
C	C language-specific.
C++	C++ language-specific.
C#	C# language-specific.
Java	Java language-specific.

Hypertext links are shown as *blue italic underlined*.

On-Line (PDF) versions of this document: Cross-references such as 'see *Contacts* on page 7' act as hypertext links: click on the reference to jump to the item.

```
%  Commands or input which the user enters on the
   command line of their computer terminal
```

`Courier` fonts indicate programming code, commands, file names, and values stored in variables and fields.

Extended code fragments are shown in shaded boxes:

```
NameComponent newName[] = new NameComponent[1];

// set id field to "example" and kind field to an empty string
newName[0] = new NameComponent ("example", "");
```

Italics and ***Italic Bold*** are used to indicate new terms, or emphasise an item.

Sans-serif and **Sans-serif Bold** are used to indicate components of a Graphical User Interface (GUI) or an Integrated Development Environment (IDE), such as a Properties tab, and sequences of actions, such as choosing **File > Save** from a menu.

The names of keyboard keys are shown in SANS-SERIF SMALL CAPS, *e.g.* RETURN. (Combinations of keys to be pressed simultaneously have their names joined with a 'plus' sign: CTRL+C and CTRL+ALT+DELETE.) Names of navigation keys and keys on the numeric pad are spelled out (*e.g.* LEFT, DOWN, PLUS, MINUS).

Angle brackets **< >** enclosing code, command arguments, and similar types of text strings, are used to indicate 'placeholders' to be replaced by user-supplied values.

Step 1: One of several steps required to complete a task.

Contacts

PrismTech can be reached at the following contact points for information and technical support.

USA Corporate Headquarters	**European Head Office**
PrismTech Corporation 400 TradeCenter Suite 5900 Woburn, MA 01801 USA	PrismTech Limited PrismTech House 5th Avenue Business Park Gateshead NE11 0NG UK
Tel: +1 781 569 5819	Tel: +44 (0)191 497 9900 Fax: +44 (0)191 497 9901

Web:	*http://www.prismtech.com*	
Technical questions:	*crc@prismtech.com*	(Customer Response Center)
Sales enquiries:	*sales@prismtech.com*	

Using RMI over DDS

CHAPTER 1 Introduction

1.1 Features

OpenSplice RMI provides an implementation of the general concept of invoking a remote method over DDS. It enhances OpenSplice DDS with a service-oriented interaction pattern that can be used with combination with the native data-centric pattern. OpenSplice RMI is a service invocation framework on top of DDS DCPS that uses DDS mechanisms to export, find and invoke services. It maps all the application-exchanged requests/replies into DDS data exchanges, and gives the ability to configure the associated QoS policies according to the application needs. Finally, OpenSplice RMI enables the definition of a distributed services space over a DDS data space with all the known DDS benefits, such as discovery, fault tolerance, performance and real-time features.

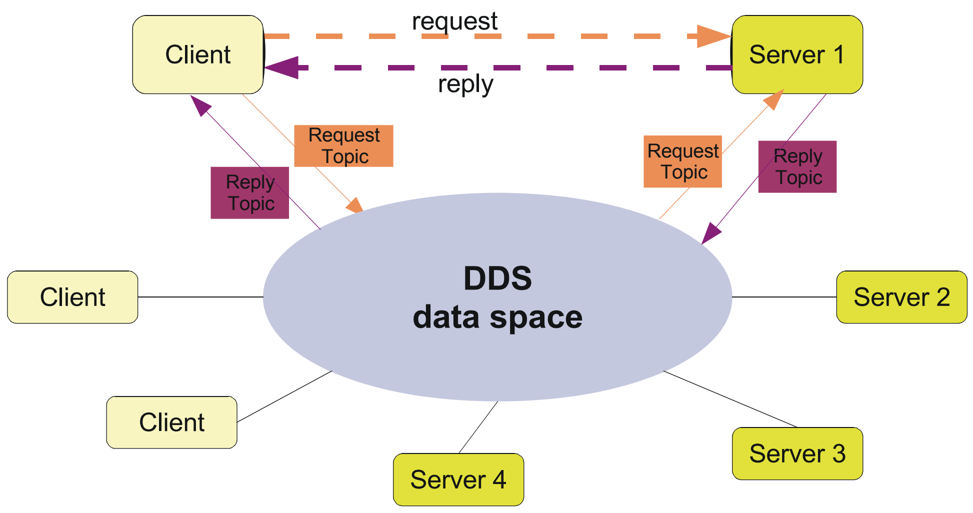


Figure 1 OpenSplice RMI Communication Scheme

OpenSplice RMI targets service-oriented applications needing a request/reply communication scheme while they can need to have a very fine control over the data and the underlying network quality of service. Typically, OpenSplice RMI can be used in systems to issue commands. Commands are a kind of stimulus that express the ability of the system to do something. As commands have the ‘do-something’ connotation, it is often useful to be informed synchronously that the command has been executed. Thanks to the various DDS QoSs, applications can associate expiration time, prioritities, persistency and so on to those commands.

1.2 Benefits

As a complementary paradigm to data centricity, OpenSplice RMI provides these benefits:

- A more productive and higher abstraction level than can be achieved manually through topic exchanges and applications synchronization.
- A unique middleware technology for mixing Global Services and Data Spaces with an easy and dynamic services registration, data declaration, and the same discovery mechanisms.
- Enables data-centric applications to use RMI without the burden of an additional middleware technology (*e.g.* CORBA).
- Strong services location transparency. Thanks to the connectionless nature of DDS, service identities do not need to include any network-related information. In OpenSplice RMI, a service is identified by a simple name. Services’ identities are exported naturally *via* a DDS publication on specific topics. Services can even move from one location to another without any impact on client applications.
- Simple API.
- Easy deployment process.

CHAPTER 2 OpenSplice RMI over DDS

2.1 Introduction

As in traditional service-oriented applications, communication from client to server is performed through a well-defined service model. The RMI module enables a user to build a service model with remote method invocation capabilities and completely hides the DDS DCPS API. Of course, using RMI does not prevent the application from using the DDS API as shown by the following figure:

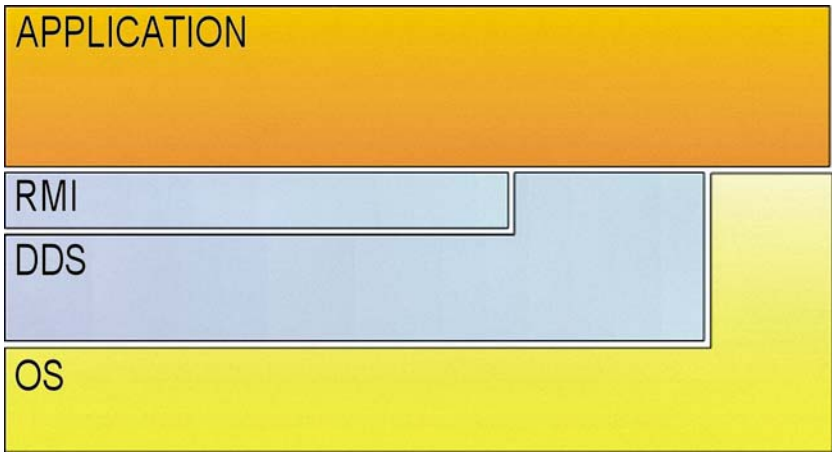


Figure 2 RMI Relationship to DDS

A service model is defined by one or more object-oriented interfaces. A DDS RMI interface is an IDL interface having a name and a set of operations. Each operation has a fixed set of typed parameters. The RMI module provides:

- A service invocation framework that maps the different services operations onto a set of DDS topics that hold the operation's invocation requests and replies. A set of mapping rules have been defined for this purpose. At runtime, this framework sets up the underlying DDS environment and handles the remote interface invocations using the basic DDS read/write operations.

- A simple and intuitive programming model for both the server application side implementing the interface, and the client application side invoking that interface. The server programming model is as simple as implementing an interface, and the client programming model is as simple as calling a local interface.
- A powerful feature to enable tuning of the invocation request and reply QoS by setting their corresponding DDS QoS policies. This feature enables developers to improve the invocations quality with real-time and high-performance features. For instance, priorities and validity durations (lifespan) could be set on the different operation requests/replies.
- Synchronous, asynchronous and oneway invocation modes. The synchronous mode is the invocation mode that blocks the client thread until the reply is sent back to him by the server. The asynchronous mode is similar to the CORBA Asynchronous Messaging Interface (AMI) callback model. It is a non-blocking mode where the client does not wait for the reply from the server, but rather provides a callback object that will be invoked by the middleware to deliver the request return values when they are received. Finally, the oneway mode is a fire-and-forget invocation mode where the client does not care about the success or failure of the invocation. A oneway method cannot return values and no reply message will ever return to the client once the request is sent to the server.
- C++ and Java implementation.

2.2 Key components

The OpenSplice DDS RMI module includes the following components:

- RMI Pre-processor (`rmipp`) – generates the interface-type-specific requests/replies topics and invocation handling classes.
- Core library – provides the runtime setup operations and a generic invocation framework.

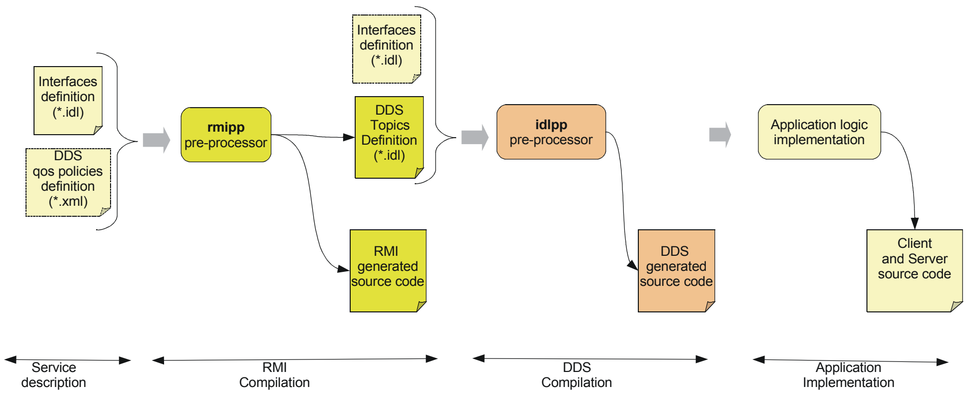
2.3 Binding Languages

The OpenSplice DDS RMI module is available for both Java and C++ languages.

CHAPTER 3 Building an RMI Application

3.1 Introduction

The process of building an OpenSplice DDS RMI application is shown in *Figure 3* below. The different steps are described in the following subsections.



Interfaces definition (*.idl)
DDS qos policies definition (*.xml)
rmipp pre-processor
Interfaces definition (*.idl)
DDS Topics Definition (*.idl)
RMI generated source code
idlpp pre-processor
DDS generated source code
Application logic implementation
Client and Server source code
Service description
RMI Compilation
DDS Compilation
Application Implementation

Figure 3 Steps Building Applications with RMI

3.2 Services description

The first step in building an RMI application is the definition of its provided services in terms of interfaces. The application interfaces should be declared using the OMG IDL language. The operations parameters can be either of basic (short, long, ...) or complex (struct, sequence, string, …) types. However, the following restrictions should be respected:

- the `Any` and the `valuetype` IDL types are not supported because they are not supported by the underlying DDS DCPS layer. `Union` type is also not supported.
- Exceptions are not supported at this time.
- Each interface must extend `DDS_RMI::Services` base interface to indicate that it is invocable over DDS. This interface is defined in the file `dds_rmi.idl`, which must be included.
- Each interface must be declared 'local'.

- Oneway operations are supported. The semantics of oneway operations is the same as for the OMG CORBA interfaces. A oneway operation must not contain any output parameter and must return a void type.

The following IDL snippet shows an example of a service data description:

```
#include "dds_rmi.idl"
module HelloWorld
{
   // interface definition
local interface HelloService : ::DDS_RMI::Services
{
   string greet();

};

};
```

3.3 QoS policies description

The OpenSplice DDS RMI module provides the ability to tune the quality of service of the services invocations (requests and/or replies), if needed, by setting the underlying DDS QoS policies. By default, the DDS RMI module uses the default values of the DDS QoS policies except for the reliability QoS policy which is set to `RELIABLE`.

If needed, the application designer can define the QoS policies to be set on the invocations in an XML file. This file must respect the XML schema given in Appendix A, *QoS policies XML schema*, starting on page 29.

Note that setting the DDS QoS policies requires a good knowledge of the rules for mapping the specified interfaces onto the DDS topics description (please refer to Chapter 5, *RMI Interface to DDS topics mapping rules*, on page 25).

The following XML snippet shows an example:

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<dcps xmlns="http://www.omg.org/dds/"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.omg.org/dds/DCPS.xsd">

<domain id="">
  <topic name="greet_req"
idltype="::HelloWorld::HelloService::greet_request" idlfile="">

    <topic_qos>
   <destinationOrderQosPolicy>
      <destinationOrderKind>
        BY_SOURCE_TIMESTAMP_DESTINATIONORDER_QOS
      </destinationOrderKind>
   </destinationOrderQosPolicy>

   <durabilityQosPolicy>
      <durabilityKind>
```

```
          PERSISTENT_DURABILITY_QOS
        </durabilityKind>
    </durabilityQosPolicy>

    <latencyBudgetQosPolicy>
        <duration>
          <nanosec>10000000</nanosec>
          <sec>0</sec>
        </duration>
    </latencyBudgetQosPolicy>

    <reliabilityQosPolicy>
        <duration>
          <nanosec>100000000</nanosec>
          <sec>0</sec>
        </duration>
        <reliabilityKind>
          RELIABLE_RELIABILITY_QOS
        </reliabilityKind>
    </reliabilityQosPolicy>
     </topic_qos>

  </topic>

</domain>
</dcps>
```

This example specifies the QoS policies to be applied on the topic invocation request of the `greet` operation of the interface `HelloWorld::HelloService`. Note that the invocation request topic is named `greet_req` and its IDL type is `HelloWorld::HelloService::greet_request`.

3.4 RMI compilation

Once the application has defined its services and (optionally) its QoS settings, these definitions are compiled to generate type-specific code for the application services invocation.

The RMI compilation is done using the `rmipp` pre-processor applied on the interfaces definition file and the QoS file if it exists. The `rmipp` usage is:

```
rmipp [-l (java | c++)] [-I <path>] [-d <directory>] [-topics
<qos_file>] [-P dll_macro_name[,<header-file>]] <interfaces_file>
```

The parameters are:

`-l (java | cpp)`	Define the target language. The C++ language is the default.
`-I <path>`	Define the include path directives.
`-d <directory>`	Define the location to place the generated files.

`-topics <qos_file>`	Define the XML file including the QoS policies settings.
`-P dll_macro_name[, <header-file>]`	*Only applicable to C and C++*. Sets export macro that will be prefixed to all functions in the generated code. This allows creating DLL's from generated code. Optionally a header file can be given that will be included in each generated file.
`<interfaces_file>`	The IDL file including the interfaces definition.

The `rmipp` compilation will generate a set of Java or C++ source files as well as an IDL file including the mapping of the provided interfaces onto the DDS topics. The generated IDL file name is the interfaces file name with '`_topics`' concatenated.

`Rmipp` follows the mapping rules described in Chapter 4, *Language mapping for OpenSplice RMI*, on page 21.

Example usage:

```
rmipp -d generated HelloService.idl
```

The generated directory will include:

```
HelloService_topics.idl
HelloService_Interface.h
HelloService_Interface.cpp
HelloService_InterfaceProxy.h
HelloService_InterfaceProxy.cpp
```

In addition, the `rmipp` compiler performs a DDS compilation to generate the DDS/DCPS code that is required to support the requests/replies transport over DDS.

3.5 Application implementation

As mentioned before, the target applications have a client/server design. A typical application includes a server part that implements the provided interfaces, and a client part that invokes these interfaces. This section describes the programming model of both parts.

3.5.1 Runtime starting and stopping

Any DDS RMI application process must initialize the RMI runtime prior to any other operation, regardless of whether it is a client and/or a server process. The runtime initialization sets up the underlying DDS infrastructure and configures it to make the services invocable and the clients capable of invoking the services. It is also important to stop the runtime when the application is no longer using RMI.

The following code snippets show the runtime initialisation and stopping procedure in C++ and Java.

RMI runtime starting and stopping in C++

```
1   #include “ddsrmi.hpp”
2
3   using namespace org::opensplice::DDS_RMI;
4
5   int main (int argc, char * argv [])
6   {
7       CRuntime_ref runtime = CRuntime::getDefaultRuntime();
8       if (runtime.get() == NULL)
9       {
10            std::cout << "Failed to get the Runtime " << std::endl;
11          exit(1);
12      }
13
14      //starting the runtime
15      bool result = runtime->start(argc, argv);
16      if (result !=true)
17      {
18          std::cout << "Failed to start the Runtime " << std::endl;
19          exit(1);
20      }
21      …
22
23      //stopping the runtime
24      result = runtime->stop();
25      if (result !=true)
26      {
27          std::cout << "Failed to stop the Runtime " << std::endl;
28          exit(1);
29      }
30  }
```

Comments below refer to line numbers in the sample code above:

(1) — Include the OpenSplice RMI library header file.
Any OpenSplice RMI application should include this file.

(3) — Declare the usage of the OpenSplice RMI library namespace.

(7-12) — Get the default DDS runtime.
This selects the default DDS domain as the data space where all subsequent RMI requests and replies will be exchanged.

(15-20) — Initialize the created runtime.
This creates all the needed DDS entities. A set of configuration options can be passed to the *`start`* operation *via* `argc` and `argv` parameters. This latter is a string array including possible option names and values, and `argc` is the length of this array. Note that these parameters are typically the same parameters that were passed to the main program so that the RMI options can be specified on the command line, each following the format ‘`--option=value`’. All of the supported options are described in Chapter 6, *RMI Runtime Configuration Options*, on page 27.

(24-28) — Stop the created runtime.

This removes all the created DDS entities and releases the RMI-allocated resources. It is strongly recommended to stop the runtime when it no longer needed.

The Java code below works in a similar way.

RMI runtime starting and stopping in Java

```
import org.opensplice.DDS_RMI;


static void main (String[] args) {

    CRuntime runtime = CRuntime.getDefaultRuntime();
    if(null == runtime)
    {
        System.out.println();
        System.exit(1);
    }

    //starting the runtime
    boolean result = runtime.start(args);
    if(!result)
    {
        System.out.println("Failed to start the Runtime") ;
        System.exit(1);
    }
    …

    //stopping the runtime
    result = runtime.stop();
    if(!result)
    {
        System.out.println("Failed to stop the Runtime") ;
        System.exit(1);
    }
}
```

3.5.2 Server programming model

At the server side of the application, each provided interface should be implemented, then instantiated and finally registered to be invocable *via* OpenSplice DDS.

To define an implementation, the application developer must write an implementation class including public methods corresponding to the operations of the related IDL interface. The `rmipp` compilation generates for each interface a skeleton class, named `::DDS_RMI::HelloWorld::HelloServiceInterface`, that must be extended by the application-supplied implementation class. The language mapping rules of the RMI IDL interfaces are given in Chapter 4, *Language mapping for OpenSplice RMI*, on page 21.

To make an interface invocable over DDS, it must be registered within the RMI framework, then activated. The registration process requires the following information:

- the implementation class object
- the server name, as well as a unique id identifying that interface inside the server.

The services activation makes the RMI runtime wait for incoming requests for all the registered services.

The following code snippets show the server programming model in Java and C++.

C++ RMI interface implementation

```
class HelloService_impl :
      public virtual DDS_RMI::HelloWorld::HelloServiceInterface
{
public:
    HelloService_impl();
   ~ HelloService_impl();

   virtual DDS::String greet ();
}
```

Java RMI interface implementation

```
public class HelloService_impl :
DDS_RMI.HelloWorld.myInterfaceInterface {

   public String greet ()
   {
      // operation implementation
   }


}
```

C++ RMI server

```
#include “ddsrmi.hpp”
#include “HelloService_Interface.hpp”

using namespace org::opensplice::DDS_RMI;

int main (int argc, char * argv [])
{

   // Runtime starting
   ….

   // implementation class instanciation
   shared_ptr<HelloService_impl> impl (new HelloService_impl());

   //interface registration
   bool res = DDS_Service::register_interface<
::DDS_RMI::HelloWorld::HelloServiceInterface, HelloService_impl> (
         impl, //implementation class
18             “HelloServer”, // server name
19             1 // unique server id
20             );
21
22
23      if(!res)
24      {
25          std::cout << "Failed to register the
HelloWorld::HelloService interface") ;
26          System.exit(1);
27      }
28      //services activation
29      runtime->run()
30      // Runtime stopping
31      …
32  }
```

Comments below refer to line numbers in the sample code above:

(1-2) — Include the OpenSplice RMI library header file as well as the generated interface skeleton header file.

(3) — Declare the usage of the OpenSplice RMI library namespace.

(10) — Start the DDS runtime.

(13) — Instantiate the implementation class of the *`HelloService`* interface and assign it to a smart pointer. The OpenSplice RMI library provides an implementation of smart pointers *via* the `shared_ptr` template class.

(16-27) — Register the *`HelloService`* interface in the default DDS domain. The `register_interface` function is a template function requiring the interface skeleton class and the interface implementation class as template parameters.

(28) — Activates all the registered services including the *`HelloServer`* service. This is a blocking call that makes the server runtime wait for incoming requests. To shut down the server runtime the `shutdown()` operation must be called.

(31) — Stop the DDS runtime.

The Java code below works in a similar way.

Java RMI server

```
static void main (String[] args) {

    // Runtime starting
    …

    // implementation class instanciation
    HelloService_impl impl = new HelloService_impl();

    // interface registration
    boolean res =
org.opensplice.DDS_RMI.DDS_Service.register_interface (
           impl, // implementation class
           “HelloServer”, // server name
           1, // unique server id
           DDS_RMI.HelloWorld.HelloServiceInterface.class //Interface
java Class
           );

    if(!res)
    {
        System.out.println("Failed to register the
HelloWorld::HelloService interface") ;
        System.exit(1);
    }
runtime.run();
    // Runtime stopping
    …
}
```

3.5.3 Client programming model

As mentioned before, OpenSplice RMI supports synchronous, asynchronous and oneway invocation modes. The following subsections present the synchronous and asynchronous programming model. The oneway programming model is similar to the synchronous one but, of course, with a different behaviour.

3.5.3.1 Synchronous invocation mode

The client part of the RMI application is as simple as calling a local class. Note that these calls block until the server-side responds or an internal timeout expires. Typically, in case of failure, the call will block until the timeout expiration. This timeout value is set by default to 10 minutes, but it may be configured *via* the interface proxy object. This object is a generated object, named `::DDS_RMI::HelloWorld::HelloServiceInterfaceProxy`, that is the local representative of the RMI interface. This object is mainly used to call the RMI services, as shown in the following client code examples.

C++ RMI client

```
#include “ddsrmi.hpp”
#include “HelloService_InterfaceProxy.hpp”

using namespace org::opensplice::DDS_RMI;

int main (int argc, char * argv [])
{

    // Runtime starting
    ….

    // Getting the interface proxy
    shared_ptr<::DDS_RMI::HelloWorld::HelloServiceInterfaceProxy>
proxy ;
    bool ret = DDS_Service::getServerProxy<
::DDS_RMI::HelloWorld::HelloServiceInterfaceProxy>
        (
16           "HelloServer", //server name
17           1, //unique proxy instance id
18           proxy  // proxy reference
19         );
20
21     // Calling the services
22     proxy->greet();
23
24     // Runtime stopping
25     …
26
27 }
```

Comments below refer to line numbers in the sample code above:

(1-2) — Include the RMI library header file as well as the generated interface proxy header file.

(3) — Declare the usage of the OpenSplice RMI library namespace.

(10) — Start the DDS runtime.

(13) — Declare a smart pointer of the *`HelloService`* interface proxy type.

(13-19) — Get the *`HelloServer`* service proxy.
The `getServerProxy` function is a template function requiring the proxy class type as a template parameter. This function accepts the service name, a proxy instance id and the smart pointer to the proxy object as parameters. In case of success, the smart pointer is set to the created proxy object. The proxy instance id is a unique identifier that refers to the created proxy. It is important to ensure the uniqueness of the identifiers of all the proxies of the same service. If the client application intends to use the same proxy in different threads, the MultiThreaded mode must be set (see section *3.5.3.3* on page 19).
If the requested service is not found., the `getServerProxy` operation will raise an `org::opensplice::DDS_RMI::SERVICE_NOT_FOUND` exception.

(22) — Invoke the `greet` operation synchronously using the created proxy.

(25) — Stop the runtime.

The Java code below works in a similar way.

Java RMI client

```
import org.opensplice.DDS_RMI.*;


static void main (String[] args) {

   // Runtime starting
   …

   // Getting the interface proxy
   try {
   DDS_RMI.HelloWorld.HelloServiceInterfaceProxy proxy =
      DDS_Service.getServerProxy (
         "HelloServer", //server name
         1, //unique proxy instance id
          DDS_RMI.HelloWorld.HelloServiceInterfaceProxy.class //
proxy java Class
       );

   // Calling the services
   proxy.greet();
   } catch (SERVICE_NOT_FOUND e) {
   // error
   }
   // Runtime stopping
   …

}
```

3.5.3.2 Asynchronous invocation mode

To invoke asynchronously a given non-oneway operation, such as the `greet` operation in the examples shown here, the client application must:

- Implement a specific reply handler class to handle the operation out/inout/return parameters if any. This handler must extend a base reply handler class that is generated for each operation and implement the `greetReply` callback function or method whose parameters are the out/inout/return parameters of the related IDL operation.
- Use the generated asynchronous function or method that maps to the IDL operation whose name is the concatenation of '`async_`' and the IDL operation name. This operation is a void operation that accepts only the `in` and `inout` IDL parameters, in addition to the reference of the implemented reply handler.

Note that the reply handler class is not re-entrant in the current implementation. It cannot handle concurrent replies. It means that if two successive asynchronous calls are made with the same reply handler instance, this latter will reject the second reply if it has not finished dispatching the first one. In this case the asynchronous call will raise a `BAD_PARAM` exception.

IMPORTANT: It is strongly recommended not to mix synchronous and asynchronous calls of the same operation without proper synchronization. The application should ensure that the asynchronous call has received its reply before requesting a synchronous one.

C++ RMI Client with asynchronous invocation

```
#include "ddsrmi.hpp"
#include "HelloService_InterfaceProxy.hpp"

using namespace org::opensplice::DDS_RMI;

/**
* Reply Handler of the 'async_greet' operation
```

```
8   *
9   */
10  class MyGreetReplyHandler :
11      public virtual   HelloWorld_HelloService_greet_Reply_Handler
12  {
13      void greet_Reply(DDS::String ret)
14      {
15            std::cout << "Reply received: " << ret << std::endl;
16      }
17  }
18
19  int main (int argc, char * argv [])
20  {
21
22  // Runtime starting
23  ….
24
25  // Getting the interface proxy
26  shared_ptr<::DDS_RMI::HelloWorld::HelloServiceInterfaceProxy>
proxy ;
27  bool ret = DDS_Service::getServerProxy<
::DDS_RMI::HelloWorld::HelloServiceInterfaceProxy>
28      (
29        “HelloServer”, //server name
30        1, // proxy instance id
31        proxy  // proxy reference
32      );
33
34  // instantiating a reply handler
35  MyGreetReplyHandler handler;
36
37  // Calling the services asynchronously
38  proxy->async_greet(&handler);
39  ...
40
41  // Runtime stopping
42  …
43
44  }
```

Comments below refer to line numbers in the sample code above:

(10-16) — Provide the implementation class of the `greet` operation reply handler.

(21) — Start the DDS runtime.

(24-31) — Get the *`HelloServer`* service proxy as for the synchronous mode.

(34) — Instantiate the `greet` reply handler class.

(37) — Invoke the `async_greet()` operation by providing the reply handler. This call is a non-blocking call. The application steps immediately to the next instruction. The invocation reply will be delivered to the application by invoking the `greet_Reply` operation of the reply handler. Note that this operation will be invoked in a middleware-provided thread.

(41) — Stop the runtime.

Note that some synchronization may be needed to not exit before the `async_greet` reply is delivered to the application.

The Java code below works in a similar way.

Java RMI Client with asynchronous invocation

```
import org.opensplice.DDS_RMI.*;

/**
     * Reply Handler of the 'async_greet' operation
     *
     */
    class MyGreetReplyHandler extends
DDS_RMI.HelloWorld.HelloServiceInterfaceProxy.greet_Reply_Handler {
        public void greet_Reply(String ret) {
            System.out.println("async_greet returns: " + ret);
        }
    };

static void main (String[] args) {

    // Runtime starting
    …

   try {
    // Getting the interface proxy
    DDS_RMI.HelloWorld.HelloServiceInterfaceProxy proxy =
       DDS_Service.getServerProxy (
         "HelloServer", //server name
         1, //server instance id
          DDS_RMI.HelloWorld.HelloServiceInterfaceProxy.class //
proxy java Class
       );

    // Calling the services asynchronously
    proxy.asynch_greet();
   } catch(SERVICE_NOT_FOUND e) {
    System.out.println("'HelloServer' service not found !");
   }

    // Runtime stopping
    …

}
```

3.5.3.3 MultiThreaded Client

The default threading model of a client application is single threaded. It means that, by default, a service proxy may not be used by multiple concurrent threads to perform service invocations. To enable or disable the multithreaded mode for clients, a configuration option must be specified in the command line as follows:

```
--RMIClientThreadingModel=[ST|MT]
```

The **ST** and **MT** option values set respectively the **S**ingle **T**hreaded and **M**ulti**T**hreaded mode. Note that this option must be set both at the client and the server side even if it sets the threading model of only the client.

CHAPTER 4 Language mapping for OpenSplice RMI

4.1 Introduction

`Rmipp` compilation follows a set of mapping rules to generate language-specific source code. Most of these rules come from the standard OMG IDL-to-C++ and IDL-to-Java mapping specifications but with some specific differences. This chapter focuses on specific parts of this mapping. For more information, please refer to the related OMG specifications.

The following figure shows the language mapping of the *`HelloService`* IDL interface previously defined.

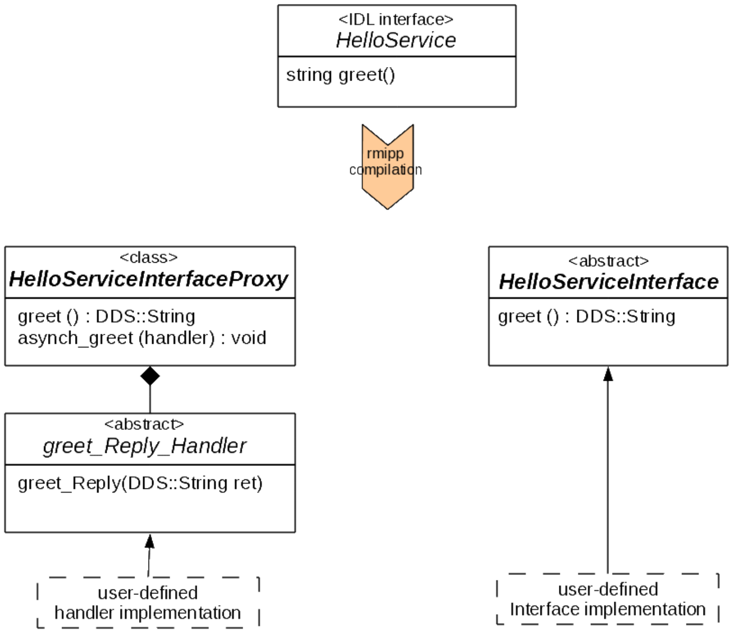


Figure 4 IDL Interface Mapping

4.2 Mapping for interfaces

An interface is mapped to two C++ (or Java) classes that contain public definitions of the operations defined in the interface. The `HelloServiceInterface` abstract class is the base class of the `HelloService` implementation class. The `HelloServiceInterfaceProxy` class is the proxy object that represents locally the remote service. The client application should get a reference to this class to be able to invoke the remote service.

4.3 Mapping for operations

Each IDL operation, if not oneway, is mapped to two C++ functions (Java methods). The first one, having the same name as the IDL operation, is used for synchronous invocations. The second one, having "async_" concatenated to the IDL operation, is used for asynchronous invocations. A oneway operation maps only to the synchronous form of the operations.

The operations parameters and return types obey the same parameter passing rules as for the standard OMG IDL-to-C++ and IDL-to-Java mapping. The asynchronous functions (methods) will return void and take only the in/inout parameters of the IDL operation, as well as a callback object used as a reply handler. This handler class is also generated for each non void operation as an inner abstract class of the proxy class as depicted in the diagram with the `greet_Reply_Handler` class. This latter should be implemented by the user to handle the asynchronous invocation reply. Hence, the `greet_Reply` function (method) provides all the inout/out/return parameters of the corresponding IDL operation.

4.4 Mapping for basic types

The table below shows the C++ and Java mapping of the IDL *types* that can be declared in the RMI services description file.

IDL *sequences* are mapped as specified by the DDS standard.

Table 1 Mapping for basic types

IDL type	C++	Java
`boolean`	DDS::Boolean	boolean
`char`	DDS::Char	char
`octet`	DDS::Octet	byte
`short`	DDS::Short	short
`unsigned short`	DDS::UShort	short
`long`	DDS::Long	int
`unsigned long`	DDS::ULong	int

Table 1 Mapping for basic types (continued)

IDL type	C++	Java
`long long`	DDS::LongLong	long
`unsigned long long`	DDS::ULongLong	long
`float`	DDS::Float	float
`double`	DDS::Double	double
`string`	DDS::String	String

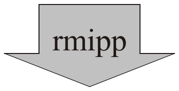
CHAPTER 5 RMI Interface to DDS topics mapping rules

5.1 Introduction

This chapter demonstrates the mapping rules driving the transformation of the IDL declarations of the RMI interfaces into the IDL declarations of the implied DDS topics.

- For each `<InterfaceName>`, a new module is created with the same name and scope in the module `DDS_RMI`, where all the topics associated with the interface operations will be made.
- Each `<InterfaceName>.<operation name>` creates two data structures, suffixed respectively with `_request` for data structure that handles the request, and `_reply` for the data structure that handles the reply.
- The `<operation name>_request` data struct will gather all `[in]` or `[inout]` parameters.
- The `<operation name>_reply` data struct will gather the return value and all `[inout]` or `[out]` parameters.
- `req_info` is used to enable the client service handler to pick the reply it is waiting for.

```
module HelloWorld {
   local interface HelloService : ::DDS_RMI::Services
   {
      void op1 (in string p1, inout short p2, out long p3);
   };
};
```



```
module DDS_RMI {
  module HelloWorld {
    module HelloService {
```

```
    struct op1_request {
            DDS_RMI::Request_Header req_info;
            string p1;
            short p2;
         };
    #pragma keylist op1_request req_info.client_id.client_impl
req_info.client_id.client_instance

        struct op1_reply {
            DDS_RMI::Request_Header req_info;
            short p2;
            long p3;
        };
    #pragma keylist op1_reply req_info.client_id.client_impl
req_info.client_id.client_instance

    };
  };
};
```

CHAPTER

6 RMI Runtime Configuration Options

6.1 Introduction

The RMI runtime can be configured by a set of command line options. These options are passed directly to the runtime start operation as described in section 3.5.1, *Runtime starting and stopping*, on page 10.

This chapter describes the set of supported options.

6.2 RMIClientThreadingModel option

```
--RMIClientThreadingModel = [ST | MT]
```

This option specifies the threading model of a given client. The 'ST' and 'MT' option values set respectively the Single-Threaded and Multi-Threaded models.

⚠ Note that this option must be set both at the client and the server side even if it sets the threading model of only the client.

6.3 RMIServiceDiscoveryTimeout option

```
--RMIServiceDiscoveryTimeout = <seconds>
```

This is a client-side option that specifies the maximum duration (in seconds) that a client application can wait to find services. It influences the execution time of the `DDS_Service.getServerProxy` operation that is used to find a given service. The default value is set to `10` seconds. The need to set this value may come from some specific deployment environements with bad communication conditions.

Appendix A *QoS policies XML schema*

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
            targetNamespace="http://www.omg.org/dds/"
            xmlns="http://www.omg.org/dds/"
            elementFormDefault="qualified">
    <xsd:element name="dcps">
        <xsd:complexType>
            <xsd:all>
              <xsd:element ref="domain" minOccurs="1" maxOccurs="1"/>
            </xsd:all>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="domain">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element ref="topic" minOccurs="1"
maxOccurs="unbounded"/>
            </xsd:sequence>
          <xsd:attribute name="id" type="xsd:string" use="required"/>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="topic">
        <xsd:complexType>
            <xsd:all>
             <xsd:element ref="keylist" minOccurs="1" maxOccurs="1"/>
                <xsd:element ref="topic_qos" minOccurs="0"
maxOccurs="1"/>
            </xsd:all>
            <xsd:attribute name="name" type="xsd:string"
use="required"/>
            <xsd:attribute name="idltype" type="xsd:string"
use="required"/>
            <xsd:attribute name="idlfile" type="xsd:string"
use="required"/>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="keylist">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element ref="keyMember" minOccurs="0"
maxOccurs="unbounded"/>
          </xsd:sequence>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="keyMember" type="xsd:string"/>

     <xsd:element name="topic_qos">
       <xsd:complexType>
        <xsd:all>
            <xsd:element ref="topicDataQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="deadlineQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="durabilityQosPolicy" minOccurs="0"
maxOccurs="1"/>
         <xsd:element ref="durabilityServiceQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="latencyBudgetQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="livelinessQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="reliabilityQosPolicy" minOccurs="0"
maxOccurs="1"/>
          <xsd:element ref="destinationOrderQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="historyQosPolicy" minOccurs="0"
maxOccurs="1"/>
           <xsd:element ref="resourceLimitsQosPolicy" minOccurs="0"
maxOccurs="1"/>
         <xsd:element ref="transportPriorityQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="lifespanQosPolicy" minOccurs="0"
maxOccurs="1"/>
            <xsd:element ref="ownershipQosPolicy" minOccurs="0"
maxOccurs="1"/>
           <xsd:element ref="timeBasedFilterQosPolicy" minOccurs="0"
maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="deadlineQosPolicy">
       <xsd:complexType>
          <xsd:all>
           <xsd:element ref="duration" minOccurs="1" maxOccurs="1"/>
          </xsd:all>
```

```
            </xsd:complexType>
         </xsd:element>

         <xsd:element name="timeBasedFilterQosPolicy">
            <xsd:complexType>
               <xsd:all>
                 <xsd:element ref="duration" minOccurs="1" maxOccurs="1"/>
               </xsd:all>
            </xsd:complexType>
         </xsd:element>

          <xsd:element name="topicDataQosPolicy">
             <xsd:complexType>
               <xsd:all>
                 <xsd:element name="value" type="xsd:base64Binary"
minOccurs="1" maxOccurs="1"/>
               </xsd:all>
             </xsd:complexType>
          </xsd:element>

         <xsd:element name="duration">
           <xsd:complexType>
             <xsd:all>
                 <xsd:element name="sec" type="xsd:string" minOccurs="1"
maxOccurs="1"/>
                <xsd:element name="nanosec" type="xsd:string" minOccurs="1"
maxOccurs="1"/>
             </xsd:all>
           </xsd:complexType>
         </xsd:element>

         <xsd:element name="durabilityQosPolicy">
           <xsd:complexType>
             <xsd:all>
                 <xsd:element ref="durabilityKind" minOccurs="1"
maxOccurs="1"/>
             </xsd:all>
           </xsd:complexType>
         </xsd:element>

         <xsd:element name="durabilityKind">
          <xsd:simpleType>
             <xsd:restriction base="xsd:string">
                 <xsd:enumeration value="VOLATILE_DURABILITY_QOS"/>
                <xsd:enumeration value="TRANSIENT_LOCAL_DURABILITY_QOS"/>
                 <xsd:enumeration value="TRANSIENT_DURABILITY_QOS"/>
                 <xsd:enumeration value="PERSISTENT_DURABILITY_QOS"/>
             </xsd:restriction>
          </xsd:simpleType>
         </xsd:element>
```

```
    <xsd:element name="durabilityServiceQosPolicy">
      <xsd:complexType>
        <xsd:all>
            <xsd:element ref="duration" minOccurs="1" maxOccurs="1"/>
            <xsd:element ref="historyKind" minOccurs="1"
maxOccurs="1"/>
            <xsd:element name="history_depth"
type="xsd:positiveInteger" minOccurs="1" maxOccurs="1"/>
          <xsd:element name="max_samples" type="xsd:positiveInteger"
minOccurs="1" maxOccurs="1"/>
            <xsd:element name="max_instances"
type="xsd:positiveInteger" minOccurs="1" maxOccurs="1"/>
            <xsd:element name="max_samples_per_instance"
type="xsd:positiveInteger" minOccurs="1" maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="historyKind">
      <xsd:simpleType>
        <xsd:restriction base="xsd:string">
            <xsd:enumeration value="KEEP_LAST_HISTORY_QOS"/>
            <xsd:enumeration value="KEEP_ALL_HISTORY_QOS"/>
        </xsd:restriction>
      </xsd:simpleType>
    </xsd:element>

    <xsd:element name="latencyBudgetQosPolicy">
        <xsd:complexType>
          <xsd:all>
            <xsd:element ref="duration" minOccurs="1" maxOccurs="1"/>
          </xsd:all>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="livelinessQosPolicy">
        <xsd:complexType>
          <xsd:all>
            <xsd:element ref="duration" minOccurs="1" maxOccurs="1"/>
            <xsd:element ref="livelinessKind" minOccurs="1"
maxOccurs="1"/>
          </xsd:all>
        </xsd:complexType>
    </xsd:element>

    <xsd:element name="reliabilityQosPolicy">
      <xsd:complexType>
        <xsd:all>
            <xsd:element ref="reliabilityKind" minOccurs="1"
maxOccurs="1"/>
```

```
           <xsd:element ref="duration" minOccurs="1" maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="reliabilityKind">
      <xsd:simpleType>
        <xsd:restriction base="xsd:string">
            <xsd:enumeration value="BEST_EFFORT_RELIABILITY_QOS"/>
            <xsd:enumeration value="RELIABLE_RELIABILITY_QOS"/>
        </xsd:restriction>
      </xsd:simpleType>
    </xsd:element>


    <xsd:element name="destinationOrderQosPolicy">
      <xsd:complexType>
        <xsd:all>
            <xsd:element ref="destinationOrderKind" minOccurs="1"
maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="destinationOrderKind">
      <xsd:simpleType>
        <xsd:restriction base="xsd:string">
            <xsd:enumeration
value="BY_RECEPTION_TIMESTAMP_DESTINATIONORDER_QOS"/>
            <xsd:enumeration
value="BY_SOURCE_TIMESTAMP_DESTINATIONORDER_QOS"/>
        </xsd:restriction>
      </xsd:simpleType>
    </xsd:element>

    <xsd:element name="livelinessKind">
      <xsd:simpleType>
        <xsd:restriction base="xsd:string">
            <xsd:enumeration value="AUTOMATIC_LIVELINESS_QOS"/>
            <xsd:enumeration
value="MANUAL_BY_PARTICIPANT_LIVELINESS_QOS"/>
           <xsd:enumeration value="MANUAL_BY_TOPIC_LIVELINESS_QOS"/>
        </xsd:restriction>
      </xsd:simpleType>
    </xsd:element>

    <xsd:element name="historyQosPolicy">
      <xsd:complexType>
        <xsd:all>
```

```
            <xsd:element ref="historyKind" minOccurs="1"
maxOccurs="1"/>
            <xsd:element name="depth" type="xsd:positiveInteger"
default="1" minOccurs="1" maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="resourceLimitsQosPolicy">
      <xsd:complexType>
        <xsd:all>
          <xsd:element name="max_samples" type="xsd:positiveInteger"
minOccurs="1" maxOccurs="1"/>
            <xsd:element name="max_instances"
type="xsd:positiveInteger" minOccurs="1" maxOccurs="1"/>
            <xsd:element name="max_samples_per_instance"
type="xsd:positiveInteger" minOccurs="1" maxOccurs="1"/>
            <xsd:element name="initial_samples"
type="xsd:positiveInteger" minOccurs="1" maxOccurs="1"/>
            <xsd:element name="initial_instances"
type="xsd:positiveInteger" minOccurs="1" maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="transportPriorityQosPolicy">
      <xsd:complexType>
        <xsd:all>
            <xsd:element name="value" type="xsd:nonNegativeInteger"
minOccurs="1" maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="lifespanQosPolicy">
      <xsd:complexType>
        <xsd:all>
           <xsd:element ref="duration" minOccurs="1" maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>

    <xsd:element name="ownershipQosPolicy">
      <xsd:complexType>
        <xsd:all>
            <xsd:element ref="ownershipKind" minOccurs="1"
maxOccurs="1"/>
        </xsd:all>
      </xsd:complexType>
    </xsd:element>
    <xsd:element name="ownershipKind">
      <xsd:simpleType>
        <xsd:restriction base="xsd:string">
            <xsd:enumeration value="SHARED_OWNERSHIP_QOS"/>
            <xsd:enumeration value="EXCLUSIVE_OWNERSHIP_QOS"/>
        </xsd:restriction>
      </xsd:simpleType>
    </xsd:element>
</xsd:schema>
```