RTI Limited Bandwidth Endpoint Discovery Plugin

User's Manual

Version 7.7.0

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Chapter 1 Introduction

The *RTI® Limited Bandwidth Endpoint Discovery (LBED) Plugin* reduces discovery time and network traffic by locally defining information about the endpoints that need to be discovered in an XML file. The default dynamic discovery process, on the other hand, sends the information about the endpoints over the network. Therefore, LBED requires all the endpoints to be known ahead of time and each must be declared in an XML file.

Discovery is the behind-the-scenes way in which *RTI Connext®* objects (*DomainParticipants*, *DataWriters*, and *DataReaders*) find out about each other. Each *DomainParticipant* maintains a database of information about all the active *DataReaders* and *DataWriters* in the same domain. This database is what makes it possible for *DataWriters* and *DataReaders* to communicate. To create and refresh the database, each application follows a common discovery process.

The default discovery mechanism in *Connext* is the one described in the DDS specification and is known as Simple Discovery Protocol, which includes two phases: Simple Participant Discovery and Simple Endpoint Discovery. The goal of these two phases is to build, for each *DomainParticipant*, a complete picture of all the entities that belong to the remote participants in its peers list, which is a list of nodes with which a participant may communicate.

During the Simple Participant Discovery phase, *DomainParticipants* learn about each other. The *DomainParticipant's* details are communicated to all other *DomainParticipants* in the same domain by sending participant declaration messages, also known as participant DATA submessages or participant announcements.

During the Simple Endpoint Discovery phase, *Connext* matches *DataWriters* and *DataReaders*. Information about each application's *DataReaders* and *DataWriters* is exchanged by sending publication/subscription declarations in DATA submessages (participant announcements), which we will refer to as publication DATAs and subscription DATAs. The Simple Endpoint Discovery phase uses reliable communication.

With Limited Bandwidth Endpoint Discovery (LBED), the Simple Participant Discovery phase still occurs, but the information normally gathered dynamically by Simple Endpoint Discovery

is instead configured statically in an XML file. The static definition of endpoint discovery information is why LBED can also be referred to as Static Endpoint Discovery.

Chapter 2 Paths Mentioned in Documentation

The documentation refers to:

- **<NDDSHOME>**

  This refers to the installation directory for *RTI® Connext®*. The default installation paths are:

  - macOS® systems:
    /Applications/rti_connext_dds-7.7.0
  - Linux systems, non-*root* user:
    /home/<*your user name*>/rti_connext_dds-7.7.0
  - Linux systems, *root* user:
    /opt/rti_connext_dds-7.7.0
  - Windows® systems, user without Administrator privileges:
    <*your home directory*>\rti_connext_dds-7.7.0
  - Windows systems, user with Administrator privileges:
    C:\Program Files\rti_connext_dds-7.7.0

  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-7.7.0\bin\rtiddsgen"
```

Or if you have defined the **NDDSHOME** environment variable:

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

- **API Reference HTML documentation**

  Default path: **<NDDSHOME>/doc/api/connext_dds/api_<language>**

- ***<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:

  - macOS systems: **/Users/<*your user name*>/rti_workspace/7.7.0/examples**
  - Linux systems: **/home/<*your user name*>/rti_workspace/7.7.0/examples**
  - Windows systems: ***<your Windows documents folder>*\rti_workspace\7.7.0\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 Installation Guide*.

Chapter 3 Getting Started

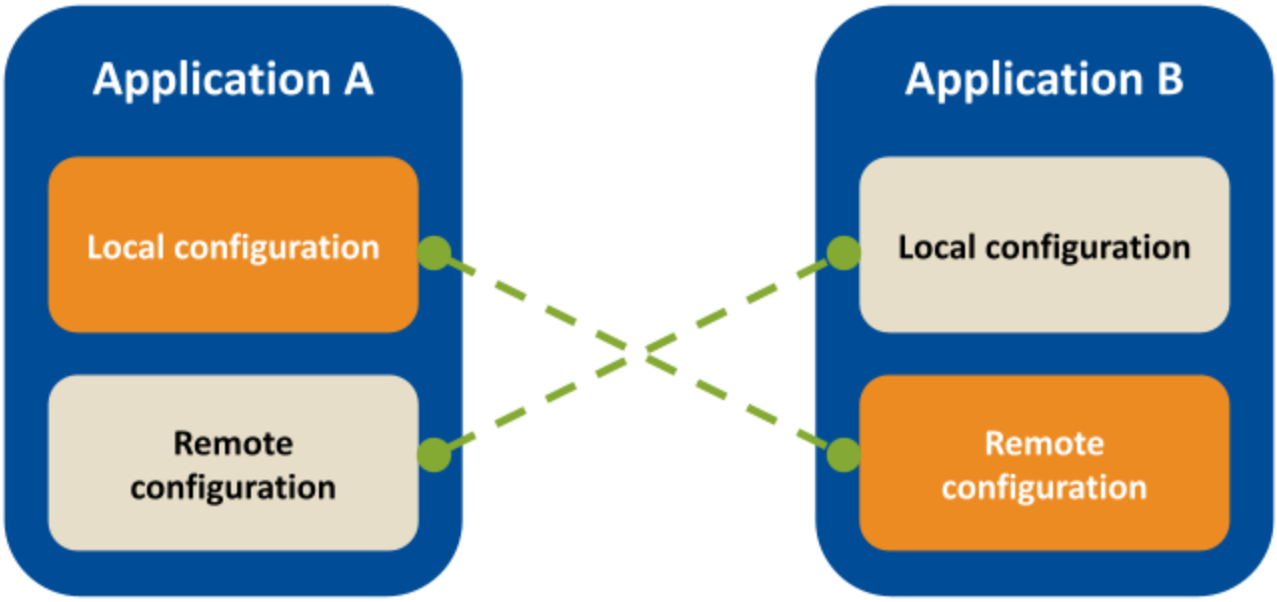
Limited Bandwidth Endpoint Discovery (LBED) is achieved with a file-based plugin. Information about the endpoints is obtained from an XML file instead of being sent dynamically over the network. This method can reduce discovery time and network traffic. However, for LBED to work, all the endpoints must be known ahead of time and described in an XML file.

When using LBED in a system, each application has two different configuration kinds:

- A local configuration, which consists of the QoS policies, *Topics*, and types the application's endpoints use. A local configuration is usually specified using XML (e.g., **USER_QOS_PROFILES.xml**).
- A remote configuration, which is required by LBED, and consists of the QoS policies, *Topics*, and types from other applications' endpoints that the application needs to discover. A remote configuration is always specified using XML (i.e., **USER_QOS_PROFILES.xml** or a separate XML file).

Figure 3.1: Applications Define Both Their Own and Other Applications' Endpoint Configurations on the next page shows a system with two applications (A and B), both using the LBED plugin. The remote configuration of A is the local configuration of B, since A needs to statically discover B's endpoints and, therefore, it needs to know their information. The same happens in the other direction.

Figure 3.1: Applications Define Both Their Own and Other Applications' Endpoint Configurations



This chapter describes how to configure the LBED Plugin in a generated *Connext* project.

> Only LBED dynamic libraries are available. Therefore, you must link with the dynamic version of the *Connext* libraries. See the RTI Connext Core Libraries Platform Notes for the dynamic libraries associated with your platform.

3.1 Generate Connext Project

1. Run **<NDDSHOME>/resource/scripts/rtisetenv_<architecture>.<shell>** in a new command prompt window, to avoid issues with paths and licensing.

   <architecture> depends on your target machine (where you will deploy your completed application), and **<shell>** depends on the shell you are using (bash, zsh, bat…). Architecture strings are listed in the RTI Connext Core Libraries Platform Notes. Examples are **x64Win64VS2017** and **armv8Linux4gcc8.5.0**.

   (See Set Up Environment Variables (rtisetenv), in "Hands-On 1" of *Introduction to Publish/Subscribe*, in the RTI Connext Getting Started Guide.)
2. Create an IDL file. For example, you may want to use the following (save it as **ExampleLBED.idl**):

```
struct ExampleLBED {
    long data;
```

```
};
```

3. Run *RTI Code Generator* (*rtiddsgen*). This guide uses the Modern C++ programming language as reference. The steps are the same for the other supported languages. Feel free to choose the language that best suits your needs. It is recommended you generate an advanced example, if supported by your language and platform; the required code modifications that will be made later in this chapter will be easier if you use the advanced example. For a brief introduction to *Code Generator*, see Run Code Generator, in "Hands-On 1" of *Introduction to Publish/Subscribe*, in the RTI Connext Getting Started Guide. Full details are in the RTI Code Generator User's Manual.

   For Linux® systems:

   ```
   $ rtiddsgen -example <architecture> -language C++11 -exampleTemplate advanced
   ExampleLBED.idl
   ```

   For Windows® systems:

   ```
   > rtiddsgen -example <architecture> -language C++11 -exampleTemplate advanced -
   ppDisable ExampleLBED.idl
   ```

The generated example will be composed of the following files:

Table 3.1 Modern C++ Files Created for "ExampleLBED.idl"

Generated Files	Description
ExampleLBED.hpp ExampleLBED.cxx ExampleLBEDPlugin.hpp ExampleLBEDPlugin.cxx	Support for the generated type in C++11.
ExampleLBED_publisher.cxx ExampleLBED_subscriber.cxx	Example Publisher and Subscriber applications. Contains a DomainParticipant with a single DataWriter/DataReader for the type defined in ExampleLBED.idl.
application.hpp	Provides common utilities to the publisher and subscriber applications, like setting the verbosity and parsing the command-line arguments.
README_<architecture>.txt	See this README for instructions on how to open and modify the files.
Makefiles and Visual Studio® project files (for Windows applications)	Architecture-dependent build files.
USER_QOS_PROFILES.xml	The Quality of Service (QoS) configuration of the DDS entities in the generated example is loaded from this file. The required configuration for using LBED in your application, as well as the static information of the endpoints, can be specified here.

In the following sections, some of the generated files mentioned above will be modified for using the *Limited Bandwidth Endpoint Discovery Plugin*.

Note: The completed XML file that we will be creating in this Getting Started exercise, if you follow the 3.5.1 Using the USER_QOS_PROFILES.xml on page 14 option, can be found in **<path to examples>/connext_dds/c++11/limited_bandwidth_plugins/lbediscovery/USER_QOS_PROFILES.xml**, for your reference.

3.2 Add Name to Each DomainParticipant

Each time a *DomainParticipant* is discovered, the LBED Plugin uses the name of that *DomainParticipant* (propagated in the participant announcements) to look for its endpoints' information in the XML file. Since the <participant_name> field is used to associate a participant with its XML information, each *DomainParticipant* using LBED must have a non-NULL name that identifies it.

> **Note:** If you plan on starting multiple applications with participants that have the same configuration and set of endpoints, these participants can reuse the same configuration and have the same name. For example, you could have two temperature sensors with the same *DomainParticipant* and QoS, each with a *DataWriter* on the "Temperature" topic. The only difference would be the data both sensors publish. If you use LBED in this case, the XML of both *DomainParticipants* will be the same; you don't need to duplicate that information and give the *DomainParticipants* different names.

The name of a *DomainParticipant* can be configured using the "ENTITY_NAME QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual. The **USER_QOS_PROFILES.xml** generated in 3.1 Generate Connext Project on page 6 already assigns a name to the *DomainParticipants*. It assigns the same name, **ExampleLBEDParticipant**, to both the *Publisher* and *Subscriber DomainParticipants*; however, to use LBED, *Publisher* and *Subscriber DomainParticipants* need to have different names because they contain different sets of endpoints. Therefore, in this exercise, we will create two separate QoS profiles: one for the *Publisher DomainParticipant* and another for the *Subscriber*, each with a different <participant_name>.

1. Remove the existing qos_profile named "ExampleLBED_Profile" in the **USER_QOS_PROFILES.xml** file and copy and paste the following two profiles:

```
<!-- The QoS profile used by the publishing entities -->
<qos_profile name="ExampleLBED_Publisher_Profile">
    <domain_participant_qos>
        <participant_name>
            <name>ExampleLBEDParticipantPublisher</name>
        </participant_name>
    </domain_participant_qos>
</qos_profile>

<!-- The QoS profile used by the subscribing entities -->
<qos_profile name="ExampleLBED_Subscriber_Profile">
    <domain_participant_qos>
        <participant_name>
            <name>ExampleLBEDParticipantSubscriber</name>
```

```
        </participant_name>
    </domain_participant_qos>
</qos_profile>
```

2. Modify **ExampleLBED_publisher.cxx** so that the *DomainParticipant*, *Topic*, *Publisher*, and *DataWriter* use the "ExampleLBED_Publisher_Profile":

```
dds::domain::DomainParticipant participant(
    domain_id,
    dds::core::QosProvider::Default().participant_qos(
        "ExampleLBED_Library::ExampleLBED_Publisher_Profile"));

...

dds::topic::Topic<ExampleLBED> topic(
    participant,
    "Example ExampleLBED",
    dds::core::QosProvider::Default().topic_qos(
        "ExampleLBED_Library::ExampleLBED_Publisher_Profile"));

...

dds::pub::Publisher publisher(
    participant,
    dds::core::QosProvider::Default().publisher_qos(
        "ExampleLBED_Library::ExampleLBED_Publisher_Profile"));

...

dds::pub::DataWriter<ExampleLBED> writer(
    publisher,
    topic,
    dds::core::QosProvider::Default().datawriter_qos(
        "ExampleLBED_Library::ExampleLBED_Publisher_Profile"),
        listener,
        status_mask);
```

3. Modify **ExampleLBED_subscriber.cxx** so that the *DomainParticipant*, *Topic*, *Subscriber*, and *DataReader* use the "ExampleLBED_Subscriber_Profile":

```
dds::domain::DomainParticipant participant(
    domain_id,
    dds::core::QosProvider::Default().participant_qos(
        "ExampleLBED_Library::ExampleLBED_Subscriber_Profile"));

...

dds::topic::Topic<ExampleLBED> topic(
    participant,
    "Example ExampleLBED",
    dds::core::QosProvider::Default().topic_qos(
        "ExampleLBED_Library::ExampleLBED_Subscriber_Profile"));
```

```
...

dds::sub::Subscriber subscriber(
    participant,
    dds::core::QosProvider::Default().subscriber_qos(
        "ExampleLBED_Library::ExampleLBED_Subscriber_Profile"));

...

dds::sub::DataReader<ExampleLBED> reader(
    subscriber,
    topic,
    dds::core::QosProvider::Default().datareader_qos(
        "ExampleLBED_Library::ExampleLBED_Subscriber_Profile"),
        listener,
        status_mask);
```

3.3 Add an RTPS Object ID to Each Endpoint

The RTPS object ID is an integer that uniquely identifies an endpoint of a specific kind (*DataWriter* or *DataReader*) within a *DomainParticipant*. Normally, the RTPS object ID is automatically assigned by *Connext* when an endpoint is created, and it is exchanged during the Simple Endpoint Discovery phase. However, the LBED Plugin replaces Simple Endpoint Discovery, so this auto-assigned RTPS object ID will not be propagated to other endpoints. In order for remote endpoints to be discovered, LBED needs to know the RTPS object ID of a remote participant's entities before discovery initiates.

Therefore, when LBED is used, you must manually define the RTPS object ID of every endpoint in the application. This can be done by means of the "DATA_WRITER_PROTOCOL QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual and "DATA_READER_PROTOCOL QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual. **The RTPS object ID values need to be unique within the same *DomainParticipant* and per endpoint kind (e.g., two *DataWriters* of the same *DomainParticipant* cannot have the same RTPS object ID, but a *DataReader* and a *DataWriter* could have the same value).**

> If your application uses RTI Connext Core Libraries XML-Based Application Creation, you do not have to manually specify the RTPS object ID. In this unique case, LBED is able to automatically infer which RTPS object ID *Connext* will assign to each endpoint. You can see an example of an application that uses LBED and *XML-Based Application Creation* in the rticonnextdds-examples section on GitHub.

1. In your **USER_QOS_PROFILES.xml**, add the following XML snippet to the <qos_profile> named "ExampleLBED_Publisher_Profile" after the <domain_participant_qos> and make sure your *DataWriter* is created using this QoS profile (review the *DataWriter's* creation call in **ExampleLBED_publisher.cxx** and make sure the name of the profile used there is the same as that used here: "ExampleLBED_Publisher_Profile"). 100 is an example value, but you could use

any other value as long as it is unique within the same *DomainParticipant* and per endpoint kind, and falls into the valid range as described for the **rtps_object_id** field in the API Reference HTML documentation.

```
<datawriter_qos>
    <protocol>
        <rtps_object_id>100</rtps_object_id>
    </protocol>
</datawriter_qos>
```

2. In your **USER_QOS_PROFILES.xml**, add the following XML snippet to the <qos_profile> named "ExampleLBED_Subscriber_Profile" after the <domain_participant_qos> and make sure your *DataReader* is created using this QoS profile (review the *DataReader's* creation call in **ExampleLBED_subscriber.cxx** and make sure the name of the profile used there is the same as that used here: "ExampleLBED_Subscriber_Profile"). 200 is an example value, but you could use any other value as long as it is unique within the same *DomainParticipant* (we could have used 100 here as well because the *DataReader* and *DataWriter* are being created by different participants) and per endpoint kind, and falls into the valid range as described for the **rtps_object_id** field in the API Reference HTML documentation.

```
<datareader_qos>
    <protocol>
        <rtps_object_id>200</rtps_object_id>
    </protocol>
</datareader_qos>
```

3.4 Enable LBED Plugin on Each DomainParticipant

The next step is to tell each *DomainParticipant* that it should use the *Limited Bandwidth Endpoint Discovery Plugin* instead of Simple Endpoint Discovery. There are two ways of doing this, and both require configuring the *DomainParticipant* QoS in the **USER_QOS_PROFILES.xml** file.

The options described below (3.4.1 Using the Builtin Discovery Plugins Mask (Recommended) below or 3.4.2 Using the LBED Plugin Properties on the next page) are mutually exclusive, which means that it is not possible to enable the plugin for the same *DomainParticipant* using both of these mechanisms at the same time. If you do, an error will be displayed and *DomainParticipant* creation will fail.

3.4.1 Using the Builtin Discovery Plugins Mask (Recommended)

The **builtin_discovery_plugins** mask (set in the *DomainParticipant's* "DISCOVERY_CONFIG QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual) can be used to select the built-in discovery plugins a *DomainParticipant* should use. This mask can be used to enable the LBED plugin in a *DomainParticipant* if its value is set to DPSE (**D**ynamic **P**articipant discovery, **S**tatic **E**ndpoint discovery).

Copy and paste the following XML snippet into the <domain_participant_qos> tag of both QoS profiles: "ExampleLBED_Publisher_Profile" and "ExampleLBED_Subscriber_Profile":

```
<discovery_config>
    <builtin_discovery_plugins>DPSE</builtin_discovery_plugins>
</discovery_config>
```

Using DPSE automatically configures the *DomainParticipant* properties and QoS in the same way as described in 3.4.2 Using the LBED Plugin Properties below.

Along with the DPSE value, the following optional LBED properties can be specified:

dds.discovery.endpoint.lbediscovery.config_file
dds.discovery.endpoint.lbediscovery.verbosity
dds.discovery.endpoint.lbediscovery.property_validation_action

See Table 4.1 LBED Configuration Properties for Connext for further information.

DPSE (Dynamic Participant discovery, Static Endpoint discovery) and SEDP (Simple Endpoint Discovery Protocol) cannot be specified simultaneously in the **builtin_discovery_plugins** mask.

If you are using both the LBED plugin and the LBPD plugin, this mask needs to be set to MASK_NONE. Therefore, in that case, DPSE cannot be used for enabling LBED. You must use the LBED plugin properties to enable it (see 3.4.2 Using the LBED Plugin Properties below).

3.4.2 Using the LBED Plugin Properties

Connext provides a mechanism to dynamically load an external plugin from an XML QoS profile, i.e., the **USER_QOS_PROFILES.xml** file we have been modifying. That mechanism is the "PROPERTY QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual.

The PROPERTY QoS policy stores name/value (string) pairs that can be used to configure certain parameters of *Connext* that are not exposed through formal QoS policies. *Connext* uses this mechanism, for example, to configure external transports and plugins.

To enable LBED using these properties, add the following XML snippet into the <domain_participant_qos> tag of both QoS profiles “ExampleLBED_Publisher_Profile" and “ExampleLBED_Subscriber_Profile”. This snippet shows the minimum required properties for enabling the plugin:

```
<property>
    <value>
        <element>
            <name>dds.discovery.endpoint.lbediscovery.library</name>
            <value>rtilbedisc</value>
        </element>
        <element>
            <name>dds.discovery.endpoint.lbediscovery.create_function</name>
            <value>DDS_LBEDiscoveryPlugin_create</value>
```

```
        </element>
        <element>
            <name>dds.discovery.endpoint.load_plugins</name>
            <value>dds.discovery.endpoint.lbediscovery</value>
        </element>
    </value>
</property>
```

For more information about the meaning of the properties above, their values, and other LBED properties that can be specified, see Table 4.1 LBED Configuration Properties for Connext.

In addition to setting the properties described above, set the **builtin_discovery_plugins mask** (using the *DomainParticipant's* "DISCOVERY_CONFIG QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual) to SPDP as shown in the XML excerpt below. The default value of this mask is SDP (Simple Discovery Protocol), which consists of two parts, Simple Participant Discovery Protocol (SPDP) and Simple Endpoint Discovery Protocol (SEDP). Set the **builtin_discovery_plugins** to just SPDP to indicate that SPDP is the only default plugin you'll be using, since you will be replacing the SEDP portion with the LBED plugin:

```
<discovery_config>
    <builtin_discovery_plugins>SPDP</builtin_discovery_plugins>
</discovery_config>
```

If you are using both the LBED plugin and the LBPD plugin, set this mask to MASK_NONE. An example of this configuration is shown in <path to examples>/connext_dds/c++11/limited_bandwidth_plugins/dil-stacking.

3.5 Add the DDS-XML Definition of the Entities

If you followed the previous steps in this chapter, you should have an application in which each *DomainParticipant* has a non-null name, each created endpoint has a predefined RTPS object ID, and both *DomainParticipants* use the LBED Plugin for the Endpoint Discovery phase. However, if you were to run the *Publisher* and the *Subscriber* now, you would see error messages similar to the following:

```
$ ./ExampleLBED_subscriber
…
ERROR [0x01016E46,0x8484F58C,0x5EBD43BE:0x000100C7{Entity=DR,MessageKind=DATA}|RECEIVE FROM
0x00000000,0x00000000,0x00000000:0x000100C2|REGISTER DP
"ExampleLBEDParticipantPublisher"|LC:Discovery]DDS_LBEDiscoveryPlugin_
registerParticipant:The
discovered DomainParticipant [guid=0x01013049,0xFA1254B0,0x6D982A45:0x000001C1] is not in
the file.
ERROR [0x01016E46,0x8484F58C,0x5EBD43BE:0x000100C7{Entity=DR,MessageKind=DATA}|RECEIVE FROM
0x00000000,0x00000000,0x00000000:0x000100C2|LC:Discovery]DDS_LBEDiscoveryPlugin_
afterRemoteParticipantEnabled:The DomainParticipant "ExampleLBEDParticipantPublisher" cannot
be registered.
…
```

```
$ ./ExampleLBED_publisher
…
```

```
ERROR [0x01013049,0xFA1254B0,0x6D982A45:0x000100C7{Entity=DR,MessageKind=DATA}|RECEIVE FROM
0x00000000,0x00000000,0x00000000:0x000100C2|REGISTER DP
"ExampleLBEDParticipantSubscriber"|LC:Discovery]DDS_LBEDiscoveryPlugin_
registerParticipant:The discovered DomainParticipant
[guid=0x01016E46,0x8484F58C,0x5EBD43BE:0x000001C1] is not in the file.
ERROR [0x01013049,0xFA1254B0,0x6D982A45:0x000100C7{Entity=DR,MessageKind=DATA}|RECEIVE FROM
0x00000000,0x00000000,0x00000000:0x000100C2|LC:Discovery]DDS_LBEDiscoveryPlugin_
afterRemoteParticipantEnabled:The DomainParticipant "ExampleLBEDParticipantSubscriber"
cannot be registered.
…
```

In addition, no data is exchanged between the *Publisher* and the *Subscriber* applications. This is because the endpoints are not being discovered. We are missing the most important requirement of the *Limited Bandwidth Endpoint Discovery Plugin*: the XML definition of the endpoints that should be discovered (the remote configuration).

The *Publisher* requires the XML definition of the *Subscriber's* endpoints. When the *Publisher* discovers the *Subscriber DomainParticipant*, the *Publisher* will use the name of the *Subscriber* to look for its definition in the XML file, and will register all the *Subscriber's* endpoints with their associated QoS, *Topics*, and types. In the same way, the *Subscriber* requires the XML definition of the *Publisher's* endpoints. The error messages above tell us that the definition of "ExampleLBEDParticipantSubscriber" and "ExampleLBEDParticipantPublisher" could not be found in the XML file (by default, the **USER_QOS_PROFILES.xml** if the **config_file** property in Table 4.1 LBED Configuration Properties for Connext was not specified). Therefore, their endpoints could not be registered.

To define the *Publisher* and *Subscriber DomainParticipants* information, the LBED Plugin uses the OMG DDS Consolidated XML Syntax (DDS-XML), a standard that determines how to represent and describe DDS entities and resources using XML. This is the same standard that *XML-Based Application Creation* uses. For more information about DDS-XML, it is recommended to read "XML Tags for Configuring Entities" in the RTI Connext Core Libraries XML-Based Application Creation Getting Started Guide or the OMG DDS Consolidated XML Syntax (DDS-XML) specification.

There are two ways of specifying the DDS-XML definition of the entities for LBED: directly in the **USER_QOS_PROFILES.xml** (in 3.5.1 Using the USER_QOS_PROFILES.xml below) or by creating a separate XML file for each *DomainParticipant* (in 3.5.2 Using a Separate XML File on page 21). **Choose one way for your application.**

3.5.1 Using the USER_QOS_PROFILES.xml

If the **config_file** property was not specified when enabling LBED in a *DomainParticipant* (see 3.4.2 Using the LBED Plugin Properties on page 12), the plugin will look for the DDS-XML definition of the endpoints in **USER_QOS_PROFILES.xml** by default. By using this approach, no additional XML files are required. Your **USER_QOS_PROFILES.xml** will contain the definition of the QoS used by your entities, as well as the DDS-XML static definition of the endpoints required by LBED. In other words, the file will contain both local and remote configurations.

LBED needs to know the following information about the entities:

- For each *DomainParticipant* using LBED whose endpoints need to be statically-discovered, LBED must know the *DomainParticipant's* topology: how many *Publishers/Subscribers* it has, how many *DataWriters/DataReaders* there are per *Publisher/Subscriber*, and if the endpoints are using an implicit *Publisher/Subscriber*.
- For the entities above, which QoS they are using.
- The *Topic* to which each endpoint is attached.
- The type that each *Topic* uses.

You will learn how to add each one of these requirements to the **USER_QOS_PROFILES.xml** file in the following sections.

To get XML file validation and autocompletion during editing, change the USER_QOS_PROFILE.xml's XSD from rti_dds_qos_profiles.xsd to rti_dds_profiles.xsd:

```
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="file:///<NDDSHOME>/resource/schema/rti_dds_profiles.xsd">
...
```

3.5.1.1 Add the types used by the endpoints

Your application *Topics* use the ExampleLBED type that was generated from the IDL in 3.1 Generate Connext Project on page 6. You need to specify the XML type definition of that type in the **USER_QOS_PROFILES.xml** file using the <types> tag.

> If your application uses a Built-in Data Type instead (see "Built-in Data Types" in the RTI Connext Core Libraries User's Manual), this definition is not required and you can skip this step.

It is possible to convert from an IDL file to XML using *Code Generator* (*rtiddsgen*):

```
$ rtiddsgen -convertToXml ExampleLBED.idl
```

This will generate a file called **ExampleLBED.xml**. Copy and paste the <types> tag and its content into the **USER_QOS_PROFILES.xml** after the <qos_library> section:

```
<types>
    <struct name= "ExampleLBED">
        <member name="data" type="int32"/>
    </struct>
</types>
```

> **This step is optional but recommended when using user-defined types.**
>
> If the definition of the type is not provided in the XML file, the LBED plugin will automatically check if there is a type with the same name registered in the *DomainParticipant* of the local application (the one that created the plugin instance) and will use its definition. This check

works out if the type in the local *DomainParticipant* is the same as the one used by the endpoints that need to be discovered, which would be true in correct system configurations. But if you have different types with the same name, you may get undefined behaviors in LBED (e.g., no discovery).

Therefore, if you decide to not add the XML type definition, to avoid errors, it is recommended that you create the *DomainParticipant* disabled, register the type in the application, and then enable the *DomainParticipant*. That way, you ensure LBED does not start registering endpoints until the type has been registered in the participant.

To create a *DomainParticipant* disabled, set **autoenable_created_entities** in the DomainParticipantFactory ENTITYFACTORY QosPolicy to false. See "Enabling DDS Entities" in the RTI Connext Core Libraries User's Manual for information about how to enable the *DomainParticipant*. See "Data Types and DDS Data Samples" in the RTI Connext Core Libraries User's Manual for information about registering types.

3.5.1.2 Add the Topics

The endpoints of the generated application use a single *Topic* called "Example ExampleLBED". In DDS-XML, *Topics* are specified inside a domain tag which, in turn, is specified inside a domain_library. This exercise assumes the application uses domain ID 0, but you can use whichever ID you prefer.

Copy and paste the following XML snippet in your **USER_QOS_PROFILES.xml** file after the types tag you added in the previous step (modify the domain_id attribute if you want to use another ID):

```
<domain_library name="ExampleLBED_Domain_Library">
    <domain name="ExampleLBED_Domain" domain_id="0">
        <register_type name="ExampleLBED" type_ref="ExampleLBED"/>
        <topic name="Example ExampleLBED" register_type_ref="ExampleLBED"/>
    </domain>
</domain_library>
```

Regarding the snippet above:

- The names of the domain_library and domain tags are just examples. You can use any names you like.
- Make sure the name attribute of the topic tag is the same as the name with which the *Topic* is created in the application.
- The LBED plugin uses the register_type tag for associating a *Topic* with its XML type definition. Therefore:
    - If your application uses a Built-in Data Type instead (see "Built-in Data Types" in the RTI Connext Core Libraries User's Manual), the register_type tag is not required and you can put the name of the Built-in Data Type directly in the *Topic's* register_type_ref attribute.

For example:

```
<domain name="ExampleLBED_Domain" domain_id="0">
    <topic name="Example ExampleLBED" register_type_ref="DDS::String"/>
</domain>
```

- **If you decided to not add the XML type definition to the file** in 3.5.1.1 Add the types used by the endpoints on page 15, the register_type tag is not required and you can put the name of your type directly in the *Topic's* register_type_ref attribute. For example:

```
<domain name="ExampleLBED_Domain" domain_id="0">
    <topic name="Example ExampleLBED" register_type_ref="ExampleLBED"/>
</domain>
```

- The register_type tag is also used for specifying the name with which the type referenced by type_ref (which must be an existing type under the types tag) is registered in the application. In this case, the XML type definition you added in 3.5.1.1 Add the types used by the endpoints on page 15 (named "ExampleLBED") is registered in the application with the same name. You must make sure the name attribute of the register_type tag is the same as the name with which the type is registered in the application code.

3.5.1.3 Add the DomainParticipants' topology

The generated application has two *DomainParticipants*: the ExampleLBEDParticipantPublisher and ExampleLBEDParticipantSubscriber. If you open the **ExampleLBED_publisher.cxx** program, you will see that ExampleLBEDParticipantPublisher has a single *Publisher* and a single *DataWriter*. The same happens for ExampleLBEDParticipantSubscriber: it has a *Subscriber* and a *DataReader*. Both end-points use the "Example ExampleLBED" *Topic* and the ExampleLBED type.

The information above is what we call "topology," and we need to represent it using DDS-XML. For that, use the domain_participant_library. Copy and paste the following XML snippet in your **USER_QOS_PROFILES.xml** file after the domain_library tag you added in the previous step:

```
<domain_participant_library name="ExampleLBED_DomainParticipant_Library">
    <domain_participant name="ExampleLBEDParticipantPublisher"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <publisher name="Pub">
            <data_writer name="DW" topic_ref="Example ExampleLBED"></data_writer>
        </publisher>
    </domain_participant>

    <domain_participant name="ExampleLBEDParticipantSubscriber"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <subscriber name="Sub">
            <data_reader name="DR" topic_ref="Example ExampleLBED"></data_reader>
        </subscriber>
    </domain_participant>
</domain_participant_library>
```

Regarding the snippet above:

- The name of the domain_participant_library is just an example. You can use any name you like.
- Make sure the name attributes of the domain_participant tags are the same as the names you specified for each *DomainParticipant* in 3.2 Add Name to Each DomainParticipant on page 8. This is the field that LBED uses to look for the *DomainParticipants'* definition in the XML file.
- Make sure the domain_ref attribute of each *DomainParticipant* links to the correct domain tag added in 3.5.1.2 Add the Topics on page 16 (that is, the domain that these participants use).
- Although LBED does not use the name attribute for *Publishers*, *Subscribers*, and endpoints, it is required by the DDS-XML standard, and *Connext*'s internal XML parser imposes a restriction on the name attribute:

  The name attribute must be unique within the same parent tag (e.g., two <data_writer> elements under the same <publisher> cannot have the same name attribute).

  Note: If your application has two or more entities that are essentially the same (e.g., your *Publisher* has two or more identical *DataWriters* with the same QoS, *Topic*, and type) and you are using *XML-Based Application Creation*, then you don't need to duplicate the information of the same entity several times in DDS-XML but with different names. You can use the multiplicity attribute instead to indicate how many entities use the same configuration (see the "Domain Participant Tag" table, in the "Participant Library" section, of the RTI Connext Core Libraries XML-Based Application Creation Getting Started Guide for more information about the multiplicity attribute, which applies to *Publishers*, *Subscribers*, and endpoints). If you are using LBED without *XML-Based Application Creation*, then you need to list each endpoint separately (with a different name attribute) and assign a different RTPS object ID to each one.

- Make sure the topic_ref attribute of each endpoint links to the correct *Topic* tag added in 3.5.1.2 Add the Topics on page 16 (that is, the *Topic* these endpoints use in the application).
- If your endpoints use the implicit *Publisher* or *Subscriber*, then the publisher or subscriber tag is not required. The data_reader and data_writer tags can live directly under the domain_participant tag.

3.5.1.4 Add the required QoS profiles to the entities

In the DDS-XML definition from the previous step, no entity specifies which QoS profile it is using, so the default QoS profile (a profile marked as is_default_qos="true" or the default QoS values if there is none) will be assumed for all of them. However, if any of your entities use a QoS profile different than the default one and it contains information that LBED needs to know (see 4.3 Supported QoS on page 33 for more information about which QoS policies LBED needs to be aware of), you must explicitly define the QoS profile that entity is using in the XML file.

For example, in this exercise, only the endpoints use a non-default QoS profile that specifies something LBED needs to know (the **rtps_object_id**), so we need to specify in DDS-XML which profiles the endpoints are using. You must make sure that the QoS profile you specify for a given entity is the same

one that this entity uses when it is created in the application, because QoS policies are used for determining the matching between entities.

This is the same XML snippet from the previous section. See the QoS profiles in bold that you need to add:

```
<domain_participant_library name="ExampleLBED_DomainParticipant_Library">
    <domain_participant name="ExampleLBEDParticipantPublisher"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <publisher name="Pub">
            <data_writer name="DW" topic_ref="Example ExampleLBED">
                <datawriter_qos
                    base_name="ExampleLBED_Library::ExampleLBED_Publisher_Profile"/>
            </data_writer>
        </publisher>
    </domain_participant>

<domain_participant name="ExampleLBEDParticipantSubscriber"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <subscriber name="Sub">
            <data_reader name="DR" topic_ref="Example ExampleLBED">
                <datareader_qos
                    base_name="ExampleLBED_Library::ExampleLBED_Subscriber_Profile"/>
            </data_reader>
        </subscriber>
    </domain_participant>
</domain_participant_library>
```

After following this tutorial, your XML file should look similar to the following. This file can also be found in **<path to examples>/connext_dds/c++11/limited_bandwidth_plugins/lbediscovery/USER_QOS_PROFILES.xml**.

```
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="file:///<NDDSHOME>/resource/schema/rti_dds_profiles.xsd">

    <qos_library name="ExampleLBED_Library">

        <!-- The QoS profile used by the publishing entities -->
        <qos_profile name="ExampleLBED_Publisher_Profile">
            <domain_participant_qos>
                <discovery_config>
                    <builtin_discovery_plugins>DPSE</builtin_discovery_plugins>
                </discovery_config>
                <participant_name>
                    <name>ExampleLBEDParticipantPublisher</name>
                </participant_name>
            </domain_participant_qos>
            <datawriter_qos>
                <protocol>
                    <rtps_object_id>100</rtps_object_id>
                </protocol>
            </datawriter_qos>
```

```
    </qos_profile>

    <!-- The QoS profile used by the subscribing entities -->
    <qos_profile name="ExampleLBED_Subscriber_Profile">
        <domain_participant_qos>
            <discovery_config>
                <builtin_discovery_plugins>DPSE</builtin_discovery_plugins>
            </discovery_config>
            <participant_name>
                <name>ExampleLBEDParticipantSubscriber</name>
            </participant_name>
        </domain_participant_qos>
        <datareader_qos>
            <protocol>
                <rtps_object_id>200</rtps_object_id>
            </protocol>
        </datareader_qos>
    </qos_profile>

</qos_library>

<types>
    <struct name= "ExampleLBED">
        <member name="data" type="int32"/>
    </struct>
</types>

<domain_library name="ExampleLBED_Domain_Library">
<!-- IMPORTANT: change the domain_id value if you plan to use a
     domain different than 0 -->
    <domain name="ExampleLBED_Domain" domain_id="0">
        <register_type name="ExampleLBED" type_ref="ExampleLBED"/>
        <topic name="Example ExampleLBED" register_type_ref="ExampleLBED"/>
    </domain>
</domain_library>

<domain_participant_library name="ExampleLBED_DomainParticipant_Library">
    <domain_participant name="ExampleLBEDParticipantPublisher"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <publisher name="Pub">
            <data_writer name="DW" topic_ref="Example ExampleLBED">
                <datawriter_qos
                    base_name="ExampleLBED_Library::ExampleLBED_Publisher_Profile"/>
            </data_writer>
        </publisher>
    </domain_participant>

    <domain_participant name="ExampleLBEDParticipantSubscriber"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <subscriber name="Sub">
            <data_reader name="DR" topic_ref="Example ExampleLBED">
                <datareader_qos
                    base_name="ExampleLBED_Library::ExampleLBED_Subscriber_Profile"/>
```

```
                </data_reader>
            </subscriber>
        </domain_participant>
    </domain_participant_library>
</dds>
```

3.5.2 Using a Separate XML File

The **config_file** property (see Table 4.1 LBED Configuration Properties for Connext) can be used to specify a separate XML file (different from **USER_QOS_PROFILES.xml**) that exclusively contains the DDS-XML static definition of the endpoints that LBED requires. By following this approach, your **USER_QOS_PROFILES.xml** file will contain the local configuration and the separate XML file the remote one.

The structure and information of that XML file is the same as explained in 3.5.1 Using the USER_QOS_PROFILES.xml on page 14. It is highly recommended to read that section before continuing with the steps below. The only difference is that you don't reuse the **USER_QOS_PROFILES.xml** file for LBED and you use a dedicated XML file instead.

In this exercise, we have chosen to create a separate XML file for each *DomainParticipant* (one for the *Publisher* and another for the *Subscriber*) but, if you prefer, you can create a single file that contains the LBED-required information for both.

The *Publisher DomainParticipant* will load the XML file with the information of the *Subscriber DomainParticipant* endpoints, and the *Subscriber DomainParticipant* will load the XML file with the information of the *Publisher*:

1. Create two new XML files in the working directory. For example, you may want to name them **LBEDPublisher.xml** and **LBEDSubscriber.xml**. The first one will contain the information of the *Publisher* participant endpoints and, the second one, the information of the *Subscriber*.
2. Modify the "ExampleLBED_Publisher_Profile" in **USER_QOS_PROFILES.xml**, adding the **config_file** property to the *DomainParticipant* QoS with the path to the **LBEDSubscriber.xml** file as value. Add it anywhere inside the <domain_participant_qos> tag.

```
<property>
    <value>
        <element>
            <name>dds.discovery.endpoint.lbediscovery.config_file</name>
            <value>LBEDSubscriber.xml</value>
        </element>
    </value>
</property>
```

3. Modify the "ExampleLBED_Subscriber_Profile" in **USER_QOS_PROFILES.xml**, adding the **config_file** property to the *DomainParticipant* QoS with the path to the **LBEDPublisher.xml** file as value. Add it anywhere inside the <domain_participant_qos> tag.

```
<property>
    <value>
        <element>
            <name>dds.discovery.endpoint.lbediscovery.config_file</name>
            <value>LBEDPublisher.xml</value>
        </element>
    </value>
</property>
```

4. Start by creating the <dds> tag in both XML files (replace <NDDSHOME> with the actual path to your *Connext* installation directory):

```
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="file:///<NDDSHOME>/resource/schema/rti_dds_
profiles.xsd">

</dds>
```

5. In **LBEDPublisher.xml**, create a qos_library and copy-paste "ExampleLBED_Publisher_Profile" from **USER_QOS_PROFILES.xml**, since this is the profile that the entities of the *Publisher* participant use. Rename it, for example, to “ExampleLBED_Publisher_Profile_Static”. This is because your application will load both the **USER_QOS_PROFILES.xml** and **LBEDPublisher.xml** files, and there cannot be two profiles with the same name.

   You can remove the <domain_participant_qos> element altogether, since the information it contains doesn’t need to be known by LBED (see 4.3 Supported QoS on page 33 for more information about which QoS policies LBED needs to know). Your profile should look similar to the following:

```
<qos_library name="ExampleLBED_Library">
    <qos_profile name="ExampleLBED_Publisher_Profile_Static">
        <datawriter_qos>
            <protocol>
                <rtps_object_id>100</rtps_object_id>
            </protocol>
        </datawriter_qos>
    </qos_profile>
</qos_library>
```

6. Do the same for **LBEDSubscriber.xml**: create a qos_library and copy-paste the "ExampleLBED_Subscriber_Profile" from **USER_QOS_PROFILES.xml**. Rename it to "ExampleLBED_Subscriber_Profile_Static" and remove the non-required information:

```
<qos_library name="ExampleLBED_Library">
    <qos_profile name="ExampleLBED_Subscriber_Profile_Static">
        <datareader_qos>
            <protocol>
                <rtps_object_id>200</rtps_object_id>
            </protocol>
        </datareader_qos>
    </qos_profile>
```

```
</qos_library>
```

7. Since both *Topics* use the same type (ExampleLBED), copy and paste the ExampleLBED XML type definition (see 3.5.1.1 Add the types used by the endpoints on page 15) to both XML files.
8. Since both endpoints use the same *Topic* (Example ExampleLBED), copy and paste the DDS-XML snippet from 3.5.1.2 Add the Topics on page 16 (the contents of the <domain_library> tag) to both XML files. Don't forget to modify the domain_id attribute if you plan to use another ID.
9. Add a <domain_participant_library> and the *Publisher DomainParticipant's* topology to **LBEDPublisher.xml** (see the XML snippet in 3.5.1.3 Add the DomainParticipants' topology on page 17):

```
<domain_participant_library name="ExampleLBED_DomainParticipant_Library">
    <domain_participant name="ExampleLBEDParticipantPublisher"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <publisher name="Pub">
            <data_writer name="DW" topic_ref="Example ExampleLBED"></data_writer>
        </publisher>
    </domain_participant>
</domain_participant_library>
```

10. Add a <domain_participant_library> and the *Subscriber DomainParticipant's* topology to **LBEDSubscriber.xml** (see the XML snippet in 3.5.1.3 Add the DomainParticipants' topology on page 17):

```
<domain_participant_library name="ExampleLBED_DomainParticipant_Library">
    <domain_participant name="ExampleLBEDParticipantSubscriber"
            domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
        <subscriber name="Sub">
            <data_reader name="DR" topic_ref="Example ExampleLBED"></data_reader>
        </subscriber>
    </domain_participant>
</domain_participant_library>
```

11. Add the QoS profiles that the entities use, as explained in 3.5.1.4 Add the required QoS profiles to the entities on page 18, to both XML files. Keep in mind that you renamed the profiles (in step 5, above), so the specified base_name must match the new names.

This is the final **LBEDPublisher.xml** file (replace <NDDSHOME> with the actual path to your *Connext* installation directory):

```
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:noNamespaceSchemaLocation="file:///<NDDSHOME>/resource/schema/rti_dds_
profiles.xsd">
    <qos_library name="ExampleLBED_Library">
        <qos_profile name="ExampleLBED_Publisher_Profile_Static">
            <datawriter_qos>
                <protocol>
                    <rtps_object_id>100</rtps_object_id>
                </protocol>
            </datawriter_qos>
```

```
        </qos_profile>
    </qos_library>

    <types>
        <struct name="ExampleLBED">
            <member name="data" type="int32" />
        </struct>
    </types>

    <domain_library name="ExampleLBED_Domain_Library">
        <domain name="ExampleLBED_Domain" domain_id="0">
            <register_type name="ExampleLBED" type_ref="ExampleLBED" />
            <topic name="Example ExampleLBED" register_type_ref="ExampleLBED" />
        </domain>
    </domain_library>

    <domain_participant_library name="ExampleLBED_DomainParticipant_Library">
        <domain_participant name="ExampleLBEDParticipantPublisher"
                domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
            <publisher name="Pub">
                <data_writer name="DW" topic_ref="Example ExampleLBED">
                    <datawriter_qos
                        base_name="ExampleLBED_Library::ExampleLBED_Publisher_Profile_
Static" />
                </data_writer>
            </publisher>
        </domain_participant>
    </domain_participant_library>
</dds>
```

This is the final **LBEDSubscriber.xml** file (replace <NDDSHOME> with the actual path to your *Connext* installation directory):

```
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:noNamespaceSchemaLocation="file:///<NDDSHOME>/resource/schema/rti_dds_
profiles.xsd">
    <qos_library name="ExampleLBED_Library">
        <qos_profile name="ExampleLBED_Subscriber_Profile_Static">
            <datareader_qos>
                <protocol>
                    <rtps_object_id>200</rtps_object_id>
                </protocol>
            </datareader_qos>
        </qos_profile>
    </qos_library>

    <types>
        <struct name="ExampleLBED">
            <member name="data" type="int32" />
        </struct>
    </types>

    <domain_library name="ExampleLBED_Domain_Library">
        <domain name="ExampleLBED_Domain" domain_id="0">
```

```
            <register_type name="ExampleLBED" type_ref="ExampleLBED" />
            <topic name="Example ExampleLBED" register_type_ref="ExampleLBED" />
        </domain>
    </domain_library>

    <domain_participant_library name="ExampleLBED_DomainParticipant_Library">
        <domain_participant name="ExampleLBEDParticipantSubscriber"
                domain_ref="ExampleLBED_Domain_Library::ExampleLBED_Domain">
            <subscriber name="Sub">
                <data_reader name="DR" topic_ref="Example ExampleLBED">
                    <datareader_qos
                        base_name="ExampleLBED_Library::ExampleLBED_Subscriber_Profile_
Static" />
                </data_reader>
            </subscriber>
        </domain_participant>
    </domain_participant_library>
</dds>
```

3.6 Run the Applications

The last step is checking that your applications' endpoints discover each other statically and that there is communication. Open two command prompts and configure the environment in both to point to the location of the dynamic libraries, as explained below.

3.6.1 Configure the Environment in Both Command Prompts

Configure the environment for *Connext* by running **<NDDSHOME>/resource/scripts/rtisetenv_<architecture>.<shell>** in both command prompts, one for the *Publisher* and one for the *Subscriber*. See Set Up Environment Variables (rtisetenv), in "Hands-On 1" of *Introduction to Publish/Subscribe*, in the RTI Connext Getting Started Guide. This will update your PATH to include the location of the *Connext* binaries.

3.6.2 Check Communication

1. Run the *Publisher* in one of the command prompts and the *Subscriber* in the other.

   If you configured a domain ID different than 0, pass the **-d** <your domain ID> argument to both binaries.
2. You should see the received data in the *Subscriber's* command prompt, which indicates successful communication:

For Linux systems:

Publisher:

```
$ ./objs/<architecture>/ExampleLBED_publisher
Writing ExampleLBED, count 0
```

```
Writing ExampleLBED, count 1
Writing ExampleLBED, count 2
Writing ExampleLBED, count 3
Writing ExampleLBED, count 4
Writing ExampleLBED, count 5
…
```

Subscriber:

```
$ ./objs/<architecture>/ExampleLBED_subscriber
ExampleLBED subscriber sleeping up to 1 sec...
[data: 0]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 1]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 2]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 3]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 4]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 5]
ExampleLBED subscriber sleeping up to 1 sec...
…
```

For Windows systems:

Publisher:

```
> objs\<architecture>\ExampleLBED_publisher.exe
Writing ExampleLBED, count 0
Writing ExampleLBED, count 1
Writing ExampleLBED, count 2
Writing ExampleLBED, count 3
Writing ExampleLBED, count 4
Writing ExampleLBED, count 5
…
```

Subscriber:

```
> objs\<architecture>\ExampleLBED_subscriber.exe
ExampleLBED subscriber sleeping up to 1 sec...
[data: 0]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 1]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 2]
```

```
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 3]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 4]
ExampleLBED subscriber sleeping up to 1 sec...
ExampleLBED subscriber sleeping up to 1 sec...
[data: 5]
ExampleLBED subscriber sleeping up to 1 sec...
…
```

3.6.3 Check that Your Endpoints Discover Each Other Statically

When LBED is used, endpoints do not exchange publication/subscription DATAs. The information that they normally provide about the endpoints that should be discovered is gathered instead from the XML file. Therefore, to verify that your applications' endpoints are discovering each other using the LBED plugin, and without sending publication/subscription DATAs, we will modify your applications to use only the UDPv4 transport so we can inspect the exchanged packages using Wireshark:

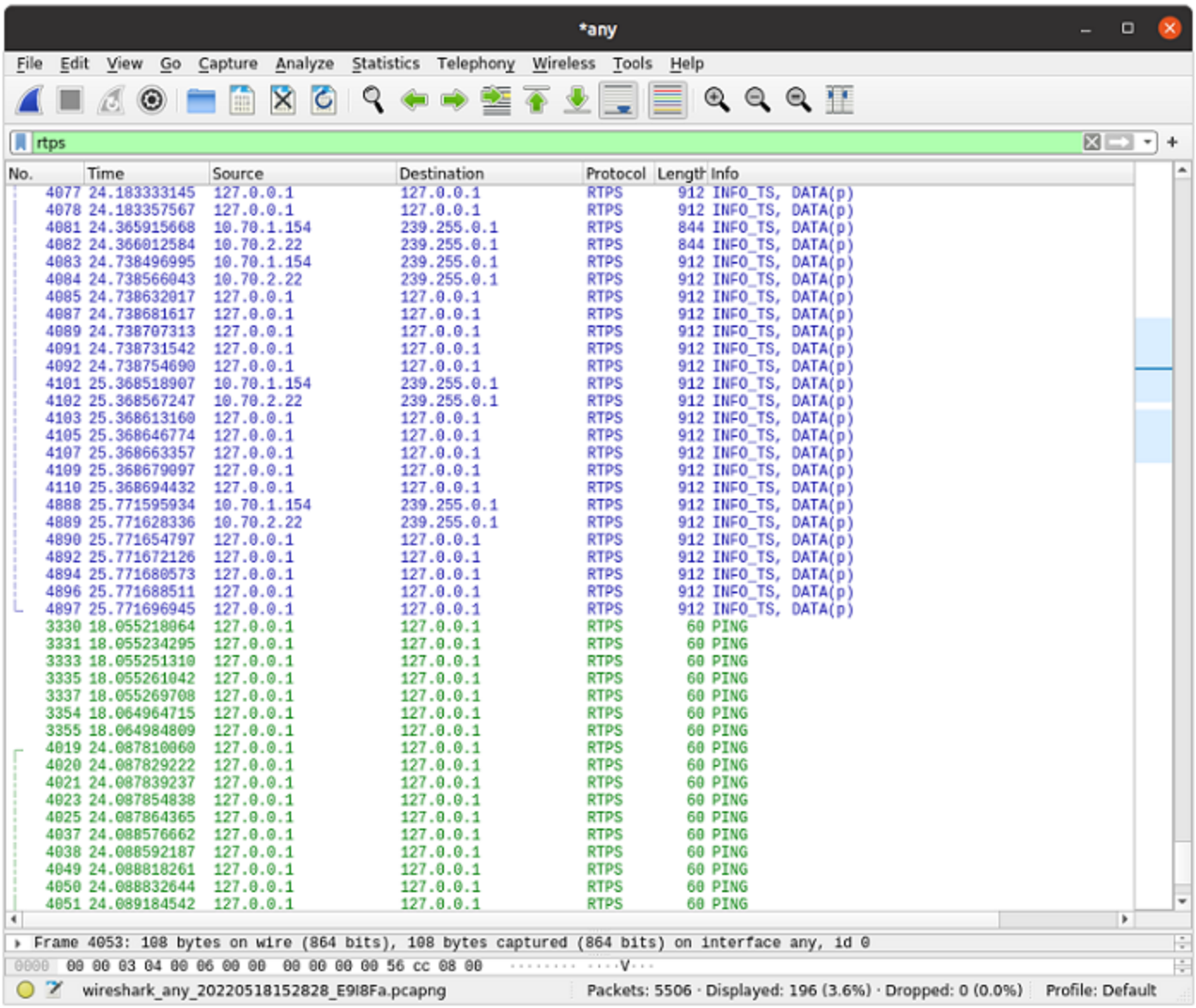
1. In your **USER_QOS_PROFILES.xml** file, add the following XML snippet to both "ExampleLBED_Publisher_Profile" and "ExampleLBED_Subscriber_Profile" in the <domain_participant_qos> tag. You can remove it once you verify LBED is working. For example, in the "ExampleLBED_Subscriber_Profile":

   ```
   <qos_profile name="ExampleLBED_Subscriber_Profile">
       <domain_participant_qos>
           <transport_builtin>
               <mask>UDPv4</mask>
           </transport_builtin>
           ...
       </domain_participant_qos>
       ...
   </qos_profile>
   ```

2. Run Wireshark and start capturing all of your interfaces. Filter captured packages by "rtps". See Using Wireshark with RTI Connext Systems for more information.
3. Run your *Publisher* and *Subscriber* applications as explained in previous sections.

Publication DATAs are shown in Wireshark as DATA(w) and subscription DATAs as DATA(r). If LBED is correctly configured, you should not see any of them in your Wireshark capture:

Figure 3.2: Wireshark Capture of Discovery Traffic when LBED is Being Used



3.7 Troubleshooting

3.7.1 System does not Recognize or Find rtiddsgen Command

Make sure *Connext* is installed correctly.

Make sure you've correctly set the PATH environment variable (your PATH should include **<NDDSHOME>/bin**). You can run **<NDDSHOME>/resource/scripts/rtisetenv_<architecture>.<shell>** to add the location of the *Connext* binaries to your PATH (see Set Up Environment

Variables (rtisetenv), in "Hands-On 1" of *Introduction to Publish/Subscribe*, in the RTI Connext Getting Started Guide).

3.7.2 rtiddsgen Displays Error (Usually in Windows systems)

If you get this error:

```
The preprocessor 'CL.EXE' cannot be found in your path.
```

Make sure your toolchain's preprocessor is available. If you are using Visual Studio®, make sure you are using a Visual Studio command prompt. Alternatively, run *rtiddsgen* with the **-ppDisable** option.

3.7.3 rtiddsgen Gives Warnings

```
File exists and will not be overwritten
```

Some files that would normally be generated already exist and will not be overwritten. These errors are expected.

3.7.4 Running Publisher/Subscriber Produces Errors

If you get this error:

```
error while loading shared libraries: libnddscpp2.so: cannot open shared object file: No
such file or directory
```

Make sure the shared library environment variable includes the directory where the *Connext* libraries reside. See 3.6.1 Configure the Environment in Both Command Prompts on page 25.

If you get this error:

```
!open library=librtilbedisc.so
```

Make sure the Limited Bandwidth Plugins bundles provided by RTI are installed correctly. In addition, make sure the shared library environment variable includes the directory where the *Connext* libraries reside. See 3.6.1 Configure the Environment in Both Command Prompts on page 25.

If you get these errors:

```
The discovered DomainParticipant [guid=...] is not in the file.
```

```
The DomainParticipant "..." cannot be registered.
```

LBED is not able to find the DDS-XML definition of a discovered *DomainParticipant*. Make sure the DDS-XML information of that participant is present in the XML file and that the "name" attribute of the <domain_participant> tag matches the one specified in the "ENTITY_NAME QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual.

You may be encountering the following issue: 4.4.1 LBED unable to load USER_QOS_PROFILES.xml if not in default locations, when using API with QosProvider on page 36.

This may not necessarily be an error: your application could be discovering an interfering *DomainParticipant* in your network that is running in the same domain.

3.7.5 Communication does not Occur between Publisher/Subscriber ([data: …] Messages not Displayed in Subscriber Prompt)

- Make sure the *Publisher* participant and the *DataWriter* are created using the "ExampleLBED_Publisher_Profile" (review the entities' creation call in **ExampleLBED_publisher.cxx** and make sure the names of the used profiles are the correct ones).
- Make sure the *Subscriber* participant and the *DataReader* are created using the "ExampleLBED_Subscriber_Profile" (review the entities' creation call in **ExampleLBED_subscriber.cxx** and make sure the names of the used profiles are the correct ones).
- Make sure the specified DDS-XML information is consistent with your applications (e.g., the *Topic*, types, and QoS specified for each endpoint in the XML are the ones that the endpoints are actually using in the applications' code).
- Make sure that you are not missing any of the steps mentioned in this exercise.
- Make sure the names specified through the "ENTITY_NAME QosPolicy (DDS Extension)" in the RTI Connext Core Libraries User's Manual for each *DomainParticipant* match the ones specified in DDS-XML. If LBED is not able to find the DDS-XML definition of a discovered *DomainParticipant*, you will see error messages similar to the ones shown in 3.5 Add the DDS-XML Definition of the Entities on page 13.
- If you are using separate XML files for LBED, make sure the *Publisher* is loading the information of the *Subscriber* and vice versa.
- If you modified the QoS of the endpoints, make sure they are compatible. See "QoS Requested vs. Offered Compatibility" in the RTI Connext Core Libraries User's Manual. You can debug if the QoS are incompatible by setting the *Connext* verbosity (not the LBED one) to WARNING. In the generated Modern C++ applications, use the **-v 2** argument to set a WARNING verbosity.

Chapter 4 Using LBED

4.1 Limitations

LBED relies exclusively on the information that is present in the XML file. Therefore, it is not able to infer anything from the endpoints that requires information that cannot be specified in DDS-XML. This imposes some limitations on the plugin:

- In the "TRANSPORT_UNICAST QosPolicy" in the RTI Connext Core Libraries User's Manual, the **receive_port** cannot be left to the default value (0). LBED is not able to automatically compute a port number, because it doesn't know the index of the discovered *DomainParticipant*. Therefore, if you want to use this QoS policy, you need to manually specify the port number that should be used. For example:

```
<unicast>
    <value>
        <element>
            <receive_port>8080</receive_port>
            <transports>
                <element>udpv4</element>
            </transports>
        </element>
    </value>
</unicast>
```

- Only the *Connext* Builtin Transport Plugins (UDPv4, UDPv6, and SHMEM) and the *RTI Real-Time WAN Transport* (UDPv4_WAN) are supported in the "TRANSPORT_UNICAST QosPolicy" in the RTI Connext Core Libraries User's Manual and "TRANSPORT_MULTICAST QosPolicy" in the RTI Connext Core Libraries User's Manual. Defining custom aliases for them is not supported.
- Mutable QoS policies supported by LBED, such as "OWNERSHIP_STRENGTH QosPolicy" in the RTI Connext Core Libraries User's Manual (see 4.3 Supported QoS on page 33), cannot be modified at runtime. It is not possible to notify the change to the

other endpoints in the system since no endpoint information is sent through the network. Endpoints rely exclusively on the configuration that is present in the static XML file.

Refer to 4.3 Supported QoS on the next page and 4.4 Known Issues on page 36 for further information about what is and is not supported in LBED.

4.2 LBED Properties

Table 4.1 LBED Configuration Properties for Connext describes the name/value pairs (properties) that you can use to configure the LBED plugin. **They should be configured at the *DomainParticipant* level.**

Table 4.1 LBED Configuration Properties for Connext

Property Name	Property Value and Description

dds.discovery.endpoint.load_plugins	Required only when the plugin is enabled using the LBED Properties (see 3.4.2 Using the LBED Plugin Properties on page 12).
	String indicating the prefix name of the plugin that will be loaded by *Connext*.
	Set the value to **dds.discovery.endpoint.<*string*>**, where <*string*> can be any string you want, as long as you use the same string consistently for all the properties in this table. Our example uses lbediscovery:
	`<element>`
	`  <name>dds.discovery.endpoint.load_plugins</name>`
	`  <value>dds.discovery.endpoint.lbediscovery</value>`
	`</element>`

dds.discovery.endpoint.<*string*>.library	Required only when the plugin is enabled using the LBED Properties (see 3.4.2 Using the LBED Plugin Properties on page 12).
	The name of the dynamic library that contains the LBED plugin implementation. This library must be in the path during run time for use by *Connext*.
	Set the value to **rtilbedisc**.
	Example:
	`<element>`
	`  <name>dds.discovery.endpoint.lbediscovery.library</name>`
	`  <value>rtilbedisc</value>`
	`</element>`

dds.discovery.endpoint.<*string*>.create_function	Required only when the plugin is enabled using the LBED Properties (see 3.4.2 Using the LBED Plugin Properties on page 12).
	The name of the function that will be called by *Connext* to create an instance of the LBED plugin.
	Set the value to **DDS_LBEDiscoveryPlugin_create**.
	Example:
	`<element>`
	`  <name>`
	`  dds.discovery.endpoint.lbediscovery.create_function`
	`  </name>`
	`  <value>DDS_LBEDiscoveryPlugin_create</value>`
	`</element>`

Table 4.1 LBED Configuration Properties for Connext

Property Name	Property Value and Description

dds.discovery.endpoint.<*string*>.config_file	Optional.
	The absolute or relative path to the file that contains the DDS-XML static definition of the endpoints that must be discovered.
	Example:
	`<element>`
	`<name>dds.discovery.endpoint.lbediscovery.config_file</name>`
	`<value>LBEDSubscriber.xml</value>`
	`</element>`
	Use this property only if:
	• You want to use a separate file to specify the DDS-XML static definition of the endpoints instead of using the **USER_QOS_PROFILES.xml** of your application. See 3.5.2 Using a Separate XML File on page 21.
	• You ran into the known issue "**LBED unable to load USER_QOS_PROFILES.xml if not in default locations, when using API with QosProvider**". See 4.4 Known Issues on page 36 for further information.

dds.discovery.endpoint.<*string*>.verbosity	Optional.
	The verbosity for the plugin, for debugging purposes.
	• -1: Silent
	• 0: Exceptions only (default)
	• 1: Warnings
	• 2 and up: Debug
	Example:
	`<element>`
	`<name>dds.discovery.endpoint.lbediscovery.verbosity</name>`
	`<value>1</value>`
	`</element>`
	Note: the LBED logging verbosity is per application. The last *DomainParticipant* using LBED and **explicitly setting this property** will apply that setting to all the *DomainParticipants* using LBED within the application. If not explicitly set, the verbosity will be left unchanged. Therefore, if no *DomainParticipant* has configured the LBED verbosity, it will be left to the default value.

dds.discovery.endpoint.<*string*>.property_validation_action	Optional. By default, property names given in the PropertyQoSPolicy are validated to avoid using incorrect or unknown names (for example, due to a typo). This property configures the validation of the property names associated with the plugin: • VALIDATION_ACTION_EXCEPTION: validate the properties. Upon failure, log errors and fail. • VALIDATION_ACTION_SKIP: skip validation. • VALIDATION_ACTION_WARNING: validate the properties. Upon failure, log warnings and do not fail. If this property is not set, the plugin property validation behavior will be the same as that of the *DomainParticipant*, which by default is VALIDATION_ACTION_EXCEPTION. See the "Property Validation" section in the RTI Connext Core Libraries User's Manual.

4.3 Supported QoS

The following lists show the QoS policies that are supported by LBED. These are the QoS policies that LBED needs to know about and that must appear in the DDS-XML file. LBED will assume the default values if any of them is not explicitly specified in the XML file. If a QoS policy that is not present in this table is specified, LBED will ignore it.

Not all of the QoS policies belong to endpoints. Some of them are specified at the *DomainParticipant*, *Topic*, *Publisher*, or *Subscriber* level. But these policies still have an impact on the configuration of the endpoint (for example, the *DomainParticipant* TRANSPORT_MULTICAST_MAPPING QoS policy may be used for determining the multicast address an endpoint should use if it has multicast enabled). Therefore, LBED also needs to know about them.

For details on these QoS, see "All QosPolicies" in the RTI Connext Core Libraries User's Manual.

DomainParticipantQos

- TransportMulticastMapping
- The following field only in the DomainParticipantResourceLimits QoS policy:
  - **channel_seq_max_length**
- TransportBuiltin
- The following field only in the WireProtocol QoS policy:
  - **rtps_well_known_ports**

TopicQos

- TopicData

PublisherQos/SubscriberQos

- GroupData
- Partition
- Presentation

DataWriterQos

- DataRepresentation
- Deadline
- DestinationOrder
- Durability
- DurabilityService
- LatencyBudget
- Lifespan
- Liveliness

- Ownership
- OwnershipStrength
- Property

  In the Simple Discovery Protocol (SDP), properties are not propagated by default during discovery, so you likely won't need to use the Property QoS policy in LBED. However, if you do want your endpoints' properties to be known by other endpoints in LBED, you can use the Property QoS policy to do that.

- The following fields only in the DataWriterProtocol QoS policy:
  - **disable_positive_acks**
  - **rtps_object_id**
  - **virtual_guid**
- Reliability
- Service
- TransportSelection
- TransportUnicast
- UserData

DataReaderQos

- DataRepresentation
- Deadline
- DestinationOrder
- Durability
- LatencyBudget
- Liveliness
- TransportMulticast
- Ownership
- Property

  In the Simple Discovery Protocol (SDP), properties are not propagated by default during discovery, so you likely won't need to use the Property QoS policy in LBED. However, if you do want your endpoints' properties to be known by other endpoints in LBED, you can use the Property QoS policy to do that.

- The following fields only in the DataWriterProtocol QoS policy:
  - **disable_positive_acks**
  - **rtps_object_id**
  - **virtual_guid**
- Reliability
- Service
- TimeBasedFilter
- TransportSelection
- TransportUnicast
- UserData

4.4 Known Issues

4.4.1 LBED unable to load USER_QOS_PROFILES.xml if not in default locations, when using API with QosProvider

This issue only applies when using an API that relies on a QosProvider to load XML QoS profiles (such as Modern C++, C#, or Python). With these APIs, the LBED plugin cannot automatically load the XML file with the endpoint configurations if both of the following are true:

- You defined the LBED information in **USER_QOS_PROFILES.xml**, which is neither located in the working directory nor referenced in the NDDS_QOS_PROFILES environment variable.
- The content of **USER_QOS_PROFILES.xml** is not specified in the **<NDDSHOME>/resource/xml/NDDS_QOS_PROFILES.xml** file.

See "How to Load XML-Specified QoS Settings" in the RTI Connext Core Libraries User's Manual for more information on where *Connext* looks for XML QoS profiles.

The LBED plugin cannot automatically load the XML file with the endpoint configurations if the XML content is not in the expected locations. This is because the LBED plugin relies on the singleton DomainParticipantFactory for loading the profiles, but the DomainParticipantFactory is not used in APIs that use a QosProvider.

As a workaround to make LBED load the file, set the **config_file** property in your **USER_QOS_PROFILES.xml** file with the path to itself. For example, if **USER_QOS_PROFILE.xml** is in **/foo/bar/**, the <domain_participant_qos> of your participant enabling LBED should look like this:

```
<!-- USER_QOS_PROFILES.xml -->
<qos_profile name="...">
    <domain_participant_qos>
        <discovery_config>
```

```
            <builtin_discovery_plugins>DPSE</builtin_discovery_plugins>
        </discovery_config>
        <property>
            <value>
                <element>
                    <name>dds.discovery.endpoint.lbediscovery.config_file</name>
                    <value>/foo/bar/USER_QOS_PROFILES.xml</value>
                </element>
                ...
            </value>
        </property>
        ...
    </domain_participant_qos>
    ...
</qos_profile>
```

[RTI Issue ID COREPLG-741]