**Trademarks**

Real-Time Innovations, RTI, NDDS, RTI Data Distribution Service, Connext, Micro DDS, the RTI logo, 1RTI and the phrase, “Your Systems. Working as one,” are registered trademarks, trademarks or service marks of Real-Time Innovations, Inc. All other trademarks belong to their respective owners.

**Copy and Use Restrictions**

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form (including electronic, mechanical, photocopy, and facsimile) without the prior written permission of Real-Time Innovations, Inc. The software described in this document is furnished under and subject to the RTI software license agreement. The software may be used or copied only under the terms of the license agreement.

This is an independent publication and is neither affiliated with, nor authorized, sponsored, or approved by, Microsoft Corporation.

The security features of this product include software developed by the OpenSSL Project for use in the OpenSSL Toolkit (http://www.openssl.org/).

**Technical Support**

Real-Time Innovations, Inc.
232 E. Java Drive
Sunnyvale, CA 94089
Phone: (408) 990-7444
Email: support@rti.com
Website: https://support.rti.com/
Contents

Chapter 1 Welcome to RTI Prototyper!
  1.1 Introduction ........................................................................................................ 1
  1.2 Paths Mentioned in Documentation .................................................................... 3

Chapter 2 Release Notes
  2.1 Limitations ........................................................................................................... 5
  2.2 What's Fixed in 6.0.0 .......................................................................................... 5
      2.2.1 Prototyper failed to publish samples for types using inheritance ............... 5
      2.2.2 Prototyper failed to publish samples for types using enums ..................... 6

Chapter 3 “Hello World” with RTI Prototyper
  3.1 Hello World Example ......................................................................................... 7
      3.1.1 Run Prototyper ............................................................................................ 8
      3.1.2 Examine the XML Configuration File ..................................................... 10
      3.1.3 Default Behavior of Prototyper for the HelloWorld Application ............... 13
  3.2 An Example using RTI Shapes Demo ................................................................. 14
      3.2.1 Run Prototyper ............................................................................................ 14
      3.2.2 Examine the XML Configuration File ..................................................... 19
  3.3 Lua Scripting Example ........................................................................................ 21
      3.3.1 Run Prototyper with Lua ............................................................................ 23

Chapter 4 Using Prototyper’s Command-Line Options ........................................ 27

Chapter 5 Understanding Prototyper
  5.1 Workflow ............................................................................................................ 30
  5.2 Configuration Files Parsed by Prototyper ......................................................... 33

Chapter 6 Configuring Prototyper Behavior Using Lua
  6.1 Specifying the Lua Code .................................................................................... 34
  6.2 Lua Execution Triggers ..................................................................................... 36

Chapter 7 Lua Component Programming Model
7.1 WRITER API .................................................................................................................. 38
7.2 READER API .................................................................................................................. 39
7.3 CONTEXT API ............................................................................................................... 41
7.4 Data Access API .......................................................................................................... 43
    7.4.1 Examples of Data Access ....................................................................................... 45

Chapter 8 Examples of Lua Scripting with Prototyper

8.1 ShapePublisher Configuration .................................................................................... 48
8.2 ShapeSubscriber Configuration .................................................................................. 51
8.3 ShapePubSub Configuration ....................................................................................... 54
      8.3.1 Splitter “Delay and Average” Example ............................................................... 57

Chapter 9 Configuring Prototyper Behavior Using XML

9.1 Shapes Demo Example, Continued .............................................................................. 62
    9.1.1 Run with Shapes Demo Application ....................................................................... 62
    9.1.2 Behavior of Prototyper for Shapes Demo Application ........................................... 68
9.2 Data Values Written by Prototyper ............................................................................ 71
    9.2.1 Values Set by Default Data-Generation Algorithm on Non-Key Members .......... 71
    9.2.2 Values Set by the Default Data-Generation Algorithm on Key Members ............. 73
    9.2.3 Controlling the Data Values Written by Prototyper ............................................. 74
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:
1.2 Paths Mentioned in Documentation

- 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 take() 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:

```c
struct BaseStruct {
    long m1;
};

struct DerivedStruct: BaseStruct {
    long m2;
};
```
2.2.2 Prototyper failed to publish samples for types using enums

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

```plaintext
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:

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

struct MyColorStruct {
    Color m1;
};
```

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

```plaintext
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.
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:
3.1.1 Run Prototyper

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:

```
<NDISHOME>/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:

```
rtiddsprototyper: 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.

```xml
<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"
```

10
3.1.2 Examine the XML Configuration File

```xml
<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>
```
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:
3.1.3 Default Behavior of Prototyper for the HelloWorld Application

- 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"
```
3.2 An Example using RTI Shapes Demo

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 data-types used by RTI Shapes Demo such that it can be used in conjunction with it.

Figure 3.2: Three DomainParticipants

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:
3.2.1 Run Prototyper

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/libnddcore.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 rtidsprototyper 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 1332619438.609556 s
color: "Key: 333582338"
x: 3
y: 3
shapesize: 3
DataReader "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"
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
data: color: "Key: 1894519218"
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

DataWriter "MyTriangleWr" wrote sample 2 on Topic "Triangle" at 1332619437.609176 s
data: color: "Key: 1894519218"
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

DataWriter "MyTriangleWr" wrote sample 3 on Topic "Triangle" at 1332619438.609384 s
data: 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.
3.2.2 Examine the XML Configuration File

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.

```xml
<!-- 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 -->
</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/rtiddsprototyper.vx
   -cfgName MyParticipantLibrary::ShapePublisher
   -luaFile shapes/Flower.lua -period 0.01
```
3.3 Lua Scripting Example

On VxWorks systems using kernel mode:

Load all the libraries:

```
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnnddscore.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnndsc.so
ld 1 < <NDDSHOME>/lib/ppc604Vx6.9gcc4.3.3/libnndscpp.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.
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. \texttt{local} A, B, C = 30, 30, 10 -- Change 'C' parameter to see various flower shapes
3. \texttt{local} ShapeWriter = \texttt{CONTAINER.WRITER[3]} -- Triangles
4. -- Global counter (preserved across invocations)
5. \texttt{if} not count \texttt{then} count = 0 \texttt{else} count = count + 1 \texttt{end}
6. \texttt{local} shape = ShapeWriter.instance;
7. \texttt{local} angle = count \texttt{mod} 360;
8. shape['x'] = 120 + (A+B) * \texttt{math.cos(angle)} + B * \texttt{math.cos((A/B-C)*angle)}
9. shape['y'] = 120 + (A+B) * \texttt{math.sin(angle)} + B * \texttt{math.sin((A/B-C)*angle)}
10. shape['shapesize'] = 5
11. shape['color'] = "RED"
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**

<table>
<thead>
<tr>
<th>Option</th>
<th>Values</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>-appId</td>
<td>&lt;integer&gt;</td>
<td>Sets the application ID used by the DomainParticipant created by Prototyper. Example: -appId 0x12345678</td>
</tr>
<tr>
<td>-cfgFile</td>
<td>&lt;string&gt;</td>
<td>Specifies the path to an XML file that Prototyper should parse to look for participant configurations. Example: -cfgFile ShapeDemoConfig.xml</td>
</tr>
<tr>
<td>-cfgName</td>
<td>&lt;string&gt;</td>
<td>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</td>
</tr>
<tr>
<td>-disableDataFill</td>
<td>N/A</td>
<td>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</td>
</tr>
<tr>
<td>-domainId</td>
<td>&lt;integer&gt;</td>
<td>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</td>
</tr>
<tr>
<td>-help</td>
<td>N/A</td>
<td>Prints a summary of the options available. Example: -help</td>
</tr>
<tr>
<td>-luaFile</td>
<td>&lt;string&gt;</td>
<td>Lua script file to load and execute</td>
</tr>
<tr>
<td>-luaFileInterval</td>
<td>&lt;float&gt;</td>
<td>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.</td>
</tr>
<tr>
<td>-luaOnData</td>
<td>&lt;boolean&gt;</td>
<td>Execute the Lua code upon data arrival</td>
</tr>
<tr>
<td>-luaOnStart</td>
<td>&lt;boolean&gt;</td>
<td>Execute the Lua code on start up</td>
</tr>
<tr>
<td>-luaOnStop</td>
<td>&lt;boolean&gt;</td>
<td>Execute the Lua code just before terminating Prototyper</td>
</tr>
</tbody>
</table>
## Table 4.1 Command-Line Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Values</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>-luaOnPeriod</td>
<td>&lt;boolean&gt;</td>
<td>Execute the Lua code because the time interval specified by -period has elapsed</td>
</tr>
</tbody>
</table>
| -participantName     | <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:
5.1 Workflow

Figure 5.1: Workflow of RTI Prototyper with Lua

Prototyper with Lua Workflow

Parse XML configuration files

Configuration name Specified?

NO

Print valid configuration names

YES

Create DomainParticipant specified by the configuration name

Prompt user for configuration name

Wait For Data to arrive OR ‘period’ to elapse (whichever happens first)

Execute the **Lua Code Component**

**Lua ‘intentExit’? or Completed ‘runDuration’?**

NO

YES

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

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

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:

```xml
<property>
  <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>
</property>
```

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

```xml
<property>
  <value>
    <element>
      <name>lua.file</name>
      <value>script.lua</value>
    </element>
  </value>
</property>
```
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

<table>
<thead>
<tr>
<th>Command-Line Argument</th>
<th>DomainParticipant Property</th>
<th>Possible Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-luaOnStart</td>
<td>lua.onStart</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>-luaOnStop</td>
<td>lua.onStop</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>-luaOnData</td>
<td>lua.onData</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>-luaOnPeriod</td>
<td>lua.onPeriod</td>
<td>true</td>
<td>false</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Member Name</th>
<th>Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
</table>
| 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 = CONTAINERCONTEXT
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/
<NDHOME>/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.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Container</strong></td>
<td></td>
</tr>
</tbody>
</table>
| 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()| Cleans the contents of all data members of the object associated with `foo_writer`, including key members | foo_writer:clear_members() |
### 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:

```lua
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:

```lua
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.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>foo_writer:write()</td>
<td>Updates <em>foo_writer.instance</em> in the data space</td>
<td>foo_writer:write()</td>
</tr>
<tr>
<td>foo_writer:dispose()</td>
<td>Disposes <em>foo_writer.instance</em> in the data space</td>
<td>foo_writer:dispose()</td>
</tr>
<tr>
<td>foo_writer:unregister()</td>
<td>Unregisters <em>foo_writer.instance</em> in the data space</td>
<td>foo_writer:unregister()</td>
</tr>
</tbody>
</table>

### Container

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>foo</td>
<td>Identifies a specific reader in the container's <strong>READER</strong> table. Possible values include:</td>
<td>local foo = 'HelloPublisher::HelloReader'</td>
</tr>
<tr>
<td></td>
<td>• The fully qualified name of a <em>DataReader</em> in the XML configuration file</td>
<td>--or--</td>
</tr>
<tr>
<td></td>
<td>• The index of a <em>DataReader</em> defined by creation order.</td>
<td>local foo = 1</td>
</tr>
</tbody>
</table>

### Entity

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>foo_reader</td>
<td>A (table) member of the <strong>READER</strong> table representing the underlying reader endpoint entity identified by 'foo'.</td>
<td>local foo_reader = READER[foo]</td>
</tr>
</tbody>
</table>

### Data

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>#foo_reader.infos</td>
<td>Number of infos or samples. The <em>samples</em> and <em>infos</em> sequences populated by the <em>take()</em> or <em>read()</em> operations and guaranteed to have the same length.</td>
<td>print(&quot;Number of infos:&quot;, #foo_reader.infos)</td>
</tr>
<tr>
<td>#foo_reader.samples</td>
<td></td>
<td>print(&quot;Number of samples:&quot;,#foo_reader.samples)</td>
</tr>
</tbody>
</table>
## 7.2 READER API

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>foo_reader.infos</td>
<td>A read-only sequence of sample information. Each element of the <code>infos</code> array is represented as a Lua table. Currently, an element, <code>infos[i]</code>, has only one field:</td>
<td>for <code>i = 1</code>, #foo_reader.infos do print(&quot;	valid_data:&quot;); foo_reader.infos[i].valid_data end -- or -- for <code>i</code>, info in ipairs(foo_reader.infos) do print(&quot;	valid_data:&quot;, info.valid_data) end</td>
</tr>
<tr>
<td></td>
<td>- <strong>valid_data:</strong> a Boolean flag indicating if the corresponding <code>samples[i]</code> holds valid data or not</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- <strong>source_timestamp:</strong> a number representing the timestamp at the source, in milliseconds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- <strong>reception_timestamp:</strong> a number representing the timestamp at reception, in milliseconds</td>
<td></td>
</tr>
<tr>
<td>foo_reader.samples</td>
<td>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., <code>foo_reader.infos[i].valid_data</code> is false) only key fields are initialized; the non-key fields are nil.</td>
<td>for <code>i = 1</code>, #foo_reader.samples do print(&quot;	color:&quot;); -- key foo_reader.samples[i]['color']) if (not foo_reader.infos[i].valid_data) then print(&quot;	invalid data!&quot;) end print(&quot;	xn:&quot;, foo_reader.samples[i]['x']) print(&quot;	yn:&quot;, foo_reader.samples[i]['y']) print(&quot;	shapesize:&quot;, foo_reader.samples[i]['shapesize']) end --or-- for <code>i</code>, shape in ipairs(foo_reader.samples) do print(&quot;	color:&quot;); shape['color']) -- key if (not foo_reader.infos[i].valid_data) then print(&quot;	invalid data!&quot;) end print(&quot;	xn:&quot;, shape['x']) print(&quot;	yn:&quot;, shape['y']) print(&quot;	shapesize:&quot;, shape['shapesize']) end</td>
</tr>
<tr>
<td></td>
<td>Lua application code can use any data sample. For details, see 7.4 Data Access API on page 43.</td>
<td></td>
</tr>
</tbody>
</table>

### Operations

<table>
<thead>
<tr>
<th>foo_reader:take() orfoo_reader:take(n)</th>
<th>Takes data from the data space, and populate the <code>foo_reader.samples</code> and <code>foo_reader.infos</code> sequences. If <code>n</code> is specified, only <code>n</code> 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 <code>take()</code> or <code>read()</code> operation.</th>
<th>foo_reader:take() foo_reader:take(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>foo_reader:read() orfoo_reader:read(n)</td>
<td>Reads data from the data space, and populate the <code>foo_reader.samples</code> and <code>foo_reader.infos</code> sequences. If <code>n</code> is specified, only <code>n</code> 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 <code>take()</code> or <code>read()</code> operation.</td>
<td>foo_reader:read() foo_reader:read(5)</td>
</tr>
</tbody>
</table>

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
<NDSDHOME>/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).

<table>
<thead>
<tr>
<th>Member Name</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>onStartEvent</td>
<td>true</td>
<td>Set to true if the Lua code has been called at start up (first execution).</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>Set by Prototyper and is read only from the lua script.</td>
</tr>
<tr>
<td>onStopEvent</td>
<td>true</td>
<td>Set to true if the Lua code has been called at shutdown (last execution).</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>Set by Prototyper and is read only from the lua script.</td>
</tr>
<tr>
<td>onDataEvent</td>
<td>true</td>
<td>Set to true if the Lua code has been called because new data is available.</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>Set by Prototyper and is read only from the lua script.</td>
</tr>
<tr>
<td>onPeriodEvent</td>
<td>true</td>
<td>Set to true if the Lua code has been called because of a periodic execution timer.</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>Set by Prototyper and is read only from the lua script.</td>
</tr>
<tr>
<td>intentExit</td>
<td>true</td>
<td>If set to true by the Lua code, specifies intent to terminate execution.</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>Set by the lua script and is read only from Prototyper.</td>
</tr>
</tbody>
</table>

**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:
### Simple Structures

<table>
<thead>
<tr>
<th>Index String</th>
<th>Equivalent OMG IDL Data Type Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
</table>
| 'anumber'    | A primitive field of a top-level structure. For example:  
\[
\text{struct StructType} \\
\text{double anumber;} \\
\text{string astring;} \\
\text{boolean abool;}
\]  
\[
\text{local adouble = data['anumber']}
\text{local astring = data['astring']}
\text{local abool = data['abool']}
\] | |
| 'astring'    | |
| 'abool'      | |

### Simple Unions

<table>
<thead>
<tr>
<th>Index String</th>
<th>Equivalent OMG IDL Data Type Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
</table>
| '#'          | The discriminator field of a top-level union. For example:  
\[
\text{union UnionType} \\
\text{switch (long)} \\
\text{case 1:} \\
\text{short ashort;} \\
\text{case 2:} \\
\text{long along;} \\
\text{case 3:} \\
\text{double adouble;} \\
\text{default:} \\
\text{string astring;}
\]  
\[
\text{local choice = data['#']}
\text{local value = data[choice]}
\] | |

### Nested Structures

<table>
<thead>
<tr>
<th>Index String</th>
<th>Equivalent OMG IDL Data Type Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
</table>
| 'outer.inner.anumber' | 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:  
\[
\text{struct NestedType} \\
\text{struct StructType inner;} \\
\text{struct TopLevelType} \\
\text{NestedType outer;}
\]  
\[
\text{local adouble = data['outer.inner.adouble']}
\text{local astring = data['outer.inner.astring']}
\text{local abool = data['outer.inner.abool']}
\] | |
### 7.4 Data Access API

#### Usage: Example Lua Code

<table>
<thead>
<tr>
<th>Index String</th>
<th>Equivalent OMG IDL Data Type Description</th>
<th>Usage: Example Lua Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>'aunion#'</td>
<td>The discriminator field of a nested union. For example:</td>
<td><code>local choice = data['aunion#']</code> <code>local value = data['aunion.'..choice]</code></td>
</tr>
</tbody>
</table>

#### Sequences and Arrays

| 'seq#' | The length of a collection (sequence or array). For example: | `local seq_length = data['seq#']` `local arr_length = data['arr#']` |
| 'arr#' |

| 'seq[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: | `local seq_k = data['seq[k]']` `local arr_k = data['arr[k]']` |
| 'arr[k]' |

| 'seq[k].adouble' | A field of the k-th element of a collection of structures. For example: | `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]` |
| 'arr[k].adouble' |

### 7.4 Data Access API

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

```lua
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.

<table>
<thead>
<tr>
<th>Underlying (DDS) Data Type</th>
<th>Lua Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDS_TK_ENUM</td>
<td>number</td>
<td>May lose precision in some cases. A Lua number is a ‘double’ in the default configuration on most platforms. For example: <code>foo_writer.instance['x'] = -5.3</code> <code>print(foo_writer.instance['x'])</code> -- = -5</td>
</tr>
<tr>
<td>DDS_TK_LONG</td>
<td>number</td>
<td>May lose precision when going from a Lua number (‘double’) to a DDS_TK_FLOAT.</td>
</tr>
<tr>
<td>DDS_TK_LONGLONG</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_OCTET</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_SHORT</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_UINTEGER</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_ULONGLONG</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_USHORT</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_FLOAT</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_DOUBLE</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_BOOLEAN</td>
<td>boolean</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_CHAR</td>
<td>string</td>
<td>Only the first letter is used when assigning from Lua. For example: <code>foo_writer.instance['x'] = &quot;hello&quot;</code> <code>print(foo_writer.instance['x'])</code> -- = &quot;h&quot;</td>
</tr>
<tr>
<td>DDS_TK_WCHAR</td>
<td>string</td>
<td>Only the first letter is used when assigning from Lua. See <a href="http://lua-users.org/wiki/LuaUnicode">http://lua-users.org/wiki/LuaUnicode</a></td>
</tr>
</tbody>
</table>
7.4.1 Examples of Data Access

<table>
<thead>
<tr>
<th>Underlying (DDS) Data Type</th>
<th>Lua Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDS_TK_STRING</td>
<td>string</td>
<td></td>
</tr>
<tr>
<td>DDS_TK_WSTRING</td>
<td>string</td>
<td>See <a href="http://lua-users.org/wiki/LuaUnicode">http://lua-users.org/wiki/LuaUnicode</a></td>
</tr>
</tbody>
</table>

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

```idl
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:

```lua
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:

```lua
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`:

```lua
local z = data['complex.z']
```

to get the value of the union called `aunion`:

```lua
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'])
```
7.4.1 Examples of Data Access

```
-- prints 'nil' because member is invalid
print(data['complex.union.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 == '1Data')
data['complex.union.1Data'] = 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/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, rtiddsprototypeso. 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. <participant_qos base_name="QosLibrary::DefaultProfile">
2.   <property>
3.     <value>
4.       <element>
5.         <name>lua.file</name>
6.         <value>shapes/ShapePublisher.lua</value>
7.       </element>
8.     </value>
9.   </property>
10. </participant_qos>
11. <!-- Timer Driven -->
12. <element>
13.   <name>lua.onData</name>
14.   <value>FALSE</value>
15. </element>
16. <element>
17.   <name>lua.onStart</name>
18.   <value>TRUE</value>
19. </element>
20. </element>
21. </participant_qos>
22. </domain_participant>
```
8.1 ShapePublisher Configuration

```
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:

![Image of RTI Shapes Demo - Domain 0](image_url)

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

```lua
1. -- Interface: parameters, inputs, outputs
2. local MyCircleWriter = CONTAINER.WRITER['MyPublisher::MyCircleWriter']
3. local MyTriangleWriter = CONTAINER.WRITER['MyPublisher::MyTriangleWriter']
4. 
5. -- Globals (preserved across invocations)
6. if count then count = count + 1
7. else -- initialize (first time)
8. count = 0
9. center = 120; radius = 70; yAmplitude = 100
10. end
11. -- print("*** iteration ", count, "***")
12. 
13. -- Write a RED circle on a 'circular' trajectory
14. local circle = MyCircleWriter.instance
15. circle['color'] = 'RED'
16. circle['x'] = center + radius * math.sin(count)
17. circle['y'] = center + radius * math.cos(count)
18. circle['shapesize'] = 30
19. MyCircleWriter:write()
20. 
21. -- Write a YELLOW Triangle on a 'vertical' trajectory
22. local triangle = MyTriangleWriter.instance
23. triangle['color'] = "YELLOW"
24. triangle['x'] = center -- radius * math.sin(count);
25. triangle['y'] = center + yAmplitude * math.cos(count)
26. triangle['shapesize'] = 30
27. MyTriangleWriter:write()
28. 
29.
```
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.


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:

```xml
<domain_participant name="ShapeSubscriber"
   domain_ref="MyDomainLibrary::ShapeDomain">
  
  <participant_qos base_name="QosLibrary::DefaultProfile">
    <property>
      <value>
        <element>
          <name>lua.file</name>
          <value>shapes/ShapeSubscriber.lua</value>
        </element>
      </value>
    </property>

    <element>
      <name>lua.onPeriod</name>
      <value>FALSE</value>
    </element>

    <element>
      <name>lua.onStart</name>
      <value>TRUE</value>
    </element>
  </participant_qos>

</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: My Participant Library::ShapeSubscriber
   ```

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

   ```
   *** iteration 319 ***
   READERMySubscriber::MySquareReader
   color:BLUE
   x: 188
   y: 156
   shapessize:20
   *** iteration 320 ***
   READERMySubscriber::MySquareReader
   color:BLUE
   x: 183
   y: 161
   shapessize:30
   READERMySubscriber::MyCircleReader
   ```
The Lua script `shapes/ShapeSubscriber.lua` is copied below.

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

53
This script illustrates how to use Lua iterators to access all the readers and samples. Line 9 uses the Lua \texttt{pairs()} iterator to traverse over all the entries in the CONTAINER.READER table. The local variables \texttt{name} and \texttt{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. \texttt{x}, \texttt{y}, \texttt{shapesize}) will be \texttt{nil}.

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

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

### 8.3 ShapePubSub Configuration

The \texttt{MyParticipantLibrary::ShapePubSub} is a \textit{data and timer driven} (default) configuration with three \texttt{DataReaders} and three \texttt{DataWriters}, for each of the ShapeDemo topics: Square, Circle, Triangle. Start/stop execution triggers are delivered to the Lua code component (\texttt{lua.onStart=true, lua.onStop=p=true}). The default Lua script associated with this configuration is \texttt{shapes/ShapePubSub.lua}. Other Lua scripts can be used with this configuration using the \texttt{--luaFile <script>} option, as we saw earlier in the \texttt{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.     <element>
8.       <name>lua.file</name>
9.     </value>
10.    </element>
11.  
12.     <!-- Data and Timer Driven (default) -->
13.    <element>
14.      <name>lua.onStart</name>
15.    </value>
16.     <element>
17.      <name>lua.onStop</name>
18.     </value>
19.  </element>
```

This script illustrates how to use \textit{Lua} iterators to access all the readers and samples. Line 9 uses the Lua \texttt{pairs()} iterator to traverse over all the entries in the CONTAINER.READER table. The local variables \texttt{name} and \texttt{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. \texttt{x}, \texttt{y}, \texttt{shapesize}) will be \texttt{nil}.

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

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

### 8.3 ShapePubSub Configuration

The \texttt{MyParticipantLibrary::ShapePubSub} is a \textit{data and timer driven} (default) configuration with three \texttt{DataReaders} and three \texttt{DataWriters}, for each of the ShapeDemo topics: Square, Circle, Triangle. Start/stop execution triggers are delivered to the Lua code component (\texttt{lua.onStart=true, lua.onStop=p=true}). The default Lua script associated with this configuration is \texttt{shapes/ShapePubSub.lua}. Other Lua scripts can be used with this configuration using the \texttt{--luaFile <script>} option, as we saw earlier in the \texttt{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:

```xml
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.     <element>
8.       <name>lua.file</name>
9.     </value>
10.    </element>
11.  
12.     <!-- Data and Timer Driven (default) -->
13.    <element>
14.      <name>lua.onStart</name>
15.    </value>
16.     <element>
17.      <name>lua.onStop</name>
18.     </value>
19.  </element>
```
8.3 ShapePubSub Configuration

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.

```lua
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. reader:take()
6. for i, shape in ipairs(reader.samples) do
7.   if (not reader.infos[i].valid_data) then break end
8.   writer.instance['color'] = shape['color']
9.   writer.instance['x'] = shape['x']
10.  writer.instance['y'] = shape['y']
11.   writer.instance['shapesize'] = shape['shapesize'] * SIZE_FACTOR
12.  writer:write()
13. 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.

```
1. -- Interface: parameters, inputs, outputs
2. local MAX_HISTORY = 6
3. local reader = CONTAINER.READER[1] -- Square
4. local delay_writer = CONTAINER.WRITER[#CONTAINER.WRITER-1] -- Circle
5. local average_writer = CONTAINER.WRITER[#CONTAINER.WRITER] -- Triangle
6. 
7. -- Function-object (closure) to maintain a first-in-first-out (FIFO) queue
8. function newFifo (max_h)
9.  local index = 0
10. local history = {}
11. return function (element)
12.  if index == max_h then index = 1 else index=index+1 end
13.  oldest = history[index]
14.  history[index] = element
15.  return oldest, #history
16. end
17. end
18. 
19. --- Re-publish input delayed by MAX_HISTORY samples
20. function delay()
21.  -- Globals (preserved across invocations)
22.  if not delay_size_history then
23.   delay_x_history = {}
24.   delay_y_history = {}
25.   delay_size_history = {}
26. end
27. 
28.  -- Iterate over each sample we got
29.  for i, shape in ipairs(reader.samples) do
30.    local color = shape['color']
31.    local x = shape['x']
32. ```
local y = shape['y']
local size = shape['shapesize']

-- SKIP sample if data is not valid
if not x then break end

-- If a new color create FIFOs to hold the last positions and averages
if not delay_size_history[color] then
delay_x_history[color] = newFifo(MAX_HISTORY)
delay_y_history[color] = newFifo(MAX_HISTORY)
delay_size_history[color] = newFifo(MAX_HISTORY)
end

-- Push a new value to the FIFO returning the oldest value and
-- the number of elements in the FIFO, including the new one just pushed
local oldest_x, samplesInHistory = delay_x_history[color](x)
local oldest_y = delay_y_history[color](y)
local oldest_size = delay_size_history[color](size)

-- write only if we have accumulated enough history and gotten
-- something out of the FIFO
if oldest_x then
    shape = delay_writer.instance
    shape['color'] = color
    shape['x'] = oldest_x
    shape['y'] = oldest_y
    shape['shapesize'] = oldest_size

    -- print(color, oldest_x, oldest_y, oldest_size)
delay_writer:write()
end

end

end

function average()
    -- Globals (preserved across invocations)
    if not x_avg then
        average_x_history = {}
        average_y_history = {}
        x_avg = {}
        y_avg = {}
    end

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

        -- SKIP sample if data is not valid
        if not x then break end

        -- If a new color create FIFOs to hold the historical values
        if not x_avg[color] then
            average_x_history[color] = newFifo(MAX_HISTORY)
            average_y_history[color] = newFifo(MAX_HISTORY)
            x_avg[color] = 0
            y_avg[color] = 0
        end

        end

end
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: RTI_DefaultMonitor_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, `rtiddsprototyper.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
9.1.1 Run with Shapes Demo Application

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"
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"
9.1.1 Run with Shapes Demo Application

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.

```xml
<participant_library name="MyParticipantLibrary">
  <domain_participant name="ControlledShapePublisher"
    domain_ref="MyDomainLibrary::ShapeDomain">
    <publisher name="MyPublisher">
      <data_writer name="MySquareWriter" topic_ref="Square">
        <datawriter_qos>
          <property>
            <element>
              <name>rti.prototyper.member:color</name>
              <value>iterator?list=[Red]</value>
            </element>
            <element>
              <name>rti.prototyper.member:x</name>
              <value>linear?begin=0,end=100</value>
            </element>
            <element>
              <name>rti.prototyper.member:y</name>
              <value>linear?begin=0,end=100</value>
            </element>
            <element>
              <name>rti.prototyper.member:shapesize</name>
              <value>linear?begin=20,end=20</value>
            </element>
          </property>
        </datawriter_qos>
      </data_writer>
      <data_writer name="MyCircleWriter" topic_ref="Circle">
        <datawriter_qos>
          <property>
            <element>
              <name>rti.prototyper.member:color</name>
              <value>iterator?list=[Orange]</value>
            </element>
            <element>
              <name>rti.prototyper.member:x</name>
              <value>linear?begin=0,end=250</value>
            </element>
            <element>
              <name>rti.prototyper.member:y</name>
              <value>linear?begin=150,end=200</value>
            </element>
          </property>
        </datawriter_qos>
      </data_writer>
    </publisher>
  </domain_participant>
</participant_library>
```

9.1.2 Behavior of Prototyper for Shapes Demo Application
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:

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

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

<table>
<thead>
<tr>
<th>Member Type</th>
<th>Values Set by Default Data-Generation Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Integer types:</strong> Octet, short, unsigned short, long, unsigned long, long long, unsigned long long</td>
<td>Integer values starting from 0 and incrementing by 1 each sample written.</td>
<td>Member: long x; x will be set to: 0, 1, 2, 3, 4, ...</td>
</tr>
<tr>
<td><strong>Floating point types:</strong> float, double</td>
<td>Floating point values starting with 0.0 and incremented by 1.0 each sample written.</td>
<td>Member: float x; x will be set to: 0.0, 1.0, 2.0, 3.0, 4.0, ...</td>
</tr>
<tr>
<td><strong>String types:</strong> string, wstring</td>
<td>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.</td>
<td>Member: string x; x will be set to: “String: 0”, “String: 1”, “String: 2”, “String: 3”, “String: 4”, ...</td>
</tr>
<tr>
<td><strong>Enumerated type</strong></td>
<td>Each value of the enumeration, starting with the first and cycling back to the beginning when all the values have been generated.</td>
<td>Enum EnumType { A, B, C }; Member: EnumType x; x will be set to: A, B, C, A, B, ...</td>
</tr>
<tr>
<td><strong>Union type</strong></td>
<td>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.</td>
<td>union UnionType { long x; 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”, ...</td>
</tr>
<tr>
<td><strong>Array type</strong></td>
<td>Set all elements to the same value using the default data-generation function for the element.</td>
<td>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</td>
</tr>
<tr>
<td><strong>Sequence type</strong></td>
<td>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.</td>
<td>Member: sequence&lt;long, 10&gt; x; Set length to 2 and x[0]=x[1]=0, 1, 2, 3, ...</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Member Type</th>
<th>Values Set by Default Data-Generation Function</th>
<th>Example</th>
</tr>
</thead>
</table>
| **Integer types:**   | Random integer value.                                                                                            | Member: `long x; //@key`  
                      | octet, short, unsigned short, long, unsigned long, long long, unsigned long long                          | `x` will be set to a random value, e.g.: 8761237                      |
| **Floating point**   | Random floating value.                                                                                         | Member: `float x; //@key`  
| types:               |                                                                                                               | `x` will be set to a random value, e.g.: 3.741723                      |
| float, double        |                                                                                                               |                                                                         |
| **String types:**    | String that follows pattern: "Key: RR" where RR is a random number.                                           | Member: `string x; //@key`  
| string, Wstring      |                                                                                                               | `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:

\[
\text{rti.prototyper.member:<replace with the name of the member>}
\]

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

\[
\text{<function name>?<parameter 1>=<value1>,<parameter2>=<value2>,...}
\]

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.

\[
\begin{align*}
\text{<struct name="ShapeType">} \\
\text{<member name="color" key="true" type="string" stringMaxLength="MAX_COLOR_LEN"/>} \\
\text{<member name="x" type="long"/>} \\
\text{<member name="y" type="long"/>} \\
\text{<member name="shapesize" type="long"/>} \\
\text{</struct>}
\end{align*}
\]

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

\[
\text{So color corresponds to the name of a member of type string.}
\]

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.
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:

```xml
<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.

```xml
<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"/>
  </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:

```xml
<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”.

```xml
<properties>
  <value>
    <element>
      <name>rti.prototyper.member:trucks#length</name>
      <value>linear?begin=6,end=10</value>
    </element>
  </value>
  <value>
    <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 “CA8888”. 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.

<table>
<thead>
<tr>
<th>Generation Function</th>
<th>Parameters</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>linear</td>
<td>begin, end, num-steps</td>
<td>linear?begin=0,end=100, numsteps=50</td>
<td>Generates 'numsteps' linearly spaced values between and including 'begin' and 'end'.</td>
</tr>
<tr>
<td>iterator</td>
<td>list</td>
<td>iterator?list=[RED,GREEN,BLUE]</td>
<td>Set each element in the list in sequence</td>
</tr>
</tbody>
</table>
### 9.2.3 Controlling the Data Values Written by Prototyper

<table>
<thead>
<tr>
<th>Generation Function</th>
<th>Parameters</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Init</td>
<td>N/A</td>
<td><code>Init</code></td>
<td>Set the value to the initialization value for the type. This is typically zero for atomic types, zero length sequences, etc.</td>
</tr>
</tbody>
</table>