RTI Connext DDS

Core Libraries

Prototyper with Lua (Experimental Feature)

Getting Started Guide

Version 6.0.0

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Chapter 1 Welcome to RTI Prototyper!

1.1 Introduction

This document assumes you have a basic understanding of *RTI® Connext® DDS* application development and concepts, such as a DDS *Domain*, *DomainParticipant*, *Topic*, *DataWriter* and *DataReader*. For an overview of these concepts, please see the *RTI Connext DDS Core Libraries Getting Started Guide*.

Part of this document also assumes that you have a basic understanding of the Lua scripting language. Examples are provided later in the document. For a complete guide to the Lua language, please see the *Lua Reference Manual* at **http://www.lua.org/manual/.**

RTI Prototyper is a tool to accelerate *RTI Connext DDS* application development and scenario testing. It provides *RTI Connext DDS* application developers with a quick and easy-to-use mechanism to try out realistic scenarios on their own computer systems and networks, and get immediate information on the expected performance, resource usage, and behavior of their system.

Starting with version 5.1.0*, Prototyper* includes an embedded Lua scripting language engine. *Lua* is a powerful, fast, lightweight, scripting language that combines simple procedural syntax with powerful data description constructs based on associative arrays and extensible semantics. To learn more about Lua, visit **www.lua.org**.

The Lua interpreter allows developers to prototype complex application behaviors without recompiling applications. This allows for rapid development of test functionality, including sending variable rates of data, data that is only sent based on events, or other scenarios that cannot be modeled with simple periodic data.

By embedding a Lua interpreter, *Prototyper* provides an easy and powerful way to define the data and behavior of distributed application components. The integration is seamless. A Lua script implementing the desired behavior can be embedded directly in the XML or stored in an external file that is loaded at run time.

With the traditional approach, if you want to try a specific *RTI Connext DDS* distributed application design and determine Key Performance Indicators (KPIs), you would have to spend significant time and effort to develop a custom prototype that could determine KPIs such as:

- Validation of the basic approach for building a distributed system
- Suitability of the data model
- Suitability of QoS settings
- Memory a particular application is likely to use.
- Time it will take for discovery to complete.
- System bandwidth the running application will consume.
- The CPU usage it will take for a particular application to publish its data at a certain rate, or to receive a certain set of Topics.
- The impact of changing data types, topics, Quality of Service, and other design parameters.

Prototyper significantly simplifies this process. Instead of writing custom code, you can:

1. Describe the system in an XML file (or files),
2. Run *Prototyper* on each computer, specifying the particular configuration for that computer,
3. Create a working distributed application, and
4. Observe the behavior of the running system and read the KPIs from the *RTI Monitor* tool.

Prototyper is a command-line executable application. Once installed, *Prototyper* can be found in the **<NDDSHOME>/bin**[1] directory as **rtiddsprototyper**. *Prototyper* takes several command-line parameters, which allow you to specify the XML configuration file, the specific *DomainParticipant* configuration to use, and other run-time parameters. You must start *Prototyper* manually on each machine where you would like to run it, specifying the appropriate parameters.

The XML file-format used by *Prototyper* is compatible with the one used for the *RTI Connext DDS* XML-Based Application Creation feature. This means that your investment in describing your system via XML can be fully leveraged during your application development. Only the application components that need to be optimized or have special requirements would need to be re-implemented in a compiled programming language (C/C++, Java, C++, C#). Other application components can be implemented in the Prototyper using the dynamic Lua scripting language. The result is much faster application development. For those application components that are reimplemented in a compiled programming language, the data types, *Topics*, *DomainParticipants*, and other entities described in the XML file can be directly created from application code and integrated into your final application without the need to recode them in the

[1]See 1.2 Paths Mentioned in Documentation on the facing page.

source files. See the *RTI Connext DDS XML-Based Application Creation Getting Started Guide* for a description of this feature and the format used to describe *RTI Connext DDS* applications in XML.

1.2 Paths Mentioned in Documentation

The documentation refers to:

- **<NDDSHOME>**

  This refers to the installation directory for *RTI® Connext® DDS*. The default installation paths are:
  - Mac® OS X® systems:
    /Applications/rti_connext_dds-6.0.0
  - UNIX-based systems, non-*root* user:
    /home/<your user name>/rti_connext_dds-6.0.0
  - UNIX-based systems, *root* user:
    /opt/rti_connext_dds-6.0.0
  - Windows® systems, user without Administrator privileges:
    <your home directory>\rti_connext_dds-6.0.0
  - Windows systems, user with Administrator privileges:
    C:\Program Files\rti_connext_dds-6.0.0

  You may also see $NDDSHOME or %NDDSHOME%, which refers to an environment variable set to the installation path.

  Wherever you see <NDDSHOME> used in a path, replace it with your installation path.

  Note for Windows Users: When using a command prompt to enter a command that includes the path **C:\Program Files** (or any directory name that has a space), enclose the path in quotation marks. For example:

  ```
  "C:\Program Files\rti_connext_dds-6.0.0\bin\rtiddsgen"
  ```

  Or if you have defined the NDDSHOME environment variable:

  ```
  "%NDDSHOME%\bin\rtiddsgen"
  ```

- **<path to examples>**

  By default, examples are copied into your home directory the first time you run *RTI Launcher* or any script in **<NDDSHOME>/bin**. This document refers to the location of the copied examples as <path to examples>.

  Wherever you see <path to examples>, replace it with the appropriate path.

  Default path to the examples:

- Mac OS X systems: **/Users/<*your user name*>/rti_workspace/6.0.0/examples**
- UNIX-based systems: **/home/<*your user name*>/rti_workspace/6.0.0/examples**
- Windows systems: **<*your Windows documents folder*>\rti_workspace\6.0.0\examples**

  Where 'your Windows documents folder' depends on your version of Windows. For example, on Windows 10, the folder is **C:\Users\<your user name>\Documents**.

Note: You can specify a different location for **rti_workspace**. You can also specify that you do not want the examples copied to the workspace. For details, see *Controlling Location for RTI Workspace and Copying of Examples* in the *RTI Connext DDS Core Libraries Getting Started Guide*.

Chapter 2 Release Notes

2.1 Limitations

- *Prototyper* is currently not supported on Android platforms. [RTI Issue ID CORE-6673]
- *Prototyper* has not been tested on INTEGRITY systems and will not work on platforms without a file system.
- Monitoring with *Prototyper* is not supported for Android, INTEGRITY, and LynxOS architectures.
- If *Prototyper* is executed with **onPeriod** set to false, some received samples may not be processed by the Lua script. This is due to a listener (installed by default in *Prototyper*) that will clear the status condition that indicates there are samples to process, even if the samples are not processed by the Lua script.

  If, for example, a new sample is received while the Lua script is still processing previously received samples, the new ones may not be seen by the script.

  You can workaround this issue by setting **onPeriod** to true on the command line or in your XML file. Then the period will eventually expire and your script can perform the **read()** or t**ake()** operation to check for unprocessed samples.

2.2 What's Fixed in 6.0.0

2.2.1 Prototyper failed to publish samples for types using inheritance

In previous releases, *Prototyper* could not publish samples for types using inheritance. For example:

```
struct BaseStruct {
    long m1;
};

struct DerivedStruct: BaseStruct {
    long m2;
```

```
};
```

When used to publish DerivedStruct samples, the utility generated errors similar this:

```
DDS_DynamicData_set_xxxx:type mismatch for field nominalValue (id=1)
```

This problem has been fixed.

[RTI Issue ID PROT-80]

2.2.2 Prototyper failed to publish samples for types using enums

In previous releases, *Prototyper* could not publish samples for types using enums. For example:

```
enum Color {
    RED = 100,
    BLUE = 200
};

struct MyColorStruct {
    Color m1;
};
```

When used to publish MyColorStruct samples, the utility generated errors similar this:

```
DDS_DynamicDataTypePlugin_validate_enum:invalid enumerator value
DDS_DynamicDataTypePlugin_process_primitive_cdr_value:invalid enumeration value
DDS_DynamicDataTypePlugin_parametrized_cdr_to_cdr:error copying CDR value
```

This problem has been fixed.

[RTI Issue ID PROT-81]

Chapter 3 “Hello World” with RTI Prototyper

This section assumes you have installed the software and configured your environment correctly. If you have not done so, please follow the steps in the *RTI Connext DDS Core Libraries Getting Started Guide*, specifically Section 2.1, *Installing Connext DDS*, and Section 3.1, *Building and Running Hello World*.

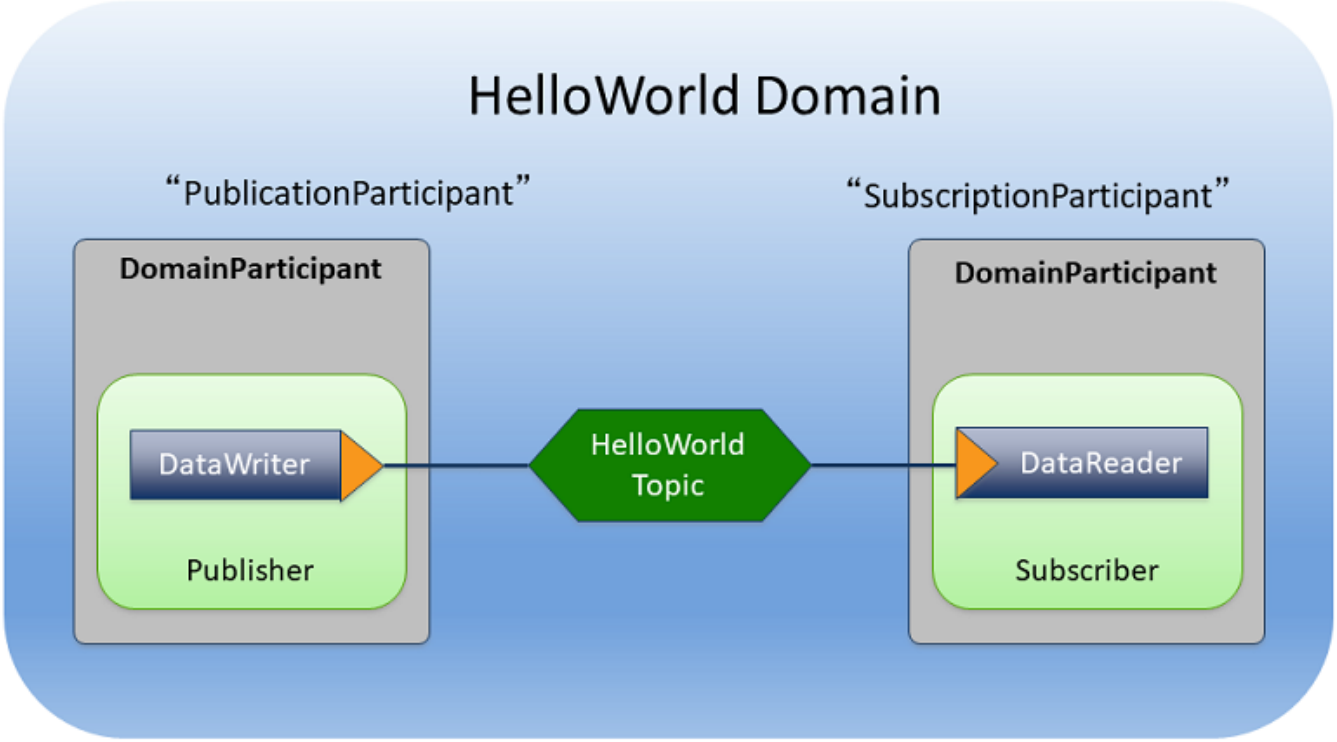
3.1 Hello World Example

The files for this example are in **<path to examples>/prototyper/hello_world**.

This simple scenario defines two *DomainParticipant* configurations, illustrated in Figure 3.1: Simple Scenario on the next page: “PublicationParticipant” which writes to the Topic “HelloWorldTopic,” and ”SubscriptionParticipant,” which subscribes to that *Topic*.

First, we will run the scenario. Then we will examine the configuration files.

Figure 3.1: Simple Scenario



The XML file defines two DomainParticipant configurations: "PublicationParticipant" and "SubscriptionParticipant"

3.1.1 Run Prototyper

On UNIX-based systems:

Open two command-shell windows. In each one, change the directory to **<path to examples>/-prototyper/hello_world**. Then type the following command in each window:

```
<NDDSHOME>/bin/rtiddsprototyper
```

On VxWorks systems using RTP mode:

Open two command-shell windows (enter **cmd**). In each one, change directory to **<path to examples>/prototyper/hello_world**. Then type the following command in each window:

```
rtp exec <NDDSHOME>/lib/<architecture>/rtiddsprototyper.vx
```

On VxWorks systems using kernel mode:

Open two command-shell windows (enter **cmd**). In each one, change directory to **<path to examples>/prototyper/hello_world**.

Load all the libraries:

```
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscore.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddsc.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscpp.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/liblua.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/librtiddsconnectorlua.so
ld 1 < <NDDSHOME>/resource/app/bin/ppc604Vx6.9gcc4.3.3/rtiddsprototyper.so
```

Start *Prototyper*:

```
taskSpawn "Test", 255, 0x8, 150000, rtiddsprototyper, ""
```

You may see these errors:

```
Undefined symbol: RTIDefaultMonitor_create (binding 1 type 0)
ld error: Module contains undefined symbol(s) and may be unusable.
value = 0 = 0x0
```

These errors will not affect the execution if monitoring is disabled (the default case). To use monitoring, load the monitoring library right before the *Prototyper* library, **rtiddsprototype.so**. For details on configuring the monitoring library, please see the "RTI Monitoring Library" section of the *RTI Connext DDS Core Libraries User's Manual*. For details on using the RTI Monitor tool, please see the *RTI Monitor Getting Started Guide*.

On Windows systems:

Open two command-prompt windows. In each one, change the directory to **<path to examples>\-prototyper\hello_world**. Then type the following command in each window:

```
<NDDSHOME>\bin\rtiddsprototyper
```

If the XML profile contains only one configuration, *Prototyper* will start that one. If more configurations are available, you will see the following output appear in each window:

```
Please select among the available configurations:
0: MyParticipantLibrary::PublicationParticipant
1: MyParticipantLibrary::SubscriptionParticipant
Please select:
```

If you do not see the above output and get the following error instead:

```
rtidsprototyper: Error configuration file not found.
```

The above message indicates that you did not run *rtiddsprototyper* from the right directory. Change directories to **<path to examples>/prototyper/hello_world** and verify you see the file **USER_QOS_PROFILES.xml** in that directory.

If you see this output:

```
Use the -cfgName option to specify a participant configuration.
NddsProtyperAgent::run: Select participant configuration error
```

This indicates that the operating system you are running on does not accept user input. Please use the **-cfgName** command-line argument to specify the desired participant configuration.

In one of the windows, type “0” (without the quotes) to select the first choice, followed by a return. In the other window, type “1” (without the quotes) to select the second choice, also followed by a return.

In the window where you typed “0” (first choice), you will see output like this:

```
Please select among the available configurations:
0: MyParticipantLibrary::PublicationParticipant
1: MyParticipantLibrary::SubscriptionParticipant
Please select: 0
DataWriter "HelloWorldWriter" wrote sample 1 on Topic "HelloWorldTopic" at 1332618800.504111 s
DataWriter "HelloWorldWriter" wrote sample 2 on Topic "HelloWorldTopic" at 1332618801.504341 s
DataWriter "HelloWorldWriter" wrote sample 3 on Topic "HelloWorldTopic" at 1332618802.504593 s
```

In the window where you typed “1” (second choice), you will see output like this:

```
Please select among the available configurations:
0: MyParticipantLibrary::PublicationParticipant
1: MyParticipantLibrary::SubscriptionParticipant
Please select: 1
DataReader "HelloWorldReader" received sample 1 on Topic "HelloWorldTopic" sent at
1332618800.504111 s
sender: "Key: 521035021"
message: "String: 1"
count: 1
DataReader "HelloWorldReader" received sample 2 on Topic "HelloWorldTopic" sent at
1332618801.504341 s
sender: "Key: 521035021"
message: "String: 2"
count: 2
DataReader "HelloWorldReader" received sample 3 on Topic "HelloWorldTopic" sent at
1332618802.504593 s
sender: "Key: 521035021"
message: "String: 3"
count: 3
```

3.1.2 Examine the XML Configuration File

Let’s review the contents of the file **USER_QOS_PROFILES.xml** in the **<path to examples>/-prototyper/hello_world** directory.

```
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation="../../../resource/schema/rti_dds_profiles.xsd"
     version="6.0.0">
    <!-- QoS Library -->
    <qos_library name="qosLibrary">
        <qos_profile name="TransientDurability"
```

```
                  is_default_qos="true">
        <datawriter_qos>
            <durability>
               <kind>TRANSIENT_LOCAL_DURABILITY_QOS</kind>

            </durability>
            <reliability>
                <kind>RELIABLE_RELIABILITY_QOS</kind>
            </reliability>
            <history>
                <kind>KEEP_LAST_HISTORY_QOS</kind>
                <depth>20</depth>
            </history>
        </datawriter_qos>
        <datareader_qos>
            <durability>
                <kind>TRANSIENT_LOCAL_DURABILITY_QOS</kind>
            </durability>
            <reliability>
                <kind>RELIABLE_RELIABILITY_QOS</kind>
            </reliability>
            <history>
                <kind>KEEP_LAST_HISTORY_QOS</kind>
                <depth>10</depth>
            </history>
        </datareader_qos>
    </qos_profile>
</qos_library>

<!-- types -->
<types>
     <const name="MAX_NAME_LEN" type="long" value="64"/>
     <const name="MAX_MSG_LEN"  type="long" value="128"/>

     <struct name="HelloWorld">
         <member name="sender"  key="true"
                 type="string"  stringMaxLength="MAX_NAME_LEN"/>
         <member name="message"
                 type="string"  stringMaxLength="MAX_MSG_LEN"/>
         <member name="count"   type="long"/>
      </struct>
</types>

<!-- Domain Library -->
<domain_library name="MyDomainLibrary" >

    <domain name="HelloWorldDomain" domain_id="0">
        <register_type name="HelloWorldType" kind="dynamicData"
                       type_ref="HelloWorld" />

        <topic name="HelloWorldTopic"
               register_type_ref="HelloWorldType"/>
    </domain>
```

```
    </domain_library>

    <!-- Participant library -->
    <participant_library name="MyParticipantLibrary">

        <domain_participant name="PublicationParticipant"
                      domain_ref="MyDomainLibrary::HelloWorldDomain">

            <publisher name="MyPublisher">
                <data_writer name="HelloWorldWriter"
                             topic_ref="HelloWorldTopic">
                    <datawriter_qos name="HelloWorld_writer_qos"
                         base_name="qosLibrary::TransientDurability"/>
                </data_writer>
            </publisher>
        </domain_participant>

         <domain_participant name="SubscriptionParticipant"
              domain_ref="MyDomainLibrary::HelloWorldDomain">

            <subscriber name="MySubscriber">

                <data_reader name="HelloWorldReader"
                             topic_ref="HelloWorldTopic">
                    <datareader_qos name="HelloWorld_reader_qos"
                         base_name="qosLibrary::TransientDurability"/>
                </data_reader>
            </subscriber>
        </domain_participant>

    </participant_library>

</dds>
```

The configuration file contains four main sections:

- QoS definition section (**<qos_library>** tag)
- Type definition section (**<types>** tag).
- Domain definition section (**<domain_library>** tag)
- Participant definition section (**<participant_library>** tag)

The structure and syntax of the XML configuration file is identical to the one used for XML Application Creation. Please see the *RTI Connext DDS XML-Based Application Creation Getting Started Guide* for a detailed description of the format of the XML configuration file.

Examining the file we can see that it defines:

- A QoS library named **qosLibrary** that contains a QoS Profile named **TransientDurability**.
- A data type named **HelloWorld** with members **sender**, **message**, and **count**.
- A domain library named **MyDomainLibrary** containing a single domain named **HelloWorldDomain** with Topic **HelloWorldTopic**.
- A *DomainParticipant* library named **MyParticipantLibrary** that contains two **DomainParticipant configurations**, **PublicationParticipant** and **SubscriptionParticipant**:
  - The **PublicationParticipant** publishes the **HelloWorldTopic**
  - The **SubscriptionParticipant** subscribes to the **HelloWorldTopic**

These definitions correspond to the distributed application shown in Figure 3.1: Simple Scenario on page 8.

3.1.3 Default Behavior of Prototyper for the HelloWorld Application

Prototyper gets its configuration from a set of XML files. By default, *Prototyper* will look in the current working directory for a file named **USER_QOS_PROFILES.xml** and read it to determine the defined participant configurations and offer them as choices.

In this example, *Prototyper* found two participant configurations and offered them as choices on the command line: **MyParticipantLibrary::PublicationParticipant** and **MyParticipantLibrary::SubscriptionParticipant**.

You can control this behavior via the command-line options so that *Prototyper* reads a different file and/or automatically starts a particular participant configuration. For example, you can type the following on the command line to use **MyParticipantLibrary::PublicationParticipant**:

On UNIX-based systems:

```
<NDDSHOME>/bin/rtiddsprototyper
   -cfgName "MyParticipantLibrary::PublicationParticipant"
```

On VxWorks systems using RTP mode:

```
rtp exec <NDDSHOME>/lib/<architecture>/rtiddsprototyper.vx
   -cfgName "MyParticipantLibrary::PublicationParticipant"
```

On VxWorks systems using kernel mode:

```
taskSpawn "Test", 255, 0x8, 150000, rtiddsprototyper,
   "-cfgName MyParticipantLibrary::PublicationParticipant"
```

On Windows systems:

```
<NDDSHOME>\bin\rtiddsprototyper
   -cfgName "MyParticipantLibrary::PublicationParticipant"
```

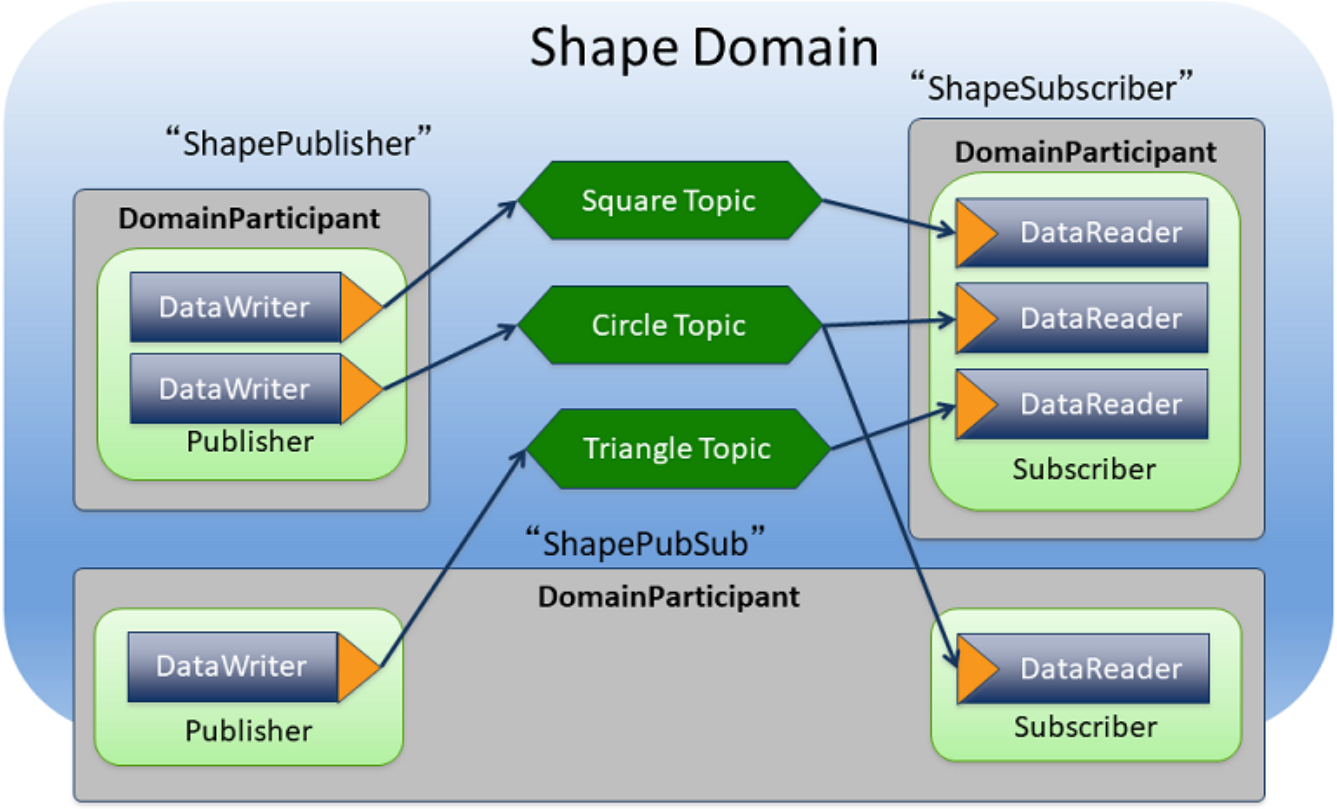
Please see 3.2 An Example using RTI Shapes Demo below for more details on *Prototyper*'s behavior and command-line options.

3.2 An Example using RTI Shapes Demo

The files for this example are in **<path to examples>/prototyper/shapes**.

This scenario defines three participant configurations, illustrated in Figure 3.2: Three DomainParticipants below: **ShapePublisher**, which writes to the Topics **Square** and **Circle**; **ShapeSubscriber**, which subscribes to the Topics **Square**, **Circle**, and **Triangle**; and **ShapePubSub**, which publishes the Topic **Triangle** and subscribes to the Topic **Circle**. The DDS *domain* is defined with the same Topics and datatypes used by *RTI Shapes Demo* such that it can be used in conjunction with it.

Figure 3.2: Three DomainParticipants



Shape Domain contains three participant configurations: ShapePublisher, ShapeSubscriber, and ShapePubSub

3.2.1 Run Prototyper

On UNIX-based systems:

Open three command-shell windows. In each one, change the directory to **<path to examples>/prototyper/shapes**. Then type the following command in each window:

```
<NDDSHOME>/bin/rtiddsprototyper
```

On VxWorks systems using RTP mode:

Open three command-shell windows (enter **cmd**). In each one, change directory to **<path to examples>/prototyper/shapes**. Then type the following command in each window:

```
rtp exec <NDDSHOME>/lib/<architecture>/rtiddsprototyper.vx
```

On VxWorks systems using kernel mode:

Open three command-shell windows (enter **cmd**). In each one, change directory to **<path to examples>/prototyper/shapes**.

Load all the libraries:

```
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscore.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddsc.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscpp.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/liblua.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/librtiddsconnectorlua.so
ld 1 < <NDDSHOME>/resource/app/bin/ppc604Vx6.9gcc4.3.3/rtiddsprototyper.so
```

Start *Prototyper*:

```
taskSpawn "Test", 255, 0x8, 150000, rtiddsprototyper, ""
```

You may see these errors:

```
Undefined symbol: RTIDefaultMonitor_create (binding 1 type 0)
ld error: Module contains undefined symbol(s) and may be unusable.
value = 0 = 0x0
```

These errors will not affect the execution if monitoring is disabled (the default case). To use monitoring, load the monitoring library right before the *Prototyper* library, **rtiddsprototype.so**. For details on configuring the monitoring library, please see the "RTI Monitoring Library" section of the *RTI Connext DDS Core Libraries User's Manual*. For details on using the RTI Monitor tool, please see the *RTI Monitor Getting Started Guide*.

On Windows systems:

Open three command-prompt windows. In each one, change the directory to **<path to examples>/prototyper/shapes**. Then type the following command in each window:

```
<NDDSHOME>\bin\rtiddsprototyper
```

You will see the following output appear on each window:

```
Please select among the available configurations:
0: MyParticipantLibrary::ShapePublisher
1: MyParticipantLibrary::ShapeSubscriber
```

```
2: MyParticipantLibrary::ShapePubSub
Please select:
```

If you do not see the above output and get the following error instead:

```
rtidsprototyper: Error configuration file not found.
```

This indicates that you did not run *rtiddsprototyper* from the right directory. Please change directories to the **<path to examples>/prototyper/shapes** directory and make sure you see a file named **USER_QOS_PROFILES.xml**.

If you see this output:

```
Use the -cfgName option to specify a participant configuration.
NddsProtyperAgent::run: Select participant configuration error
```

The above messages indicate that the operating system you are running on does not accept user input. Please use the **-cfgName** command-line argument to specify the desired participant configuration.

In the first window, type “0” (without the quotes) to select the first choice, followed by a return.

In the second window, type “1” (without the quotes) to select the second choice, also followed by a return.

In the third window, type “2”.

In the window where you typed “0” (first choice), you should see output like this:

```
Please select among the available configurations:
0: MyParticipantLibrary::ShapePublisher
1: MyParticipantLibrary::ShapeSubscriber
2: MyParticipantLibrary::ShapePubSub
Please select: 0

DataWriter "MySquareWriter" wrote sample 1 on Topic "Square" at 1332619432.759611 s
DataWriter "MyCircleWriter" wrote sample 1 on Topic "Circle" at 1332619432.759720 s
DataWriter "MySquareWriter" wrote sample 2 on Topic "Square" at 1332619433.759838 s
DataWriter "MyCircleWriter" wrote sample 2 on Topic "Circle" at 1332619433.759953 s
DataWriter "MySquareWriter" wrote sample 3 on Topic "Square" at 1332619434.760090 s
DataWriter "MyCircleWriter" wrote sample 3 on Topic "Circle" at 1332619434.760202 s
DataWriter "MySquareWriter" wrote sample 4 on Topic "Square" at 1332619435.760281 s
DataWriter "MyCircleWriter" wrote sample 4 on Topic "Circle" at 1332619435.760432 s
DataWriter "MySquareWriter" wrote sample 5 on Topic "Square" at 1332619436.760471 s
DataWriter "MyCircleWriter" wrote sample 5 on Topic "Circle" at 1332619436.760591 s
DataWriter "MySquareWriter" wrote sample 6 on Topic "Square" at 1332619437.760687 s
DataWriter "MyCircleWriter" wrote sample 6 on Topic "Circle" at 1332619437.760819 s
DataWriter "MySquareWriter" wrote sample 7 on Topic "Square" at 1332619438.760921 s
DataWriter "MyCircleWriter" wrote sample 7 on Topic "Circle" at 1332619438.761073 s
```

We can see it has two writers, **MySquareWriter** and **MyCircleWriter**; we should also see how at the periodic rate it writes two samples, one on each *DataWriter*. This is because the **ShapePublisher** configuration specified two writers: one for Square and one for Circle.

In the window where you typed “1” (second choice), you should see output similar to this:

```
Please select among the available configurations:
0: MyParticipantLibrary::ShapePublisher
```

```
1: MyParticipantLibrary::ShapeSubscriber
2: MyParticipantLibrary::ShapePubSub
Please select: 1

DataReader "MySquareRdr" received sample 4 on Topic "Square" sent at 1332619435.760281 s
color: "Key: 628974580"
x: 4
y: 4
shapesize: 4
DataReader "MyCircleRdr" received sample 4 on Topic "Circle" sent at 1332619435.760432 s
color: "Key: 1894519218"
x: 4
y: 4
shapesize: 4
DataReader "MySquareRdr" received sample 5 on Topic "Square" sent at 1332619436.760471 s
color: "Key: 628974580"
x: 5
y: 5
shapesize: 5
DataReader "MyCircleRdr" received sample 5 on Topic "Circle" sent at 1332619436.760591 s
color: "Key: 1894519218"
x: 5
y: 5
shapesize: 5
DataReader "MyTriangleRdr" received sample 2 on Topic "Triangle" sent at 1332619437.609176 s
color: "Key: 333582338"
x: 2
y: 2
shapesize: 2
DataReader "MySquareRdr" received sample 6 on Topic "Square" sent at 1332619437.760687 s
color: "Key: 628974580"
x: 6
y: 6
shapesize: 6
DataReader "MyCircleRdr" received sample 6 on Topic "Circle" sent at 1332619437.760819 s
color: "Key: 1894519218"
x: 6
y: 6
shapesize: 6
DataReader "MyTriangleRdr" received sample 3 on Topic "Triangle" sent at 1332619438.609384 s
color: "Key: 333582338"
x: 3
y: 3
shapesize: 3DataReader "MySquareRdr" received sample 7 on Topic "Square" sent at
1332619438.760921 s
color: "Key: 628974580"
x: 7
y: 7
shapesize: 7
DataReader "MyCircleRdr" received sample 7 on Topic "Circle" sent at 1332619438.761073 s
color: "Key: 1894519218"
x: 7
y: 7
shapesize: 7
DataReader "MyTriangleRdr" received sample 4 on Topic "Triangle" sent at 1332619439.609556 s
color: "Key: 333582338"
```

```
x: 4
y: 4
shapesize: 4
```

We see that initially it is receiving samples “Key: 628974580” of Topic Square, and “Key: 1894519218” of Topic Circle. After a while, it also starts receiving samples with “Key: 333582338” of Topic Triangle.

Note that depending on the relative timing when your applications start, the results you see may differ from this.

The reason for this is that the **ShapeSubscriber** configuration subscribes to Square, Circle, and Triangle. Initially we had only started the **ShapePublisher** configuration, which just publishes samples “Key: 628974580” on Topic Square and “Key: 1894519218” on the Topic Circle. After a little while, we started the **ShapePubSub**” configuration which publishes samples of the Topic Triangle with the key “Key: 333582338”.

In the window where you typed “2” (third choice), you should see output similar to this:

```
Please select among the available configurations:
0: MyParticipantLibrary::ShapePublisher
1: MyParticipantLibrary::ShapeSubscriber
2: MyParticipantLibrary::ShapePubSub
Please select: 2

DataWriter "MyTriangleWr" wrote sample 1 on Topic "Triangle" at 1332619436.608954 s
DataReader "MyCircleRdr" received sample 5 on Topic "Circle" sent at 1332619436.760591 s
color: "Key: 1894519218"
x: 5
y: 5
shapesize: 5

DataWriter "MyTriangleWr" wrote sample 2 on Topic "Triangle" at 1332619437.609176 s
DataReader "MyCircleRdr" received sample 6 on Topic "Circle" sent at 1332619437.760819 s
color: "Key: 1894519218"
x: 6
y: 6
shapesize: 6

DataWriter "MyTriangleWr" wrote sample 3 on Topic "Triangle" at 1332619438.609384 s
DataReader "MyCircleRdr" received sample 7 on Topic "Circle" sent at 1332619438.761073 s
color: "Key: 1894519218"
x: 7
y: 7
shapesize: 7
```

We initially see that it is writing data on the Topic Triangle *and* receiving data on the Topic Circle. The only values on Topic Circle are the ones from the **ShapePublisher**, which is only writing samples with the key “Key: 1894519218”.

Depending on the relative timing in which you started your applications your results may differ from these.

If you look carefully at the output of the **ShapeSubscriber** and **ShapePubSub** configurations, you may notice that they do not receive the first samples that are published by the **ShapePublisher** configuration.

You should not be too concerned about this. It is because the default Quality of Service (QoS) settings used in this scenario specify that the data should only be sent to the readers that are present at the time the data is sent (this is known as VOLATILE Durability). It can be easily changed; that is in fact what the QoS profile used in the did.

3.2.2 Examine the XML Configuration File

Let's review the content of **USER_QOS_PROFILES.xml** in the **<path to examples>/-prototyper/shapes** directory.

```
<!--
RTI Connext DDS Deployment
-->
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation="../../../resource/schema/rti_dds_profiles.xsd"
     version="6.0.0">

    <!-- QoS Library -->
    <qos_library name="qosLibrary">
        <qos_profile name="defaultProfile" is_default_qos="true">
        </qos_profile>
    </qos_library>

    <!-- types -->
    <types>
         <const name="MAX_COLOR_LEN" type="long" value="32"/>

         <struct name="ShapeType"
             <member name="color" key="true"
                      type="string" stringMaxLength="MAX_COLOR_LEN"/>
             <member name="x" type="long"/>
             <member name="y" type="long"/>
             <member name="shapesize" type="long"/>
         </struct>
    </types>

    <!-- Domain Library -->
    <domain_library name="MyDomainLibrary" >

        <domain name="ShapeDomain" domain_id="0">
            <register_type name="ShapeType" kind="dynamicData"
                           type_ref="ShapeType" />

            <topic name="Square"   register_type_ref="ShapeType"/>
            <topic name="Circle"   register_type_ref="ShapeType"/>
            <topic name="Triangle" register_type_ref="ShapeType"/>

        </domain>
    </domain_library>

    <!-- Participant library -->
```

```
    <participant_library name="MyParticipantLibrary">

        <!-- 1st participant: publishes Square and Circle
        -->
        <domain_participant name="ShapePublisher"
                            domain_ref="MyDomainLibrary::ShapeDomain">

            <publisher name="MyPublisher">
                <data_writer name="MySquareWriter" topic_ref="Square"/>
                <data_writer name="MyCircleWriter" topic_ref="Circle"/>
            </publisher>
        </domain_participant>

        <!-- 2nd participant: subscribes Square, Circle, and Triangle
        -->
        <domain_participant name="ShapeSubscriber"
                             domain_ref="MyDomainLibrary::ShapeDomain">

            <subscriber name="MySubscriber">
                <data_reader name="MySquareRdr"   topic_ref="Square"/>
                <data_reader name="MyCircleRdr"   topic_ref="Circle"/>
                <data_reader name="MyTriangleRdr" topic_ref="Triangle"/>
            </subscriber>
        </domain_participant>

        <!-- 3rd participant: publishes Triangle and subscribes Circle
        -->
        <domain_participant name="ShapePubSub"
                             domain_ref="MyDomainLibrary::ShapeDomain">

            <publisher name="MyPublisher">
                <data_writer name="MyTriangleWr" topic_ref="Triangle"/>
            </publisher>

            <subscriber name="MySubscriber">
                <data_reader name="MyCircleRdr"  topic_ref="Circle"/>
            </subscriber>
        </domain_participant>

    </participant_library>
</dds>
```

Similar to what we saw in the HelloWorld example, the configuration file contains four main sections:

- QoS definition section (<qos_library> tag).
- Type definition section (<types> tag).
- Domain definition section (<domain> tag).
- Participant definition section (<participant_library> tag).

The structure and syntax of the XML configuration file is identical to the one used for XML-Based Application Creation. See the *RTI Connext DDS XML-Based Application Creation Getting Started Guide* for a detailed description of the format of the XML configuration file.

Examining the file, we can see that it defines:

- A QoS library, **qosLibrary**, containing a single QoS Profile, **defaultProfile** .
- A data type ShapeType with fields **color**, **x**, **y**, and **shapesize**.
- A domain library, **MyDomainLibrary**, containing a single domain, **ShapeDomain**, with topics Square, Circle, and Triangle. All these topics use the same registered data type, **ShapeType**.
- A DomainParticipant library, **MyParticipantLibrary**, containing three **DomainParticipant** configurations: **ShapePublisher**, **ShapeSubscriber**, and **ShapePubSub**.
    - The **ShapePublisher** configuration publishes the topics Square and Circle.
    - The **ShapeSubscriber** configuration subscribes to topics Square, Circle, and Triangle.
    - The **ShapePubSub** configuration publishes topic Triangle and subscribes to topic Circle.

These definitions correspond to the distributed application shown in Figure 3.2: Three DomainParticipants on page 14.

3.3 Lua Scripting Example

The files for this example are in the directory **<path to examples>/prototyper/lua**. The configuration for this example is in the file **USER_QOS_PROFILES.xml**.

This scenario defines three participant configurations, illustrated in Figure 3.3: Overview of Lua Scripting Example on page 23: ShapePublisher, which writes to the Topics Square, Circle, and Triangle; ShapeSubscriber, which subscribes to the Topics Square, Circle, and Triangle; and ShapePubSub, which subscribes and publishes the Topics Square, Circle, and Triangle. The DDS domain is defined with the same Topics and data-types used by *RTI Shapes Demo* so that it can be used in conjunction with it.

To run the example open a shell, change to **<path to examples>/prototyper/lua** and run the command (all on one line):

On UNIX-based systems:

```
.<NDDSHOME>/bin/rtiddsprototyper
        -cfgName MyParticipantLibrary::ShapePublisher
        -luaFile shapes/Flower.lua -period 0.01
```

On VxWorks systems using RTP mode:

```
rtp exec <NDDSHOME>/lib/<architecture>/rtiddsprototyper.vx
        -cfgName MyParticipantLibrary::ShapePublisher
        -luaFile shapes/Flower.lua -period 0.01
```

On VxWorks systems using kernel mode:

Load all the libraries:

```
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscore.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddsc.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscpp.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/liblua.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/librtiddsconnectorlua.so
ld 1 < <NDDSHOME>/resource/app/bin/ppc604Vx6.9gcc4.3.3/rtiddsprototyper.so
```

Start *Prototyper*:

```
taskSpawn "Test", 255, 0x8, 150000, rtiddsprototyper,
        "-cfgName MyParticipantLibrary::ShapePublisher
         -luaFile shapes/Flower.lua -period 0.01"
```

You may see these errors:

```
Undefined symbol: RTIDefaultMonitor_create (binding 1 type 0)
ld error: Module contains undefined symbol(s) and may be unusable.
value = 0 = 0x0
```

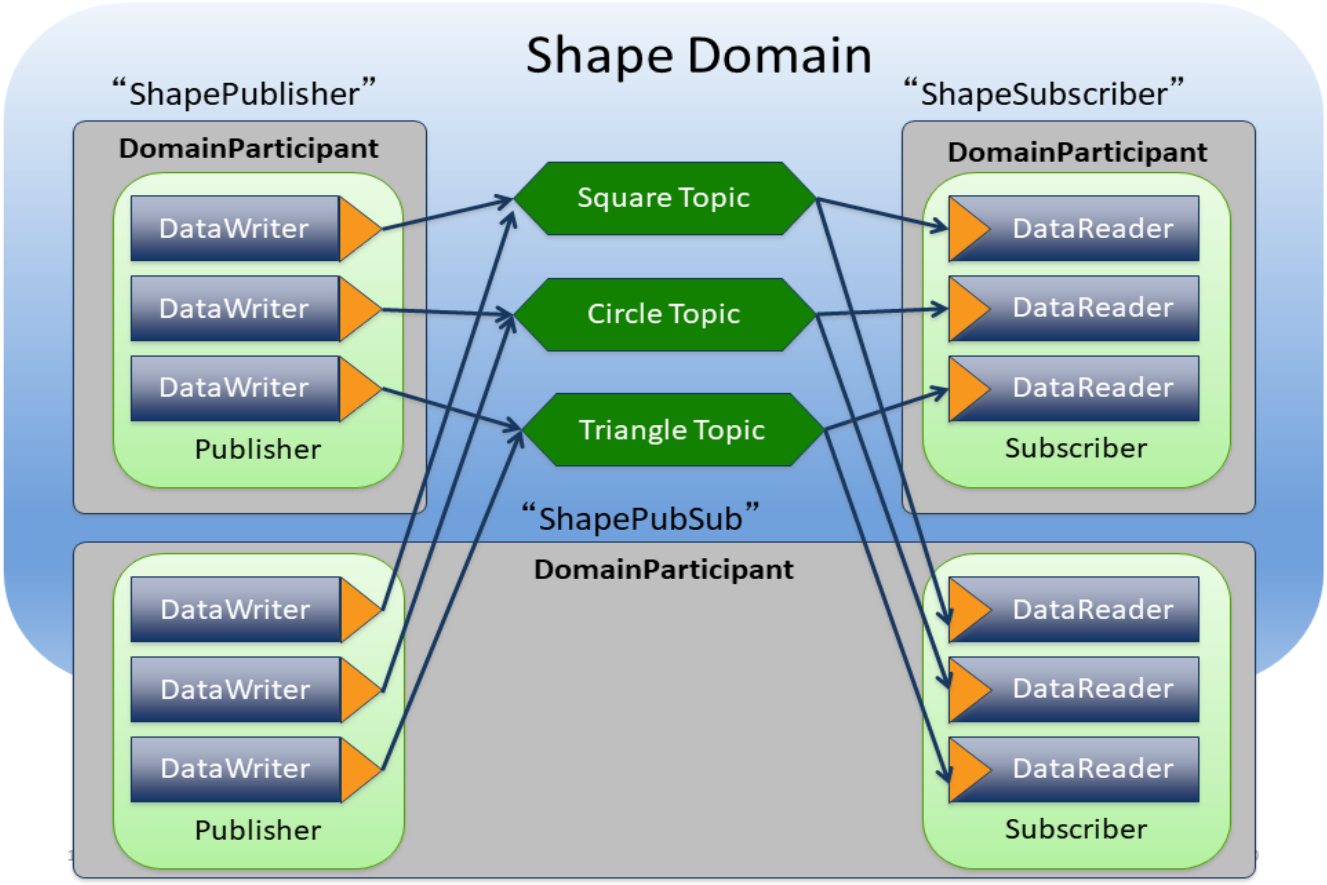
These errors will not affect the execution if monitoring is disabled (the default case). To use monitoring, load the monitoring library right before the *Prototyper* library, **rtiddsprototype.so**. For details on configuring the monitoring library, please see the "RTI Monitoring Library" section of the *RTI Connext DDS Core Libraries User's Manual*. For details on using the RTI Monitor tool, please see the *RTI Monitor Getting Started Guide*.

On Windows systems:

```
<NDDSHOME>\bin\rtiddsprototyper
        -cfgName MyParticipantLibrary::ShapePublisher
        -luaFile shapes\Flower.lua -period 0.01
```

The selected configuration creates *DataWriters* for topics Square, Circle, Triangle in DDS domain 0. It also loads and executes the Lua script named **shapes/Flower.lua**. The script is executed when the timer trigger occurs: periodically every 0.01s.

Figure 3.3: Overview of Lua Scripting Example



3.3.1 Run Prototyper with Lua

Start the *RTI Shapes Demo* application.

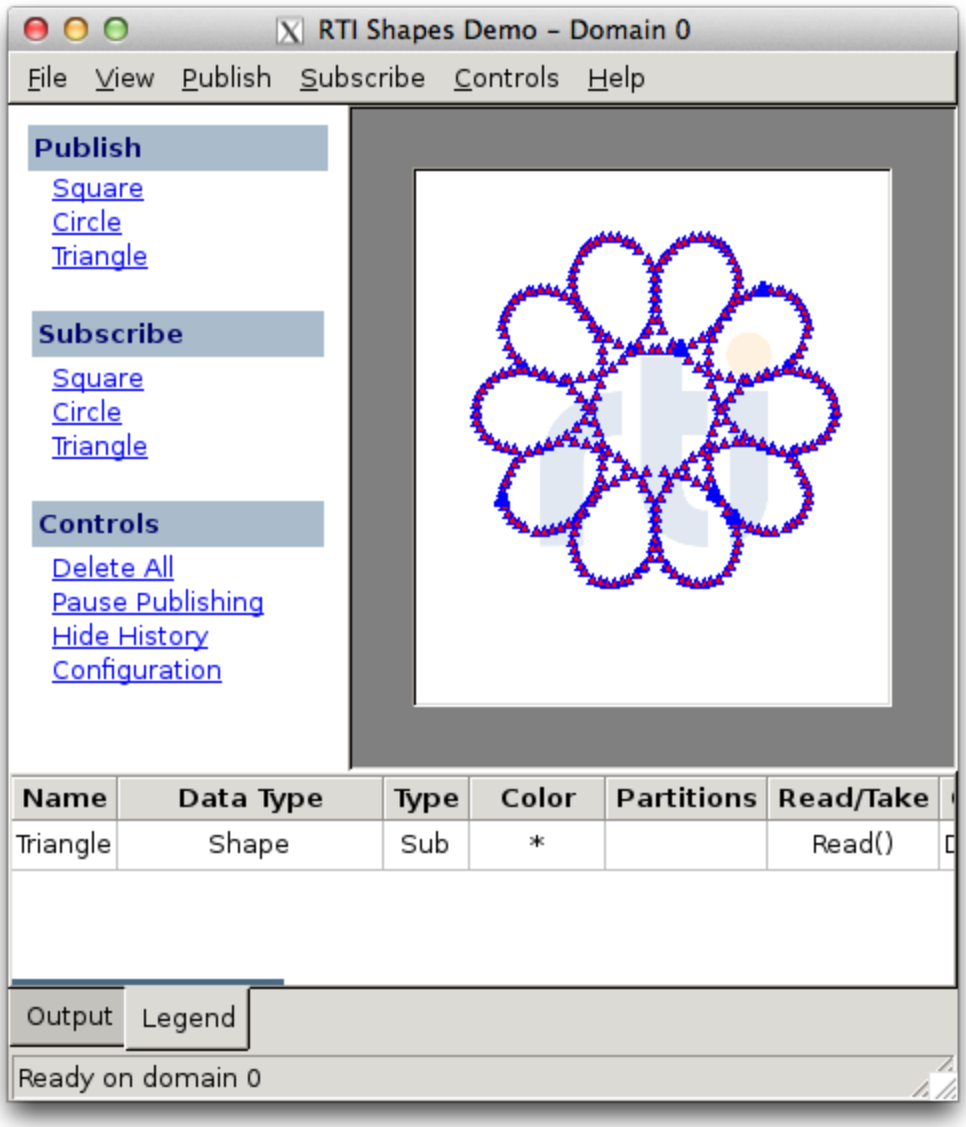
To start *RTI Shapes Demo,* open *RTI Launcher*, select the **Learn** tab and click on the **Shapes Demo** icon.

Or to start it from a command prompt:

```
<NDDSHOME>/bin/rtishapesdemo
```

Subscribe to Triangles with a History depth of 500.

You should see a flower appearing in the *Shapes Demo* window:



Open the **shapes/Flower.lua** script in an editor.

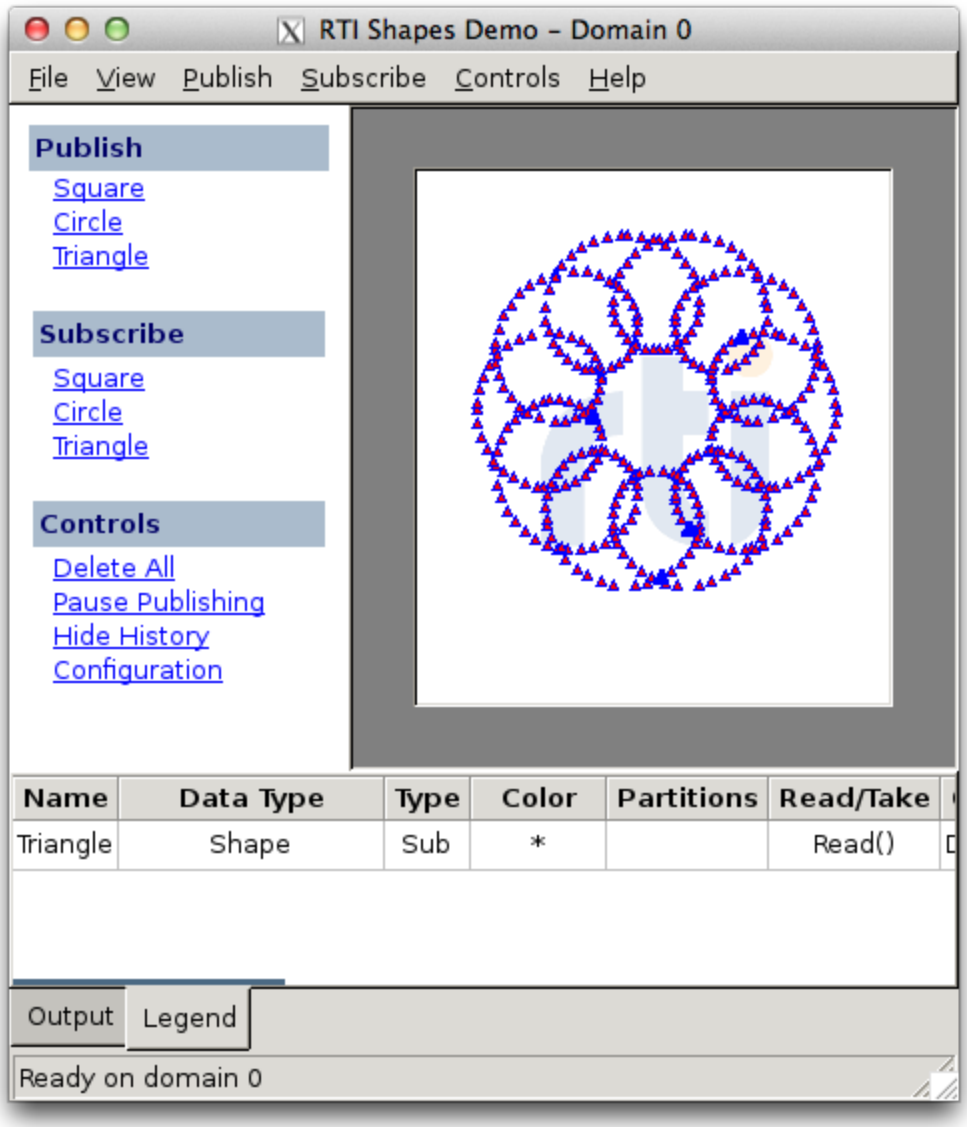
```
1. -- Interface: parameters, inputs, outputs
2.  local  A, B, C = 30, 30, 10  -- Change 'C' parameter to see various flower shapes
3.  local  ShapeWriter = CONTAINER.WRITER[3] -- Triangles
4.
5.  -- Global counter (preserved across invocations)
6.  if  not  count  then  count = 0  else  count = count + 1 end
7.
8.  local  shape = ShapeWriter.instance;
9.  local  angle = count % 360;
10.
11.  shape['x'] = 120 + (A+B) * math.cos(angle) + B * math.cos((A/B-C)*angle)
12.  shape['y'] = 120 + (A+B) * math.sin(angle) + B * math.sin((A/B-C)*angle)
13.
14.  shape['shapesize'] = 5
15.  shape['color'] = "RED"
16.
```

```
17.  ShapeWriter:write()
```

- Lines 2-3 specify the interface of the Lua code component in terms of the parameters, the inputs and outputs. In this example, there are three parameters (A, B, C on Line 2), no inputs, and one output (Line 3).
- Line 6 initializes a global counter that is incremented each time the Lua script runs. Lua global variables are preserved across the invocations of the script. The rtiddsprototyper will call the script periodically at the rate specified by the **–period** command-line argument (or a default of 1 second if this command-line argument is not specified).
- Lines 8-9 set local variables to make the code more readable.
- Lines 11-15 set the different attributes on the shape data-object bound to the *DataWriter* per the formula to create a flower.
- Line 17 performs the write operation, which will publish the updates shape over DDS.

Using the code editor, change the value of the parameter C on Line 2 to -10 and save the file.

Watch the flower change in real-time. Try different values of C to see various flower shapes.



Note that *Prototyper* does not need to be restarted to change the Lua code being executed. This shows the *Dynamic Code Editing* capabilities to create real-time behavior changes.

Chapter 4 Using Prototyper's Command-Line Options

Prototyper is a command-line tool. You can control its behavior via command-line options. You can invoke *Prototyper* with the **-help** option to see a list of the valid options and a short summary of each:

On UNIX-based systems:

```
<NDDSHOME>/bin/rtiddsprototyper -help
```

On VxWorks systems using RTP mode:

```
rtp exec <NDDSHOME>/bin/rtiddsprototyper.vx -help
```

On VxWorks systems using kernel mode:

```
cd <NDDSHOME>
```

Load all the libraries:

```
ld 1 < lib/ppc604Vx6.9gcc4.3.3/libnddscore.so
ld 1 < lib/ppc604Vx6.9gcc4.3.3/libnddsc.so
ld 1 < lib/ppc604Vx6.9gcc4.3.3/libnddscpp.so
ld 1 < lib/ppc604Vx6.9gcc4.3.3/liblua.so
ld 1 < lib/ppc604Vx6.9gcc4.3.3/librtiddsconnectorlua.so
ld 1 < resource/app/bin/ppc604Vx6.9gcc4.3.3/rtiddsprototyper.so
```

Start *Prototyper*:

```
taskSpawn "Test", 255, 0x8, 150000, rtiddsprototyper, "-help"
```

You may see these errors:

```
Undefined symbol: RTIDefaultMonitor_create (binding 1 type 0)
ld error: Module contains undefined symbol(s) and may be unusable.
value = 0 = 0x0
```

These errors will not affect the execution if monitoring is disabled (the default case). To use

monitoring, load the monitoring library right before the *Prototyper* library, **rtiddsprototype.so**. For details on configuring the monitoring library, please see the "RTI Monitoring Library" section of the *RTI Connext DDS Core Libraries User's Manual*. For details on using the RTI Monitor tool, please see the *RTI Monitor Getting Started Guide*.

On Windows systems

```
<NDDSHOME>\bin\rtiddsprototyper -help
```

The command-line options are summarized in Table 4.1 Command-Line Options.

Note: Command-line options override the corresponding setting, if any, specified in the configuration file.

Table 4.1 Command-Line Options

Option	Values	Purpose
-appId	<integer>	Sets the application ID used by the *DomainParticipant* created by *Prototyper*. Example: -appId 0x12345678
-cfgFile	<string>	Specifies the path to an XML file that *Prototyper* should parse to look for participant configurations. Example: -cfgFile ShapeDemoConfig.xml
-cfgName	<string>	Specifies the name of the configuration that describes the *DomainParticipant* that will be created by *Prototyper*. The configuration name must correspond to one of the participant configurations in the XML files loaded by *Prototyper*. Example: -cfgName ParticipantLibrary::ShapePublisher
-disableDataFill	N/A	Instructs *Prototyper* that is should *not* set the values of the data written. In this situation, the values written are the ones that correspond to the data as initialized by the corresponding TypeSupport factory. Typically this sets all scalar values to zero, sequences to zero length, and strings to empty. **NOTE:** This setting is ignored when using Lua scripting. Example: -disableDataFill
-domainId	<integer>	Domain ID to be used. If specified, it is used instead of the domain ID specified in the XML. Default = value specified in the XML. Example: -domainId 23
-help	N/A	Prints a summary of the options available. Example: -help
-luaFile	<string>	Lua script file to load and execute
-luaFileInterval	<float>	*Prototyper* will check the Lua script file for changes every n seconds. If n is negative, Prototyper will not try to reload the lua script file.
-luaOnData	<boolean>	Execute the Lua code upon data arrival
-luaOnStart	<boolean>	Execute the Lua code on start up
-luaOnStop	<boolean>	Execute the Lua code just before terminating *Prototyper*

Table 4.1 Command-Line Options

Option	Values	Purpose
-luaOnPeriod	<boolean>	Execute the Lua code because the time interval specified by -period has elapsed
-par-ticipantName	<string>	Specifies the name used for the participant. It will be propagated in the DomainParticipant QoS within the ENTITY_NAME QoS Policy. Example: -participantName MyShapePrototype
-period	<float>	If Lua scripting is being used, indicates the period, in seconds, at which the Lua script executes (see Figure 5.1: Workflow of RTI Prototyper with Lua on page 31) If Lua scripting is not used, indicates the period in seconds at which data is sent (see Figure 5.2: Workflow of RTI Prototyper without Lua on page 32). Each period, one sample will be written on each *DataWriter* within the *DomainParticipant*. Example: -period 1.5
-runDuration	<float>	Indicates the total time in seconds that *Prototyper* will run. After this time elapsed *Prototyper* will exit. Example: -runDuration 100
-verbosity	<integer>	Sets the verbosity level. Example: -verbosity 2
-version	N/A	Print the version of the *Connext DDS* core libraries used. Example: -version

Chapter 5 Understanding Prototyper

Prototyper is an application-development tool whose purpose is to facilitate the rapid development and scenario testing of Connext DDS applications. Using *Prototyper,* an application developer or system integrator can quickly answer questions related to the performance of applications such as:

- How does the application architecture map to DDS?
- How does the distributed application perform functionally?
- How big will applications be if they create a certain number of *DataWriters* and *DataReaders* publishing and subscribing to certain Topics with specified data-types?
- How much CPU will a specific application consume on a particular hardware platform when publishing data to a set of subscribers under a concrete scenario?
- How long it would take for discovery to occur given a set of computers which a publishing and subscribing certain Topics?
- How does a choice of data model or QoS work for the application?
- How are some of these answers affected by changing QoS settings?

5.1 Workflow

Internally, *Prototyper* executes the workflow shown in Figure 5.1: Workflow of RTI Prototyper with Lua on the next page when used with Lua:

Figure 5.1: Workflow of RTI Prototyper with Lua

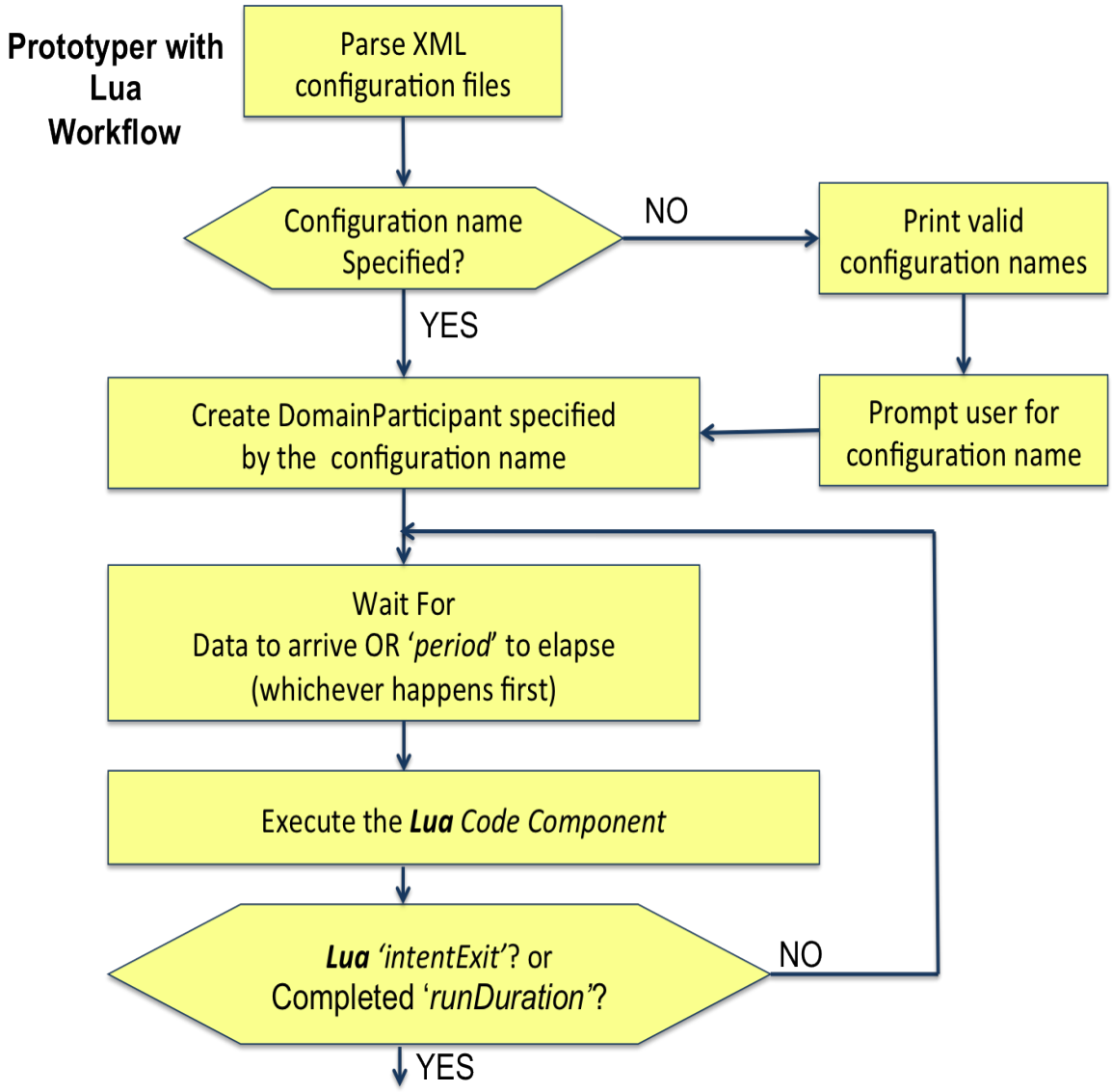
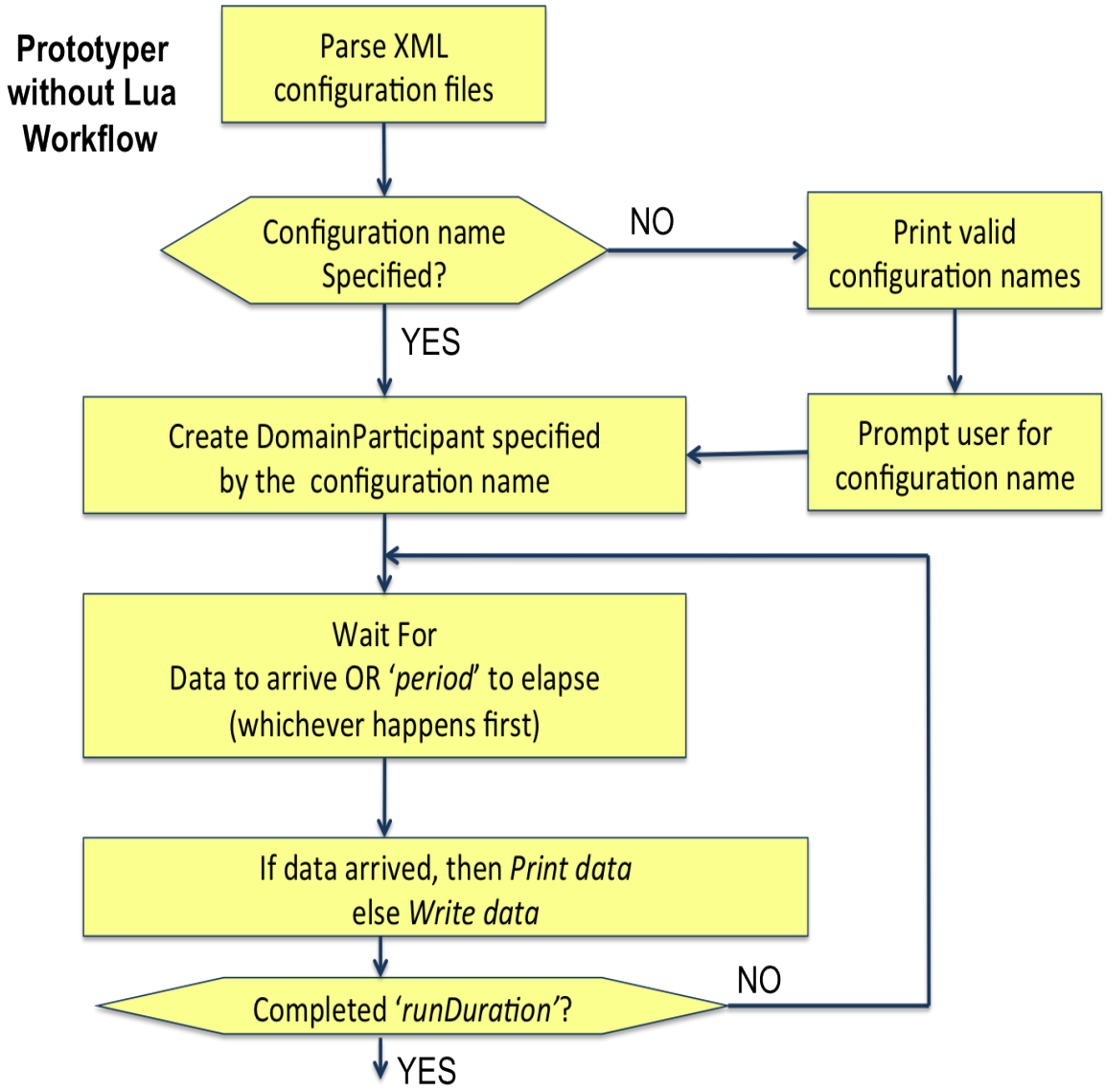


Figure 5.2: Workflow of RTI Prototyper without Lua on the facing page shows the workflow without Lua.

Figure 5.2: Workflow of RTI Prototyper without Lua



The most important aspects of the workflow are:

- *Prototyper* creates a single *DomainParticipant* identified by its configuration name. All DDS Entities within the *DomainParticipant* are automatically created.
- *Prototyper* installs a Waitset with a timeout of 'period' and attaches a StatusCondition on DATA_AVAILABLE_STATUS for each of the *DataReader* entities within the *DomainParticipant*. Whenever data arrives or the period expires, the Waitset unblocks for execution.
- *Prototyper* creates data objects for each *DataWriter* within the *DomainParticipant*.
- When Lua is used, the Lua Code Component determines the behavior.

- When Lua is not used:
  - *Prototyper* prints the received data on each of the *DataReader* entities.
  - If there is no data, *Prototyper* periodically writes data using each *DataWriter* within the *DomainParticipant*. The content of the data is modified each time the data is written. By default, *Prototyper* uses an internal algorithm which cycles through a range of values consistent with the data type. This behavior can be changed, as described in 9.2.3 Controlling the Data Values Written by Prototyper on page 74.

5.2 Configuration Files Parsed by Prototyper

By default, *Prototyper* looks in the standard location for XML QoS Profile files and loads them if they are found. (See Configuring QoS with XML, in the RTI Connext DDS Core Libraries User's Manual.) The XML QoS Profile files can contain participant configurations as well.

These locations are:

- **$NDDSHOME/resource/qos_ profiles_6.x.y/xml/NDDS_ QOS_ PROFILES.xml**

  This file is loaded automatically if it exists (not the default) and ignore_resource_profile in the PROFILE QosPolicy is FALSE (the default). **NDDS_ QOS_PROFILES.xml** does not exist by default. However, **NDDS_QOS_PROFILES.example.xml** is shipped with the host bundle of the product; you can copy it to **NDDS_QOS_PROFILES.xml** and modify it for your own use. The file contains the default QoS values that will be used for all entity kinds. (First to be loaded)
- File specified in the **NDDS_QOS_PROFILES** Environment Variable

  The files (or XML strings) separated by semicolons referenced in this environment variable, if any, are loaded automatically. These files are loaded after the **NDDS_QOS_PROFILES.xml** and they are loaded in the order they appear listed in the environment variable.
- **<working directory>/USER_QOS_PROFILES.xml**

  This file is loaded automatically if it exists in the 'working directory' of the application, that is, the directory from which the application is run. This file is loaded last.

In addition, *Prototyper* will load the XML file specified by the command-line option **-cfgFile** (see 3.2 An Example using RTI Shapes Demo on page 14).

Prototyper will look for participant configurations in all these files. *Prototyper* will exit, printing an error message if no participant configurations are found, or if the participant configuration specified by the command-line option, **-cfgName**, is not found within the loaded files.

Chapter 6 Configuring Prototyper Behavior Using Lua

Prototyper allows arbitrary behavior to be associated with of the application structure defined in the XML configuration. Custom behavior can be defined using the Lua programming language, thus making it possible to create sophisticated applications that process data of the fly.

Configuring *Prototyper* to use Lua Scripting is straightforward. All you have to do is specify the Lua code to be executed and the triggers that specify when the code is to be executed.

6.1 Specifying the Lua Code

The Lua code may be specified on the command line when invoking *Prototyper* or as a property on a *DomainParticipant* in the XML configuration file. The settings for specifying the code are listed in Table 6.1 Command-Line Arguments and DomainParticipant Properties for Using Lua.

Table 6.1 Command-Line Arguments and DomainParticipant Properties for Using Lua

Command-Line Argument	DomainParticipant Property	Possible Values	Description
N/A	lua.script	A chunk of Lua code	A block of Lua code to execute.
-luaFile	lua.file	A file (path) name	An additional chunk of Lua code to execute, stored in a file. Default: empty
-luaFileInterval	N/A	*n* (default 10 sec)	*Prototyper* will check the script file for changes every *n* seconds. If *n* is negative, *Prototyper* will not try to reload the file

Prototyper looks for Lua code to execute in the following places, in the following order:

1. A lua script embedded in the XML configuration file, specified as the value of the **lua.script** property on a *DomainParticipant*.

2. A lua file:
    a. Specified using the command line option **–luaFile** <*filename*>
    b. Or, if **–luaFile** is not specified on the command line, a property called **lua.file** on the selected *DomainParticipant*, specified in the XML configuration file.

Note that both an embedded script and a file may be specified. The embedded script specified in the XML is always executed before the external file. Together, the two Lua chunks form the code block executed by the Lua engine when execution is triggered.

Here an example of the **lua.script** property:

```
....
<domain_participant name="ShapeSubscriber"
                    domain_ref="MyDomainLibrary::ShapeDomain">
     <participant_qos>
       <property>
           <value>
               <element>
                   <name>lua.script</name>
                   <value>
                        for  name,reader  in  pairs(CONTAINER.READER) do
                            reader:take()
                            for  i  = 1, #reader.samples do
                                print(name, "color:",
                                          reader.samples[i]['color'])
                            end
                        end
                   </value>
               </element>
           </value>
       </property>
</participant_qos>
```

The same script can be specified in a file referenced by the **lua.file** property:

```
...
<domain_participant name="ShapeSubscriber"
                                    domain_ref="MyDomainLibrary::ShapeDomain">
    <participant_qos>
        <property>
            <value>
                <element>
                    <name>lua.file</name>
                    <value>script.lua</value>
                </element>
            </value>
        </property>
    </participant_qos>
```

6.2 Lua Execution Triggers

The Lua code is executed when certain triggers happen.

An execution trigger may be specified as a property on a *DomainParticipant* in the XML configuration file, or on the command line when invoking *Prototyper*. The command line settings override those specified as a *DomainParticipant* property. When an execution trigger is specified both as a property and on the command line, the setting specified on the command line is used.

The execution triggers are listed below, including the default values in **bold**.

Table 6.2 Lua Execution Triggers

Command-Line Argument	DomainParticipant Property	Possible Values	Description
-luaOnStart	lua.onStart	**true** | false	Execute the code on startup
-luaOnStop	lua.onStop	**true** | false	Execute the code just before terminating Prototyper
-luaOnData	lua.onData	**true** | false	Execute the code upon data arrival
-luaOnPeriod	lua.onPeriod	**true** | false	Execute the code because the time interval specified by -period has elapsed

Chapter 7 Lua Component Programming Model

Prototyper is a container for the Lua engine.

All the information related to the execution state of *Prototyper* and all the references to the DDS entities created by *Prototyper* from the XML configuration are mapped and organized into a Lua global *container* table called **PROTOTYPER**. *Prototyper* also defines a global variable called 'CONTAINER' to reference the logical container table. Thus:

```
CONTAINER = PROTOTYPER
```

In the examples below, we use logical container names. The global container table contains three tables, described below.

Member Name	Description	Usage: Example Lua Code
	Container	

WRITER	A **sequence** to access all the configured *DataWriter* entities and their data	`print("WRITER:")`
		`local WRITER = CONTAINER.WRITER`
		`for name,writer in pairs(WRITER)`
		`do`
		`  print(name, writer)`
		`end`

READER	A **sequence** to access all the configured *DataReader* entities and their data	`print("READER:")`
		`local READER = CONTAINER.READER`
		`for name,reader in pairs(READER)`
		`do`
		`  print(name, reader)`
		`end`

CONTEXT	A table containing variables that represent the state of the container (*Prototyper*) at each specific execution. It can also be used to indicate intentions of the Lua code to the container (*Prototyper*).	`print("CONTEXT")`
		`local CONTEXT = CONTAINER.CONTEXT`
		`for name,value in pairs(CONTEXT)`
		`do`
		`  print(name, value)`
		`end`

The above example Lua code fragments are here: **<path to examples>/prototyper/lua/generic/tables.lua**

You can examine the contents for a given configuration using the **–luaFile generic/tables.lua** command-line option to *Prototyper*. For example, on a UNIX-based system:

```
cd <path to examples>/prototyper/lua/
<NDDSHOME>/bin/rtiddsprototyper -luaFile generic/tables.lua
```

7.1 WRITER API

Each *DataWriter* declared in the XML configuration is automatically added into a Lua table called WRITER that is stored into the global container table.

If your XML configuration declares a *DataWriter* called HelloWriter belonging to the publisher called HelloPublisher you can access to it by name:

```
local hello_writer = CONTAINER.WRITER['HelloPublisher::HelloWriter']
```

It's also possible access a *DataWriter* by index. The index, starts from 1 and it is a number that represent the *DataWriter* creation order:

```
local hello_writer = CONTAINER.WRITER[1]
```

It is important to note that the writer obtained is still a Lua table.

The writer-side Lua API is summarized in the table below.

Item	Description	Usage: Example Lua Code
	Container	

foo	Identifies a specific writer in the container's WRITER table. Possible values include:
	The fully qualified name of a *DataWriter* in the XML configuration file.
	The index of a *DataWriter* defined by creation order.
		`local foo = 'HelloPublisher::HelloWriter'`
		-- or --
		`local foo = 1`

	Entity	
foo_writer	A (table) member of the WRITER table representing the underlying writer endpoint entity identified by 'foo'.	`local foo_writer = WRITER[foo]`
	Data	

foo_writer-.instance	The data-object or instance associated with 'foo_writer.'
	The instance is represented as a Lua table. Lua application code can use this data-object. For details, see 7.4 Data Access API on page 43
		`foo_writer.instance['x'] = 100`
		`foo_writer.instance['y'] = 100`
		`foo_writer.instance['shapesize'] = 30`
		`foo_writer.instance['color'] = "BLUE"`

	Operations	
foo_writer:clear_members()	Clears the contents of all data members of the object associated with foo_writer, including key members	`foo_writer:clear_members()`

Item	Description	Usage: Example Lua Code
foo_writer:write()	Updates **foo_writer.instance** in the data space	`foo_writer:write()`
foo_writer-:dispose()	Disposes **foo_writer.instance** in the data space	`foo_writer:dispose()`
foo_writer-:unregister()	Unregisters **foo_writer.instance** in the data space	`foo_writer:unregister()`

7.2 READER API

Each *DataReader* declared in the XML configuration is automatically added into a Lua table called READER that is stored into the global container table.

If your XML configuration declares a *DataReader* called HelloReader belonging to the subscriber called HelloSubscriber you can access to it by name:

```
local hello_reader = CONTAINER.READER['HelloSubscriber::HelloReader']
```

It's also possible to access a *DataReader* by index. The index starts at 1 and is a number that represent the *DataReader* creation order:

```
local hello_reader = CONTAINER.READER[1]
```

It is important to note that the reader obtained is still a Lua table.

The reader-side Lua API is summarized in the table below.

Item	Description	Usage: Example Lua Code
	Container	

foo	Identifies a specific reader in the container's READER table. Possible values include:
	• The fully qualified name of a *DataReader* in the XML configuration file
	• The index of a *DataReader* defined by creation order.
		`local foo = 'HelloPublisher::HelloReader'`
		-- or --
		`local foo = 1`

	Entity	
foo_reader	A (table) member of the READER table representing the underlying reader endpoint entity identified by 'foo'.	`local foo_reader = READER[foo]`
	Data	
#foo_reader.infos #foo_reader.samples	Number of infos or samples. The **samples** and **infos** sequences populated by the **take()** or **read()** operations and guaranteed to have the same length.	`print("Number of infos:", #foo_reader.infos)` `print("Number of samples:",#foo_reader.samples)`

Item	Description	Usage: Example Lua Code

foo_reader.infos	A read-only sequence of sample information. Each element of the **infos** array is represented as a Lua table.
	Currently, an element, **infos[i]**, has only one field:
	• **valid_data**: a Boolean flag indicating if the corresponding **samples[i]** holds valid data or not
	• **source_timestamp**: a number representing the timestamp at the source, in milliseconds
	• **reception_timestamp**: a number representing the timestamp at reception, in milliseconds
		`for i = 1, #foo_reader.infos do`
		`  print("\t valid_data:",`
		`  foo_reader.infos[i].valid_data)`
		`end-- or --`
		`for i, info in ipairs(foo_reader.infos) do`
		`  print("\t valid_data:", info.valid_data)`
		`end`

foo_reader.samples	A read-only sequence of data samples. Each element of the data sample sequence is represented as a Lua table.
	Data fields are accessed by name. If a sample is invalid (i.e., **foo_reader.infos[i].valid_data** is false) only key fields are initialized; the non-key fields are nil.
	Lua application code can use any data sample. For details, see 7.4 Data Access API on page 43.
		`for i = 1, #foo_reader.samples do`
		`  print("\t color:",  -- key`
		`  foo_reader.samples[i]['color'])`
		`  if (not foo_reader.infos[i].valid_data)`
		`  then`
		`  print("\t invalid data!")`
		`  end`
		`  print("\t x:", foo_reader.samples[i]['x'])`
		`  print("\t y:", foo_reader.samples[i]['y'])`
		`  print("\t shapesize:",`
		`  foo_reader.samples[i]['shapesize'])`
		`end`
		-- or --
		`for i, shape in ipairs(foo_reader.samples) do`
		`  print("\t color:", shape['color']) -- key`
		`  if (not foo_reader.infos[i].valid_data)`
		`  then`
		`  print("\t invalid data!")`
		`  end`
		`  print("\t x:", shape['x'])`
		`  print("\t y:", shape['y'])`
		`  print("\t shapesize:", shape['shapesize'])`
		`end`

Operations		
foo_reader:take() or foo_reader:take(n)	Takes data from the data space, and populate the **foo_reader.samples** and **foo_reader.infos** sequences. If *n* is specified, only *n* samples or less will be taken. Taking the data removes it from the data-space. Thus, those samples will not be seen by a subsequent **take()** or **read()** operation.	`foo_reader:take()` `foo_reader:take(5)`
foo_reader:read() or foo_reader:read(n)	Reads data from the data space, and populate the **foo_reader.samples** and **foo_reader.infos sequences**. If *n* is specified, only *n* sample or less will be read. Reading the data keeps it in the data-space. Thus, those samples may be seen again in a subsequent **take()** or **read()** operation.	`foo_reader:read()` `foo_reader:read(5)`

This example illustrates the above code fragments:

<path to examples>/prototyper/lua/generic/gsg.lua

You can run these code fragments using the *Prototyper* **–luaFile generic/gsg.lua** option. For example, on a UNIX-based system:

```
cd <path to examples>/prototyper/lua
<NDDSHOME>/bin/rtiddsprototyper -cfgName MyParticipantLibrary::ShapePubSub -luaFile
generic/gsg.lua
```

7.3 CONTEXT API

A table called CONTEXT is automatically created and added to the global container table.

The CONTEXT table provides access to the container's (*Prototyper)* execution state. In addition, Lua code can indicate intents (e.g., terminate execution) to be carried out by the container.

The execution context API is summarized below (with defaults in **bold**).

Member Name	Values	Description
onStartEvent	**true** | false	Set to true if the Lua code has been called at start up (first execution). Set by *Prototyper* and is read only from the lua script.
onStopEvent	**true** | false	Set to true if the Lua code has been called at shutdown (last execution). Set by *Prototyper* and is read only from the lua script.
onDataEvent	**true** | false	Set to true if the Lua code has been called because new data is available. Set by *Prototyper* and is read only from the lua script.
onPeriodEvent	**true** | false	Set to true if the Lua code has been called because of a periodic execution timer. Set by *Prototyper* and is read only from the lua script.
intentExit	true | **false**	If set to true by the Lua code, specifies intent to terminate execution. Set by the lua script and is read only from *Prototyper.* **Note:** If the command line option **-luaOnStop true** is specified, the Lua code will be executed one more time just before exiting.

This example shows the events as they happen:

<path to examples>/prototyper/lua/generic/events.lua

You can examine the events for a given configuration using the *Prototyper* **–luaFile generic/events.lua** command-line option. For example, on a UNIX-based system:

```
cd <path to examples>/prototyper/lua/
<NDDSHOME>/rtiddsprototyper -luaFile generic/events.lua
-luaOnStart true -luaOnStop true -luaOnData true -luaOnPeriod true
```

Index String	Equivalent OMG IDL Data Type Description	Usage: Example Lua Code
	Simple Structures	

‘anumber’
‘astring’
‘aboolean’
	A primitive field of a top-level structure.
	For example:
	`struct StructType {`
	`double anumber;`
	`string astring;`
	`boolean abool;`
	`}`
		`local adouble = data['adouble']local astring = data['astring']local abool = data['abool']`

	Simple Unions	

‘#’	The discriminator field of a top-level union.
	For example:
	`union UnionType`
	`switch (long) {`
	`case 1:`
	`short ashort;`
	`case 2:`
	`long along;`
	`case 3:`
	`double adouble;`
	`default:`
	`string astring;`
	`};`
		`local choice = data['#']`
		`local value = data[choice]`

	Nested Structures	

‘outer.inner.anumber’
‘outer.inner.astring;
‘outer.inner.aboolean’
	A leaf field of a nested data type. Each ‘.’ represents a nesting level. There can be arbitrary levels of nesting. The example shows only three levels.
	For example:
	`struct NestedType {`
	`StructType inner;`
	`}`
	`struct TopLevelType {`
	`NestedType outer;`
	`}`
		`local adouble = data['outer.inner.adouble']`
		`local astring = data['outer.inner.astring']`
		`local abool = data['outer.inner.abool']`

Index String	Equivalent OMG IDL Data Type Description	Usage: Example Lua Code
'aunion#'	The discriminator field of a nested union. For example: `struct TopLevelType2 { UnionType aunion; }`	`local choice = data['aunion#']local value = data['aunion.'..choice]`
Sequences and Arrays		
'seq#' 'arr#'	The length of a collection (sequence or array). For example: `struct CollectionType { sequence<double> seq; double arr[10]; }`	`local seq_length = data['seq#']` `local arr_length = data['arr#']`
'seq[k]' 'arr[k]'	The k-th element of a primitive collection. Lua conventions for sequences are used; thus the first element has an index, k = 1. For example: `struct CollectionType { sequence<double> seq; double arr[10]; }`	`local seq_k = data['seq[k]']` `local arr_k = data['arr[k]']`

'seq[k].adouble'
'arr[k].adouble'
	A field of the k-the element of a collection of structures.
	For example:
	`struct StructCollectionType{ sequence<StructType> seq; StructType arr[10]; }`
		`local seq_k_choice = data['seq[k]#']`
		`local seq_k_val = data['seq[k].' .. seq_k_choice]`
		`local arr_k_choice = data['arr[k]#']`
		`local arr_k_val = data['arr[k].' .. arr_k_choice]`

7.4 Data Access API

Once we have a reference to Writer we can access data-object associated with it using the ***instance*** table:

```
local data = foo_writer.instance
```

Similarly, once we have a Reader reference, we can access data-samples associated with it using the ***samples*** sequence:

```
local data = foo_reader.samples[i]
```

The ‘data’ (witer.instance or reader.samples[i]) is a Lua table that is indexed by a string to access a field of the underlying (DDS) data type. For example:

```
-- get the data field “x” --
x = data['x']
```

or

```
-- set the data field “x” --
data['x'] = 5
```

If the data table index string does not specify a valid field (of the underlying data type), the result (of a get) is **nil**. Setting an invalid field is a **no-op**; instead a warning message is logged.

In addition, note that Reader data is **read-only**. Setting a reader sample field is a “no-op”, resulting in a warning message being logged. On the other hand, writer instance fields can be both retrieved (get) and assigned (set) to.

The table below summarizes the rules for constructing the index string to access data fields. The rules apply recursively to address arbitrarily nested data types.

The type of the Lua variables follows that of the field in the underlying data type. The type mapping is summarized below.

Underlying (DDS) Data Type	Lua Type	Notes

DDS_TK_ENUM
DDS_TK_LONG
DDS_TK_LONGLONG
DDS_TK_OCTET
DDS_TK_SHORT
DDS_TK_ULONG
DDS_TK_ ULONGLONG
DDS_TK_USHORT
	number	May lose precision in some cases. A Lua number is a ‘double’ in the default configuration on most platforms.
		For example:
		`foo_writer.instance['x'] = -5.3`
		`print(foo_writer.instance['x']) -- = -5`

DDS_TK_FLOAT DDS_TK_DOUBLE	number	May lose precision when going from a Lua number (‘double’) to a DDS_TK_FLOAT.
DDS_TK_BOOLEAN	boolean	

DDS_TK_CHAR	string	Only the first letter is used when assigning from Lua.
		For example:
		`foo_writer.instance['x'] = "hello"`
		`print(foo_writer.instance['x']) -- = “h”`

DDS_TK_WCHAR	string	Only the first letter is used when assigning from Lua. See http://lua-users.org/wiki/LuaUnicode

Underlying (DDS) Data Type	Lua Type	Notes
DDS_TK_STRING	string	
DDS_TK_WSTRING	string	See http://lua-users.org/wiki/LuaUnicode

Enums defined in IDL are mapped to numbers in Lua. For example, consider the IDL enumeration:

```
enum AlarmLevel { WARNING, ERROR };
```

In the Lua script, an AlarmLevel field would have numeric values 0 and 1. The Lua script could map those ordinal values back to more meaningful names by defining a Lua AlarmLevel table, as follows:

```
AlarmLevel =  {  WARNING = 0,   ERROR = 1  }
```

Now the Lua code can refer to the enum values as AlarmLevel.WARNING and AlarmLevel.ERROR.

7.4.1 Examples of Data Access

Let's consider the following data type:

```
union AUnion switch (long) {
       case 1:
          short sData;
       case 2:
          long lData;
};
struct BType {
   float y;
   double z;
  long[10] array;
  AUnion aunion;

}
struct AType {
  long x;
  string color;
  BType complex;
}
```

To get the field z:

```
-- get the data
local z = data['complex.z']
```

To get the value of the union called 'aunion':

```
local choice = data['complex.aunion#']
local value = data['complex.aunion.'.. choice]
-- if choice == sData, prints value else prints nil
print(data['complex.aunion.sData'])
-- if choice == lData, prints value else prints nil
print(data['complex.aunion.lData])
```

```
-- prints 'nil' because member is invalid
print(data['complex.aunion.does_not_exist'])
```

The discriminator is set automatically for you when you set a field in the union:

```
-- the discriminator is automatically set to 2 (i.e. discriminator field == 'lData')
data['complex.aunion.lData'] = 5
```

To get the length of the collection called ‘array’:

```
-- get the length
local length = data['complex.array#']
```

To access the third element of the ‘array’ (indexes start at 1):

```
print(data['complex.array[3]'])
```

Combining the above, we can print all the members of the collection:

```
-- get the length
local length = data['complex.array']
for i=1,length do
          print(data['complex.array['..i..']']])
end
-- prints 'nil' because the index is invalid
print(data['complex.array[11]'])
```

Chapter 8 Examples of Lua Scripting with Prototyper

These examples illustrate how to program some common scenarios.

The XML for this example can be found here:

<path to examples>/prototyper/lua/USER_QOS_PROFILES.xml

To execute the examples:

On UNIX-based systems:

```
cd <path to examples>/prototyper/lua
<NDDSHOME>/bin/rtiddsprototyper
```

On VxWorks systems using RTP mode:

```
cd <path to examples>/prototyper/lua
rtp exec <NDDSHOME>/lib/<architecture>/rtiddsprototyper.vx
```

On VxWorks systems using kernel mode:

```
cd <path to examples>/prototyper/lua
```

Load all the libraries:

```
ld 1 < ../../../lib/ppc604Vx6.9gcc4.3.3/libnddscore.so
ld 1 < ../../../lib/ppc604Vx6.9gcc4.3.3/libnddsc.so
ld 1 < ../../../lib/ppc604Vx6.9gcc4.3.3/libnddscpp.so
ld 1 < ../../../lib/ppc604Vx6.9gcc4.3.3/liblua.so
ld 1 < ../../../lib/ppc604Vx6.9gcc4.3.3/librtiddsconnectorlua.so
ld 1 < <NDDSHOME>/resource/app/bin/ppc604Vx6.9gcc4.3.3/rtiddsprototyper.so
```

Start *Prototyper*:

```
taskSpawn "Test",255, 0x8,150000, rtiddsprototyper,""
```

You may see these errors:

```
Undefined symbol: RTIDefaultMonitor_create (binding 1 type 0)
ld error: Module contains undefined symbol(s) and may be unusable.
value = 0 = 0x0
```

These errors will not affect the execution if monitoring is disabled (the default case). To use monitoring, load the monitoring library right before the *Prototyper* library, **rtiddsprototype.so**. For details on configuring the monitoring library, please see the "RTI Monitoring Library" section of the *RTI Connext DDS Core Libraries User's Manual*. For details on using the RTI Monitor tool, please see the *RTI Monitor Getting Started Guide*.

On Windows systems:

```
cd <path to examples>\prototyper\Lua
<NDDSHOME>\bin\rtiddsprototyper
```

You will see the following prompt:

```
Please select among the available configurations:
0: MyParticipantLibrary::ShapePublisher
1: MyParticipantLibrary::ShapeSubscriber
2: MyParticipantLibrary::ShapePubSub
Please select:
```

Let's examine these in more detail.

8.1 ShapePublisher Configuration

The **MyParticipantLibrary::ShapePublisher** is a timer driven (lua.onData=false) configuration with three *DataWriters*, one for each of the *Shapes Demo* topics: Square, Circle, Triangle. Start/Stop execution triggers are delivered to the Lua code component (lua.onStart=true, lua.onStop=true). The default Lua script associated with this configuration is **shapes/ShapePublisher.lua**. Other Lua scripts can be used with this configuration using the **–luaFile <script>** option, as we saw earlier in the 3.3 Lua Scripting Example on page 21. This configuration is suitable for creating a variety of applications that just publish shapes.

The XML configuration is copied below:

```
1. <!-- ShapePublisher: Publishes Square, Circle, Triangle -->
2.  <domain_participant name="ShapePublisher"
3.    domain_ref="MyDomainLibrary::ShapeDomain">
4.
5.    <participant_qos base_name="QosLibrary::DefaultProfile">
6.      <property>
7.        <value>
8.          <element>
9.            <name>lua.file</name>
10.           <value>shapes/ShapePublisher.lua</value>
11.         </element>
12.
13.         <!-- Timer Driven -->
14.         <element>
15.           <name>lua.onData</name>
16.           <value>FALSE</value>
17.         </element>
18.         <element>
19.           <name>lua.onStart</name>
20.           <value>TRUE</value>
21.         </element>
```

```
22.         <element>
23.           <name>lua.onStop</name>
24.           <value>TRUE</value>
25.         </element>
26.       </value>
27.     </property>
28.   </participant_qos>
29.
30.   <publisher name="MyPublisher">
31.     <data_writer name="MySquareWriter" topic_ref="Square" />
32.     <data_writer name="MyCircleWriter" topic_ref="Circle" />
33.     <data_writer name="MyTriangleWriter" topic_ref="Triangle" />
34.   </publisher>
35. </domain_participant>
```

Lines 9-10 set the name of the file containing the default script. Lines 14-17 turn off execution upon data arrival (it is somewhat moot because this configuration does not have *DataReaders*). Lines 18-21 and 22-25 configure execution to also occur of the start and stop events. Lines 31-33 define three *DataWriters*: for Squares, Circles and Triangles respectively.

Examples that use this configuration are listed below:

- **shapes/ShapePublisher.lua** ***(default)***
- **shapes/Flower.lua** (3.3 Lua Scripting Example on page 21)
- **shapes/Figure8.lua**
- **shapes/FileInputAdapter.lua**

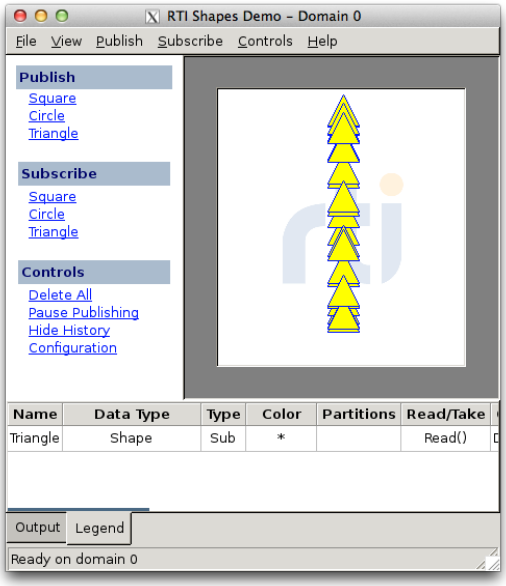
Let's examine the default Lua script, **shapes/ShapePublisher.lua**, associated with this configuration.

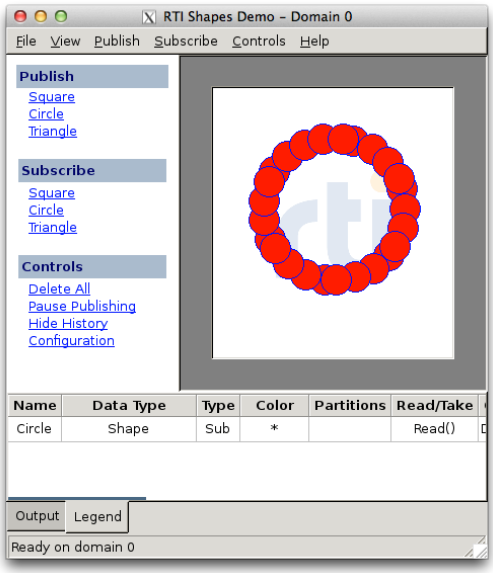
This example publishes a red circle in a circular trajectory and a yellow triangle moving up and down.

1. Start two instances of *Shapes Demo* on domain 0. In the first one, subscribe to circles with history = 25. In the second one, subscribe to triangles with history = 25.
2. After starting *Prototyper* (see Examples of Lua Scripting with Prototyper (Chapter 8 on page 47)), select this option:

```
0: MyParticipantLibrary::ShapePublisher
```

3. You should see the following:





The Lua script **shapes/ShapePublisher.lua** is copied below.

```
-- Interface: parameters, inputs, outputs
 local  MyCircleWriter = CONTAINER.WRITER['MyPublisher::MyCircleWriter']
 local  MyTriangleWriter = CONTAINER.WRITER['MyPublisher::MyTriangleWriter']

 -- Globals (preserved across invocations)
 if  count  then  count = count + 1
 else  -- initialize (first time)
 count = 0
 center = 120; radius = 70; yAmplitude = 100
  end
 -- print("*** iteration ", count,  "***")


 -- Write a RED circle on a 'circular' trajectory
 local  circle = MyCircleWriter.instance
 circle['color'] = 'RED'
 circle['x'] = center + radius * math.sin(count)
 circle['y'] = center + radius * math.cos(count)
 circle['shapesize'] = 30

 MyCircleWriter:write()


 -- Write a YELLOW Triangle on a 'vertical' trajectory
 local  triangle = MyTriangleWriter.instance
 triangle['color'] = "YELLOW"
 triangle['x'] = center  --  radius * math.sin(count);
 triangle['y'] = center  + yAmplitude * math.cos(count)
 triangle['shapesize'] = 30

 MyTriangleWriter:write()


```

```
34.
35.  -- Dispose the data objects upon stopping:
36.  if  CONTAINER.CONTEXT.onStopEvent then
37.  print("disposing")
38.  MyCircleWriter:dispose()
39.  MyTriangleWriter:dispose()
40.  end
41.
42.  -- stop the simulation after N iterations
43.  if  count > 25  then  CONTAINER.CONTEXT.intentExit = true  end
```

Lines 1-3 define the Lua component interface by declaring the inputs (readers), outputs (writers), and the parameters used by the component as local variables. Lines 8-9 initialize global variables including a counter. Line 6 increments the global counter. The global variables are preserved across invocations of the code.

Lines 15 and 25 create local variables for convenience. Lines 16-19 setup new state of a circle data-object, and Line 21 publishes it. Lines 26-29 setup new state of a triangle data-object, and Line 31 publishes it. Lines 38-39 dispose the two shapes when a stop event occurs.

Stopping *Prototyper* using ^C will trigger execution of the stop event. Line 43 terminates the execution after 25 times. Termination will also trigger the stop event.

8.2 ShapeSubscriber Configuration

The **MyParticipantLibrary::ShapeSubscriber** is a data driven (lua.onPeriod=false) configuration with three *DataReaders*, one for each of the *Shapes Demo* topics: Square, Circle, Triangle. Start/Stop execution triggers are delivered to the Lua code component (lua.onStart=true, lua.onStop=true). The default Lua script associated with this configuration is shapes/ShapeSubscriber.lua. Other Lua scripts can be used with this configuration using the **–luaFile <script>** option, as we saw earlier in 3.3 Lua Scripting Example on page 21. This configuration is suitable for creating a variety of applications that just subscribe to shapes.

The XML configuration is copied below:

```
1. <!-- ShapeSubscriber: Subscribes to Square, Circle, and Triangle -->
2.  <domain_participant name="ShapeSubscriber"
3.    domain_ref="MyDomainLibrary::ShapeDomain">
4.
5.    <participant_qos base_name="QosLibrary::DefaultProfile">
6.      <property>
7.        <value>
8.          <element>
9.            <name>lua.file</name>
10.           <value>shapes/ShapeSubscriber.lua</value>
11.         </element>
12.
13.         <!-- Data Driven -->
14.         <element>
15.           <name>lua.onPeriod</name>
16.           <value>FALSE</value>
17.         </element>
18.         <element>
19.           <name>lua.onStart</name>
20.           <value>TRUE</value>
21.         </element>
```

```
22.         <element>
23.           <name>lua.onStop</name>
24.           <value>TRUE</value>
25.         </element>
26.       </value>
27.     </property>
28.   </participant_qos>
29.
30.   <subscriber name="MySubscriber">
31.     <data_reader name="MySquareReader" topic_ref="Square" />
32.     <data_reader name="MyCircleReader" topic_ref="Circle" />
33.     <data_reader name="MyTriangleReader" topic_ref="Triangle" />
34.   </subscriber>
35. </domain_participant>
```

Lines 9-10 set the name of the file containing the default script. Lines 14-17 turn off periodic execution—the execution happens only upon data arrival (data-driven). Lines 18-21 and 22-25 configure execution to also occur of the start and stop events. Lines 31-33 define three *DataReaders*: for Squares, Circles and Triangles respectively.

Examples that use this configuration are listed below.

- **shapes/ShapeSubscriber.lua** (default)

Let's examine the default Lua script, **shapes/ShapeSubscriber.lua**, associated with this configuration. This example prints the shapes published by *Shapes Demo*.

1. Run *ShapesDemo* on domain 0 and publish a Square, a Circle and a Triangle.
2. After starting *Prototyper* (see Examples of Lua Scripting with Prototyper (Chapter 8 on page 47)), select option 1:

   ```
   1: MyParticipantLibrary::ShapeSubscriber
   ```

3. You should see the following on the *Prototyper* terminal:

   ```
   :
   *** iteration  319     ***
   READERMySubscriber::MySquareReader
   READERMySubscriber::MyCircleReader
   READERMySubscriber::MyTriangleReader
     color:BLUE
     x:  188
     y:  156
    shapesize:20
   *** iteration 320 ***
   READERMySubscriber::MySquareReader
     color:BLUE
     x:  183
     y:  161
     shapesize:30
   READERMySubscriber::MyCircleReader
   READERMySubscriber::MyTriangleReader
   *** iteration 321 ***
   READERMySubscriber::MySquareReader
   ```

```
READERMySubscriber::MyCircleReader
READERMySubscriber::MyTriangleReader
  color:ORANGE
  x:  183
  y:  103
  shapesize:30
*** iteration 322 ***
READERMySubscriber::MySquareReader
READERMySubscriber::MyCircleReader
  color:RED
  x:  39
  y:  133
  shapesize:30
READERMySubscriber::MyTriangleReader
*** iteration 323 ***
READERMySubscriber::MySquareReader
READERMySubscriber::MyCircleReader
  color:BLUE
  x:  195
  y:  153
  shapesize:30
READERMySubscriber::MyTriangleReader
  color:BLUE
  x:  186
  y:  158
  shapesize:20
*** iteration 324 ***
READERMySubscriber::MySquareReader
  color:BLUE
  x:  180
  y:  162
  shapesize:30
READERMySubscriber::MyCircleReader
READERMySubscriber::MyTriangleReader
```

The Lua script **shapes/ShapeSubscriber.lua** is copied below.

```
1. -- Interface: parameters, inputs, outputs
2.  -- Input: All the configured readers
3.
4.  -- Globals (preserved across invocations)
5.  if not count then count = 0 else count = count + 1 end
6.  print("*** iteration ", count,  "***")
7.
8.  -- Iterate over all the readers
9.  for   name,reader   in   pairs(CONTAINER.READER) do
10.
11.     print("READER", name)
12.     reader:take()
13.
14.     for  i, shape   in   ipairs(reader.samples) do
15.
16.         print("\t color:", shape['color']) -- key
17.
18.         if (not   reader.infos[i].valid_data) then
19.             print("\t invalid data!")
20.         end
21.
22.         print("\t x:", shape['x'])
```

```
23.         print("\t y:", shape['y'])
24.         print("\t shapesize:", shape['shapesize'])
25.
26.     end
27.  end
```

This script illustrates how to use *Lua* iterators to access all the readers and samples. Line 9 uses the Lua **pairs()** iterator to traverse over all the entries in the CONTAINER.READER table. The local variables **name** and **reader** are bound to each record in the table. Thus, the scripts iterates over all the data readers in the XML configuration.

Line 11 prints the reader's name. Line 12 takes all the samples from the data space. Lines 14-26 print the contents of each sample taken from the data space. Note that for samples with invalid data, the non-key fields (i.e. **x, y, shapesize**) will be **nil**.

Line 14 shows the use of the Lua **ipairs()** iterator to traverse over the samples in the reader.samples array. The local variables **i** and **shape** are bound to each record in the array. Thus, the **for** loop iterates over all the samples.

For more details on the *Lua* **pairs()** and **ipairs()** iterators, please refer to *Chapter 7 - Iterators and the Generic for* in the excellent book *Programming in Lua*.

8.3 ShapePubSub Configuration

The **MyParticipantLibrary::ShapePubSup** is a *data and timer driven* (default) configuration with three *DataReaders* and three *DataWriters*, for each of the ShapeDemo topics: Square, Circle, Triangle. Start/stop execution triggers are delivered to the Lua code component (**lua.onStart=true, lua.onStopp=true**). The default Lua script associated with this configuration is **shapes/ShapePubSub.lua**. Other Lua scripts can be used with this configuration using the **–luaFile <script>** option, as we saw earlier in the 3.3 Lua Scripting Example on page 21. This configuration is suitable for creating a variety of applications that publish and subscribe to shapes.

The XML configuration is copied below:

```
1. <!-- ShapePubSub: Publishes & Subscribes Square, Circle, Triangle -->
2.  <domain_participant name="ShapePubSub"
3.    domain_ref="MyDomainLibrary::ShapeDomain">
4.
5.    <participant_qos base_name="QosLibrary::DefaultProfile">
6.      <property>
7.        <value>
8.          <element>
9.            <name>lua.file</name>
10.           <value>shapes/ShapePubSub.lua</value>
11.         </element>
12.
13.         <!-- Data and Timer Driven (default) -->
14.         <element>
15.           <name>lua.onStart</name>
16.           <value>TRUE</value>
17.         </element>
18.         <element>
19.           <name>lua.onStop</name>
```

```
20.          <value>TRUE</value>
21.        </element>
22.      </value>
23.    </property>
24.  </participant_qos>
25.
26.  <publisher name="MyPublisher">
27.    <data_writer name="MySquareWriter" topic_ref="Square" />
28.    <data_writer name="MyCircleWriter" topic_ref="Circle" />
29.    <data_writer name="MyTriangleWriter" topic_ref="Triangle" />
30.  </publisher>
31.
32.  <subscriber name="MySubscriber">
33.    <data_reader name="MySquareReader" topic_ref="Square" />
34.    <data_reader name="MyCircleReader" topic_ref="Circle" />
35.    <data_reader name="MyTriangleReader" topic_ref="Triangle" />
36.  </subscriber>
37. </domain_participant>
```

Lines 9-10 set the name of the file containing the default script. The execution happens when either data arrives or a periodic timer event to occur (default). Lines 14 -17 and 18-21 configure execution to also occur of the start and stop events. Lines 27-29 define three *DataWriters*: for Squares, Circles and Triangles respectively. Lines 33-35 define three *DataReaders*: for Squares, Circles and Triangles respectively.

Examples that use this configuration are:

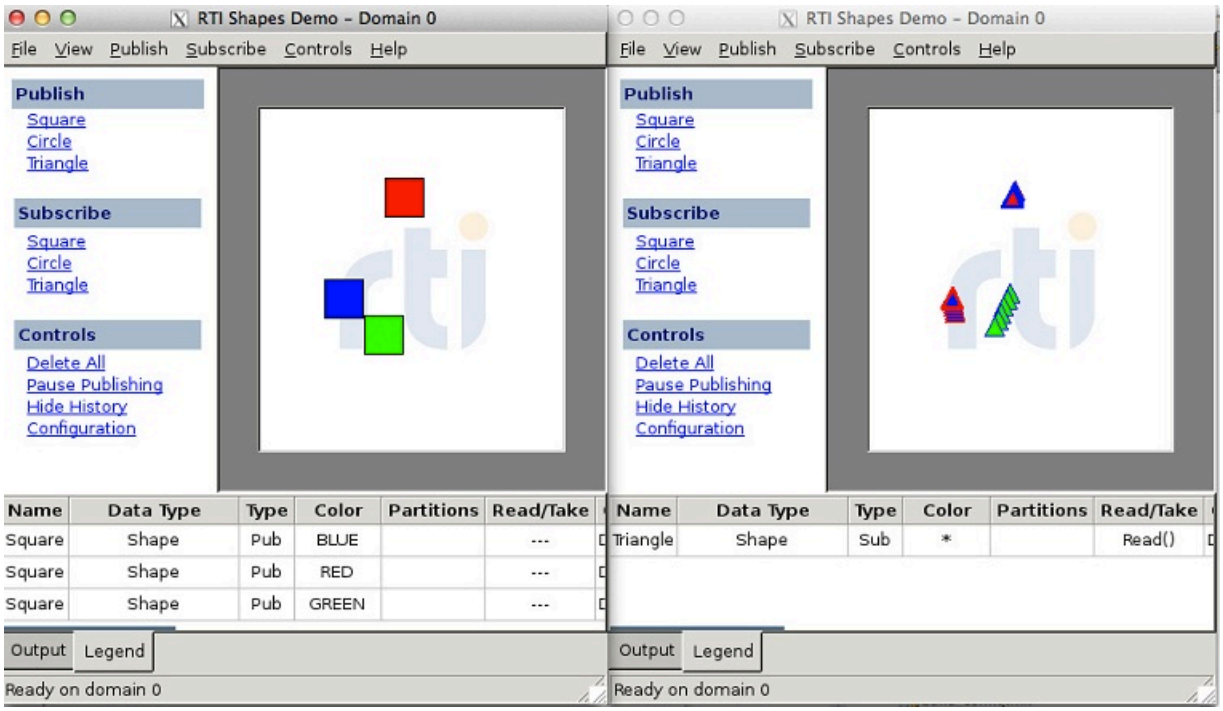
- **shapes/ShapePubSub.lua** (default)
- **shapes/Aggregator.lua**
- **shapes/Correlator.lua**
- **shapes/SplitterDelayNAverage.lua**

Let's examine the default Lua script, **shapes/ShapePubSub.lua**, associated with this configuration. This example subscribes to Squares and transforms them into Triangles of a different size, while preserving the color and the location.

1. Start Shapes Demo on domain 0, and publish Squares of different colors.
2. Start another instance of *Shapes Demo* in domain 0 and subscribe to Triangles.
3. After starting *Prototyper* (see Examples of Lua Scripting with Prototyper (Chapter 8 on page 47)), select this option:

```
2: MyParticipantLibrary::ShapePubSub
```

You should see the following:



The Lua script, **shapes/ShapePubSub.lua**, is copied below.

```
1. -- Interface: parameters, inputs, outputs
2.  local  SIZE_FACTOR = 0.5  -- change the factor to see the size changing
3.  local  reader = CONTAINER.READER['MySubscriber::MySquareReader']
4.  local  writer = CONTAINER.WRITER['MyPublisher::MyTriangleWriter']
5.
6.  reader:take()
7.
8.  for  i, shape  in  ipairs(reader.samples) do
9.
10.     if (not  reader.infos[i].valid_data) then  break  end
11.
12.     writer.instance['color'] = shape['color']
13.     writer.instance['x'] = shape['x']
14.     writer.instance['y'] = shape['y']
15.     writer.instance['shapesize'] = shape['shapesize'] * SIZE_FACTOR
16.
17.     writer:write()
18.  end
```

Lines 1-4 define the Lua component interface by declaring the parameters, inputs (readers), and outputs (writers) as local variables.

Line 6 takes the squares from the data-space. Line 8 uses the Lua **ipairs()** iterator (8.2 ShapeSubscriber Configuration on page 51) to traverse the list of incoming samples. Lines 12-15 transform a valid sample into the corresponding triangle, with size scaled by SIZE_FACTOR. Line 17 writes the triangle to the data-space. The transformation is repeated for each incoming square sample.

Change the SIZE_FACTOR (Line 2) using an editor, to shrink or stretch the size of the triangles in real-time. There is no need to restart *Prototyper*.

8.3.1 Splitter “Delay and Average” Example

This example illustrates how to use split an incoming stream into two output streams. One of the output streams is the same as the input stream, but delayed by MAX_HISTORY samples. The other is a moving average over the last MAX_HISTORY samples. It also illustrates how to keep state in the Lua component such that the output depends not just on the inputs available on the current iteration, but also in the data and computations performed in the past.

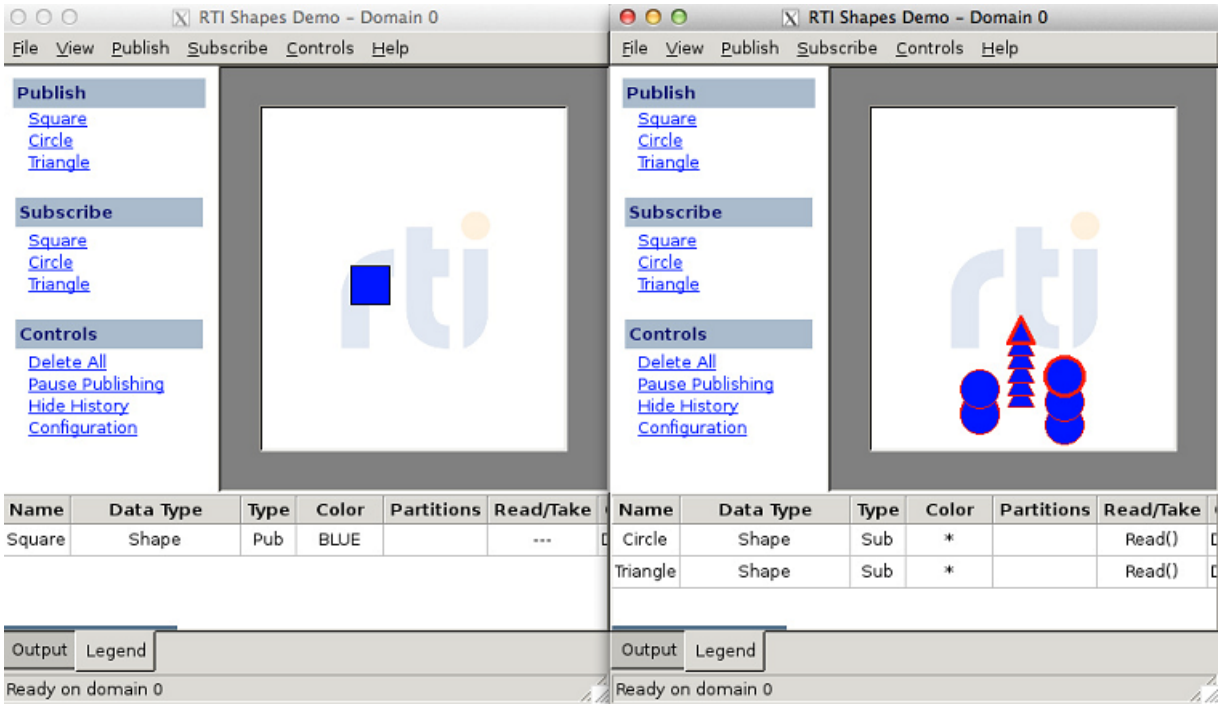
This example also highlights some of the capabilities of Lua. It shows definition and use of Lua functions to perform more complex computations. It also illustrates how in Lua functions are first-class elements that can be assigned to variables and returned by other functions. Finally, the example illustrates how the lexical scoping feature in Lua can be used to create function objects that maintain internal state and therefore offer some of the characteristics of classes.

This example subscribes to Squares and splits the incoming stream into two streams—a delayed stream as Circles, and a moving average stream as Triangles. For each color of a square there is a corresponding circle and a triangle of the same color. At any point in time, the position of each circle corresponds to the position that the same color square had MAX_HISTORY samples before. At any point in time the position of each triangle corresponds to the moving average of the last MAX_HISTORY samples of the same color.

1. Start *Shapes Demo* on domain 0, and publish a Square. Let the Square bounce from side-to-side.
2. Start another instance of *Shapes Demo* in domain 0 and subscribe to Circles and Triangles.
3. Start *Prototyper* (see Examples of Lua Scripting with Prototyper (Chapter 8 on page 47)) using the **SplitterDelayNAverage.lua** component. For example, on a UNIX-based system:

```
<NDDSHOME>/bin/rtiddsprototyper
    -cfgName MyParticipantLibrary::ShapePubSub
    -luaFile shapes/SplitterDelayNAverage.lua
```

You should see something similar to the following.



The Lua script **shapes/SplitterDelayNAverage.lua** is copied below.

```
-- Interface: parameters, inputs, outputs
local MAX_HISTORY = 6
local reader = CONTAINER.READER[1] -- Square
local delay_writer = CONTAINER.WRITER[#CONTAINER.WRITER-1] -- Circle
local average_writer = CONTAINER.WRITER[#CONTAINER.WRITER]  -- Triangle

-- Function-object (closure) to maintain a first-in-first-out (FIFO) queue
function newFifo (max_h)
    local index = 0
     local history = {}
    local max_history = max_h
    return function (element)
        if index == max_history then index = 1 else index=index+1 end
        oldest = history[index]
        history[index] = element
        return oldest, #history
    end
 end

 --- Re-publish input delayed by MAX_HISTORY samples
 function delay()
    -- Globals (preserved across invocations)
    if not delay_size_history then
        delay_x_history    = {}
        delay_y_history    = {}
        delay_size_history = {}
    end

    -- Iterate over each sample we got
    for i, shape in ipairs(reader.samples) do
         local color = shape['color']
         local x = shape['x']
```

```
33.         local  y = shape['y']
34.         local  size = shape['shapesize']
35.
36.         -- SKIP sample if data is not valid
37.         if  not  x  then  break  end
38.
39.         -- If a new color create FIFOs to hold the last positions and averages
40.         if  not  delay_size_history[color] then
41.              delay_x_history[color] = newFifo(MAX_HISTORY)
42.              delay_y_history[color] = newFifo(MAX_HISTORY)
43.              delay_size_history[color] = newFifo(MAX_HISTORY)
44.         end
45.
46.          -- Push a new value to the FIFO returning the oldest value and
47.          -- the number of elements in the FIFO, including the new one just pushed
48.            local  oldest_x, samplesInHistory = delay_x_history[color](x)
49.            local  oldest_y = delay_y_history[color](y)
50.            local  oldest_size = delay_size_history[color](size)
51.
52.            -- write only if we have accumulated enough history and gotten
53.            -- something out of the FIFO
54.            if  oldest_x  then
55.                shape = delay_writer.instance
56.                shape['color'] = color
57.                shape['x'] = oldest_x
58.                shape['y'] = oldest_y
59.                shape['shapesize'] = oldest_size
60.
61.                -- print(color, oldest_x, oldest_y, oldest_size)
62.                delay_writer:write()
63.            end
64.     end
65. end
66.
67. --- Publish the moving average of the last MAX_HISTORY samples
68. function  average()
69.    -- Globals (preserved across invocations)
70.    if  not  x_avg  then
71.        average_x_history    = {}
72.        average_y_history    = {}
73.        x_avg = {}
74.        y_avg = {}
75.    end
76.
77.    -- Iterate over each sample we got
78.    for  i, shape  in  ipairs(reader.samples) do
79.         local  color = shape['color']
80.         local  x = shape['x']
81.         local  y = shape['y']
82.
83.         -- SKIP sample if data is not valid
84.         if  not  x  then  break  end
85.
86.         -- If a new color create FIFOs to hold the historical values
87.         if  not  x_avg[color] then
88.              average_x_history[color] = newFifo(MAX_HISTORY)
89.              average_y_history[color] = newFifo(MAX_HISTORY)
90.              x_avg[color] = 0
91.              y_avg[color] = 0
92.          end
93.
```

```
94.          -- Push a new value to the FIFO returning the oldest value and
95.          -- the number of elements in the FIFO, including the new one
96.          -- just pushed
97.          local  oldest_x, samplesInHistory = average_x_history[color](x)
98.          local  oldest_y = average_y_history[color](y)
99.
100.         -- compute the moving average
101.         if  oldest_x  then
102.              x_avg[color] = x_avg[color] + (x - oldest_x)/samplesInHistory
103.              y_avg[color] = y_avg[color] + (y - oldest_y)/samplesInHistory
104.         else
105.     x_avg[color] = (x_avg[color] * (samplesInHistory-1) + x)/samplesInHistory
106.     y_avg[color] = (y_avg[color] * (samplesInHistory-1) + y)/samplesInHistory
107.         end
108.
109.         -- write
110.         shape = average_writer.instance
111.         shape['color'] = color
112.         shape['x'] = x_avg[color]
113.         shape['y'] = y_avg[color]
114.         shape['shapesize'] = 20
115.
116.         -- print(color, x_avg[color], y_avg[color])
117.         average_writer:write()
118.     end
119. end
120.
121. -- main ---
122. reader:read() -- update the local cache
123. delay()
124. average()
125. reader:take() -- empty the local cache
```

Lines 1-5 define the interface of the Lua component in terms of the parameters, inputs (readers), outputs (writers).

Lines 8-18 define a function called **newFifo()**. This function defines some local variables within its scope. Including a Lua table (history) that is used as an array to hold historical values. The **newFifo()** returns another function that is defined as an anonymous function in lines 12 to 17.

You can think of **newFifo()** as a constructor of a class with only one method (the anonymous function). When **newFifo()** is called and the result assigned to a variable (an in line 41 to 43) the inner anonymous function is returned. This assignment carries its outer scope or context the function needs to operate, which contains the variables **index**, **history**, and **max_history**. This feature of Lua is called Closure and effectively makes the value returned by **newFifo()** behave as a function object.

The **newFifo()** function object stores the last MAX_HISTORY values pushed into it. Each time a new value is pushed, the old value that was pushed MAX_HISTORY iterations before is returned, assuming there was one. In addition to returning the old value, the function also returns the number of objects it holds (see line 16).

The **newFifo()** is used by two independent functions: **delay()** and **average()** to store the last MAX_HISTORY samples. These functions are called in Line 123-124, one after the other on the same input. To

ensure they operate on the same input samples, the **reader:read()** operation is used (Line 122). The samples are finally removed from the data space in Line 125.

Let’s look at the **delay()** function in Lines 21-65.

Lines 22-27 initialize global variables the first time the delay() function is run. These include three tables to hold the FIFOs indexed by the color of the Square.

Line 30 iterates over all the data samples read on the reader.

Lines 40-44 initialize the FIFOs in case a square of a previously unseen color is received.

Lines 48-50 store the 3 FIFOs that are relevant to the color being processed. Lines 48-50 push the current values of **x**, **y**, and **shapesize** into the respective FIFOs and pop the ones that were pushed MAX_ HISTORY before, if any. Note that in line 48 we get not just the popped value for **x** but also the number of elements in the FIFO and place that into the variable named **samplesInHistory**. This illustrates how Lua can return multiple values from a function.

Lines 55 to 59 stage the value of the delayed shape to publish into the sample associated with the delayed stream writer.

Line 62 writes the sample using the delayed stream writer.

The **average()** function in Lines 68-119 is similar and is left as an exercise to the reader.

Chapter 9 Configuring Prototyper Behavior Using XML

Before the Lua interpreter capability was introduced in *Prototyper*, data fields could only be set using a rudimentary XML based configuration. This section describes that XML configuration and the default behavior when Lua is not used.

9.1 Shapes Demo Example, Continued

9.1.1 Run with Shapes Demo Application

Exit the three *Prototyper* applications started in 3.2.1 Run Prototyper on page 14 if they are still running. We will run them again, but this time we will use a different configuration file to control the data values *Prototyper* writes.

On UNIX-based systems:

Open three command-shell windows.

In each window, change the directory to **<path to examples>/prototyper/shapes**. Then type the following command in each window:

```
<NDDSHOME>/bin/rtiddsprototyper -cfgFile ShapeDemoConfig.xml
```

On VxWorks systems using RTP mode:

Open three command-shell windows (enter **cmd**). In each one, change directory to **<path to examples>/prototyper/shapes**. Then type the following command in each window:

```
rtp exec <NDDSHOME>/lib/<architecture>/rtiddsprototyper.vx
-cfgFile ShapeDemoConfig.xml
```

On VxWorks systems using kernel mode:

Open three command-shell windows (enter **cmd**). In each one, change directory to **<path to examples>/prototyper/shapes**.

Load all the libraries:

```
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscore.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddsc.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnddscpp.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/liblua.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/librtiddsconnectorlua.so
ld 1 < <NDDSHOME>/resource/app/bin/ppc604Vx6.9gcc4.3.3/rtiddsprototyper.so
```

Start *Prototyper*:

```
taskSpawn "Test", 255, 0x8, 150000, rtiddsprototyper,
        "-cfgFile ShapeDemoConfig.xml"
```

You may see these errors:

```
Undefined symbol: RTIDefaultMonitor_create (binding 1 type 0)
ld error: Module contains undefined symbol(s) and may be unusable.
value = 0 = 0x0
```

These errors will not affect the execution if monitoring is disabled (the default case). To use monitoring, load the monitoring library right before the *Prototyper* library, **rtiddsprototype.so**. For details on configuring the monitoring library, please see the "RTI Monitoring Library" section of the *RTI Connext DDS Core Libraries User's Manual*. For details on using the RTI Monitor tool, please see the *RTI Monitor Getting Started Guide*.

On Windows systems:

Open three command-shell (Windows terminal) windows.

In each window, change the directory to **<path to examples>/prototyper/shapes**. Then type the following command in each window:

```
<NDDSHOME>\bin\rtiddsprototyper.bat -cfgFile ShapeDemoConfig.xml
```

The last argument, following the **-cfgFile** option, specifies an additional configuration file to read.

You will see the following output appear in each window:

```
Please select among the available configurations:
0: MyParticipantLibrary::ShapePublisher
1: MyParticipantLibrary::ShapeSubscriber
2: MyParticipantLibrary::ShapePubSub
3: MyParticipantLibrary::ControlledShapePublisher
4: MyParticipantLibrary::ControlledShapeSubscriber
5: MyParticipantLibrary::ControlledShapePubSub
Please select:
```

We see three more configurations (indices 3 to 5) beyond the ones we get if we do not specify **–cfgFile ShapeDemoConfig.xml**. These additional configurations have “Controlled” in their name.

The additional configurations are the result of reading the configuration file **ShapeDemoConfig.xml** specified in the command line. The participant configurations defined in the **USER_QOS_PROFILES.xml** file still appear. This is because the file **USER_QOS_PROFILE.xml** is also being read. This is desirable; as we will see later the new configurations defined in **ShapeDemoConfig.xml** are using information that was defined in **USER_QOS_PROFILE.xml**.

1. In the first window, type “3” (without the quotes) to select the first choice, followed by a return.
2. In the second type “4” (without the quotes) to select the second choice, also followed by a return.
3. In the third window type “5” (without the quotes).

In the first window (where you typed “3”) you will see output like this:

```
Please select among the available configurations:
0: ParticipantLibrary::ShapePublisher
1: ParticipantLibrary::ShapeSubscriber
2: ParticipantLibrary::ShapePubSub
3: ParticipantLibrary::ControlledShapePublisher
4: ParticipantLibrary::ControlledShapeSubscriber
5: ParticipantLibrary::ControlledShapePubSub
Please select: 3

DataWriter "MySquareWriter" wrote sample 1 on Topic "Square" at 1332634406.819248 s
DataWriter "MyCircleWriter" wrote sample 1 on Topic "Circle" at 1332634406.819343 s
DataWriter "MySquareWriter" wrote sample 2 on Topic "Square" at 1332634407.819631 s
DataWriter "MyCircleWriter" wrote sample 2 on Topic "Circle" at 1332634407.819794 s
DataWriter "MySquareWriter" wrote sample 3 on Topic "Square" at 1332634408.819853 s
DataWriter "MyCircleWriter" wrote sample 3 on Topic "Circle" at 1332634408.819977 s
DataWriter "MySquareWriter" wrote sample 4 on Topic "Square" at 1332634409.820010 s
DataWriter "MyCircleWriter" wrote sample 4 on Topic "Circle" at 1332634409.820189 s
DataWriter "MySquareWriter" wrote sample 5 on Topic "Square" at 1332634410.820311 s
DataWriter "MyCircleWriter" wrote sample 5 on Topic "Circle" at 1332634410.820490 s
DataWriter "MySquareWriter" wrote sample 6 on Topic "Square" at 1332634411.820494 s
DataWriter "MyCircleWriter" wrote sample 6 on Topic "Circle" at 1332634411.820686 s
DataWriter "MySquareWriter" wrote sample 7 on Topic "Square" at 1332634412.820663 s
DataWriter "MyCircleWriter" wrote sample 7 on Topic "Circle" at 1332634412.820845 s
DataWriter "MySquareWriter" wrote sample 8 on Topic "Square" at 1332634413.820869 s
DataWriter "MyCircleWriter" wrote sample 8 on Topic "Circle" at 1332634413.821030 s
DataWriter "MySquareWriter" wrote sample 9 on Topic "Square" at 1332634414.821189 s
DataWriter "MyCircleWriter" wrote sample 9 on Topic "Circle" at 1332634414.821348 s
```

We can see it has two writers: **MySquareWriter** and **MyCircleWriter** We should also see how at the periodic rate, it writes two samples, one on each *DataWriter*. This is because the **ShapePublisher** configuration specified two writers: one for Square and one for Circle.

In the window where you typed “4”, you will see output like this:

```
Please select among the available configurations:
0: ParticipantLibrary::ShapePublisher
1: ParticipantLibrary::ShapeSubscriber
2: ParticipantLibrary::ShapePubSub
3: ParticipantLibrary::ControlledShapePublisher
```

```
4: ParticipantLibrary::ControlledShapeSubscriber
5: ParticipantLibrary::ControlledShapePubSub
Please select: 4

DataReader "MySquareRdr" received sample 4 on Topic "Square" sent at 1332634409.820010 s
color: "Red"
x: 3
y: 3
shapesize: 20
DataReader "MyCircleRdr" received sample 4 on Topic "Circle" sent at 1332634409.820189 s
color: "Orange"
x: 3
y: 153
shapesize: 30
DataReader "MySquareRdr" received sample 5 on Topic "Square" sent at 1332634410.820311 s
color: "Red"
x: 4
y: 4
shapesize: 20
DataReader "MyCircleRdr" received sample 5 on Topic "Circle" sent at 1332634410.820490 s
color: "Orange"
x: 4
y: 154
shapesize: 30
DataReader "MySquareRdr" received sample 6 on Topic "Square" sent at 1332634411.820494 s
color: "Red"
x: 5
y: 5
shapesize: 20
DataReader "MyCircleRdr" received sample 6 on Topic "Circle" sent at 1332634411.820686 s
color: "Orange"
x: 5
y: 155
shapesize: 30
DataReader "MyTriangleRdr" received sample 2 on Topic "Triangle" sent at 1332634412.308678 s
color: "Green"
x: 101
y: 1
shapesize: 30
DataReader "MySquareRdr" received sample 7 on Topic "Square" sent at 1332634412.820663 s
color: "Red"
x: 6
y: 6
shapesize: 20
DataReader "MyCircleRdr" received sample 7 on Topic "Circle" sent at 1332634412.820845 s
color: "Orange"
x: 6
y: 156
shapesize: 30
DataReader "MyTriangleRdr" received sample 3 on Topic "Triangle" sent at 1332634413.308962 s
color: "Yellow"
x: 102
y: 2
shapesize: 30
DataReader "MySquareRdr" received sample 8 on Topic "Square" sent at 1332634413.820869 s
color: "Red"
```

```
x: 7
y: 7
shapesize: 20
DataReader "MyCircleRdr" received sample 8 on Topic "Circle" sent at 1332634413.821030 s
color: "Orange"
x: 7
y: 157
shapesize: 30
DataReader "MyTriangleRdr" received sample 4 on Topic "Triangle" sent at 1332634414.309190 s
color: "Green"
x: 103
y: 3
shapesize: 30
DataReader "MySquareRdr" received sample 9 on Topic "Square" sent at 1332634414.821189 s
color: "Blue"
x: 8
y: 8
shapesize: 20
DataReader "MyCircleRdr" received sample 9 on Topic "Circle" sent at 1332634414.821348 s
color: "Orange"
x: 8
y: 158
shapesize: 30
```

The output is similar to what we saw in 3.2.1 Run Prototyper on page 14. The significant difference is the values taken by the data. Before, the values were assigned by a default internal algorithm that we could not control. Now the data values are set according to a specification in **ShapeDemoConfig.xml**, which makes the values reasonable for the specific *Shapes Demo* application. We see **color** values like Red, Orange, Green, and **shapesize** values of 20 and 30, etc. We will examine the configuration that caused this to happen later in 9.1.2 Behavior of Prototyper for Shapes Demo Application on page 68.

In the window where you typed “5”, you will see output like this:

```
Please select among the available configurations:
0: ParticipantLibrary::ShapePublisher
1: ParticipantLibrary::ShapeSubscriber
2: ParticipantLibrary::ShapePubSub
3: ParticipantLibrary::ControlledShapePublisher
4: ParticipantLibrary::ControlledShapeSubscriber
5: ParticipantLibrary::ControlledShapePubSub
Please select: 5
DataWriter "MyTriangleWr" wrote sample 1 on Topic "Triangle" at 1332634411.308089 s
DataReader "MyCircleRdr" received sample 6 on Topic "Circle" sent at 1332634411.820686 s
color: "Orange"
x: 5
y: 155
shapesize: 30
DataWriter "MyTriangleWr" wrote sample 2 on Topic "Triangle" at 1332634412.308678 s
DataReader "MyCircleRdr" received sample 7 on Topic "Circle" sent at 1332634412.820845 s
color: "Orange"
x: 6
y: 156
shapesize: 30
DataWriter "MyTriangleWr" wrote sample 3 on Topic "Triangle" at 1332634413.308962 s
DataReader "MyCircleRdr" received sample 8 on Topic "Circle" sent at 1332634413.821030 s
color: "Orange"
```

```
x: 7
y: 157
shapesize: 30
DataWriter "MyTriangleWr" wrote sample 4 on Topic "Triangle" at 1332634414.309190 s
DataReader "MyCircleRdr" received sample 9 on Topic "Circle" sent at 1332634414.821348 s
color: "Orange"
x: 8
y: 158
shapesize: 30
```

The output is similar to what we saw in 3.2.1 Run Prototyper on page 14. The significant difference is in the values of the data itself, which as we will see below are now controlled via settings in **ShapeDemoConfig.xml**.

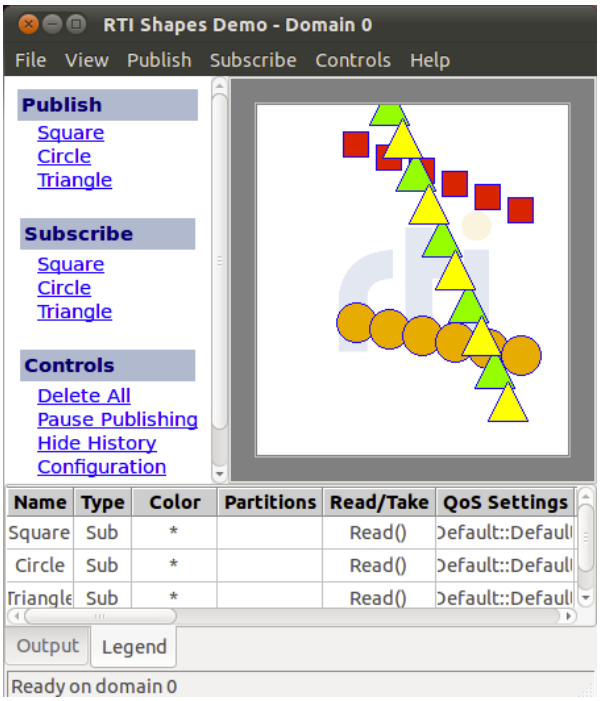
Run the RTI Shapes Demo Application

To start *RTI Shapes Demo,* open *RTI Launcher*, select the **Learn** tab and click on the **Shapes Demo** icon.

Once you have started *Shapes Demo,* click on the links to subscribe to Square, Circle, and Triangle topics.

You should immediately see the different shapes being drawn on the screen as the *Shapes Demo* GUI receives them.

This should look like the screenshot below:



Shapes Demo is receiving the same data as *Prototyper* when run with the **ControlledShapesSubscriber** configuration. Therefore we see updates for Topic Square with color RED (published by instances of *Prototyper* with configuration **ControlledShapesPublisher**), updates for Topic Circle with color ORANGE (also published by *Prototyper* with configuration **ControlledShapesPublisher**), and updates for Topic Triangle with color alternating between GREEN and YELLOW.

We can also publish something from *Shapes Demo*, for example the Topic Square with color BLUE and we will immediately see it both in the *Shapes Demo* window (which subscribes to its own data) as well as the instance of *Prototyper* that is running with the **ControlledShapesSubscriber** configuration. This is left as an exercise to the reader.

9.1.2 Behavior of Prototyper for Shapes Demo Application

Prototyper reads its configuration from both the **USER_QOS_PROFILES.xml** and **ShapeDemoConfig.xml** files in the **<path to examples>/prototyper/shapes** directory. In these two files, *Prototyper* finds six participant configurations and offers these configurations as choices on the command line.

As an alternative, you can control this behavior using the **-cfgName** command-line option so that *Prototyper* automatically starts with a particular participant configuration.

For example, to create the *DomainParticipant* using the **MyParticipantLibrary::ShapePublisher** configuration, on a UNIX-based system you would enter this command:

```
<NDDSHOME>/bin/rtiddsprototyper -cfgName "MyParticipantLibrary::ShapePublisher"
```

The participant configurations that we used to interact with *Shapes Demo* are defined in the **ShapeDemoConfig.xml** file. The configurations in this file control the values written by the *DataWriters*

in a specific way to make them better suited to the scenario being run. For example, we see that the **color** members are set to reasonable values (RED, ORANGE, GREEN, YELLOW). The values for the other members such as **x**, **y**, and **shapesize**, are also set in a way that allows *Shapes Demo* to display the data. To see how this is done, let's review the content of **ShapeDemoConfig.xml**, found in the directory **<path to examples>/prototyper/shapes**.

```
1. <!--
2.  RTI Connext DDS Deployment
3.  -->
4.  <dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
5.       xsi:noNamespaceSchemaLocation="../../../resource/schema/rti_dds_profiles.xsd"
6.       version="6.0.0">
7.
8.      <!-- Participant library -->
9.      <participant_library name="MyParticipantLibrary">
10.
11.         <domain_participant name="ControlledShapePublisher"
12.                             domain_ref="MyDomainLibrary::ShapeDomain">
13.
14.             <publisher name="MyPublisher">
15.                 <data_writer name="MySquareWriter" topic_ref="Square">
16.                     <datawriter_qos>
17.                       <property>
18.                         <value>
19.                           <element>
20.                             <name>rti.prototyper.member:color</name>
21.                             <value>iterator?list=[Red]</value>
22.                           </element>
23.                           <element>
24.                             <name>rti.prototyper.member:x</name>
25.                             <value>linear?begin=0,end=100</value>
26.                           </element>
27.                           <element>
28.                             <name>rti.prototyper.member:y</name>
29.                             <value>linear?begin=0,end=100</value>
30.                           </element>
31.                           <element>
32.                             <name>rti.prototyper.member:shapesize</name>
33.                             <value>linear?begin=20,end=20</value>
34.                           </element>
35.                         </value>
36.                       </property>
37.                     </datawriter_qos>
38.                 </data_writer>
39.                 <data_writer name="MyCircleWriter" topic_ref="Circle">
40.                     <datawriter_qos>
41.                       <property>
42.                         <value>
43.                           <element>
44.                             <name>rti.prototyper.member:color</name>
45.                             <value>iterator?list=[Orange]</value>
46.                           </element>
47.                           <element>
48.                             <name>rti.prototyper.member:x</name>
49.                             <value>linear?begin=0,end=250</value>
50.                           </element>
51.                           <element>
52.                             <name>rti.prototyper.member:y</name>
53.                             <value>linear?begin=150,end=200</value>
```

```
54.                          </element>
55.                          <element>
56.                            <name>rti.prototyper.member:shapesize</name>
57.                            <value>linear?begin=30,end=30</value>
58.                          </element>
59.                        </value>
60.                      </property>
61.                    </datawriter_qos>
62.                  </data_writer>
63.              </publisher>
64.          </domain_participant>
65.
66.          <domain_participant name="ControlledShapeSubscriber"
67.                       domain_ref="MyDomainLibrary::ShapeDomain">
68.
69.              <subscriber name="MySubscriber">
70.                <data_reader name="MySquareRdr"  topic_ref="Square"/>
71.                <data_reader name="MyCircleRdr"  topic_ref="Circle"/>
72.               <data_reader name="MyTriangleRdr" topic_ref="Triangle"/>
73.           </subscriber>
74.         </domain_participant>
75.
76.         <domain_participant name="ControlledShapePubSub"
77.                       domain_ref="MyDomainLibrary::ShapeDomain">
78.
79.           <publisher name="MyPublisher">
80.             <data_writer name="MyTriangleWr" topic_ref="Triangle">
81.               <datawriter_qos>
82.                 <property>
83.                   <value>
84.                     <element>
85.                       <name>rti.prototyper.member:color</name>
86.                       <value>iterator?list=[Green,Yellow]</value>
87.                     </element>
88.                     <element>
89.                       <name>rti.prototyper.member:x</name>
90.                       <value>linear?begin=100,end=200</value>
91.                     </element>
92.                     <element>
93.                       <name>rti.prototyper.member:y</name>
94.                       <value>linear?begin=0,end=250</value>
95.                     </element>
96.                     <element>
97.                       <name>rti.prototyper.member:shapesize</name>
98.                       <value>linear?begin=30,end=30</value>
99.                      </element>
100.                   </value>
101.                 </property>
102.               </datawriter_qos>
103.             </data_writer>
104.           </publisher>
105.           <subscriber name="MySubscriber">
106.             <data_reader name="MyCircleRdr" topic_ref="Circle"/>
107.           </subscriber>
108.         </domain_participant>
109.  </participant_library>
110.  </dds>
```

The first thing to notice is that there are no **<types>** or **<domain_library>** sections in this file. This is because the configurations defined in this file are reusing the same data-types and DDS *domains* already

defined in the **USER_QOS_PROFILES.xml** so there is no need to define new ones here. It often makes sense to extract all the type and domain information into a separate XML file that is shared, so that configuration files defining specific application scenarios in that DDS *domain* can all reuse the same DDS type and Topic model.

The second thing to notice is that the *Property* QoS in the *DataWriter* configuration specifies the values that *Prototyper* will use when publishing data on that *DataWriter*. See lines 17-36, 41-60, and 82-101 within the <properties> tag.

DataWriter properties whose names have the prefix "**rti.prototyper.member**:" are interpreted by *Prototyper* as instructions for setting the value of the data-member whose name follows the ":" character.

For example, the property on line 86, **rti.prototyper.member:color** instructs the *DataWriter* on how to set the color of the Triangle Topics that it publishes. The instructions **"iterator?list=[Green,Yellow]"** tells the *DataWriter* to publish both green and yellow triangles.

An instruction that begins with "linear" specifies a range of values that can be used to set the member. For example, on lines 89- 90, we see:

```
<name>rti.prototyper.member:x</name>
<value>linear?begin=100,end=200</value>
```

This means the value for ***x*** should be set linearly within the range 100-200. This is consistent with what we see for the "Green" and "Yellow" triangles.

Please see 9.2 Data Values Written by Prototyper below for more details on *Prototyper*'s behavior and the syntax for constraining the values it publishes.

9.2 Data Values Written by Prototyper

The value of the data written is changed for each sample written. Unless otherwise specified, *Prototyper* uses a default data-generation algorithm to set each member in the data. You can change this behavior by using property settings in the corresponding *DataWriter*.

The default data-generation algorithm operates differently for non-key data members (also known as regular data members) and for key data members.

9.2.1 Values Set by Default Data-Generation Algorithm on Non-Key Members

The default data-generation algorithm sets every non-key data member in the sample to a value that approximates an incrementing counter, coerced to be appropriate for the member data-type. This approach makes it easy to observe the data and see how progress is being made.

For example, as we saw in the HelloWorld output in , the default algorithm will set each integer member to the values 0, 1, 2, 3, … in sequence. Float members will be set to the values 0.0, 1.0, 2.0. String members will be set to "String: 0", "String: 1", "String: 2".

The following table describes how the default algorithm sets each regular (non-key) member.

Member Type	Values Set by Default Data-Generation Function	Example

Integer types:
Octet,
short, unsigned short,
long, unsigned long,
long long,
unsigned long long
	Integer values starting from 0 and incrementing by 1 each sample written.	`Member:`
		`long x;`
		x will be set to: 0, 1, 2, 3, 4, …

Floating point types:
float, double
	Floating point values starting with 0.0 and incremented by 1.0 each sample written.	`Member:`
		`float x;`
		x will be set to: 0.0, 1.0, 2.0, 3.0, 4.0, …

String types:
string, wstring
	String that follows the pattern:
	“String: %d”
	where %d is replaced by the value of a counter that starts at 0 and increments by 1 for each sample written.
		`Member:`
		`string x;`
		x will be set to:
		`“String: 0”, “String: 1”,`
		`“String: 2”, “String: 3”,`
		`“String: 4”, …`

Enumerated type	Each value of the enumeration, starting with the first and cycling back to the beginning when all the values have been generated.	`enum EnumType {`
		`A, B, C`
		`};`
		`Member:`
		`EnumType x;`
		x will be set to: A, B, C, A, B, …

Union type	Union discriminator set to always select the last member.
	The value of the last member is set according to its type using the default data-generation function.
		`union UnionType (long) {`
		`case 1: long along;`
		`case 2: float afloat;`
		`case 3: string aString;`
		`};`
		`Member:`
		`UnionType x;`
		x will always be set as case 3, with x.aString taking these values:
		`“String: 0”, “String: 1”, “String: 2”, “String: 3”,`
		`…`

Array type	Set all elements to the same value using the default data-generation function for the element.	`Member:`
		`long x[3];`
		x[0], x[1], x[2] will be set to the same incrementing values, e.g.:
		`x[0] = x[1] = x[2] = 0`
		`x[0] = x[1] = x[2] = 1`
		`x[0] = x[1] = x[2] = 2`

Sequence type	Sets the length to 1 and the single element to a value using the default data-generation function for non-key members of that type.	`Member:`
		`sequence<long,10> x;`
		Set length to 2 and x[0]=x[1]=0,1,2,3,…

9.2.2 Values Set by the Default Data-Generation Algorithm on Key Members

The default data-generation algorithm sets the key data members to a constant value so all samples from a single *DataWriter* correspond to the same data-object instance (same value of the key). The actual value is random but set appropriately for each data type. The table below shows the values set for key members for each member type.

Member Type	Values Set by Default Data-Generation Function	Example

Integer types:
octet,
short, unsigned short,
long, unsigned long,
long long, unsigned long long
	Random integer value.	`Member:`
		`long x; //@key`
		x will be set to a random value, e.g.: 8761237

Floating point types:
float, double
	Random floating value.	`Member:`
		`float x; //@key`
		x will be set to a random value, e.g.: 3.741723

String types:
string, Wstring
	String that follows pattern: “Key: RR”
	where RR is a random number.
		`Member:`
		`string x; //@key`
		x will be set to a random string, e.g.: “Key: 76896713”

Enumerated type	Random member of the enumeration.	`enum EnumType {`
		`A, B, C`
		`};`
		`Member:`
		`EnumType x;`
		x will be set to a random element, e.g.: B

Union type	Union discriminator set to always select the last member.
	The value of the last member is set according to its type using the default data-generation function for a key member.
		`union UnionType (long) {`
		`case 1: long along;`
		`case 2: float afloat;`
		`case 3: string aString;`
		`};`
		`Member:`
		`UnionType x;`
		x will be set as case 3 and x.aString set to a random string, e.g.: “Key: 76896713”

Array type	Sets all elements to the same value using the default data-generation function for key member of that type.	`Member:`
		`long x[3];`
		x[0], x[1], x[2] will be set to the same random value, e.g.: 8761237

Sequence type	Sets the length to 1 and the single element to a value using the default data-generation function for key member of that type.	`Member:`
		`sequence<long,10> x;`
		Sets length to 1 and x[0] to a random value, e.g.: 8761237

9.2.3 Controlling the Data Values Written by Prototyper

The application can change the default data-generation algorithm so that the values are more appropriate for the scenario being prototyped. Currently this feature is quite limited. It will be expanded in the future.

The value of the data members published by *Prototyper* can be controlled by setting the Property QoS for the corresponding *DataWriter*.

The Property QoS is a general QoS policy in the *DataWriter*. It accepts a sequence of property (name, value) pairs and can be used for many purposes. This QoS policy is described in detail in the *RTI Connext DDS Core Libraries User's Manual* (Section 6.5.17).

Prototyper looks at the properties in the *DataWriter* whose names have the prefix "**rti.prototyper**" and uses corresponding value fields to control the behavior of that member as it relates to the *DataWriter*.

To change the values that *Prototyper* writes for a specific *DataWriter* you set the property with a name that follows the pattern:

```
rti.prototyper.member:<replace with the name of the member>
```

The property is set to a value that describes the data-generation function for that member. This property value follows the pattern:

```
<function name>?<parameter 1>=<value1>,<parameter2>=<value2>,…
```

For example, we used the following property in the example in 9.1.2 Behavior of Prototyper for Shapes Demo Application on page 68 to specify that *Prototyper* should set the **color** member to the values Green and Yellow, successively.

```
<element>
    <name>rti.prototyper.member:color</name>
    <value>iterator?list=[Green,Yellow]</value>
</element>
```

Recall that the corresponding data-type for the *topic* written by the *DataWriter* was defined as:

```
        <struct name="ShapeType">
            <member name="color"  key="true"
                    type="string"  stringMaxLength="MAX_COLOR_LEN"/>
            <member name="x" type="long"/>
            <member name="y" type="long"/>
            <member name="shapesize" type="long"/>
        </struct>
```

So **color** corresponds to the name of a member of type string.

To specify how to set the values of a nested member, provide the full name of the member using the '**.**' character to navigate to the nested substructures, just as you would do if you were to access the member from a language such as C/C++ or Java.

For example, assume the following data-type schemas for Plane and Coordinates.

```
<types>
     <struct name="Coordinates">
         <member name="latitude" type="long"/>
         <member name="longitude" type="long"/>
         <member name="height" type="long"/>
     </struct>

     <struct name="Plane">
         <member name="airline" type="string" key="true"/>
        <member name="flight_num" type="long" key="true"/>
        <member name="coordinates"  type="nonBasic"
                 nonBasicTypeName="Coordinates"/>
     </struct>
</types>
```

To specify that *Prototyper* should set the values of the latitude within the coordinates of a Plane linearly between 20 and 60, set the following property on the *DataWriter* that is publishing the Plane data:

```
<element>
   <name>rti.prototyper.member:coordinates.latitude</name>
   <value>linear?begin=20,end=60</value>
</element>
```

The values of array or sequence members can also be specified:

- To specify how to set *all* the elements in the array or sequence, use the name of the array or sequence field followed by empty square brackets ([]).
- To specify how to set a *specific* member at index **k**, use the name of the array or sequence field followed by a "[k]" string. (where **k** should be replaced with the actual value of the index you want to control).

Sequences support having a length that is smaller than their capacity (maximum length). To facilitate control of sequence length, the following heuristic is used: If a rule specifies how an element of the sequence at a particular index "k" should be set, then the length of the sequence will be adjusted to be at least "k+1" such that the sequence can contain an element at index "k". There are two exceptions to this rule: (1) if the index exceeds the capacity, and (2) if an explicit rule has been specified for the length of the sequence itself. Setting the length of the sequence explicitly is described in the next few paragraphs.

For example, assume the following data-type schemas for TruckFleet, Truck, and Location.

```
<types>
    <const name="MAX_TRUCKS" type="long" value="1024"/>

    <struct name="Location">
        <member name="latitude" type="long"/>
        <member name="longitude" type="long"/>
    </struct>

    <struct name="Truck">
        <member name="license_plate" type="string" key="true"/>
```

```
        <member name="location"  type="nonBasic"
                nonBasicTypeName="Location"/>
    </struct>

    <struct name="TruckFleet">
        <member name="fleet_name" type="string" key="true"/>
        <member name="trucks"  type="nonBasic"  nonBasicTypeName="Truck"
                sequenceMaxLength="MAX_TRUCKS"/>
    </struct>
</types>
```

To specify that all Trucks must have a location with latitude set linearly between 40 and 65:

```
<properties>
    <value>
      <element>
        <name>rti.prototyper.member:trucks[].location.latitude</name>
        <value>linear?begin=40,end=65</value>
      </element>
    </value>
</properties>
```

Since there are no rules that specify the sequence length or the elements at a specific index, the length of the sequence will be set to 1.

The following properties show how to specify that the first Truck (the one at index 0) in the fleet should have its license plate set to “CA91RTI6” and its latitude Location set linearly to values between 40 and 45. They also specify that the fourth truck (the one at index 3) should have its license plate set to “CA94NDDS7” and its latitude Location set linearly to values between 60 and 65:

```
<properties>
    <value>
      <element>
        <name>rti.prototyper.member:trucks[0].license_plate</name>
        <value>iterator?list=[CA91RTI6]</value>
      </element>
      <element>
        <name>rti.prototyper.member:trucks[0].location.latitude</name>
        <value>linear?begin=40,end=45</value>
      </element>
      <element>
        <name>rti.prototyper.member:trucks[3].license_plate</name>
        <value>iterator?list=[CA94NDDS7]</value>
      </element>
      <element>
        <name>rti.prototyper.member:trucks[3].location.latitude</name>
        <value>linear?begin=60,end=65</value>
      </element>
    </value>
</properties>
```

Since there are rules specifying how to set elements 0 and 3 of the sequence, the sequence length will be set to 4 (such that it can have elements with indices 0, 1, 2, and 3).

The lengths of sequences can also be controlled explicitly. This is done by using the name of the array followed by the suffix '#length'. For example to specify that *Prototyper* should write samples that contain from 6 to 10 Trucks, linearly you can use the following properties:

```
<properties>
    <value>
      <element>
        <name>rti.prototyper.member:trucks#length</name>
        <value>linear?begin=6,end=10</value>
      </element>
    </value>
</properties>
```

If the length of the sequence is specified explicitly as above, then it takes precedence over specifications of the values of sequence elements at particular indices. This means that first the length of the sequence is determined according to the explicit rule, and then any rules that apply to the elements with indices between 0 and length-1 are applied. Rules for elements with indices outside the length are ignored.

For example, the following properties specify that *Prototyper* should write samples that contain from 6 to 10 Trucks, linearly, and that any Truck with an index of 8 will be assigned the license place "CA8888".

```
<properties>
    <value>
      <element>
        <name>rti.prototyper.member:trucks#length </name>
        <value> linear?begin=6,end=10</value>
      </element>
      <element>
        <name>rti.prototyper.member:trucks[8].license_plate</name>
        <value>iterator?list=[CA8888]</value>
      </element>
    </value>
</properties>
```

In the example above, successive **TruckFleet** samples will set the **trucks** sequence to a length of 7, 8, 9, and 10. Samples with lengths 9 and 10 will set the **license_plate** member of the **Truck** at index 8 to "CA 8888". Samples with 6, 7, and 8 Trucks will not set that member because its index exceeds what the *trucks* array can accommodate.

The choices available for the data-generation algorithms are listed in the table below. As mentioned, this feature is currently limited. It will be extended in future releases.

Generation Function	Parameters	Example	Description
linear	begin, end, numsteps	`linear?begin=0,end=100, numsteps=50`	Generates 'numsteps' linearly spaced values between and including 'begin' and 'end'.
iterator	list	`iterator?list= [RED,GREEN,BLUE]`	Set each element in the list in sequence

Generation Function	Parameters	Example	Description
Init	N/A	`Init`	Set the value to the initialization value for the type. This is typically zero for atomic types, zero length sequences, etc.