RTI Connext Micro

User's Manual

Version 2.4.14.1

Contents

RTI® Connext® DDS Micro provides a small-footprint, modular messaging solution for resource-limited devices that have limited memory and CPU power, and may not even be running an operating system. It provides the communications services that developers need to distribute time-critical data. Additionally, *Connext Micro* is designed as a certifiable component in high-assurance systems.

Key benefits of *Connext Micro* include:

- Accommodations for resource-constrained environments.
- Modular and user extensible architecture.
- Designed to be a certifiable component for safety-critical systems.
- Seamless interoperability with *RTI Connext DDS Professional*.

Chapter 1

Introduction

1.1 What is RTI Connext Micro?

RTI Connext Micro is network middleware for distributed real-time applications. It provides the communications service programmers need to distribute time-critical data between embedded and/or enterprise devices or nodes. *Connext Micro* uses the publish-subscribe communications model to make data distribution efficient and robust. *Connext Micro* simplifies application development, deployment and maintenance and provides fast, predictable distribution of time-critical data over a variety of transport networks. With *Connext Micro*, you can:

- Perform complex one-to-many and many-to-many network communications.
- Customize application operation to meet various real-time, reliability, and quality-of-service goals.
- Provide application-transparent fault tolerance and application robustness.
- Use a variety of transports.

Connext Micro implements the Data-Centric Publish-Subscribe (DCPS) API within the OMG's Data Distribution Service (DDS) for Real-Time Systems. DDS is the first standard developed for the needs of real-time systems. DCPS provides an efficient way to transfer data in a distributed system.

With *Connext Micro*, systems designers and programmers start with a fault-tolerant and flexible communications infrastructure that will work over a wide variety of computer hardware, operating systems, languages, and networking transport protocols. *Connext Micro* is highly configurable so programmers can adapt it to meet the application's specific communication requirements.

1.1.1 RTI Connext Cert versus RTI Connext Micro

RTI Connext Micro and *RTI Connext Cert* originate from the same source base, but as of *Connext Micro* 2.4.6 the two are maintained as two independent releases. The latest release with certification evidence is *Connext Cert* 2.4.5. However, features that exist in *Connext Micro* and *Connext Cert* behave identically and the source code is written following identical guidelines. *Connext Cert* only supports a subset of the features found in *Connext Micro*. In the API reference manuals, APIs that are supported by *Connext Cert* are clearly marked.

1.1.2 Optional Certification Package

An optional Certification Package is available for systems that require certification to DO-178C or other safety standards. This package includes the artifacts required by a certification authority. The Certification Package is licensed separately from Connext DDS Cert.

To use an existing Certification Package, an application must be linked against the same libraries included in the Certification Package. Contact RTI Support, support@rti.com, for details.

1.1.3 Publish-Subscribe Middleware

Connext Micro is based on a publish-subscribe communications model. Publish-subscribe (PS) middleware provides a simple and intuitive way to distribute data. It decouples the software that creates and sends data—the data publishers—from the software that receives and uses the data—the data subscribers. Publishers simply declare their intent to send and then publish the data. Subscribers declare their intent to receive, then the data is automatically delivered by the middleware. Despite the simplicity of the model, PS middleware can handle complex patterns of information flow. The use of PS middleware results in simpler, more modular distributed applications. Perhaps most importantly, PS middleware can automatically handle all network chores, including connections, failures, and network changes, eliminating the need for user applications to program of all those special cases. What experienced network middleware developers know is that handling special cases accounts for over 80% of the effort and code.

1.2 Supported DDS Features

Connext Micro supports a subset of the DDS DCPS standard. A brief overview of the supported features are listed here. For a detailed list, please refer to the C API Reference and C++ API Reference.

1.2.1 DDS Entity Support

Connext Micro supports the following DDS entities. Please refer to the documentation for details.

- DomainParticipantFactory
- DomainParticipant
- Topic
- Publisher
- Subscriber
- DataWriter
- DataReader

1.2.2 DDS QoS Policy Support

Connext Micro supports the following DDS Qos Policies. Please refer to the documentation for details.

- DDS_DataReaderProtocolQosPolicy
- DDS_DataReaderResourceLimitsQosPolicy
- DDS_DataWriterProtocolQosPolicy
- DDS_DataWriterResourceLimitsQosPolicy
- DDS_DeadlineQosPolicy
- DDS_DiscoveryQosPolicy
- DDS_DomainParticipantResourceLimitsQosPolicy
- DDS_DurabilityQosPolicy
- DDS_DestinationOrderQosPolicy
- DDS_EntityFactoryQosPolicy
- DDS_HistoryQosPolicy
- DDS_LivelinessQosPolicy
- DDS_OwnershipQosPolicy
- DDS_OwnershipStrengthQosPolicy
- DDS_ReliabilityQosPolicy
- DDS_ResourceLimitsQosPolicy
- DDS_RtpsReliableWriterProtocol_t
- DDS_SystemResourceLimitsQosPolicy
- DDS_TransportQosPolicy

- DDS_UserTrafficQosPolicy
- DDS_WireProtocolQosPolicy

1.3 Standards and Interoperability

Connext Micro implements the Object Management Group (OMG) Data Distribution Service (DDS) standard (version 1.4), and the Real-Time Publish-Subscribe (RTPS) wire interoperabilty protocol standard (version 2.2).

Connext Micro supports a subset of the submessages defined by the Real-Time Publish-Subscribe (RTPS) interoperability specification. Data fragment submessages are not supported. The messages are compatible with Wireshark and its RTPS packet dissector.

Connext Micro, RTI *Connext Micro*, and *Connext DDS* are wire-interoperable, unless stated otherwise (see below), and API compatible for APIs specified by the DDS standard. For non-standard APIs, *Connext Micro*, RTI *Connext Micro*, and *Connext DDS* are incompatible. Please refer to *Working with RTI Connext Micro and RTI Connext DDS* for more information.

1.3.1 DDS Wire Compatibility

Connext Micro is compliant with RTPS 2.2, but does not support and ignore the following RTPS sub-messages:

Submessage	Supported	DDS Standard	Connext DDS Core
DATA_FRAG	No	Yes	Yes
NACK_FRAG	No	Yes	Yes
HEARTBEAT_FRAG	No	Yes	No
INFO_SRC	No	Yes	Yes
INFO_REPLY	No	Yes	Yes
INFO_REPLY_IPV4	No	Yes	Yes

1.3.2 Profile / Feature

Connext Micro does not support mutable Qos policies.

Submessage	Supported	DDS Standard	Connext DDS Core
USER_DATA	No	Yes	Yes
TOPIC_DATA	No	Yes	Yes
DURABILITY	Partially (1)	Yes	Yes
PRESENTATION	Partially (2)	Yes	Yes
DEADLINE	Yes	Yes	Yes
LATENCY_BUDGET	No	Yes	Yes
LIVELINESS	Partially (3)	Yes	Yes

continues on next page

Table 1.1 – continued from previous page

Submessage	Supported	DDS Standard	Connext DDS Core
TIME_BASED_FILTER	No	Yes	Yes
PARTITION	No	Yes	Yes
RELIABILITY	Yes (4)	Yes	Yes
TRANSPORT_PRIORITY	No	Yes	Yes
LIFESPAN	No	Yes	Yes
DESTINATION_ORDER	Partially (5)	Yes	Yes
HISTORY	Partially (6)	Yes	Yes
RESOURCE_LIMITS	Yes (7)	Yes	Yes
ENTITY_FACTORY	Yes	Yes	Yes
WRITER_DATA_LIFECYCLE	No	Yes	Yes
READER_DATA_LIFECYCLE	No	Yes	Yes
OWNERSHIP	Yes	Yes	Yes
OWNERSHIP_STRENGTH	Yes	Yes	Yes
DURABILITY_SERVICE	No	Yes	Yes
ContentFilteredTopic	No	Yes	Yes
QueryCondition	No	Yes	Yes
MultiTopic	No	Yes	No
ASYNCHRONOUS_PUBLISHER	No	No	Yes
AVAILABILITY	No	No	Yes
BATCH	Only reception	No	Yes
DATA_READER_PROTOCOL	rtps_object_id	No	Yes
DATA_WRITER_PROTOCOL	Partially (8)	No	Yes
DISCOVERY	Yes	No	Yes
DISCOVERY_CONFIG	No	No	Yes
ENTITY_NAME	Partially (9)	No	Yes
EVENT	No	No	Yes
LOCATORFILTER	No	No	Yes
LOGGING	No	No	Yes
MULTICHANNEL	No	No	Yes
PROPERTY	No	No	Yes
PUBLISH_MODE	No	No	Yes
RECEIVER_POOL	No	No	Yes
SERVICE	No	No	Yes
TYPE_CONSISTENCY_ENFORCEMENT	No	No	Yes
TYPESUPPORT	Yes	No	Yes
WIRE_PROTOCOL	Yes	No	Yes

NOTES:

1. VOLATILE and TRANSIENT_LOCAL
2. No, DW offers access_scope = TOPIC, coherent_access = FALSE and ordered_access = TRUE DR requests access_scope = INSTANCE, coherent_access = FALSE and ordered_access = FALSE
3. AUTOMATIC (infinite only), MANUAL_BY_PARTICIPANT (infinite only), MAN-

UAL_BY_TOPIC (finite and infinite)

4. BEST_EFFORT and RELIABLE, only max_blocking_time=0
5. DataWriter: Yes, DataReader only supports BY_RECEPTION_TIMESTAMP
6. Only KEEP_LAST
7. Only finite resource limits
8. The following are supported:
   - heartbeat_period
   - heartbeats_per_max_samples
   - max_heartbeat_retries
   - max_send_window_size
   - rtps_object_id
9. DomainParticipant only

1.3.3 DDS API Support

For supported APIs, please refer to:

- C API Reference
- C++ API Reference

1.4 RTI Connext DDS Documentation

Throughout this document, we may suggest reading sections in other *RTI Connext DDS* documents. These documents are in your *RTI Connext DDS* installation directory under **rti-connext-dds-<version>/doc/manuals**. A quick way to find them is from *RTI Launcher's* Help panel, select "Browse Connext Documentation".

Since installation directories vary per user, links are not provided to these documents on your local machine. However, we do provide links to documents on the RTI Documentation site for users with Internet access.

New users can start by reading Parts 1 (Introduction) and 2 (Core Concepts) in the *RTI Connext DDS Core Libraries User's Manual*. These sections teach basic DDS concepts applicable to all RTI middleware, including *RTI Connext DDS Professional* and *RTI Connext Micro*. You can open the *RTI Connext DDS Core Libraries User's Manual* from *RTI Launcher's* Help panel.

The RTI Community provides many resources for users of DDS and the RTI Connext family of products.

1.5 OMG DDS Specification

For the original DDS reference, the OMG DDS specification can be found in the OMG Specifications under "Data Distribution Service".

1.6 Other Products

RTI Connext Micro is one of several products in the *RTI Connext* family of products:

RTI Connext Cert is a subset of RTI *Connext Micro*. *Connext Cert* does not include the following features because Certification Evidence is not yet available for them. If you require Certification Evidence for any of these features, please contact RTI.

- C++ language API.
- Multi-platform support.
- Dynamic endpoint discovery.
- delete() APIs (e.g. delete_datareader()).
- Batching.
- UDP Transformations.

RTI Connext DDS Professional addresses the sophisticated databus requirements in complex systems including an API compliant with the Object Management Group (OMG) Data Distribution Service (DDS) specification. DDS is the leading data-centric publish/subscribe (DCPS) messaging standard for integrating distributed real-time applications. *Connext DDS Professional* is the dominant industry implementation with benefits including:

- OMG-compliant DDS API
- Advanced features to address complex systems
- Advanced Quality of Service (QoS) support
- Comprehensive platform and network transport support
- Seamless interoperability with rtime

RTI Connext DDS Professional includes rich integration capabilities:

- Data transformation
- Integration support for standards including JMS, SQL databases, file, socket, Excel, OPC, STANAG, LabVIEW, Web Services and more
- Ability for users to create custom integration adapters
- Optional integration with Oracle, MySQL and other relational databases
- Tools for visualizing, debugging and managing all systems in real-time

RTI Connext DDS Professional also includes a rich set of tools to accelerate debugging and testing while easing management of deployed systems. These components include:

- Administration Console
- Distributed Logger
- Monitor
- Monitoring Library
- Recording Service

Chapter 2

Installation

2.1 Installing the RTI Connext Micro Package

RTI Connext Micro is provided in two zip archives:

- rti_connext_dds_micro-<version>-Unix.zip
- rti_connext_dds_micro-<version>-Windows.zip

where <version> matches the product version, such as *2.4.14.1*.

The only difference between the two archives is the line endings in the source code. The archive ending in Unix uses LF line endings, and the archive ending in Windows CRLF line endings.

RTI Connext Micro requires a Java Run-Time Environment (JRE) to run *rtiddsgen* and version 1.8.121 or better is required. Note that JRE 1.9 and higher is not supported. If a compatible JRE run-time environment is not already installed a compatible JRE can be installed from one of the following bundles:

- rti_connext_dds_micro-<version>-jre-darwin.zip – JRE for Darwin 32 and 64 Bit
- rti_connext_dds_micro-<version>-jre-i86Linux.zip – JRE for 32 bit Linux
- rti_connext_dds_micro-<version>-jre-i86Win32.zip – JRE for 32 bit Windows
- rti_connext_dds_micro-<version>-jre-x64Linux.zip – JRE for 64 bit Linux
- rti_connext_dds_micro-<version>-jre-x64Win64.zip – JRE for 64 bit Windows

Once installed, you will see a directory */me_bundle_name/-<version>*. in the installation directory. This installation directory contains this documentation, the *rtiddsgen* code generation tool, and source code.

2.2 Setting Up Your Environment

This section includes information regaring compiling and linking an application against *Connext Micro* and how to set up an environment. Note that this section is generic and common for all platforms; the platform notes section may include additional information relevant for a specific platform.

The `RTIMEHOME` environment variable must be set to the installation directory path for *RTI Connext Micro*.

2.2.1 Compiler Preprocessor Defines

All application code including *Connext Micro* header-files and all code generated with *rtiddsgen* **must** be compiled with `-DRTI_CERT=1` flag when using the *Connext Micro* CERT profile.

When compiling against release libraries the `-DNDEBUG=1` flag **must** be added.

2.2.2 Compiler Header Files Path

When compiling an application, the *Connext Micro* header files are located in the following directory and the compiler's include search path must include this directory:

```
RTIMEHOME/include
```

2.2.3 Libraries

The *Connext Micro* library comes in two different flavors:

- `Release`: Compiled without additional debug information.
- `Debug`: Compiled with additional debug information. Libraries with debug have a `d` suffix.

2.3 Building Connext Micro

This section is for users who are already familiar with CMake and may have built earlier versions of *Connext Micro*. The sections following describe the process in detail and are recommended for everyone building *Connext Micro*.

This section assumes that the *Connext Micro* source-bundle has been downloaded and installed, that CMake (version 2.8.4 or higher) has been added to your PATH environment variable, and that the `$RTIMEHOME` environment variable has been set to the installation directory path for *Connext Micro*.

1. Make sure CMake (2.8.4+) is installed and available on your path.
2. Run the `rtime-make` script.

On UNIX®, Linux®, and macOS® systems:

```
$RTIMEHOME/resource/script/rtime-make --config Debug --target self␣
↪\
            --name i86Linux2.6gcc4.4.5 -G "Unix Makefiles" --build
```

On Windows® systems:

```
$RTIMEHOME\resource\scripts\rtime-make --config Debug --target␣
↪self \
        --name i86Win32VS2010 -G "Visual Studio 10 2010" --build
```

Note: `rti-make` uses a series of arguments to build *Connext Micro* for the appropriate environment. Please refer to *Building Connext Micro with rtime-make* for details.

---

3. You will find the compiled *Connext Micro* libraries here:

   On UNIX-based systems:

   ```
   $RTIMEHOME/lib/i86Linux2.6gcc4.4.5
   ```

   On Windows systems:

   ```
   $RTIMEHOME\lib\i86Win32VS2010
   ```

   Note: `rtime-make` uses the platform specified with `--name` to determine a few settings needed by *Connext Micro*. Please refer to *Preparing for a Build* for details.

For help, enter:

```
$RTIMEHOME\resource\scripts\rtime-make --help
```

To list available targets, enter:

```
$RTIMEHOME\resource\scripts\rtime-make --list
```

For help with a specific target, except self, enter:

```
$RTIMEHOME\resource\scripts\rtime-make --target <target> --help
```

Chapter 3

Getting Started

3.1 Define a Data Type

To distribute data using *Connext Micro*, you must first define a data type, then run the *rtiddsgen* utility. This utility will generate the type-specific support code that *Connext Micro* needs and the code that makes calls to publish and subscribe to that data type.

Connext Micro accepts types definitions in Interface Definition Language (IDL) format.

For instance, the HelloWorld examples provided with *Connext Micro* use this simple type, which contains a string "msg" with a maximum length of 128 chars:

```
::

    struct HelloWorld
    {
        string<128> msg;
    };
```

For more details, see *Data Types* in the *User's Manual*.

3.2 Generate Type Support Code with rtiddsgen

You will provide your IDL as an input to *rtiddsgen*. *rtiddsgen* supports code generation for the following standard types:

- octet, char, wchar
- short, unsigned short
- long, unsigned long

- long long, unsigned long long float
- double, long double
- boolean
- string
- struct
- array
- enum
- wstring
- sequence
- union
- typedef
- value type

The script to run *rtiddsgen* is in *<your_top_level_dir>/rtiddsgen/scripts*.

To generate support code for data types in a file called HelloWorld.idl:

```
rtiddsgen -micro -language C -replace HelloWorld.idl
```

Run `rtiddsgen -help` to see all available options. For the options used here:

- The `-micro` option is necessary to generate support code specific to *Connext Micro*, as *rtiddsgen* is also capable of generating support code for *Connext DDS*, and the generated code for the two are different. Note that *Connext Micro* and *RTI Connext Cert* use the same *rtiddsgen* and similar code is generated. However, when the generated code is compiled with RTI_CERT certain APIs are excluded.
- The `-language` option specifies the language of the generated code. *Connext Micro* supports C and C++ (with `-language C++`).
- The `-replace` option specifies that the new generated code will replace, or overwrite, any existing files with the same name.

rtiddsgen generates the following files for an input file HelloWorld.idl:

- **HelloWorld.h and HelloWorld.c**. Operations to manage a sample of the type, and a DDS sequence of the type.
- **HelloWorldPlugin.h and HelloWorldPlugin.c**. Implements the type-plugin interface defined by *Connext Micro*. Includes operations to serialize and deserialize a sample of the type and its DDS instance keys.
- **HelloWorldSupport.h and HelloWorldSupport.c**. Support operations to generate a type-specific a *DataWriter* and *DataReader*, and to register the type with a DDS *DomainParticipant*.

3.3 Configure UDP Transport

You may need to configure the UDP transport component that is pre-registered by *RTI Connext Micro*. To change the properties of the UDP transport, first the UDP component has be unregistered, then the properties have to be updated, and finally the component must be re-registered with the updated properties.

Example code:

- Unregister the pre-registered UDP component:

```
/* Unregister the pre-registered UDP component */
if (!RT_Registry_unregister(registry, "_udp", NULL, NULL))
{
    /* failure */
}
```

- Configure UDP transport properties:

```
struct UDP_InterfaceFactoryProperty *udp_property = NULL;

udp_property = (struct UDP_InterfaceFactoryProperty *)
    malloc(sizeof(struct UDP_InterfaceFactoryProperty));
if (udp_property != NULL)
{
    *udp_property = UDP_INTERFACE_FACTORY_PROPERTY_DEFAULT;

    /* allow_interface: Names of network interfaces allowed to send/receive.
     * Allow one loopback (lo) and one NIC (eth0).
     */
    REDA_StringSeq_set_maximum(&udp_property->allow_interface,2);
    REDA_StringSeq_set_length(&udp_property->allow_interface,2);

    *REDA_StringSeq_get_reference(&udp_property->allow_interface,0) = DDS_String_
↪dup("lo");
    *REDA_StringSeq_get_reference(&udp_property->allow_interface,1) = DDS_String_
↪dup("eth0");
}
else
{
    /* failure */
}
```

- Re-register UDP component with updated properties:

```
if (!RT_Registry_register(registry, "_udp",
                      UDP_InterfaceFactory_get_interface(),
                     (struct RT_ComponentFactoryProperty*)udp_property, NULL))
{
    /* failure */
}
```

For more details, see the *Transports* section in the *User's Manual*.

3.4 Create DomainParticipant, Topic, and Type

A DomainParticipantFactory creates *DomainParticipants*, and a *DomainParticipant* itself is the factory for creating *Publishers*, *Subscribers*, and *Topics*.

When creating a *DomainParticipant*, you may need to customize DomainParticipantQos, notably for:

- **Resource limits**. Default resource limits are set at minimum values.
- **Initial peers**.
- **Discovery**. The name of the registered discovery component (typically "dpde" or "dpse") must be assigned to DiscoveryQosPolicy's name. Please note that in *Connext Cert*, only the DPSE discovery plugin is supported.
- **Participant Name**. Every *DomainParticipant* is given the same default name. Must be unique when using DPSE discovery.

Example code:

- Create a *DomainParticipant* with configured DomainParticipantQos:

```
DDS_DomainParticipant *participant = NULL;
struct DDS_DomainParticipantQos dp_qos =
     DDS_DomainParticipantQos_INITIALIZER;
DDS_DomainParticipantFactory *factory = NULL;
RT_Registry_T *registry = NULL;

/* DDS domain of DomainParticipant */
DDS_Long domain_id = 0;


factory = DDS_DomainParticipantFactory_get_instance();

if (factory == NULL)
{
    /* something failed, exit */
    exit(-1);
}

registry = DDS_DomainParticipantFactory_get_registry(factory);

if (registry == NULL)
{
    /* something failed, exit */
    exit(-1);
}

if (!RT_Registry_register(registry, DDSHST_WRITER_DEFAULT_HISTORY_NAME,
```

(continues on next page)

(continued from previous page)

```
                        WHSM_HistoryFactory_get_interface(), NULL, NULL))
{
    /* something failed, exit */
    exit(-1);
}

if (!RT_Registry_register(registry, DDSHST_READER_DEFAULT_HISTORY_NAME,
                        RHSM_HistoryFactory_get_interface(), NULL, NULL))
{
    /* something failed, exit */
    exit(-1);
}

/* Name of your registered Discovery component */
if (!RT_ComponentFactoryId_set_name(&dp_qos.discovery.discovery.name, "dpde"))
{
     /* failure */
}

/* Initial peers: use only default multicast peer */
DDS_StringSeq_set_maximum(&dp_qos.discovery.initial_peers,1);
DDS_StringSeq_set_length(&dp_qos.discovery.initial_peers,1);
*DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers,0) =
    DDS_String_dup("239.255.0.1");

/* Resource limits */
dp_qos.resource_limits.max_destination_ports = 32;
dp_qos.resource_limits.max_receive_ports = 32;
dp_qos.resource_limits.local_topic_allocation = 1;
dp_qos.resource_limits.local_type_allocation = 1;
dp_qos.resource_limits.local_reader_allocation = 1;
dp_qos.resource_limits.local_writer_allocation = 1;
dp_qos.resource_limits.remote_participant_allocation = 8;
dp_qos.resource_limits.remote_reader_allocation = 8;
dp_qos.resource_limits.remote_writer_allocation = 8;

/* Participant name */
strcpy(dp_qos.participant_name.name, "Participant_1");

participant =
     DDS_DomainParticipantFactory_create_participant(factory,
                                                     domain_id,
                                                     &dp_qos,
                                                     NULL,
                                                     DDS_STATUS_MASK_NONE);
 if (participant == NULL)
 {
     /* failure */
 }
```

3.4.1 Register Type

Your data types that have been generated from IDL need to be registered with the *DomainParticipants* that will be using them. Each registered type must have a unique name, preferably the same as its IDL defined name.

```
DDS_ReturnCode_t retcode;

retcode = DDS_DomainParticipant_register_type(participant,
                                              "HelloWorld",
                                              HelloWorldTypePlugin_get());
if (retcode != DDS_RETCODE_OK)
{
    /* failure */
}
```

3.4.2 Create Topic of Registered Type

DDS *Topics* encapsulate the types being communicated, and you can create *Topics* for your type once your type is registered.

A topic is given a name at creation (e.g. "Example HelloWorld"). The type associated with the *Topic* is specified with its registered name.

```
DDS_Topic *topic = NULL;

topic = DDS_DomainParticipant_create_topic(participant,
                                           "Example HelloWorld",
                                           "HelloWorld",
                                           &DDS_TOPIC_QOS_DEFAULT,
                                           NULL,
                                           DDS_STATUS_MASK_NONE);

if (topic == NULL)
{
    /* failure */
}
```

3.4.3 DPSE Discovery: Assert Remote Participant

DPSE Discovery relies on the application to specify the other, or remote, *DomainParticipants* that its local *DomainParticipants* are allowed to discover. Your application must call a DPSE API for each remote participant to be discovered. The API takes as input the name of the remote participant.

```
/* Enable discovery of remote participant with name Participant_2 */
retcode = DPSE_RemoteParticipant_assert(participant, "Participant_2");
if (retcode != DDS_RETCODE_OK)
{
```

(continues on next page)

(continued from previous page)

```
    /* failure */
}
```

For more information, see the *DDS Domains* section in the *User's Manual*.

3.5 Create Publisher

A publishing application needs to create a DDS *Publisher* and then a *DataWriter* for each *Topic* it wants to publish.

In *Connext Micro*, PublisherQos in general contains no policies that need to be customized, while DataWriterQos does contain several customizable policies.

- Create *Publisher*:

```
DDS_Publisher *publisher = NULL;
publisher = DDS_DomainParticipant_create_publisher(participant,
                                                   &DDS_PUBLISHER_QOS_DEFAULT,
                                                   NULL,
                                                   DDS_STATUS_MASK_NONE);
if (publisher == NULL)
{
    /* failure */
}
```

For more information, see the *Sending Data* section in the User's Manual.

3.6 Create DataWriter

```
DDS_DataWriter *datawriter = NULL;
struct DDS_DataWriterQos dw_qos = DDS_DataWriterQos_INITIALIZER;
struct DDS_DataWriterListener dw_listener = DDS_DataWriterListener_INITIALIZER;

/* Configure writer Qos */
dw_qos.protocol.rtps_object_id = 100;
dw_qos.reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;
dw_qos.resource_limits.max_samples_per_instance = 2;
dw_qos.resource_limits.max_instances = 2;
dw_qos.resource_limits.max_samples =
    dw_qos.resource_limits.max_samples_per_instance * dw_qos.resource_limits.max_
↪instances;
dw_qos.history.depth = 1;
dw_qos.durability.kind = DDS_VOLATILE_DURABILITY_QOS;
dw_qos.protocol.rtps_reliable_writer.heartbeat_period.sec = 0;
```

(continues on next page)

(continued from previous page)

```
dw_qos.protocol.rtps_reliable_writer.heartbeat_period.nanosec = 250000000;

/* Set enabled listener callbacks */
dw_listener.on_publication_matched = HelloWorldPublisher_on_publication_matched;

datawriter =
    DDS_Publisher_create_datawriter(publisher,
                                    topic,
                                    &dw_qos,
                                    &dw_listener,
                                    DDS_PUBLICATION_MATCHED_STATUS);
if (datawriter == NULL)
{
    /* failure */
}
```

The DataWriterListener has its callbacks selectively enabled by the DDS status mask. In the example, the mask has set the on_publication_matched status, and accordingly the DataWriterListener has its on_publication_matched assigned to a callback function.

```
void HelloWorldPublisher_on_publication_matched(void *listener_data,
                                                DDS_DataWriter * writer,
                                                const struct DDS_
↪PublicationMatchedStatus *status)
{
    /* Print on match/unmatch */
    if (status->current_count_change > 0)
    {
        printf("Matched a subscriber\n");
    }
    else
    {
        printf("Unmatched a subscriber\n");
    }
}
```

3.6.1 DPSE Discovery: Assert Remote Subscription

A publishing application using DPSE discovery must specify the other *DataReaders* that its *DataWriters* are allowed to discover. Like the API for asserting a remote participant, the DPSE API for asserting a remote subscription must be called for each remote *DataReader* that a *DataWriter* may discover.

Whereas asserting a remote participant requires only the remote *Participant*'s name, asserting a remote subscription requires more configuration, as all QoS policies of the subscription necessary to determine matching must be known and thus specified.

```
struct DDS_SubscriptionBuiltinTopicData rem_subscription_data =
    DDS_SubscriptionBuiltinTopicData_INITIALIZER;
```

(continues on next page)

(continued from previous page)

```
/* Set Reader's protocol.rtps_object_id */
rem_subscription_data.key.value[DDS_BUILTIN_TOPIC_KEY_OBJECT_ID] = 200;

rem_subscription_data.topic_name = DDS_String_dup("Example HelloWorld");
rem_subscription_data.type_name = DDS_String_dup("HelloWorld");

rem_subscription_data.reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

retcode = DPSE_RemoteSubscription_assert(participant,
                                         "Participant_2",
                                         &rem_subscription_data,
                                         HelloWorld_get_key_kind(HelloWorldTypePlugin_
↪get(),
                                         NULL)));
if (retcode != DDS_RETCODE_OK)
{
    /* failure */
}
```

3.6.2 Writing Samples

Within the generated type support code are declarations of the type-specific *DataWriter*. For the HelloWorld type, this is the HelloWorldDataWriter.

Writing a HelloWorld sample is done by calling the write API of the HelloWorldDataWriter.

```
HelloWorldDataWriter *hw_datawriter;
DDS_ReturnCode_t retcode;
HelloWorld *sample = NULL;

/* Create and set sample */
sample = HelloWorld_create();
if (sample == NULL)
{
    /* failure */
}
sprintf(sample->msg, "Hello World!");

/* Write sample  */
hw_datawriter = HelloWorldDataWriter_narrow(datawriter);

retcode = HelloWorldDataWriter_write(hw_datawriter, sample, &DDS_HANDLE_NIL);
if (retcode != DDS_RETCODE_OK)
{
    /* failure */
}
```

For more information, see the *Sending Data* section in the *User's Manual*.

3.7 Create Subscriber

A subscribing application needs to create a DDS *Subscriber* and then a *DataReader* for each *Topic* to which it wants to subscribe.

In *Connext Micro*, SubscriberQos in general contains no policies that need to be customized, while DataReaderQos does contain several customizable policies.

```
DDS_Subscriber *subscriber = NULL;
subscriber = DDS_DomainParticipant_create_subscriber(participant,
                                                     &DDS_SUBSCRIBER_QOS_DEFAULT,
                                                     NULL,
                                                     DDS_STATUS_MASK_NONE);
if (subscriber == NULL)
{
    /* failure */
}
```

For more information, see the *Receiving Data* section in the User's Manual.

3.8 Create DataReader

```
DDS_DataReader *datareader = NULL;
struct DDS_DataReaderQos dr_qos = DDS_DataReaderQos_INITIALIZER;
struct DDS_DataReaderListener dr_listener = DDS_DataReaderListener_INITIALIZER;

/* Configure Reader Qos */
dr_qos.protocol.rtps_object_id = 200;
dr_qos.resource_limits.max_instances = 2;
dr_qos.resource_limits.max_samples_per_instance = 2;
dr_qos.resource_limits.max_samples =
    dr_qos.resource_limits.max_samples_per_instance * dr_qos.resource_limits.max_
↪instances;
dr_qos.reader_resource_limits.max_remote_writers = 10;
dr_qos.reader_resource_limits.max_remote_writers_per_instance = 10;
dr_qos.history.depth = 1;
dr_qos.durability.kind = DDS_VOLATILE_DURABILITY_QOS;
dr_qos.reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

/* Set listener callbacks */
dr_listener.on_data_available = HelloWorldSubscriber_on_data_available;
dr_listener.on_subscription_matched = HelloWorldSubscriber_on_subscription_matched;

datareader = DDS_Subscriber_create_datareader(subscriber,
                                              DDS_Topic_as_topicdescription(topic),
                                              &dr_qos,
                                              &dr_listener,
                                              DDS_DATA_AVAILABLE_STATUS | DDS_
↪SUBSCRIPTION_MATCHED_STATUS);
```

(continues on next page)

(continued from previous page)

```
if (datareader == NULL)
{
    /* failure */
}
```

The DataReaderListener has its callbacks selectively enabled by the DDS status mask. In the example, the mask has set the DDS_SUBSCRIPTION_MATCHED_STATUS and DDS_DATA_AVAILABLE_STATUS statuses, and accordingly the DataReaderListener has its on_subscription_matched and on_data_available assigned to callback functions.

```
void HelloWorldSubscriber_on_subscription_matched(void *listener_data,
                                                  DDS_DataReader * reader,
                                                  const struct DDS_
↪SubscriptionMatchedStatus *status)
{
    if (status->current_count_change > 0)
    {
        printf("Matched a publisher\n");
    }
    else
    {
        printf("Unmatched a publisher\n");
    }
}
```

```
void HelloWorldSubscriber_on_data_available(void* listener_data,
                                            DDS_DataReader* reader)
{
    HelloWorldDataReader *hw_reader = HelloWorldDataReader_narrow(reader);
    DDS_ReturnCode_t retcode;
    struct DDS_SampleInfo *sample_info = NULL;
    HelloWorld *sample = NULL;

    struct DDS_SampleInfoSeq info_seq =
        DDS_SEQUENCE_INITIALIZER(struct DDS_SampleInfo);
    struct HelloWorldSeq sample_seq =
        DDS_SEQUENCE_INITIALIZER(HelloWorld);

    const DDS_Long TAKE_MAX_SAMPLES = 32;
    DDS_Long i;

    retcode = HelloWorldDataReader_take(hw_reader,
       &sample_seq, &info_seq, TAKE_MAX_SAMPLES,
       DDS_ANY_SAMPLE_STATE, DDS_ANY_VIEW_STATE, DDS_ANY_INSTANCE_STATE);

    if (retcode != DDS_RETCODE_OK)
    {
        printf("failed to take data: %d\n", retcode);
        goto done;
    }
```

(continues on next page)

(continued from previous page)

```
    /* Print each valid sample taken */
    for (i = 0; i < HelloWorldSeq_get_length(&sample_seq); ++i)
    {
        sample_info = DDS_SampleInfoSeq_get_reference(&info_seq, i);

        if (sample_info->valid_data)
        {
            sample = HelloWorldSeq_get_reference(&sample_seq, i);
            printf("\nSample received\n\tmsg: %s\n", sample->msg);
        }
        else
        {
            printf("not valid data\n");
        }
    }

    HelloWorldDataReader_return_loan(hw_reader, &sample_seq, &info_seq);

 done:
    HelloWorldSeq_finalize(&sample_seq);
    DDS_SampleInfoSeq_finalize(&info_seq);
}
```

3.8.1 DPSE Discovery: Assert Remote Publication

A subscribing application using DPSE discovery must specify the other *DataWriters* that its *DataReaders* are allowed to discover. Like the API for asserting a remote participant, the DPSE API for asserting a remote publication must be called for each remote *DataWriter* that a *DataReader* may discover.

```
struct DDS_PublicationBuiltinTopicData rem_publication_data =
    DDS_PublicationBuiltinTopicData_INITIALIZER;

/* Set Writer's protocol.rtps_object_id */
rem_publication_data.key.value[DDS_BUILTIN_TOPIC_KEY_OBJECT_ID] = 100;

rem_publication_data.topic_name = DDS_String_dup("Example HelloWorld");
rem_publication_data.type_name = DDS_String_dup("HelloWorld");

rem_publication_data.reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

retcode = DPSE_RemotePublication_assert(participant,
                                        "Participant_1",
                                        &rem_publication_data,
                                        HelloWorld_get_key_kind(HelloWorldTypePlugin_
↪get(),
                                        NULL)));
if (retcode != DDS_RETCODE_OK)
{
```

(continues on next page)

(continued from previous page)

```
    /* failure */
}
```

Asserting a remote publication requires configuration of all QoS policies necessary to determine matching.

3.8.2 Receiving Samples

Accessing received samples can be done in a few ways:

- **Polling**. Do read or take within a periodic polling loop.
- **Listener**. When a new sample is received, the DataReaderListener's on_data_available is called. Processing is done in the context of the middleware's receive thread. See the above HelloWorldSubscriber_on_data_available callback for example code.
- **Waitset**. Create a waitset, attach it to a status condition with the data_available status enabled, and wait for a received sample to trigger the waitset. Processing is done in the context of the user's application thread. (Note: the code snippet below is taken from the shipped HelloWorld_dpde_waitset example).

```
DDS_WaitSet *waitset = NULL;
struct DDS_Duration_t wait_timeout = { 10, 0 }; /* 10 seconds */
DDS_StatusCondition *dr_condition = NULL;
struct DDS_ConditionSeq active_conditions =
    DDS_SEQUENCE_INITIALIZER(struct DDS_ConditionSeq);

if (!DDS_ConditionSeq_initialize(&active_conditions))
{
    /* failure */
}

if (!DDS_ConditionSeq_set_maximum(&active_conditions, 1))
{
    /* failure */
}

waitset = DDS_WaitSet_new();
if (waitset == NULL )
{
    /* failure */
}

dr_condition = DDS_Entity_get_statuscondition(DDS_DataReader_as_entity(datareader));

retcode = DDS_StatusCondition_set_enabled_statuses(dr_condition,
                                                   DDS_DATA_AVAILABLE_STATUS);
if (retcode != DDS_RETCODE_OK)
{
    /* failure */
```

(continues on next page)

(continued from previous page)

```
}

retcode = DDS_WaitSet_attach_condition(waitset,
                                       DDS_StatusCondition_as_condition(dr_condition));
if (retcode != DDS_RETCODE_OK)
{
    /* failure */
}

retcode = DDS_WaitSet_wait(waitset, active_conditions, &wait_timeout);

switch (retcode) {
    case DDS_RETCODE_OK:
    {
        /* This WaitSet only has a single condition attached to it
         * so we can implicitly assume the DataReader's status condition
         * to be active (with the enabled DATA_AVAILABLE status) upon
         * successful return of wait().
         * If more than one conditions were attached to the WaitSet,
         * the returned sequence must be examined using the
         * commented out code instead of the following.
         */

        HelloWorldSubscriber_take_data(HelloWorldDataReader_narrow(datareader));

        /*
        DDS_Long active_len = DDS_ConditionSeq_get_length(&active_conditions);
        for (i = active_len - 1; i >= 0; --i)
        {
            DDS_Condition *active_condition =
                *DDS_ConditionSeq_get_reference(&active_conditions, i);

            if (active_condition ==
                    DDS_StatusCondition_as_condition(dr_condition))
            {
                total_samples += HelloWorldSubscriber_take_data(
                                 HelloWorldDataReader_narrow(datareader));
            }
            else if (active_condition == some_other_condition)
            {
                do_something_else();
            }
        }
        */
        break;
    }
    case DDS_RETCODE_TIMEOUT:
    {
        printf("WaitSet_wait timed out\n");
        break;
    }
```

(continues on next page)

(continued from previous page)

```
    default:
    {
        printf("ERROR in WaitSet_wait: retcode=%d\n", retcode);
        break;
    }
}
```

3.8.3 Filtering Samples

In lieu of supporting Content-Filtered Topics, a DataReaderListener in *Connext Micro* provides callbacks to do application-level filtering per sample.

- **on_before_sample_deserialize**. Through this callback, a received sample is presented to the application before it has been deserialized or stored in the *DataReader*'s queue.
- **on_before_sample_commit**. Through this callback, a received sample is presented to the application after it has been deserialized but before it has been stored in the *DataReader*'s queue.

You control the callbacks' sample_dropped parameter; upon exiting either callback, the *DataReader* will drop the sample if sample_dropped is true. Consequently, dropped samples are not stored in the *DataReader*'s queue and are not available to be read or taken.

Neither callback is associated with a DDS Status. Rather, each is enabled when assigned, to a non-NULL callback.

NOTE: Because it is called after the sample has been deserialized, on_before_sample_commit provides an additional sample_info parameter, containing some of the usual sample information that would be available when the sample is read or taken.

The HelloWorld_dpde example's subscriber has this on_before_sample_commit callback:

```
DDS_Boolean HelloWorldSubscriber_on_before_sample_commit(
    void *listener_data,
    DDS_DataReader *reader,
    const void *const sample,
    const struct DDS_SampleInfo *const sample_info,
    DDS_Boolean *dropped)
{
    HelloWorld *hw_sample = (HelloWorld *)sample;

    /* Drop samples with even-numbered count in msg */
    HelloWorldSubscriber_filter_sample(hw_sample, dropped);

    if (*dropped)
    {
        printf("\nSample filtered, before commit\n\tDROPPED - msg: %s\n",
               hw_sample->msg);
    }
```

(continues on next page)

(continued from previous page)

```
    return DDS_BOOLEAN_TRUE;
}

...

dr_listener.on_before_sample_commit =
    HelloWorldSubscriber_on_before_sample_commit;
```

For more information, see the *Receiving Data* section in the User's Manual.

3.9 Examples

Connext Micro provides buildable example applications, in the **example/** directory. Each example comes with instructions on how to build and run an application.

In addition to the provided examples, the RTI Code Generator available with *Connext Micro* can generate example DDS applications with a type definition file as input. For more information read the guide in *Example Generation*.

Note that by default, all the examples link against release libraries. To build release libraries:

```
./resource/scripts/rtime-make --name x64Darwin17clang9.0 --target self --build --config␣
↪Release
```

To build the examples against the debug libraries, specify the DEBUG option:

```
make DEBUG=Y
```

- **HelloWorld_transformations**. Same as HelloWorld_dpde, except it uses UDP transformations to send encrypted packets using OpenSSL.
- **RTPS**. Example of an RTPS emitter that bypasses the DDS module and APIs to send RTPS discovery and user data.
- **Latency**. Measures the end-to-end latency of *Connext Micro*.
- **Throughput**. Measures the end-to-end throughput of *Connext Micro*.

3.10 Example Generation

The RTI Code Generator available with *Connext Micro* can generate DDS example applications with a type definition file as input.

Note: Before running the RTI Code Generator, you might need to add

`<Connext Micro install folder>/rtiddsgen/scripts`

to your PATH environment variable.

To generate an example:

```
rtiddsgen -example -language <C|C++> [-namespace] <file with type definition>
```

This command generates an example using the default example template, which uses the Dynamic Participant Dynamic Endpoint (DPDE) discovery plugin.

rtiddsgen accepts the following options:

- `-example`: Generates type files, example files, and CMakelists files.
- `-language <C|C++>`: Generates C or C++ code.
- `-namespace`: Enables C++ namespaces when the language option is C++.

The generated example can be compiled using CMake <https://cmake.org/>_ and the CMakelists.txt file generated by the RTI Code Generator. A README.txt file is also generated with a description of the example and instructions for how to compile and run the examples.

The RTI Code Generator can also generate examples using custom templates by using the option `-exampleTemplate <templateName>`.

To generate an example using a custom template instead of the default one:

```
rtiddsgen -example -exampleTemplate <template name> -language <C|C++> [-namespace] <file␣
↪with type definition>
```

To see the list of the available templates, use the following command:

```
rtiddsgen -showTemplates
```

The output from the command will look similar to this:

```
List of example templates per language:
    - C:
        - cert
        - dpse
        - static_udp
        - waitsets
    - C++:
        - dpse
```

(continues on next page)

(continued from previous page)

```
      - waitsets
  - C++ Namespace:
      - dpse
      - waitsets
```

The following command will generate an example in the C language, using the 'waitsets' custom template instead of the default template:

```
rtiddsgen -example -exampleTemplate waitsets -language C <file with type definition>
```

3.10.1 Description of Examples

All examples consist of a publication and subscription pair to send and receive the type provided by user. Two applications are compiled: one to send samples and another to receive samples.

- **Default template** Discovery of endpoints is done with the dynamic-endpoint discovery. Only the UDP and INTRA transports are enabled. The subscriber application creates a DataReader, which uses a listener to receive notifications about new samples and matched publishers. These notifications are received in the middleware thread (instead of the application thread).
- **cert** An example that only uses APIs that are compatible with *Connext Cert*.
- **dpse** The only difference from the default template is that the discovery of endpoints is done with static-endpoint discovery. Static-endpoint discovery uses function calls to statically assert information about remote endpoints belonging to remote DomainParticipants.
- **static_udp** The only difference from the default template is that this example uses a static UDP interface configuration. Using this API, the UDP transport is statically configured. This is useful in systems that are not able to return the installed UDP interfaces (name, IP address, mask…).
- **waitsets** The only difference from the default template is that the Subscriber application creates a DataReader that uses a Waitset (instead of a listener) to receive notifications about new samples and matched publishers. These notifications are received in the middleware thread (instead of the application thread).

3.10.2 How to Compile the Generated Examples

Before compiling, set the environment variable RTIMEHOME to the *Connext Micro* installation directory.

Depending on the number of network interfaces installed on the local machine, you might need to restrict which interfaces are used by *Connext Micro*.

Use the option `-udp_intf <interface name>` when running the example.

The *Connext Micro* source bundle includes rtime-make (on Linux and macOS systems) or rtime-make.bat (on Windows systems) to simplify invocation of CMake. This script is a convenient

way to invoke CMake with the correct options. For example:

Linux

```
cd "<${envMap.idlFileName}Application directory>"

rtime-make --config <Debug|Release> --build --name x64Linux3gcc4.8.2 --target Linux --
↪source-dir . \
     -G "Unix Makefiles" --delete [-DRTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE=true]
```

macOS

```
cd "<${envMap.idlFileName}Application directory>"

rtime-make --config <Debug|Release> --build --name x64Darwin17.3.0Clang9.0.0 --target␣
↪Darwin --source-dir . \
      -G "Unix Makefiles" --delete [-DRTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE=true]
```

Windows

```
cd "<${envMap.idlFileName}Application directory>"

rtime-make.bat --config <Debug|Release> --build --name i86Win32VS2010 --target Windows --
↪source-dir . \
     -G "Visual Studio 10 2010" --delete [-DRTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE_eq_
↪true]
```

The executable can be found in the directory 'objs'.

It is also possible to compile using CMake, e.g., when the *Connext Micro* source bundle is not installed.

Linux

```
cmake [-DRTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE=true] [-DCMAKE_BUILD_TYPE=
↪<Debug|Release>] -G "Unix Makefiles" \
      -B./<your build directory> -H. -DRTIME_TARGET_NAME=x64Linux3gcc4.8.2"

cmake --build ./<your build directory> [--config <Debug|Release>]
```

macOS

```
cmake [-DRTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE=true] [-DCMAKE_BUILD_TYPE=
↪<Debug|Release>] -G "Unix Makefiles" \
      -B./<your build directory> -H. -DRTIME_TARGET_NAME=x64Darwin17.3.0Clang9.0.0"

cmake --build ./<your build directory> [--config <Debug|Release>]
```

Windows

```
cmake [-DRTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE=true] [-DCMAKE_BUILD_TYPE=
↪<Debug|Release>] -G "Visual Studio 10 2010" \
      -B./<your build directory> -H. -DRTIME_TARGET_NAME=i86Win32VS2010"
```

(continues on next page)

(continued from previous page)

```
cmake --build .\<your build directory> [--config <Debug|Release>]
```

The executable can be found in the directory 'objs'.

The following options are accepted:

- `-DRTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE=true` adds a rule to regenerate type support plugin source files if the input file with the type definition changes. Default value is 'false'.

3.10.3 How to Run the Generated Examples

By default, the example tries to guess which interfaces it should use to receive samples. This can cause communication problems if the number of available interfaces is greater than the maximum number of interfaces supported by *Connext Micro*. For this reason, it is recommended to restrict the number of interfaces used by the application.

Use the option `-udp_intf <interface name>` when running the example.

For example, if the example has been compiled for Linux x64Linux3gcc4.8.2, run the subscriber with this command:

```
objs/x64Linux3gcc4.8.2/<Type definition file name>_subscriber [-domain <Domain_ID>] [-
↪peer <address>] \
            [-sleep <sleep_time>] [-count <seconds_to_run>] [-udp_intf <interface name>]
```

and run the publisher with this command:

```
objs/x64Linux3gcc4.8.2/<Type definition file name>_publisher [-domain <Domain_ID> -peer
↪<address>] \
            [-sleep <sleep_time>] [-count <seconds_to_run>] [-udp_intf <interface name>]
```

Chapter 4

User's Manual

4.1 Initializing the Connext Micro Library

Connext Micro has been designed to integrate with a wide range of operating systems, network stacks, and CPUs. For this reason, *Connext Micro* places few restrictions on how it is integrated. The memory management API defined by *Connext Micro* may be implemented using standard C libray APIs such as *malloc()* and *free()*, or something hardware specific relying on memory being allocated from a specific memory region.

In order to allow a degree of flexibility, integrations may be configurable at run-time. This configuration may require validation before it is safe to make specific calls, such as allocating memory.

In order to guarantee consistency accross all integrations for when it is safe to call APIs, *Connext Micro* requires that its library is initialized with *DDS_DomainParticipantFactory_get_instance* before any public APIs are called, unless an API is documented to be safe to call before *DDS_DomainParticipantFactory_get_instance*. *DDS_DomainParticipantFactory_get_instance* initializes an integration, providing an opportunity for integrations to validate its configuration.

Note: This restriction is not limited to DDS APIs, but extends to **all** public APIs, such as sequence APIs, type-support APIs, string APIs, and component APIs.

Connext Micro is initialized with a successful call to *DDS_DomainParticipantFactory_get_instance*. On success, *DDS_DomainParticipantFactory_get_instance* returns a reference to a *DDS_DomainParticipantFactory*; on failure, 'nil' is returned:

```
DDS_DomainParticipantFactory *factory = NULL;

factory = DDS_DomainParticipantFactory_get_instance();

if (factory == NULL)
{
```

(continues on next page)

(continued from previous page)

```
    /* something failed, exit */
    exit(-1);
}

/* Safe to call other public APIs */
```

After a successful call to *DDS_DomainParticipantFactory_get_instance*, public APIs are safe to call as documented. APIs that **must not** be called before *DDS_DomainParticipantFactory_get_instance* have the following additional description:

```
API Restriction:
This function must only be called after DDS_DomainParticipantFactory_get_instance.
```

Warning: *DDS_DomainParticipantFactory_get_instance* is not guarenteed to be thread-safe.

4.1.1 rtiddsgen

rtiddsgen is the type support compiler included with *Connext Micro*. *rtiddsgen* generates code to send and receive data types across the network, as well as to allocate memory to store data types in memory. These memory allocations use the memory management APIs defined by *Connext Micro*.

Because each integration determines how these APIs are implemented, it is important that TypeSupport APIs are **not** called until *Connext Micro* has been initialized. APIs such as *FooTypeSupport_create_data* and *FooTypeSupport_delete_data* are **not** safe to call until after a successful call to *DDS_DomainParticipantFactory_get_instance*:

```
DDS_DomainParticipantFactory *factory = NULL;
Foo *sample = NULL;

/* NOT ALLOWED */
sample = FooTypeSupport_create_data();

factory = DDS_DomainParticipantFactory_get_instance();

if (factory == NULL)
{
    /* something failed, exit */
    exit(-1);
}

/* ALLOWED */
sample = FooTypeSupport_create_data();
if (sample == NULL)
{
    /* something failed, exit */
    exit(-1);
}
```

(continues on next page)

(continued from previous page)

```
/* Calls other public APIs */
```

4.1.2 The Connext Micro System API

The *Connext Micro* System API enables applications to configure the behavior of *Connext Micro* at runtime. Which configuration options are available depends on the specific integration.

However, because the *Connext Micro* system must be configured **before** *Connext Micro* is initialized, it is safe to call public System APIs before *DDS_DomainParticipantFactory_get_instance*, such as *OSAPI_System_get_property* and *OSAPI_System_set_property*:

```
struct OSAPI_SystemProperty sys_property = OSAPI_SystemProperty_INITIALIZER;
DDS_DomainParticipantFactory *factory = NULL;

if (!OSAPI_System_get_property(&sys_property))
{
    /* error */
    return;
}

/* Set sys_property */

if (!OSAPI_System_set_property(&sys_property))
{
    /* error */
    return;
}

factory = DDS_DomainParticipantFactory_get_instance();
if (factory == NULL)
{
    /* error */
    return;
}
```

4.1.3 Component Registration

Connext Micro consists of core APIs and additional components that extend its functionality. *Connext Micro* includes two components which **must** always be registered with *Connext Micro* before any DDS entities can be created: the *writer* and *reader* history caches. The following code sample demonstrates how to register these:

```
#include "wh_sm/wh_sm_history.h"
#include "rh_sm/rh_sm_history.h"


DDS_DomainParticipantFactory *factory = NULL;
```

(continues on next page)

(continued from previous page)

```
RT_Registry_T *registry = NULL;

factory = DDS_DomainParticipantFactory_get_instance();

if (factory == NULL)
{
    /* something failed, exit */
    exit(-1);
}

registry = DDS_DomainParticipantFactory_get_registry(factory);

if (registry == NULL)
{
    /* something failed, exit */
    exit(-1);
}

if (!RT_Registry_register(registry, DDSHST_WRITER_DEFAULT_HISTORY_NAME,
                          WHSM_HistoryFactory_get_interface(), NULL, NULL))
{
    /* something failed, exit */
    exit(-1);
}

if (!RT_Registry_register(registry, DDSHST_READER_DEFAULT_HISTORY_NAME,
                          RHSM_HistoryFactory_get_interface(), NULL, NULL))
{
    /* something failed, exit */
    exit(-1);
}
```

Connext Micro includes other components, such as *Discovery* plugins and the *UDP Transport*. These are documented in other sections.

4.2 Data Types

How data is stored or laid out in memory can vary from language to language, compiler to compiler, operating system to operating system, and processor to processor. This combination of language/compiler/operating system/processor is called a *platform*. Any modern middleware must be able to take data from one specific platform (for example, C/gcc.7.3.0/Linux®/PPC) and transparently deliver it to another (for example, C/gcc.7.3.0/Linux/Arm® v8). This process is commonly called *serialization/deserialization*, or *marshalling/demarshalling*.

Connext Micro data samples sent on the same *Connext Micro* topic share a data type. This type defines the fields that exist in the DDS data samples and what their constituent types are. The middleware stores and propagates this meta-information separately from the individual DDS

data samples, allowing it to propagate DDS samples efficiently while handling byte ordering and alignment issues for you.

To publish and/or subscribe to data with *Connext Micro*, you will carry out the following steps:

1. Select a type to describe your data and use the *RTI Code Generator* to define a type at compile-time using a language-independent description language.

   The *RTI Code Generator* accepts input in the following formats:

   - **OMG IDL**. This format is a standardized component of the DDS specification. It describes data types with a C++-like syntax. A link to the latest specification can be found here: https://www.omg.org/spec/IDL.
   - **XML in a DDS-specific format**. This XML format is terser, and therefore easier to read and write by hand, than an XSD file. It offers the general benefits of XML-extensibility and ease of integration, while fully supporting DDS-specific data types and concepts. A link to the latest specification, including a description of the XML format, can be found here: https://www.omg.org/spec/DDS-XTypes/.
   - **XSD format**. You can describe data types with XML schemas (XSD). A link to the latest specification, including a description of the XSD format, can be found here: https://www.omg.org/spec/DDS-XTypes/.

   Define a type programmatically at run time.

   This method may be appropriate for applications with dynamic data description needs: applications for which types change frequently or cannot be known ahead of time.

2. Register your type with a logical name.
3. Create a *Topic* using the type name you previously registered.

   If you've chosen to use a built-in type instead of defining your own, you will use the API constant corresponding to that type's name.

4. Create one or more *DataWriters* to publish your data and one or more *DataReaders* to subscribe to it.

   The concrete types of these objects depend on the concrete data type you've selected, in order to provide you with a measure of type safety.

Whether publishing or subscribing to data, you will need to know how to create and delete (only in *Connext Micro* DDS data samples and how to get and set their fields. These tasks are described in the section on Working with DDS Data Samples in the *RTI Connext DDS Core Libraries User's Manual* (available here if you have Internet access).

4.2.1 Introduction to the Type System

A *user data type* is any custom type that your application defines for use with *RTI Connext Micro*. It may be a structure, a union, a value type, an enumeration, or a typedef (or language equivalents).

Your application can have any number of user data types. They can be composed of any of the primitive data types listed below or of other user data types.

Only structures, unions, and value types may be read and written directly by *Connext Micro*; enums, typedefs, and primitive types must be contained within a structure, union, or value type. In order for a *DataReader* and *DataWriter* to communicate with each other, the data types associated with their respective Topic definitions must be identical.

- octet, char, wchar
- short, unsigned short
- long, unsigned long
- long long, unsigned long long
- float
- double, long double
- boolean
- enum (with or without explicit values)
- bounded string and wstring

The following type-building constructs are also supported:

- module (also called a package or namespace)
- pointer
- array of primitive or user type elements
- bounded sequence of elements—a sequence is a variable-length ordered collection, such as a vector or list
- typedef
- union
- struct
- value type, a complex type that supports inheritance and other object-oriented features

To use a data type with *Connext Micro*, you must define that type in a way the middleware understands and then register the type with the middleware. These steps allow *Connext Micro* to serialize, deserialize, and otherwise operate on specific types. They will be described in detail in the following sections.

Sequences

A sequence contains an ordered collection of elements that are all of the same type. The operations supported in the sequence are documented in the C API Reference and C++ API Reference HTML documentation.

Elements in a sequence are accessed with their index, just like elements in an array. Indices start at zero in all APIs. Unlike arrays, however, sequences can grow in size. A sequence has two sizes associated with it: a physical size (the "maximum") and a logical size (the "length"). The physical size indicates how many elements are currently allocated by the sequence to hold; the logical size indicates how many valid elements the sequence actually holds. The length can vary from zero up to the maximum. Elements cannot be accessed at indices beyond the current length.

A sequence must be declared as bounded. A sequence's "bound" is the maximum number of elements that the sequence can contain at any one time. A finite bound is very important because it allows *RTI Connext Micro* to preallocate buffers to hold serialized and deserialized samples of your types; these buffers are used when communicating with other nodes in your distributed system.

The bound is either *excplict* or *implicit*:

1. An *explicit* bound is given directly in the IDL:

```
struct MyType
{
    //Maximum of 32 longs
    sequence<32> a_long_seq;
}
```

2. An *implicit* bound uses the unbounded notation in IDL, but relies on the -sequenceSize parameter passed to *rtiddsgen* for the maximum length:

```
struct MyType
{
    sequence<long> a_long_seq;
}

By default, any unbounded sequences found in an IDL file will be given
a default bound of 100 elements. This default value can be overwritten
using *RTI Code Generator's* **-sequenceSize** command-line argument
(see |rtiddsgen_um_cmdlineargs_verbose| in
the *RTI Code Generator User's Manual*, available |rtiddsgen_um_cmdlineargs|_
if you have Internet access).
```

Strings and Wide Strings

Connext Micro supports both strings consisting of single-byte characters (the IDL string type) and strings consisting of wide characters (IDL wstring). The wide characters supported by *Connext Micro* are large enough to store 4-byte Unicode/UTF16 characters.

Like sequences, strings must be bounded. A string's "bound" is its maximum length (not counting the trailing NULL character in C and C++).

In C and Traditional C++, strings are mapped to *char**.

The bound is either *excplict* or *implicit*:

1. An *explicit* bound is given directly in the IDL:

```
struct MyType
{
    //Maximum of 32 bytes + NUL termination
    string<32> a_string;
}
```

2. An *implicit* bound uses the unbounded notation in IDL, but relies on the -stringSize parameter passed to *rtiddsgen* for the maximum length:

```
struct MyType
{
    // Unbounded notation, but not unbounded. Bound determined
    // by the -stringSize parameter to rtiddsgen
    string a_string;
}


By default, any unbounded string found in an IDL file will be given a
default bound of 255 elements. This default value can be overwritten
using *RTI Code Generator's* **-stringSize** command-line argument
(see |rtiddsgen_um_cmdlineargs_verbose| in the
*RTI Code Generator User's Manual*, available |rtiddsgen_um_cmdlineargs|_
if you have Internet access).
```

IDL String Encoding

The "Extensible and Dynamic Topic Types for DDS specification" (https://www.omg.org/spec/DDS-XTypes/) standardizes the default encoding for strings to UTF-8. This encoding shall be used as the wire format. Language bindings may use the representation that is most natural in that particular language. If this representation is different from UTF-8, the language binding shall manage the transformation to/from the UTF-8 wire representation.

As an extension, *Connext Micro* offers ISO_8859_1 as an alternative string wire encoding.

This section describes the encoding for IDL strings across different languages in *Connext Micro* and how to configure that encoding.

- C, Traditional C++ (only in *Connext Micro*)

  IDL strings are mapped to a NULL-terminated array of *DDS_Char_ (char*)*. Users are responsible for using the right character encoding (UTF-8 or ISO_8859_1) when populating the string values. This applies to all generated code, DynamicData, and Built-in data types. The middleware does not transform from the language binding encoding to the wire encoding.

IDL Wide Strings Encoding

The "Extensible and Dynamic Topic Types for DDS specification" (https://www.omg.org/spec/DDS-XTypes/) standardizes the default encoding for wide strings to UTF-32. This encoding shall be used as the wire format.

Wide-string characters have a size of 4 bytes on the wire with UTF-32 encoding.

Language bindings may use the representation that is most natural in that particular language. If this representation is different from UTF-32, the language binding shall manage the transformation to/from the UTF-32 wire representation.

- C, Traditional C++

  IDL wide strings are mapped to a NULL-terminated array of DDS_Wchar *(DDS_Wchar*)*. DDS_WChar is an unsigned 4-byte integer. Users are responsible for using the right character encoding (UTF-32) when populating the wide-string values. This applies to all generated code, DynamicData, and Built-in data types. *Connext Micro* does not transform from the language binding encoding to the wire encoding.

Sending Type Information on the Network

Connext Micro can send type information the network using a concept called type objects. A type objects is a description of a type suitable to network transmission, and is commonly used by for example tools to visualize data from any application.

However, please note that *Connext Micro* does not support sending type information on the network. Instead, tools can load type information from XML files generated from IDL using *rtiddsgen*. Please refer to the *RTI Code Generator's User's Manual* for more information (available here if you have Internet access).

4.2.2 Creating User Data Types with IDL

You can create user data types in a text file using IDL (Interface Description Language). IDL is programming-language independent, so the same file can be used to generate code in C and Traditional C++ (only *Connext Micro*). *RTI Code Generator* parses the IDL file and automatically generates all the necessary routines and wrapper functions to bind the types for use by *Connext Micro* at run time. You will end up with a set of required routines and structures that your application and *Connext Micro* will use to manipulate the data.

Please refer to the section on Creating User Data Types with IDL in the *RTI Connext DDS Core Libraries User's Manual* for more information (available here if you have Internet access).

Note: Not all features in *RTI Code Generator* are supported when generating code for *Connext Micro*, see *Unsupported Features of rtiddsgen with Connext Micro*.

4.2.3 Working with DDS Data Samples

You should now understand how to define and work with data types. Now that you have chosen one or more data types to work with, this section will help you understand how to create and manipulate objects of those types.

In C:

You create and delete your own objects from factories, just as you create *Connext Micro* objects from factories. In the case of user data types, the factory is a singleton object called the type support. Objects allocated from these factories are deeply allocated and fully initialized.

```
/* In the generated header file: */
struct MyData {
    char* myString;
};
/* In your code: */
MyData* sample = MyDataTypeSupport_create_data();
char* str = sample->myString; /*empty, non-NULL string*/

/* not support in Micro Cert */
MyDataTypeSupport_delete_data(sample);
```

In Traditional C++:

Without the **-constructor option**, you create and delete objects using the TypeSupport factories.

```
MyData* sample = MyDataTypeSupport::create_data();
char* str = sample->myString; // empty, non-NULL string
// ...
MyDataTypeSupport::delete_data(sample);
```

Please refer to the section on Working with DDS Data Samples in the *RTI Connext DDS Core Libraries User's Manual* for more information (available here if you have Internet access).

4.3 DDS Entities

The main classes extend an abstract base class called a DDS *Entity*. Every DDS *Entity* has a set of associated events known as statuses and a set of associated Quality of Service Policies (QosPolicies). In addition, a *Listener* may be registered with the *Entity* to be called when status changes occur. DDS *Entities* may also have attached DDS *Conditions*, which provide a way to wait for status changes. *Figure 4.1: Overview of DDS Entities* presents an overview in a UML diagram.

Please note that *RTI Connext Micro* does not support the following:

- **MultiTopic**

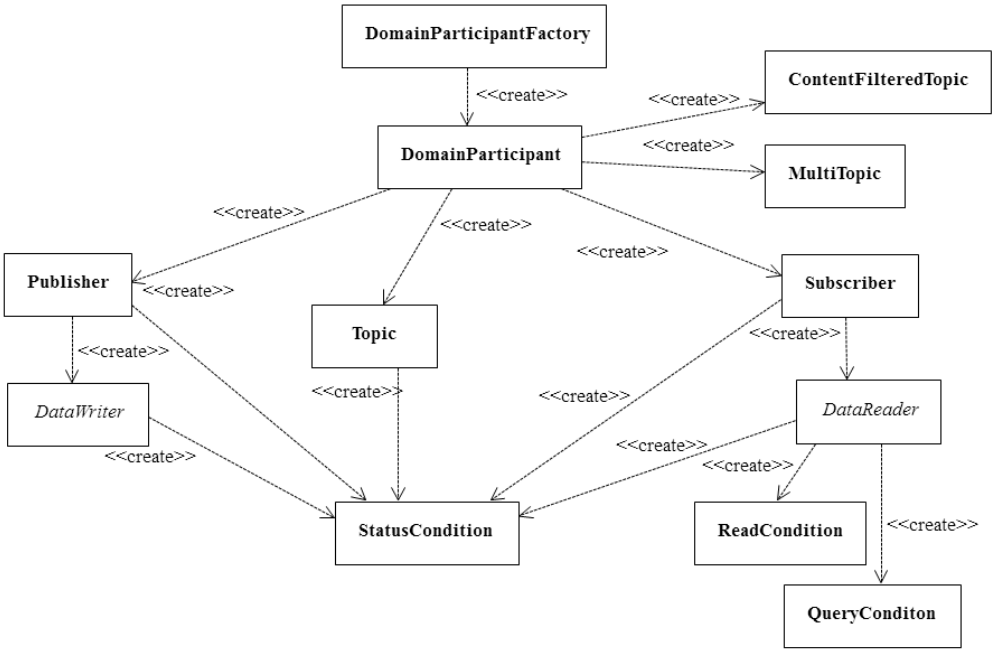


Figure 4.1: Overview of DDS Entities

- **ContentFilteredTopic**
- **ReadCondition**
- **QueryConditions**

For a general description of DDS *Entities* and their operations, please refer to the DDS Entities chapter in the *RTI Connext DDS Core Libraries User's Manual* (available here if you have Internet access). Note that *RTI Connext Micro* does not support all APIs and QosPolicies; please refer to the C API Reference and C++ API Reference documentation for more information.

4.4 Sending Data

This section discusses how to create, configure, and use *Publishers* and *DataWriters* to send data. It describes how these *Entities* interact, as well as the types of operations that are available for them.

The goal of this section is to help you become familiar with the *Entities* you need for sending data. For up-to-date details such as formal parameters and return codes on any mentioned operations, please see the C API Reference and C++ API Reference documentation.

4.4.1 Preview: Steps to Sending Data

To send DDS samples of a data instance:

1. Create and configure the required *Entities*:
   a. Create a *DomainParticipant*.
   b. Register user data types with the *DomainParticipant*. For example, the '**FooDataType**'.
   c. Use the *DomainParticipant* to create a *Topic* with the registered data type.
   d. Use the *DomainParticipant* to create a *Publisher*.
   e. Use the *Publisher* or *DomainParticipant* to create a *DataWriter* for the *Topic*.
   f. Use a type-safe method to cast the generic *DataWriter* created by the *Publisher* to a type-specific *DataWriter*. For example, '**FooDataWriter**'. Optionally, register data instances with the *DataWriter*. If the *Topic*'s user data type contain key fields, then registering a data instance (data with a specific key value) will improve performance when repeatedly sending data with the same key. You may register many different data instances; each registration will return an instance handle corresponding to the specific key value. For non-keyed data types, instance registration has no effect.
2. Every time there is changed data to be published:
   a. Store the data in a variable of the correct data type (for instance, variable '**Foo**' of the type '**FooDataType**').
   b. Call the **FooDataWriter**'s **write()** operation, passing it a reference to the variable '**Foo**'.
      - For non-keyed data types or for non-registered instances, also pass in **DDS_HANDLE_NIL**.
      - For keyed data types, pass in the instance handle corresponding to the instance stored in 'Foo', if you have registered the instance previously. This means that the data stored in 'Foo' has the same key value that was used to create instance handle.
   c. The **write()** function will take a snapshot of the contents of '**Foo**' and store it in *Connext DDS* internal buffers from where the DDS data sample is sent under the criteria set by the *Publisher's* and *DataWriter's* QosPolicies. If there are matched *DataReaders*, then the DDS data sample will have been passed to the physical transport plug-in/device driver by the time that **write()** returns.

4.4.2 Publishers

An application that intends to publish information needs the following *Entities*: *DomainParticipant*, *Topic*, *Publisher*, and *DataWriter*. All *Entities* have a corresponding specialized *Listener* and a set of QosPolicies. A *Listener* is how *Connext DDS* notifies your application of status changes relevant to the *Entity*. The QosPolicies allow your application to configure the behavior and resources of the *Entity*.

- A *DomainParticipant* defines the DDS domain in which the information will be made available.
- A *Topic* defines the name under which the data will be published, as well as the type (format) of the data itself.
- An application writes data using a *DataWriter*. The *DataWriter* is bound at creation time to a *Topic*, thus specifying the name under which the *DataWriter* will publish the data and the type associated with the data. The application uses the *DataWriter's* **write()** operation to indicate that a new value of the data is available for dissemination.
- A *Publisher* manages the activities of several *DataWriters*. The *Publisher* determines when the data is actually sent to other applications. Depending on the settings of various QosPolicies of the *Publisher* and *DataWriter*, data may be buffered to be sent with the data of other *DataWriters* or not sent at all. By default, the data is sent as soon as the *DataWriter's* **write()** function is called.

  You may have multiple *Publishers*, each managing a different set of *DataWriters*, or you may choose to use one *Publisher* for all your *DataWriters*.

4.4.3 DataWriters

To create a *DataWriter*, you need a *DomainParticipant*, *Publisher*, and a *Topic*.

You need a *DataWriter* for each *Topic* that you want to publish. For more details on all operations, see the C API Reference and C++ API Reference documentation.

For more details on creating, deleting, and setting up *DataWriters*, see the DataWriters section in the *RTI Connext DDS Core Libraries User's Manual* (available here if you have Internet access).

4.4.4 Publisher QosPolicies

Please refer to the C API Reference and C++ API Reference for details on supported QosPolicies.

4.4.5 DataWriter QosPolicies

Please refer to the C API Reference and C++ API Reference for details on supported QosPolicies.

4.5 Receiving Data

This section discusses how to create, configure, and use *Subscribers* and *DataReaders* to receive data. It describes how these objects interact, as well as the types of operations that are available for them.

The goal of this section is to help you become familiar with the *Entities* you need for receiving data. For up-to-date details such as formal parameters and return codes on any mentioned operations, please see the C API Reference and C++ API Reference documentation.

4.5.1 Preview: Steps to Receiving Data

There are three ways to receive data:

- Your application can explicitly check for new data by calling a *DataReader's* **read()** or **take()** operation. This method is also known as *polling for data*.
- Your application can be notified asynchronously whenever new DDS data samples arrive—this is done with a *Listener* on either the *Subscriber* or the *DataReader*. *RTI Connext Micro* will invoke the *Listener's* callback routine when there is new data. Within the callback routine, user code can access the data by calling **read()** or **take()** on the *DataReader*. This method is the way for your application to receive data with the least amount of latency.
- Your application can wait for new data by using *Conditions* and a *WaitSet*, then calling **wait()**. *Connext Micro* will block your application's thread until the criteria (such as the arrival of DDS samples, or a specific status) set in the *Condition* becomes true. Then your application resumes and can access the data with **read()** or **take()**.

The *DataReader's* **read()** operation gives your application a copy of the data and leaves the data in the *DataReader's* receive queue. The *DataReader's* **take()** operation removes data from the receive queue before giving it to your application.

To prepare to receive data, create and configure the required Entities:

1. Create a *DomainParticipant*.
2. Register user data types with the *DomainParticipant*. For example, the '**FooDataType**'.
3. Use the *DomainParticipant* to create a *Topic* with the registered data type.
4. Use the *DomainParticipant* to create a *Subscriber*.
5. Use the *Subscriber* or *DomainParticipant* to create a *DataReader* for the *Topic*.
6. Use a type-safe method to cast the generic *DataReader* created by the *Subscriber* to a type-specific *DataReader*. For example, '**FooDataReader**'.

Then use one of the following mechanisms to receive data.

- To receive DDS data samples by polling for new data:
  - Using a **FooDataReader**, use the **read()** or **take()** operations to access the DDS data samples that have been received and stored for the *DataReader*. These operations can be invoked at any time, even if the receive queue is empty.
- To receive DDS data samples asynchronously:
  - Install a *Listener* on the *DataReader* or *Subscriber* that will be called back by an internal *Connext Micro* thread when new DDS data samples arrive for the *DataReader*.

1. Create a *DDSDataReaderListener* for the *FooDataReader* or a *DDSSubscriberListener* for *Subscriber*. In C++ you must derive your own *Listener* class from those base classes. In C, you must create the individual functions and store them in a structure.

   If you created a *DDSDataReaderListener* with the **on_data_available()** callback enabled: **on_data_available()** will be called when new data arrives for that **DataReader**.

   If you created a *DDSSubscriberListener* with the **on_data_on_readers()** callback enabled: **on_data_on_readers()** will be called when data arrives for any *DataReader* created by the *Subscriber*.

2. Install the *Listener* on either the *FooDataReader* or *Subscriber*.

   For the *DataReader*, the *Listener* should be installed to handle changes in the **DATA_AVAILABLE** status.

   For the *Subscriber*, the *Listener* should be installed to handle changes in the **DATA_ON_READERS** status.

3. Only 1 *Listener* will be called back when new data arrives for a *DataReader*.

   Connext Micro will call the *Subscriber's Listener* if it is installed. Otherwise, the *DataReader's Listener* is called if it is installed. That is, the **on_data_on_readers()** operation takes precedence over the **on_data_available()** operation.

   If neither *Listeners* are installed or neither *Listeners* are enabled to handle their respective statuses, then *Connext Micro* will not call any user functions when new data arrives for the *DataReader*.

4. In the **on_data_available()** method of the *DDSDataReaderListener*, invoke **read()** or **take()** on the *FooDataReader* to access the data.

   If the **on_data_on_readers()** method of the *DDSSubscriberListener* is called, the code can invoke **read()** or **take()** directly on the *Subscriber's DataReaders* that have received new data. Alternatively, the code can invoke the *Subscriber's* **notify_datareaders()** operation. This will in turn call the **on_data_available()** methods of the *DataReaderListeners* (if installed and enabled) for each of the *DataReaders* that have received new DDS data samples.

To wait (block) until DDS data samples arrive:

1. Use the *DataReader* to create a *StatusCondition* that describes the DDS samples for which you want to wait. For example, you can specify that you want to wait for never-before-seen DDS samples from *DataReaders* that are still considered to be 'alive.'
2. Create a *WaitSet*.
3. Attach the *StatusCondition* to the *WaitSet*.
4. Call the *WaitSet's* **wait()** operation, specifying how long you are willing to wait for the desired DDS samples. When **wait()** returns, it will indicate that it timed out, or that the attached Condition become true (and therefore the desired DDS samples are available).
5. Using a **FooDataReader**, use the **read()** or **take()** operations to access the DDS data samples that have been received and stored for the *DataReader*.

4.5.2 Subscribers

An application that intends to subscribe to information needs the following *Entities*: *DomainParticipant*, *Topic*, *Subscriber*, and *DataReader*. All *Entities* have a corresponding specialized *Listener* and a set of QosPolicies. The *Listener* is how *RTI Connext Micro* notifies your application of status changes relevant to the *Entity*. The QosPolicies allow your application to configure the behavior and resources of the *Entity*.

- The *DomainParticipant* defines the DDS domain on which the information will be available.
- The *Topic* defines the name of the data to be subscribed, as well as the type (format) of the data itself.
- The *DataReader* is the *Entity* used by the application to subscribe to updated values of the data. The *DataReader* is bound at creation time to a *Topic*, thus specifying the named and typed data stream to which it is subscribed. The application uses the *DataWriter's* **read()** or **take()** operation to access DDS data samples received for the *Topic*.
- The *Subscriber* manages the activities of several *DataReader* entities. The application receives data using a *DataReader* that belongs to a *Subscriber*. However, the *Subscriber* will determine when the data received from applications is actually available for access through the *DataReader*. Depending on the settings of various QosPolicies of the *Subscriber* and *DataReader*, data may be buffered until DDS data samples for associated *DataReaders* are also received. By default, the data is available to the application as soon as it is received.

For more information on creating and deleting *Subscribers*, as well as setting QosPolicies, see the Subscribers section in the *RTI Connext DDS Core Libraries User's Manual* (available here if you have Internet access).

4.5.3 DataReaders

To create a *DataReader*, you need a *DomainParticipant*, a *Topic*, and a *Subscriber*. You need at least one *DataReader* for each *Topic* whose DDS data samples you want to receive.

For more details on all operations, see the C API Reference and C++ API Reference HTML documentation.

4.5.4 Using DataReaders to Access Data (Read & Take)

For user applications to access the data received for a *DataReader*, they must use the type-specific derived class or set of functions in the C API Reference. Thus for a user data type '**Foo**', you must use methods of the **FooDataReader** class. The type-specific class or functions are automatically generated if you use *RTI Code Generator*.

4.5.5 Subscriber QosPolicies

Please refer to the C API Reference and C++ API Reference for details on supported QosPolicies.

4.5.6 DataReader QosPolicies

Please refer to the C API Reference and C++ API Reference for details on supported QosPolicies.

4.6 DDS Domains

This section discusses how to use *DomainParticipants*. It describes the types of operations that are available for them and their QosPolicies.

The goal of this section is to help you become familiar with the objects you need for setting up your *RTI Connext Micro* application. For specific details on any mentioned operations, see the C API Reference and C++ API Reference documentation.

4.6.1 Fundamentals of DDS Domains and DomainParticipants

DomainParticipants are the focal point for creating, destroying (only in *Connext Micro*), and managing other *RTI Connext Micro* objects. A DDS *domain* is a logical network of applications: only applications that belong to the same DDS *domain* may communicate using *Connext Micro*. A DDS *domain* is identified by a unique integer value known as a domain ID. An application participates in a DDS domain by creating a *DomainParticipant* for that domain ID.

As seen in *Figure 4.2: Relationship between Applications and DDS Domains*, a single application can participate in multiple DDS domains by creating multiple *DomainParticipants* with different domain IDs. *DomainParticipants* in the same DDS domain form a logical network; they are isolated from *DomainParticipants* of other DDS domains, even those running on the same set of physical

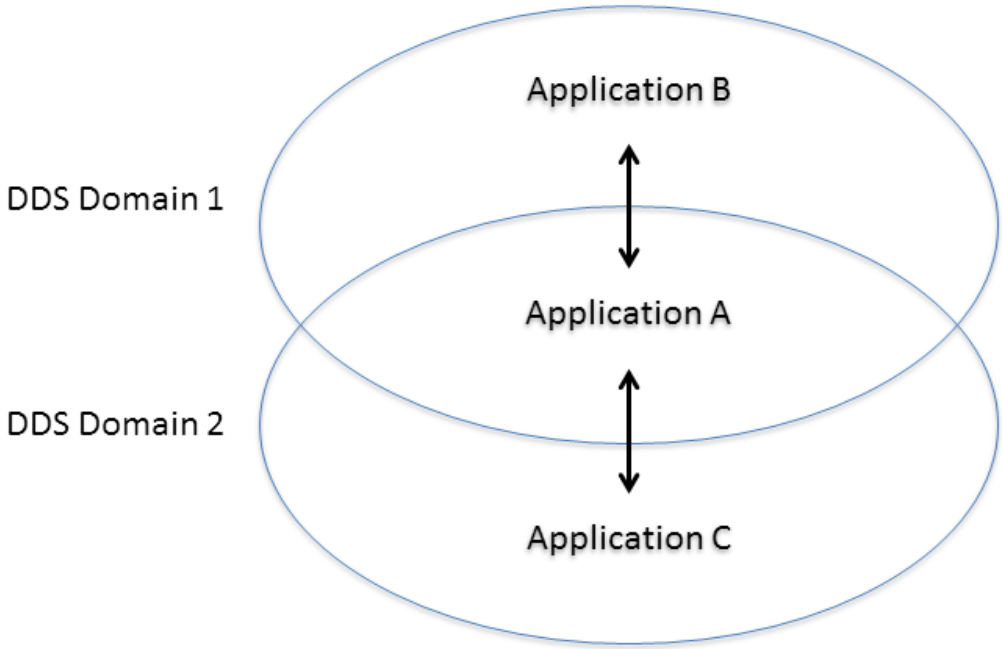


Figure 4.2: Relationship between Applications and DDS Domains
Applications can belong to multiple DDS domains—*A* belongs to DDS domains 1 and 2. Applications in the same DDS domain can communicate with each other, such as *A* and *B*, or *A* and *C*. Applications in different DDS domains, such as *B* and *C*, are not even aware of each other and will not exchange messages.

computers sharing the same physical network. *DomainParticipants* in different DDS domains will never exchange messages with each other. Thus, a DDS domain establishes a "virtual network" linking all *DomainParticipants* that share the same domain ID.

An application that wants to participate in a certain DDS domain will need to create a *DomainParticipant*. As seen in *Figure 4.3: DDS Domain Module*, a *DomainParticipant* object is a container for all other *Entities* that belong to the same DDS domain. It acts as factory for the *Publisher*, *Subscriber*, and *Topic* entities. (As seen in *Sending Data* and *Receiving Data*, in turn, *Publishers* are factories for *DataWriters* and *Subscribers* are factories for *DataReaders*.) *DomainParticipants* cannot contain other *DomainParticipants*.

Like all *Entities*, *DomainParticipants* have QosPolicies and *Listeners*. The *DomainParticipant* entity also allows you to set 'default' values for the QosPolicies for all the entities created from it or from the entities that it creates (*Publishers*, *Subscribers*, *Topics*, *DataWriters*, and *DataReaders*).

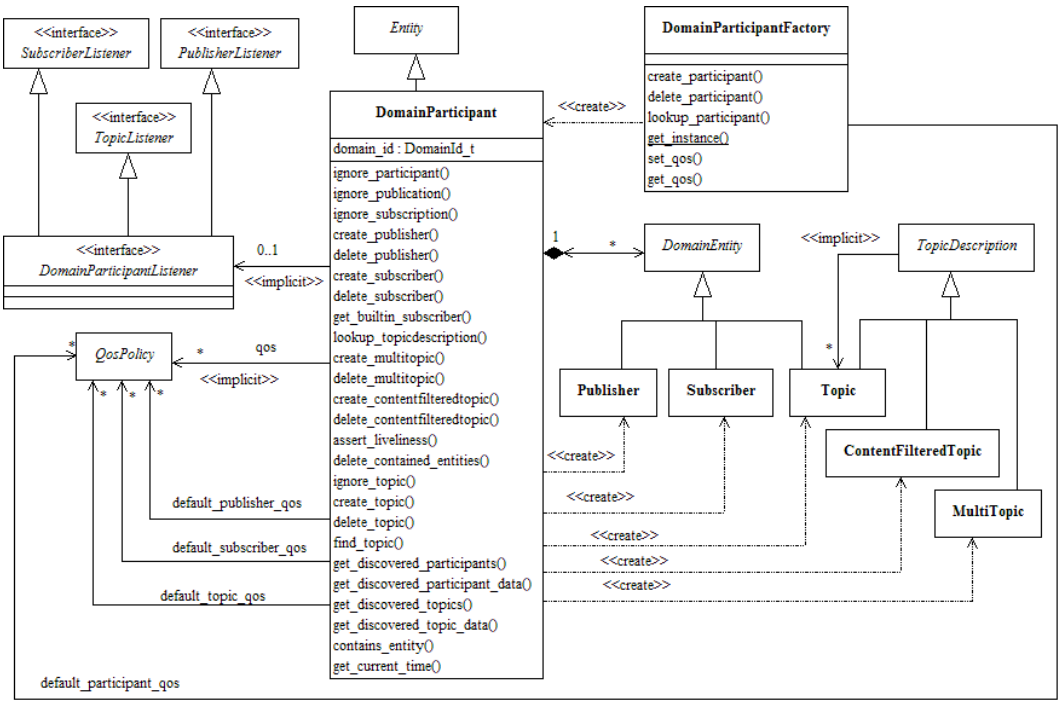


Figure 4.3: DDS Domain Module
Note: MultiTopics are not supported.

4.6.2 Discovery Announcements

Each *DomainParticipant* announces information about itself, such as which locators other *DomainParticipants* must use to communicate with it. A locator is an address that consists of an address kind, a port number, and an address. Four locator types are defined:

- A **unicast meta-traffic locator**. This locator type is used to identify where unicast discovery messages shall be sent. A maximum of four locators of this type can be specified.

- A **multicast meta-traffic locator**. This locator type is used to identify where multicast discovery messages shall be sent. A maximum of four locators of this type can be specified.
- A **unicast user-traffic locator**. This locator type is used to identify where unicast user-traffic messages shall be sent. A maximum of four locators of this type can be specified.
- A **multicast user-traffic locator**. This locator type is used to identify where multicast user-traffic messages shall be sent. A maximum of four locators of this type can be specified.

It is important to note that a maximum of *four* locators of *each* kind can be sent in a *DomainParticipant* discovery message.

The locators in a *DomainParticipant*'s discovery announcement is used for two purposes:

- It informs other *DomainParticipants* where to send their discovery announcements to this *DomainParticipants*.
- It informs the *DataReaders* and *DataWriters* in other *DomainParticipants* where to send data to the *DataReaders* and *DataWriters* in this *DomainParticipant* unless a *DataReader* or *DataWriter* specifies its own locators.

If a *DataReader* or *DataWriter* specifies their own locators, only user-traffic locators can be specified, then the exact same rules apply as for the *DomainParticipant*.

This document uses *address* and *locator* interchangeably. An address corresponds to the port and address part of a locator. The same address may exist as different kinds, in which case they are unique.

For more details about the discovery process, see the *Discovery* section.

4.7 Transports

4.7.1 Introduction

In *RTI Connext Micro*, DDS entities exchange information using transports. Transports exhange data with peer transports, and *Connext Micro* entities can generally exchange information using different types of transports, e.g. UDPv4 or a serial port. All transports send and receive RTPS messages encapsulated in the transport's native format, e.g. UDP packets.

Note: This version of *Connext Micro* only supports UDPv4 and a special transport for internal communication within a DDS *DomainParticipant*.

Connext Micro has a pluggable-transport architecture. The core of *Connext Micro* is transport agnostic; it does not make any assumptions about the actual transports used to send and receive messages. Instead, *Connext Micro* uses an abstract "transport API" to interact with the transport

plugins that implement that API. A transport plugin implements the abstract transport API, and performs the actual work of sending and receiving messages over a physical transport.

A transport can send and receive on addresses as defined by the concrete transport. For example, the *Connext Micro* UDP transport can listen to and send to UDPv4 ports and addresses. In order to establish communication between two transports, the addresses that the transport can listen to must be determined and announced to other *DomainParticipants* that want to communicate with it. This section describes how the addresses are reserved and how these addresses are used by the DDS layer in *Connext Micro*.

While the NETIO interface is not limited to DDS, the rest of this document is written in the context of how *Connext Micro* uses the NETIO interfaces as part of the DDS implementation.

Note that *Connext Micro* does not support RTPS fragmentation and is limited to IDL data types less than or equal to 63000 bytes **or** the maximum transmission unit (MTU) of the underlying transport, whichever is smaller.

Also note that *Connext Micro* does not query the MTU size from the registered transport plugins. If an IDL data-type exceeds the MTU size, the data will be silently discarded.

Connext Micro does not track the maximum receive unit (MRU) of other nodes in the system. Therefore, *Connext Micro* relies on consistent configuration accross all the nodes in the system in order to successfully send and receive data. For example, if a *Connext Micro* node has a MRU of 8000 bytes and another *Connext Micro* node sends 9000 bytes (with a sufficiently large MTU), the data will be sent, but not received.

4.7.2 Transport Limits

The following limitations apply to all *Connext Micro* transports.

IDL Data Types and Size

Connext Micro does not support RTPS fragmentation and is limited to IDL data types less than or equal to 63000 bytes *or* the maximum transmission unit (MTU) of the underlying transport, whichever is smaller.

Maximum Transmission Unit (MTU)

Connext Micro does not query the MTU size from the registered transport plugins. If the MTU size is exceeded, the data will be silently discarded.

Maximum Receive Unit (MRU)

Connext Micro does not track the maximum receive unit (MRU) of other nodes in the system. Therefore, *Connext Micro* relies on consistent configuration accross all the nodes in the system in order to successfully send and receive data. For example, if a node has a MRU of 8000 bytes and another node sends 9000 bytes (with a sufficiently large MTU), the data will be sent, but not received.

4.7.3 Transport Registration

RTI Connext Micro supports different transports and transports must be registered with *RTI Connext Micro* before they can be used. A transport must be given a name when it is registered and this name is later used when configuring discovery and user-traffic. A transport name cannot exceed 7 UTF-8 characters.

The following example registers the UDP transport with *RTI Connext Micro* and makes it available to all DDS applications within the same memory space. Please note that each DDS applications creates its *own* instance of a transport. Resources are *not* shared between instances of a transport unless stated.

For example, to register two UDP transports with the names myudp1 and myudp2, the following code is required:

```
DDS_DomainParticipantFactory *factory;
RT_Registry_T *registry;
struct UDP_InterfaceFactoryProperty udp_property;

factory = DDS_DomainParticipantFactory_get_instance();
registry = DDS_DomainParticipantFactory_get_registry(factory);

/* Set UDP properties */
if (!RT_Registry_register(registry,"myudp1",
                          UDP_InterfaceFactory_get_interface(),
                          &udp_property._parent._parent,NULL))
{
    return error;
}

/* Set UDP properties */
if (!RT_Registry_register(registry,"myudp2",
                          UDP_InterfaceFactory_get_interface(),
                          &udp_property._parent._parent,NULL))
{
    return error;
}
```

Before a DomainParticipant can make use of a registered transport, it must enable it for use within the DomainParticipant. This is done by setting the TransportQoS. For example, to enable only myudp1, the following code is required (error checking is not shown for clarity):

```
DDS_StringSeq_set_maximum(&dp_qos.transports.enabled_transports,1);
DDS_StringSeq_set_length(&dp_qos.transports.enabled_transports,1);
*DDS_StringSeq_get_reference(&dp_qos.transports.enabled_transports,0) =
                                                    REDA_String_dup("myudp1");
```

To enable both transports:

```
DDS_StringSeq_set_maximum(&dp_qos.transports.enabled_transports,2);
DDS_StringSeq_set_length(&dp_qos.transports.enabled_transports,2);
*DDS_StringSeq_get_reference(&dp_qos.transports.enabled_transports,0) =
                                                    REDA_String_dup("myudp1");
*DDS_StringSeq_get_reference(&dp_qos.transports.enabled_transports,1) =
                                                    REDA_String_dup("myudp2");
```

Before enabled transports may be used for communication in *Connext Micro*, they must be registered and added to the DiscoveryQos and UserTrafficQos policies. Please see the section on *Discovery* for details.

4.7.4 Transport Addresses

In order for DDS entities to communicate, the DDS entities must know each other's location. DDS entities may be colocated in the same DDS *DomainParticipant*, may be located in different DDS *DomainParticipants* within the same node, or may be located on different nodes connected by a network.

In DDS, a location is called a *locator*. A locator uniquely describes how to reach one or more DDS entitites in a network. A DDS locator consists of the following parts:

- The locator *kind* identifies the type of locators, e.g. UDPv4.
- The locator *port* identifies the location of DDS entities at an address. The port number of a locator is not directly configurable; rather, it is configured indirectly by the DDS_WireProtocolQosPolicy (rtps_well_known_ports) of the *DomainParticipant's* QoS, where a well-known, interoperable RTPS port number is assigned.
- The locator *address* indentifies the network address. Transports are concerned with exchanging messages using the network address.

Reserving Addresses and Ports

Address reservation is the process to determine which locators should be used in the discovery announcement. Which transports and addresses to be used are determined as described in *Discovery*.

When a *DomainParticipant* is created, it calculates a port number and tries to reserve this port on all addresses available in *all* the transports based on the registration properties. If the port cannot be reserved on all transports, then it releases the port on *all* transports and tries again. If no free port can be found, the process fails and the *DomainParticipant* cannot be created.

Warning: If an address is specified without the transport name as a prefix, e.g. "192.168.1.1" instead of "_udp://192.168.1.1", and multiple transports understand the address, only the *last* transport found will try to reserve the address. Which transport is the *last* is non-determinstic. This capability is present to be backwards compatible with earlier versions of *Connext Micro*, but **should not be used**; this feature may be deprecated in future versions. Always specify addresses using the transport name as the prefix.

Address Limitations

The number of locators which can be announced is limited to *only* the first *four* of each type, across *all* transports available for each policy. If more than four are available of any type, these are *ignored*. This is by design, although it may be changed in future versions. The order in which the locators are read is also not known, thus the exact four locators which will be used are not deterministic.

To ensure that *all* the desired addresses and *only* the desired address are used in a transport, follow these rules:

- Make sure that no more than four unicast addresses and four multicast addresses can be returned across *all* transports for discovery traffic.
- Make sure that no more than four unicast addresses and four multicast addresses can be returned across *all* transports for user traffic.
- Make sure that no more than four unicast addresses and four multicast addresses can be returned across *all* transports for user-traffic, for *DataReader* and *DataWriter* specific locators, and that they do *not* duplicate any of the *DomainParticipant*'s locators.

Address Notation

In *Connext Micro*, all addresses are specified as ASCII strings. The full address format is:

```
< > denotes optional
[ ] denotes range or discreet values, unless enclosed in ''
    which means a literal.

ADDRESS = <PREFIX://><ADDRESS> |
          @<PREFIX://><ADDRESS> |
          INDEX@<PREFIX>://<ADDRESS>

INDEX = INTEGER | '[' INTEGER ']' | '[' INTEGER-INTEGER ']' | '[' -INTEGER ']'

PREFIX = [a-zA-Z_][0-9a-zA-Z_]+

INTEGER = DEC_INTEGER | HEX_INTEGER

DEC_INTEGER = [0-9]+
```

(continues on next page)

(continued from previous page)

```
HEX_INTEGER = [0x|0X][0-9a-fA-F]+

ADDRESS = 0 or more 8bit characters
```

Note that while the `PREFIX` is marked optional, it should always be used.

4.7.5 RTPS

The RTPS transport encapsulates user-data in RTPS messages and parses received RTPS messages for user-data. This chapter describes how to configure RTPS.

Registration of RTPS

RTPS is automatically registered when a *DDS_DomainParticipantFactory* is initialized with *DDS_DomainParticipantFactory_get_instance()*. In order to change the RTPS configuration, it is necessary to first unregister it from the participant factory, set the properties, and then register RTPS with the new properties. This process is identical to other plugins in *Connext Micro*, such as the UDP transport and discovery plugins.

The following code shows the steps:

```
int main(int argc,char *argv)
{
    struct RTPS_InterfaceFactoryProperty *rtps_property = NULL;
    DDS_DomainParticipantFactory *factory = NULL;
    RT_Registry_T *registry = NULL;
    struct RTPS_InterfaceFactoryProperty *rtps_property = NULL;

    /* get the Domain Participant factory and registry*/
    factory = DDS_DomainParticipantFactory_get_instance();

    registry =  DDS_DomainParticipantFactory_get_registry
                    (DDS_DomainParticipantFactory_get_instance());


    /* unregister the RTPS transport */
    if (!RT_Registry_unregister(registry, NETIO_DEFAULT_RTPS_NAME,
                                NULL,NULL))
    {
        printf("failed to unregister rtps\n");
        return 0;
    }

    rtps_property = (struct RTPS_InterfaceFactoryProperty *)
            malloc(sizeof(struct RTPS_InterfaceFactoryProperty));

    if (rtps_property == NULL)
```

(continues on next page)

(continued from previous page)

```
    {
        printf("failed to allocate rtps properties\n");
        return 0;
    }

    /* Set the new properties and register RTPS again */

    if (!RT_Registry_register(registry, NETIO_DEFAULT_RTPS_NAME,
                RTPS_InterfaceFactory_get_interface(),
                (struct RT_ComponentFactoryProperty*)rtps_property,
                 NULL))
    {
        printf("failed to register rtps\n");
        return 0;
    }


    DDS_DomainParticipantFactory_create_participant(
       factory, domain_id,&dp_qos, NULL,DDS_STATUS_MASK_NONE);
}
```

Please note that the RTPS properties *must* be valid for the *entire* life-cycle of the participant factory because RTPS *does not* make an internal copy. This saves memory when properties are stored in preallocated memory (for example in ROM).

Overriding the Builtin RTPS Checksum Functions

Some applications may require specialized functions to guarantee message integrity or may have special hardware that supports faster checksum calculations. *Connext Micro* provides a way for users to override the builtin checksum functions. Note that if a different checksum is calculated it may prevent interoperability with other DDS implementations.

Checksum function definition

A checksum function must define a structure of the following type:

```
typedef struct RTPS_ChecksumClass
{
    RTPS_ChecksumClassId_T class_id;
    void *context;
    RTPS_CalculateChecksum_T calculate_checksum;
} RTPS_ChecksumClass_T;
```

The type has three members:

1. class_id - The class ID must be:
    - RTPS_CHECKSUM_CLASSID_BUILTIN32 for the 32-bit checksum.
    - RTPS_CHECKSUM_CLASSID_BUILTIN64 for the 64-bit checksum.

- RTPS_CHECKSUM_CLASSID_BUILTIN128 for the 128-bit checksum.

2. context - An opaque object for you to provide context for this function. This context will be passed to the *calculate_checksum* every time it is called.
3. checksum_calculate - The function pointer to the checksum function. The function is defined as

```
typedef RTI_BOOL
(*RTPS_ChecksumCalculate_T)(void *context,
                            const struct REDA_Buffer *buf,
                            RTI_UINT32 buf_length,
                            RTPS_Checksum_T *checksum);
```

   - context: *Connext Micro* will pass in the context as defined in the class.
   - buf: An array of REDA_Buffer. Each REDA_Buffer includes a pointer and size of the buffer.
   - buf_length: The size of the array.

   RTPS_Checksum_T checksum: This is the out parameter of this function. It is a union defined as follows:

```
typedef union RTPS_Checksum
{
        RTI_UINT32 checksum32;
        RTI_UINT64 checksum64;
        RTI_UINT8 checksum128[16];
} RTPS_Checksum_T;
```

Please note the following *important* information regarding the output values:

1. The number returned in checksum32 is assumed to be in *host order* endinaness.
2. The number returned in checksum64 is assumed to be in *host order* endinaness.
3. checksum128 is treated as an octet array.

Example

Below is an example implementation of a custom CRC-32 function using the Intel intrinsic functions. It shows the QoS that needs to be set, as well as how to override the builtin checksum function.

```
RTI_BOOL
CrcClassTest_custom_crc32_other(void *context,
                                const struct REDA_Buffer *buf,
                                unsigned int buf_length,
                                union RTPS_CrcChecksum *checksum)
{
    RTI_UINT32 crc = 0;
    unsigned char *data = (unsigned char *) buf[0].pointer;
    RTI_UINT32 length = buf[0].length;
```

(continues on next page)

(continued from previous page)

```
    int k;

    UNUSED_ARG(k);
    UNUSED_ARG(context);
    UNUSED_ARG(buf_length);

    for (k = 0; k < length; k++)
    {
        crc = _mm_crc32_u8(crc, data[k]);
    }

    checksum->checksum32 = crc;

    return RTI_TRUE;
}


int main(int argc,char *argv)
{
    struct DDS_DomainParticipantQos dp_qos =
            DDS_DomainParticipantQos_INITIALIZER;
    struct RTPS_InterfaceFactoryProperty *rtps_property = NULL;
    DDS_DomainParticipantFactory *factory = NULL;
    RT_Registry_T *registry = NULL;
    struct RTPS_InterfaceFactoryProperty *rtps_property = NULL;

    /* Instantiate a RTPS_CrcClass for your custom function*/
    struct RTPS_ChecksumClass custom_crc32 =
    {
        RTPS_CHECKSUM_CLASSID_BUILTIN32, /*class_id*/
        NULL, /*context*/
        CrcClassTest_custom_crc32_other /*Custom function*/
    };

    /* get the Domain Participant factory and registry*/
    factory = DDS_DomainParticipantFactory_get_instance();

    registry =  DDS_DomainParticipantFactory_get_registry
                    (DDS_DomainParticipantFactory_get_instance());


    /* unregister the RTPS transport */
    if (!RT_Registry_unregister(registry, NETIO_DEFAULT_RTPS_NAME,
                                NULL,NULL))
    {
        printf("failed to unregister rtps\n");
        return 0;
    }

    rtps_property = (struct RTPS_InterfaceFactoryProperty *)
            malloc(sizeof(struct RTPS_InterfaceFactoryProperty));
```

(continues on next page)

(continued from previous page)

```
    if (rtps_property == NULL)
    {
        printf("failed to allocate rtps properties\n");
        return 0;
    }


    /* the rtps property takes the structure with the custom
     * function
     */

    *rtps_property = RTPS_INTERFACE_FACTORY_DEFAULT;
    rtps_property->checksum.allow_builtin_override = RTI_TRUE;
    rtps_property->checksum.builtin_checksum32_class = custom_crc32;

    /* register the RTPS transport */
    if (!RT_Registry_register(registry, NETIO_DEFAULT_RTPS_NAME,
                RTPS_InterfaceFactory_get_interface(),
                (struct RT_ComponentFactoryProperty*)rtps_property,
                 NULL))
    {
        printf("failed to register rtps\n");
        return 0;
    }


    /* modify the domain participant qos */
    dp_qos.protocol.compute_crc = DDS_BOOLEAN_TRUE;
    dp_qos.protocol.check_crc = DDS_BOOLEAN_TRUE;
    dp_qos.protocol.require_crc = DDS_BOOLEAN_TRUE;
    dp_qos.protocol.computed_crc_kind =  DDS_CHECKSUM_BUILTIN32;
    dp_qos.protocol.allowed_crc_mask = DDS_CHECKSUM_BUILTIN32;

    /* use the qos and the factory to create a participant */

    DDS_DomainParticipantFactory_create_participant(
       factory, domain_id,&dp_qos, NULL,DDS_STATUS_MASK_NONE);
}
```

4.7.6 INTRA Transport

The builtin intra participant transport (INTRA) is a transport that bypasses RTPS and reduces the number of data-copies from three to one for data published by a *DataWriter* to a *DataReader* within the same participant. When a sample is published, it is copied directly to the data reader's cache (if there is space). This transport is used for communication between *DataReaders* and *DataWriters* created within the same participant by default.

Please refer to *Threading Model* for important details regarding application constraints when using this transport.

Registering the INTRA Transport

The builtin INTRA transport is a *RTI Connext Micro* component that is automatically registered when the DDS_DomainParticipantFactory_get_instance() method is called. By default, data published by a *DataWriter* is sent to all *DataReaders* within the same participant using the INTRA transport.

In order to prevent the INTRA transport from being used it is necessary to remove it as a transport and a user-data transport. The following code shows how to only use the builtin UDP transport for user-data.

```
struct DDS_DomainParticipantQos dp_qos =
                            DDS_DomainParticipantQos_INITIALIZER;

REDA_StringSeq_set_maximum(&dp_qos.transports.enabled_transports,1);
REDA_StringSeq_set_length(&dp_qos.transports.enabled_transports,1);
*REDA_StringSeq_get_reference(&dp_qos.transports.enabled_transports,0) =
                                    REDA_String_dup(NETIO_DEFAULT_UDP_NAME);

/* Use only unicast for user-data traffic. */
REDA_StringSeq_set_maximum(&dp_qos.user_traffic.enabled_transports,1);
REDA_StringSeq_set_length(&dp_qos.user_traffic.enabled_transports,1);
*REDA_StringSeq_get_reference(&dp_qos.user_traffic.enabled_transports,0) =
                                    REDA_String_dup("_udp://");
```

Note that the INTRA transport is never used for discovery traffic internally. It is not possible to disable matching of *DataReaders* and *DataWriters* within the same participant.

Reliability and Durability

Because a sample sent over INTRA bypasses the RTPS reliability and DDS durability queue, the Reliability and Durability Qos policies are *not* supported by the INTRA transport. However, by creating all the *DataReaders* before the *DataWriters* durability is not required.

Threading Model

The INTRA transport does not create any threads. Instead, a *DataReader* receives data over the INTRA transport in the context of the *DataWriter*'s *send thread*.

This model has two *important limitations*:

- Because a *DataReader*'s on_data_available() listener is called in the context of the *DataWriter*'s send thread, a *DataReader* may potentially process data at a different priority than intended (the *DataWriter*'s). While it is generally not recommended to process data in a *DataReader*'s on_data_available() listener, it is particularly important *to not do so* when using the INTRA transport. Instead, use a DDS WaitSet or a similar construct to wake up a separate thread to process data.
- Because a *DataReader*'s on_data_available() listener is called in the context of the *DataWriter*'s send thread, any method called in the on_data_available() listener is done in the context of the *DataWriter*'s stack. Calling a *DataWriter* **write()** in the callback could result in an infinite call stack. Thus, it is recommended *not* to call in this listener any *Connext Micro* APIs that write data.

4.7.7 UDP Transport

This section describes the builtin *RTI Connext Micro* UDP transport and how to configure it.

The builtin UDP transport (UDP) is a fairly generic UDPv4 transport. *Connext Micro* supports the following functionality:

- Unicast
- Manual configuration of network interfaces
- Allow/Deny lists to select which network interfaces can be used
- Configuration of receive threads
- Simple NAT configuration
- Multicast
- Automatic detection of available network interfaces

Registering the UDP Transport

The builtin UDP transport is a *Connext Micro* component that is automatically registered when the DDS_DomainParticipantFactory_get_instance() method is called. To change the UDP configuration, it is necessary to first unregister the transport as shown below:

```
DDS_DomainParticipantFactory *factory = NULL;
RT_Registry_T *registry = NULL;
```

(continues on next page)

(continued from previous page)

```
factory = DDS_DomainParticipantFactory_get_instance();
registry = DDS_DomainParticipantFactory_get_registry(factory);

/* The builtin transport does not return any properties (3rd param) or
 * listener (4th param)
 */
if (!RT_Registry_unregister(registry, "_udp", NULL, NULL))
{
    /* ERROR */
}
```

When a component is registered, the registration takes the properties and a listener as the 3rd and 4th parameters. In general, it is up to the caller to manage the memory for the properties and the listeners. There is no guarantee that a component makes a copy.

The following code-snippet shows how to register the UDP transport with new parameters.

```
struct UDP_InterfaceFactoryProperty *udp_property = NULL;

/* Allocate a property structure for the heap, it must be valid as long
 * as the component is registered
 */
udp_property = (struct UDP_InterfaceFactoryProperty *)
                    malloc(sizeof(struct UDP_InterfaceFactoryProperty));
if (udp_property != NULL)
{
    *udp_property = UDP_INTERFACE_FACTORY_PROPERTY_DEFAULT;

    /* Only allow network interface "eth0" to be used;
     */
    REDA_StringSeq_set_maximum(&udp_property->allow_interface, 1);
    REDA_StringSeq_set_length(&udp_property->allow_interface, 1);

    *REDA_StringSeq_get_reference(&udp_property->allow_interface, 0) =
                                                REDA_String_dup("eth0");

    /* Register the transport again, using the builtin name
     */
    if (!RT_Registry_register(registry, "_udp",
                         UDP_InterfaceFactory_get_interface(),
                        (struct RT_ComponentFactoryProperty*)udp_property,
                        NULL))
    {
        /* ERROR */
    }
}
else
{
    /* ERROR */
}
```

It should be noted that the UDP transport can be registered with any name, but all transport QoS

policies and initial peers must refer to this name. If a transport is referred to and it does not exist, an error message is logged.

It is possible to register multiple UDP transports with a DomainParticipantFactory. It is also possible to use different UDP transports within the same *DomainParticipant* when multiple network interfaces are available (either physical or virtual).

When UDP transformations are enabled, this feature is always enabled and determined by the allow_interface and deny_interface lists. If any of the lists are non-empty the UDP transports will bind each receive socket to the specific interfaces.

When UDP transformations are not enabled, this feature is determined by the value of the enable_interface_bind. If this value is set to **RTI_TRUE** and the allow_interface and/or deny_interface properties are non-empty, the receive sockets are bound to specific interfaces.

Threading Model

The UDP transport creates one receive thread for each unique UDP receive resource. By default, two UDP threads are created:

- A multicast receive thread for discovery data (assuming multicast is available and enabled)
- A unicast receive thread for discovery data
- A unicast receive thread for user data

Additional threads may be created depending on the transport configuration for a *DomainParticipant*, *DataReader*, and *DataWriter*. The UDP transport creates threads based on the following criteria:

- Each unique unicast port creates a new thread
- Each unique multicast address *and* port creates a new thread

For example, if a *DataReader* specifies its own multicast receive address, a new receive thread will be created.

Configuring UDP Receive Threads

All threads in the UDP transport share the same thread settings. It is important to note that all the UDP properties must be set before the UDP transport is registered. *Connext Micro* preregisters the UDP transport with default settings when the DomainParticipantFactory is initialized. To change the UDP thread settings, use the following code.

```
struct UDP_InterfaceFactoryProperty *udp_property = NULL;
struct UDP_InterfaceFactoryProperty udp_property =
                            UDP_INTERFACE_FACTORY_PROPERTY_DEFAULT;

/* Allocate a property structure for the heap, it must be valid as long
 * as the component is registered
 */
```

(continues on next page)

(continued from previous page)

```
udp_property = (struct UDP_InterfaceFactoryProperty *)
                    malloc(sizeof(struct UDP_InterfaceFactoryProperty));
*udp_property = UDP_INTERFACE_FACTORY_PROPERTY_DEFAULT;

/* Please refer to OSAPI_ThreadOptions for possible options */
udp_property->recv_thread.options = ...;

/* The stack-size is platform dependent, it is passed directly to the OS */
udp_property->recv_thread.stack_size = ....

/* The priority is platform dependent, it is passed directly to the OS */
udp_property->recv_thread.priority = ....

if (!RT_Registry_register(registry, "_udp",
                          UDP_InterfaceFactory_get_interface(),
                          (struct RT_ComponentFactoryProperty*)udp_property,
                          NULL))
{
    /* ERROR */
}
```

UDP Configuration

All the configuration of the UDP transport is done via the UDP_InterfaceFactoryProperty.

allow_interface

The allow_interface string sequence determines which interfaces are allowed to be used for communication. Each string element is the name of a network interface, such as "en0" or "eth1".

If this sequence is empty, all interface names pass the allow test. The default value is empty. Thus, all interfaces are allowed.

deny_interface

The deny_interface string sequence determines which interfaces are not allowed to be used for communication. Each string element is the name of a network interface, such as "en0" or "eth1".

If this sequence is empty, the test is false. That is, the interface is allowed. Note that the deny list is checked *after* the allow list. Thus, if an interface appears in both, it is denied. The default value is empty, thus no interfaces are denied.

max_send_buffer_size

The max_send_buffer_size is the maximum size of the send socket buffer and it *must* be at least as big as the largest sample. Typically, this buffer should be a multiple of the maximum number of samples that can be sent at any given time. The default value is 256KB.

max_receive_buffer_size

The max_receive_buffer_size is the maximum size of the receive socket buffer and it *must* be at least as big as the largest sample. Typically, this buffer should be a multiple of the maximum number of samples that can be received at any given time. The default value is 256KB.

max_message_size

The max_message_size is the maximum size of the message which can be received, including any packet overhead. The default value is 65507 bytes.

multicast_ttl

The multicast_ttl is the Multicast Time-To-Live (TTL). This value is only used for multicast. It limits the number of hops a packet can pass through before it is dropped by a router. The default value is 1.

nat

Connext Micro supports firewalls with NAT. However, this feature has limited use and only supports translation between a private and public IP address. UDP ports are not translated. Furthermore, because *Connext Micro* does not support any hole punching technique or WAN server, this feature is only useful when the private and public address mapping is static and known in advance. For example, to test between an Android emulator and the host, the following configuration can be used:

```
UDP_NatEntrySeq_set_maximum(&udp_property->nat,2);
UDP_NatEntrySeq_set_length(&udp_property->nat,2);

/* Translate the local emulator  eth0 address 10.10.2.f:7410 to
 * 127.0.0.1:7410. This ensures that the address advertised by the
 * emulator to the host machine is the host's loopback interface, not
 * the emulator's host interface
 */
UDP_NatEntrySeq_get_reference(&udp_property->nat,0)->
                            local_address.kind = NETIO_ADDRESS_KIND_UDPv4;
UDP_NatEntrySeq_get_reference(&udp_property->nat,0)->
                            local_address.port = 7410;
```

(continues on next page)

(continued from previous page)

```
UDP_NatEntrySeq_get_reference(&udp_property->nat,0)->
                            local_address.value.ipv4.address = 0x0a00020f;

UDP_NatEntrySeq_get_reference(&udp_property->nat,0)->
                            public_address.kind = NETIO_ADDRESS_KIND_UDPv4;
UDP_NatEntrySeq_get_reference(&udp_property->nat,0)->
                            public_address.port = 7410;
UDP_NatEntrySeq_get_reference(&udp_property->nat,0)->
                            public_address.value.ipv4.address = 0x7f000001;

/* Translate the local emulator  eth0 address 10.10.2.f:7411 to
 * 127.0.0.1:7411. This ensures that the address advertised by the
 * emulator to the host machine is the host's loopback interface
 */
UDP_NatEntrySeq_get_reference(&udp_property->nat,1)->
                            local_address.kind = NETIO_ADDRESS_KIND_UDPv4;
UDP_NatEntrySeq_get_reference(&udp_property->nat,1)->
                            local_address.port = 7411;
UDP_NatEntrySeq_get_reference(&udp_property->nat,1)->
                            local_address.value.ipv4.address = 0x0a00020f;

UDP_NatEntrySeq_get_reference(&udp_property->nat,1)->
                            public_address.kind = NETIO_ADDRESS_KIND_UDPv4;
UDP_NatEntrySeq_get_reference(&udp_property->nat,1)->
                            public_address.port = 7411;
UDP_NatEntrySeq_get_reference(&udp_property->nat,1)->
                            public_address.value.ipv4.address = 0x7f000001;
```

if_table

The if_table provides a method to manually configure which interfaces are available for use; for example, when using IP stacks that do not support reading interface lists. The following example shows how to manually configure the interfaces.

```
/* The arguments to the UDP_InterfaceTable_add_entry functions are:
 * The if_table itself
 * The network address of the interface
 * The netmask of the interface
 * The name of the interface
 * Interface flags. Valid flags are:
 *   UDP_INTERFACE_INTERFACE_UP_FLAG        - The interface is UP
 *   UDP_INTERFACE_INTERFACE_MULTICAST_FLAG - The interface supports multicast
 */
if (!UDP_InterfaceTable_add_entry(&udp_property->if_table,
                                  0x7f000001,0xff000000,"loopback",
                                  UDP_INTERFACE_INTERFACE_UP_FLAG |
                                  UDP_INTERFACE_INTERFACE_MULTICAST_FLAG))

{
```

(continues on next page)

(continued from previous page)

```
    /* Error */
}
```

multicast_interface

The multicast_interface may be used to select a particular network interface to be used to send multicast packets. The default value is any interface (that is, the OS selects the interface).

is_default_interface

The is_default_interface flag is used to indicate that this *Connext Micro* network transport shall be used if no other transport is found. The default value is **RTI_TRUE**.

disable_auto_interface_config

Normally, the UDP transport will try to read out the interface list (on platforms that support it). Setting disable_auto_interface_config to **RTI_TRUE** will prevent the UDP transport from reading the interface list.

Note that in *Connext Cert* this value is ignored and interfaces *must* always be configured manually.

recv_thread

The recv_thread field is used to configure all the receive threads. Please refer to *Threading Model* for details.

enable_interface_bind

When this is set to **TRUE** the UDP transport binds each receive port to a specific interface when the allow_interface/deny_interface lists are non-empty. This allows multiple UDP transports to be used by a single *DomainParticipant* at the expense of an increased number of threads. This property is ignored when transformations are enabled and the allow_interface/deny_interface lists are non-empty.

source_rules

Rules for how to transform received UDP payloads based on the source address.

destination_rules

Rules for how to transform sent UDP payloads based on the destination address.

transform_udp_mode

Determines how regular UDP is supported when transformations are supported. When transformations are enabled the default value is **UDP_TRANSFORM_UDP_MODE_DISABLED**.

transform_locator_kind

The locator to use for locators that have transformations. When transformation rules have been enabled, they are announced as a vendor specific locator. This property overrides this value.

NOTE: Changing this value may prevent communication.

UDP Transformations

The UDP transform feature enables custom transformation of incoming and outgoing UDP payloads based on transformation rules between a pair of source and destination IP addresses. Some examples of transformations are encrypted data or logging.

This section explains how to implement and use transformations in an application and is organized as follows:

- *Overview*
- *Creating a Transformation Library*
- *Creating Transformation Rules*
- *Interoperability*
- *Error Handling*
- *Example Code*
- *Examples*
- *OS Configuration*

Overview

The UDP transformation feature enables custom transformation of incoming and outgoing UDP payloads. For the purpose of this section, a UDP payload is defined as a sequence of octets sent or received as a single UDP datagram excluding UDP headers – typically UDP port numbers – and trailers, such as the optional used checksum.

An outgoing payload is the UDP payload passed to the network stack. The transformation feature allows a custom transformation of this payload just before it is sent. The UDP transport receives payloads to send from an upstream layer. In *Connext Micro* this layer is typically RTPS, which creates payloads containing one or more RTPS messages. The transformation feature enables transformation of the entire RTPS payload before it is passed to the network stack.

The same RTPS payload may be sent to one or more locators. A locator identifies a destination address, such as an IPv4 address, a port, such as a UDP port, and a transport kind. The address and port are used by the UDP transport to reach a destination. However, only the destination address is used to determine which transformation to apply.

An incoming payload is the UDP payload received from the network stack. The transformation feature enables transformation of the UDP payload received from the network stack *before* it is passed to the upstream interface, typically RTPS. The UDP transport only receives payloads destined for one of its network interface addresses, but may receive UDP payloads destined for many different ports. The transformation does not take a port into account, only the source address. In *Connext Micro* the payload is typically a RTPS payload containing one or more RTPS messages.

UDP transformations are registered with *Connext Micro* and used by the UDP transport to determine how to transform payloads based on a source or destination address. Please refer to *Creating a Transformation Library* for details on how to implement transformations and *Creating Transformation Rules* for how to add rules.

Transformations are local resources. There is no exchange between different UDP transports regarding what a transformation does to a payload. This is considered a-priori knowledge and depends on the implementation of the transformation. Any negotiation of e.g. keys must be handled before the UDP transport is registered. Thus, if a sender and receiver do not apply consistent rules, they may not be able to communicate, or incorrect data may result. Note that while information is typically in the direction from a *DataWriter* to a *DataReader*, a reliable *DataReader* also send protocol data to a *DataWriter*. These messages are also transformed.

Network Interface Selection

When a *DomainParticipant* is created, it first creates an instance of each transport configured in the DomainParticipantQos::transports QoS policy. Thus, each UDP transport registered with *Connext Micro* must have a unique name (up to 7 characters). Each registered transport can be configured to use all or some of the available interfaces using the allow_interface and deny_interface properties. The registered transports may now be used for either discovery data (specified in DomainParticipantQos::discovery), user_traffic (specified in DomainParticipantQos::user_traffic) or both. The *DomainParticipant* also queries the transport for which addresses it is capable of sending to.

When a participant creates multiple instances of the UDP transport, it is important that instances use non-overlapping networking interface resources.

Data Reception

Which transport to use for discovery data is determined by the DomainParticipantQos::discovery QoS policy. For each transport listed, the *DomainParticipant* reserves a network address to listen to. This network address is sent as part of the discovery data and is used by other *DomainParticipants* as the address to send discovery data for this *DomainParticipant*. Because a UDP transformation only looks at source and destination addresses, if different transformations are needed for discovery and user-data, different UDP transport registrations must be used and hence different network interfaces.

Data Transmission

Which address to send data to is based on the locators received as part of discovery and the peer list.

Received locators are analyzed and a transport locally registered with a *DomainParticipant* is selected based on the locator kind, address and mask. The first matching transport is selected. If a matching transport is not found, the locator is discarded.

NOTE: A transport is not a matching criteria at the same level as a QoS policy. If a discovered entity requests user data on a transport that doesn't exist, it is not unmatched.

The peer list, as specified by the application, is a list of locators to send participant discovery announcements to. If the transport to use is not specified, e.g. "udp1@192.168.1.1", but instead "192.168.1.1", then all transports that understand this address will send to it. Thus, in this case the latter is used, and two different UDP transports are registered; they will both send to the same address. However, one transport may send transformed data and the other may not depending on the destination address.

Creating a Transformation Library

The transformation library is responsible for creating and performing transformations. Note that a library is a logical concept and does not refer to an actual library in, for example, UNIX. A library in this context is a collection of routines that together creates, manages, and performs transformations. How these routines are compiled and linked with an application using *Connext Micro* is out of scope of this section.

The transformation library must be registered with *Connext Micro*'s run-time and must implement the required interfaces. This ensures proper life-cycle management of transformation resources as well as clear guidelines regarding concurrency and memory management.

From *Connext Micro*'s run-time point of view, the transformation library must implement methods so that:

- A library can be initialized.

- A library can be instantiated.
- An instance of the library performs and manages transformations.

The first two tasks are handled by *Connext Micro*'s run-time factory interface which is common for all libraries managed by *Connext Micro*. The third task is handled by the transformation interface, which is specific to UDP transformations.

The following describes the relationship between the different interfaces:

- A library is initialized once when it is registered with *Connext Micro*.
- A library is finalized once when it is unregistered from *Connext Micro*.
- Multiple library instances can be created. If a library is used twice, for example registered with two different transports, two different library contexts are created using the factory interface. *Connext Micro* assumes that concurrent access to two different instances is allowed.
- Different instances of the library can be deleted independently. An instance is deleted using the factory interface.
- A library instance creates specific source or destination transformations. Each transformation is expected to transform a payload to exactly one destination or from one source.

The following relationship is true between the UDP transport and a UDP transformation library:

- Each registered UDP transport may make use of one or more UDP transformation libraries.
- A DDS *DomainParticipant* creates one instance of each registered UDP transport.
- Each instance of the UDP transport creates one instance of each enabled transformation library registered with the UDP transport.
- Each Transformation rule created by the UDP transport creates one send or one receive transformation.

Creating Transformation Rules

Transformation rules decide how a payload should be transformed based on either a source or destination address. Before a UDP transport is registered, it must be configured with the transformation libraries to use, as well as which library to use for each source and destination address. For each UDP payload sent or received, an instance of the UDP transport searches for a matching source or destination rule to determine which transformation to apply.

The transformation rules are added to the UDP_InterfaceFactoryProperty before registration takes place.

If no transformation rules have been configured, all payloads are treated as regular UDP packets.

If no send rules have been asserted, the payload is sent as is. If all outgoing messages are to be transformed, a single entry is sufficient (address = 0, mask = 0).

If no receive rules have been asserted, it is passed upstream as is. If all incoming messages are to be transformed, a single entry is sufficient (address = 0, mask = 0).

If no matching rule is found, the packet is dropped and an error is logged.

NOTE: UDP_InterfaceFactoryProperty is immutable after the UDP transport has been registered.

Interoperability

When the UDP transformations has enabled at least one transformation, it will only inter-operate with another UDP transport which also has at least one transformation.

UDP transformations does not interoperate with *RTI Connext DDS Professional*.

Error Handling

The transformation rules are applied on a local basis and correctness is based on configuration. It is not possible to detect that a peer participant is configured for different behavior and errors cannot be detected by the UDP transport itself. However, the transformation interface can return errors which are logged.

Example Code

Example Header file MyUdpTransform.h:

```
#ifndef MyUdpTransform_h
#define MyUdpTransform_h

#include "rti_me_c.h"
#include "netio/netio_udp.h"
#include "netio/netio_interface.h"

struct MyUdpTransformFactoryProperty
{
    struct RT_ComponentFactoryProperty _parent;
};

extern struct RT_ComponentFactoryI*
MyUdpTransformFactory_get_interface(void);

extern RTI_BOOL
MyUdpTransformFactory_register(RT_Registry_T *registry,
                               const char *const name,
                               struct MyUdpTransformFactoryProperty *property);

extern RTI_BOOL
MyUdpTransformFactory_unregister(RT_Registry_T *registry,
                 const char *const name,
                 struct MyUdpTransformFactoryProperty **);

#endif
```

Example Source file MyUdpTransform.c:

```
/*ce
 * \file
 * \defgroup UDPTransformExampleModule MyUdpTransform
 * \ingroup UserManuals_UDPTransform
 * \brief UDP Transform Example
 *
 * \details
 *
 * The UDP interface is implemented as a NETIO interface and NETIO interface
 * factory.
 */

 /*ce \addtogroup UDPTransformExampleModule
  * @{
  */
#include <stdio.h>

#include "MyUdpTransform.h"


/*ce
 * \brief The UDP Transformation factory class
 *
 * \details
 * All Transformation components must have a factory. A factory creates one
 * instance of the component as needed. In the case of UDP transformations,
 * \rtime creates one instance per UDP transport instance.
 */
struct MyUdpTransformFactory
{
    /*ce
     * \brief Base-class. All \rtime Factories must inherit from RT_ComponentFactory.
     */
    struct RT_ComponentFactory _parent;

    /*ce
     * \brief A pointer to the properties of the factory.
     *
     * \details
     *
     * When a factory is registered with \rtime it can be registered with
     * properties specific to the component. However \rtime does not
     * make a copy ( that would require additional methods). Furthermore, it
     * may not be desirable to make a copy. Instead, this decision is
     * left to the implementer of the component. \rtime does not access
     * any custom properties.
     */
    struct MyUdpTransformFactoryProperty *property;
};

/*ce
 * \brief The custom UDP transformation class.
```

(continues on next page)

(continued from previous page)

```
 *
 * \details
 * The MyUdpTransformFactory creates one instance of this class for each
 * UDP interface created. In this example one packet buffer (NETIO_Packet_T),
 * is allocated and a buffer to hold the transformed data (\ref buffer)
 *
 * Only one transformation can be done at a time and it is synchronous. Thus,
 * it is sufficient with one buffer to transform input and output per
 * instance of the MyUdpTransform.
 */
struct MyUdpTransform
{
    /*ce
     * \brief Base-class. All UDP transforms must inherit from UDP_Transform
     */
    struct UDP_Transform _parent;

    /*ce \brief A reference to its own factory, if properties must be accessed
     */
    struct MyUdpTransformFactory *factory;

    /*ce \brief NETIO_Packet to hold a transformed payload.
     *
     * \details
     *
     * \rtime uses a NETIO_Packet_T to abstract data payload and this is
     * what is being passed betweem the UDP transport and the transformation.
     * The transformation must convert a payload into a NETIO_Packet. This
     * is done with NETIO_Packet_initialize_from. This function saves all
     * state except the payload buffer.
     */
    NETIO_Packet_T packet;

    /*ce \brief The payload to assign to NETIO_Packet_T
     *
     * \details
     *
     * A transformation cannot do in-place transformations because the input
     * buffer may be sent multiple times (for example due to reliability).
     * A transformation instance can only transform one buffer at a time
     * (send or receive). The buffer must be large enough to hold a transformed
     * payload. When the the transformation is created it receives a
     * \ref UDP_TransformProperty. This property has the max send and
     * receive buffers for transport and can be used to sise the buffer.
     * Please refer to \ref UDP_InterfaceFactoryProperty::max_send_message_size
     * and \ref UDP_InterfaceFactoryProperty::max_message_size.
     */
    char *buffer;

    /*ce \brief The maximum length of the buffer. NOTE: The buffer must
     * be 1 byte larger than the largest buffer.
```

(continues on next page)

(continued from previous page)

```
     */
    RTI_SIZE_T max_buffer_length;
};

/*ce \brief Forward declaration of the interface implementation
 */
static struct UDP_TransformI MyUdpTransform_fv_Intf;

/*ce \brief Forward declaration of the interface factory implementation
 */
static struct RT_ComponentFactoryI MyUdpTransformFactory_fv_Intf;

/*ce \brief Method to create an instance of MyUdpTransform
 *
 * \param[in] factory The factory creating this instance
 * \param[in] property Generic UDP_Transform properties
 *
 * \return A pointer to MyUdpTransform on sucess, NULL on failure.
 */
RTI_PRIVATE struct MyUdpTransform*
MyUdpTransform_create(struct MyUdpTransformFactory *factory,
                      const struct UDP_TransformProperty *const property)
{
    struct MyUdpTransform *t;

    OSAPI_Heap_allocate_struct(&t, struct MyUdpTransform);
    if (t == NULL)
    {
        return NULL;
    }

    /* All component instances must initialize the parent using this
     * call.
     */
    RT_Component_initialize(&t->_parent._parent,
                            &MyUdpTransform_fv_Intf._parent,
                            0,
                            (property ? &property->_parent : NULL),
                            NULL);

    t->factory = factory;

    /* Allocate a buffer that is the larger of the send and receive
     * size.
     */
    t->max_buffer_length = property->max_receive_message_size;
    if (property->max_send_message_size > t->max_buffer_length )
    {
        t->max_buffer_length = property->max_send_message_size;
    }
```

(continues on next page)

(continued from previous page)

```
    /* Allocate 1 extra byte */
    OSAPI_Heap_allocate_buffer(&t->buffer,t->max_buffer_length+1,
                               OSAPI_ALIGNMENT_DEFAULT);

    if (t->buffer == NULL)
    {
        OSAPI_Heap_free_struct(t);
        t = NULL;
    }

    return t;
}

/*ce \brief Method to delete an instance of MyUdpTransform
 *
 * \param[in] t Transformation instance to delete
 */
RTI_PRIVATE void
MyUdpTransform_delete(struct MyUdpTransform *t)
{
    OSAPI_Heap_free_buffer(t->buffer);
    OSAPI_Heap_free_struct(t);
}

/*ce \brief Method to create a transformation for an destination address
 *
 * \details
 *
 * For each asserted destination rule a transform is created by the transformation
 * instance. This method determines how a UDP payload is transformed before
 * it is sent to an address that matches destination & netmask.
 *
 * \param[in]  udptf       UDP Transform instance that creates the transformation
 * \param[out] context     Pointer to a transformation context
 * \param[in]  destination Destination address for the transformation
   \param[in]  netmask     The netmask to apply to this destination.
 * \param[in]  user_data   The user_data the rule was asserted with
 * \param[in]  property    UDP transform specific properties
 * \param[out] ec          User defined error code
 *
 * \return RTI_TRUE on success, RTI_FALSE on failure
 */
RTI_PRIVATE RTI_BOOL
MyUdpTransform_create_destination_transform(
                            UDP_Transform_T *const udptf,
                            void **const context,
                            const struct NETIO_Address *const destination,
                            const struct NETIO_Netmask *const netmask,
                            void *user_data,
                            const struct UDP_TransformProperty *const property,
                            RTI_INT32 *const ec)
```

(continues on next page)

(continued from previous page)

```
{
    struct MyUdpTransform *self = (struct MyUdpTransform*)udptf;
    UNUSED_ARG(self);
    UNUSED_ARG(destination);
    UNUSED_ARG(user_data);
    UNUSED_ARG(property);
    UNUSED_ARG(ec);
    UNUSED_ARG(netmask);

    /* Save the user-data to determine which transform to apply later */
    *context = (void*)user_data;

    return RTI_TRUE;
}

/*ce \brief Method to delete a transformation for an destination address
 *
 *
 * \param[in]  udptf       UDP Transform instance that created the transformation
 * \param[out] context     Pointer to a transformation context
 * \param[in]  destination Destination address for the transformation
 * \param[in]  netmask     The netmask to apply to this destination.
 * \param[out] ec          User defined error code
 *
 * \return RTI_TRUE on success, RTI_FALSE on failure
 */
RTI_PRIVATE RTI_BOOL
MyUdpTransform_delete_destination_transform(UDP_Transform_T *const udptf,
                                void *context,
                                const struct NETIO_Address *const destination,
                                const struct NETIO_Netmask *const netmask,
                                RTI_INT32 *const ec)
{
    UNUSED_ARG(udptf);
    UNUSED_ARG(context);
    UNUSED_ARG(destination);
    UNUSED_ARG(ec);
    UNUSED_ARG(netmask);

    return RTI_TRUE;
}

/*ce \brief Method to create a transformation for an source address
 *
 * \details
 *
 * For each asserted source rule a transform is created by the transformation
 * instance. This method determines how a UDP payload is transformed when
 * it is received from an address that matches source & netmask.
 *
 * \param[in]  udptf       UDP Transform instance that creates the transformation
```

(continues on next page)

(continued from previous page)

```
 * \param[out] context     Pointer to a transformation context
 * \param[in]  source      Destination address for the transformation
   \param[in]  netmask     The netmask to apply to this destination.
 * \param[in]  user_data   The user_data the rule was asserted with
 * \param[in]  property    UDP transform specific properties
 * \param[out] ec          User defined error code
 *
 * \return RTI_TRUE on success, RTI_FALSE on failure
 */
RTI_PRIVATE RTI_BOOL
MyUdpTransform_create_source_transform(UDP_Transform_T *const udptf,
                           void **const context,
                           const struct NETIO_Address *const source,
                           const struct NETIO_Netmask *const netmask,
                           void *user_data,
                           const struct UDP_TransformProperty *const property,
                           RTI_INT32 *const ec)
{
    struct MyUdpTransform *self = (struct MyUdpTransform*)udptf;
    UNUSED_ARG(self);
    UNUSED_ARG(source);
    UNUSED_ARG(user_data);
    UNUSED_ARG(property);
    UNUSED_ARG(ec);
    UNUSED_ARG(netmask);

    *context = (void*)user_data;

    return RTI_TRUE;
}

/*ce \brief Method to delete a transformation for an source address
 *
 *
 * \param[in]  udptf       UDP Transform instance that created the transformation
 * \param[out] context     Pointer to a transformation context
 * \param[in]  source      Source address for the transformation
 * \param[in]  netmask     The netmask to apply to this destination.
 * \param[out] ec          User defined error code
 *
 * \return RTI_TRUE on success, RTI_FALSE on failure
 */
RTI_PRIVATE RTI_BOOL
MyUdpTransform_delete_source_transform(UDP_Transform_T *const udptf,
                                       void *context,
                                       const struct NETIO_Address *const source,
                                       const struct NETIO_Netmask *const netmask,
                                       RTI_INT32 *const ec)
{
    UNUSED_ARG(udptf);
    UNUSED_ARG(context);
```

(continues on next page)

(continued from previous page)

```
    UNUSED_ARG(source);
    UNUSED_ARG(ec);
    UNUSED_ARG(netmask);

    return RTI_TRUE;
}

/*ce \brief Method to transform data based on a source address
 *
 * \param[in]  udptf       UDP_Transform_T that performs the transformation
 * \param[in]  context     Reference to context created by \ref MyUdpTransform_create_
↪source_transform
 * \param[in]  source      Source address for the transformation
 * \param[in]  in_packet   The NETIO packet to transform
 * \param[out] out_packet  The transformed NETIO packet
 * \param[out] ec          User defined error code
 *
 * \return RTI_TRUE on success, RTI_FALSE on failure
 */
RTI_PRIVATE RTI_BOOL
MyUdpTransform_transform_source(UDP_Transform_T *const udptf,
                                void *context,
                                const struct NETIO_Address *const source,
                                const NETIO_Packet_T *const in_packet,
                                NETIO_Packet_T **out_packet,
                                RTI_INT32 *const ec)
{
    struct MyUdpTransform *self = (struct MyUdpTransform*)udptf;
    char *buf_ptr,*buf_end;
    char *from_buf_ptr,*from_buf_end;
    UNUSED_ARG(context);
    UNUSED_ARG(source);

    *ec = 0;

    /* Assigned the transform buffer to the outgoing packet
     * saving state from the incoming packet. In this case the
     * outgoing length is the same as the incoming. How to buffer
     * is filled in is of no interest to \rtime. All it cares about is
     * where it starts and where it ends.
     */
    if (!NETIO_Packet_initialize_from(
                                &self->packet,in_packet,
                                self->buffer,self->max_buffer_length,
                                0,NETIO_Packet_get_payload_length(in_packet)))
    {
        return RTI_FALSE;
    }

    *out_packet = &self->packet;
```

(continues on next page)

(continued from previous page)

```
    buf_ptr = NETIO_Packet_get_head(&self->packet);
    buf_end = NETIO_Packet_get_tail(&self->packet);
    from_buf_ptr = NETIO_Packet_get_head(in_packet);
    from_buf_end = NETIO_Packet_get_tail(in_packet);

    /* Perform a transformation based on the user-data */
    while (from_buf_ptr < from_buf_end)
    {
        if (context == (void*)1)
        {
            *buf_ptr = ~(*from_buf_ptr);
        }
        else if (context == (void*)2)
        {
            *buf_ptr = (*from_buf_ptr)+1;
        }

        ++buf_ptr;
        ++from_buf_ptr;
    }

    return RTI_TRUE;
}

/*ce \brief Method to transform data based on a destination address
 *
 * \param[in]  udptf       UDP_Transform_T that performs the transformation
 * \param[in]  context     Reference to context created by \ref MyUdpTransform_create_
↪destination_transform
 * \param[in]  destination Source address for the transformation
 * \param[in]  in_packet   The NETIO packet to transform
 * \param[out] packet_out  The transformed NETIO packet
 * \param[out] ec          User defined error code
 *
 * \return RTI_TRUE on success, RTI_FALSE on failure
 */
RTI_PRIVATE RTI_BOOL
MyUdpTransform_transform_destination(UDP_Transform_T *const udptf,
                                     void *context,
                                     const struct NETIO_Address *const destination,
                                     const NETIO_Packet_T *const in_packet,
                                     NETIO_Packet_T **packet_out,
                                     RTI_INT32 *const ec)
{
    struct MyUdpTransform *self = (struct MyUdpTransform*)udptf;
    char *buf_ptr,*buf_end;
    char *from_buf_ptr,*from_buf_end;
    UNUSED_ARG(context);
    UNUSED_ARG(destination);

    *ec = 0;
```

(continues on next page)

(continued from previous page)

```
    if (!NETIO_Packet_initialize_from(
                                &self->packet,in_packet,
                                self->buffer,8192,
                                0,NETIO_Packet_get_payload_length(in_packet)))
    {
        return RTI_FALSE;
    }

    *out_packet = &self->packet;

    buf_ptr = NETIO_Packet_get_head(&self->packet);
    buf_end = NETIO_Packet_get_tail(&self->packet);
    from_buf_ptr = NETIO_Packet_get_head(in_packet);
    from_buf_end = NETIO_Packet_get_tail(in_packet);

    while (from_buf_ptr < from_buf_end)
    {
        if (context == (void*)1)
        {
            *buf_ptr = ~(*from_buf_ptr);
        }
        else if (context == (void*)2)
        {
            *buf_ptr = (*from_buf_ptr)-1;
        }

        ++buf_ptr;
        ++from_buf_ptr;
    }

    return RTI_TRUE;
}

/*ce \brief Definition of the transformation interface
 */
RTI_PRIVATE struct UDP_TransformI MyUdpTransform_fv_Intf =
{
    RT_COMPONENTI_BASE,
    MyUdpTransform_create_destination_transform,
    MyUdpTransform_create_source_transform,
    MyUdpTransform_transform_source,
    MyUdpTransform_transform_destination,
    MyUdpTransform_delete_destination_transform,
    MyUdpTransform_delete_source_transform
};

/*ce \brief Method called by \rtime to create an instance of transformation
 */
MUST_CHECK_RETURN RTI_PRIVATE RT_Component_T*
MyUdpTransformFactory_create_component(struct RT_ComponentFactory *factory,
```

(continues on next page)

(continued from previous page)

```
                        struct RT_ComponentProperty *property,
                        struct RT_ComponentListener *listener)
{
    struct MyUdpTransform *t;
    UNUSED_ARG(listener);

    t = MyUdpTransform_create(
                (struct MyUdpTransformFactory*)factory,
                (struct UDP_TransformProperty*)property);

    return &t->_parent._parent;
}

/*ce \brief Method called by \rtime to delete an instance of transformation
 */
RTI_PRIVATE void
MyUdpTransformFactory_delete_component(
                                        struct RT_ComponentFactory *factory,
                                        RT_Component_T *component)
{
    UNUSED_ARG(factory);

    MyUdpTransform_delete((struct MyUdpTransform*)component);
}

/*ce \brief Method called by \rtime when a factory is registered
 */
MUST_CHECK_RETURN RTI_PRIVATE struct RT_ComponentFactory*
MyUdpTransformFactory_initialize(struct RT_ComponentFactoryProperty* property,
                                 struct RT_ComponentFactoryListener *listener)
{
    struct MyUdpTransformFactory *fac;
    UNUSED_ARG(property);
    UNUSED_ARG(listener);

    OSAPI_Heap_allocate_struct(&fac,struct MyUdpTransformFactory);

    fac->_parent._factory = &fac->_parent;
    fac->_parent.intf = &MyUdpTransformFactory_fv_Intf;
    fac->property = (struct MyUdpTransformFactoryProperty*)property;

    return &fac->_parent;
}

/*ce \brief Method called by \rtime when a factory is unregistered
 */
RTI_PRIVATE void
MyUdpTransformFactory_finalize(struct RT_ComponentFactory *factory,
                        struct RT_ComponentFactoryProperty **property,
                        struct RT_ComponentFactoryListener **listener)
{
```

(continues on next page)

(continued from previous page)

```
    struct MyUdpTransformFactory *fac =
            (struct MyUdpTransformFactory*)factory;

    UNUSED_ARG(property);
    UNUSED_ARG(listener);

    if (listener != NULL)
    {
        *listener = NULL;
    }

    if (property != NULL)
    {
        *property = (struct RT_ComponentFactoryProperty*)fac->property;
    }

    OSAPI_Heap_free_struct(factory);

    return;
}

/*ce \brief Definition of the factory interface
 */
RTI_PRIVATE struct RT_ComponentFactoryI MyUdpTransformFactory_fv_Intf =
{
    UDP_INTERFACE_INTERFACE_ID,
    MyUdpTransformFactory_initialize,
    MyUdpTransformFactory_finalize,
    MyUdpTransformFactory_create_component,
    MyUdpTransformFactory_delete_component,
    NULL
};

struct RT_ComponentFactoryI*
MyUdpTransformFactory_get_interface(void)
{
    return &MyUdpTransformFactory_fv_Intf;
}

/*ce \brief Method to register this transformation in a registry
 */
RTI_BOOL
MyUdpTransformFactory_register(RT_Registry_T *registry,
                               const char *const name,
                               struct MyUdpTransformFactoryProperty *property)
{
    return RT_Registry_register(registry, name,
                           MyUdpTransformFactory_get_interface(),
                           &property->_parent, NULL);
}
```

(continues on next page)

(continued from previous page)

```
/*ce \brief Method to unregister this transformation from a registry
 */
RTI_BOOL
MyUdpTransformFactory_unregister(RT_Registry_T *registry,
            const char *const name,
            struct MyUdpTransformFactoryProperty **property)
{
    return RT_Registry_unregister(registry, name,
                                  (struct RT_ComponentFactoryProperty**)property,
                                  NULL);
}

/*! @} */
```

Example configuration of rules:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#include "common.h"

void
MyAppApplication_help(char *appname)
{
    printf("%s [options]\n", appname);
    printf("options:\n");
    printf("-h                  - This text\n");
    printf("-domain <id>        - DomainId (default: 0)\n");
    printf("-udp_intf <intf>    - udp interface (no default)\n");
    printf("-peer <address>     - peer address (no default)\n");
    printf("-count <count>      - count (default -1)\n");
    printf("-sleep <ms>         - sleep between sends (default 1s)\n");
    printf("\n");
}

struct MyAppApplication*
MyAppApplication_create(const char *local_participant_name,
                        const char *remote_participant_name,
                        DDS_Long domain_id, char *udp_intf, char *peer,
                        DDS_Long sleep_time, DDS_Long count)
{
    DDS_ReturnCode_t retcode;
    DDS_DomainParticipantFactory *factory = NULL;
    struct DDS_DomainParticipantFactoryQos dpf_qos =
        DDS_DomainParticipantFactoryQos_INITIALIZER;
    struct DDS_DomainParticipantQos dp_qos =
        DDS_DomainParticipantQos_INITIALIZER;
    DDS_Boolean success = DDS_BOOLEAN_FALSE;
    struct MyAppApplication *application = NULL;
```

(continues on next page)

(continued from previous page)

```
    RT_Registry_T *registry = NULL;
    struct UDP_InterfaceFactoryProperty *udp_property = NULL;
    struct DPDE_DiscoveryPluginProperty discovery_plugin_properties =
        DPDE_DiscoveryPluginProperty_INITIALIZER;
    UNUSED_ARG(local_participant_name);
    UNUSED_ARG(remote_participant_name);

    /* Uncomment to increase verbosity level:
       OSAPILog_set_verbosity(OSAPI_LOG_VERBOSITY_WARNING);
     */
    application = (struct MyAppApplication *)malloc(sizeof(struct MyAppApplication));

    if (application == NULL)
    {
        printf("failed to allocate application\n");
        goto done;
    }

    application->sleep_time = sleep_time;
    application->count = count;

    factory = DDS_DomainParticipantFactory_get_instance();

    if (DDS_DomainParticipantFactory_get_qos(factory,&dpf_qos) != DDS_RETCODE_OK)
    {
        printf("failed to get number of components\n");
        goto done;
    }

    dpf_qos.resource_limits.max_components = 128;

    if (DDS_DomainParticipantFactory_set_qos(factory,&dpf_qos) != DDS_RETCODE_OK)
    {
        printf("failed to increase number of components\n");
        goto done;
    }

    registry = DDS_DomainParticipantFactory_get_registry(
                                DDS_DomainParticipantFactory_get_instance());

    if (!RT_Registry_register(registry, DDSHST_WRITER_DEFAULT_HISTORY_NAME,
                              WHSM_HistoryFactory_get_interface(), NULL, NULL))
    {
        printf("failed to register wh\n");
        goto done;
    }

    if (!RT_Registry_register(registry, DDSHST_READER_DEFAULT_HISTORY_NAME,
                              RHSM_HistoryFactory_get_interface(), NULL, NULL))
    {
        printf("failed to register rh\n");
```

(continues on next page)

(continued from previous page)

```
        goto done;
    }

    if (!MyUdpTransformFactory_register(registry,"T0",NULL))
    {
        printf("failed to register T0\n");
        goto done;
    }

    if (!MyUdpTransformFactory_register(registry,"T1",NULL))
    {
        printf("failed to register T0\n");
        goto done;
    }

    /* Configure UDP transport's allowed interfaces */
    if (!RT_Registry_unregister(registry, NETIO_DEFAULT_UDP_NAME, NULL, NULL))
    {
        printf("failed to unregister udp\n");
        goto done;
    }

    udp_property = (struct UDP_InterfaceFactoryProperty *)
                            malloc(sizeof(struct UDP_InterfaceFactoryProperty));
    if (udp_property == NULL)
    {
        printf("failed to allocate udp properties\n");
        goto done;
    }
    *udp_property = UDP_INTERFACE_FACTORY_PROPERTY_DEFAULT;

    /* For additional allowed interface(s), increase maximum and length, and
       set interface below:
    */
    udp_property->max_send_message_size = 16384;
    udp_property->max_message_size = 32768;

    if (udp_intf != NULL)
    {
        REDA_StringSeq_set_maximum(&udp_property->allow_interface,1);
        REDA_StringSeq_set_length(&udp_property->allow_interface,1);
        *REDA_StringSeq_get_reference(&udp_property->allow_interface,0) =
                DDS_String_dup(udp_intf);
    }


    /* A rule that says: For payloads received from 192.168.10.* (netmask is
     * 0xffffff00), apply transformation T0.
     */
    if (!UDP_TransformRules_assert_source_rule(
            &udp_property->source_rules,
```

(continues on next page)

(continued from previous page)

```
        0xc0a80ae8,0xffffff00,"T0",(void*)2))
{
    printf("Failed to assert source rule\n");
    goto done;
}

/* A rule that says: For payloads sent to 192.168.10.* (netmask is
 * 0xffffff00), apply transformation T0.
 */
if (!UDP_TransformRules_assert_destination_rule(
        &udp_property->destination_rules,
        0xc0a80ae8,0xffffff00,"T0",(void*)2))
{
    printf("Failed to assert source rule\n");
    goto done;
}

/* A rule that says: For payloads received from 192.168.20.* (netmask is
 * 0xffffff00), apply transformation T1.
 */
if (!UDP_TransformRules_assert_source_rule(
        &udp_property->source_rules,
        0xc0a81465,0xffffff00,"T1",(void*)1))
{
    printf("Failed to assert source rule\n");
    goto done;
}

/* A rule that says: For payloads received from 192.168.20.* (netmask is
 * 0xffffff00), apply transformation T1.
 */
if (!UDP_TransformRules_assert_destination_rule(
        &udp_property->destination_rules,
        0xc0a81465,0xffffff00,"T1",(void*)1))
{
    printf("Failed to assert source rule\n");
    goto done;
}

if (!RT_Registry_register(registry, NETIO_DEFAULT_UDP_NAME,
                    UDP_InterfaceFactory_get_interface(),
                   (struct RT_ComponentFactoryProperty*)udp_property, NULL))
{
   printf("failed to register udp\n");
   goto done;
}

DDS_DomainParticipantFactory_get_qos(factory, &dpf_qos);
dpf_qos.entity_factory.autoenable_created_entities = DDS_BOOLEAN_FALSE;
DDS_DomainParticipantFactory_set_qos(factory, &dpf_qos);
```

(continues on next page)

(continued from previous page)

```
    if (peer == NULL)
    {
        peer = "127.0.0.1"; /* default to loopback */
    }

    if (!RT_Registry_register(registry,
                              "dpde",
                              DPDE_DiscoveryFactory_get_interface(),
                              &discovery_plugin_properties._parent,
                              NULL))
    {
        printf("failed to register dpde\n");
        goto done;
    }

    if (!RT_ComponentFactoryId_set_name(&dp_qos.discovery.discovery.name,"dpde"))
    {
        printf("failed to set discovery plugin name\n");
        goto done;
    }

    DDS_StringSeq_set_maximum(&dp_qos.discovery.initial_peers,1);
    DDS_StringSeq_set_length(&dp_qos.discovery.initial_peers,1);
    *DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers,0) = DDS_String_
↪dup(peer);

    DDS_StringSeq_set_maximum(&dp_qos.discovery.enabled_transports,1);
    DDS_StringSeq_set_length(&dp_qos.discovery.enabled_transports,1);

    /* Use network interface 192.168.10.232 for discovery. T0 is used for
     * discovery
     */
    *DDS_StringSeq_get_reference(&dp_qos.discovery.enabled_transports,0) = DDS_String_
↪dup("_udp://192.168.10.232");

    DDS_StringSeq_set_maximum(&dp_qos.user_traffic.enabled_transports,1);
    DDS_StringSeq_set_length(&dp_qos.user_traffic.enabled_transports,1);

    /* Use network interface 192.168.20.101 for user-data. T1 is used for
     * this interface.
     */
    *DDS_StringSeq_get_reference(&dp_qos.user_traffic.enabled_transports,0) = DDS_String_
↪dup("_udp://192.168.20.101");

    /* if there are more remote or local endpoints, you need to increase these limits */
    dp_qos.resource_limits.max_destination_ports = 32;
    dp_qos.resource_limits.max_receive_ports = 32;
    dp_qos.resource_limits.local_topic_allocation = 1;
    dp_qos.resource_limits.local_type_allocation = 1;
    dp_qos.resource_limits.local_reader_allocation = 1;
    dp_qos.resource_limits.local_writer_allocation = 1;
```

(continues on next page)

(continued from previous page)

```
    dp_qos.resource_limits.remote_participant_allocation = 8;
    dp_qos.resource_limits.remote_reader_allocation = 8;
    dp_qos.resource_limits.remote_writer_allocation = 8;

    application->participant =
        DDS_DomainParticipantFactory_create_participant(factory, domain_id,
                                                        &dp_qos, NULL,
                                                        DDS_STATUS_MASK_NONE);

    if (application->participant == NULL)
    {
        printf("failed to create participant\n");
        goto done;
    }

    sprintf(application->type_name, "HelloWorld");
    retcode = DDS_DomainParticipant_register_type(application->participant,
                                                  application->type_name,
                                                  HelloWorldTypePlugin_get());
    if (retcode != DDS_RETCODE_OK)
    {
        printf("failed to register type: %s\n", "test_type");
        goto done;
    }

    sprintf(application->topic_name, "HelloWorld");
    application->topic =
        DDS_DomainParticipant_create_topic(application->participant,
                                           application->topic_name,
                                           application->type_name,
                                           &DDS_TOPIC_QOS_DEFAULT, NULL,
                                           DDS_STATUS_MASK_NONE);

    if (application->topic == NULL)
    {
        printf("topic == NULL\n");
        goto done;
    }

    success = DDS_BOOLEAN_TRUE;

  done:

    if (!success)
    {
        if (udp_property != NULL)
        {
            free(udp_property);
        }
        free(application);
        application = NULL;
```

(continues on next page)

(continued from previous page)

```
    }

    return application;
}

DDS_ReturnCode_t
MyAppApplication_enable(struct MyAppApplication * application)
{
    DDS_Entity *entity;
    DDS_ReturnCode_t retcode;

    entity = DDS_DomainParticipant_as_entity(application->participant);

    retcode = DDS_Entity_enable(entity);
    if (retcode != DDS_RETCODE_OK)
    {
        printf("failed to enable entity\n");
    }

    return retcode;
}

void
MyAppApplication_delete(struct MyAppApplication *application)
{
    DDS_ReturnCode_t retcode;
    RT_Registry_T *registry = NULL;

    retcode = DDS_DomainParticipant_delete_contained_entities(application->participant);
    if (retcode != DDS_RETCODE_OK)
    {
        printf("failed to delete conteined entities (retcode=%d)\n",retcode);
    }

    if (DDS_DomainParticipant_unregister_type(application->participant,
                  application->type_name) != HelloWorldTypePlugin_get())
    {
        printf("failed to unregister type: %s\n", application->type_name);
        return;
    }

    retcode = DDS_DomainParticipantFactory_delete_participant(
                                DDS_DomainParticipantFactory_get_instance(),
                                application->participant);

    if (retcode != DDS_RETCODE_OK)
    {
        printf("failed to delete participant: %d\n", retcode);
        return;
    }
```

(continues on next page)

(continued from previous page)

```
    registry = DDS_DomainParticipantFactory_get_registry(
                                DDS_DomainParticipantFactory_get_instance());

    if (!RT_Registry_unregister(registry, "dpde", NULL, NULL))
    {
        printf("failed to unregister dpde\n");
        return;
    }
    if (!RT_Registry_unregister(registry, DDSHST_READER_DEFAULT_HISTORY_NAME, NULL,␣
↪NULL))
    {
        printf("failed to unregister rh\n");
        return;
    }
    if (!RT_Registry_unregister(registry, DDSHST_WRITER_DEFAULT_HISTORY_NAME, NULL,␣
↪NULL))
    {
        printf("failed to unregister wh\n");
        return;
    }

    free(application);

    DDS_DomainParticipantFactory_finalize_instance();
}
```

Examples

The following examples illustrate how this feature can be used in a system with a mixture of different types of UDP transport configurations.

For the purpose of the examples, the following terminology is used:

- Plain communication – No transformations have been applied.
- Transformed User Data – Only the user-data is transformed, discovery is plain.
- Transformed Discovery – Only the discovery data is transformed, user-data is plain.
- Transformed Data – Both discovery and user-data are transformed. Unless stated otherwise the transformations are different.

A transformation Tn is a transformation such that an outgoing payload transformed with Tn can be transformed back to its original state by applying Tn to the incoming data.

A network interface can be either physical or virtual.

Plain Communication Between 2 Nodes

In this system two Nodes, A and B, are communicating with plain communication. Node A has one interface, a0, and Node B has one interface, b0.

Node A:

- Register the UDP transport Ua with allow_interface = a0.
- DomainParticipantQos.transports.enabled_transports = “Ua”
- DomainParticipantQos.discovery.enabled_transports = ”Ua://”
- DomainParticipantQos.user_data.enabled_transports = ”Ua://”

Node B:

- Register the UDP transport Ub with allow_interface = b0.
- DomainParticipantQos.transports.enabled_transports = “Ub”
- DomainParticipantQos.discovery.enabled_transports = ”Ub://”
- DomainParticipantQos.user_data.enabled_transports = ”Ub://”

Transformed User Data Between 2 Nodes

In this system two Nodes, A and B, are communicating with transformed user data. Node A has two interfaces, a0 and a1, and Node B has two interfaces, b0 and b1. Since each node has only one peer, a single transformation is sufficient.

Node A:

- Add a destination transformation T0 to Ua0, indicating that all sent data is transformed with T0.
- Add a source transformation T1 to Ua0, indicating that all received data is transformed with T1.
- Register the UDP transport Ua0 with allow_interface = a0.
- Register the UDP transport Ua1 with allow_interface = a1.
- No transformations are registered with Ua1.
- DomainParticipantQos.transports.enabled_transports = “Ua0”,”Ua1”
- DomainParticipantQos.discovery.enabled_transports = ”Ua1://”
- DomainParticipantQos.user_traffic.enabled_transports = ”Ua0://”

Node B:

- Add a destination transformation T1 to Ub0, indicating that all sent data is transformed with T1.

- Add a source transformation T0 to Ub0, indicating that all received data is transformed with T0.
- Register the UDP transport Ub0 with allow_interface = b0.
- Register the UDP transport Ub1 with allow_interface = b1.
- No transformations are registered with Ub1.
- DomainParticipantQos.transports.enabled_transports = “Ub0”,”Ub1”
- DomainParticipantQos.discovery.enabled_transports = ”Ub1://”
- DomainParticipantQos.user_traffic.enabled_transports = ”Ub0://”

Ua0 and Ub0 perform transformations and are used for user-data. Ua1 and Ub1 are used for discovery and no transformations takes place.

Transformed Discovery Data Between 2 Nodes

In this system two Nodes, A and B, are communicating with transformed user data. Node A has two interfaces, a0 and a1, and Node B has two interfaces, b0 and b1. Since each node has only one peer, a single transformation is sufficient.

Node A:

- Add a destination transformation T0 to Ua0, indicating that all sent data is transformed with T0.
- Add a source transformation T1 to Ua0, indicating that all received data is transformed with T1.
- Register the UDP transport Ua0 with allow_interface = a0.
- Register the UDP transport Ua1 with allow_interface = a1.
- No transformations are registered with Ua1.
- DomainParticipantQos.transports.enabled_transports = “Ua0”,”Ua1”
- DomainParticipantQos.discovery.enabled_transports = ”Ua0://”
- DomainParticipantQos.user_data.enabled_transports = ”Ua1://”

Node B:

- Add a destination transformation T1 to Ub0, indicating that all sent data is transformed with T1.
- Add a source transformation T0 to Ub0, indicating that all received data is transformed with T0.
- Register the UDP transport Ub0 with allow_interface = b0.
- Register the UDP transport Ub1 with allow_interface = b1.
- No transformations are registered with Ub1.

- DomainParticipantQos.transports.enabled_transports = “Ub0”,”Ub1”
- DomainParticipantQos.discovery.enabled_transports = ”Ub0://”
- DomainParticipantQos.user_data.enabled_transports = ”Ub1://”

Ua0 and Ub0 perform transformations and are used for discovery. Ua1 and Ub1 are used for user-data and no transformation takes place.

Transformed Data Between 2 Nodes (same transformation)

In this system two Nodes, A and B, are communicating with transformed data using the same transformation for user and discovery data. Node A has one interface, a0, and Node B has one interface, b0.

Node A:

- Add a destination transformation T0 to Ua0, indicating that all sent data is transformed with T0.
- Add a source transformation T1 to Ua0, indicating that all received data is transformed with T1.
- Register the UDP transport Ua0 with allow_interface = a0.
- DomainParticipantQos.transports.enabled_transports = “Ua0”
- DomainParticipantQos.discovery.enabled_transports = ”Ua0://”
- DomainParticipantQos.user_data.enabled_transports = ”Ua0://”

Node B:

- Add a destination transformation T1 to Ub0, indicating that all sent data is transformed with T1.
- Add a source transformation T0 to Ub0, indicating that all received data is transformed with T0.
- Register the UDP transport Ub0 with allow_interface = b0.
- DomainParticipantQos.transports.enabled_transports = “Ub0”
- DomainParticipantQos.discovery.enabled_transports = ”Ub0://”
- DomainParticipantQos.user_data.enabled_transports = ”Ub0://”

Ua0 and Ub0 performs transformations and are used for discovery and for user-data.

Transformed Data Between 2 Nodes (different transformations)

In this system two Nodes, A and B, are communicating with transformed data using different transformations for user and discovery data. Node A has two interfaces, a0 and a1, and Node B has two interfaces, b0 and b1.

Node A:

- Add a destination transformation T0 to Ua0, indicating that all sent data is transformed with T0.
- Add a source transformation T1 to Ua0, indicating that all received data is transformed with T1.
- Add a destination transformation T2 to Ua1, indicating that all sent data is transformed with T2.
- Add a source transformation T3 to Ua1, indicating that all received data is transformed with T3.
- Register the UDP transport Ua0 with allow_interface = a0.
- Register the UDP transport Ua1 with allow_interface = a1.
- DomainParticipantQos.transports.enabled_transports = “Ua0”,”Ua1”
- DomainParticipantQos.discovery.enabled_transports = ”Ua0://”
- DomainParticipantQos.user_data.enabled_transports = ”Ua1://”

Node B:

- Add a destination transformation T1 to Ub0, indicating that all sent data is transformed with T1.
- Add a source transformation T0 to Ub0, indicating that all received data is transformed with T0.
- Add a destination transformation T3 to Ub1, indicating that all sent data is transformed with T3.
- Add a source transformation T2 to Ub1, indicating that all received data is transformed with T2.
- Register the UDP transport Ub0 with allow_interface = b0.
- Register the UDP transport Ub1 with allow_interface = b1.
- DomainParticipantQos.transports.enabled_transports = “Ub0”,”Ub1”
- DomainParticipantQos.discovery.enabled_transports = ”Ub0://”
- DomainParticipantQos.user_data.enabled_transports = ”Ub1://”

Ua0 and Ub0 perform transformations and are used for discovery. Ua1 and Ub1 perform transformations and are used for user-data.

OS Configuration

In systems with several network interfaces, *Connext Micro* cannot ensure which network interface should be used to send a packet. Depending on the UDP transformations configured, this might be a problem.

To illustrate this problem, let's assume a system with two nodes, A and B. Node A has two network interfaces, a0 and a1, and Node B has two network interfaces, b0 and b1. In this system, Node A is communicating with Node B using a transformation for discovery and a different transformation for user data.

Node A:

- Add a destination transformation T0 to Ua0, indicating that sent data to b0 is transformed with T0.
- Add a source transformation T1 to Ua0, indicating that received data from b0 is transformed with T1.
- Add a destination transformation T2 to Ua1, indicating that sent data to b1 is transformed with T2.
- Add a source transformation T3 to Ua1, indicating that received data from b1 is transformed with T3.
- Register the UDP transport Ua0 with allow_interface = a0.
- Register the UDP transport Ua1 with allow_interface = a1.
- DomainParticipantQos.transports.enabled_transports = "Ua0","Ua1"
- DomainParticipantQos.discovery.enabled_transports = "Ua0://"
- DomainParticipantQos.user_data.enabled_transports = "Ua1://"

Node B:

- Add a destination transformation T1 to Ub0, indicating that sent data to a0 is transformed with T1.
- Add a source transformation T0 to Ub0, indicating that received data from a0 transformed with T0.
- Add a destination transformation T3 to Ub1, indicating that sent data to a1 is transformed with T3.
- Add a source transformation T2 to Ub1, indicating that received data from a1 transformed with T2.
- Register the UDP transport Ub0 with allow_interface = b0.
- Register the UDP transport Ub1 with allow_interface = b1.
- DomainParticipantQos.transports.enabled_transports = "Ub0","Ub1"
- DomainParticipantQos.discovery.enabled_transports = "Ub0://"
- DomainParticipantQos.user_data.enabled_transports = "Ub1://"

Node A sends a discovery packet to Node B to interface b0. This packet will be transformed using T0 as specified by Node A's configuration. When this packet is received in Node B, it will be transformed using either T0 or T2 depending on the source address. Node's A OS will use a0 or a1 to send this packet but *Connext Micro* cannot ensure which one will be used. In case the OS sends the packet using a1, the wrong transformation will be applied in Node B.

Some systems have the possibility to configure the source address that should be used when a packet is sent. In POSIX systems, the command `ip route add <string> dev <interface>` can be used.

By typing the command `ip route add < b0 ip >/32 dev a0` in Node A, the OS will send all packets to Node B's b0 IP address using interface a0. This would ensure that the correct transformation is applied in Node B. The same should be done to ensure that user data is sent with the right address `ip route add < b1 ip >/32 dev a1`. Of course, similar configuration is needed in Node B.

4.7.8 ARINC 653 Transport

This section describes the ARINC transport and how to configure it.

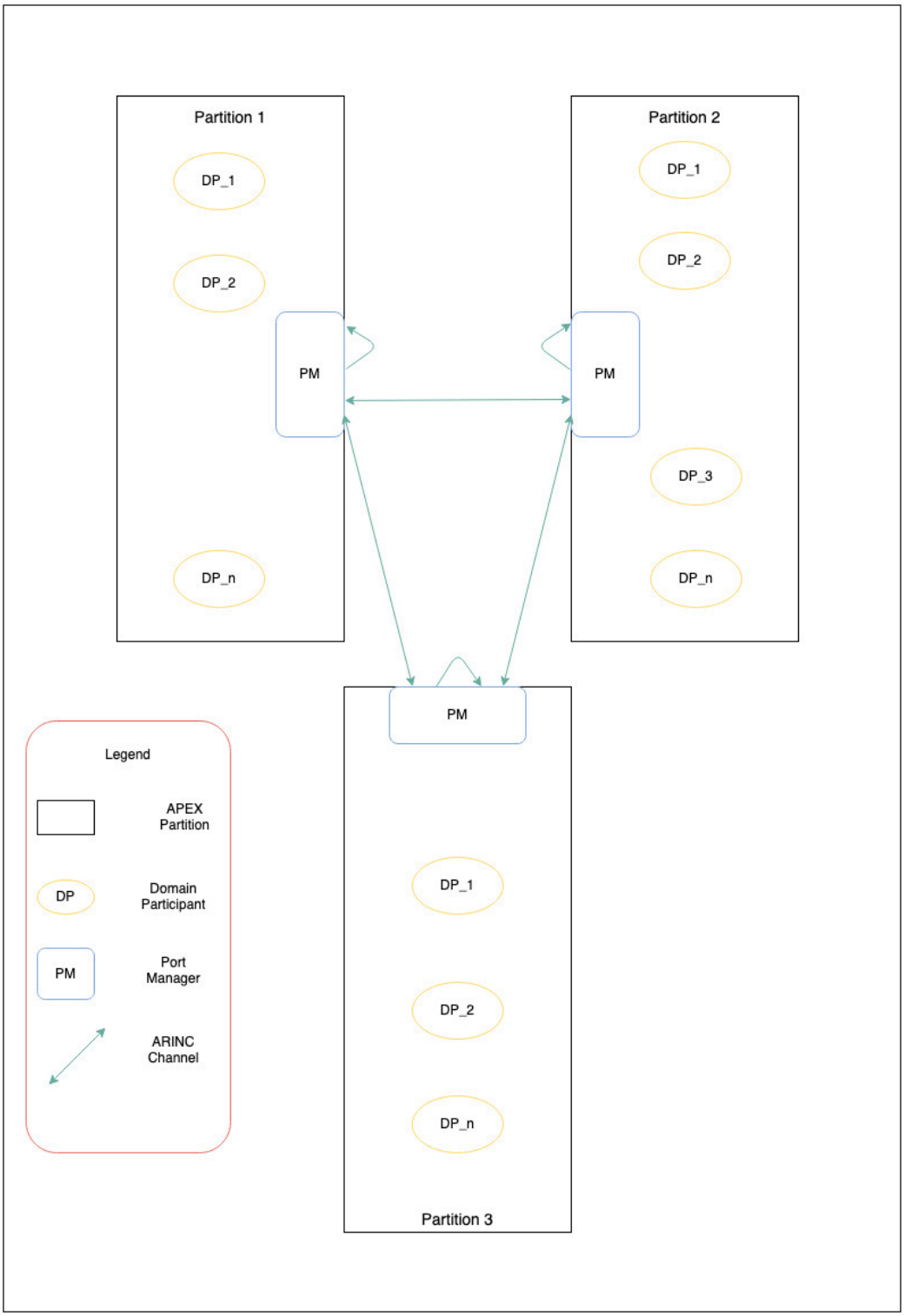
The ARINC transport allows a user to use queuing ports defined by the ARINC 653 APEX API for inter-partition and intra-partition communication.

There are two major components to be configured when using this transport:

- The **Port Manager**, which manages all the ports configured for a *partition*;
- The **ARINC Interface** which is configured per *DomainParticipant*.

ARINC Channels Configuration

All ARINC 653 ports and channels are statically configured in the module OS (MOS) configuration. The diagram below shows a typical configuration.



To avoid a mesh network between all the *DomainParticipants*, the ARINC transport shares the APEX queuing ports between all the participants in a partition. This requires the user to configure a mesh network of APEX channels between all of the partitions. Also, note that a channel is required with send and receive ports on the same partition for intra-partition communication.

The properties of ARINC 653 ports must be replicated in the Port Manager properties, which are detailed below.

The Port Manager

The Port Manager is configured as a separate RT component per partition (once per DomainParticipantFactory) and manages all the send and receive APEX Queuing ports from this partition. The *DomainParticipants* share all the ports in the Port Manager. The Port Manager is also responsible for sending and receiving data from these ports and forwarding them to their destination.

Note: The Port Manager factory must be registered before any ARINC interface is registered/created.

The following table details the properties to be configured in the PortManagerFactoryProperty:

Table 4.1: Properties for configuring the Port Manager

Property Name	Property Value Description
`receive_ports`	A sequence of ARINC_ReceivePortProperty. Configures all the receive ports used by this partition.
`send_routes`	A sequence of ARINC_RouteProperty. Configures all the send ports and their destinations used by this partition.
`thread_property`	The properties of the *ARINC 653 PROCESS* created to receive all the messages from different ports. It is **required** that this PROCESS has the highest priority.
`max_managed_interfaces`	Maximum number of ARINC Interfaces managed by this port manager. This number is typically equal to the number of DomainParticipants in the partition.
`sync_processing`	Boolean to configure synchronous processing of received messages. It is *false* by default. **Note:** When this is set to true all messages received are processed synchronously in the context of the Port manager Process (shared between multiple *DomainParticipants*) all the way upto the DDS Reader. In asynchronous mode the messages are handed off to another *ARINC 653 Process* inside the ARINC Interface. Since the port manager is shared between many *DomainParticipants* synchronous processing can lead to the port manager blocking multiple participants.

Below is an example for setting up and registering the port manager:

```
struct ARINC_RouteProperty *route_property;
struct ARINC_PortManagerFactoryProperty *port_mgr_prop = NULL;
struct ARINC_ReceivePortProperty *receive_port_prop = NULL;
RT_Registry_T *registry = NULL;
```

(continues on next page)

(continued from previous page)

```
port_mgr_prop = (struct ARINC_PortManagerFactoryProperty*)malloc(
                                sizeof(struct ARINC_PortManagerFactoryProperty));
*port_mgr_prop = ARINC_PORTMANAGER_FACTORY_PROPERTY_DEFAULT;

/*Configuring APEX process attributes in OSAPI Thread property*/
port_mgr_prop->thread_property.port_property.parent.deadline = SOFT;
port_mgr_prop->thread_property.port_property.parent.period = 500000000;
port_mgr_prop->thread_property.port_property.parent.time_capacity = 500000000;
port_mgr_prop->thread_property.stack_size = 32000;
port_mgr_prop->thread_property.priority = 99;
#define RTI_PORTMGR_RECV_THREAD_NAME "rti.ARINC.pm.rcv_thrd"
OSAPI_Memory_zero(&port_mgr_prop->thread_property.port_property.parent.name, MAX_NAME_
↪LENGTH);
    OSAPI_Memory_copy(&port_mgr_prop->thread_property.port_property.parent.name,
                      RTI_PORTMGR_RECV_THREAD_NAME, OSAPI_String_length(RTI_PORTMGR_RECV_
↪THREAD_NAME));

port_mgr_prop->sync_processing = RTI_FALSE;

/* Name of queuing port sending to Connext application partition */
#define RTI_APP_SEND_PORT_NAME "Part1_send"

ARINC_RoutePropertySeq_set_maximum(&port_mgr_prop->send_routes, 1);
ARINC_RoutePropertySeq_set_length(&port_mgr_prop->send_routes, 1);
route_property = (struct ARINC_RouteProperty*)
        ARINC_RoutePropertySeq_get_reference(&port_mgr_prop->send_routes, 0);
OSAPI_Memory_copy(route_property->send_port_property.port_name,
                      RTI_APP_SEND_PORT_NAME, OSAPI_String_length(RTI_APP_SEND_PORT_NAME));
route_property->send_port_property.max_message_size = 1024;
route_property->send_port_property.max_queue_size = 20;
route_property->channel_identifier = 1;

/* Name of queuing port receiving from Connext application partition */
#define RTI_APP_RECV_PORT_NAME "Part1_recv"

ARINC_ReceivePortPropertySeq_set_maximum(&port_mgr_prop->receive_ports,1);
ARINC_ReceivePortPropertySeq_set_length(&port_mgr_prop->receive_ports,1);
receive_port_prop = (struct ARINC_ReceivePortProperty*)
        ARINC_ReceivePortPropertySeq_get_reference(&port_mgr_prop->receive_ports,0);
receive_port_prop->receive_port_property.max_message_size = 1024;
receive_port_prop->receive_port_property.max_queue_size = 20;
receive_port_prop->max_receive_queue_size = 20;
receive_port_prop->channel_identifier = 1;
OSAPI_Memory_copy(receive_port_prop->receive_port_property.port_name,
            RTI_APP_RECV_PORT_NAME, OSAPI_String_length(RTI_APP_RECV_PORT_NAME));


registry = DDS_DomainParticipantFactory_get_registry(
        DDS_DomainParticipantFactory_get_instance());
if (!RT_Registry_register(registry,
```

(continues on next page)

(continued from previous page)

```
            NETIO_DEFAULT_PORTMANAGER_NAME,
            ARINC_PortManagerFactory_get_interface(),
            (struct RT_ComponentFactoryProperty*)port_mgr_prop,NULL))
{
    printf("failed to register port mgr\n");

}
```

ARINC Interface

The ARINC interface is the NETIO transport interface that is registered with each participant. The transport interface is the lowest layer for a *DomainParticipant* through which all data is routed. The ARINC interface maintains the internal tables per *DomainParticipant* to accept and route data to the correct internal *DataWriters* and *DataReaders*. When the ARINC interface is created for the first participant it automatically creates the port manager instance.

The ARINC interface can be configured with the following properties in the ARINC_InterfaceFactoryProperty:

Table 4.2: Properties for Configuring the ARINC Interface

Property Name	Property Value Description
recv_thread	The properties of the *ARINC 653 PROCESS* created to process messages destined for this Interface from the port manager.
`queue_size`	The internal queue is maintained by each ARINC interface. These are the maximum number of messages this interface can hold as they are processed by the `recv_thread` configured above.

Note: If the `sync_processing` in PortManagerFactoryProperty is set to true, the above properties have no effect. No receive thread or internal queues are created for the ARINC interface.

Below is an example for setting up and registering the ARINC interface:

```
struct ARINC_InterfaceFactoryProperty *arinc_property = NULL;
RT_Registry_T *registry = NULL;

arinc_property = (struct ARINC_InterfaceFactoryProperty*)
                 malloc(sizeof(struct ARINC_InterfaceFactoryProperty));
*arinc_property = ARINC_INTERFACE_FACTORY_PROPERTY_DEFAULT;
      arinc_property->recv_thread.port_property.parent.deadline = SOFT;
arinc_property->recv_thread.port_property.parent.period = INFINITE_TIME_VALUE;
arinc_property->recv_thread.port_property.parent.time_capacity = INFINITE_TIME_
↪VALUE;
arinc_property->recv_thread.stack_size = 16000;
arinc_property->recv_thread.priority = 97;
```

(continues on next page)

(continued from previous page)

```
#define RTI_RECV_THREAD_NAME "rti.ARINC.p2.rcv_thrd"
OSAPI_Memory_zero(&arinc_property->recv_thread.port_property.parent.name, MAX_
↪NAME_LENGTH);
OSAPI_Memory_copy(&arinc_property->recv_thread.port_property.parent.name,
                  RTI_RECV_THREAD_NAME, OSAPI_String_length(RTI_RECV_THREAD_
↪NAME));

registry = DDS_DomainParticipantFactory_get_registry(
        DDS_DomainParticipantFactory_get_instance());
if (!RT_Registry_register(registry, NETIO_DEFAULT_ARINC_NAME,
                ARINC_InterfaceFactory_get_interface(),
                                  (struct RT_ComponentFactoryProperty*)arinc_
↪property, NULL))
{
    printf("failed to register arinc\n");

}
```

If an application requires multiple participants in the same partition, it is necessary to register a separate ARINC transport component for each participant. Each component can be registered with a different configuration in order to define a unique configuration for each participant. Below is an example of how to register a second ARINC transport component named `ar_2`.

```
struct ARINC_InterfaceFactoryProperty *arinc_property = NULL;
RT_Registry_T *registry = NULL;

arinc_property = (struct ARINC_InterfaceFactoryProperty*)
                 malloc(sizeof(struct ARINC_InterfaceFactoryProperty));
*arinc_property = ARINC_INTERFACE_FACTORY_PROPERTY_DEFAULT;
      arinc_property->recv_thread.port_property.parent.deadline = SOFT;
arinc_property->recv_thread.port_property.parent.period = INFINITE_TIME_VALUE;
arinc_property->recv_thread.port_property.parent.time_capacity = INFINITE_TIME_
↪VALUE;
arinc_property->recv_thread.stack_size = 16000;
arinc_property->recv_thread.priority = 96;

#define RTI_RECV_THREAD_NAME "rti.ARINC.p2.2.rcv_thrd"
OSAPI_Memory_zero(&arinc_property->recv_thread.port_property.parent.name, MAX_
↪NAME_LENGTH);
OSAPI_Memory_copy(&arinc_property->recv_thread.port_property.parent.name,
                  RTI_RECV_THREAD_NAME, OSAPI_String_length(RTI_RECV_THREAD_
↪NAME));

registry = DDS_DomainParticipantFactory_get_registry(
        DDS_DomainParticipantFactory_get_instance());
if (!RT_Registry_register(registry, "ar_2",
                ARINC_InterfaceFactory_get_interface(),
                                  (struct RT_ComponentFactoryProperty*)arinc_
↪property, NULL))
{
    printf("failed to register ar_2\n");
```

(continues on next page)

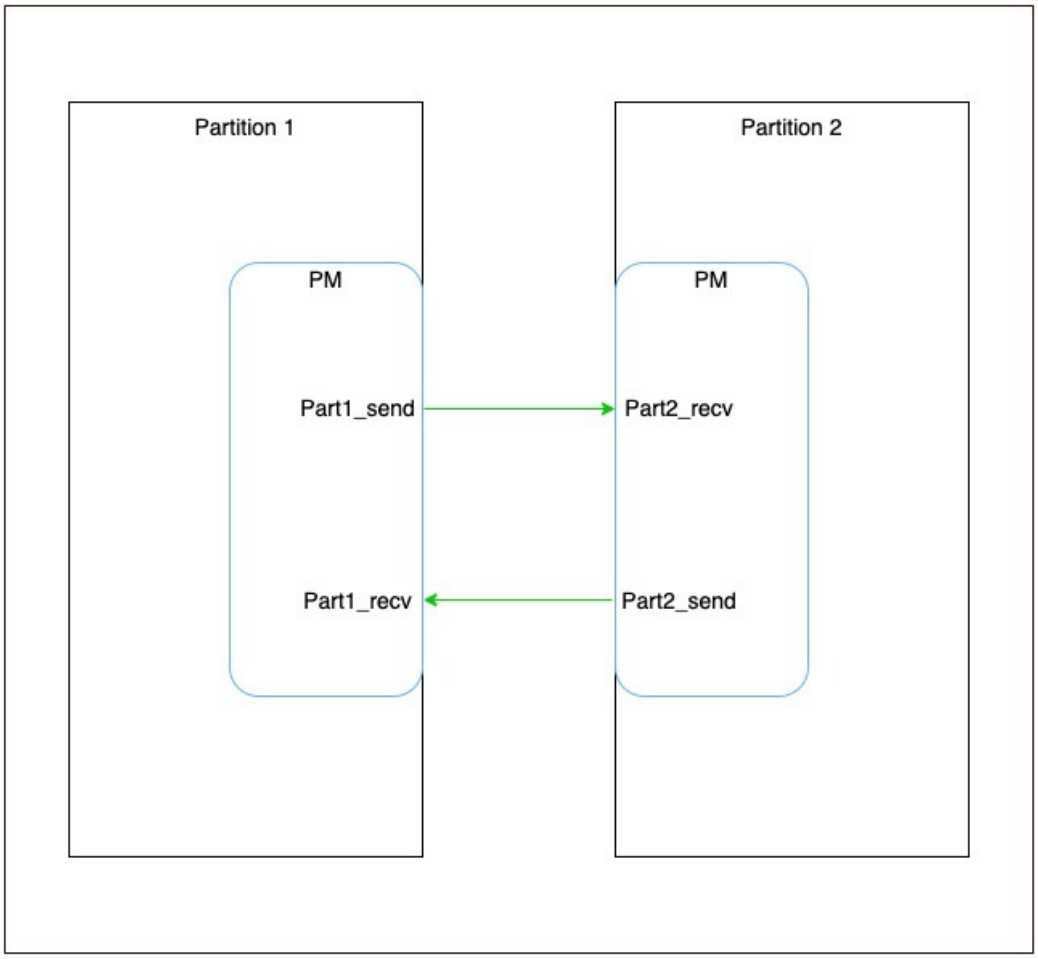
(continued from previous page)

```
}
```

Addressing Model

Communication in the ARINC transport takes place over ARINC channels. ARINC channels are logical connections between ARINC Send and Receive ports. These channels have a logical address to facilitate communication configured using the channel identifier in the send and receive port property. These channel identifiers are unsigned 32-bit integers. Each Send port and the complementing Receive port which completes the channel should have the same channel identifier.

For example, if we have two channels between two partitions as shown in the diagram below:



The snippet below describes their configuration. Notice that channel identifiers match between the send and receive ports of the same channel.

```
/* Name of queuing port sending to Connext application partition */
#define RTI_APP_SEND_PORT_NAME "Part1_send"
```

(continues on next page)

(continued from previous page)

```
ARINC_RoutePropertySeq_set_maximum(&port_mgr_prop->send_routes, 1);
ARINC_RoutePropertySeq_set_length(&port_mgr_prop->send_routes, 1);
route_property = (struct ARINC_RouteProperty*)
        ARINC_RoutePropertySeq_get_reference(&port_mgr_prop->send_routes, 0);
OSAPI_Memory_copy(route_property->send_port_property.port_name,
        RTI_APP_SEND_PORT_NAME, OSAPI_String_length(RTI_APP_SEND_PORT_NAME));
route_property->send_port_property.max_message_size = 1024;
route_property->send_port_property.max_queue_size = 20;
route_property->channel_identifier = 1;

/* Name of queuing port receiving from Connext application partition */
#define RTI_APP_RECV_PORT_NAME "Part1_recv"
ARINC_ReceivePortPropertySeq_set_maximum(&port_mgr_prop->receive_ports,1);
ARINC_ReceivePortPropertySeq_set_length(&port_mgr_prop->receive_ports,1);
  eceive_port_prop = (struct ARINC_ReceivePortProperty*)
          ARINC_ReceivePortPropertySeq_get_reference(&port_mgr_prop->receive_ports,0);
receive_port_prop->receive_port_property.max_message_size = 1024;
receive_port_prop->receive_port_property.max_queue_size = 20;
receive_port_prop->max_receive_queue_size = 20;
receive_port_prop->channel_identifier = 2;
OSAPI_Memory_copy(receive_port_prop->receive_port_property.port_name,
              RTI_APP_RECV_PORT_NAME, OSAPI_String_length(RTI_APP_RECV_PORT_NAME));
```

```
#define RTI_APP_SEND_PORT_NAME "Part2_send"

ARINC_RoutePropertySeq_set_maximum(&port_mgr_prop->send_routes, 1);
ARINC_RoutePropertySeq_set_length(&port_mgr_prop->send_routes, 1);
route_property = (struct ARINC_RouteProperty*)
        ARINC_RoutePropertySeq_get_reference(&port_mgr_prop->send_routes, 0);
OSAPI_Memory_copy(route_property->send_port_property.port_name,
        RTI_APP_SEND_PORT_NAME, OSAPI_String_length(RTI_APP_SEND_PORT_NAME));
route_property->send_port_property.max_message_size = 1024;
route_property->send_port_property.max_queue_size = 20;
route_property->channel_identifier = 2;

/* Name of queuing port receiving from Connext application partition */
#define RTI_APP_RECV_PORT_NAME "Part2_recv"

ARINC_ReceivePortPropertySeq_set_maximum(&port_mgr_prop->receive_ports,1);
ARINC_ReceivePortPropertySeq_set_length(&port_mgr_prop->receive_ports,1);
receive_port_prop = (struct ARINC_ReceivePortProperty*)
          ARINC_ReceivePortPropertySeq_get_reference(&port_mgr_prop->receive_ports,0);
receive_port_prop->receive_port_property.max_message_size = 1024;
receive_port_prop->receive_port_property.max_queue_size = 20;
receive_port_prop->max_receive_queue_size = 20;
receive_port_prop->channel_identifier = 1;
OSAPI_Memory_copy(receive_port_prop->receive_port_property.port_name,
      RTI_APP_RECV_PORT_NAME, OSAPI_String_length(RTI_APP_RECV_PORT_NAME));
```

Now the channel identifier can be used as an address to send messages over this channel. For example, Partition 1 may set its initial peers as:

```
struct DDS_DomainParticipantQos dp_qos = DDS_DomainParticipantQos_INITIALIZER;
DDS_StringSeq_set_maximum(&dp_qos.discovery.initial_peers,1);
DDS_StringSeq_set_length(&dp_qos.discovery.initial_peers,1);

/*send discovery data on channel 1*/
*DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers,0) =
    DDS_String_dup("_arinc://1");
```

Partition 1 may also set the enabled transports to receive data as follows:

```
struct DDS_DomainParticipantQos dp_qos = DDS_DomainParticipantQos_INITIALIZER;
/* Receive user-data traffic on channel number 2. */
DDS_StringSeq_set_maximum(&dp_qos.user_traffic.enabled_transports,1);
DDS_StringSeq_set_length(&dp_qos.user_traffic.enabled_transports,1);
*DDS_StringSeq_get_reference(&dp_qos.user_traffic.enabled_transports,0) =
                      DDS_String_dup("_arinc://2");

/* Receive discovery traffic on channel number 2. */
DDS_StringSeq_set_maximum(&dp_qos.discovery.enabled_transports,1);
DDS_StringSeq_set_length(&dp_qos.discovery.enabled_transports,1);
 *DDS_StringSeq_get_reference(&dp_qos.discovery.enabled_transports,0) =
                               DDS_String_dup("_arinc://2");
```

If there was a second participant in Partition 1, it must use a different ARINC interface configuration by enabling a separate ARINC transport. Such an transport must first be registered, as described in *ARINC Interface*. Below is an example of how to configure the QoS of a second participant in the same partition to use the `ar_2` ARINC transport component:

```
struct DDS_DomainParticipantQos dp2_qos = DDS_DomainParticipantQos_INITIALIZER;
DDS_StringSeq_set_maximum(&dp2_qos.discovery.initial_peers,1);
DDS_StringSeq_set_length(&dp2_qos.discovery.initial_peers,1);

/*send discovery data on channel 3*/
*DDS_StringSeq_get_reference(&dp2_qos.discovery.initial_peers,0) =
    DDS_String_dup("ar_2://3");

/* Receive user-data traffic on channel number 4. */
DDS_StringSeq_set_maximum(&dp2_qos.user_traffic.enabled_transports,1);
DDS_StringSeq_set_length(&dp2_qos.user_traffic.enabled_transports,1);
*DDS_StringSeq_get_reference(&dp2_qos.user_traffic.enabled_transports,0) =
                      DDS_String_dup("ar_2://4");

/* Receive discovery traffic on channel number 4. */
DDS_StringSeq_set_maximum(&dp2_qos.discovery.enabled_transports,1);
DDS_StringSeq_set_length(&dp2_qos.discovery.enabled_transports,1);
 *DDS_StringSeq_get_reference(&dp2_qos.discovery.enabled_transports,0) =
                               DDS_String_dup("ar_2://4");
```

Unlike some other transports, such as UDP, it necessary to specify the specific address or addresses in the enabled transport lists. If no address is provided with the ARINC Interface name, then creation of the entity will fail. This explicit configuration prevents unexpected behavior from unintentionally listening on an address.

Addressing Misconfiguration

The ARINC locators specified in the initial peers and enabled transports lists will be automatically verified to correspond to a channel configured in the Port Manager. If a participants's initial peer list contains an ARINC locator which does not match a send channel, then creation of the participant will fail. If an ARINC locator in the enabled transports of a Domain Participant, Data Writer, or Data Reader does not match a receive channel, then creation of that entity will fail.

However, Micro does not consider reachability as a factor in determining matching. It is possible for an ARINC locator to be received during the discovery process which corresponds to an address which is not reachable by that participant. This locator will be ignored because it is expected that unreachable locators will sometimes be received. In that case, a Data Writer and Data Writer can match even if there is not a channel on which they can communicate. This situation is considered misconfiguration of the application.

Threading Model

The port manager creates an ARINC 653 process to receive messages from the ports. This process can work in two modes dictated by the `sync_processing` property.

When `sync_processing` is true, every message received is routed to the correct interface. When this message is being processed, it blocks messages being received from other ports and hence blocks other participants. The ARINC interface does not create any process since messages are processed in the context of the port manager's Receive process.

When `sync_processing` is false, (the default behavior) the port manager's process adds messages to an internal queue for the destination ARINC interface. The ARINC interface process then processes it asynchronously. This ARINC interface process and the queue size are configured using the ARINC_InterfaceFactoryProperty. Asynchronous processing of messages allows the port manager process to not block other participants but add costs as additional processes and queues per ARINC interface.

4.8 Discovery

This section discusses the implementation of discovery plugins in *RTI Connext Micro*. For a general overview of discovery in *RTI Connext Micro*, see *What is Discovery?*.

Connext Micro discovery traffic is conducted through transports. Please see the *Transports* section for more information about registering and configuring transports.

4.8.1 What is Discovery?

Discovery is the behind-the-scenes way in which *RTI Connext Micro* objects (*DomainParticipants*, *DataWriters*, and *DataReaders*) on different nodes find out about each other. Each *DomainParticipant* maintains a database of information about all the active *DataReaders* and *DataWriters* that are in the same DDS 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.

This section describes the default discovery mechanism known as the 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 that are in its peers list. The peers list is the list of nodes with which a participant may communicate. It starts out the same as the *initial_peers* list that you configure in the DISCOVERY QosPolicy. If the accept_unknown_peers flag in that same QosPolicy is TRUE, then other nodes may also be added as they are discovered; if it is FALSE, then the peers list will match the initial_peers list, plus any peers added using the *DomainParticipant's* **add_peer()** operation.

The following section discusses how *Connext Micro* objects on different nodes find out about each other using the default Simple Discovery Protocol (SDP). It describes the sequence of messages that are passed between *Connext Micro* on the sending and receiving sides.

Note that this chapter is shared between *Connext Micro* and *Connext Cert*. However *Connext Cert* only supports static endpoint discovery described in *Static Discovery Plugin*.

The discovery process occurs automatically, so you do not have to implement any special code. For more information about advanced topics related to Discovery, please refer to the Discovery chapter in the *RTI Connext DDS Core Libraries User's Manual* (available here if you have Internet access).

Simple Participant Discovery

This phase of the Simple Discovery Protocol is performed by the Simple Participant Discovery Protocol (SPDP) and is common for both dynamic and static endpoint discovery.

During the Participant Discovery phase, *DomainParticipants* learn about each other. The *DomainParticipant*'s details are communicated to all other *DomainParticipants* in the same DDS domain by sending participant declaration messages, also known as participant *DATA* submessages. The details include the *DomainParticipant*'s unique identifying key (GUID or Globally Unique ID described below), transport locators (addresses and port numbers), and QoS. These messages are sent on a periodic basis using best-effort communication.

Participant DATAs are sent periodically to maintain the liveliness of the *DomainParticipant*. They are also used to communicate changes in the *DomainParticipant*'s QoS. Only changes to QosPolicies that are part of the *DomainParticipant*'s built-in data need to be propagated.

When receiving remote participant discovery information, *Connext Micro* determines if the local participant matches the remote one. A 'match' between the local and remote participant occurs only if the local and remote participant have the same Domain ID. This matching process occurs as soon as the local participant receives discovery information from the remote one. If there is no

match, the discovery DATA is ignored, resulting in the remote participant (and all its associated entities) not being discovered.

When a *DomainParticipant* is deleted, a participant *DATA (delete)* submessage with the *DomainParticipant*'s identifying GUID is sent.

The GUID is a unique reference to an entity. It is composed of a GUID prefix and an Entity ID. By default, the GUID prefix is calculated. The entityID is set by *Connext Micro* (you may be able to change it in a future version).

Once a pair of remote participants have discovered each other, they can move on to the Endpoint Discovery phase, which is how *DataWriters* and *DataReaders* find each other.

Simple Endpoint Discovery

This phase of the Simple Discovery Protocol is performed by the Simple Endpoint Discovery Protocol (SEDP).

During the Endpoint Discovery phase, *DataWriters* and *DataReaders* are *matched*. Information (GUID, QoS, etc.) about your application's *DataReaders* and *DataWriters* is exchanged by sending publication/subscription declarations in DATA messages that we will refer to as *publication DATAs* and *subscription DATAs*. The Endpoint Discovery phase uses reliable communication.

These declarations or DATA messages are exchanged until each *DomainParticipant* has a complete database of information about the participants in its peers list and their entities. Then the discovery process is complete and the system switches to a steady state. During steady state, *participant DATAs* are still sent periodically to maintain the liveliness status of participants. They may also be sent to communicate QoS changes or the deletion of a *DomainParticipant*.

When a remote *DataWriter/DataReader* is discovered, *Connext Micro* determines if the local application has a matching *DataReader/DataWriter*. A 'match' between the local and remote entities occurs only if the *DataReader* and *DataWriter* have the same *Topic*, same data type, and compatible QosPolicies. Furthermore, if the *DomainParticipant* has been set up to ignore certain *DataWriters/DataReaders*, those entities will not be considered during the matching process.

This 'matching' process occurs as soon as a remote entity is discovered, even if the entire database is not yet complete: that is, the application may still be discovering other remote entities.

A *DataReader* and *DataWriter* can only communicate with each other if each one's application has hooked up its local entity with the matching remote entity. That is, both sides must agree to the connection.

Please refer to the section on Discovery Implementation in the *RTI Connext DDS Core Libraries User's Manual* for more details about the discovery process (available here if you have Internet access).

4.8.2 Configuring Participant Discovery Peers

An *RTI Connext Micro DomainParticipant* must be able to send participant discovery announcement messages for other *DomainParticipants* to discover itself, and it must receive announcements from other *DomainParticipants* to discover them.

To do so, each *DomainParticipant* will send its discovery announcements to a set of locators known as its peer list, where a peer is the transport locator of one or more potential other *DomainParticipants* to discover.

The Peer Address

A peer descriptor string of the initial_peers sequence defines the interface and address of the locator to which to send, as well as the indices of participants to which to send. The peer descriptor format is:

```
< > denotes optional
[ ] denotes range or discreet values, unless enclosed in ''
    which means a literal.

ADDRESS = <PREFIX://><ADDRESS> |
          @<PREFIX://><ADDRESS> |
          INDEX@<PREFIX>://<ADDRESS>

INDEX = INTEGER | '[' INTEGER ']' | '[' INTEGER-INTEGER ']' | '[' -INTEGER ']'

PREFIX = [a-zA-Z_][0-9a-zA-Z_]+

INTEGER = DEC_INTEGER | HEX_INTEGER

DEC_INTEGER = [0-9]+

HEX_INTEGER = [0x|0X][0-9a-fA-F]+

ADDRESS = 0 or more 8bit characters
```

Note that while the `PREFIX` is marked optional, it should always be used.

Remember that every *DomainParticipant* has a participant index that is unique within a DDS domain. The participant index (also referred to as the participant ID), together with the DDS domain ID, is used to calculate the network ports on which *DataReaders* of that participant will receive messages. Thus, by specifying the participant index, or a range of indices, for a peer locator, that locator becomes one or more ports to which messages will be sent only if addressed to the entities of a particular *DomainParticipant*. Specifying indices restricts the number of participant announcements sent to a locator where other *DomainParticipants* exist and, thus, should be considered to minimize network bandwidth usage.

For example:

```
DDS_StringSeq_set_maximum(&dp_qos.discovery.initial_peers, 5);
DDS_StringSeq_set_length(&dp_qos.discovery.initial_peers, 5);

/* If the index is not specified, it defaults to 5, thus sending to
 * the first 6 participant IDs on at IP address 192.168.1.1 using
 * the transport registered as _udp.
 */
*DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers, 0) =
     DDS_String_dup("_udp://192.168.1.1");

/* Only send participant annoucements to multicast address 239.255.0.1
 * using the transport registered as _udp. Note that for multicast
 * addresses the index is not relevant since it is a shared address.
 */
*DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers, 1) =
     DDS_String_dup("_udp://239.255.0.1");

/* Send annoucements to participant ID 1,2,3, and 4 on 10.10.30.101
 * using the transport registered as _udp.
 */
*DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers, 2) =
     DDS_String_dup("[1-4]@_udp://10.10.30.101");

/* Send annoucements to participant ID 2 on address 10.10.30.102
 * using the transport registered as _udp.
 */
*DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers, 3) =
     DDS_String_dup("[2]@_udp://10.10.30.102");

/* Send annoucements to participant ID 0-8 on address 10.10.30.102
 * using the transport registered as _udp.
 */
*DDS_StringSeq_get_reference(&dp_qos.discovery.initial_peers, 4) =
     DDS_String_dup("8@_udp://10.10.30.102");
```

4.8.3 Configuring Initial Peers and Adding Peers

DiscoveryQosPolicy_initial_peers is the list of peers a *DomainParticipant* sends its participant announcement messages, when it is enabled, as part of the discovery process.

DiscoveryQosPolicy_initial_peers is an empty sequence by default.

Peers can also be added to the list, before and after a *DomainParticipant* has been enabled, by using DomainParticipant_add_peer.

The *DomainParticipant* will start sending participant announcement messages to the new peer as soon as it is enabled.

4.8.4 Configuring Discovery Data Reception

In order to *receive* discovery and user data, it is necessary to configure the `DomainParticipantQos.discovery.enabled_transports` sequence. This is a sequence of transport addresses to listen for discovery data on, and is sent as part of the participant annoucements. Other *DomainParticipants* will send to these addresses.

The address format for configuring data reception uses the following format:

```
< > denotes optional
[ ] denotes range or discreet values, unless enclosed in ''
    which means a literal.

ADDRESS = <PREFIX://><ADDRESS>

PREFIX = [a-zA-Z_][0-9a-zA-Z_]+

ADDRESS = 0 or more 8bit characters
```

Note that while the `PREFIX` is marked optional, it should always be used.

For example, to receive on a single unicast address:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.discovery.enabled_transports, 1);
DDS_StringSeq_set_length(&DomainParticipantQos.discovery.enabled_transports, 1);

/* Receive on the unicast address 192.168.1.1 using the transport registered
 * as _udp.
 */
*DDS_StringSeq_get_reference(&DomainParticipantQos.discovery.enabled_transports, 0) =
                            DDS_String_dup("_udp://192.168.1.1");
```

To receive on all unicast addresses allowed by the transport:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.discovery.enabled_transports, 1);
DDS_StringSeq_set_length(&DomainParticipantQos.discovery.enabled_transports, 1);

/* Receive on all unicast addresses allowed by the transport registered
 * as _udp. This is not recommended if more than 4 network interfaces are
 * allowed as it is non-deterministic which interfaces will be used.
 */
*DDS_StringSeq_get_reference(&DomainParticipantQos.discovery.enabled_transports, 0) =
                            DDS_String_dup("_udp://");
```

To receive on one unicast address and one multicast address:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.discovery.enabled_transports, 2);
DDS_StringSeq_set_length(&DomainParticipantQos.discovery.enabled_transports, 2);

*DDS_StringSeq_get_reference(&DomainParticipantQos.discovery.enabled_transports, 0) =
                            DDS_String_dup("_udp://192.168.1.1");
```

(continues on next page)

(continued from previous page)

```
*DDS_StringSeq_get_reference(&DomainParticipantQos.discovery.enabled_transports, 1) =
                              DDS_String_dup("_udp://239.255.0.1");
```

To receive on one multicast address:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.discovery.enabled_transports, 1);
DDS_StringSeq_set_length(&DomainParticipantQos.discovery.enabled_transports, 1);

*DDS_StringSeq_get_reference(&DomainParticipantQos.discovery.enabled_transports, 0) =
                              DDS_String_dup("_udp://239.255.0.1");
```

4.8.5 Configuring User Data Reception

In order to *receive* discovery and user data, it is necessary to configure the `DomainParticipantQos.user_traffic.enabled_transports` sequence. This is a sequence of default transport addresses to listen for user data on, unless a *DataReader* or *DataWriter* specifies its own address, and is sent as part of the participant annoucements. Other *DomainParticipants* will send to these addresses.

The address format for configuring data reception uses the following format:

```
< > denotes optional
[ ] denotes range or discreet values, unless enclosed in ''
    which means a literal.

ADDRESS = <PREFIX://><ADDRESS>

PREFIX = [a-zA-Z_][0-9a-zA-Z_]+

ADDRESS = 0 or more 8bit characters
```

Note that while the `PREFIX` is marked optional, it should always be used.

For example, to receive on a single unicast address:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.user_traffic.enabled_transports, 1);
DDS_StringSeq_set_length(&DomainParticipantQos.user_traffic.enabled_transports, 1);

/* Receive on the unicast address 192.168.1.1 using the transport registered
 * as _udp.
 */
*DDS_StringSeq_get_reference(&DomainParticipantQos.user_traffic.enabled_transports, 0) =
                              DDS_String_dup("_udp://192.168.1.1");
```

To receive on all unicast addresses allowed by the transport:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.user_traffic.enabled_transports, 1);
DDS_StringSeq_set_length(&DomainParticipantQos.user_traffic.enabled_transports, 1);

/* Receive on all unicast addresses allowed by the transport registered
 * as _udp. This is not recommended if more than 4 network interfaces are
```

(continues on next page)

(continued from previous page)

```
 * allowed as it is non-deterministic which interfaces will be used.
 */
*DDS_StringSeq_get_reference(&DomainParticipantQos.user_traffic.enabled_transports, 0) =
                              DDS_String_dup("_udp://");
```

To receive on one unicast address and one multicast address:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.user_traffic.enabled_transports, 2);
DDS_StringSeq_set_length(&DomainParticipantQos.user_traffic.enabled_transports, 2);

*DDS_StringSeq_get_reference(&DomainParticipantQos.user_traffic.enabled_transports, 0) =
                              DDS_String_dup("_udp://192.168.1.1");

*DDS_StringSeq_get_reference(&DomainParticipantQos.user_traffic.enabled_transports, 1) =
                              DDS_String_dup("_udp://239.255.0.1");
```

Note: When both multicast and unicast is specified, the following rules are used:

- New data is sent over multicast.
- Retransmissions are sent over unicast.

To receive on one multicast address:

```
DDS_StringSeq_set_maximum(&DomainParticipantQos.user_traffic.enabled_transports, 1);
DDS_StringSeq_set_length(&DomainParticipantQos.user_traffic.enabled_transports, 1);

*DDS_StringSeq_get_reference(&DomainParticipantQos.user_traffic.enabled_transports, 0) =
                              DDS_String_dup("_udp://239.255.0.1");
```

4.8.6 Configuring User Data Reception per DataReader or DataWriter

A *DataReader* and *DataWriter* can specify its own addresses in the `DataReaderQos.transport.enabled_transports` and `DataWriterQos.transport.enabled_transports` policies. The address format is exactly the same as for `DomainParticipantQos.user_traffic.enabled_transports`, with the restriction that a *DataWriter* can only specify its own unicast addresses.

4.8.7 Discovery Plugins

When a *DomainParticipant* receives a participant discovery message from another *DomainParticipant*, it will engage in the process of exchanging information of user-created *DataWriter* and *DataReader* endpoints.

RTI Connext Micro provides two ways of determinig endpoint information of other *DomainParticipants*: *Dynamic Discovery Plugin* and *Static Discovery Plugin*.

Dynamic Discovery Plugin

Dynamic endpoint discovery uses builtin discovery *DataWriters* and *DataReader* to exchange messages about user created *DataWriter* and *DataReaders*. A *DomainParticipant* using dynamic participant, dynamic endpoint (DPDE) discovery will have a pair of builtin *DataWriters* for sending messages about its own user created *DataWriters* and *DataReaders*, and a pair of builtin *DataReaders* for receiving messages from other *DomainParticipants* about their user created *DataWriters* and *DataReaders*.

Given a *DomainParticipant* with a user *DataWriter*, receiving an endpoint discovery message for a user *DataReader* allows the *DomainParticipant* to get the type, topic, and QoS of the *DataReader* that determine whether the *DataReader* is a match. When a matching *DataReader* is discovered, the *DataWriter* will include that *DataReader* and its locators as destinations for its subsequent writes.

Static Discovery Plugin

Static endpoint discovery uses function calls to statically assert information about remote endpoints belonging to remote *DomainParticipants*. An application with a *DomainParticipant* using dynamic participant, static endpoint (DPSE) discovery has control over which endpoints belonging to particular remote *DomainParticipants* are discoverable.

Whereas dynamic endpoint-discovery can establish matches for all endpoint-discovery messages it receives, static endpoint-discovery establishes matches *only* for the endpoint that have been asserted programmatically. When a *DomainParticipant* receives a participant discovery message from another *DomainParticipant*, it will engage in the process of matching previously asserted user-created *DataWriter* and *DataReader* endpoints.

With DPSE, a user needs to know *a priori* the configuration of the entities that will need to be discovered by its application. The user must know the names of all *DomainParticipants* within the DDS domain and the exact QoS of the remote *DataWriters* and *DataReaders*.

Please refer to the C API Reference and C++ API Reference for the following remote entity assertion APIs:

- DPSE_RemoteParticipant_assert
- DPSE_RemotePublication_assert
- DPSE_RemoteSubscription_assert

Remote Participant Assertion

Given a local *DomainParticipant*, static discovery requires first the names of remote *DomainParticipants* to be asserted, in order for endpoints on them to match. This is done by calling DPSE_RemoteParticipant_assert with the name of a remote *DomainParticipant*. The name must match the name contained in the participant discovery announcement produced by that *DomainParticipant*. This has to be done reciprocally between two *DomainParticipants* so that they may discover one another.

For example, a *DomainParticipant* has entity name "participant_1", while another *DomainParticipant* has name "participant_2." participant_1 should call DPSE_RemoteParticipant_assert("participant_2") in order to discover participant_2. Similarly, participant_2 must also assert participant_1 for discovery between the two to succeed.

```
/* participant_1 is asserting (remote) participant_2 */
retcode = DPSE_RemoteParticipant_assert(participant_1,
                                        "participant_2");
if (retcode != DDS_RETCODE_OK) {
    printf("participant_1 failed to assert participant_2\n");
    goto done;
}
```

Remote Publication and Subscription Assertion

Next, a *DomainParticipant* needs to assert the remote endpoints it wants to match that belong to an already asserted remote *DomainParticipant*. The endpoint assertion function is used, specifying an argument which contains all the QoS and configuration of the remote endpoint. Where DPDE gets remote endpoint QoS information from received endpoint-discovery messages, in DPSE, the remote endpoint's QoS must be configured locally. With remote endpoints asserted, the *DomainParticipant* then waits until it receives a participant discovery announcement from an asserted remote *DomainParticipant*. Once received that, all endpoints that have been asserted for that remote *DomainParticipant* are considered discovered and ready to be matched with local endpoints.

Assume participant_1 contains a *DataWriter*, and participant_2 has a *DataReader*, both communicating on topic HelloWorld. participant_1 needs to assert the *DataReader* in participant_2 as a remote subscription. The remote subscription data passed to the operation must match exactly the QoS actually used by the remote *DataReader*:

```
/* Set participant_2's reader's QoS in remote subscription data  */
rem_subscription_data.key.value[DDS_BUILTIN_TOPIC_KEY_OBJECT_ID] = 200;
rem_subscription_data.topic_name = DDS_String_dup("Example HelloWorld");
rem_subscription_data.type_name = DDS_String_dup("HelloWorld");
rem_subscription_data.reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

/* Assert reader as a remote subscription belonging to (remote) participant_2 */
retcode = DPSE_RemoteSubscription_assert(participant_1,
                                         "participant_2",
                                         &rem_subscription_data,
                                         HelloWorld_get_key_kind(HelloWorldTypePlugin_
↪get(), NULL));
if (retcode != DDS_RETCODE_OK)
{
    printf("failed to assert remote subscription\n");
    goto done;
}
```

Reciprocally, participant_2 must assert participant_1's *DataWriter* as a remote publication, also specifying matching QoS parameters:

```
/* Set participant_1's writer's QoS in remote publication data  */
rem_publication_data.key.value[DDS_BUILTIN_TOPIC_KEY_OBJECT_ID] = 100;
rem_publication_data.key.value.topic_name = DDS_String_dup("Example HelloWorld");
rem_publication_data.key.value.type_name = DDS_String_dup("HelloWorld");
rem_publication_data.key.value.reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

/* Assert writer as a remote publication belonging to (remote) participant_1 */
retcode = DPSE_RemotePublication_assert(participant_2,
                                        "participant_1",
                                        &rem_publication_data,
                                        HelloWorld_get_key_kind(HelloWorldTypePlugin_
↪get(), NULL));
if (retcode != DDS_RETCODE_OK)
{
    printf("failed to assert remote publication\n");
    goto done;
}
```

When participant_1 receives a participant discovery message from participant_2, it is aware of participant_2, based on its previous assertion, and it knows participant_2 has a matching *DataReader*, also based on the previous assertion of the remote endpoint. It therefore establishes a match between its *DataWriter* and participant_2's *DataReader*. Likewise, participant_2 will match participant_1's *DataWriter* with its local *DataRead*, upon receiving one of participant_1's participant discovery messages.

Note, with DPSE, there is no runtime check of QoS consistency between *DataWriters* and *DataReaders*, because no endpoint discovery messages are exchanged. This makes it extremely important that users of DPSE ensure that the QoS set for a local *DataWriter* and *DataReader* is the same QoS being used by another *DomainParticipant* to assert it as a remote *DataWriter* or *DataReader*.

4.8.8 Asymmetric Matching and Lost Samples

The DDS discovery process is necessary to establish communication between a *DataWriter* and a *DataReader*. However, it is important to understand that DDS applications do not connect to each other; there is no handshake protocol to ensure that a *DataReader* is ready to receive data from a *DataWriter*. Thus, it is possible that a *DataWriter* matches a *DataReader* before the *DataReader* matches the *DataWriter* (and vice versa). For this reason, it is possible that data published by a *DataWriter* is not received by the *DataReader*, even on a local network.

The reason for this asymmetric behavior can be for any number of reasons, such as, but not limited to:

- Network delays
- Packets taking different paths through the network
- Address resolution delays
- OS scheduling

DDS offers some solutions to mitigate this problem, e.g., the DURABILITY QoS policy, but in other cases it may be necessary for applications to implement their own synchronization protocols.

4.9 Configuring Resource Limits

4.9.1 Introduction

Connext Micro is designed for use in real-time systems and uses a predictable and deterministic memory manager to ensure that memory growth is not unbounded, OS memory fragmentation is eliminated and memory usage can be determined a-priori. The advantage with this design is that proper operation is ensured as soon as steady state has been reached. However, it also places an additional burden on the system designer to properly configure each resource limit. The purpose of this document is to describe all resource limits in *Connext Micro*, what the behavioral impact is, and what the impact on memory usage is.

4.9.2 Resource Limits

All resource limits in *Connext Micro* are specified in a QoS policy or property. Please refer to the links to the API Reference below for more details, and refer to the *Micro Memory Map* below for an overview of how the memory is used by each resource limit.

DomainParticipantFactoryQos

See DomainParticipantFactoryQos for more detail.

DomainParticipantQos

The DomainParticipantQos controls resources that are applicable to the entire DomainParticipant. All the resources specified in the DomainParticipantQos are allocated when the DomainParticipant is created with the DDS_DomainParticipantFactory_create_participant() call.

DataReaderQos

The DataReaderQos controls the resources used by the DDS_DataReader. Each DDS_DataReader allocates its own resources, even DDS_DataReader's of the same DDS_Topic. For this reason is it advised to limit the number of DDS_DataReader's per DDS_Topic to one.

DataWriterQos

The DataWriterQos controls the resources allocated by a DDS_DataWriter. Each DDS_DataWriter allocates its own resources, even DDS_DataWriters of the same DDS_Topic. For this reason is it advised to limit the number of DDS_DataWriters per topic to one.

UDP Transport

See UDP Transport for more details.

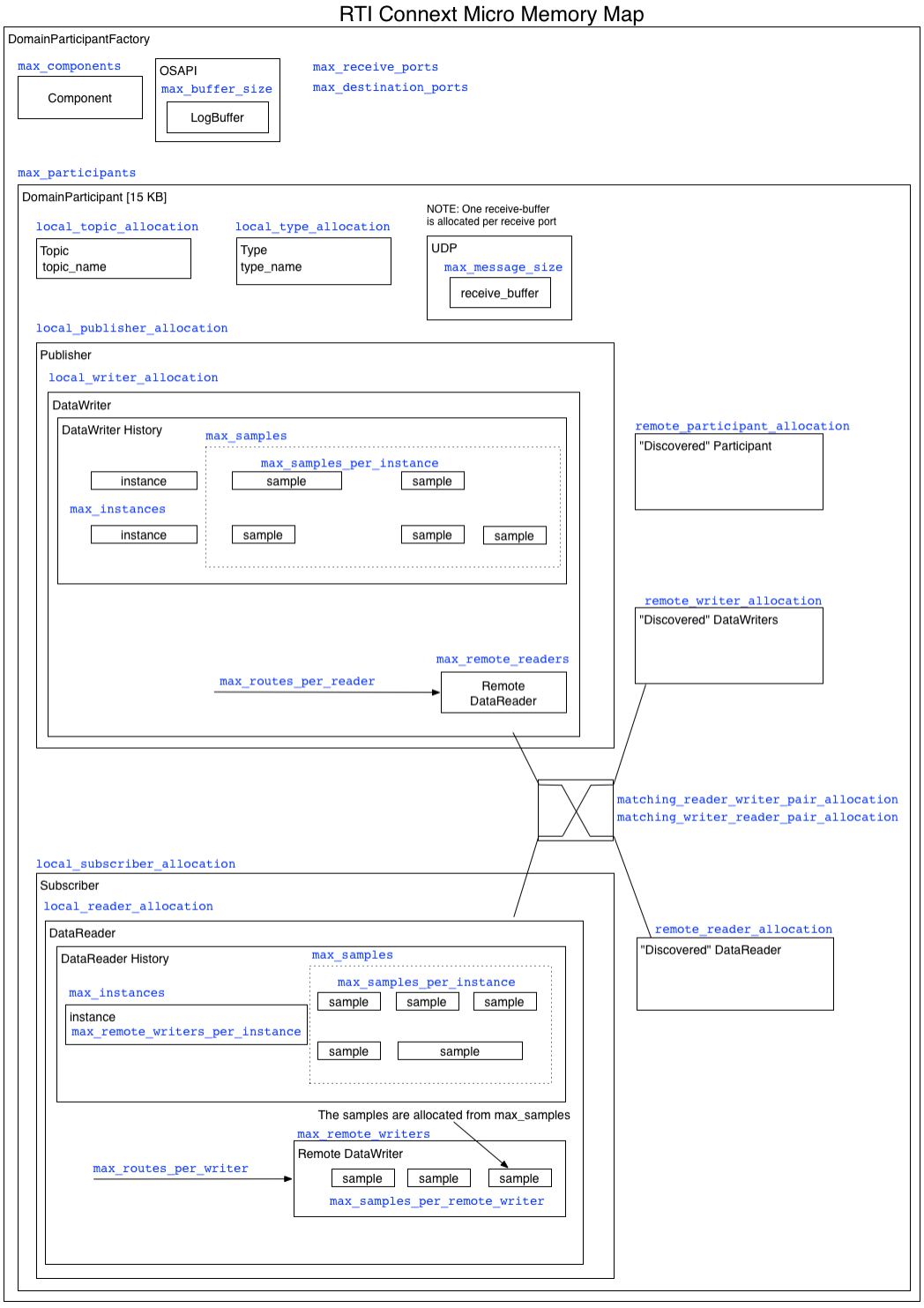
Dynamic Participant Static Endpoint (DPSE)

The Dynamic Participant Static Endpoint (DPSE) discovery plugin creates one DDS_DataWriter and one DDS_DataReader for the ParticipantBuiltinTopicData. The memory for the plugin includes the memory allocated by the DDS_DataReader and DDS_DataWriter. The memory allocated by the properties must be added for total memory usage.

Dynamic Participant Dynamic Endpoint (DPDE)

The Dynamic Participant Dynamic Endpoint (DPDE) discovery plugin creates one DDS_DataWriter and one DDS_DataReader for each ParticipantBuiltinTopicData, PublicationBuiltinTopicData, and SubscriptionBuiltinTopicData. The memory for the plugin includes the memory allocated by these DDS_DataReaders and DDS_DataWriters. The memory allocated by the properties must be added for total memory usage.

Memory Map


RTI Connext Micro Memory Map
DomainParticipantFactory
max_components
Component
OSAPI
max_buffer_size
LogBuffer
max_receive_ports
max_destination_ports
max_participants
DomainParticipant [15 KB]
local_topic_allocation
Topic
topic_name
local_type_allocation
Type
type_name
NOTE: One receive-buffer
is allocated per receive port
UDP
max_message_size
receive_buffer
local_publisher_allocation
Publisher
local_writer_allocation
DataWriter
DataWriter History
max_samples
max_samples_per_instance
instance
sample
sample
max_instances
instance
sample
sample
sample
remote_participant_allocation
"Discovered" Participant
remote_writer_allocation
"Discovered" DataWriters
max_remote_readers
max_routes_per_reader
Remote
DataReader
matching_reader_writer_pair_allocation
matching_writer_reader_pair_allocation
local_subscriber_allocation
Subscriber
local_reader_allocation
DataReader
DataReader History
max_samples
max_samples_per_instance
max_instances
instance
max_remote_writers_per_instance
sample
sample
sample
sample
sample
remote_reader_allocation
"Discovered" DataReader
The samples are allocated from max_samples
max_remote_writers
Remote DataWriter
max_routes_per_writer
sample
sample
sample
max_samples_per_remote_writer

4.9.3 Dynamic Memory Allocation

Connext Micro allocates heap memory to create internal data-structures. It is important to know that *Connext Micro* manages memory allocated from the system heap using its own internal memory management, and only returns memory allocated from the system back to the system when something is deleted. That is, if an application never deletes anything, no memory is returned to the system.

As a rule of thumb, in *Connext Micro* the only APIs that allocate heap memory are:

- DDS_DomainParticipantFactory_get_instance().
- Those that contain the word "new", i.e. DDS_WaitSet_new().
- Those that contain the word "create", i.e. DDS_DomainParticipantFactory_create_participant().

And the only APIs that free memory are:

- DDS_DomainParticipantFactory_finalize_instance().
- Those that contain the word "delete", i.e. OSAPI_Waitset_delete().
- Those that contain the word "free", i.e. DDS_String_free().

Connext Micro does not support dynamically allocating resources beyond the initial configuration. That is, all resource limits must be finite. This restriction may be removed in a future version.

4.9.4 Internal Resource Allocation

Connext Micro allocates additional resources to entities based on internal needs. As a result, resource limits set by the user will often appear to have increased by a constant when read back. This is because *Connext Micro* uses additional internal readers and other entities. *Connext Micro* takes the user-defined value and adds a constant depending on the resource limit, topic and entity being used. For specific values, consult the table below.

See Heap Usage for further details on the amount of memory used by each resource limit in the memory model.

Table 4.3: *Connext Micro* Internal resource limit Modifications

resource limit	Modifications by Feature	
`local_topic_allocation`	DPSE[1]	1
	DPDE[2]	3
`local_type_allocation`	DPSE	1
	DPDE	3
`local_writer_allocation`	DPSE	1
	DPDE	3
`local_reader_allocation`	DPSE	1
	DPDE	3
`local_publisher_allocation`	DPSE	1
	DPDE	1
`local_subscriber_allocation`	DPSE	1
	DPDE	1
`matching_writer_reader_pair_allocation`	DPSE	1
	DPDE	`remote_participant_allocation` * 6

4.10 Generating Type Support with rtiddsgen

4.10.1 Why Use rtiddsgen?

For *Connext Micro* to publish and subscribe to topics of user-defined types, the types have to be defined and programmatically registered with *Connext Micro*. A registered type is then serialized and deserialized by *Connext Micro* through a pluggable type interface that each type must implement.

Rather than have users manually implement each new type, *Connext Micro* provides the *rtiddsgen* utility for automatically generating type support code.

4.10.2 IDL Type Definition

rtiddsgen for *Connext Micro* accepts types defined in IDL. The HelloWorld examples included with *Connext Micro* use the following HelloWorld.idl:

```
struct HelloWorld
{
    string<128> msg;
};
```

[1] Dynamic Participant Static Endpoint. Not used concurrently with DPDE.
[2] Dynamic Participant Dynamic Endpoint. Not used concurrently with DPSE.

For further reference, see the section on Creating User Data Types with IDL in the *RTI Connext DDS Core Libraries User's Manual* (available here if you have Internet access).

4.10.3 Generating Type Support

Before running *rtiddsgen*, some environment variables must be set:

- `RTIMEHOME` sets the path of the *Connext Micro* installation directory
- `RTIMEARCH` sets the platform architecture (e.g. i86Linux2.6gcc4.4.5 or i86Win32VS2010)
- `JREHOME` sets the path for a Java JRE

Note that a JRE is shipped with *Connext Micro* on platforms supported for the execution of rtiddsgen (Linux®, Windows®, and Mac® OS X®). It is not necessary to set `JREHOME` on these platforms, unless a specific JRE is preferred.

C

Run *rtiddsgen* from the command line to generate C language type-support for a UserType.idl (and replace any existing generated files):

```
.. only:: not cert
```

> $rti_connext_micro_root/rtiddsgen/scripts/rtiddsgen -micro -language C -replace UserType.idl

C++

Run *rtiddsgen* from the command line to generate C++ language type-support for a UserType.idl (and replace any existing generated files):

```
> $rti_connext_micro_root/rtiddsgen/scripts/rtiddsgen -micro -language C++ -replace␣
↪UserType.idl
```

Notes on Command-Line Options

In order to target *Connext Micro* when generating code with *rtiddsgen*, the `-micro` option must be specified on the command line.

To list all command-line options specifically supported by *rtiddsgen* for *Connext Micro*, enter:

```
> rtiddsgen -micro -help
```

Existing users might notice that that previously available options, `-language microC``and ``-language microC++`, have been replaced by `-micro -language C` and``-micro -language C++``, respectively. It is still possible to specify `microC` and `microC++` for backwards compatibility, but users are advised to switch to using the `-micro` command-line option along with other arguments.

Generated Type Support Files

rtiddsgen will produce the following header and source files for each IDL file passed to it:

- UserType.h and UserType.c (.cxx for C++) implement creation/intialization and deletion (only for *Connext Micro* of a single sample and a sequence of samples of the type (or types) defined in the IDL description.
- UserTypePlugin.h and UserTypePlugin.c (.cxx for C++) implement the pluggable type interface that *Connext Micro* uses to serialize and deserialize the type.
- UserTypeSupport.h and UserTypeSupport.c(xx) define type-specific *DataWriters* and *DataReaders* for user-defined types.

4.10.4 Using custom data-types in Connext Micro Applications

A *Connext Micro* application must first of all include the generated headers. Then it must register the type with the *DomainParticipant* before a topic of that type can be defined. For an example HelloWorld type, the following code registers the type with the participant and then creates a topic of that type:

```
#include "HelloWorldPlugin.h"
#include "HelloWorldSupport.h"

/* ... */

retcode = HelloWorldTypeSupport_register_type(application->participant,
                                              "HelloWorld");
if (retcode != DDS_RETCODE_OK)
{
    /* Log an error */
    goto done;
}

application->topic = DDS_DomainParticipant_create_topic(
                                        application->participant,
                                        "Example HelloWorld",
                                        "HelloWorld",
                                        &DDS_TOPIC_QOS_DEFAULT, NULL,
                                        DDS_STATUS_MASK_NONE);

if (application->topic == NULL)
{
    /* Log an error */
    goto done;
}
```

See the full HelloWorld examples for further reference.

4.10.5 Customizing generated code

rtiddsgen allows *Connext Micro* users to select whether they want to generate code to subscribe to and/or publish a custom data-type. When generating code for subscriptions, only those parts of code dealing with deserialization of data and the implementation of a typed *DataReader* endpoint are generated. Conversely, only those parts of code addressing serialization and the implementation of a *DataWriter* are considered when generating publishing code.

Control over these options is provide by two command-line arguments:

- `-reader` generates code for deserializing custom data-types and creating *DataReaders* from them.
- `-writer` generates code for serializing custom data-types and creating *DataWriters* from them.

If neither of these two options are supplied to *rtiddsgen*, they will both be considered active and code for both *DataReaders* and *DataWriters* will be generated. If only one of the two options is supplied to *rtiddsgen*, only that one is enabled. If both options are supplied, both are enabled.

4.10.6 Unsupported Features of rtiddsgen with Connext Micro

Connext Micro supports a subset of the features and options in *rtiddsgen*. Use `rtiddsgen -micro -help` to see the list of features supported by *rtiddsgen* for *Connext Micro*.

4.11 Threading Model

4.11.1 Introduction

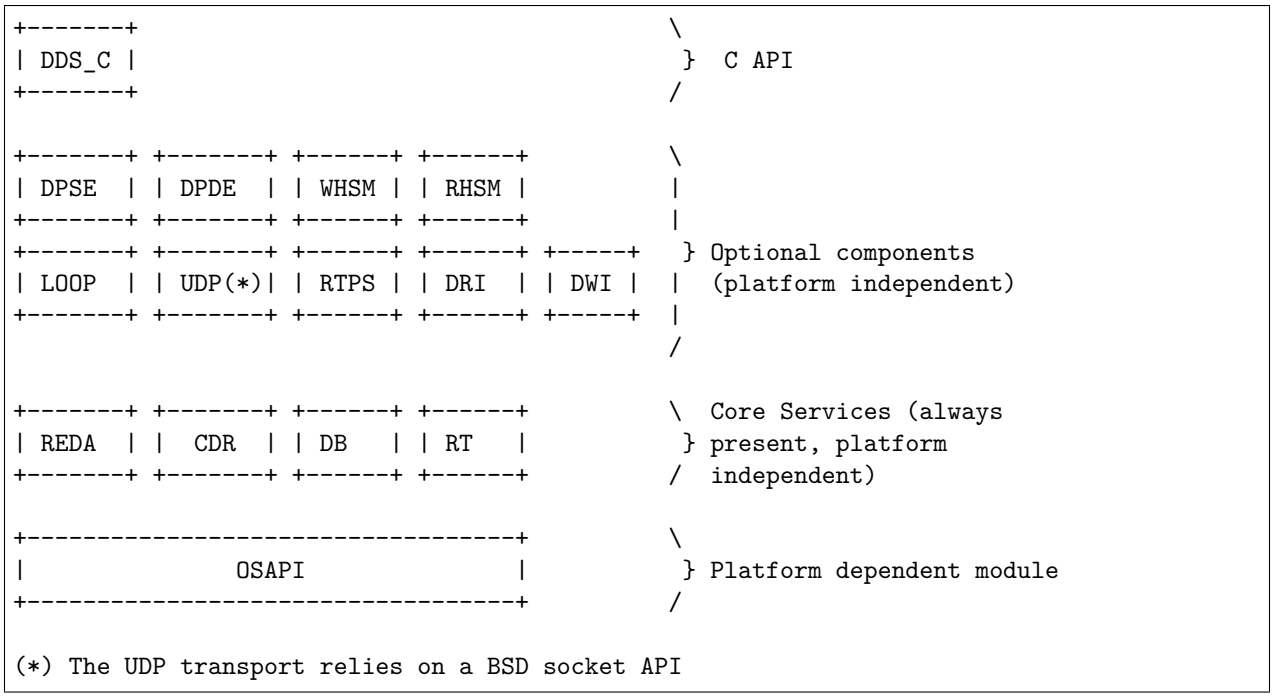
This section describes the threading model, the use of critical sections, and how to configure thread parameters in *RTI Connext Micro*. Please note that the information contained in this document applies to application development using *Connext Micro*. For information regarding *porting* the *Connext Micro* thread API to a new OS, please refer to *Porting RTI Connext Micro*.

This section includes:

- *Architectural Overview*
- *Threading Model*
- *UDP Transport Threads*

4.11.2 Architectural Overview

RTI Connext Micro consists of a core library and a number of components. The core library provides a porting layer, frequently used data-structures and abstractions, and the DDS API. Components provide additional functionality such as UDP communication, DDS discovery plugins, DDS history caches, etc.



4.11.3 Threading Model

RTI Connext Micro is architected in a way that makes it possible to create a port of *Connext Micro* that uses no threads, for example on platforms with no operating system or where the OS itself creates the threads which calls into *Connext Micro*. Thus, the following discussion is only applicable to *Connext Micro* libraries from RTI that runs on operating systems where *Connext Micro* is allowed to create threads. The platform specific notes provide additional information regarding integration with specific environments.

OSAPI Threads

The *Connext Micro* OSAPI layer creates one thread per OS process. This thread manages all the *Connext Micro* timers, such as deadline and liveliness timers. This thread is created by the *Connext Micro* OSAPI System when the OSAPI_System_initialize() function is called. When the *Connext Micro* DDS API is used DomainParticipantFactory_get_instance() calls this function once.

Configuring OSAPI Threads

The timer thread is configured through the OSAPI_SystemProperty structure and any changes must be made before OSAPI_System_initialize() is called. In *Connext Micro*, DomainParticipantFactory_get_instance() calls OSAPI_System_initialize(). Thus, if it is necessary to change the system timer thread settings, it must be done before DomainParticipantFactory_get_instance() is called the first time.

Please refer to OSAPI_Thread for supported thread options. Note that not all options are supported by all platforms.

```
struct OSAPI_SystemProperty sys_property = OSAPI_SystemProperty_INITIALIZER;

if (!OSAPI_System_get_property(&sys_property))
{
    /* ERROR */
}

/* Please refer to OSAPI_ThreadOptions for possible options */
sys.property.timer_property.thread.options = ....;

/* The stack-size is platform dependent, it is passed directly to the OS */
sys.property.timer_property.thread.stack_size = ....

/* The priority is platform dependent, it is passed directly to the OS */
sys.property.timer_property.thread.priority = ....

if (!OSAPI_System_set_property(&sys_property))
{
    /* ERROR */
}
```

UDP Transport Threads

Of the components that RTI provides, only the UDP component creates threads. The UDP transport creates one receive thread for each unique UDP receive resource. Thus, two UDP threads are created by default:

- A unicast receive thread for discovery data
- A unicast receive thread for user-data

Additional threads may be created depending on the transport configuration for a *DomainParticipant*, *DataReader* and *DataWriter*. The UDP transport creates threads based on the following criteria:

- Each unique unicast port creates a new thread
- Each unique multicast address *and* port creates a new thread

For example, if a *DataReader* specifies its own multicast receive address a new receive thread will be created.

Configuring UDP Receive Threads

All threads in the UDP transport share the same thread settings. It is important to note that all the UDP properties must be set before the UDP transport is registered. *Connext Micro* pre-registers the UDP transport with default settings when the DomainParticipantFactory is initialized. To change the UDP thread settings, use the following code.

```
RT_Registry_T *registry = NULL;
DDS_DomainParticipantFactory *factory = NULL;
struct UDP_InterfaceFactoryProperty *udp_property = NULL;

factory = DDS_DomainParticipantFactory_get_instance();

udp_property = (struct UDP_InterfaceFactoryProperty *)
                    malloc(sizeof(struct UDP_InterfaceFactoryProperty));
*udp_property = UDP_INTERFACE_FACTORY_PROPERTY_DEFAULT;

registry = DDS_DomainParticipantFactory_get_registry(factory);

if (!RT_Registry_unregister(registry, "_udp", NULL, NULL))
{
    /* ERROR */
}

/* Please refer to OSAPI_ThreadOptions for possible options */
udp_property->recv_thread.options = ...;

/* The stack-size is platform dependent, it is passed directly to the OS */
udp_property->recv_thread.stack_size = ....

/* The priority is platform dependent, it is passed directly to the OS */
udp_property->recv_thread.priority = ....

if (!RT_Registry_register(registry, "_udp",
                          UDP_InterfaceFactory_get_interface(),
                          (struct RT_ComponentFactoryProperty*)udp_property,
                          NULL))
{
    /* ERROR */
}
```

General Thread Configuration

The *Connext Micro* architecture consists of a number of components and layers, and each layer and component has its own properties. It is important to remember that the layers and components are configured independently of each other, as opposed to configuring everything through DDS. This design makes it possible to relatively easily swap out one part of the library for another.

All threads created based on *Connext Micro* OSAPI APIs use the same OSAPI_ThreadProperty structure.

4.11.4 Thread-Safety

All public APIs have a note about thread-safety included in the API reference manuals. It is important that an application does not violate thread-safety guidelines.

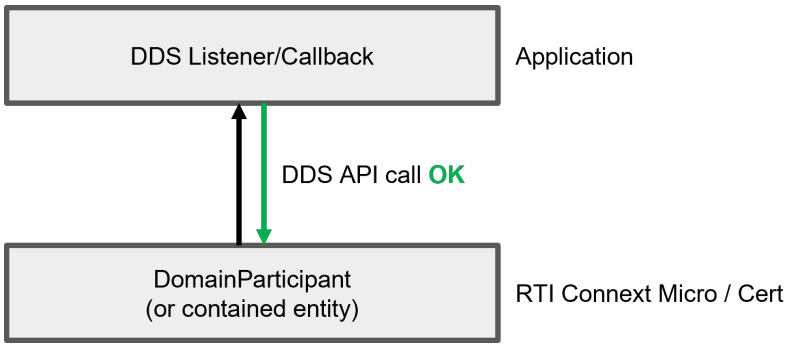
RTI Connext Micro may create multiple threads, but from an application point of view, there is only a single critical section protecting all DDS resources within a *DomainParticipant*.

Note: Although *Connext Micro* may create multiple mutexes, these are used to protect resources in the OSAPI layer, and are thus not relevant when using the public DDS APIs.

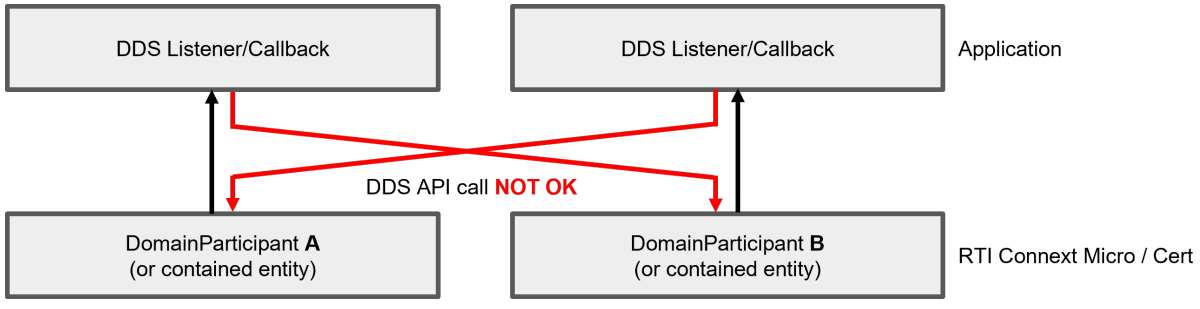
Calling DDS APIs from listeners and callbacks

When DDS is executing in a listener, it holds a critical section. Thus it is important to return as quickly as possible to avoid stalling network I/O.

There are no deadlock scenarios when a listener calls *Connext Micro* DDS APIs from the **same** *DomainParticipant* (and contained entities) that the listener was called from, as shown in the diagram below:



Warning: It is **not** safe to call DDS APIs from a **different** *DomainParticipant* than the one listener was called from, as shown in the diagram below. This may result in a deadlock situation.



Warning: There are no checks on whether or not an API call will cause problems, such as deleting a participant when processing data in on_data_available from a reader within the same participant.

Calling DDS APIs from a type-plugin

A user type-plugin that is registered with the *DomainParticipant* is subject to the following rules:

- The key kind is constant.
- The plugin is constant for a given DDS entity (*Topic*, *DataWriter*, or *DataReader*).
- The plugin data must be protected if thread safety is a concern, as it is user data and not protected by *Connext Micro*.

Note: A type-plugin generated from an IDL file with the *rtiddsgen* IDL compiler included with *Connext Micro* will satisfy these rules.

4.12 Batching

This section is organized as follows:

- *Overview*
- *Interoperability*
- *Performance*
- *Example Configuration*

4.12.1 Overview

Batching refers to a mechanism that allows *RTI Connext Micro* to collect multiple user data DDS samples to be sent in a single network packet, to take advantage of the efficiency of sending larger packets and thus increase effective throughput.

Connext Micro supports receiving batches of user data DDS samples, but does not support any mechanism to collect and send batches of user data.

Receiving batches of user samples is transparent to the application, which receives the samples as if the samples had been received one at a time. Note though that the reception sequence number refers to the sample sequence number, not the RTPS sequence number used to send RTPS messages. The RTPS sequence number is the batch sequence number for the entire batch.

A *Connext Micro DataReader* can receive both batched and non-batched samples.

For a more detailed explanation, please refer to the BATCH QosPolicy section in the *RTI Connext DDS Core Libraries User's Manual* (available here if you have Internet access).

4.12.2 Interoperability

RTI Connext DDS Professional supports both sending and receiving batches, whereas *RTI Connext Micro* supports only receiving batches. Thus, this feature primarily exists in *Connext Micro* to interoperate with *RTI Connext DDS* applications that have enabled batching. An *Connext Micro DataReader* can receive both batched and non-batched samples.

4.12.3 Performance

The purpose of batching is to increase throughput when writing small DDS samples at a high rate. In such cases, throughput can be increased several-fold, approaching much more closely the physical limitations of the underlying network transport.

However, collecting DDS samples into a batch implies that they are not sent on the network immediately when the application writes them; this can potentially increase latency. But, if the application sends data faster than the network can support, an increased proportion of the network's available bandwidth will be spent on acknowledgements and DDS sample resends. In this case, reducing that overhead by turning on batching could decrease latency while increasing throughput.

4.12.4 Example Configuration

This section includes several examples that explain how to enable batching in *RTI Connext DDS Professional*. For more detailed and advanced configuration, please refer to the *RTI Connext DDS Core Libraries User's Manual*.

- This configuration ensures that a batch will be sent with a maximum of 10 samples:

```
<datawriter_qos>
    <publication_name>
        <name>HelloWorldDataWriter</name>
    </publication_name>
    <batch>
        <enable>true</enable>
        <max_samples>10</max_samples>
    </batch>
</datawriter_qos>
```

- This configuration ensures that a batch is automatically flushed after the delay specified by max_flush_delay. The delay is measured from the time the first sample in the batch is written by the application:

```
<datawriter_qos>
    <publication_name>
        <name>HelloWorldDataWriter</name>
    </publication_name>
```

(continues on next page)

(continued from previous page)

```
    <batch>
        <enable>true</enable>
        <max_flush_delay>
            <sec>1</sec>
            <nanosec>0</nanosec>
        </max_flush_delay>
    </batch>
</datawriter_qos>
```

- The following configuration ensures that a batch is flushed automatically when max_data_bytes is reached (in this example 8192).

```
<datawriter_qos>
    <publication_name>
        <name>HelloWorldDataWriter</name>
    </publication_name>
    <batch>
        <enable>true</enable>
        <max_data_bytes>8192</max_data_bytes>
    </batch>
</datawriter_qos>
```

Note that max_data_bytes does not include the metadata associated with the batch samples.

Batches must contain whole samples. If a new batch is started and its initial sample causes the serialized size to exceed max_data_bytes, *RTI Connext DDS Professional* will send the sample in a single batch.

4.13 Message Integrity Checking

Connext Micro uses the DDS-I/RTPS protocol for communication between DDS applications, and RTPS messages are sent and received by a transport. When an RTPS message is sent across a communication link, such as Ethernet, it is possible that some bits may change value. These errors may cause communication failures or incorrect data to be received. In order to *detect* these types of errors, transports such as UDP often include a checksum to validate the integrity of the data: a sender adds the checksum to the transmitted data and the receiver validates that the calculated checksum for the received data matches the checksum received from the sender. If the checksums are different, a data corruption has occurred.

By default, *Connext Micro* relies on the underlying transport, such as UDP, to handle data integrity checking. However, the underlying transport may not provide sufficient integrity checking, or may itself introduce errors that *Connext Micro* must be able to detect regardless of the transport.

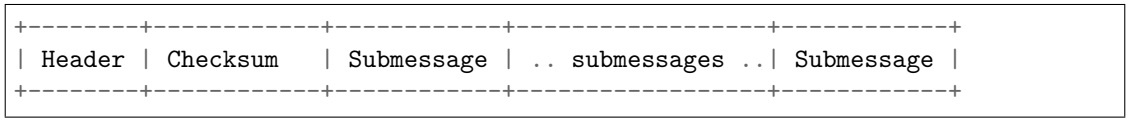
In order to address both of these scenarios for *any* transport, *Connext Micro* supports RTPS message integrity checking by adding a checksum to the RTPS message itself. This chapter describes the setup and default options to access this feature.

For information on how to write custom checksum functions, please refer to *RTPS*.

4.13.1 RTPS Checksum

Connext Micro implements checksum validation on a complete RTPS message. A typical RTPS message without a checksum has the following structure:

When the message integrity checking feature is enabled, the structure of the RTPS message changes as illustrated below:



The sender calculates the checksum for the entire message with a checksum field set to 0 and places the result in the checksum field.

The receiver saves the the received checksum, sets the received checksum field to 0, and calculates the checksum for the entire message. It then compares the calculated checksum with the received checksum. If the checksums differ, the entire RTPS message is considered corrupted.

Note that the checksum is used *only* for error *detection* and *not* for error *correction*.

4.13.2 Configurations

You can configure your application to define which algorithms to use and validate as well as the requirements enforced by the participant when communicating with other participants using the *DDS_WireProtocolQosPolicy*.

Configuring the message integrity checking consists of the two parts:

1. Selecting the checksum algorithm.
2. Configuring how a participant applies the checksums.

Selecting a checksum algorithm

Connext Micro supports three built-in algorithms and can be configured to use any of the following algorithms:

1. DDS_CHECKSUM_BUILTIN32: CRC-32 As defined by ISO/IEC 13239:2002.
2. DDS_CHECKSUM_BUILTIN64: CRC-64 As defined by ISO/IEC 13239:2002.
3. DDS_CRC_BUILTIN128: MD5 Message Digest

The CRC functions have the following properties:

Checksum	Polynom	Initial Value	Input Reflected	Output Reflected	XOR Value
CRC-32	0x04c11db7	2^32 - 1	true	true	2^32 - 1
CRC-64	0x1b	2^64 - 1	true	true	2^64 -1

In addition, four custom algorithms can implemented and used:

1. DDS_CHECKSUM_CUSTOM32
2. DDS_CHECKSUM_CUSTOM64
3. DDS_CHECKSUM_CUSTOM128
4. DDS_CHECKSUM_CUSTOM256

Please refer to *RTPS* for information on how to implement custom checksum functions.

Configuring the DDS DomainParticipant

The RTPS message integrity feature is configured in the *DDS_WireProtocolQosPolicy* for a participant. This QoS determines which RTPS checksum should be allowed, and if checksums should be sent and/or validated.

The following three fields determine how a participant uses RTPS checksums:

- *compute_crc* - This configures the participant to send a checksum with each RTPS message. Which checksum to send is determined by *computed_crc_kind*.
- *check_crc* - This configures the participant to verify the checksum in each received RTPS message if the checksum is present. If the checksum is valid, the message is accepted; otherwise, the message is dropped. If a message is received *without* a checksum, it is accepted and processed.
- *require_crc* - This configures the participant to *require* that a checksum is present in the receiving packet. Messages without a checksum are dropped without further processing. Note that this option is orthogonal to the *check_crc options*. This option only requires that a checksum is included, it does not validate it. To validate and only accept messages with a checksum, *both* check_crc and require_crc must be *true*.

The following two fields determine which checksums are used:

- *computed_crc_kind* - The checksum type to include in each RTPS message when *compute_crc* is *true*.
- *allowed_crc_mask* - A mask of all checksum algorithms that the participant can verify. This allows the participant to receive messages from other participants with a different *computed_crc_kind*. A participant will ignore a participant that is sending a checksum that it cannot validate.

For example, the following snippet shows how to configure the participant to:

- Send all messages (except the participant announcements; see the *Participant Discovery and Participant Compatibility* section below) with *DDS_CHECKSUM_BUILTIN64*.

- Accept *DDS_CHECKSUM_BUILTIN32*, *DDS_CHECKSUM_BUILTIN64*, and *DDS_CHECKSUM_BUILTIN128* algorithms.

```
struct DDS_DomainParticipantQos dp_qos =
                                    DDS_DomainParticipantQos_INITIALIZER;

dp_qos.protocol.computed_crc_kind =  DDS_CHECKSUM_BUILTIN64;

dp_qos.protocol.allowed_crc_mask = DDS_CHECKSUM_BUILTIN32
                                    | DDS_CHECKSUM_BUILTIN64
                                    | DDS_CHECKSUM_BUILTIN128;
```

4.13.3 Participant Discovery and Participant Compatibility

Connext Micro ensures that participants establish communication with each other only when they have compatible checksum configurations. If *compute_crc* is *true*, all messages sent from the participant are protected by a checksum. Since each participant can use a different type of checksum, a mechanism is required to ensure that participants are compatible during discovery.

To bootstrap this mechanism, all participant announcements (if *compute_crc* is set to true) include a checksum of type *DDS_CHECKSUM_BUILTIN32*. The participant announcement carries information about the *computed_crc_kind* (the checksum kind used by the participant) and the *allowed_crc_mask* (the checksum kinds understood by the participant), and whether or not the participant requires a checksum for each RTPS message (if *require_crc* is set to true). Please note that messages with *DDS_CHECKSUM_BUILTIN32* checksum are *always* accepted to enable discovering new participants.

For a Participant (A) to match with another Participant (B), the *computed_crc_kind* of Participant (B) must be a strict subset of the *allowed_crc_mask* of Participant (A) and vice versa. If Participant (B) does not send a checksum (*compute_crc* is set to false), it can only match Participant (A) if it does not set *require_crc* to true.

4.13.4 Interoperability with Connext DDS Professional

Connext DDS Professional supports a CRC 32-bit checksum. However, the RTPS submessage used by *Connext DDS Professional* to include a checksum is different from the one used by *Connext Micro* and what has been standardized by the OMG. *Connext Micro always* accepts *Connext DDS Professional*'s CRC32 and treats it as a *DDS_CHECKSUM_BUILTIN32*. However, in order to enable interoperability with *Connext DDS Professional* and enable *Connext DDS Professional* to validate the checksum, it is necessary to change the transmit mode of *Connext Micro*. Two transmit modes are available:

- RTPS_CRC_TXMODE_OMG - Use the standard method as defined by the OMG. This is the default mode. The checksums sent by *Connext Micro* are *not* understood by *Connext DDS Professional*, and *Connext DDS Professional* will accept the messages as not having a CRC32.
- RTPS_CRC_TXMODE_RTICRC32 - CRC32 Mode. This mode sets the *computed_crc_kind* to *DDS_CRC_BUILTIN32*. The checksum sent by *Connext Micro* is un-

derstood by Pro. Use this option only if the *Connext DDS Professional* application in your system needs checksum validation and has set *check_crc* to *true*.

4.14 Working With Sequences

4.14.1 Introduction

RTI Connext Micro uses IDL as the language to define data-types. One of the constructs in IDL is the *sequence*: a variable-length vector where each element is of the same type. This section describes how to work with sequences; in particular, the string sequence since it has special properties.

4.14.2 Working with Sequences

Overview

Logically a sequence can be viewed as a variable-length vector with N elements, as illustrated below. Note that sequences indices are 0 based.

There are three types of sequences in *Connext Micro*:

- Builtin sequences of primitive IDL types.
- Sequences defined in IDL using the sequence keyword.
- Sequences defined by the application.

The following builtin sequences exist (please refer to C API Reference and C++ API Reference for the complete API).

IDL Type	*Connext Micro* Type	*Connext Micro* Sequence
octet	DDS_Octet	DDS_OctetSeq
char	DDS_Char	DDS_CharSeq
boolean	DDS_Boolean	DDS_BooleanSeq
short	DDS_Short	DDS_ShortSeq
unsigned short	DDS_UnsignedShort	DDS_UnsignedShortSeq
long	DDS_Long	DDS_LongSeq
unsigned long	DDS_UnsignedLong	DDS_UnsignedLongSeq
enum	DDS_Enum	DDS_EnumSeq
wchar	DDS_Wchar	DDS_WcharSeq
long long	DDS_LongLong	DDS_LongLongSeq
unsigned long long	DDS_UnsignedLongLong	DDS_UnsignedLongLongSeq
float	DDS_Float	DDS_FloatSeq
double	DDS_Double	DDS_DoubleSeq
long double	DDS_LongDouble	DDS_LongDoubleSeq
string	DDS_String	DDS_StringSeq
wstring	DDS_Wstring	DDS_WstringSeq

The following are important properties of sequences to remember:

- All sequences in *Connext Micro must* be finite.
- All sequences defined in IDL are sized based on IDL properties and *must* not be resized. That is, *never* call **set_maximum()** on a sequence defined in IDL. This is particularly important for string sequences.
- Application defined sequences can be resized using **set_maximum()** or **ensure_length()**.
- There are two ways to use a **DDS_StringSeq** (they are type-compatible):
  - A **DDS_StringSeq** originating from IDL. This sequence is sized based on maximum sequence length *and* maximum string length.
  - A **DDS_StringSeq** originating from an application. In this case the sequence element memory is unmanaged.
- All sequences have an initial length of 0.

Working with IDL Sequences

Sequences that originate from IDL are created when the IDL type they belong to is created. IDL sequences are always initialized with the maximum size specified in the IDL file. The maximum size of a type, and hence the sequence size, is used to calculate memory needs for serialization and deserialization buffers. Thus, changing the size of an IDL sequence can lead to hard to find memory corruption.

The string and wstring sequences are special in that not only is the maximum sequence size allocated, but because strings are also always of a finite maximum length, the maximum space needed for each string element is also allocated. This ensure that *Connext Micro* can prevent memory overruns and validate input.

Some typical scenarios with a long sequence and a string sequence defined in IDL is shown below:

```
/* In IDL */
struct SomeIdlType
{
    // A sequence of 20 longs
    sequence<long,20> long_seq;

    // A sequence of 10 strings, each string has a maximum length of 255 bytes
    // (excluding NUL)
    sequence<string<255>,10> string_seq;
}

/* In C source */
SomeIdlType *my_sample = SomeIdlTypeTypeSupport_create_data()

DDS_LongSet_set_length(&my_sample->long_seq,5);
DDS_StringSeq_set_length(&my_sample->string_seq,5);

/* Assign the first 5 longs in long_seq */
for (i = 0; i < 5; ++i)
{
    *DDS_LongSeq_get_reference(&my_sample->long_seq,i) = i;
    snprintf(*DDS_StringSeq_get_reference(&my_sample->string_seq,0),255,"SomeString %d",
↪i);
}

/* The delete call is _not_ available in Micro Cert */
SomeIdlTypeTypeSupport_delete_data(my_sample);

/* In C++ source */
SomeIdlType *my_sample = SomeIdlTypeTypeSupport::create_data()

/* Assign the first 5 longs in long_seq */

my_sample->long_seq.length(5);
my_sample->string_seq.length(5);

for (i = 0; i < 5; ++i)
{
    /* use method */
    *DDSLongSeq_get_reference(&my_sample->long_seq,i) = i;
    snprintf(*DDSStringSeq_get_reference(&my_sample->string_seq,i),255,"SomeString %d",
↪i);

    /* or assignment */
    my_sample->long_seq[i] = i;
    snprintf(my_sample->string_seq[i],255,"SomeString %d",i);
}

/* The delete call is _not_ available in Micro Cert */
SomeIdlTypeTypeSupport::delete_data(my_sample);
```

Note that in the example above the sequence length is set. The maximum size for each sequence is

set when my_sample is allocated.

A special case is to copy a string sequence from a sample to a string sequence defined outside of the sample. This is possible, but care *must* be taken to ensure that the memory is allocated properly:

Consider the IDL type from the previous example. A string sequence of equal size can be allocated as follows:

```
struct DDS_StringSeq app_seq = DDS_SEQUUENCE_INITIALIZER;

/* This ensures that memory for the strings are allocated upfront */
DDS_StringSeq_set_maximum_w_max(&app_seq,10,255);

DDS_StringSeq_copy(&app_seq,&my_sample->string_seq);
```

If instead the following code was used, memory for the string in **app_seq** would be allocated as needed.

```
struct DDS_StringSeq app_seq = DDS_SEQUUENCE_INITIALIZER;

/* This ensures that memory for the strings are allocated upfront */
DDS_StringSeq_set_maximum(&app_seq,10);

DDS_StringSeq_copy(&app_seq,&my_sample->string_seq);
```

Working with Application Defined Sequences

Application defined sequences work in the same way as sequences defined in IDL with two exceptions:

- The maximum size is 0 by default. It is necessary to call **set_maximum** or ensure_length to allocate space.
- **DDS_StringSet_set_maximum** does not allocate space for the string pointers. The memory must be allocated on a per needed basis and calls to **_copy** may reallocate memory as needed. Use **DDS_StringSeq_set_maximum_w_max** or **DDS_StringSeq_ensure_length_w_max** to also allocate pointers. In this case **_copy** will *not* reallocate memory.

  Note that it is not allowed to mix the use of calls that pass the max (ends in **_w_max**) and calls that do not. Doing so may cause memory leaks and/or memory corruption.

  ```
  struct DDS_StringSeq my_seq = DDS_SEQUENCE_INITIALIZER;

  DDS_StringSeq_ensure_length(&my_seq,10,20);

  for (i = 0; i < 10; i++)
  {
      *DDS_StringSeq_get_reference(&my_seq,i) = DDS_String_dup("test");
  }
  ```

(continues on next page)

(continued from previous page)

```
/* The finalize call is _not_ available in Micro Cert */
DDS_StringSeq_finalize(&my_seq);
```

DDS_StringSeq_finalize automatically frees memory pointed to by each element using **DDS_String_free**. All memory allocated to a string element should be allocated using a **DDS_String** function.

It is possible to assign any memory to a string sequence element if all elements are released manually first:

```
struct DDS_StringSeq my_seq = DDS_SEQUENCE_INITIALIZER;

DDS_StringSeq_ensure_length(&my_seq,10,20);

for (i = 0; i < 10; i++)
{
    *DDS_StringSeq_get_reference(&my_seq,i) = static_string[i];
}

/* Work with the sequence */

for (i = 0; i < 10; i++)
{
    *DDS_StringSeq_get_reference(&my_seq,i) = NULL;
}

DDS_StringSeq_finalize(&my_seq);
```

4.15 Debugging

Please note that this chapter applies to *Connext Micro* and *Connext Cert*. However, in *Connext Cert* logging is *only* available in the *Debug* libraries.

4.15.1 Overview

Connext Micro maintains a log of events occuring in a *Connext Micro* application. Information on each event is formatted into a log entry. Each entry can be stored in a buffer, stringified into a displayable log message, and/or redirected to a user-defined log handler.

For a list of error codes, please refer to C Logging Reference or C++ Logging Reference.

4.15.2 Configuring Logging

By default, *Connext Micro* sets the log verbosity to *Error*. It can be changed at any time by calling **OSAPI_Log_set_verbosity()** using the desired verbosity as a parameter.

Note that when compiling with RTI_CERT defined, logging is completely removed.

The *Connext Micro* log stores new log entries in a log buffer.

The default buffer size is different for Debug and Release libraries. The Debug libraries are configured to use a much larger buffer than the Release ones. A custom buffer size can be configured using the **OSAPI_Log_set_property()** function. For example, to set a buffer size of 128 bytes:

```
struct OSAPI_LogProperty prop = OSAPI_LogProperty_INIITALIZER;

OSAPI_Log_get_property(&prop);
prop.max_buffer_size = 128;
OSAPI_Log_set_property(&prop);
```

Note that if the buffer size is too small, log entries will be truncated in order to fit in the available buffer.

The function used to write the logs can be set during compilation by defining the macro OSAPI_LOG_WRITE_BUFFER. This macro shall have the same parameters as the function prototype **OSAPI_Log_write_buffer_T**.

It is also possible to set this function during runtime by using the function **OSAPI_Log_set_property()**:

```
struct OSAPI_LogProperty prop = OSAPI_LogProperty_INIITALIZER;

OSAPI_Log_get_property(&prop);
prop.write_buffer = <pointer to user defined write function>;
OSAPI_Log_set_property(&prop);
```

A user can install a log handler function to process each new log entry. The handler must conform to the definition OSAPI_LogHandler_T, and it is set by **OSAPI_Log_set_log_handler()**.

When called, the handler has parameters containing the raw log entry and detailed log information (e.g., error code, module, file and function names, line number).

The log handler is called for every new log entry, even when the log buffer is full. An expected use case is redirecting log entries to another logger, such as one native to a particular platform.

4.15.3 Log Message Kinds

Each log entry is classified as one of the following kinds:

- *Error*. An unexpected event with negative functional impact.
- *Warning*. An event that may not have negative functional impact but could indicate an unexpected situation.
- *Information*. An event logged for informative purposes.

By default, the log verbosity is set to *Error*, so only error logs will be visible. To change the log verbosity, simply call the function **OSAPI_Log_set_verbosity()** with the desired verbosity level.

4.15.4 Interpreting Log Messages and Error Codes

A log entry in *Connext Micro* has a defined format.

Each entry contains a header with the following information:

- *Length*. The length of the log message, in bytes.
- *Module ID*. A numerical ID of the module from which the message was logged.
- *Error Code*. A numerical ID for the log message. It is unique within a module.

Though referred to as an "error" code, it exists for all log kinds (error, warning, info).

The module ID and error code together uniquely identify a log message within *Connext Micro*.

Connext Micro can be configured to provide additional details per log message:

- *Line Number*. The line number of the source file from which the message is logged.
- *Module Name*. The name of the module from which the message is logged.
- *Function Name*. The name of the function from which the message is logged.

When an event is logged, by default it is printed as a message to standard output. An example error entry looks like this:

```
[943921909.645099999]ERROR: ModuleID=7 Errcode=200 X=1 E=0 T=1
dds_c/DomainFactory.c:163/DDS_DomainParticipantFactory_get_instance: kind=19
```

- *X* Extended debug information is present, such as file and line number.
- *E* Exception, the log message has been truncated.
- *T* The log message has a valid timestamp (successful call to OSAPI_System_get_time()).

A log message will need to be interpreted by the user when an error or warning has occurred and its cause needs to be determined, or the user has set a log handler and is processing each log message based on its contents.

A description of an error code printed in a log message can be determined by following these steps:

- Navigate to the module that corresponds to the Module ID, or the printed module name in the second line. In the above example, "ModuleID=7" corresponds to DDS.
- Search for the error code to find it in the list of the module's error codes. In the example above, with "Errcode=200," search for "200" to find the log message that has the value "(DDSC_LOG_BASE + 200)".

4.16 Connext Micro Hardcoded Resource Limits

4.16.1 Introduction

Connext Micro contains a few resource limits that are not configurable in a QoS policy or property. Note that not every single constant used in *Connext Micro* is addressed. The focus is on resource limits that may prevent an application using *Connext Micro* from behaving correctly. For example, the maximum number of participants that can be discovered on a node may impact an application. On the other hand, a resource limit that has no functional impact, for example the maximum length of the discovery plugin name, is not described in this document.

When a resource limit is exceeded an error message is logged. An explanation can be found in the documentation. Note that some resource limits may be exceeded when calling an API and others may be exceeded as part of processing incoming data. Thus, it may be necessary to look at log output to see the failure reason.

Although *Connext Micro* can be compiled from source it is recommended to consult with RTI before making any changes to the hard coded limits.

4.16.2 Summary

Resource	Limit
Number of domain participants per OS process	8
Max topic name length	255
Max type name length	255
Max number of discovery plugins used by a domain participant	1
Max number of announced receive addresses for discovery data by a domain participant	4
Max number of announced receive addresses for user-data data by a domain participant	4
Max number of addresses that can be received (per meta-unicast, meta-multicast, user-unicast, user-multicast)	4

4.16.3 Operating Services API (OSAPI)

- The maximum number of object IDs are 2^32-1
  - DDS objects require a unique object_id. The encoding dictated by the RTPS specification limits the number of DDS objects within a domain participant to 2^24.
  - User impact - None.
- The maximum number of timers that can be created is 8
  - Each DomainParticipant allocates 1 timer
    - User impact - The maximum number of domain participants in a single OS process is limited to 8. This limit is based on empirical data; only specialized applications such as tools typically use more than 2 domain participants.
- *Connext Micro* cannot run continously for longer than approximately 68 years.
  - User impact - Do not run an application using *Connext Micro* for longer than approximately 68 years before restarting it.
- *Connext Micro* does not support a calendar time after January 1 2038.
  - User impact
    - The DESTINATION_ORDER source_timestamp relies on the difference between two timestamps to determine if two samples are considered to have the same timestamp in case time has been adjusted backwards. A platform that relies on absolute time may not support this. It is possible to write samples with a manually specified timestamp to mitigate this limitation.
    - Timestamp information for samples may be incorrect after January 1 2038.

4.16.4 DDS C API

- Maximum Topic name length - 255 (including NUL termination)
  - The limit is specified as 256 including NUL termination in the RTPS specification, refer to 9.6.2.2.2 in the RTPS specification (OMG formal/2009-01-05).
- Maximum Type name length - 255 (including NUL termination)
  - The limit is specified as 256 including NUL termination in the RTPS specification, refer to 9.6.2.2.2 in the RTPS specification (OMG formal/2009-01-05).
- Maximum number of matched data-writers (per data-reader) - 1,000,000
  - This limit determines how many data-writers each data-reader can match.
- Maximum number of matched data-readers (per data-writer) - 100,000,000
  - This limit determines how many data-readers each data-writer can match.
- Maximum number of locators of each type which can be sent in the participant announcement - 4

  - This limit determines the number of unique network address that can be advertised as part of discovery. The limit is per locator type. That is, the limit is applicable to discovery and user-data (total of 4 each)

- Maximum number of discovery plugins which can be used by the domain participant - 1
  - User impact: Must choose either static or dynamic discovery.
- Maximum timeout for a DDS WaitSet is approximately 40 days.
  - **User impact: After 40 days, the DDS WaitSet will time out, possibly with** no active conditions.

4.16.5 Dynamic Discovery Plugin (DPDE)

- Maximum number of received locators - 4
  - This limit determines the number of unique network addresses that can be advertised as part of discovery.
  - The limit is per locator type. That is, the same limit is applicable to discovery unicast, discovery multicast, user-data unicast, and user-data multicast.

4.16.6 Static Discovery Plugin (DPSE)

- Maximum number of received locators - 4
  - This limit determines the number of unique network address that can be advertised as part of discovery.
  - The limit is per locator type. That is, the same limit is applicable to discovery unicast, discovery multicast, user-data unicast, and user-data multicast.

4.16.7 RTPS Protocol Implementation (RTPS)

- Unlimited max_samples is defined as 100000000
- Maximum number of external RTPS interfaces - 16
  - This limits the number of participants to 16 per OS process.
  - This limit is reduced to 8 due to the OS limit.

4.17 Building Against FACE Conformance Libraries

This section describes how to build *Connext Micro* using the FACE™ conformance test tools.

4.17.1 Requirements

Connext Micro Source Code

The *Connext Micro* source code is available from RTI's Support portal.

FACE Conformance Tools

RTI does not distribute the FACE conformance tools.

CMake

The *Connext Micro* source is distributed with a **CMakeList.txt** project file. CMake is an easy to use tool that generates makefiles or project files for various build-tools, such has UNIX makefiles, Microsoft® Visual Studio® project files, and Xcode.

CMake can be downloaded from https://www.cmake.org.

4.17.2 FACE Golden Libraries

The FACE conformance tools use a set of golden libraries. There are different golden libraries for different FACE services, languages and profiles. *Connext Micro only* conforms to the safetyExt and safety profile of OSS using the C language.

Building the FACE Golden Libraries

The FACE conformance tools ship with their own set of tools to build the golden libraries. Please follow the instructions provided by FACE. In order to build the FACE golden libraries, it is necessary to port to the required platform. RTI has only tested *Connext Micro* on Linux 2.6 systems with GCC 4.4.5. The complete list of files modified by RTI are included below in source form.

4.17.3 Building the Connext Micro Source

The following instructions show how to built the *Connext Micro* source:

- Extract the source-code. Please note that the remaining instructions assume that only a single platform is built from the source.
- In the top-level source directory, enter the following:

```
shell> cmake-gui .
```

This will start the CMake GUI where all build configuration takes place.

- Click the "Configure" button.
- Select UNIX Makefiles from the drop-down list.
- Select "Use default compilers" or "Specify native compilers" as required. Press "Done."
- Click "Configure" again. There should not be any red lines. If there are, click "Configure" again.

  NOTE: A red line means that a variable has not been configured. Some options could add new variables. Thus, if you change an option a new red lines may appear. In this case configure the variable and press "Configure."
- Expand the CMAKE and RTIMICRO options and configure how to build *Connext Micro*:

```
CMAKE_BUILD_TYPE: Debug or blank. If Debug is used, the |me| debug
                  libraries are built.

RTIMICRO_BUILD_API: C or C++
   C   - Include the C API. For FACE, only C is supported.
   C++ - Include the C++ API.

RTIMICRO_BUILD_DISCOVERY_MODULE: Dynamic | Static | Both
   Dynamic - Include the dynamic discovery module.
   Static  - Include the static discovery module.
   Both    - Include both discovery modules.

RTIMICRO_BUILD_LIBRARY_BUILD:
   Single    - Build a single library.
   RTI style - Build the same libraries RTI normally ships. This is useful
               if RTI libraries are already being used and you want to use
               the libraries built from source.

RTIMICRO_BUILD_LIBRARY_TYPE:
    Static -  Build static libraries.
    Shared -  Build shared libraries.

RTIMICRO_BUILD_LIBRARY_PLATFORM_MODULE: POSIX

RTIMICRO_BUILD_LIBRARY_TARGET_NAME: <target name>
   Enter a string as the name of the target. This is also used as the
   name of the directory where the built libraries are placed.
   If you are building libraries to replace the libraries shipped by RTI,
   you can use the RTI target name here. It is then possible to set
   RTIMEHOME to the source tree (if RTI style is selected for
   RTIMICRO_BUILD_LIBRARY_BUILD).

RTIMICRO_BUILD_ENABLE_FACE_COMPLIANCE: Select level of FACE compliance
    None            - No compliance required
    General         - Build for compliance with the FACE general profile
```

(continues on next page)

(continued from previous page)

```
    Safety Extended - Build for compliance with the FACE safety extended profile
    Safety          - Build for compliance with the FACE safety profile

RTIMICRO_BUILD_LINK_FACE_GOLDEBLIBS:
    Check if linking against the static FACE conformance test libraries.
    NOTE: This check-box is only available if FACE compliance is different
    from "None".

RTIMICRO_BUILD_LINK_FACE_GOLDEBLIBS:
    If the  RTIMICRO_BUILD_LINK_FACE_GOLDEBLIBS is checked the path to the
    top-level FACE root must be specified here.
```

- Click "Configure".
- Click "Generate".
- Build the generated project.
- Libraries are placed in **lib/<RTIMICRO_BUILD_LIBRARY_TARGET_NAME>**.

Chapter 5

Building and Porting Connext Micro

5.1 RTI Connext Micro Supported Platforms

RTI Connext Micro is a source product and all platforms supported by RTI are supported. However, RTI does not test and validate the libraries on all permutations of CPU types, compiler version and OS version.

5.1.1 Reference Platforms

The following are reference platforms for which the platform-dependent layers provided with the *RTI Connext Micro* product are tested as part of standard product release:

- Windows®
- Linux®
- Unix™ (POSIX Compliant)
- Wind River® VxWorks®
- Express Logic® ThreadX®
- FreeRTOS™
- macOS® X (Darwin)
- QNX® 6.6, 7
- AUTOSAR® 4.0.3, 4.2.2
- Deos™

5.1.2 Known Customer Platforms

RTI Connext Micro has been ported to a number of platforms by our customers, such as:

- uC/OS™
- uLinux
- Win32
- Android™
- iOS®
- TI's Stellaris® Arm® Cortex®-M3 and -M4 with only TI device drivers, no OS
- Baremetal - Arm Cortex-M4
- INTEGRITY®-178
- VxWorks 653 2.x, 3.x
- DDC-I Deos™
- LynxOS®-178
- VOS™

RTI Connext Micro is known to run with the following network stacks: - BSD® socket-based stack - Windows Socket library - VxWorks Network stack - ThreadX Network stack - RTNet® - lwIP (event and blocking mode) - QNX Network stack - GHS IPFlite and general purpose stack

5.2 Building the Connext Micro Source

5.2.1 Introduction

RTI Connext Micro has been engineered for reasonable portability to common platforms and environments, such as Darwin, iOS, Linux, and Windows. This document explains how to build the *Connext Micro* source-code. The focus of this document is building *Connext Micro* for an architecture supported by RTI (please refer to *RTI Connext Micro Supported Platforms* for more information). Please refer to *Porting RTI Connext Micro* for documentation on how to port *Connext Micro* to an *unsupported* architecture.

This manual is written for developers and engineers with a background in software development. It is recommended to read the document in order, as one section may refer to or assume knowledge about concepts described in a preceding section.

5.2.2 The Host and Target Environment

The following terminology is used to refer to the environment in which *Connext Micro* is built and run:

- The *host* is the machine that runs the software to compile and link *Connext Micro*.
- The *target* is the machine that runs *Connext Micro*.
- In many cases *Connext Micro* is built *and* run on the same machine. This is referred to as a *self-hosted environment*.

The *environment* is the collection of tools, OS, compiler, linker, hardware etc. needed to build and run applications.

The word *must* describes a requirement that must be met. Failure to meet a *must* requirement may result in failure to compile, use or run *Connext Micro*.

The word *should* describes a requirement that is strongly recommended to be met. A failure to meet a *should* recommendation may require modification to how *Connext Micro* is built, used, or run.

The word *may* is used to describe an optional feature.

The Host Environment

RTI Connext Micro has been designed to be easy to build and to require few tools on the host.

The host machine **must**:

- support long filenames (8.3 will not work). *Connext Micro* does not require a case sensitive file-system.
- have the necessary compiler, linkers, and build-tools installed.

The host machine **should**:

- have CMake (www.cmake.org) version 2.8.4 or higher installed. Note that it is not required to use CMake to build *Connext Micro*, and in some cases it may also not be recommended. As a rule of thumb, if *RTI Connext Micro* can be built from the command-line, CMake is recommended.
- be able to run bash shell scripts (Unix type systems) or BAT scripts (Windows machines).

Typical examples of host machines are:

- a Linux PC with the GNU tools installed (make, gcc, g++, etc).
- a Mac computer with Xcode and the command-line tools installed.
- a Windows computer with Microsoft Visual Studio Express edition.
- a Linux, Mac or Windows computer with an embedded development tool-suite.

The Target Environment

Connext Micro has been designed to run on a wide variety of targets. For example, *Connext Micro* can be ported to run with no OS, an RTOS, GNU libc or a non-standard C library etc. This section only lists the minimum requirements. Please refer to *Porting RTI Connext Micro* for how to port *Connext Micro*.

The target machine must:

- support 8, 16, 32 and 64-bit signed and unsigned integers. Note that a 16-bit CPU (or even 8-bit) is supported as long as the listed types are supported.

  Connext Micro supports 64-bit CPUs and uses native 64-bit arithmetic internally.

The target compiler should:

- have a C compiler that is C99 compliant. Note that many non-standard compilers work, but may require additional configuration.
- have a C++ compiler that is C++98 compliant (Not required for only *Connext Cert* since C++ is not supported).

The remainder of this manual assumes that the target environment is one supported by RTI:

- POSIX (Linux, Darwin, QNX®, VOS, iOS, Android).
- VxWorks 6.9 or later.
- Windows.
- QNX.

5.2.3 Overview of the Connext Micro Source

The source-code is exactly the same as developed and tested by RTI. No filtering or modifications are performed.

```
RTIMEHOME--+-- CMakeLists.txt
           |
           +-- build -- cmake --+-- Debug --+-- <ARCH> -- <project-files>
           |                    |
           |                    |
           |                    +-- Release --+-- <ARCH> -- <project-files>
           +-- doc --
           |
           +-- example
           |
           +-- include
           |
           +-- lib +-- <ARCH> -- <libraries>
           |
           +-- resource --+-- cmake
           |              |
           |              +-- scripts
```

(continues on next page)

(continued from previous page)

```
        |
        +-- rtiddsgen
        |
        +-- src
```

In this document, `RTIMEHOME` refers to the root directory where the rti_connext_dds_micro is extracted and installed.

Directory Structure

The recommended directory structure is described below and *should* be used (1) because:

- the *rtime-make* script that is part of the installation expects this directory structure to run CMake .
- this directory structure supports multiple architectures.

NOTE 1: This applies to builds using CMake. To build in a custom environment, please refer to *Custom Build Environments*. Please note that *Connext Cert* can *only* be built with *cmake*.

CMakeLists.txt is the main input file to CMake and is used to generate build files.

The *RTIMEHOME/include* directory contains the public header files. By default it is identical to *RTIMEHOME/include*. However, custom ports will typically add files to this directory.

The *RTIMEHOME/lib* directory is empty by default. All libraries successfully built with the CMake generated build-files, regardless of which generator was used, will be copied to the *RTIMEHOME/lib* directory.

The *RTIMEHOME/src* directory contains the *Connext Micro* source files. RTI does not support modifications to these files unless explicitly stated in the porting guide. A custom port will typically add specific files to this directory.

The *RTIMEHOME/build* directory is empty by default. CMake generates one set of build-files for each configuration. A build configuration can be an architecture, *Connext Micro* options, language selection, etc. This directory will contain CMake generated build-files per architecture per configuration. By convention the *Debug* directory is used to generate build-files for debug libraries and the *Release* directory is used for release libraries.

The following naming conventions are used regardless of the build-tool:

- Static libraries have a *z* suffix.
- Shared libraries do *not* have an additional suffix.
- Debug libraries have a *d* suffix.
- Release libraries do *not* have an additional suffix.

The following libraries are built:

- *rti_me* - the core library, including the DDS C API
- *rti_me_discdpde* - the Dynamic Participant Dynamic Endpoint plugin

- *rti_me_discdpse* - the Dynamic Participant Static Endpoint plugin
- *rti_me_rhsm* - the Reader History plugin
- *rti_me_whsm* - the Writer History plugin
- *rti_me_cpp* - the C++ API

Note: The names above are the *Connext Micro* library names. Depending on the target architecture, the library name is prefixed with *lib* and the library suffix also varies between target architectures, such as .so, .dylib, etc.

For example:

- rti_mezd indicates a static debug library
- rti_me indicates a dynamically linked release library

5.2.4 Compiling Connext Micro

This section describes in detail how to compile *Connext Micro* using CMake (version 2.8.4 or higher). It starts with an example that uses the included scripts followed by a section showing how to build manually.

CMake, available from www.cmake.org, is the preferred tool to build *Connext Micro* because it simplifies configuring the *Connext Micro* build options and generates build files for a variety of environments. Note that CMake itself does not compile anything. CMake is used to *generate* build files for a number of environments, such as make, Eclipse® CDT, Xcode® and Visual Studio. Once the build-files have been generated, any of the tools mentioned can be used to build *Connext Micro*. This system makes it easier to support building *Connext Micro* in different build environments. CMake is easy to install with pre-built binaries for common environments and has no dependencies on external tools.

NOTE: It is not required to use CMake. Please refer to *Custom Build Environments* for other ways to build *Connext Micro*.

Building Connext Micro with rtime-make

The *Connext Micro* source bundle includes a bash (UNIX) and BAT (Windows) script to simplify the invocation of CMake. These scripts are a convenient way to invoke CMake with the correct options.

On UNIX-based systems:

```
$RTIMEHOME/resource/script/rtime-make --config Debug --target self \
             --name i86Linux2.6gcc4.4.5 -G "Unix Makefiles" --build
```

On Windows systems:

```
$RTIMEHOME\resource\scripts\rtime-make --config Debug --target self \
          --name i86Win32VS2010 -G "Visual Studio 10 2010" --build
```

Explanation of arguments:

- `--config Debug` : Create Debug build.
- `--target <target>` : The target for the sources to be built. "self" indicates that the host machine is the target and *Connext Micro* will be built with the options that CMake automatically determines for the local compiler. Please refer to *Cross-Compiling Connext Micro* for information on specifying the target architecture to build for.
- `--name <name>` : The name of the build, shall be a descriptive name following the recommendation on naming described in section *Preparing for a Build*. If `--name` is not specified, the value for `--target` will be used as the name.
- `--build`: Build the generated project files.
- If gcc is part of the name, GCC is assumed.
- If clang is part of the name, clang is assumed.
- If cert is part of the name, a Connext Cert build is assumed.
- If Win32 is part of the name, a 32 bit Windows build is assumed.
- If Win64 is part of the name, a 64 bit Windows build is assumed.

To get a list of all the options:

```
rtime-make -h
```

To get help for a specific target:

```
rtime-make --target <target> --help
```

Manually Building with CMake

Preparing for a Build

As mentioned, it is recommended to create a unique directory for each build configuration. A build configuration can be created to address specific architectures, compiler settings, or different *Connext Micro* build options.

RTI recommends assigning a descriptive *name* to each build configuration, using a common format. While there are no requirements to the format for functional correctness, the tool-chain files in *Cross-Compiling Connext Micro* uses the **RTIME_TARGET_NAME** variable to determine various compiler options and selections.

RTI uses the following name format:

```
{cpu}{OS}{compiler}_{config}
```

In order to avoid a naming conflict with RTI, the following name format is recommended:

```
{prefix}_{cpu}{OS}{compiler}_{config}
```

Some examples:

- acme_ppc604FreeRTOSgcc4.6.1 - *Connext Micro* for a PPC 604 CPU running FreeRTOS compiled with gcc 4.6.1, compiled by acme.
- acme_i86Win32VS2015 - *Connext Micro* for an i386 CPU running Windows XP or higher compiled with Visual Studio 2015, compiled by acme.
- acme_i86Linux4gcc4.4.5_test - a test configuration build of *Connext Micro* for an i386 CPU running Linux 3 or higher compiled with gcc 4.4.5, compiled by acme.

Files built by each build configuration will be stored under *RTIMEHOME/build/[Debug | Release]/<name>*. These directories are referred to as build directories or `RTIMEBUILD`. The structure of the `RTIMEBUILD` depends on the generated build files and should be regarded as an intermediate directory.

Creating Build Files for Connext Micro Using the CMake GUI

Start the CMake GUI, either from a terminal window or a menu.

Please note that the Cmake GUI does *not* set the **CMAKE_BUILD_TYPE** variable. This variable is used to determine the names of the *Connext Micro* libraries. Thus, it is necessary to add **CMAKE_BUILD_TYPE** manually and specify either Debug or Release. To add this variable manually, click the 'Add Entry' button, specify the name as a string type.

As an alternative, rtime-make's `--gui` option can be used. This option starts the CMake and also adds the **CMAKE_BUILD_TYPE** option when the CMake GUI exits.

Please note that when using Visual Studio or Xcode, it is important to build the same configuration as was specified with rtime-make's `--config` option. While it is possible to build a different configuration from the IDE, selecting a different configuration does *not* update the build configuration generated for *Connext Micro*.

The GUI should be started from the `RTIMEHOME` directory. If this is not the case, check that:

- The source directory is the location of `RTIMEHOME`.
- The binary directory is the location of `RTIMEBUILD`.

With the CMake GUI running:

- Press 'Configure'.
- Select a generator. You must have a compatible tool installed to process the generated files.
- Select 'Use default native compilers'.
- Press 'Done'.
- Press 'Configure'.
- Check 'Grouped'.

- Expand RTIME and select your build options. All available build options for *Connext Micro* are listed here.
- Type a target name for **RTIME_TARGET_NAME**. This should be the same as the *<name>* used to create the `RTIMEBUILD` directory, that is the `RTIMEBUILD` should be on the form *<path>/<RTIME_TARGET_NAME>*.
- Press 'Configure'. All red lines should disappear. Due to how CMake works, it is strongly recommended to always press 'Configure' whenever a value is changed for a variable. Other variables may depend on the modified variable and pressing 'Configure' will mark those with a red line. No red lines means everything has been configured.
- Press 'Generate'. This creates the build-files in the `RTIMEBUILD` directory. Whenever an option is changed and Configure is re-run, press Generate again.
- Exit the GUI.

Depending on the generator, do one of the following:

- For IDE generators (such as Eclipse, Visual Studio, Xcode) open the generated solution/project files and build the project/solution.
- For command-line tools (such as make, nmake, ninja) change to the RTIMEBUILD directory and run the build-tool.

After a successful build, the output is placed in RTIMEHOME/lib/<name>.

The generated build-files may contain different sub-projects that are specific to the tool. For example, when using Xcode or Visual Studio, the following targets are available:

- ALL_BUILD - Builds all the projects.
- rti_me_<name> - Builds only the specific library. Note that that dependent libraries are built first.
- ZERO_CHECK - Runs CMake to regenerate project files in case something changed in the build input. This target does not need to be built manually.

For command-line tools, try `<tool> help` for a list of available targets to build. For example, if UNIX makefiles were generated:

```
make help
```

Creating Build Files for Connext Micro Using CMake from the Command Line

Open a terminal window in the `RTIMEHOME` directory and create the `RTIMEBUILD` directory. Change to the `RTIMEBUILD` directory and invoke cmake using the following arguments:

```
cmake -G <generator> -DCMAKE_BUILD_TYPE=<Debug | Release> \
      -DCMAKE_TOOLCHAIN_FILE=<toolchain file>  \
      -DRTIME_TARGET_NAME=<target-name>
```

Depending on the generator, do one of the following:

- For IDE generators (such as Eclipse, Visual Studio, Xcode) open the generated solution/project files and build the project/solution.
- For command-line tools (such as make, nmake, ninja) run the build-tool.

After a successful build, the output is placed in *RTIMEHOME/lib/<name>*.

The generated build-files may contain different sub-projects that are specific to the tool. For example, in Xcode and Visual Studio the following targets are available:

- ALL_BUILD - Builds all the projects.
- rti_me_<name> - Builds only the specific library. Note that that dependent libraries are built first.
- ZERO_CHECK - Runs CMake to regenerate project-files in case something changed in the build input. This target does not need to be built manually.

For command-line tools, try `<tool> help` for a list of available targets to build. For example, if UNIX makefiles were generated:

```
make help
```

CMake Flags used by Connext Micro

The following CMake flags (-D) are understood by *Connext Micro* and may be useful when building outside of the source bundle installed by RTI. An example would be incorporating the *Connext Micro* source in a project tree and invoking cmake directly on the CMakeLists.txt provided by *Connext Micro*.

- `-DRTIME_TARGET_NAME=\<name\>` - The name of the target (equivalant to `--name` to rtime-make). The default value is the name of the source directory.
- `-DRTIME_CMAKE_ROOT=\<path\>` - Where to place the CMake build files. The default value is *<source>/build/cmake*.
- `-DRTIME_BUILD_ROOT=\<path\>` - Where to place the intermediate build files. The default value is *<source>/build*.
- `-DRTIME_SYSTEM_FILE=\<file\>` or an empty string - This file can be used to set the PLATFORM_LIBS variable used by *Connext Micro* to link with. If an empty string is specified no system file is loaded. This option may be useful when cmake can detect all that is needed. The default value is not defined, which means try to detect the system to build for.
- `-DRTI_NO_SHARED_LIB=true` - Do not build shared libraries. The default is undefined, which means shared libraries are built. NOTE: This flag must be undefined to build shared libraries. Setting the value to false is not supported.
- `-DRTI_MANUAL_BUILDID=true` - Do not automatically generate a build ID. The default value is undefined, which means generate a new build each time the libraries are built. Setting the value to false is not supported. The build ID is in its own source and only forces a recompile of a few files. Note that it is necessary to generate a build ID at least once (this is done

automatically). Also, a build ID is not supported for cmake versions less than 2.8.11 because the TIMESTAMP function does not exist.

5.2.5 Connext Micro Compile Options

The *Connext Micro* source supports compile-time options. These options are in general used to control:

- Enabling/Disabling features.
- Inclusion/Exclusion of debug information.
- Inclusion/Exclusion of APIs.
- Target platform definitions.
- Target compiler definitions.

NOTE: It is no longer possible to build a single library using CMake. Please refer to *Custom Build Environments* for information on customized builds.

Connext Micro Debug Information

Please note that *Connext Micro* debug information is independent of a debug build as defined by a compiler. In the context of *Connext Micro*, debug information refers to inclusion of:

- Logging of error-codes.
- Tracing of events.
- Precondition checks (argument checking for API functions).

Unless explicitly included/excluded, the following rule is used:

- For CMAKE_BUILD_TYPE = Release, the NDEBUG preprocessor directive is defined. Defining NDEBUG includes logging, but excludes tracing and precondition checks. Please note that **all** logging is **disabled** in *Connext Cert* release libraries.
- For CMAKE_BUILD_TYPE = Debug, the NDEBUG preprocessor directive is undefined. With NDEBUG undefined, logging, tracing and precondition checks are included.

To manually determine the level of debug information, the following options are available:

- **OSAPI_ENABLE_LOG** (Include/Exclude/Default)
  - Include - Include logging.
  - Exclude - Exclude logging.
  - Default - Include logging based on the default rule.
- **OSAPI_ENABLE_TRACE** (Include/Exclude/Default)
  - Include - Include tracing.
  - Exclude - Exclude tracing.

  - Default - Include tracing based on the default rule.

- **OSAPI_ENABLE_PRECONDITION** (Include/Exclude/Default)
  - Include - Include tracing.
  - Exclude - Exclude tracing.
  - Default - Include precondition checks based on the default rule.

Connext Micro Platform Selection

The *Connext Micro* build system looks for target platform files in *RTIMEHOME/include/osapi*. All files that match *osapi_os_*.h are listed under **RTIME_OSAPI_PLATFORM**. Thus, if a new port is added it will automatically be listed and available for selection.

The default behavior, <auto detect>, is to try to determine the target platform based on header-files. The following target platforms are known to work:

- Linux
- VOS
- QNX
- Darwin
- Win32
- VxWorks 6.9 and later

However, for custom ports this may not work. Instead the appropriate platform definition file can be selected here.

Connext Micro Compiler Selection

The *Connext Micro* build system looks for target compiler files in *RTIMEHOME/include/osapi*. All files that match *osapi_cc_*.h are listed under **RTIME_OSAPI_COMPILER**. Thus, if a new compiler definition file is added it will automatically be listed and available for selection.

The default behavior, <auto detect>, is to try to determine the target compiler based on header-files. The following target compilers are known to work:

- GCC (stdc)
- clang (stdc)
- MSVC (stdc)

However, for others compilers this this may not work. Instead the appropriate compiler definition file can be selected here.

Connext Micro UDP Options

Checking the **RTIME_UDP_ENABLE_IPALIASES** disables filtering out IP aliases. Note that this currently only works on platforms where each IP alias has its own interface name, such as eth0:1, eth1:2, etc.

Checking the **RTIME_UDP_ENABLE_TRANSFORMS_DOC** enables UDP transformations in the UDP transport.

Checking the **RTIME_UDP_EXCLUDE_BUILTIN** excludes the UDP transport from being built.

5.2.6 Cross-Compiling Connext Micro

Cross-compiling the *Connext Micro* source-code uses the exact same process described in *Compiling Connext Micro*, but requires a additonal *tool-chain file*. A tool-chain file is a CMake file that describes the compiler, linker, etc. needed to build the source for the target. *Connext Micro* includes a few basic, generic tool-chain files for cross-compilation. In general it is expected that users will provide their own cross-compilation tool-chain files.

To see a list of available targets, use `--list` :

```
rtime-make --list
```

By convention, RTI only provides generic tool-chain files that can be used to build for a broad range of targets. For example, the Linux target can be used to build for any Linux architecture as long as it is a self-hosted build. The same is true for Windows and Darwin systems. The VxWorks tool-chain file uses the Wind River environment variables to select the compiler.

For example, to build on a Linux machine with Kernel 2.6 and gcc 4.7.3:

```
rtime-make --target Linux --name i86Linux2.6gcc4.7.3 --config Debug --build
```

By convention, a specific name such as i86Linux2.6gcc4.4.5 is expected to only build for a specific target architecture. Note however that this cannot be enforced by the script provided by RTI. To create a target specific tool-chain file, copy the closest matching file and add it to the *RTIMEHOME/source/Unix/resource/CMake/architectures* or *RTIMEHOME/source/windows/resource/CMake/architectures* directory.

Once a tool-chain file has been created, or a suitable file has been found, edit it as needed. Then invoke rtime-make, specifying the new tool-chain file as the target architecture. For example:

```
rtime-make --target i86Linux2.6gcc4.4.5 --config Debug --build
```

5.2.7 Custom Build Environments

The preferred method to build *Connext Micro* is to use CMake. However, in some cases it may be more convenient, or even necessary, to use a custom build environment. For example:

- Embedded systems often have numerous compiler, linker and board specific options that are easier to manage in a managed build.
- The compiler cannot be invoked outside of the build environment, it may be an integral part of the development environment.
- Sometimes better optimization may be achieved if all the components of a project are built together.
- It is easier to port *Connext Micro*.

Importing the Connext Micro Code

The process for importing the *Connext Micro* Source Code into a project varies depending on the development environment. However, in general the following steps are needed:

- Create a new project or open an existing project.
- Import the entire *Connext Micro* source tree from the file-system. Note that some environments let you choose whether to make a copy only link to the original files.
- Add the following include paths:
  - <root>/include
  - <root>/src/dds_c/domain
  - <root>/src/dds_c/infrastructure
  - <root>/src/dds_c/publication
  - <root>/src/dds_c/subscription
  - <root>/src/dds_c/topic
  - <root>/src/dds_c/type
- Add a compile-time definition `-DRTIME_TARGET_NAME="target name"` (note that the " must be included).
- Add a compile-time definition `-DNDEBUG` for a release build.
- Add a compile-time definition of either `-DRTI_ENDIAN_LITTLE` for a little-endian platform or `-DRTI_ENDIAN_BIG` for a big-endian platform.
- If custom OSAPI definitions are used, add a compile-time definition `-DOSAPI_OS_DEF_H="my_os_file"`.
- If custom compiler definitions are used, add a compile-time definition `-DOSAPI_CC_DEF_H="my_cc_file.h"` .

5.3 Connext Micro for QNX

5.3.1 Introduction

This chapter includes details regarding how *Connext Micro* is supported on QNX. Please note that this documentation does *not* include information regarding installation of QNX itself. Please consult your QNX documentation for how to install QNX.

- *QNX Platform Notes*
- *OS Resource Usage*
- *Build environment*
- *Compiling with rtime-make*

5.3.2 QNX Platform Notes

Connext Micro uses an abstract platform API that must be ported to different platforms. This section discusses the impementation of the platform abtractions on the QNX platform.

- *Heap*
- *Mutex*
- *Semaphores*
- *Timers*
- *Time*
- *Threads*
- *Sockets*

Heap

Connext Micro allocates memory using the *malloc* API. This memory is managed internally by *Connext Micro* and is not freed.

Mutex

Connext Micro uses recursive mutexes to protect its critical sections. Because all *Connext Micro* APIs are synchronous, a mutex *take* operation blocks until the mutex becomes available. It is unexptected behavior if a mutex does not become available.

Note: QNX creates all mutexes such that priority inversion does not occur (SSR-3286-0760, Document QMS3286, QNX OS for Safety 2.1).

Semaphores

Connext Micro uses a semaphore to implement the DDS WaitSet. One semaphore is implemented with a condition variable while another sempahore is implemented with an internal timer (e.g. a *DDS_WaitSet* with a finite duration) that signals the condition variable upon timeout.

The resolution of a semaphore is rounded up to the nearest clock tick + 1. Thus, a semaphore may take up to 2 clock ticks (at most) extra to time out. The timeout is tied to the tick-time mentioned in *Timers*.

Note: *Connext Micro* does not support multiple threads blocking on a semaphore. None of the public *Connext Micro* APIs would cause multiple threads to block on the same semaphore.

Timers

Connext Micro implements its own software timers to support timed events such as periodic participant announcements and checking for missed deadlines.

The timer resolution for *Connext Micro* timers is 10 milliseonds. This cannot be changed without recompiling *Connext Micro*.

Connext Micro requires an external (to *Connext Micro*) clock tick to run its internal timers. On QNX, this clock tick is implemented with a POSIX real-time timer and the SIGRTMIN signal. This cannot be changed.

When the SIGRTMIN signal is raised, a timer handler signals a semaphore, which wakes up a separate thread that runs the timers. Thus, the timers are updated in a separate thread, not in the context of the signal handler.

In addition to runnning the internal timers, *Connext Micro* maintains an internal clock that is started when *Connext Micro* is first initialized, and which is incremented in each clock-tick. The clock-tick is maintained as a 32-bit signed second counter and a 32-bit unsigned nanosecond counter.

This internal clock is known as the "tick-time" and is a function of the number of clock-ticks, not the actual time. The tick-time is used to control semaphore timeout, deadline, and liveliness.

Time

DDS APIs use the time of day to timestamp samples. On QNX, this timestamp is retrieved using *gettimeofday*. Note that no check is performed on the returned time of day (such as time going backwards).

The time is also used to determine the interval between two samples when the sample ordering is per source timestamp on the *DataWriter*.

Threads

Connext Micro creates threads to run timers and process data received from the network.

By default, threads are created with the:

- *PTHREAD_EXPLICIT_SCHED* attribute.
- *PTHREAD_CREATE_DETACHED* attribute.
- OS default stack size.
- priority inheritied from spawning thread.

If the OSAPI_ThreadOptions *OSAPI_THREAD_REALTIME_PRIORITY* is used, the following attributes are set as well:

- *PTHREAD_SCOPE_SYSTEM*
- *SCHED_FIFO*

Two types of thread priorties can be set:

- **Absolute**

  A priority equal to or larger than zero is used as is, and must be within the range allowed by the OS.

- **Calculated**

  A priority between [*OSAPI_THREAD_PRIORITY_LOW*, *OSAPI_THREAD_PRIORITY_HIGH*] is calculated using the following formula:

```
OS.min_priority + (((OS.max_priority - OS.min_priority) * priority_level)/OSAPI_
↪THREAD_PRIORITY_HIGH);
```

Sockets

Connext Micro creates a single socket to send data with and one socket for each receive thread created. If a multicast address is specified to receive data on, multicast loopback is automatically enabled.

5.3.3 OS Resource Usage

Connext Micro uses OS resources to implement the *Connext Micro* abstraction layer. The following table outlines the type and amount of resources used by different entities and objects:

Entity	mutex	condition	timer	socket	threads
DDS_DomainParticipantFactory	3	0	1	0	1
DDS_DomainParticipant	2	0	0	0	0
DDS_DataReader	1	0	0	0	0
DDS_DataWriter	1	0	0	0	0
DDS_Publisher	1	0	0	0	0
DDS_Subscriber	1	0	0	0	0
DDS_WaitSet	3	2	0	0	0
DDS_GuardCondition	1	0	0	0	0
UDP Transport Send (per Participant)	0	0	0	1	0
UDP Transport Receive (per Receive locator)	0	0	0	1	1 per Receive locator

Resources:

- mutex - POSIX mutex created with `pthread_mutex_init`
- condition - POSIX condition variable created with `pthread_cond_init`
- timer - POSIX real-time timer create with `timer_create` and using the signal SIGMINRT.
- socket - socket created with `socket`
- threads - POSIX thread created with `pthread_create`

5.3.4 Build environment

Source is included with *Connext Micro* and it is possible to compile *Connext Micro* from source. However, in the case of *Connext Cert* **only binaries** provided as part of the Certification Data Package are valid with the certification evidence. Compiling the source may be useful for development purposes.

Connext Micro is typically cross-compiled for QNX from a Linux host machine. Before *Connext Micro* can be compiled with the supplied *cmake* files, it is required to run the QNX setup script located in the QNX installation directory. For example, in a Linux environment:

```
source qnxsdp-env.sh
```

5.3.5 Compiling with rtime-make

Connext Micro includes *cmake* files for the following QNX architectures:

- armv8QNX7.0.4qcc_gpp5.4.0 - QNX SDP 7, ARMv8
- armv8QOS2.1qcc_gpp5.4.0 - QNX OS for Safety 2.1, ARMv8

To compile for these architectures, execute the following command:

```
resource/scripts/rtime-make --target <architecture> --build --config Release
```

5.4 Building the Connext Micro Source for FreeRTOS

5.4.1 Introduction

This section explains the environment used to run *Connext Micro* on FreeRTOS + lwIP and is organized as follows:

- *Overview*
- *Configuration*
- *CMake Support*

5.4.2 Overview

Connext Micro is known to run on the FreeRTOS operating system with the lwIP protocol stack. STM32F769I-DISC0 has been chosen as reference hardware. This development kit has a STM32F769NIH6 microcontroller with 2 Mbytes of Flash memory and 512 Kbytes of RAM. For a full description, please refer to the microcontroller documentation.

STM provides a toolchain called SW4STM32. SW4STM32 is a free multi-OS software environment based on Eclipse, which supports the full range of STM32 microcontrollers and associated boards. SW4STM32 includes the GCC C/C++ compiler, a GDB-based debugger, and an Eclipse-based IDE.

STM also provides STM32CubeF7. STM32CubeF7 gathers all the generic embedded software components required to develop an application on the STM32F7 microcontrollers in a single package.

STM32CubeF7 also includes many examples and demonstration applications. The example *LwIP_HTTP_Server_Socket_RTOS* is particularly useful as it provides a working FreeRTOS + lwIP configuration.

The following versions of the different components have been used:

- SW4STM32 version 2.1
- STM32Cube_FW_F7 version V1.7.0
- FreeRTOS version V9.0.0
- lwIP version V2.0.0

5.4.3 Configuration

Example lwIP and FreeRTOS configurations are provided below for reference. This configuration must be tuned according to your needs. Details about how to configure these third-party components can be found in the FreeRTOS and lwIP documentation.

- Example configuration for lwIP:

```
#ifndef __LWIPOPTS_H__
#define __LWIPOPTS_H__

#include <limits.h>

#define NO_SYS                  0

/* ---------- Memory options ---------- */
#define MEM_ALIGNMENT           4

#define MEM_SIZE                (50*1024)

#define MEMP_NUM_PBUF           10

#define MEMP_NUM_UDP_PCB        6

#define MEMP_NUM_TCP_PCB        10

#define MEMP_NUM_TCP_PCB_LISTEN 5

#define MEMP_NUM_TCP_SEG        8

#define MEMP_NUM_SYS_TIMEOUT    10


/* ---------- Pbuf options ---------- */
#define PBUF_POOL_SIZE          8

#define PBUF_POOL_BUFSIZE       1524

/* ---------- IPv4 options ---------- */
#define LWIP_IPV4                1

/* ---------- TCP options ---------- */
#define LWIP_TCP                1
#define TCP_TTL                 255
```

(continues on next page)

(continued from previous page)

```
#define TCP_QUEUE_OOSEQ         0

#define TCP_MSS                 (1500 - 40)      /* TCP_MSS = (Ethernet MTU - IP header␣
↪size - TCP header size) */

#define TCP_SND_BUF             (4*TCP_MSS)

#define TCP_SND_QUEUELEN        (2* TCP_SND_BUF/TCP_MSS)

#define TCP_WND                 (2*TCP_MSS)


/* ---------- ICMP options ---------- */
#define LWIP_ICMP               1


/* ---------- DHCP options ---------- */
#define LWIP_DHCP               1


/* ---------- UDP options ---------- */
#define LWIP_UDP                1
#define UDP_TTL                 255


/* ---------- Statistics options ---------- */
#define LWIP_STATS 0

/* ---------- link callback options ---------- */
#define LWIP_NETIF_LINK_CALLBACK        1

/*
   ----------------------------------------
   ---------- Checksum options ----------
   ----------------------------------------
*/

/*
The STM32F7xx allows computing and verifying checksums by hardware
*/
#define CHECKSUM_BY_HARDWARE


#ifdef CHECKSUM_BY_HARDWARE
  /* CHECKSUM_GEN_IP==0: Generate checksums by hardware for outgoing IP packets.*/
  #define CHECKSUM_GEN_IP                   0
  /* CHECKSUM_GEN_UDP==0: Generate checksums by hardware for outgoing UDP packets.*/
  #define CHECKSUM_GEN_UDP                  0
  /* CHECKSUM_GEN_TCP==0: Generate checksums by hardware for outgoing TCP packets.*/
  #define CHECKSUM_GEN_TCP                  0
  /* CHECKSUM_CHECK_IP==0: Check checksums by hardware for incoming IP packets.*/
```

(continues on next page)

(continued from previous page)

```
  #define CHECKSUM_CHECK_IP               0
  /* CHECKSUM_CHECK_UDP==0: Check checksums by hardware for incoming UDP packets.*/
  #define CHECKSUM_CHECK_UDP              0
  /* CHECKSUM_CHECK_TCP==0: Check checksums by hardware for incoming TCP packets.*/
  #define CHECKSUM_CHECK_TCP              0
  /* CHECKSUM_CHECK_ICMP==0: Check checksums by hardware for incoming ICMP packets.*/
  #define CHECKSUM_GEN_ICMP               0
#else
  /* CHECKSUM_GEN_IP==1: Generate checksums in software for outgoing IP packets.*/
  #define CHECKSUM_GEN_IP                 1
  /* CHECKSUM_GEN_UDP==1: Generate checksums in software for outgoing UDP packets.*/
  #define CHECKSUM_GEN_UDP                1
  /* CHECKSUM_GEN_TCP==1: Generate checksums in software for outgoing TCP packets.*/
  #define CHECKSUM_GEN_TCP                1
  /* CHECKSUM_CHECK_IP==1: Check checksums in software for incoming IP packets.*/
  #define CHECKSUM_CHECK_IP               1
  /* CHECKSUM_CHECK_UDP==1: Check checksums in software for incoming UDP packets.*/
  #define CHECKSUM_CHECK_UDP              1
  /* CHECKSUM_CHECK_TCP==1: Check checksums in software for incoming TCP packets.*/
  #define CHECKSUM_CHECK_TCP              1
  /* CHECKSUM_CHECK_ICMP==1: Check checksums by hardware for incoming ICMP packets.*/
  #define CHECKSUM_GEN_ICMP               1
#endif


/*
   ----------------------------------------------
   ---------- Sequential layer options ----------
   ----------------------------------------------
*/
#define LWIP_NETCONN                    1

/*
   ------------------------------------
   ---------- Socket options ----------
   ------------------------------------
*/
#define LWIP_SOCKET                     1

/*
   ---------------------------------
   ---------- OS options ----------
   ---------------------------------
*/

#define TCPIP_THREAD_NAME              "TCP/IP"
#define TCPIP_THREAD_STACKSIZE          1000
#define TCPIP_MBOX_SIZE                 6
#define DEFAULT_UDP_RECVMBOX_SIZE       2000
#define DEFAULT_TCP_RECVMBOX_SIZE       2000
#define DEFAULT_ACCEPTMBOX_SIZE         2000
```

(continues on next page)

(continued from previous page)

```
#define DEFAULT_THREAD_STACKSIZE        500
#define TCPIP_THREAD_PRIO               osPriorityHigh

/**
 * LWIP_SO_RCVBUF==1: Enable SO_RCVBUF processing.
 */
#define LWIP_SO_RCVBUF                  1


/**
 * Instruct lwIP to use the errno provided by libc instead of the errno in lwIP.
 * If your libc doesn't include errno, you might need to delete these macros.
 */
#undef LWIP_PROVIDE_ERRNO
#define LWIP_ERRNO_INCLUDE "errno.h"

#endif /* __LWIPOPTS_H__ */
```

- Example configuration for FreeRTOS:

```
#ifndef FREERTOS_CONFIG_H
#define FREERTOS_CONFIG_H

/*-----------------------------------------------------------
 * Application specific definitions.
 *
 * These definitions should be adjusted for your application requirements.
 *
 * THESE PARAMETERS ARE DESCRIBED WITHIN THE 'CONFIGURATION' SECTION OF THE
 * FreeRTOS API DOCUMENTATION AVAILABLE ON THE FreeRTOS.org WEB SITE.
 *
 * See http://www.freertos.org/a00110.html.
 *----------------------------------------------------------*/

/* Ensure stdint is only used by the compiler, and not the assembler. */
#if defined(__ICCARM__) || defined(__CC_ARM) || defined(__GNUC__)
 #include <stdint.h>
 extern uint32_t SystemCoreClock;
#endif

#define configUSE_PREEMPTION            1
#define configUSE_IDLE_HOOK             0
#define configUSE_TICK_HOOK             0
#define configCPU_CLOCK_HZ              (SystemCoreClock)
#define configTICK_RATE_HZ              ((TickType_t)1000)
#define configMAX_PRIORITIES            (7)
#define configMINIMAL_STACK_SIZE        ((uint16_t)128)
#define configTOTAL_HEAP_SIZE           ((size_t)(400 * 1024))
#define configMAX_TASK_NAME_LEN         (16)
```

(continues on next page)

(continued from previous page)

```
#define configUSE_TRACE_FACILITY          1
#define configUSE_16_BIT_TICKS            0
#define configIDLE_SHOULD_YIELD           1
#define configUSE_MUTEXES                 1
#define configQUEUE_REGISTRY_SIZE         8
#define configCHECK_FOR_STACK_OVERFLOW    0
#define configUSE_RECURSIVE_MUTEXES       1
#define configUSE_MALLOC_FAILED_HOOK      0
#define configUSE_APPLICATION_TASK_TAG    0
#define configUSE_COUNTING_SEMAPHORES     1
#define configGENERATE_RUN_TIME_STATS     0

/* Co-routine definitions. */
#define configUSE_CO_ROUTINES           0
#define configMAX_CO_ROUTINE_PRIORITIES (2)

/* Software timer definitions. */
#define configUSE_TIMERS              1
#define configTIMER_TASK_PRIORITY     (2)
#define configTIMER_QUEUE_LENGTH      10
#define configTIMER_TASK_STACK_DEPTH 1280

/* Set the following definitions to 1 to include the API function, or zero
to exclude the API function. */
#define INCLUDE_vTaskPrioritySet        1
#define INCLUDE_uxTaskPriorityGet       1
#define INCLUDE_vTaskDelete             1
#define INCLUDE_vTaskCleanUpResources   0
#define INCLUDE_vTaskSuspend            1
#define INCLUDE_vTaskDelayUntil         0
#define INCLUDE_vTaskDelay              1
#define INCLUDE_xTaskGetSchedulerState 1

/* Cortex-M specific definitions. */
#ifdef __NVIC_PRIO_BITS
 /* __BVIC_PRIO_BITS will be specified when CMSIS is being used. */
 #define configPRIO_BITS         __NVIC_PRIO_BITS
#else
 #define configPRIO_BITS         4        /* 15 priority levels */
#endif

#define configLIBRARY_LOWEST_INTERRUPT_PRIORITY   0xf

#define configLIBRARY_MAX_SYSCALL_INTERRUPT_PRIORITY 5

#define configKERNEL_INTERRUPT_PRIORITY   ( configLIBRARY_LOWEST_INTERRUPT_PRIORITY <<␣
↪(8 - configPRIO_BITS) )

#define configMAX_SYSCALL_INTERRUPT_PRIORITY  ( configLIBRARY_MAX_SYSCALL_INTERRUPT_
↪PRIORITY << (8 - configPRIO_BITS) )
```

(continues on next page)

(continued from previous page)

```
#define configASSERT( x ) if( ( x ) == 0 ) { taskDISABLE_INTERRUPTS(); for( ;; ); }

#define vPortSVCHandler    SVC_Handler
#define xPortPendSVHandler PendSV_Handler

#endif /* FREERTOS_CONFIG_H */
```

5.4.4 CMake Support

Connext Micro includes support to compile libraries for FreeRTOS using CMake . It is assumed that the *Connext Micro* source-bundle has been downloaded and installed and that CMake is available.

1. Make sure CMake is in the path.
2. Define the following environment variables:
   - CONFIG_PATH : Path where the FreeRTOSConfig.h and lwipopts.h files are located.
   - FREERTOS_PATH : Path to FreeRTOS source code and header files.
   - LWIP_PATH : Path to lwIP source code and header files.
   - PATH : Update your path with the location of the C and C++ compiler. By default arm-none-eabi-gcc and arm-none-eabi-g++ are used as C and C++ compilers.
3. Enter the following command:

```
cd <rti_me install directory>
resource/scripts/rtime-make --target FreeRTOS --name cortexm7FreeRTOS9.
↪0gcc7.3.1 -G "Unix Makefiles" --build
```

4. The *Connext Micro* libraries are available in:

```
<rti_me install directory>/lib/cortexm7FreeRTOS9.0gcc7.3.1
```

NOTE: rtime-make uses the name specified with –name to determine a few settings needed by *Connext Micro*. Please refer to *Preparing for a Build* for details.

5.5 Building the Connext Micro Source for ThreadX

5.5.1 Introduction

This section explains the environment used to run *Connext Micro* on the Threadx® + NetX™ and is organized as follows:

- *Overview*

- *Configuration*
- *CMake Support*

5.5.2 Overview

Connext Micro is known to run on the ThreadX operating system and NetX network stack. The Renesas™ SK-S7G2 Starter Kit has been chosen as reference hardware. This starter kit has a Synergy S7G2 microcontroller with 4 Mbytes of flash memory and 640 KBytes of SRAM. For a full description, please refer to the microcontroller and starter kit documentation (https://www.renesas.com/us/en/products/synergy/hardware/kits/sk-s7g2.html).

Renesas provides an Eclipse-based integrated development environment (IDE) called e^2 studio. The Synergy® Software Package (SSP) provides several middleware components like ThreadX and NetX. e^2 studio and the SSP allow you to create solutions based on ThreadX and NetX for the Renesas SK-S7G2.

Renesas provides several examples for the SK-S7G2 and e^2 studio. The DHCP client example is particularly useful, as it provides a working ThreadX and NetX configuration.

We used the following components to build the *Connext Micro* application:

- e^2 studio version 5.4.0.018
- SSP version 1.2.0
- ThreadX 5.7
- NetX 5.8

5.5.3 Configuration

e^2 studio allows you to configure ThreadX and NetX. *Connext Micro* expects two variables to be configured in NetX with the following default names:

- g_ip0 : This is the expected name of the NetX IP instance.
- g_packet_pool0 : This is the expected name of the NextX packet pool instance.

5.5.4 CMake Support

Connext Micro includes support to compile libraries for ThreadX/NetX using CMake . It is assumed that the *Connext Micro* source-bundle has been downloaded and installed and that CMake is available.

1. Make sure CMake is in the path.
2. Define the following environment variables:
    - SYNERGY_PATH : Path to your Synergy project. This is needed to add the include paths to the ThreadX and NetX public header files, and other header files used by the ThreadX and NetX public header files.

- PATH : Update your path with the location of the C and C++ compilers. By default arm-none-eabi-gcc and arm-none-eabi-g++ are used as C and C++ compilers.

3. Enter the following command:

```
cd <rti_me install directory>
resource/scripts/rtime-make --target ThreadX --name cortexm4ThreadX5.8gcc4.
↪9.3 -G "Unix Makefiles" --build
```

4. The *Connext Micro* libraries are available in:

```
<rti_me install directory>/lib/cortexm4ThreadX5.8gcc4.9.3
```

NOTE: rtime-make uses the name specified with –name to determine a few settings needed by *Connext Micro*. Please refer to *Preparing for a Build* for details.

5.6 Connext Micro on AUTOSAR

5.6.1 Introduction

Connext Micro includes support for AUTOSAR™ and enables *Connext Micro* applications to run on AUTOSAR systems. The support has been tested on the Infineon™ AURIX™ Application Kit TC297 TFT development board with Elektrobit™ (EB) AUTOSAR implementation version 4.0.3 and Mentor™ AUTOSAR implementation version 4.2.2 and compiler TASKING™ v6.2r2.

Note that *Connext Micro* requires the C-type "double" to be 64 bits. Any compiler option that treats a "double" as a "float" must not be enabled.

This manual explains how to compile and configure *Connext Micro* to run on AUTOSAR systems and the AUTOSAR configuration needed by *Connext Micro*.

- *AUTOSAR Configuration*
- *AUTOSAR Port Details*
- *Compiling*
- *Interoperability*
- *Compiling Applications*

5.6.2 AUTOSAR Configuration

Properties

AUTOSAR port properties must be set before any call to a *Connext Micro* API. This is done by using *OSAPI_System_get_property()* followed by *OSAPI_System_set_property()*:

```
/* Example application with two areas in the heap */

#define NUMBER_OF_HEAP_AREAS 2
#define HEAP_AREA_1_SIZE 10*1024
#define HEAP_AREA_2_SIZE 130*1024

const RTI_PRIVATE uint32 heap_area_size[NUMBER_OF_HEAP_AREAS] =
{
    HEAP_AREA_1_SIZE,
    HEAP_AREA_2_SIZE
};

RTI_PRIVATE char heap_area1[HEAP_AREA_1_SIZE];
RTI_PRIVATE char heap_area2[HEAP_AREA_2_SIZE];

RTI_PRIVATE char* const heap_area[NUMBER_OF_HEAP_AREAS] =
{
    heap_area1,
    heap_area2
};

static Std_ReturnType
Application_get_socket(
    TcpIp_DomainType domain,
    TcpIp_ProtocolType protocol,
    P2VAR(TcpIp_SocketIdType, AUTOMATIC, TCPIP_APPL_DATA) socket_id)
{
    /* The name of this call depends on the SocketAdaptor name configured
     * in the AUTOSAR project
     */
    return TcpIp_TcpIpSocketOwner_0GetSocket(domain, protocol, socket_id);
}

RTI_BOOL
Application_set_system_properties(void)
{
    struct OSAPI_SystemProperty system_property;

    if (!OSAPI_System_get_property(&system_property))
    {
        printf("failed to get system properties\n");
        return RTI_FALSE;
    }

    /* Task OSAPI_SystemAutosar_timer_task is configured to run every 10 ms */
```

(continues on next page)

(continued from previous page)

```
    system_property.port_property.timer_resolution_ms = 10;

    system_property.port_property.number_of_heap_areas = NUMBER_OF_HEAP_AREAS;
    system_property.port_property.heap_area_size = heap_area_size;
    system_property.port_property.heap_area = heap_area;

    /* Connext DDS Micro will use Resources as synchronization method */
    system_property.port_property.sync_type = OSAPI_AUTOSAR_SYNCKIND_RESOURCES;
    system_property.port_property.first_resource_id = RTIME_Resource01;
    system_property.port_property.last_resource_id = RTIME_Resource26;
    #if RTIME_AUTOSAR_SPINLOCK_ENABLED
    system_property.port_property.spinlock_id = 0;
    #endif /* RTI_CERT */

    system_property.port_property.semaphore_max_count = 2;
    system_property.port_property.first_give_event = RTIME_Semaphore_Give_
↪Event;
    system_property.port_property.first_timeout_event = RTIME_Semaphore_
↪Timeout_Event;
    system_property.port_property.first_alarm = RTIME_Semaphore_Alarm;

    system_property.port_property.use_socket_owner = TRUE;
    system_property.port_property.max_receive_sockets = 2;
    system_property.port_property.number_of_rcv_buffers = 0;
    system_property.port_property.rcv_buffer_size = 0;
    system_property.port_property.get_socket = Application_get_socket;
    system_property.port_property.send_data = NULL;
    system_property.port_property.local_addr_id = 0;

    system_property.port_property.use_udp_thread = FALSE;
    system_property.port_property.udp_receive_task_id = 0;
    system_property.port_property.udp_packet_received_event = 0;

    if (!OSAPI_System_set_property(&system_property))
    {
        printf("failed to set system properties\n");
        return RTI_FALSE;
    }

    return RTI_TRUE;
}
```

Tasks

Micro Timer Task

Connext Micro uses a timer task, which manages all the *Connext Micro* timers, such as deadline and liveliness timers. This task must be started before the first call to DDS_DomainParticipantFactory_get_instance(). This task must be run at a constant period, e.g., every 10 ms. Note that the priority of this task must be set based on the required system behavior.

It is important that the port properties are configured with the value of *OSAPI_PortProperty::timer_resolution_ms* equal to the Timer Task period.

This task needs at least 5 KB stack. The name of this task is *OSAPI_SystemAutosar_timer_task*. The task implementation can be found in the file autosarSystem.c.

Micro UDP Task

Connext Micro provides a callback function that must be called when a UDP packet is received. These callback functions are *NETIO_Autosar_TcpIp_udp_rx_indication()* and *NETIO_Autosar_TcpIp_pdu_callout()*. It is very important that one of these functions is called for the on-packet reception. Typically *NETIO_Autosar_TcpIp_udp_rx_indication()* is called when a SocketOwner is configured in the AUTOSAR configuration and *NETIO_Autosar_TcpIp_pdu_callout()* is typically used when SocketOwner is not configured in the AUTOSAR configuration.

It is important that the port properties are configured with a correct value in *OSAPI_PortProperty::use_socket_owner*. Set this field to TRUE only if you have configured SocketOwner in the AUTOSAR TcpIp configuration.

When *Connext Micro* receives an on-packet reception notification, the packet can be processed in the notification callback or in a different task. If *OSAPI_PortProperty::use_udp_thread* is set to TRUE, the packet is copied to an internal buffer, the "UDP Packet received event" is set, and the packet will be processed in a different task. Otherwise the packet is processed immediately.

The configuration of the *OSAPI_PortProperty::use_udp_thread*, *OSAPI_PortProperty::udp_receive_task_id* and *OSAPI_PortProperty::udp_packet_received_event* is the responsibility of the application.

Connext Micro **requires** one semaphore to be configured for the UDP Task if *OSAPI_PortProperty::use_udp_thread* is TRUE. This semaphore is used to temporarily suspend the UDP Task from a best-effort DDS DataReader if the DDS DataReader is unable to process new samples; this can happen if the DataReader is out of resources when samples have already been received by the network stack.

This semaphore **must** use the first *OSAPI_PortProperty::first_give_event*, *OSAPI_PortProperty::first_timeout_event*, and *OSAPI_PortProperty::first_alarm*. Please refer to *Semaphores* for details for how to configure semaphores.

Normally a UDP packet can be processed in the notification callback if the function *OSAPI_Autosar_TcIp_udp_rx_indication()* or *NETIO_Autosar_TcpIp_pdu_callout()* is called from another

task. The UDP task is normally only needed in case *OSAPI_Autosar_TcIp_udp_rx_indication()* or *NETIO_Autosar_TcpIp_pdu_callout()* is called from an ISR.

This task should be started only once. Note that this is not a periodic task and the task never completes.

The UDP task waits for a "UDP Packet received event." When this event is received, the task reads the packet from the internal buffer, processes it and waits again for the event.

This task must have at least 5 KB stack and must be configured as an extended task (only extended tasks can wait for an event).

The priority of this task must be assigned based on system requirements.

The name of this task is *NETIO_Autosar_udp_receive_task* and the task implementation can be found in the file autosarSocket.c.

The task configuration must include all necessary references to the event used to notify a UDP packet reception.

Application Task

The application task defines the DDS entities required by the application.

Critical Sections

Connext Micro can be configured to use different synchronization methods to protect critical sections. These critical sections synchronize access to objects shared among the different tasks (Timer task, UDP task, and user tasks).

First, configure the *OSAPI_PortProperty::sync_type* in the AUTOSAR port properties. For example, if *Connext Micro* is configured with tasks running on different cores, a *Spinlock* must be used.

The supported methods, and how to configure *Connext Micro* to use them, are described below:

- *Resources*
- *Spinlock*

For a cert build, the only synchronization method supported is *Resources*.

Resources

With this synchronization method, *Connext Micro* uses AUTOSAR resources to protect critical sections.

Only use this configuration if *Connext Micro* will be executed from one core.

All AUTOSAR resources used by *Connext Micro* must have consecutive IDs. Configure *OSAPI_PortProperty::first_resource_id* and *OSAPI_PortProperty::last_resource_id* with the "ID" of the first and last resource used by *Connext Micro*.

The number of resources needed depends on the number of DataWriter and DataReader objects that are created, the discovery plugin that is used, the *AUTOSAR Configuration* and the build configuration (whether the Log Module is excluded or not).

The following APIs and modules use one or more resources to protect critical sections:

API	Number of resources needed
`AUTOSAR OSAPI Heap module`	1
`AUTOSAR OSAPI Mutex module`	1
`AUTOSAR NETIO UDP module`	1 or 2. If the UDP task is used, by setting *OSAPI_PortProperty::use_udp_thread* to TRUE, one additional resource is needed to synchronize socket internal buffers.
`DPDE discovery plugin`	11
`DPSE discovery plugin`	5
`DDS_DomainParticipantFactory_get_instance()`	4 or 5. If the Log module is included in the compilation one additional resource is needed.
`DDS_DomainParticipantFactory_create_participant()`	2
`DDS_DomainParticipant_create_topic()`	1
`DDS_DomainParticipant_create_publisher()`	1
`DDS_DomainParticipant_create_subscriber()`	1
`DDS_Publisher_create_datawriter()`	1
`DDS_Publisher_create_datareader()`	1
`DDS_WaitSet_new()`	1

A basic *Connext Micro* application using the DPDE discovery plugin and one *DataWriter* uses 24 resources:

Table 5.1: Basic application using DPDE discovery plugin

API	Number of resources needed
`AUTOSAR OSAPI Heap module`	1
`AUTOSAR OSAPI Mutex module`	1
`AUTOSAR NETIO UDP module`	1
`DPDE discovery plugin`	11
`DDS_DomainParticipantFactory_get_instance()`	5 (Log module included in the compilation)
`DDS_DomainParticipantFactory_create_participant()`	2
`DDS_DomainParticipant_create_topic()`	1
`DDS_DomainParticipant_create_publisher()`	1
`DDS_Publisher_create_datawriter()`	1

A basic *Connext Micro* application using DPSE discovery plugin and one *DataWriter* uses 18 resources:

Table 5.2: Basic application using DPSE discovery plugin

API	Number of resources needed
`AUTOSAR OSAPI Heap module`	1
`AUTOSAR OSAPI Mutex module`	1
`AUTOSAR NETIO UDP module`	1
`DPSE discovery plugin`	5 (Log module included in the compilation)
`DDS_DomainParticipantFactory_get_instance()`	5
`DDS_DomainParticipantFactory_create_participant()`	2
`DDS_DomainParticipant_create_topic()`	1
`DDS_DomainParticipant_create_publisher()`	1
`DDS_Publisher_create_datawriter()`	1

To configure *Connext Micro* to use the resources to protect critical sections, set *OSAPI_PortProperty::sync_type equal* to *OSAPI_Autosar_SyncKind_T::OSAPI_AUTOSAR_SYNCKIND_RESOURCES*.

Spinlock

When the *spinlock* synchronization method is used, *Connext Micro* uses an OSEK spinlock to protect critical sections.

Only use this configuration if *Connext Micro* will be used from more than one core.

To configure *Connext Micro* to use spinlock to protect critical sections set *OSAPI_PortProperty::sync_type* equal to *OSAPI_Autosar_SyncKind_T::OSAPI_AUTOSAR_SYNCKIND_SPINLOCK.*

TCP/IP Configuration

A CDD socket owner can be optionally used. Set *OSAPI_PortProperty::use_socket_owner* to TRUE only if a SocketOwner is configured in the AUTOSAR TcpIp configuration. If a SocketOwner is used, a pointer to the *TcpIp_<Up>GetSocket* must be configured in *OSAPI_PortProperty::get_socket*. If a SocketOwner is not used, a pointer to a function which can send data must be configured in *OSAPI_PortProperty::send_data*.

Depending on the DDS discovery configuration, a maximum of 3 UDP sockets are needed for each participant created. All function declarations needed to configure the SocketOwner can be found in the file osapi_os_autosar.h and are:

- *NETIO_Autosar_TcpIp_pdu_callout()*
- *NETIO_Autosar_TcpIp_udp_rx_indication()*

It is very important that the on-packet reception function *OSAPI_Autosar_TcIp_udp_rx_indication()* or *NETIO_Autosar_TcpIp_pdu_callout()* is called. If there is an OS configuration error, this function might not be called.

It is important to note that the IP address identifier representing the local IP address and the EthIf controller used to bind the socket to can be configured in the property *OSAPI_PortProperty::local_addr_id*. This should be configured in Elektrobit Tresos as a *TCPIP_UNICAST TcpIpAddressType.*

It is possible to configure *Connext Micro* to not use a SocketOwnwer. If a SocketOwner is not used, it is important to configure AUTOSAR such that one of the functions *OSAPI_Autosar_TcIp_udp_rx_indication()* or *NETIO_Autosar_TcpIp_pdu_callout()* is called when a UDP packet is received.

Only unicast receive sockets are supported.

It is very important that the TCP/IP interface is running and an IP address is assigned before a DomainParticipant is created, otherwise the DomainParticipant creation might fail because sockets cannot be created.

Events

Depending on the configuration, only one event might be used. One event is required by the UDP receive callback to notify the UDP receive task that a UDP packet is available.

The ID of this event can be configured in *OSAPI_PortProperty::udp_packet_received_event*.

This event is only needed if *OSAPI_PortProperty::use_udp_thread* is set to TRUE. Please refer to *Micro UDP Task* for details.

DDS WaitSets require more events; please refer to *Semaphores* for details.

Semaphores

Connext Micro uses semaphores to create WaitSets and to support blocking the UDP receive task if *OSAPI_PortProperty::use_udp_thread* is TRUE. OSEK and AUTOSAR do not define any semaphore objects. For this reason, semaphores are implemented using events and alarms. For each semaphore, two events and one alarm must be added to the AUTOSAR configuration.

If *OSAPI_PortProperty::use_udp_thread* is TRUE, one semaphore is needed. This semaphore must use the first event and alarm IDs, and these IDs **must** be assigned to the UDP Task. Please refer to *Micro UDP Task* for details.

For each WaitSet, two semaphores are needed.

WaitSet.wait() can be called only from the task that created the WaitSet.

If WaitSets are not used, or if *OSAPI_PortProperty::use_udp_thread* is FALSE, you do not need to allocate any resources or alarms for semaphores. In this case set the following properties to 0:

- *OSAPI_PortProperty::semaphore_max_count*
- *OSAPI_PortProperty::first_give_event*
- *OSAPI_PortProperty::first_timeout_event*
- *OSAPI_PortProperty::first_alarm*

The semaphore implementation uses two events and one alarm for each semaphore that is created (a total of four events and two alarms are needed for each WaitSet).

One event, the *give* event, is set in the *OSAPI_Semaphore_give()* method. The other event, the timeout event, is used to signal a timeout in the semaphore. The alarm must be configured to set the give event. The *OSAPI_Semaphore_take()* method starts the alarm and waits for either of the two events to occur.

Give events must have consecutive event IDs, starting at *OSAPI_PortProperty::first_give_event* (e.g., 1, 2, 4). Timeout events must have consecutive event IDs starting at *OSAPI_PortProperty::first_timeout_event* (e.g., 8, 16, 32). Alarms must have consecutive IDs starting at *OSAPI_PortProperty::first_alarm* (e.g., 1, 2, 3). So an alarm with ID 1 must set timeout event 8; alarm ID 2 must set timeout event 16, and so on.

The alarm for semaphore implementation must be configured as 'RELATIVE'. The counter used to trigger the alarm must be configured with one tick per millisecond. If this is not done properly, the semaphore timeout will occur sooner or later than expected.

Memory

Connext Micro uses a buffer for all its memory allocations. The buffer can span across several non-adjacent areas. The number of areas can be configured in *OSAPI_PortProperty::number_of_heap_areas*. The size required for this buffer depends on the number of DDS entities created and their QoS. The size of each area can be configured in *OSAPI_PortProperty::heap_area_size*. The start address for each of the areas can be configured in *OSAPI_PortProperty::heap_area*.

This buffer location and size can be modified, but it is recommended to use a buffer of at least 100 KB.

All allocations within *Connext Micro* are protected by a critical section. For more information see *Critical Sections*.

5.6.3 AUTOSAR Port Details

Logging

Connext Micro can optionally use the AUTOSAR Det module:

- Set the right log verbosity in *Connext Micro* by calling *OSAPI_Log_set_verbosity()*. The default verbosity is *OSAPI_LOG_VERBOSITY_ERROR*.
- Set the AUTOSAR log display handler by calling *OSAPI_Log_set_display_handler(OSAPI_AutosarLog_default_display, NULL)*. The file osapi_autosar.h contains the declaration of the function *OSAPI_AutosarLog_default_display()*.
- *Connext Micro* calls *Det_ReportError()* with the module ID *RTIME_DDS_MODULE_ID* and the instance ID *RTIME_DDS_INSTANCE_ID*. These can be found in file osapi_os_autosar.h.

Connext Micro logging can be disabled by adding the following options when compiling with CMake:

- -DRTIME_OSAPI_ENABLE_LOG=Exclude (when compiling on a Windows system, replace the symbol = with *_eq_*).

If the *Connext Micro* sources are not compiled with CMake, logging can be disabled by adding the compiler flags *OSAPI_ENABLE_TRACE=0* and *OSAPI_ENABLE_LOG=0*.

The function used to write logs can be configured using the macro *OSAPI_LOG_WRITE_BUFFER* in the file osapi_os_autosar.h. The default value for this macro is *printf()*, which on some platforms will write on the serial port. This can be useful for debugging purposes, but it can be slow, causing tasks to have longer execution times than allowed. If this is the case, it is recommended that you disable logging or use a different function by calling *OSAPI_AutosarLog_default_display()*.

WaitSets

For each WaitSet that will be created, you need to adjust the configuration to have two semaphores. The semaphore implementation needs two events and one alarm.

A WaitSet wait operation can only be called from the task that created the WaitSet.

Note that events cannot be set for a task that is in the suspended state. As semaphore implementation is based on events, the task that reads all received samples must be running before any sample is received.

UDP Automatic Configuration

UDP automatic configuration is not currently supported. See the HelloWorld_static_dpde example to learn how to statically configure the UDP transport.

5.6.4 Compiling

This section explains how to build the *Connext Micro* source-code for AUTOSAR.

Building Connext Micro with rtime-make

The *Connext Micro* source bundle includes a bash (on Linux and macOS systems) or BAT (on Windows systems) script to simplify the invocation of *cmake* called *rtime-make*. These scripts provide a convenient way to invoke *cmake* with the correct options.

On Linux and macOS systems, the script is located in:

```
resource/scripts/rtime-make
```

On Windows systems, the script is located in:

```
resource\scripts\rtime-make
```

The following environment variables are needed to compile for an Elektrobit implementation:

- OSEK_TOOLCHAIN_PATH : Path to the toolchain used to compile. E.g., TASKING install folder.
- OSEK_PATH : Path to AUTOSAR implementation installation.

Environment variables example to compile *Connext Micro* libraries for an Elektrobit AUTOSAR implementation:

- OSEK_TOOLCHAIN_PATH : /c/TASKING/TriCorev6.2r2
- OSEK_PATH : /c/eb

Environment variables example to compile *Connext Micro* libraries for a Mentor™ implementation:

- OSEK_TOOLCHAIN_PATH : /c/TASKING/TriCorev6.2r2
- OSEK_PATH : /c/AUTOSAR

cmake toolchain files are included to compile *Connext Micro* for Elektrobit and Mentor AUTOSAR implementations. Example commands to build AUTOSAR libraries:

- Libraries for Elektrobit using a Windows prompt and Unix Makefile generator (that uses Tasking mktc.exe as the make program):

```
<path-to-rtime-make>/rtime-make --target Autosar --name␣
↪tc29xtOsekCoreTasking6.2r2 --build --config Debug -G "Unix Makefiles"
↪</B>
```

- Libraries for Elektrobit using a Windows prompt and a Ninja generator:

```
<path-to-rtime-make>/rtime-make --target Autosar --name␣
↪tc29xtOsekCoreTasking6.2r2 --build --config Debug -G "Ninja"</B>
```

- Libraries for Mentor using MSys and a Unix Makefile generator:

```
<path-to-rtime-make>/rtime-make --target Autosar --name␣
↪tc29xtVSTARTasking6.2r2 --build --config Debug -G "Unix Makefiles"</B>
↪
```

Importing the Connext Micro Source Code

Read the general rules for importing the *Connext Micro* source code in *Building the Connext Micro Source*.

To build the AUTOSAR port, either define *-D___autosar___* or:

- -DOSAPI_OS_DEF_H=”osapi_os_autosar.h”
- -DOSAPI_CC_DEF_H=”osapi_cc_autosar.h”

5.6.5 Interoperability

The *Connext Micro* AUTOSAR port does not have any additional restrictions regarding interoperability. The same interoperability considerations as for other ports apply to the AUTOSAR port. For more information, please refer to *Working with RTI Connext Micro and RTI Connext DDS*.

5.6.6 Compiling Applications

When compiling applications for this platform, please note the following in addition to the information in build_environment:

- The type-support code generated with `rtiddsgen` must be compiled with the Tasking compiler option *–integer-enumeration*
- If using Tasking v6.2r2 or Tasking v6.2r2p1, do **not** compile with -O3. This optimization level may introduce errors. This has been fixed in Tasking v6.2r2p2 and later.
- The `double` type **must** be compiled with doubles as **8 bytes**. That is, do **not** use the Tasking compiler option to treat `doubles` as `floats`.

5.7 Porting RTI Connext Micro

RTI Connext Micro has been engineered for reasonable portability to platforms and environments which RTI does not have access to. This porting guide describes the features required by *Connext Micro* to run. The target audience is developers familiar with general OS concepts, the standard C library, and embedded systems.

Connext Micro uses an abstraction layer to support running on a number of platforms. The abstraction layer, OSAPI, is an abstraction of functionality typically found in one or more of the following libraries and services:

- Operating System calls
- Device drivers
- Standard C library

The OSAPI module is designed to be relatively easy to move to a new platform. All functionality, with the exception of the UDP transport which must be ported, is contained within this single module. It should be noted that although some functions may not seem relevant on a particular platform, they must still be implemented as they are used by other modules. For example, the port running on Stellaris with no OS support still needs to implement a threading model.

Please note that the OSAPI module is not designed to be a general purpose abstraction layer; its sole purpose is to support the execution of *Connext Micro*.

5.7.1 Updating from Connext Micro 2.4.8 and earlier

In *RTI Connext Micro* 2.4.9, a few changes were made to simplify incorporating new ports. To upgrade an existing port to work with 2.4.9, follow these rules:

- Any changes to osapi_config.h should be placed in its own file (see *Directory Structure*).
- Define the OSAPI_OS_DEF_H preprocessor directive to include the file (refer to *OS and CC Definition Files*).
- For compiler-specific definitions, please refer to *OS and CC Definition Files*.
- Please refer to *Heap Porting Guide* for changes to the Heap routines that need to be ported.

5.7.2 Directory Structure

The source shipped with *Connext Micro* is identical to the source developed and tested by RTI (with the exception of the the line-endings difference between the Unix and Windows source-bundles).

The source-bundle directory structure is as follows:

```
RTIMEHOME--+-- CmakeLists.txt
           |
           +-- build -- cmake --+-- Debug --+-- <ARCH> -- <project-files>
           |                    |
           |                    |
           |                    +-- Release --+-- <ARCH> -- <project-files>
           +-- doc --
           |
           +-- example
           |
           +-- include
           |
           +-- lib +-- <ARCH> -- <libraries>
           |
           +-- resource --+-- cmake
           |              |
           |              +-- scripts
           |
           +-- rtiddsgen
           |
           +-- src
```

The include directory contains the external interfaces, those that are available to other modules. The src directory contains the implementation files. Please refer to *Building the Connext Micro Source* for how to build the source code.

The remainder of this document focuses on the files that are needed to add a new port. The following directory structure is expected:

```
---+-- include --+-- osapi --+-- osapi_os_\<port\>.h
   |                          |
```

(continues on next page)

(continued from previous page)

```
|                        +-- osapi_cc_<compiler>.h
|
+-- src --+-- osapi --+-- common -- <common files>
                      |
                      +-- <port> --+-- <port>Heap.c
                                   |
                                   +-- <port>Mutex.c
                                   |
                                   +-- <port>Process.c
                                   |
                                   +-- <port>Semaphore.c
                                   |
                                   +-- <port>String.c
                                   |
                                   +-- <port>System.c
                                   |
                                   +-- <port>Thread.c
                                   |
                                   +-- <port>shmSegment.c
                                   |
                                   +-- <port>shmMutex.c
```

The *osapi_os_<port>.h* file contains OS specific definitions for various data-types. The <port> name should be short and in lower case, for example *myos*.

The *osapi_cc_<compiler>.h* file contains compiler specific definitions. The <compiler> name should be short and in lower case, for example *mycc*. The osapi_cc_stdc.h file properly detects GCC and MSVC and it is not necessary to provide a new file if one of these compilers is used.

The <port>Heap.c, <port>Mutex.c, <port>Process.c, <port>Semaphore.c, <port>String.c and <port>System.c files shall contain the implementation of the required APIs.

NOTE: It is *not* recommended to modify source files shipped with *Connext Micro*. Instead if it is desired to start with code supplied by RTI it is recommended to *copy* the corresponding sub-directory, for example posix, and rename it. This way it is easier to upgrade *Connext Micro* while keeping existing ports.

5.7.3 OS and CC Definition Files

The *include/osapi/osapi_os_<port>.h* file contains OS and platform specific definitions used by OSAPI and other modules. To include the platform specific file, define **OSAPI_OS_DEF_H** as a preprocessor directive.

```
-DOSAPI_OS_DEF_H=\"osapi_os_<port>.h\"
```

It should be noted that *Connext Micro* does not use auto-detection programs to detect the host and target build environment and only relies on predefined macros to determine the target environment. If *Connext Micro* cannot determine the target environment, it is necessary to manually configure the correct OS definition file by defining **OSAPI_OS_DEF_H** (see above).

The *include/osapi/osapi_cc_<compiler>.h* file contains compiler specific definitions used by OSAPI and other modules. To include the platform specific file, define **OSAPI_CC_DEF_H** as a preprocessor directive.

```
-DOSAPI_CC_DEF_H=\"osapi_cc_<compiler>.h\"
```

Endianness of some platforms is determined automatically via the platform specific file, but for others either **RTI_ENDIAN_LITTLE** or **RTI_ENDIAN_BIG** must be defined manually for little-endian or big-endian, respectively.

5.7.4 Heap Porting Guide

Connext Micro uses the heap to allocate memory for internal data-structures. With a few exceptions, *Connext Micro* does *not* return memory to the heap. Instead, *Connext Micro* uses internal pools to quickly allocate and free memory for specific types. Only the initial memory is allocated directly from the heap. The following functions must be ported:

- OSAPI_Heap_allocate_buffer
- OSAPI_Heap_free_buffer

However, if the OS and C library supports the standard malloc and free APIs define the following in the *osapi_os_<port>.h* file:

```
#define OSAPI_ENABLE_STDC_ALLOC   (1)
#define OSAPI_ENABLE_STDC_REALLOC (1)
#define OSAPI_ENABLE_STDC_FREE    (1)
```

Please refer to the OSAPI_Heap API for definition of the behavior. The available source code contains implementation in the file *osapi/<port>/<port>Heap.c*.

5.7.5 Mutex Porting Guide

Connext Micro relies on mutex support to protect internal data-structures from corruption when accessed from multiple threads.

The following functions must be ported:

- OSAPI_Mutex_new
- OSAPI_Mutex_delete
- OSAPI_Mutex_take_os
- OSAPI_Mutex_give_os

Please refer to the OSAPI_Mutex API for definition of the behavior. The available source code contains implementation in the file *osapi/<port>/<port>Mutex.c*

5.7.6 Semaphore Porting Guide

Connext Micro relies on semaphore support for thread control. If *Connext Micro* is running on a non pre-emptive operating system with no support for IPC and thread synchronization, it is possible to implement these functions as no-ops. Please refer to *Thread Porting Guide* for details regarding threading.

The following functions must be ported:

- OSAPI_Semaphore_new
- OSAPI_Semaphore_delete
- OSAPI_Semaphore_take
- OSAPI_Semaphore_give

Please refer to the OSAPI_Semaphore API for definition of the behavior. The available source code contains implementation in the file *osapi/<port>/<port>Semaphore.c*.

5.7.7 Process Porting Guide

Connext Micro only uses the process API to retrieve a unique ID for the applications.

The following functions must be ported:

- OSAPI_Process_getpid

Please refer to the OSAPI_Process_getpid API for definition of the behavior. The available source code contains implementation in the file *osapi/<port>/<port>Process.c*.

5.7.8 System Porting Guide

The system API consists of functions which are more related to the hardware on which *Connext Micro* is running than on the operating system. As of *Connext Micro* 2.3.1, the system API is implemented as an interface as opposed to the previous pure function implementation. This change makes it easier to adapt *Connext Micro* to different hardware platforms without having to write a new port.

The system interface is defined in OSAPI_SystemI, and a port must implement all the methods in this structure. In addition, the function OSAPI_System_get_native_interface must be implemented. This function must return the system interface for the port (called the native system interface).

The semantics for the methods in the interface are exactly as defined by the corresponding system function. For example, the method OSAPI_SystemI::get_time must behave exactly as that described by OSAPI_System_get_time.

The following system interface methods must be implemented in the OSAPI_SystemI structure:

- OSAPI_SystemI::get_timer_resolution
- OSAPI_SystemI::get_time

- OSAPI_SystemI::start_timer
- OSAPI_SystemI::stop_timer
- OSAPI_SystemI::generate_uuid
- OSAPI_SystemI::get_hostname
- OSAPI_SystemI::initialize
- OSAPI_SystemI::finalize

Please refer to the OSAPI_System API for definition of the behavior. The available source code contains implementation in the file: *osapi/<port>/<port>System.c*.

Migrating a 2.2.x port to 2.3.x

In *Connext Micro* 2.3.x, changes where made to how the system API is implemented. Because of these changes, existing ports must be updated, and this section describes how to make a *Connext Micro* 2.2.x port compatible with *Connext Micro* 2.3.x.

If you have ported *Connext Micro* 2.2.x the following steps will make it compatible with version 2.3.x:

- Rename the following functions and make them private to your source code. For example, rename OSAPI_System_get_time to OSAPI_MyPortSystem_get_time etc.
  - OSAPI_System_get_time
  - OSAPI_System_get_timer_resolution
  - OSAPI_System_start_timer
  - OSAPI_System_stop_timer
  - OSAPI_System_generate_uuid
- Implement the following new methods.
  - OSAPI_SystemI::get_hostname
  - OSAPI_SystemI::initialize
  - OSAPI_SystemI::finalize
- Create a system structure for your port using the following template:

```
 struct OSAPI_MyPortSystem
{
    struct OSAPI_System _parent;

    Your system variable
};

static struct OSAPI_MyPortSystem OSAPI_System_g;
```

(continues on next page)

(continued from previous page)

```
/* OSAPI_System_gv_system is a global system variable used by the
 * generic system API. Thus, the name must be exactly as
 * shown here.
 */
struct OSAPI_System * OSAPI_System_gv_system = &OSAPI_System_g._parent;
```

- Implement OSAPI_System_get_native_interface method and fill the OSAPI_SystemI structure with all the system methods.

5.7.9 Thread Porting Guide

The thread API is used by *Connext Micro* to create threads. Currently only the UDP transport uses threads and it is a goal to keep the generic *Connext Micro* core library free of threads. Thus, if *Connext Micro* is ported to an environment with no thread support, the thread API can be stubbed out. However, note that the UDP transport must be ported accordingly in this case; that is, all thread code must be removed and replaced with code appropriate for the environment.

The following functions must be ported:

- OSAPI_Thread_create
- OSAPI_Thread_sleep

Please refer to the OSAPI_Thread API for definition of the behavior. The available source code contains implementation in the file *srcC/osapi/<platform>/Thread.c*.

5.8 Port Validation

5.8.1 Introduction

This section explains how to build and run the *Connext Micro* Port Validation and is organized as follows:

- *Overview*
- *Building the Port Validation Tests*
- *Running the Tests*
- *Embedded Platforms*
- *Porting UTEST*

5.8.2 Overview

After porting *Connext Micro*, it is important to confirm that your code works as expected. For this, *Connext Micro* comes with a suite of tests that you compile and run to validate your port.

The tests only cover the functionality described in the porting instructions earlier in this chapter *Porting RTI Connext Micro*.

The tests are a subset of the tests RTI runs internally. They are just exported for your use. RTI does not support any changes to the tests. The tests are built with RTI's internal unit testing framework, 'UTEST'. Everything needed to run the tests is shipped along with the rest of *Connext Micro*. The directory layout is as follows:

```
RTIMEHOME/----+---- CMakeLists.txt
              |
              +---- include
              |
              +---- src
              |
              +---- resource
              |
              +---- lib
              |
              +---- build
              |
              +---- test --+-- test --+-- setting --- <UTEST-SRC>
                           |
                           +-- osapi --+-- common -- <OSAPI-TEST-SRC>
                           |           |
                           |           +-- test ---- <OSAPITester>
                           |
                           +-- netio --+-- autosar ---- <NETIO-TEST-SRC>
                           |           |
                           |           +-- common ----- <NETIO-TEST-SRC>
                           |           |
                           |           +-- test ------- <NETIOTester>
                           |           |
                           |           +-- udp  ------- <NETIO-TEST-SRC>
                           |
                           +-- include --- test ---- <UTEST-HDR>
```

The test folder includes four sub-folders. The 'test' and 'include' folders contain the UTEST framework that is required to run the unit tests. 'osapi' and 'netio' both contain common folders (containing the test source), as well as test folders (containing the test files).

5.8.3 Building the Port Validation Tests

By default, the port validation tests are not built. We recommend that you review *Building the Connext Micro Source*, since the same rules and considerations apply when building the port validation tests.

If you will be using the ctest (CMake test driver program) set the domain ID used to run the tests using this environment variable in your terminal:

On Linux and macOS systems:

```
export RTIME_TEST_CONFIG_ID="<your domain ID #>"
```

On Windows systems:

```
set RTIME_TEST_CONFIG_ID="<your domain ID #>"
```

Building with rtime-make

Use the option `--test` when running 'rtime-make'.

On Linux and macOS systems:

```
<RTIMEHOME>/resource/scripts/rtime-make --config Debug --target self \
--name i86Linux2.6gcc4.4.5 -G "Unix Makefiles" --build --test
```

On Windows systems:

```
<RTIMEHOME>\resource\scripts\rtime-make.bat --config Debug --target self \
--name i86Win32VS2010 -G "Visual Studio 10 2010" --build --test
```

Explanation of arguments:

- `--test` : **Build the port validation tests.**
- `--config Debug` : Create a Debug build.
- `--target <target>` : The target for the source files to be built. See *Building Connext Micro with rtime-make* for information on specifying the target architecture. "self" indicates that the host machine is also the target and *Connext Micro* will be built with the options that CMake automatically determines for the local compiler.
- `--name <name>` : The name of the build. Use a descriptive name following the recommendations on naming in section *Preparing for a Build*. If `--name` is not specified, the value for `--target` will be used as the name.
- `--build`: Build the generated project files.

Manually building with CMake

The process for building the port validation tests manually with CMake is the same as building the *Connext Micro* libraries manually with CMake. Follow the instructions in *Manually Building with CMake*. To build the port validation tests, you just need to ensure that the flag RTI_BUILD_UNITTESTS is set to true, so use `-DRTI\_BUILD\_UNITTESTS=true` when invoking CMake.

Custom Build Environments

The preferred method to build *Connext Micro* is to use CMake. However, in some cases it may be more convenient, or even necessary, to use a custom build environment. Please refer to *Custom Build Environments* to learn how to import *Connext Micro* code.

Additionally, in order to build the port validation tests the following steps are needed:

- Add compile-time definition '___autosar___' (Only for AUTOSAR Systems).
- Add compile-time definition '___freertos___' (Only for FreeRTOS Systems).
- Add the following include paths:
  - <RTIMEHOME>/test/include
  - <RTIMEHOME>/test/netio/autosar (Only for AUTOSAR Systems).
  - <RTIMEHOME>/test/netio/common
  - <RTIMEHOME>/test/netio/test
  - <RTIMEHOME>/test/netio/udp
  - <RTIMEHOME>/test/osapi/common
  - <RTIMEHOME>/test/osapi/test
- Import all source files from the folder <RTIMEHOME>/test/test
- To build the NETIO test, import all source files from the folder <RTIMEHOME>/test/netio
- To build the OSPIA test, import all source files from the folder <RTIMEHOME>/test/osapi

As explained above, you need to build and run two images, one with NETIO tests and another one with OSAPI tests.

5.8.4 Running the Tests

Setting Up a Config File

Since both OSAPI and NETIO run system tests, a config file is required. A template file for the unit-test configuration can be found in:

```
<RTIMEHOME>/resource/test/test.cfg
```

The template looks like this:

```
property
{
    netio.udp.allow_interface_multicast=1;
}

property user = "test"
{
    netio.udp.allow_interface="lo";
    netio.udp.allow_interface_address=0x7F000001;
    netio.udp.allow_interface_netmask=0xffffff00;
    netio.udp.multicast_if="lo";
    osapi.system.my_hostname="my_hostname";
}
```

Update the fields to reflect:

- Interface name, interface address and interface netmask
- Multicast

Running the tests using a configuration file

For systems with CMake, after compiling the tests you can simply run this command:

```
`ctest`
```

For extended output, run:

```
`ctest -V`
```

You need to run this command from the CMake build directory, that would be <RTIME-HOME>/build/cmake/Debug|Release/<arch>.

Otherwise you can run the executables directly with the following commands:

```
./test/bin/<arch>/osapiTester(d) -id <domain id> -config "./resource/test/test.cfg" -
↪user test

./test/bin/<arch>/netioTester(d) -id <domain id> -config "./resource/test/test.cfg" -
↪user test
```

Note: The environment variable RTIME_TEST_CONFIG_ID is only used when running the tests with 'ctest'. When running the test executables directly, use the parameter `-id` to indicate the domain ID.

Running the tests on platforms without a file system

On platforms without a file system, it is not possible to use a configuration file to run the port validation tests. In this case, the configuration can be passed as parameters to the test application, like this:

```
./test/bin/<arch>/osapiTester -id <domain id>
-property osapi.system.my\_hostname=<hostname>
-property netio.udp.allow\_interface=<Interface name>
-property netio.udp.allow\_interface\_address=<Interface IP address>
-property netio.udp.allow\_interface\_netmask=<Interface mask>
-property netio.udp.allow\_interface\_multicast=<1\|0>
-property netio.udp.multicast\_if=<Multicast Interface name>
```

```
./test/bin/<arch>/netioTester -id <domain id>
-property osapi.system.my\_hostname=<hostname>
-property netio.udp.allow\_interface=<Interface name>
-property netio.udp.allow\_interface\_address=<Interface IP address>
-property netio.udp.allow\_interface\_netmask=<Interface mask>
-property netio.udp.allow\_interface\_multicast=<1\|0>
-property netio.udp.multicast\_if=<Multicast Interface name>
```

Test Results

After running 'ctest -V', the output should be as follows:

```
test 1
    Start 1: osapi

1: Test command: /Users/garrett/workspace/RTI/connextmicro/rti/build/release/
↪connextmicro/2.4.14/source/unix/build/cmake/unix/lib/osapiTesterzd "-id" "67" "-config
↪" "./resource/test/test.cfg"
1: Test timeout computed to be: 9.99988e+06
1: hostname is Foothill.local
1: property netio.udp.allow_interface_multicast already exists
1: time/interface ..................................................: Passed
1: time/performance ................................................: Passed
1: system/hostname .................................................: Passed
1: system/lua ......................................................: Passed
1: mutex/basic .....................................................: Passed
1: mutex/lua .......................................................: Passed
1: semaphore/basic .................................................: Passed
1: semaphore/thread ................................................: Passed
1: semaphore/timeout ...............................................: Passed
1: semaphore/timeout_mt ............................................: Passed
1: semaphore/lua ...................................................: Passed
1: thread/basic ....................................................: Passed
1: thread/advanced .................................................: Passed
1: thread/priority .................................................: Passed
1: thread/lua ......................................................: Passed
```

(continues on next page)

(continued from previous page)

```
1: timer/1s ..................................................: Passed
1: timer/3s ..................................................: Passed
1: timer/MICRO-221 ...........................................: Passed
1: timer/MICRO-240 ...........................................: Passed
1: timer/MICRO-839 ...........................................: Passed
1: timer/MICRO-1617 ..........................................: Passed
1: timer/sec_nsec ............................................: Passed
1: timer/lua .................................................: Passed
1: process/pid_as_string .....................................: Passed
1: process/getpid ............................................: Passed
1: osapi:TESTS COMPLETED
1/2 Test #1: osapi ............................   Passed   73.49 sec
test 2
    Start 2: netio

2: Test command: /Users/garrett/workspace/RTI/connextmicro/rti/build/release/
↪connextmicro/2.4.14/rti_me.2.0/source/unix/build/cmake/unix/lib/netioTesterzd "-id"
↪"67" "-config" "./resource/test/unittest.cfg"
2: Test timeout computed to be: 9.99988e+06
2: hostname is Foothill.local
2: property netio.udp.allow_interface_multicast already exists
2: address/parser ............................................: Passed
2: address/resolver ..........................................: Passed
2: address/ifname ............................................: Passed
2: route/precondition ........................................: Passed
2: route/lua .................................................: Passed
2: route/precondition ........................................: Passed
2: route/route ...............................................: Passed
2: route/default_mc_route ....................................: Passed
2: route/lua .................................................: Passed
2: udp/route .................................................: Passed
2: udp/iftable ...............................................: Passed
2: udp/unicast ...............................................: Passed
2: udp/multicast .............................................: Passed
2: udp/multicast_reserve .....................................: Passed
2: udp/nat ...................................................: Passed
2: udp/max_message_size ......................................: Passed
2: udp/strrchr ...............................................: Passed
2: udp/lua ...................................................: Passed
2: packet/set_head_tail ......................................: Passed
2: netio:TESTS COMPLETED
2/2 Test #2: netio ............................   Passed   80.75 sec

100% tests passed, 0 tests failed out of 2
```

When a test fails, the output will be as follows:

```
1: system/hostname ...........................................: Failed (FAILURE:␣
↪SystemTester.c:523 osapi.system.my_hostname not set)

2: udp/iftable ...............................................: Failed (FAILURE:␣
↪UDPInterfaceTester.c:2397 netio.udp.allow_interface property not found)
```

If a test fails, the test execution stops and any following tests will not run. In the above example, you can see that the tests OSAPI 'system/hostname' and NETIO 'udp/iftable' failed.

Troubleshooting

If the tests fail on hostname and iftable such as:

```
1: system/hostname ..........................................................: Failed␣
↪(FAILURE: SystemTester.c:523 osapi.system.my_hostname not set)

2: udp/iftable ..............................................................: Failed␣
↪(FAILURE: UDPInterfaceTester.c:2397 netio.udp.allow_interface property not found)
```

then you have incorrectly declared your domain ID. Refer to *Setting Up a Config File* for more information.

5.8.5 Embedded Platforms

When developing for an embedded platform, you will commonly need to create an image with all the software: OS, BSP, middleware, user application, etc. In this situation, you must create static libraries only, instead of executables.

Two static libraries are generated, one with the OSAPI tests and another with the NETIO tests. These are osapiTesterz(d) and netioTesterz(d) (the d suffix indicates whether it is a debug library if present or a release library if not present).

You need to build two images, one using the OSAPI test library and another using the NETIO test library. We recommend building and running one release image using the release libraries and one debug image using the debug libraries.

There is a third static library, rti_me_testz(d), which contains the UTEST framework. This library is needed to build both the OSAPI and NETIO tests.

For example, to build NETIO tests, use the following libraries:

- netioTesterz(d)
- rti_me_testz(d)
- librti_mez(d)

AUTOSAR Systems

Before continuing, you should become familiar with the configuration needed to run *Connext Micro* on an AUTOSAR system. We recommend that you review *Connext Micro on AUTOSAR*.

The file <RTIMEHOME>/test/include/test/test_autosar.h contains the string definitions with all the properties that are used to run the port validation tests. That is, the following definition:

```
#define DEVICE_ETH_IP_STR "0xc0000002"
```

can be used when the IP address configured on an AUTOSAR system is 192.0.0.2. In your build system, you need to define the properties that do not match with your configuration. That is, you need to define `DEVICE_ETH_IP_STR`in your build system to use a different IP address.

You need to add compile-time definition '___autosar___'.

The specific configuration needed to run the port validation tests on an AUTOSAR system includes the following:

- The default timer task period used to run the AUTOSAR port validation tests is 10 ms. If your timer task is configured with a different periodicity, define 'TIMER_TASK_PERIOD_MS' with that periodicity value, in ms.
- The default IP address used by the AUTOSAR port validation tests is "0xc0000002". If your AUTOSAR configuration uses a different IP address, define 'DEVICE_ETH_IP_STR' with the string representation of that IP address.
- The default IP mask used by the AUTOSAR port validation tests is "0xffffff00". If your AUTOSAR configuration uses a different IP mask, define 'DEVICE_ETH_IP_STR' with the string representation of that IP mask.
- The AUTOSAR port validation tests need at least 140 KB of RAM to run. AUTOSAR system properties (OSAPI_SystemProperty) must be configured correctly with at least this amount of memory in the heap. You need to define variables 'const uint32 heap_area_size[NUMBER_OF_HEAP_AREAS];' and 'char* const heap_area[NUMBER_OF_HEAP_AREAS];'. It is also possible to define NUMBER_OF_HEAP_AREAS in your build system (default value is 2).
- The AUTOSAR port validation tests use 2 semaphores. 2 timeout events, 2 give events and 2 alarms are needed. You need to define 'RTIME_Semaphore_Give_Event' with the ID of the first semaphore give event, 'RTIME_Semaphore_Timeout_Event' with the ID of the first semaphore timeout event, and 'RTIME_Semaphore_Alarm' with the ID of the first semaphore alarm.
- The AUTOSAR port validation tests can be configured to either use resources (for single core) or spinlock (for multicore) synchronization. The default is to use resources. You need to define 'RTIME_SYNC_TYPE' with a different value in your build system.
- If using resources synchronization: the AUTOSAR port validation tests use 26 AUTOSAR resources. You need to define 'RTIME_Resource01' with the ID of the first resource and 'RTIME_Resource26' with the ID of the last resource.
- If using spinlock synchronization: you need to define 'RTIME_Spinlock' with the spinlock ID.
- 3 UDP sockets are created. The AUTOSAR configuration must allow that.
- The AUTOSAR port validation tests use SocketOwner ID 1 to create sockets. If your AUTOSAR configuration uses a different SocketOwner, you need to define 'RTIME_SOCK_OWNER_ID' with the ID of the SocketOwner that can be used to create sockets.
- The AUTOSAR port validation tests use ID 0 as the IP address identifier representing the local IP address and EthIf controller to bind the socket to. If your AUTOSAR configuration

uses a different ID, you need to define 'RTIME_LOCAL_ADDR_ID' with the correct value.

- The 'UDP receive task' and 'UDP receive event' are mandatory. Some tests use them while some others don't. You need to define their IDs using the macros 'NETIO_Autosar_udp_receive_task' and 'RTIME_UDP_Receive_Event'.
- The AUTOSAR port does not provide and does not need a 'OSAPI_Thread_sleep()' function. But the AUTOSAR port validation tests do need that functionality. The implementation is based on an alarm and an event. OSAPI_Thread_sleep() sets an alarm with ID 'RTIME_Sleep_Alarm' and waits until the event with ID 'RTIME_Sleep_Event' is set.
- An alarm must be configured to set an event when it expires. It is important that the alarm is triggered by a counter based on a 1 ms tick and when the alarm expires. You need to define in your build system the alarm ID and the event ID using 'RTIME_Sleep_Alarm' and 'RTIME_Sleep_Event'.
- A task with the name 'Micro_UnitTests_Task' must be configured in the AUTOSAR configuration. This is the task that runs the port validation tests. The task shall have at least 32 KB stack. The implementation of this task is provided by the AUTOSAR port validation tests.
- Test results will be printed to the standard output used by 'printf()'.

FreeRTOS Systems

Before continuing, you should become familiar with the configuration needed to run *Connext Micro* on a FreeRTOS system. We recommend that you review *Building the Connext Micro Source for FreeRTOS*.

The file <RTIMEHOME>/test/include/test/test_freertos.h contains the string definitions with all the properties that are used to run the port validation tests. That is, the following definition:

```
#define DEVICE_ETH_IP_STR "0xc0000002"
```

can be used when the IP address configured on a FreeRTOS system is 192.0.0.2. In your build system, you need to define the properties that do not match with your configuration. That is, you need to define `DEVICE_ETH_IP_STR`in your build system to use a different IP address.

Some NETIO tests send UDP packet to the local IP address. For that reason it is necessary to set the following lwIP flag:

```
#define LWIP_NETIF_LOOPBACK             1
```

You need to add compile-time definition '___freertos___'.

We recommend that you create a separate thread and call the UTEST main function (UTEST_main()) for platforms without dynamic linking. This thread should have at least 32 KB of stack.

An example implementation of that thread is:

```
void UTEST_freertos_main(void *param)
{
    /* Avoid compiler warning */
    (void)param;

    /* Wait until network is available */
#ifdef USE_DHCP
    while(DHCP_state != DHCP_ADDRESS_ASSIGNED)
    {
        OSAPI_Thread_sleep(1000);
    }
#else
    vTaskDelay(5000 / portTICK_RATE_MS);
#endif

    (void)UTEST_main();

    vTaskDelete(NULL);
}
```

5.8.6 Porting UTEST

If you wrote a new *Connext Micro* port, you will also need to port the porting validation module. Most of the changes needed are only in the file <RTIMEHOME>/include/test/test_setting.h.

1. Check for a compiler flag that identifies your platform. For example, Linux would be **___linux___**. If your compiler does not provide such a flag, you can add a flag to your build system, i.e. **my_platform**.

2. As explained in *Running the tests on platforms without a file system*, you can pass the test configuration through a file or through a string. Write a new section in the file <RTIMEHOME>/include/test/test_setting.h where you configure this. After this comment at the beginning of the file:

   ```
   /* If the platform has not been specified, attempt to determine it. */
   ```

   Write a section like the following:

   ```
   #if \_\_my_platform\_\_
   #ifndef MYCOMPANY_MYPLATFORM
   #define MYCOMPANY_MYPLATFORM
   #endif /* MYCOMPANY_MYPLATFORM */
   #include "test_myplatform.h"
   #define HAVE_CONFIG_FILE 0
   #define HAVE_ARG_STRING  1
   #ifdef HAVE_TEST_RESULTS_FILE
   #undef HAVE_TEST_RESULTS_FILE
   #endif
   #define HAVE_TEST_RESULTS_FILE 0
   #endif /* \_\_my_platform\_\_ */
   ```

The file "test_myplatform.h" is optional. You can create it to add any definitions that are useful for your tests.

If your platform does not have a file system, the value of *HAVE_CONFIG_FILE* shall be 0 and the value of *HAVE_ARG_STRING* shall be 1. You also need to undef *HAVE_TEST_RESULTS_FILE*. If your platform has a file system, you might need to change the logic, but that is optional.

3. In the file <RTIMEHOME>/include/test/test_setting.h, define the maximum length of the system name, so the new platform is recognized by UTEST. For example:

```
#elif defined(RTI_AUTOSAR)
#define UTEST_SYSTEM_NAME_MAX_LENGTH 255
#elif defined(MYCOMPANY_MYPLATFORM)
#define UTEST_SYSTEM_NAME_MAX_LENGTH 255
#else
#error "Unknown platform. Please port UT_System.c to this platform."
#endif
```

The third and fourth lines are new. You can also include any platform header file in this new code.

4. If you have defined `HAVE_ARG_STRING`as 1, you need to provide the string that will be used as an argument. Create the file <RTIMEHOME>/include/test/test_myplatform.h with the following content:

```
#define UTEST_ARG_STRING(argv0_) \
  "-property netio.udp.allow_interface_multicast=1 " \
  "-property netio.udp.allow_interface=eth0 " \
  "-property netio.udp.allow_interface_address=" DEVICE_ETH_IP_STR " " \
  "-property netio.udp.allow_interface_netmask=" DEVICE_MASK_STR " " \
  "-property netio.udp.multicast_if=eth0 " \
  "-property osapi.system.my_hostname=Myplatform-host " \
  "-id 80 "
```

Depending on your platform, the property values might be different. For instance, if your platform doesn't have multicast you will need to set `netio.udp.allow_interface_multicast=0`.

5. If your new platform supports dynamic linking, executable binaries with OSAPI and NETIO tests are generated when you build the port validation tests.

6. If your new platform does not support dynamic linking, only static libraries with OSAPI and NETIO tests are generated when you build the port validation tests. These libraries provide a UTEST_main() function. We recommend that you create a separate thread and call that UTEST_main() function from that thread. This thread should have at least 32 KB of stack.

5.9 Building Connext Micro with compatibility for Connext Cert

It is possible to compile *Connext Micro* to support only the same set of APIs and features as *Connext Cert*. This is useful to enable the development of a safety-certified project using *Connext Micro* before the certification of *Connext Cert* is completed. Once *Connext Cert* certification is finished, it will be easier to switch from *Connext Micro* to *Connext Cert* if *Connext Micro* has been compiled with compatibility for *Connext Cert*.

When compiling *Connext Micro* with compatibility for *Connext Cert*, the following restrictions apply:

- The C++ API is not supported.
- Dynamic Participant Dynamic Endpoint (DPDE) discovery is not compiled by default. To make application development easier, DPDE can be enabled (any application using this discovery cannot be certified). DPDE discovery is not certified.
- Memory deallocation is not possible.
- Any API that deallocates memory is not supported. In other words, any API whose name includes "finalize", "free", or "delete" is not supported (such as `DDS_DomainParticipantFactory_delete_participant()`, `DDS_DomainParticipantQos_finalize()`, `OSAPI_Heap_free()`).
- Only POSIX®-compliant systems (Linux, macOS, QNX, etc.), VxWorks and AUTOSAR are supported (Windows systems are not supported).
- Only static libraries are compiled. Dynamic libraries are not supported.
- Only one static library is built. While *Connext Micro* consists of different libraries for discovery, reader and writer history, etc, *Connext Cert* consists of only one library.
- Code generated by the *Connext Micro* code generator is compatible with *Connext Cert*, but the code must be generated again with the *Connext Cert* code generator.
- The Log module is only available in the debug build.
- The UDP transport shall be configured statically by using the API `UDP_InterfaceTable_add_entry()` and setting `UDP_InterfaceFactoryProperty.disable_auto_interface_config` equal to `RTI_TRUE`.
- `OSAPI_Thread_sleep()` is not available.
- Batching reception is not supported.
- UDP Transformations are not supported.

To compile *Connext Micro* with compatibility with *Connext Cert*, you only need to set the CMake flag RTIME_CERT when compiling. For example, the following command compiles *Connext Micro* on a Linux system with *Connext Cert* compatibility:

```
resource/scripts/rtime-make --target Linux --name x64Linux4gcc9.3.0
    --build --config Debug -DRTIME_CERT=1
```

The CMake flag RTIME_CERT instructs the build system to build *Connext Micro* with *Connext Cert* compatibility. In the previous example, a 64-bit debug library is generated in the directory `lib/x64Linux4gcc9.3.0`.

Instead of using the flag -DRTIME_CERT=1, it is also possible to add the suffix "_cert" to the build name, and the build system will automatically set the RTIME_CERT flag. For example:

```
resource/scripts/rtime-make --target Linux --name
    x64Linux4gcc9.3.0_cert --build --config Release
```

The previous command compiles a 64-bit release library in the directory `lib/x64Linux4gcc9.3.0_cert`.

As mentioned earlier, it is possible to enable DPDE (Dynamic Participant Dynamic Endpoint) discovery, but this discovery is not certified so any application using it cannot be certified. To enable DPDE discovery when building *Connext Micro* with *Connext Cert* compatibility, simply add the following flag when compiling: **-DRTIME_EXCLUDE_DPDE=0**.

Chapter 6

Working with RTI Connext Micro and RTI Connext DDS

In some cases, it may be necessary to write an application that is compiled against both RTI *Connext Micro*, *RTI Connext Cert*, and *RTI Connext DDS*. In general this is not easy to do because RTI *Connext Micro* and *RTI Connext Cert* supports a very limited set of features compared to *RTI Connext DDS*. However, while *RTI Connext Cert* is subset of RTI *Connext Micro*, it is relatively easy to write applications that support both.

Due to the nature of the DDS API and the philosophy of declaring behavior through QoS profiles instead of using different APIs, it may be possible to share common code. In particular, *RTI Connext DDS* supports configuration through QoS profile files, which eases the job of writing portable code.

Please refer to *Introduction* for an overview of features and what is supported by *RTI Connext Micro*. Note that *RTI Connext DDS* supports many extended APIs that are not covered by the DDS specification, for example APIs that create DDS entities based on QoS profiles.

6.1 Development Environment

There are no conflicts between *RTI Connext Micro* and *RTI Connext DDS* with respect to library names, header files, etc. It is advisable to keep the two installations separate, which is the normal case.

RTI Connext Micro uses the environment variable RTIMEHOME to locate the root of the *RTI Connext Micro* installation.

RTI Connext DDS uses the environment variable NDDSHOME to locate the root of the *RTI Connext DDS* installation.

6.2 Non-standard APIs

The DDS specification omits many APIs and policies necessary to configure a DDS application, such as transport, discovery, memory, logging, etc. In general, *RTI Connext Micro* and *RTI Connext DDS* do not share APIs for these functions.

It is recommended to configure *RTI Connext DDS* using QoS profiles as much as possible.

6.3 QoS Policies

QoS policies defined by the DDS standard behave the same between *RTI Connext Micro* and *RTI Connext DDS*. However, note that *RTI Connext Micro* does not always support all the values for a policy and in particular unlimited resources are not supported.

Unsupported QoS policies are the most likely reason for not being able to switch between *RTI Connext Micro* and *RTI Connext DDS*.

6.4 Standard APIs

APIs that are defined by the standard behave the same between *RTI Connext Micro* and *RTI Connext DDS*.

6.5 IDL Files

RTI Connext Micro and *RTI Connext DDS* use the same IDL compiler (rtiddsgen) and *RTI Connext Micro* typically ships with the latest version. However, *RTI Connext Micro* and *RTI Connext DDS* use different templates to generate code and it is not possible to share the generated code. Thus, while the same IDL can be used, the generated output must be saved in different locations.

6.6 Interoperability

In general, *RTI Connext Micro* and *RTI Connext DDS* are wire interoperable, unless noted otherwise.

All RTI products, aside from *RTI Connext Micro*, are based on *RTI Connext DDS*. Thus, in general *RTI Connext Micro* is compatible with RTI tools and other products. The following sections provide additional information for each product.

When trying to establish communication between an *RTI Connext Micro* application that uses the Dynamic Participant / Static Endpoint (DPSE) discovery module and an RTI product based on *RTI Connext DDS*, every participant in the DDS system must be configured with a unique participant name. While the static discovery functionality provided by *RTI Connext DDS* allows participants

on different hosts to share the same name, *RTI Connext Micro* requires every participant to have a different name to help keep the complexity of its implementation suitable for smaller targets.

When interoperating with *RTI Connext DDS*, *RTI Connext Micro* must specify at least one unicast transport for each DataWriter and DataReader, either from DDS_DomainParticipantQos::transports or the endpoint DDS_DataReaderQos::transport and DDS_DataWriterQos::transport, as it expects to use the unicast transport's RTPS port mapping to determine automatic participant IDs if needed. This also affects *RTI Connext Micro* itself, where participant IDs must be set manually if only multicast transports are enabled.

Also, when interoperating with *RTI Connext DDS*, only one multicast transport can be specified per DataReader of *RTI Connext Micro*.

6.7 Admin Console

Admin Console can discover and display *RTI Connext Micro* applications that use full dynamic discovery (DPDE). When using static discovery (DPSE), it is required to use the Limited Bandwidth Endpoint Discovery (LBED) that is available as a separate product for *RTI Connext DDS*. With the library a configuration file with the discovery configuration must be provided (just as in the case for products such as Routing Service, etc.). This is provided through the QoS XML file.

Data can be visualized from *RTI Connext Micro* DataWriters. Keep in mind that *RTI Connext Micro* does not currently distribute type information and the type information has to be provided through an XML file using the "Create Subscription" dialog. Unlike some other products, this information cannot be provided through the QoS XML file. To provide the data types to Admin Console, first run the code generator with the `-convertToXml` option:

```
rtiddsgen -convertToXml <file>
```

Then click on the "Load Data Types from XML file" hyperlink in the "Create Subscription" dialog and add the generated IDL file.

Other Features Supported:

- Match analysis is supported.
- Discovery-based QoS are shown.

The following resource limits in *RTI Connext Micro* must be incremented as follows when using Admin Console:

- Add 24 to DDS_DomainParticipantResourceLimitsQosPolicy::remote_reader_allocation
- Add 24 to DDS_DomainParticipantResourceLimitsQosPolicy::remote_writer_allocation
- Add 1 to DDS_DomainParticipantResourceLimitsQosPolic::remote_participant_allocation
- Add 1 to DDS_DomainParticipantResourceLimitsQosPolicy::remote_participant_allocation if data-visualization is used

RTI Connext Micro does not currently support any administration capabilities or services, and does not match with the Admin Console DataReaders and DataWriters. However, if matching

DataReaders and DataWriters are created, e.g., by the application, the following resource must be updated:

- Add 48 to DDS_DomainParticipantResourceLimitsQosPolicy::matching_writer_reader_pair_allocation

6.8 Distributed Logger

This product is not supported by *RTI Connext Micro*.

6.9 LabVIEW

The LabVIEW toolkit uses *RTI Connext DDS*, and it must be configured as any other *RTI Connext DDS* application. A possible option is to use the builtin *RTI Connext DDS* profile: BuiltinQosLib::Generic.ConnextMicroCompatibility.

6.10 Monitor

This product is not supported by *RTI Connext Micro*.

6.11 Recording Service

6.11.1 RTI Recorder

RTI Recorder is compatible with *RTI Connext Micro* in the following ways:

- If static endpoint discovery is used, Recorder is compatible starting with version 5.1.0.3 and onwards.
- If dynamic endpoint discovery is used (not supported by *Connext Cert*), Recorder is compatible with *RTI Connext Micro* the same way it is with any other DDS application.
- In both cases, type information has to be provided via XML. Read Recording Data with *RTI Connext Micro* for more information.

6.11.2 RTI Replay

RTI Replay is compatible with *RTI Connext Micro* in the following ways:

- If static endpoint discovery is used, Replay is compatible starting with version 5.1.0.3 and onwards.
- If dynamic endpoint discovery is used (not supported by *Connext Cert*), Replay is compatible with *RTI Connext Micro* the same way it is with any other DDS application.

- In both cases, type information has to be provided via XML. Read Recording Data with *RTI Connext Micro* for more information on how to convert from IDL to XML.

6.11.3 RTI Converter

Databases recorded with *RTI Connext Micro* contains no type information in the DCPSPublication table, but the type information can be provided via XML. Read Recording Data with *RTI Connext Micro* for more information on how to convert from IDL to XML.

6.12 Spreadsheet Addin

RTI Connext Micro can be used with Spreadsheet Add-in starting with version 5.2.0. The type information must be loaded from XML files.

6.13 Wireshark

Wireshark fully supports *RTI Connext Micro*.

6.14 Persistence Service

RTI Connext Micro only supports VOLATILE and TRANSIENT_LOCAL durability and does not support the use of Persistence Service.

Chapter 7

API Reference

RTI Connext Micro features API support for C and C++. Select the appropriate language below in order to access the corresponding API Reference HTML documentation.

- C API Reference
- C++ API Reference

Chapter 8

Release Notes

8.1 Supported Platforms and Programming Languages

Connext Micro supports the C and traditional C++ language bindings.

Note that RTI only tests on a subset of the possible combinations of OSs and CPUs. Please refer to the following table for a list of specific platforms and the specific configurations that are tested by RTI.

Table 8.1: Tested Platforms

OS	CPU	Compiler	RTI Architecture Abbreviation
Elektrobit™ AUTOSAR™ 4.0.3	Infineon™ AURIX™ TriCore™ TC297	Tasking 6.2r2	tc29xtOsekCoreTasking6.2r2
Mentor™ AUTOSAR 4.2.2	Infineon AURIX TriCore TC297	Tasking 6.2r2	tc29xtVSTARTasking6.2r2
Red Hat® Enterprise Linux® 6.0, 6.1 (Kernel version 2.6)	x86	gcc 4.4.5	i86Linux2.6gcc4.4.5
Ubuntu® 18.04 (Kernel version 4)	x64	gcc 7.3.0	x64Linux4gcc7.3.0
Ubuntu 16.04 (Kernel version 3)	x86	gcc 5.4.0	i86Linux3gcc5.4.0
PPC Linux (Kernel version 3)	ppce500mc	gcc 4.7.2	ppce500mcLinux3gcc4.7.2
macOS® 10.16	x64	clang 8.0	x64Darwin16clang8.0
QNX® 7.0	armv8	qcc 5.4.0	armv8QNX7.0.0qcc_gpp5.4.0
QNX 6.6	armv7a	qcc 4.7.3	armv7aQNX6.6.0qcc_cpp4.7.3
QNX 6.6	i86	qcc 4.7.3	i86QNX6.6qcc_cpp4.7.3
Windows® 7	x64	Visual Studio® 2015	x64Win64VS2015
VxWorks 6.9	ppc604	gcc 4.3.3	ppc604Vx6.9gcc4.3.3 and ppc604Vx6.9gcc4.3.3_rtp
QNX® OS for Safety 2.1	armv8	qcc 5.4.0	armv8QOS2.1qcc_gpp5.4.0

8.2 API Interoperability

8.2.1 Important Interoperability Changes

This release of *Connext Micro* includes the following changes in API compatability with previous release:

- *DDS_DomainParticipantFactory_get_instance* **must** be called before other APIs. This is required to ensure that a platform integration is properly configured and initialized before other APIs are called. APIs that need special attention have an additional attribute `API Restriction` to indicate any restrictions.

8.3 What's New in 2.4.14.1

2.4.14.1 is a cumulative bug fix release and does not include any new features.

8.4 What's Fixed in 2.4.14.1

8.4.1 Invalid samples in batched data did not count as 'lost samples'

Invalid samples in batched data were not counted as lost samples, and did not trigger *Connext Micro* to call *on_sample_lost()* when the "on_sample_lost" notification was enabled.

This issue has been resolved.

[RTI Issue ID MICRO-2289]

8.4.2 Local variables in header file may have caused compiler warning

Local variables were incorrectly defined in ReaderHistory.c and may have caused a compiler warning.

This issue has been resolved.

[RTI Issue ID MICRO-2785]

8.4.3 Non-default timer resolutions may have caused an incorrect timeout

Compiling *Connext Micro* with a non-default timer resolution may have caused incorrect timeouts.

This issue has been resolved.

[RTI Issue ID MICRO-2794]

8.4.4 Missing checks for *max_routes_per_reader* and *max_routes_per_writer*

The *DDS_DataReaderQos.reader_resource_limits.max_routes_per_writer* and *DDS_DataWriterQos.writer_resource_limits.max_routes_per_reader* were missing a check that the values were in the range [1,2000]. They were also missing from the methods *DDS_DataReaderQos_is_equal* and *DDS_DataWriterQos_is_equal* respectively.

This issue has been resolved.

[RTI Issue ID MICRO-2830, MICRO-2937]

8.4.5 Missing NULL checks for *enabled_transports*

In previous releases, it was not checked that the *enabled_transports* QoS policy setting did not contain NULL pointers.

This issue has been resolved.

[RTI Issue ID MICRO-3117]

8.4.6 Possible exception due to misaligned RTPS header

In previous releases, if multiple RTPS messages were received in the same UDP payload, a misaligned RTPS message header could cause an exception.

Note: *RTI Connext Micro* does not send multiple RTPS messages in the same UDP payload.

This issue has been resolved.

[RTI Issue ID MICRO-2866]

8.4.7 *DDS_SubscriptionBuiltinTopicData_copy* did not copy the PresentationQosPolicy

The *DDS_SubscriptionBuiltinTopicData_copy* function did not copy the PresentationQosPolicy.

This issue has been resolved.

[RTI Issue ID MICRO-2897]

8.4.8 Possible failure to start timer

On architctures using the *posix* port of *Connext Micro*, the DomainParticipantFactory may have failed to initialize if compiled to use signals or if CLOCK_MONOTONIC was not available.

This issue has been resolved.

[RTI Issue ID MICRO-2904]

8.4.9 Sample timestamp now set to 0 if timestamp cannot be retrieved

If the reception timestamp for a sample cannot be retrieved, the reception timestamp is set to 0.

[RTI Issue ID MICRO-2909]

8.4.10 *Qos_copy* functions did not validate input arguments

In previous releases, the *Qos_copy* APIs did not validate that the input arguments were not NULL.

This issue has been resolved.

[RTI Issue ID MICRO-2913]

8.4.11 Unused parameter *DOMAIN_PARTICIPANT_RESOURCE_LIMITS.matching_reader_writer_pair_allocation* removed

The QoS policy setting *DOMAIN_PARTICIPANT_RESOURCE_LIMITS.matching_reader_writer_pair_allocation* was not used and has been removed from the *DOMAIN_PARTICIPANT_RESOURCE_LIMITS* structure.

[RTI Issue ID MICRO-2915]

8.4.12 *DDS_DomainParticpant_add_peer* may have returned success on failure

DDS_DomainParticpant_add_peer may have returned success even if the peer was not added.

This issue has been resolved.

[RTI Issue ID MICRO-2929]

8.4.13 *DDS_StringSeq_copy* did not validate input arguments

In previous versions, *DDS_StringSeq_copy* did not check that the source and destination arguments were different before copying.

This issue has been resolved.

In addition, the documentation for *Seq_copy* has been updated to clearly state that overlapping memory regions are not supported, with the exception of copying to itself.

[RTI Issue ID MICRO-2964]

8.4.14 Memory leak in C++ classes for builtin topic data types and certain QoSes

SupportMethodsGen.hxx did not implement a destructor, which could have caused a memory leak when using the C++ API for builtin topic data types and certain QoSes.

This problem has been fixed.

[RTI Issue ID MICRO-2971]

8.4.15 Possible NULL pointer exception in generated code if the system was out of memory

In previous releases, it was possible to get a NULL pointer exception in the generated code if the system was out of memory during initialization.

This issue would have occurred during DDS entity creation, as memory is only allocated during entity creation.

This issue has been resolved.

[RTI Issue ID MICRO-2986]

8.4.16 A DataWriter could run out of resources if sample was not added to cache

In rare cases, a *DataWriter* could run out of resources if a sample could be successfully serialized, but not added to the writer cache.

This issue has been resolved.

[RTI Issue ID MICRO-3034]

8.4.17 Missing source code files

In previous releases, the following source code files were missing:

- UDPTransformations.c
- UDPTransformations.h
- DPSEVersion.c

This problem has been fixed.

[RTI Issue ID MICRO-3042]

8.4.18 Possible serialization beyond stream buffer

In previous releases, *CDR_Stream_check_size* did not check for underflow. As a result, it was possible to serialize data beyond the buffer boundary if the buffer assigned to the stream was too small.

This is only an issue for applications assigning too small of a buffer to a stream.

This issue has been resolved.

[RTI Issue ID MICRO 3147, MICRO-3200]

8.4.19 *RELIABILITY.max_blocking_time* must be zero

In previous releases, a non-zero *RELIABILITY.max_blocking_time* was supported on a *DataReader*. This feature is not supported in this release.

[RTI Issue ID MICRO-3148]

8.4.20 Possible DataReader or DataWriter creation failure with multiple DomainParticipants

In previous releases, creating *DataReaders* or *DataWriters* in different threads for different *DomainParticipants* could fail due to a race condition.

This issue has been resolved.

[RTI Issue ID MICRO-3151]

8.4.21 Incorrect *lease_duration* may have been used for a discovered participant

In previous releases, if the *lease_duration* was not sent by a remote *DomainParticipant*, a previously received value was used instead.

This issue has been resolved.

Note that RTI's DDS implementations send the *lease_duration*.

[RTI Issue ID MICRO-3254]

8.4.22 Missing consistency check for *DESTINATION_ORDER.source_timestamp_tolerance*

In previous releases, a check that *DESTINATION_ORDER.source_timestamp_tolerance* was normalized was missing (nanosecond < 1 seconds).

This issue has been resolved.

[RTI Issue ID MICRO-3272]

8.4.23 Improved error detection for unresolved addresses

In previous releases, an unresolved address was ignored. In this release, if an address cannot be resolved, it results in a failure. This means that all addresses passed to the *add_peer* API and the *enabled_transports* QoS policy must be valid, otherwise entity creation will fail.

[RTI Issue ID MICRO-3276]

8.4.24 *DDS_StatusCondition_set_enabled_statuses* did not trigger if an active condition was enabled

In previous releases, if a StatusCondition enabled by a call to *DDS_StatusCondition_set_enabled_statuses* was already active, the StatusCondition did not trigger.

This issue has been resolved.

[RTI Issue ID MICRO-3308]

8.4.25 Race condition in DDS *enable* APIs

In previouses releases, a race condition existed if the same DDS entity was enabled from multiple threads at the same time.

This issue has been resolved.

[RTI Issue ID MICRO-3311]

8.4.26 DDS WaitSet may have timed out later than timeout value

In very rare cases, an error message taking a mutex may have been logged when using the POSIX real-time timers. This may have resulted in a delayed timeout for *DDS_WaitSets*.

This issue has been resolved.

[RTI Issue ID MICRO-3330]

8.4.27 SYSTEM_RESOURCE_LIMITS.max_components QoS policy cannot be changed

In previous releases, the documentation incorrectly specified that the `SYSTEM_RESOURCE_LIMITS.max_components` QoS policy could be changed. This has been corrected to state that it cannot be changed. The default value has also been increased to 64.

[RTI Issue ID MICRO-4102]

8.4.28 Incorrect heartbeat sent before first sample when first_write_sequence_number is not 1

In previous releases, if the `DataWriterQos.protocol.rtps_reliable_writer.first_write_sequence_number` was different from the default value of 1, heartbeats sent before the first sample was written would indicate 1 as the first sample available. This would cause a *DataReader* to wait for samples with a sequence number less than `DataWriterQos.protocol.rtps_reliable_writer.first_write_sequence_number` until a heartbeat with the correct first sequence number was received.

This issue has been resolved.

[RTI Issue ID MICRO-4081]

8.4.29 Robustness check added to verify that participant GUIDs are unique within a DomainParticipantFactory

A check has been added to `DomainParticipantFactory_create_participant` to validate that *DomainParticipants* created within the same `DomainParticipantFactory` have unique GUIDs, and return *nil* if this is not the case.

[RTI Issue ID MICRO-4062]

8.4.30 DDS_Entity_enable was not thread-safe for a DomainParticipant

DDS_Entity_enable was not thread-safe, which may have led to race conditions. This issue has been resolved.

[RTI Issue ID MICRO-3381]

8.4.31 Missing input verification for API functions

The following functions did not have a precondition check:

- *DDS_PublicationBuiltinTopicData_initialize()*
- *DDS_SubscriptionBuiltinTopicData_initialize()*
- *DDS_ParticipantBuiltinTopicData_initialize()*

This issue has been resolved.

[RTI Issue ID MICRO-3442]

8.4.32 Incorrect return values from REDA_String

REDA_String_compare and *REDA_String_ncompare* would return incorrect values when NULL was passed in as one of the parameters. This issue has been resolved.

[RTI Issue ID MICRO-3461]

8.4.33 Incorrect return values from QoS APIs

The following functions have been corrected to return *DDS_RETCODE_BAD_PARAMETER* instead of *DDS_RETCODE_PRECONDITION_NOT_MET*:

- *DDS_DomainParticipantFactoryQos_copy*
- *DDS_DomainParticipantFactoryQos_initialize*
- *DDS_DomainParticipantQos_copy*
- *DDS_DomainParticipantQos_initialize*
- *DDS_SubscriberQos_copy*
- *DDS_SubscriberQos_initialize*
- *DDS_DataReaderQos_copy*
- *DDS_DataReaderQos_initialize*

[RTI Issue ID MICRO-3572]

8.4.34 DDS_Wstring_cmp did not match the implementation name DDS_Wstring_compare

The DDS Wstring compare function was incorrectly documented as being `DDS_Wstring_cmp` instead of `DDS_Wstring_compare`.

This issue has been resolved.

[RTI Issue ID MICRO-3529]

8.4.35 Race condition during participant discovery

A race condition existed during participant discovery.

This issue has been resolved.

[RTI Issue ID MICRO-3365]

8.4.36 A DataWriter with BEST_EFFORT and TRANSIENT_LOCAL may run out of resources

A DataWriter with BEST_EFFORT and TRANSIENT_LOCAL QoS policies may run out of resources when `DataWriterQos.resource_limits.max_samples_per_instance > 1`.

Note: Resending of historical samples (`DataWriterQos.durability.kind = TRANSIENT_LOCAL`) requires a `DataWriterQos.reliability.kind = RELIABLE` Qos Policy. Thus, the combination of BEST_EFFORT and TRANSIENT_LOCAL is not useful, although it is a legal combination.

[RTI Issue ID MICRO-4508]

8.4.37 Connext Micro may have repeated requesting a sample that was no longer available from a DataWriter

If *Connext Micro* detects a missing sample when using `DDS_RELIABLE_RELIABILITY_QOS` reliability, it will request the sample to be resent, but if the sample is no longer available from the DataWriter, the DataWriter may send a GAP message to indicate the sample is not longer available.

Connext Micro failed to interpret the GAP message correctly if the first sequence number in the GAP message was equal to the bitmap base of the GAP message. In this case, *Connext Micro* failed to ignore the no-longer-available sample and kept sending a request for the sample.

This problem has been fixed.

[RTI Issue ID MICRO-4668]

8.4.38 DDS_Subscriber_lookup_datareader may return a DataReader that was created by a different Subscriber

The `DDS_Subscriber_lookup_datareader` API searches for a DataReader for a given TopicDescription created by the Subscriber. However, in previous releases, the returned DataReader could belong to a different Subscriber if multiple DataReaders were created for the same Topic in different Subscribers.

This problem has been fixed.

[RTI Issue ID MICRO-4569]

8.4.39 DDS_Publisher_lookup_datawriter may return a DataWriter that was created by a different Publisher

The `DDS_Publisher_lookup_datawriter` API searches for a DataWriter for a given Topic created by the Publisher. However, in previous releases, the returned DataWriter could belong to a different Publisher if multiple DataWriters were created for the same Topic in different Publishers.

This problem has been fixed.

[RTI Issue ID MICRO-4570]

8.4.40 A reliable DataWriter may ignore requests to resend samples

If a DataWriter has received multiple requests to resend samples before its periodic heartbeat period expires, the DataWriter may ignore the request if the requested sample has been sent and is also the first expected sample by the requesting DataReader.

This problem has been fixed.

[RTI Issue ID MICRO-5183]

8.4.41 Compiler warning due to reliance on deprecated implicit copy constructor for C++

In previous releases, compiling with C++ could produce the following warning:

```
warning: definition of implicit copy constructor
```

This issue has been fixed. This release adds copy constructors for C++ classes where the use of implicit implicit copy constructors have been deprecated.

[RTI Issue ID MICRO-5340]

8.4.42 RTPS message may have been rejected

An RTPS message may have been rejected if it had a HDR_EXT and the last RTPS submessage had a length that is not a multiple of 4.

This issue has been fixed.

[RTI Issue ID MICRO-5387]

8.4.43 Warning about hostname not supported in posixSystem.c

Compiling posixSystem.c could produce the following warning:

```
warning: RTI Micro does not support retrieving the hostname for CERT. Set hostname␣
↪manually [-Wcpp]
```

This warning was unnecessary and has been removed.

[RTI Issue ID MICRO-5412]

8.4.44 False positive compiler warning

Compiling with GCC 11 could produce the following warning:

```
warning: 'presentation' may be used uninitialized [-Wmaybe-uninitialized]
```

This was a false positive since `presentation` was deserialized. This problem has been fixed.

[RTI Issue ID MICRO-5428]

8.5 Previous Releases

8.5.1 What's New in 2.4.14

Important Interoperability Changes

DataWriter's Default Reliability Changed to Reliable

The default reliability for a DataWriter has been changed from best-effort to reliable.

This solves interoperability problems when the remote DomainParticipant does not send the QoS value if configured with its default value. However, this may cause interoperability problems with previous releases if the former default reliability QoS is used.

Support for AUTOSAR Classic

This release includes support for Elektrobit AUTOSAR 4.0.3 and Mentor AUTOSAR 4.2.2 on Infineon AURIX TriCore TC297. Please refer to *Connext Micro on AUTOSAR* for details.

Support for detecting corrupted RTPS messages

This release includes support for detecting and discarding corrupted RTPS messages. A checksum is computed over the DDS RTPS message including the RTPS Header. This checksum is sent as a new RTPS submessage. The subscribing application detects this new submessage and validates the contained checksum. When a corrupted RTPS message is detected, the message is dropped.

To enable the use of a checksum in a DomainParticipant, there are three new fields in the *WireProtocolQosPolicy*: compute_crc, check_crc, and require_crc:

- To send the checksum, enable *compute_crc* at the sending application.
- To drop corrupted messages, enable *check_crc*.
- To ignore a participant with compute_crc set to *false*, enable *require_crc*.

Please refer to *Message Integrity Checking* in the *Connext Micro* User's Manual for details.

Port Validation for Connext Micro

After porting *Connext Micro*, it is important to confirm that your code works as expected. For this purpose, *Connext Micro* comes with a suite of tests that you can compile and run to validate your port.

New Documentation on Compiling Connext Micro for Connext Cert Compatibility

This release includes a new chapter on how to compile *Connext Micro* with for compatibility with Connext Cert. See *Building Connext Micro with compatibility for Connext Cert*.

ThreadX CMake Files and New Documentation on Building Connext Micro for ThreadX + NetX

Connext Micro libraries can now be compiled using rtime-make and CMake for ThreadX + NetX. There is a new section in the documentation on building for the ThreadX operating system and NetX network stack, including example configurations. See *Building the Connext Micro Source for ThreadX*.

Updated Example CMakeLists.txt to Automatically Regenerate Code when IDL or XML File Changes

The CMakeLists.txt generated by the Code Generator now has a rule that will regenerate type-support files if the IDL or XML file with the type definition changes. The rule is conditional: it is only added if the option RTIME_IDL_ADD_REGENERATE_TYPESUPPORT_RULE is set to TRUE when invoking CMake.

Message Logged when Samples Received Out of Order

This release logs an additional message when a sample is received out of order and reliability is enabled. This will occur if a reliable sample with a data submessage is received with a sequence number higher than the lowest, next expected sequence number.

Message Logged when Sequence Numbers Received More than Once

This release logs an additional message if a sample is received more than once when reliability is enabled. This means that a sample with the same sequence number has already been received.

Ability to Send Logs over UDP

This release includes support for sending logs over UDP. The destination IP address and UDP port can be configured in the AUTOSAR port properties.

rtime-make Provides Help for a Specific Target

The help output from the script rtime-make has been improved to show that is possible to get help for a specific target.

Use the command "rtime-make –target <target> –help" to print help for the target.

FreeRTOS CMake Files

The *Connext Micro* libraries can now be compiled using rtime-make and CMake for FreeRTOS.

Improved Documentation on Building Connext Micro for AUTOSAR Systems

The documentation on building *Connext Micro* for AUTOSAR systems has been improved with information about the number of resources needed. See *Resources*.

Examples Used Undocumented APIs

The provided examples, and those created by the Code Generator, were using Foo_create() and Foo_delete() to create and delete samples. Those APIs are not documented and should not be used. The examples have been changed to use FooTypeSupport_create_data() and FooTypeSupport_delete_data() instead.

New CMake Option to Enable Real-Time Timers on QNX and Linux Systems

Connext Micro has supported POSIX.4 real-time timers as a way to run the its internal timers. However, this feature has only been available by updating the osapi_os_posix.h header file and has been disabled by default because it relies on POSIX signals that may interfere with an application, such as if an application uses fork() and one of the exec system calls without setting the signal mask.

Connext Micro uses the signal SIGRTMIN by default. To change this, it is necessary to modify the constant OSAPISYSTEM_POSIX4_TIMER_SIGNAL at the beginning of src/osapi/posix/posixSystem.c. Please note that the number of signals available varies between systems.

To enable this feature on a QNX or Linux system, pass the following additional option to cmake or rtime-make:

New -showTemplates and -exampleTemplate options for Code Generator

This release introduces two new Code Generator command-line options, -showTemplates and -exampleTemplates.

The -showTemplates option prints and generates an XML file containing a list of available example templates in your Connext DDS installation, organized per language.

When you use the -exampleTemplate option, you can specify one of these example templates, which are in $RTIMEHOME/rtiddsgen/resource/templates/example/<language>/<templateName>/. You may also create your own templates and place them in this directory.

To use -exampleTemplates, you must also use one of the following command-line options:

- -create examplefiles
- -update examplefiles
- -example

When you use the -exampleTemplates option, Code Generator will generate the example you specified, instead of the default one. For example:

```
rtiddsgen -language C++ -example -exampleTemplate <exampleTemplateName> foo.idl
```

Dynamic memory allocations removed from Dynamic Discovery Plugin

The dynamic discovery plugin in *Connext Micro* allocated memory dynamically for discovered topic and type names after the DomainParticipant was enabled. This release includes improvements that make it possible to avoid all memory allocations.

Dynamic memory allocations are avoided by creating the DomainParticipant in a disabled state and creating all local endpoints before the DomainParticipant is enabled. A DomainParticipant is created in a disabled state by setting

DomainParticipantFactoryQos.entity_factory.autoenable_created_entities = DDS_BOOLEAN_TRUE

before calling *create_participant()*. When all entities have been created, call *enable()* on the DomainParticipantFactory to enable all entities.

Reduced default socket send/receive buffer size for QNX systems

Some QNX kernels have a maximum send and receive socket buffer size smaller than the default value used by *Connext Micro*. The default send and receive socket buffer size has been changed to 64 Kbytes in *Connext Micro* for QNX builds.

8.5.2 What's Fixed in 2.4.14

Small Enums Caused Serialization Errors

In previous releases, enum types that were represented internally as 1 or 2 byte values caused serialization and deserialization errors. This problem has been resolved by adding support for enum types with 1 or 2 byte internal memory representations. The wire representation for enums is unchanged at 4 bytes.

[RTI Issue ID MICRO-2249]

-Wcast-function-type and -Wdeprecated Compiler Warnings

This release fixes two different compiler warnings:

- When compiling *Connext Micro* with GCC8 (or later versions) and `-Wcast-function-type`, the compiler printed warnings such as:

```
cast between incompatible function types
```

- When compiling *Connext Micro* with a C++11 compiler and `-Wdeprecated`, the compiler printed warnings such as:

```
warning: definition of implicit copy constructor
```

Both of these issues have been fixed. Note that neither issue caused incorrect behavior.

[RTI Issue ID MICRO-2488]

Documentation did not list all Entities that Support Transport QosPolicy

The previous documentation did not list all the entities that support the DDS_TransportQosPolicy. This problem has been fixed.

The DDS entities that support the DDS_TransportQosPolicy are the DomainParticipant, DataWriter and DataReader.

[RTI Issue ID MICRO-2503]

Generated Examples Registered Wrong Type Name

The generated code for *Connext Micro* may have registered the wrong type name if you used the option `-create examplefiles` and IDL such as:

```
module My_Module {
   struct My_Entity {
      long id; //@key
   };
};
```

This generated an example that registered a type with a name that was incompatible with the type name used by other DDS tools that were configured with the same IDL file. This issue has been fixed.

[RTI Issue ID MICRO-2605]

For C++ Types Generated by rtiddsgen that have Inheritance, the ParentCclass was also Declared in the Class as Another Member

Consider the following Foo.idl file, used to generate code with rtiddsgen:

```
struct Base
{
     long x;
};

struct Foo: Base {
     long y;
};
```

This generated the following Foo.h file:

```
class Base
{
    long x;
};

class Foo: public Base
{
    Base parent;
    long y;
};
```

Note that the class Foo inherited from the class Base, and its first field was a 'parent' field of type 'Base'. This should not happen, since it results in extra space being taken for each sample that will not be used.

This problem has been fixed. The generated Foo class no longer has a 'parent' field of type 'Base'.

[RTI Issue ID MICRO-2633]

DomainParticipant not Rediscovered if Terminated and Restarted Before its Lease Duration Expired

A DomainParticipant was not rediscovered if it was terminated and restarted before its lease duration expired. For example, if an application with a DomainParticipant was terminated with Control-C and restarted before the DomainParticipant's lease duration expired, the DomainParticipant would not be rediscovered. However, if the DomainParticipant was deleted with delete_participant() this problem would not occur. This issue has been resolved.

[RTI Issue ID MICRO-2672]

OSAPI_Log_clear did not Zero Out Log Buffer Memory

OSAPI_Log_clear() did not zero out the log buffer memory. This problem has been resolved. Now it will set the buffer memory to zero when it resets the buffer head.

[RTI Issue ID MICRO-2678]

Error in Generated C/C++ Code when Two Members of Different Enumerations had Same Name

The generated C/C++ code for an IDL file containing enumerations with members that had the same name would not compile. For example, consider this IDL:

```
module a {
     module b {
             enum Foo {
                      GREEN, RED
            }
```

(continues on next page)

(continued from previous page)

```
    ;};
};
module c {
      module d {
          enum Bar {
               GREEN, YELLOW
          };
     };
};
```

The above IDL produced the following code:

```
typedef enum c_d_Foo
{
    GREEN ,
    RED
} c_d_Foo;


typedef enum c_d_Bar
{
    GREEN ,
    YELLOW
} c_d_Bar;
```

And it produced an error similar to this when trying to compile it:

```
test.h:82: error: redeclaration of enumerator ‘GREEN’
test.h:25: error: previous definition of ‘GREEN’ was here
```

This release introduces a new command-line option in RTI Code Generator, `-qualifiedEnumerator`, which allows you to generate fully qualified enumerator names. This avoids having conflicting names in C/C++.

For example, given this IDL:

```
module myModule{
    enum Color2 {
       GREEN,
       RED
     };

   union MyUnion switch (Color2){
     case GREEN:
            long m1;
     case RED:
             long m2;
     };
};
```

The following table shows the code that will be generated without the new option and with it:

Table 8.2: Effect of using -qualifiedEnumerator

Language	without -qualifiedEnumerator (default)	with -qualifiedEnumerator

C	`typedef enum myModule_Color2`
	`{`
	`  GREEN ,`
	`  RED`
	`} myModule_Color2;`
	
	`typedef struct myModule_MyUnion {`
	`  myModule_Color2 _d;`
	`  struct myModule_MyUnion_u`
	`  {`
	
	`  DDS_Long m1 ;`
	`  DDS_Long m2 ;`
	`  }_u;`
	
	`} myModule_MyUnion ;`
		`typedef enum myModule_Color2`
		`{`
		`  myModule_Color2_GREEN ,`
		`  myModule_Color2_RED`
		`} myModule_Color2;`
		
		`typedef struct myModule_MyUnion {`
		
		`  myModule_Color2 _d;`
		`  struct myModule_MyUnion_u`
		`  {`
		
		`  DDS_Long m1 ;`
		`  DDS_Long m2 ;`
		`  }_u;`
		
		`} myModule_MyUnion ;`

C++	`typedef enum myModule_Color2`
	`{`
	`  GREEN ,`
	`  RED`
	`} myModule_Color2;`
	
	`typedef struct myModule_MyUnion {`
	
	`  typedef struct myModule_`
	`↪MyUnionSeq Seq;`
	`  ...`
	`  myModule_Color2 _d;`
	`  struct myModule_MyUnion_u`
	`  {`
	
	`  DDS_Long m1 ;`
	`  DDS_Long m2 ;`
	`  }_u;`
	
	`} myModule_MyUnion ;`
		`typedef enum myModule_Color2`
		`{`
		`  myModule_Color2_GREEN ,`
		`  myModule_Color2_RED`
		`} myModule_Color2;`
		
		`typedef struct myModule_MyUnion {`
		
		`  typedef struct myModule_`
		`↪MyUnionSeq Seq;`
		`  ...`
		`  myModule_Color2 _d;`
		`  struct myModule_MyUnion_u`
		`  {`
		
		`  DDS_Long m1 ;`
		`  DDS_Long m2 ;`
		`  }_u;`
		
		`} myModule_MyUnion ;`

continues on next page

Table 8.2 – continued from previous page

Language	without -qualifiedEnumerator (default)	with -qualifiedEnumerator
C++ Namespace	`namespace myModule {` `  typedef enum Color2` `  {` `  GREEN ,` `  RED` `  } Color2;` `  typedef struct MyUnion {` `  typedef struct MyUnionSeq␣ ↪Seq;` `  ...` `  myModule::Color2 _d;` `  struct MyUnion_u` `  {` `  DDS_Long m1 ;` `  DDS_Long m2 ;` `  }_u;` `  } MyUnion ;` `};`	`namespace myModule {` `  typedef enum Color` `  {` `  Color_GREEN ,` `  Color_BLUE` `  } Color;` `  typedef struct MyUnion {` `  typedef struct MyUnionSeq␣ ↪Seq;` `  ...` `  myModule::Color2 _d;` `  struct MyUnion_u` `  {` `  DDS_Long m1 ;` `  DDS_Long m2 ;` `  }_u;` `  } MyUnion ;` `} ;`

[RTI Issue ID MICRO-2718]

Incorrect Documentation Regarding Changeability of QoS

The previous release's documentation incorrectly stated that some QoS are changeable, when they are not. This has been fixed.

The DomainParticipantFactory.EntityFactoryQosPolicy is always changeable. The following are changeable until the entity is enabled:

- DomainParticipant.EntityFactoryQosPolicy
- Publisher.EntityFactoryQosPolicy
- Subscriber.EntityFactoryQosPolicy

[RTI Issue ID MICRO-2749]

Unexpected Behavior when Copying a DDS_UnsignedShortSeq with 0 Length

When copying a DDS_UnsignedShortSeq with 0 length, the destination sequence length was not set to 0. This issue has been fixed.

[RTI Issue ID MICRO-2756]

Incorrect Range Documented for DDS_ResourceLimitsQosPolicy.max_samples

The range for DDS_ResourceLimitsQosPolicy.max_samples was incorrectly documented as `max_samples >= max_instances * max_samples_per_instance`.

While that is correct for *Connext Cert*, the correct range for *Connext Micro* is `max_samples >= max_instances`.

The documentation has been corrected.

[RTI Issue ID MICRO-2757]

Wrong Compiler Option for AUTOSAR Elektrobit Platform caused 'double' to Compile as 4 Bytes instead of 8

CMake files include an option to optimize doubles as floats when compiling for the AUTOSAR classic Elektrobit platform. This caused the serialization and deserialization of type double to fail.

This optimization has been removed; now the size of type 'double' is 8 bytes when compiling for the AUTOSAR classic Elektrobit platform.

[RTI Issue ID MICRO-2823]

Log Message with Random Characters Printed

In some cases, a log message was printed with random characters. For example:

```
$ Alignment32 id\:000000\,sig\:06\,src\:000000\,op\:flip1\,pos\:1

[1612981807.603703999]ERROR: ModuleID=5 Errcode=20021 X=1 E=1 T=1
 hV F ~ycV{/:0/:
```

This issue has been resolved.

[RTI Issue ID MICRO-2877]

Event Masks of Semaphores in AUTOSAR Port were Calculated Incorrectly

Event masks of semaphores in the AUTOSAR port were calculated incorrectly. This only affected semaphore implementation and Waitsets. This issue has been resolved.

[RTI Issue ID MICRO-2953]

PUBLICATION_MATCHED_STATUS and *SUBSCRIPTION_MATCHED_STATUS* may never have triggered a WaitSet if the status was enabled after the *DomainParticipant* was enabled

A StatusCondition with *PUBLICATION_MATCHED_STATUS* or *SUBSCRIPTION_MATCHED_STATUS* enabled may never have triggered a WaitSet, if the status was enabled after the *DomainParticipant* was enabled.

This issue has been resolved.

[RTI Issue ID MICRO-2219]

Unicast DataReader stopped receiving samples after DataWriter matched with a multicast DataReader

A *DataReader* with a unicast locator stopped receiving samples from a matched *DataWriter* when another *DataReader* with a multicast locator matched with that *DataWriter*.

This problem has been resolved. Now all matched *DataReaders* will receive samples, regardless of whether their locators are unicast or multicast.

[RTI Issue ID MICRO-2369]

A RTPS *max_window_size* not divisible by 32 may have resulted in retransmission of wrong sequence number

An RTPS *max_window_size* not divisible by 32 may have caused retransmission of a sequence number not being requested. Note that the default value is divisible by 32.

This issue has been resolved.

[RTI Issue ID MICRO-2287]

POSIX mutex implementation did not conform with FACE Safety Profile

The POSIX mutex implementation did not conform with the FACE Safety Profile. This release conforms to the FACE Safety profile for single-core CPU architectures.

[RTI Issue ID MICRO-2275]

Waitset with timeout of 0 did not return immediately

A Waitset with a 0 timeout did not return immediately, but was rounded up to one clock period.

This issue has been resolved.

[RTI Issue ID MICRO-2278, MICRO-2264]

For AUTOSAR the IP address is now used to generate a unique DomainParticipant ID

In previous versions of *Connext Micro* for AUTOSAR the timestamp was used to generate a unique DomainParticipant ID. This release uses the IP address from the Autosar configuration by default.

[RTI Issue ID MICRO-2342]

8.5.3 What's New in 2.4.12

Shared UDP port for discovery and user-data in a DomainParticipant

This release allows sharing a UDP port per DomainParticipant for discovery and user-traffic. The advantage is that *Connext Micro* will create a single receive thread for unicast instead of two.

The disadvantage is that this port mapping is not compliant with the DDS Interoperability Wire Protocol and communication with other DDS implementations might not be possible.

This feature may only be used if multicast *or* unicast is used for both discovery and user traffic. If both unicast *and* multicast are enabled this feature cannot be used.

To enable this feature assign the same value to both builtin and user port offsets in RtpsWellKnownPorts_t.

DomainParticipants no longer allocate dynamic memory during deletion

DomainParticipants will no longer allocate dynamic memory during deletion.

New QoS parameter to set maximum outstanding samples allowed for remote DataWriter

A new QoS parameter has been exposed for the endpoint discovery endpoints in the dynamic endpoint discovery plugin (DPDE). The new field, *max_samples_per_remote_builtin_endpoint_writer* in DPDE_DiscoveryPluginProperty, can be set to increase the number of samples a remote writer may have per builtin endpoint reader and thus decrease network traffic. Please refer to the DPDE for a description of this new parameter.

New QoS parameter to adjust preemptive ACKNACK period

A new QoS parameter has been introduced to expose the preemptive ACKNACK period on DataReaders. The new parameter is configured with:

- *DDS_DataReaderQos.protocol.rtps_reliable_reader.nack_period* for user data readers
- *builtin_endpoint_reader_nack_period* for the builtin discovery endpoints in the Dynamic discovery plugin

Please refer to *API Reference* API for details.

Deserialization of Presentation QoS policy

This release provides better support for the Presentation QoS policy. Previously this QoS policy was not supported by the DataWriter; the default value was assumed for a discovered DataReader, which caused an "Unknown QoS" warning when it was received. In this release, DataWriters will deserialize the Presentation QoS policy and check for compatibility.

8.5.4 What's Fixed in 2.4.12

Examples used DomainParticipant_register_type instead of FooTypeSupport_register_type

In previous versions the examples registered types using "DDS_DomainParticipant_register_type()" instead of the recommended "FooTypeSupport_register_type()". This version has updated the examples to use the recommended "FooTypeSupport_register_type()" instead.

[RTI Issue ID MICRO-1922]

A DataReader and DataWriter with incompatible liveliness kind and infinite lease_duration matched

In previous versions *Connext Micro* allowed a DataWriter to match a DataReader if the liveliness kind was incompatible *but* the liveliness duration was infinite. However, the OMG DDS specification mandates stricter matching rules and in this version a DataReader and DataWriter will *only* match when both the liveliness duration and kind are compatible:

1. Requested Liveliness Lease duration is greater than or equal to the Offered lease duration.

2. Requested Liveliness kind is less than or equal to the Offered Liveliness kind where AUTOMATIC_LIVELINESS_KIND < MANUAL_BY_PARTICIPANT_LIVELINESS_KIND < MANUAL_BY_TOPIC_LIVELINESS_KIND.

Note that this did not affect communication between *Connext Micro* applications since with an infinite liveliness duration, the liveliness will never expire, regardless of kind.

[RTI Issue ID MICRO-2007]

Warning at compilation time for FreeRTOS port

An incompatible pointer type warning was printed at compilation time when compiling for FreeRTOS. This issue has been resolved.

[RTI Issue ID MICRO-2090]

Using *DDS_NOT_ALIVE_INSTANCE_STATE* caused compilation error in C and C++

Using the constant DDS_NOT_ALIVE_INSTANCE_STATE caused a linker error due to a missing definition. This issue has been resolved.

[RTI Issue ID MICRO-2243]

Seq_copy() did not work when the source sequence is a loaned/discontiguous sequence

Calling *FooSeq_copy()* on a loaned or discontiguous sequence did not work correctly. This issue has been fixed.

[RTI Issue ID MICRO-2053]

Warnings when compiling the example generated by Code Generator

When compiling the example generated by rtiddsgen, the compiler may have given warnings about unused variables. The generated code has been updated to avoid these warnings.

[RTI Issue ID MICRO-1700]

Unable to generate code for XML or XSD defined types

Previous releases of *Connext Micro* did not include the XML and XSD schemas required to generate type-support code from XML or XSD files. This issue has been resolved.

[RTI Issue ID MICRO-1709]

Linker error in C++ application when C types were used

Compiling generated C type-support code as C++ caused compilation errors. This issue has been resolved.

[RTI Issue ID MICRO-1750]

Failure to link for VxWorks RTP using shared libraries compiled with CMake

Due to use of incorrect compiler and linker options for VxWorks RTP mode a linker error occurred when compiling projects generated with CMake®. This issue has been resolved.

[RTI Issue ID MICRO-1909]

rtiddsgen may have failed on Windows systems when -jre was specified

The rtiddsen -jre option did not accept paths with spaces. This issue has been resolved.

[RTI Issue ID MICRO-1952]

rtime-make did not work when it was started from different shell than Bash

rtime-make requires Bash on Unix systems. However it did not explicitly launch Bash and would fail if started from a Bash incompatible shell. This has been fixed.

[RTI Issue ID MICRO-2013]

Linker error when using shared libraries on VxWorks systems

There was a linker error when compiling the examples for ppc604Vx6.9gcc4.3.3 using shared libraries. The compiler reported that the libraries could not be found. This issue has been resolved.

[RTI Issue ID MICRO-1841]

A run-time error may have occurred on Windows or when compiling for FACE when using hostnames in the peer list

Due to incorrect use of the getaddrinfo() API on Windows or POSIX when compiling for FACE, a run-time error may have occured when resolving hostnames. This issue has been fixed.

[RTI Issue ID MICRO-1957]

Entity ID generation was not thread-safe

Entity ID generation for DataReaders and DataWriters was not thread-safe and may have lead to duplicate entity IDs. This problem has been resolved.

[RTI Issue ID MICRO-2104]

DomainParticipant creation failed if active interface had invalid IP

An active interface without a valid IP address assigned may have caused DomainParticipant creation to fail. This problem has been resolved. Now if an interface with an invalid IP address is used, it will be ignored and the DomainParticipant will still be created.

[RTI Issue ID MICRO-1602]

rtime-make did not work when there was a space in the installation path

The rtime-make script did not work when *Connext Micro* was installed in a directory path containing spaces. This issues has been resolved.

[RTI Issue ID MICRO-1622]

Sample filtering methods were always added to the subscriber code for C

The generated subscriber example code always included code to filter sample-based fields in the IDL type. However, if the generated IDL file was modified to exclude these fields, the code would fail to compile. The generated code now includes instructions for how to filter instead.

[RTI Issue ID MICRO-1980]

'Failure to give mutex' error

In Connext DDS Micro 2.4.11, a subtle race condition may have occurred on multi-core machines. When this happened, an error message about failing to give a mutex would be printed: error code (EC) 44 in module 1 (OSAPI). This problem has been resolved.

[RTI Issue ID MICRO-2095]

UDP interface warning using valid interfaces

Connext DDS Micro logged a warning if no new interfaces were added for each address listed in enabled_transports. This applied to the enabled_transports field in the DiscoveryQosPolicy and UserTrafficQosPolicy in the DomainParticipantQos, and the DDS_TransportQosPolicy in the DataReaderQos and DataWriterQos. This problem has been resolved. Now Connext DDS Micro will only log a warning if no new interfaces are added per enabled transport.

[RTI Issue ID MICRO-2018]

A DataReader May Stop Receiving Samples When Filtering Callbacks Are Used

When using *on_before_deserialize()* or *on_before_commit()* to drop samples the DataReader may have been depleted of resources and stop receiving data. This issue has been fixed.

[RTI Issue ID MICRO-1930]

DDS_WaitSet_wait() returned DDS_RETCODE_ERROR if unblocked with no active conditions

An application that used a combination of polling a DataReader and blocking on a DDS_WaitSet may have caused *DDS_WaitSet_wait()* to return DDS_RETCODE_ERROR. This happened if the DDS_WaitSet was unblocked by an attached condition, but there were no active conditions. This problem has been resolved.

[RTI Issue ID MICRO-2115]

Large timeout values may have caused segmentation fault

Timeout values larger than 2000s may have caused a segmentation fault during creation of DDS entities. This issue has been fixed.

[RTI Issue ID MICRO-2192]

HelloWorld_dpde_waitset C++ example uses wrong loop variable for printing data

When multiple samples are loaned by calling take, the HelloWorld_dpde_waitset C++ example uses the wrong loop variable, *i*, with *data_seq* instead of the correct index *b*. This issue has been resolved.

[RTI Issue ID MICRO-2158]

WaitSet_wait returned generic error when returned condition sequence exceeded capacity

If the number of returned conditions exceeded the maximum size of the returned condition sequence, a generic error, DDS_RETCODE_ERROR, was returned instead of the expected error, DDS_RETCODE_OUT_OF_RESOURCES. This problem has been resolved.

[RTI Issue ID MICRO-1933]

Publication handle not set in SampleInfo structure when on_before_sample_commit() called

The *publication_handle* member of the DDS_SampleInfo structure passed to a DataReader's *on_before_sample_commit()* function was not set. This issue has been fixed.

[RTI Issue ID MICRO-2121]

Duplicate DATA messages are sent to multicast in some cases

Duplicate DATA messages were sent to multicast when multiple DataReaders were configured with multicast and unicast receive addresses. This issue has been fixed.

[RTI Issue ID MICRO-2043]

GUID generation on QNX for processes run one after another may lead to duplicate GUIDs

On QNX systems, two processes run one after another in quick order may end up with the same GUID. The probability of GUID reuse has been reduced in this release.

[RTI Issue ID MICRO-2109]

Read/take APIs returned more than *depth* samples if an instance returned to alive without application reading *NOT_ALIVE* sample

If an instance transitioned from *NOT_ALIVE_NO_WRITERS* or *NOT_ALIVE_DISPOSED* to *ALIVE* and the application did not read/take the sample indicating *NOT_ALIVE_NO_WRITERS* or *NOT_ALIVE_DISPOSED*, the number of samples returned would exceed the *depth* set by the History QoS policy. This issue has been fixed.

[RTI Issue ID MICRO-2196]

Segmentation fault if *OSAPI_Semaphore_give()* was called from one thread while another called *OSAPI_Semaphore_delete()*

An application may have terminated with a segmentation fault if *OSAPI_Semaphore_give()* was called from one thread while another called *OSAPI_Semaphore_delete()* on Unix-like systems. This issue has been resolved.

[RTI Issue ID MICRO-2209]

Communication problems between Connext DDS Professional 6 and Connext DDS Micro 2.4.11

Connext DDS Professional 6 advertises support for RTPS protocol version 2.3, while Connext DDS Micro 2.4.11 and earlier only accepted RTPS 2.1. Therefore tools such as Admin Console 6.0.0 did not properly discover entities from a Micro 2.4.11 application. This release of Connext DDS Micro complies with RTPS 2.1 and later minor versions (such as 2.3). Unsupported RTPS messages are ignored.

[RTI Issue Id MICRO-2008]

OSAPI_System_get_ticktime() not implemented for FreeRTOS

OSAPI_System_get_ticktime() was not implemented for FreeRTOS. An application using a finite DDS deadline or liveliness would have a run-time failure. This issue has been resolved.

[RTI Issue ID MICRO-2240]

8.5.5 What's New in 2.4.11

Support for ThreadX/NetX

Support for the ThreadX operating system, version 5.7, and the NetX TCP/IP network stack, version 5.9.

Batching (reception only)

Batching reception. Please refer to the new user's manual UserManuals_Batching for details.

UDP Transformations

Please refer to the new user's manual ref UserManuals_UDPTransform for details.

Optionally exclude builtin UDP Transport from compilation

Setting the flag -DRTIME_UDP_EXCLUDE_BUILTIN=1 excludes the UDP transport from being built. This setting can be useful if communication is done using only shared memory, INTRA, or a custom UDP transport.

Publication handle of DataWriter now provided upon DataReaderListener sample loss

When the DDS_DataReaderListener's on_sample_lost event is triggered, the returned DDS_SampleLostStatus.sample_info now contains the publication_handle of the DataWriter that originally wrote the lost sample(s).

DataWriters offer TOPIC presentation

Connext Micro DataWriters now offer the DDS_TOPIC_PRESENTATION_QOS presentation (when coherent_access = FALSE). This presentation is compatible with any reader using DDS_TOPIC_PRESENTATION_QOS and DDS_INSTANCE_PRESENTATION_QOS, when ordered_access = TRUE and ordered_access = FALSE.

Micro readers will remain unchanged and will only support DDS_INSTANCE_PRESENTATION_QOS when ordered_access = FALSE.

New warning if a configured UDP transport does not have any interface

A warning in logs has been added to notify you when a configured UDP transport does not have any interface. This condition normally indicates a wrong UDP configuration, which might result in discovery and/or communication failure.

8.5.6 What's Fixed in 2.4.11

MICRO-1814 Incorrect thread ID returned for VxWorks RTP

The function OSAPI_Thread_self() when called by a VxWorks Real-Time Process (RTP) always returned the (process) ID of the RTP, even for tasks spawned by the RTP. This issue has been fixed.

[RTI Issue ID MICRO-1814]

NULL listener and non-empty status mask not allowed for C++ DataReader

A C++ DataReader was incorrectly not allowed to be created with a NULL DataReaderListener and a non-empty status mask (i.e., not DDS_STATUS_MASK_NONE).

[RTI Issue ID MICRO-1807]

accept_unknown_peers did not work when Shared Memory transport was enabled in RTI Connext DDS Pro

When *Connext Micro* discovered a RTI Connext DDS Pro application with Shared Memory transport enabled, *Connext Micro* failed to correctly use the UDPv4 locators instead.

This issue has been fixed.

[RTI Issue ID MICRO-1798]

Calling FooSeq_set_maximum() repeatedly with the same maximum size results in seg-fault

In RTI *Connext Micro* 2.4.10.x and earlier, calling FooSeq_set_maximum() repeatedly with the same maximum size on an IDL sequence type containing non-primitive types (such as enums or other structures) caused a segmentation fault.

This issue has been fixed.

[RTI Issue ID MICRO-1786]

CMake reports error if CMake version 2.8.10.2 or 2.8.10.1 is used

Connext Micro buildable sources can not be compiled with CMake versions 2.8.10.1 or 2.8.10.2.

This issue has been fixed.

[RTI Issue ID MICRO-1748]

OS error code (errno) not logged if sendto() returned error

The OS error code (errno) was not correctly logged if sendto() returned an error.

This issue has been fixed.

[RTI Issue ID MICRO-1712]

Codegen might generate an incorrect pub/sub example if opction "-create typefiles" is not used

Wrong example code is generated in case rtiddsgen is executed with option -create examplefiles and option -create typefiles is NOT used.

This issue has been fixed.

[RTI Issue ID MICRO-1696]

Generated examples use always the last structure in the idl

Examples generated using Codegen use always the last structure in the idl file, even if it is not top-level.

This issue has been fixed.

[RTI Issue ID MICRO-1694]

Instance might not have been disposed or unregistered under some conditions

Unregistered or disposed samples were not processed when preceded by a GAP sub-message within the same RTPS message.

This issue has been fixed.

[RTI Issue ID MICRO-1692]

Reliable Endpoints with only multicast locators may not communicate

A reliable DataReader configured with only multicast (no unicast) locator(s) may have failed to discover or communicate with a reliable DataWriter. Both built-in discovery endpoints and user-data endpoints were affected.

This issue has been fixed.

[RTI Issue ID MICRO-1687]

Access to DDSEntity instance handles from C++ API

Users of RTI Connext DDS Micro's C++ API can now access instance handles of any DDS entity using method DDSEntity::get_instance_handle.

[RTI Issue ID MICRO-1681]

Syntax changed for initial peer participant index range

When configuring the initial peers of a DomainParticipant (e.g. DDS_DomainParticipantQos.discovery.initial_peers), the syntax for specifying a range of participant indices for a peer locator has changed: a hyphen is now the separator, replacing a comma. In general, a peer "[x-y]@<address>" means that participant discovery messages will be sent to the address for participant indices x through y.

[RTI Issue ID MICRO-1680]

lookup_instance() is not thread safe

The lookup_instance() was not thread safe in *Connext Micro* 2.4.10.x and earlier. If an application was calling lookup_instance() from both a listener and a WaitSet/polling thread at the same time, the instance handle could be corrupted.

This issue has been fixed.

[RTI Issue ID MICRO-1679]

CMakeLists.txt and README.txt created when they should not

Codegen generates project files CMakeLists.txt and README.txt are generated even when project files are not generated.

This issue has been fixed.

[RTI Issue ID MICRO-1673]

No communication when DomainParticipant used same GUID as another DomainParticipant in different domain

Given an application that creates DomainParticipants in different DDS domains, a DomainParticipant created with the same Participant GUID (i.e., the GUID Prefix portion of the GUID) as created for a DomainParticipant in a different domain will fail to discover or communicate with other endpoints within its own domain. A workaround would be for the application to assign unique GUIDs for all DomainParticipants across all domains. This issue has been fixed.

This issue has been fixed.

[RTI Issue ID MICRO-1671]

Compiler error might happen when lwIP is used

An incorrectly defined compiler macro causes a compilation error when lwIP stack is used and LWIP_DNS is defined.

This issue has been fixed.

[RTI Issue ID MICRO-1664]

Wrong C++ code generated for unkeyed types when using IDL modules and -namespace option

Code generated with the following command failed if a struct with the same name was defined in two namespaces, and the first namespace did not have any key:

rtiddsgen -micro -example HelloWorld.idl -replace -language C++ -namespace

This issue has been fixed.

[RTI Issue ID MICRO-1663]

DDS_WaitSet_wait does not work if OSAPI_Semaphore_take() returns an error

DDS_WaitSet_wait does not work if OSAPI_Semaphore_take() returns an error; RETCODE_PRECONDITION_NOT_MET is always returned.

This issue has been fixed.

[RTI Issue ID MICRO-1658]

Log buffer could overflow on 64-bit architectures, causing application crash

The log buffer may have overflowed on 64-bit architectures and caused an application crash.

This issue has been fixed.

[RTI Issue ID MICRO-1657]

Fix API realloc in Windows OSAPI

Windows implementation of function realloc did not allow a NULL input pointer, this is wrong and posix implementation and Windows API allow it. This has the effect that function DDS_String_replace() fails when the input string is a NULL pointer.

This issue has been fixed.

[RTI Issue ID MICRO-1655]

New samples for an instance may not be received if an instance goes back to ALIVE when using read()

Due to an issue in the resource calculation for the DataReader, new samples for an instance may not have been received if the instance went back to ALIVE when using any of the read() APIs.

This issue has been fixed.

[RTI Issue ID MICRO-1651]

INTRA transport caused subscription matches to use additional resources

An issue in the matching between a reader and writer caused a reader to be matched with the same writer twice if auto enable was set to FALSE.

This issue has been fixed.

[RTI Issue ID MICRO-1650]

Resolved memory leak in class RTRegistry

When using previous versions of *Connext Micro*, C++ applications might have experienced resource leakage upon finalization of middleware resources using the method DDSDomainParticipantFactory::finalize_instance. The leaks were caused by unfreed memory blocks still owned by the class RTRegistry, and they have now been resolved. No additional action is required of users.

This issue has been fixed.

[RTI Issue ID MICRO-1637]

Windows Debug DLLs are built without debug information

Windows Debug DLLs are built without debug information what prevents debugging. This is happening when building with CMake or the rtime-make script.

This issue has been fixed.

[RTI Issue ID MICRO-1634]

Use hardcoded build ID when not compiling with CMake

When compiling using CMake or the script rtime-make, *Connext Micro* libraries have a build lD (buildid), which consist of the current time and date. A hardcoded constant ID is used as the build ID when compilation is not done using CMake or the script rtime-make.

This issue has been fixed.

[RTI Issue ID MICRO-1632]

Example makefiles do not support 64bit compilation

Example makefiles used always option -m32. This has been changed to use -m32 or -m64 depending on the platform configuration.

Examples can be compiled now for 32 and 64 bits platforms.

This issue has been fixed.

[RTI Issue ID MICRO-1628]

Compilation error might happen when code is generated using option -namespace

Compilation error fixed in generated source code when option -namespace is used and IDL file has modules and compilation uses shared libraries.

This issue has been fixed.

[RTI Issue ID MICRO-1620]

8.5.7 What's New in 2.4.10.4

Batching (reception only)

This release includes batching reception. Please refer to the new user manual for Batching for details.

C++ examples

A new C++ example using Waitsets (HelloWorld_dpde_waitset) is included.

8.5.8 What's Fixed in 2.4.10.4

Improve KEEP_LAST

To reclaim resources in version 2.4.10 and earlier the DataReader cache tries to remove the oldest sample only. If that is on loan it cannot be removed and in case a new sample is received it cannot be added to the DataReader cache.

This issue has been fixed.

[RTI Issue ID MICRO-1754]

Locator might be duplicated when NAT is configured

When Network Address Translation (NAT) is configured in the transport UDP properties, a duplicated locator might be sent in discovery packets.

This issue has been fixed.

[RTI Issue ID MICRO-1756]

Segmentation fault might happen when a DataReader cannot be created

If the creation of a DataReader fails before all fields in the DataReader structure are initialized, a NULL pointer access may have occur while finalizing the already created objects.

This issue has been fixed.

[RTI Issue ID MICRO-1755]

CMake reports error if CMake version 2.8.10.2 or 2.8.10.1 is used

RTI Connext DDS Micro buildable sources could not be compiled with CMake 2.8.10.1 or 2.8.10.2.

This issue has been fixed.

[RTI Issue ID MICRO-1748]

Wrong TUDP locator kind sent when using UDP transformations

When using UDP transformations the locator kind was always set as 0, intead of the configured value in ref UDP_InterfaceFactoryProperty.transform_locator_kind

This issue has been fixed.

[RTI Issue ID MICRO-1685]

Compile shipped examples for a 64 bits architecture

Before this release shipped examples makefiles could only compile 32 bits architectures. Makefiles have been modified to support also 64 bits architectures.

This issue has been fixed.

[RTI Issue ID MICRO-1628]

OSAPI_Heap_realloc() Windows implementation fixed

The Windows implementation of function OSAPI_Heap_realloc() had a precondition to check for a NULL pointer as input parameter. This is wrong as in this case the function shall allocate a new buffer (equivalent to malloc()).

This issue has been fixed.

[RTI Issue ID MICRO-1655]

Use API DDSDomainParticipant::delete_contained_entities() in C++ examples

Shipped C++ examples now use DDSDomainParticipant::delete_contained_entities() to delete all DSS entities in a DDS Participant. This is easier than using DDSDomainParticipant::delete_topic(), DDSDomainParticipant::unregister_type(), etc.

This issue has been fixed.

[RTI Issue ID MICRO-1656]

Memory leak in shipped examples fixed

Shipped examples were not releasing correctly some of the allocated structures when application finalized.

This issue has been fixed.

[RTI Issue ID MICRO-1676]

C++ shipped examples might release an object twice.

C++ shipped examples might release an object twice in case of error.

This issue has been fixed.

[RTI Issue ID MICRO-1677]

Backwards Compatability

Change in on_before_sample_deserialize callback.

In 2.4.10 and earlier the stream passed to on_before_sample_deserialize callback started at the encapsulation header followed by user data. However, with the added support for batched samples this is no longer possible. Instead the stream now starts at the user-data payload. Note that the only supported encapsulation format for user-data is CDR. This may change in future versions.

The examples have been updated to reflect the change. Please refer to the examples for details.

8.5.9 What's New in 2.4.10.1

UDP Transformations

This release includes UDP Transformations which enables regular UDP sockets to be used with custom payload transformations. Please refer to ref UserManuals_UDPTransform for details. The UDP Transformation feature is enabled by default in this release. However, future releases may disable the feature by default. Thus, it is advised to always compile with the UDP Transformation feature enabled (-DRTIME_UDP_ENABLE_TRANSFORMS=1 to cmake).

NOTE: In the the EAR for 2.4.10.1 the default behavior was to allow both plain UDP and transformed UDP traffic when transformations was compiled in. This has changed. The default is to disable regular UDP. In order to support it the transform_udp_mode must be set to UDP_TRANSFORM_UDP_MODE_ENABLED. Since this may change in future release it is advised to always set the correct mode of operation.

8.5.10 What's Fixed in 2.4.10.1

Race Condition when Log Buffer is Full and a Custom Log-handler is Installed

A race condition existed when a custom log handler was installed and the log buffer was full. A temporary message was created to hold the minimum log data and when the custom log handler was called it was possible that a new log entry was added while the custom log handler parsed the temporary message.

This has been fixed in this version.

[RTI Issue ID MICRO-1641]

8.5.11 What's New in 2.4.10

Generate Example Application with rtiddsgen

It is now possible to generate an example application for RTI Connext Micro using rtiddsgen. To generate an example:

:: rtiddsgen -language C | C++ -micro -example <IDL File>

A CMakeLists.txt file is generated that can be used with rtime-make:

:: rtime-make [options] –srcdir <path to CMakeLists.txt>

Please refer to the generated README.txt file for details.

BY_SOURCE_TIMESTAMP_DESTINATIONORDER Support on DataWriter

The DataReader and DataWriter Qos policy now includes the DDS_DestinationOrderQosPolicy:

- The DDS DataReader only supports BY_RECEPTION_DESTINATION_ORDER (the default value).
- The DDS DataWriter supports BY_RECEPTION_TIMESTAMP_DESTINATION_ORDER and BY_SOURCE_TIMESTAMP_DESTINATION_ORDER.

Please refer to the DDS reference manual for details.

[RTI Issue ID MICRO-1597]

8.5.12 What's Fixed in 2.4.10

Linker Warning for Missing PDB Files

The i86Win32VS2010 libraries shipped with *Connext Micro* did not include PDB files. For this reason, when compiling an application a warning similar to the following may have been shown:

:: rti_mezd.lib(BuiltinTopicData.obj) : warning LNK4099: PDB 'dds_czd.pdb' was not found with 'rti_mezd.lib(BuiltinTopicData.obj)' or at '<path>\dds_czd.pdb'; linking object as if no debug info

The warning was harmless and only indicates that debug information was missing for the linked libraries.

[RTI Issue ID MICRO-1556]

Linking with Dynamic Windows C Run-Time (CRT)

All shipped *Connext Micro* libraries for Windows platforms (static release/debug, dynamic release/debug) now link with the dynamic Windows C Run-Time (CRT). Previously, the static *Connext Micro* libraries statically linked the CRT.

An existing Windows project that is linking with the *Connext Micro* static libraries must update the RunTime Library settings.

In Visual Studio, select C/C++, Code Generation, Runtime Library, select:

- Multi-threaded DLL (/MD) instead of Multi-threaded (/MT) for static release libraries.
- Multi-threaded Debug DLL (/MDd) instead of Multi-threaded Debug (/MTd) for static debug libraries.

For command-line compilation, use:

- /MD instead of /MT for static release libraries.
- /MDd instead of /MTd for static debug libraries.

In addition, it may be necessary to ignore the static run-time libraries in their static configurations. In Visual Studio, select Linker, Input in the project properties and add libcmtd;libcmt to the 'Ignore Specific Default Libraries' entry.

For command-line linking, add /NODEFAULTLIB:"libcmtd" /NODEFAULTLIB:"libcmt" to the linker options.

[RTI Issue ID MICRO-1572]

DDS_Publisher_create_datawriter() May Fail to Create a New Datawriter

When an application reaches the local_writer_allocation resource limit, where subsequent calls to DDS_Publisher_create_datawriter() fail to create a new DataWriter, calling DDS_Publisher_delete_datawriter() should reclaim resources of the deleted DataWriter and allow the creation of a new DataWriter. However, in the previous release, in certain cases there was a problem with reclaiming DataWriter resources that prevented the creation of a new DataWriter.

Deleting a DataWriter or DataReader involves acknowledgements from matched applications. Thus, calling DDS_Publisher_delete_datawriter() is not an instantaneous operation so resources may not be available immediately. When this case occurs, calling DDS_Publisher_create_datawriter() after a short duration may be successful. The maximum time for a resource to be released is the maximum time a response is expected from a matched application based on the DPDE discovery plugin configuration for the built-in discovery endpoints.

[RTI Issue ID MICRO-1579]

DataReader May Not Reclaim NOT_ALIVE Instances when DataWriter Deleted or Liveliness Lost

Applications using read()/take() in on_data_available may not have received NOT_ALIVE_NO_WRITERS for instances that changed state to NOT_ALIVE_NO_WRITERS when a deleted data writer or data reader lost liveliness with a data writer caused the change. This has been fixed.

[RTI Issue ID MICRO-1580]

A Datawriter may fail to release instance resources if a peer is inactive while the Participant liveliness expires

A reliable DataWriter can mark a matched DataReader as inactive if the DataReader fails to respond to heartbeats, as configured by max_heartbeat_retries. However, if a DataReader is marked as inactive and the Participant liveliness for the DataReader's Participant expires, a DataWriter afterwards may have failed to reclaim instances resources if unregister_instance() was called. This has been fixed.

[RTI Issue ID MICRO-1581]

A Reliable DataWriter With max_samples_per_instance = 1 May Run Out of Resources After Multiple Unregistrations of Single Instance

A reliable DataWriter with max_samples_per_instance = 1 may have run out of instance resources if the same instance is unregistered multiple times before an acknowledgement is received from a matched DataReader. This has been fixed.

[RTI Issue ID MICRO-1583]

Connext Micro Fails to Discover Endpoints created by Connext Core if the Endpoints are Deleted or Modified

If an application developed with RTI Connext Core used set_qos() on an enabled endpoint or deleted and created new endpoints before *Connext Micro* had discovered the deleted endpoints, *Connext Micro* failed to discovery new endpoints. This has been fixed.

[RTI Issue ID MICRO-1588]

Incorrect Log Output in a Complete Log Message could not be Stored

If there was insufficient space to store a complete log-message, the default display function would incorrectly try to print log-data beyond the log-buffer. This has been fixed.

[RTI Issue ID MICRO-1589]

Possible Segmentation Fault when Unregistering TRANSIENT_LOCAL Instance

Calling unregister_instance() on the same TRANSIENT_LOCAL instance may have caused a segmentation fault. The segmentation fault occured when a call to unregister_instance() is acknowledged and a later call on unregister_instance() for the same instance had not been acknowledged yet. For the segmentation fault to occur there must be more than 1 call to unregister_instance() within the history depth. This has been fixed.

[RTI Issue ID MICRO-1590]

Support to map IDL modules to C++ namespaces in generated type-plugins

The rtiddsgen included by this release will correctly generate C++ code for data types defined within IDL modules, when passed the "-namespace" argument. Consider the following IDL:

```
module A {
  struct Foo {
    long bar;
  };
};

module B {
  struct Foo {
    long bar;
  };
};
```

C++ code generated by previous releases of rtiddsgen for this IDL input would fail to build if the "-namespace" argument was used to map each IDL module to a C++ namespace.

Some of the automatically generated data types were incorrectly being exported with C linkage, effectively disabling the C++ namespaces. This would cause duplicate symbols to be detected if two types with the same name were defined in two different modules.

[RTI Issue ID MICRO-1600]

Possible Memory Access Violation when Receiving Malformed RTPS Message

When a received RTPS message had its message and submessage headers processed, *Connext Micro* incorrectly did not validate for all cases that there was sufficient space in the message's receive buffer before accessing a field of a header. Consequently, reception of certain malformed messages could have resulted in memory access violations. The problem has been fixed by always validating for sufficient buffer. This has been fixed.

[RTI Issue ID MICRO-1614]

In Some Cases an Incorrect Timeout Calculation Caused 100% CPU Load

Some combinations of timeouts, clock resolution and resource-limits may have caused an incorrect timeout to be scheduled causing an infinite loop in the timer thread.

If multiple timers expires at the same time and the timeout is exactly:

:: (dp_qos.resource_limits.remote_participant_allocation + (3*dp_qos.resource_limits.local_writer_allocation) + (3*dp_qos.resource_limits.local_reader_allocation) + 1) / 2 * timer_resolution

the next timeout may be scheduled for immediate timeout, causing the timer thread to consume excessive CPU.

[RTI Issue ID MICRO-1617]

8.5.13 What's New in 2.4.9

Improved Support for adding new Ports

Some changes were made to how *Connext Micro* includes different ports. In versions before 2.4.9 new ports would typically update osapi_config.h and add a new directory with an implementation for the required OSAPI functions. As of 2.4.9 osapi_config.h was re-factored and OS and compiler specific functions were moved to two new files:

- osapi_os_<osname>.h This file contains OS specific information. RTI ships three files: osapi_os_posix.h, osapi_os_windows.h and osapi_os_vxworks.h. It is recommended to add a new osapi_os_<osname>.h file when a new OS is added.
- osapi_cc_<osname>.h This file contains compiler specific informations. RTI ship osapi_cc_stds.c which works with Microsoft Visual Studio, clang and GCC.

Please refer to ref OSAPIUserManuals_PortingModule for details.

Updated Build Environment to Build RTI Connext Micro

Connext Micro now includes better support for adding CMake tool-chain files and also includes a better infrastructure to manage multiple builds of *Connext Micro*. It is strongly encouraged to read ref OSAPIUserManuals_SourceModule for details to get familiar with the new build environment.

Example CMake Tool-chain Files for Cross-Compilation

Connext Micro ships with a more cmake tool-chain files for Linux, Darwin, Windows and VxWorks. Please refer to ref OSAPIUserManuals_SourceModule for details.

[RTI Issue ID MICRO-706]

Host Bundle without the Java RunTime Available

A new smaller host bundle that does not include Java Runtime Environments (JRE) is now available for download. A host bundle with JREs included is still available.

With Java being necessary for the rtiddsgen utility, rtiddsgen now picks Java based on the following order:

- New rtiddsgen command line option -jre
- JREHOME environment variable
- JAVA_HOME environment variable
- JRE shipped with the host bundle
- PATH environment variable

[RTI Issue ID MICRO-1520]

Support for 64-bit Platforms

Connext Micro was written for 32 bit architectures and is for all practical purposes a 32 bit application. There is no advantage to compiling *Connext Micro* for a 64 bit architecture and the only reason to do so is if *Connext Micro* must execute in a 64 bit environment for other reasons, such as other applications being 64 bit or 64 bit libraries not being available.

Connext Micro is compiled and tested on various 64 bit architectures (iOS, MacOS, Windows, Linux, VxWorks). However, when doing so the following must be kept in mind:

- *Connext Micro* does not work with any data-type larger than what the transport supports and up to a maximum of 2 GB.
- Timestamps in *Connext Micro* are limited to seconds encoded as a signed 32 bit integer.

POSIX Compliance Improvements

Connext Micro supports various POSIX like operating systems. Due to small differences in the implementations not all POSIX like are equal and OS specific adaptations are necessary.

As of 2.4.9 *Connext Micro*'s POSIX OSAPI implementation conforms to:

- POSIX Std 1003.1, 2004 Edition (_POSIX_C_SOURCE 200112L)
- X/Open 6 (_XOPEN_SOURCE 600)

The *Connext Micro* UDP transport uses ioctl calls to enable certain socket features. The required flags are in non-standard header-files on some operating system. In addition, not all POSIX-like operating systems support all the features. *Connext Micro* checks which OS it is compiled for by testing the presence of preprocessor flags. As of 2.4.9 *Connext Micro* has been built and tested on the following operating systems that supports a POSIX API (osapi_os.h):

- Linux (_linux_)
- Mac OS X (10.6 and later) ((_APPLE) && defined(MACH_))
- QNX 6.x (_QNXNTO_)
- VOS (_VOS_)
- iOS (((_APPLE) && defined(MACH_))
- Android (_linux_ && _ANDROID_)

NOTE: An additional compile option to enable certain non-POSIX features can be enabled to unchecking the RTIME_OSAPI_ENABLE_STRICT_POSIX option in the cmake-gui or by defining the C preprocessor flag -DOSAPI_ENABLE_STRICT_POSIX=1

C++ Support for find_topic()

The operation DDS_DomainParticipant_find_topic() is now natively supported by the C++ API as DDSDomainParticipant::find_topic().

Types Are Automatically Unregistered Upon Deleting Contained Entities

In previous releases, types must be unregistered manually from a DomainParticipant before the participant can be deleted. Now in this release, all registered types are automatically unregistered when calling DDS_DomainParticipant_delete_contained_entitites().

NOTE: It is legal to register the same type multiple times as long as it is registered with the same type-plugin. If manually unregistering a type, the type must be unregistered the same number of times as it was registered. DDS_DomainParticipant_delete_contained_entitites() ignores the number of times a type has been registered since all entities using a type are deleted first.

8.5.14 What's Fixed in 2.4.9

Improved Documentation

The *Connext Micro* documentation has been improved for the following topics:

- Compiling the *Connext Micro* source (ref OSAPIUserManuals_SourceModule)
- Filtering of samples by a DDS DataReader (ref UserManuals_MicroAndCore)
- How to use *Connext Micro* with RTI Recorder (ref UserManuals_MicroAndCore)
- Compatibility between *Connext Micro* and other RTI Products (ref UserManuals_MicroAndCore)

[RTI Issue ID MICRO-711, MICRO-1521, MICRO-1538, MICRO-1555]

Losing Participant Liveliness Stops Communication

Previously, given a DomainParticipant "P1" whose endpoints are communicating with other endpoints belonging to other DomainParticipants, when P1 detected liveliness lost with one other DomainParticipant, communication incorrectly stopped with endpoints belonging to other DomainParticipants as well.

[RTI Issue ID MICRO-1543]

DDSTopic::narrow() Returned Incorrect Value in C++

The function lookup_topicdescription() returned a DDSTopicDescription that caused DDSTopic::narrow() to segmentation fault when this DDSTopicDescription was passed to other functions.

DDSTopic::narrow() now correctly returns a DDSTopic when passed a DDSTopicDescription found with lookup_topicdescription().

[RTI Issue ID MICRO-1544]

PRECONDITION_NOT_MET Returned by deleted_topic() When Topic Is Not Use

delete_topic() incorrectly returned PRECONDITION_NOT_MET if there where multiple references to it (for example via find_topic()). This has been corrected and delete_topic() now returns DDS_RETCODE_OK if there are multiple references, but the reference count can be decremented.

[RTI Issue ID MICRO-1545]

Instance Resources Not Reclaimed When Unregistered

When an instance is unregistered on the data writer that is best-effort with infinite deadline or using TRANSIENT_LOCAL durability, the data writer fails to free the resources being used. As a result, new instances cannot be written. This has been fixed and when an instance is unregistered all resources associated with the key is released.

[RTI Issue ID MICRO-1546]

Invalid Memory Read Reported in Log.c

Some memory profile tools reported an invalid read in Log.c. This was caused by an invalid pointer access when the log buffer was full and has been corrected.

[RTI Issue ID MICRO-1550]

Unsupported Functions When Compiling With RTI_CERT Has Been Removed From Generated Code

Code generated by rtiddsgen to support user data types has been updated to properly support compilation with the flag RTI_CERT. All unsupported operations (e.g. FooTypeSupport_delete_data) are now excluded when RTI_CERT is specified.

[RTI Issue ID MICRO-1558]

The HelloWorld_cert Example Now Compiles When Linked Against a Library Built With RTI_CERT

The HelloWorld_cert called functions that were not supported by libraries built with RTI_CERT. This has been corrected.

[RTI Issue ID MICRO-1561]

Hostnames Are No Longer Validated

Previously in *Connext Micro* 2.4.6, a function to validate IP hostnames as defined by RFC-952 was added and called before passing them to the OS. However, this function was too restrictive and excluded valid service names. Hostname validation is now only done directly by the OS.

[RTI Issue ID MICRO-1563]

A Participant May Not Be Rediscovered In Case Of Asymmetric Liveliness Loss

This problem was only present when using dynamic discovery.

Consider two participants A and B. In the previous release, if A lost liveliness with B, but B did not lose liveliness with A, then A did not completely rediscover B when their connection was reestablished. The problem was that since B had not lost liveliness with A, when a connection was reestablished, B thought A was already up to date on endpoint discovery. Hence, A did not rediscover the endpoints in B. This release has fixed this issue.

[RTI Issue ID MICRO-1571]

A Non-keyed Endpoint Matches a Keyed Endpoint

When performing matching between A DataReader and DataWriter the entity kind was not checked. This means a keyed DataReader would match a non-keyed DataWriter and a non-keyed DataReader would match an keyed DataWriter.

This issue would can happen if two different IDLs files are used to create DataReaders and DataWriters of the same topic and type.

Note that *Connext Micro* does not support type validation. If two (or more) IDLs are used to describe the same keyed type there is no check that the key-fields are the same. Thus, even with this issue resolved there are still potential pitfalls with multiple IDLs for the same type.

[RTI Issue ID MICRO-1574]

8.5.15 What's New in 2.4.8

2.4.8 is a maintenance release with no new features.

8.5.16 What's Fixed in 2.4.8

Consistent support for assignment operator in C++

The assignment operator for the DDS Qos, Qos policy and Status structures were not consistently supported. This has been fixed in this release as follows:

- All QoS structures support the default generated C++ assignment operator.
- All QoS policy structures support the default generated C++ assignment operator.
- All Status structures support the default generated C++ assignment operator.

In addition, all QoS structures support the == and != operators.

[RTI Issue ID MICRO-1541]

DPSE API renamed to avoid conflict with assert()

The DPSE C++ API had methods called assert. However, this conflicts with the C assert() macro. This has been fixed in this release by updating the DPSE C++ API to be inline with the C API. The new API is:

```
class DDSCPPDllExport DPSEDiscoveryPlugin
{
public:
  static DDS_ReturnCode_t
  RemoteParticipant_assert(DDSDomainParticipant *const participant,
                           const char *rem_participant_name);

  static DDS_ReturnCode_t
  RemotePublication_assert(DDSDomainParticipant * const participant,
                           const char *const rem_participant_name,
                           const struct DDS_PublicationBuiltinTopicData *const data,
                           NDDS_TypePluginKeyKind key_kind);

  static DDS_ReturnCode_t
  RemoteSubscription_assert(DDSDomainParticipant * const participant,
                            const char *const rem_participant_name,
                            const struct DDS_SubscriptionBuiltinTopicData *const data,
                            NDDS_TypePluginKeyKind key_kind);
};
```

[RTI Issue ID MICRO-1539]

8.5.17 What's New in 2.4.7

2.4.7 is a maintenance release with no new features.

8.5.18 What's Fixed in 2.4.7

Statuses are passed as pointers instead of references to DDSDomainParticipantListeners

The statuses in the DDSDomainParticipantListener methods are now passed by reference instead of by pointer.

[RTI Issue ID MICRO-1524]

Missing assignment operator = in RT_ComponentFactoryId

The C++ API did not include the assignment operator for the RT_ComponentFactoryId type. The following assignment operators have been added:

```
RT_ComponentFactoryId& operator=(const char *const name);
RT_ComponentFactoryId& operator=(const RT_ComponentFactoryId& from);
const RT_ComponentFactoryId& operator=(const RT_ComponentFactoryId& from) const;
```

[RTI Issue ID MICRO-1525]

CMAKE_C_FLAGS_ORIGINAL in CMakeLists.txt misspelled

The CMAKE_C_FLAGS_ORIGINAL variable in the CMakeLists.txt file was misspelled causing the original C_FLAGS to be ignored. This has been corrected in this release.

[RTI Issue ID MICRO-1526]

Missing const qualifier for the sequence [] operator

The C++ API was missing the const qualifier for the sequence [] operator. This has been corrected in this release with these operators:

```
T& operator[] (RTI_INT32 index);
const T& operator[] (RTI_INT32 index) const;
```

[RTI Issue ID MICRO-1527]

Missing primitive IDL sequences in C++

The C++ API did not include sequence of the primitive IDL types. This has been corrected in this release. Please refer to ref DDSUserManuals_SequenceModule for more information about the sequence API.

[RTI Issue ID MICRO-1529]

8.5.19 What's New in 2.4.6

Important API Changes

This version of *Connext Micro* includes a number of API changes to improve compatibility with rticore and make the API more robust to input argument errors such as string length violations. Please note that some of the changes are incompatible with earlier version of *Connext Micro*.

Changed and Incompatible APIs:

- DDS_SEQUENCE_INITIALIZER(t) has changed to DDS_SEQUENCE_INITIALIZER. That is, the sequence element type is no longer passed in.

- Foo_seq_get_contiguous_buffer replaces Foo_seq_get_buffer.
- DDSTopic now uses multiple inheritance. Thus, it is no longer necessary to explicitly convert a topic to a topic description with the as_topicdescription() method when creating calling create_datareader() in C++.
- The idref_DiscoveryComponent_name value has changed type from a char pointer to a RT_ComponentFactoryId_T type. Use ref RT_ComponentFactoryId_set_name to set the name of the discovery plugin name.
- All C++ statuses are passed as a const reference instead of a const pointer to the listeners.

New APIs:

- By default the full sequence API has been enabled. In previous versions only a limited subset was enabled. NOTE: For RTI_CERT the default sequence API is still the limited API.
- The following new sequence methods have been added to the full sequence API (excluding the DDSConditionSeq):
  - ensure_length
  - to_array
  - from_array
  - operator[] in C++ is equivalent to get_reference()
  - operator= is equivalent to _copy()
  - operator== is equivalent to _is_equal()
  - operator!= is equivalent to !_is_equal()
- The following new sequence methods have been added to the DDSConditionSeq:
  - ensure_length
  - operator[] in C++ is equivalent to get_reference()
  - operator= is equivalent to _copy()
  - operator== is equivalent to _is_equal()
  - operator!= is equivalent to !_is_equal()
- RTIBool has been added (it is used by rticore) and is equivalent to RTI_BOOL in *Connext Micro*.
- A new method idref_EntityNameQosPolicy_set_name has been added to set the idref_EntityNameQosPolicy_name field.
- Please refer to ref rl_new_246_MICRO-1512 for new C++ APIs.

Run-time Memory Footprint Has Been Significantly Reduced

The internal representation of state information has been refactored, significantly reducing run-time memory usage.

Please refer to the ref DDSUserManuals_ResourceModule guide for details.

New FooTypeSupport operations

The FooTypeSupport code generated for a user-defined Foo data type now includes three additional operations:

- FooTypeSupport::get_type_name
- FooTypeSupport::create_data
- FooTypeSupport::delete_data

These operations are available to users of both the C and C++ APIs.

All public C API now natively available to C++ users

The missing parts of RTI Connext Micro's public C API have now been added to the public C++ API, so that C++ users don't have to rely on C operations to implement their applications.

C++ developers are also not required to include any C header file anymore, but they must instead rely on newly available C++ header files.

Please refer to ref CPPApiModule for a list of APIs.

Status data passed by reference to C++ listeners

All callbacks exposed by the DDS listeners of the C++ API (DDSDataReaderListener, DDSDataWriterListener, DDSTopicListener, and other derived classes) now accept the status data passed in by the middleware as a C++ reference, rather than a pointer.

TheParticipantFactory now available to C++ users

The variable TheParticipantFactory is now available to users of the C++ API to reference the singleton instance of DDSDomainParticipantFactory.

Status types now available in DDS:: C++ namespace

All the status types (e.g. DDS_SubscriptionMatchedStatus) have been exposed to C++ users as part of the DDS:: namespace (e.g. DDS::SubscriptionMatchedStatus).

Foo::copy_data() takes const argument

The pointer specifying the source sample passed to the generated operation Foo::copy_data() (C++ API) is now of "const" type.

ConditionSeq added to C++ DDS namespace

C++ developers can now refer to data type DDS_ConditionSeq as DDS::ConditionSeq.

First 2-Bytes Of GUID Assigned to Vendor ID

In order to be interoperable with the Real-Time Publish-Subscribe Wire Protocol DDS Interoperability Wire Protocol (DDSI-RTPS), version 2.2, the first 2-bytes of every GUID are now automatically assigned to the OMG-specified Vendor ID.

8.5.20 What's Fixed in 2.4.6

POSIX Threads Were Created Without Names

Previous releases on POSIX platforms created threads with no names. In this release, if thread naming is supported, a POSIX thread created with the *Connext Micro* OSAPI_Thread_new() function will have its thread name set.

[RTI Issue ID MICRO-638]

Prerequisite for HelloWorld_android updated in README.txt

The README.txt file for Android did not clarify that is it necessary to install the NDK tool-chain as a standalone toolchain. This has been fixed.

[RTI Issue ID MICRO-807]

CPP/HelloWorld_dpde example does not overwrite RTIMEHOME

In previous releases of *Connext Micro*, the CPP/HelloWorld_dpde example overwrote the RTIMEHOME environment variable, making it impossible for developers to point it to any custom value.

This error was fixed and the example can now be compiled with any valid value of RTIMEHOME.

[RTI Issue ID MICRO-834]

Transport Not Supporting Multicast Did Not Ignore Multicast

Previously, if a multicast address was specified as a discovery or user_traffic address, it was not correctly ignored by transports that did not support multicast. Consequently, an application may have failed to create a DomainParticipant. This has been fixed in this release.

[RTI Issue ID MICRO-1153]

Discovery Messages Incorrectly Dropped When Containing Non-Standard Locators

When a discovery message was received with a non-standard locator, such as for an unsupported transport, rather than just ignore the locator, the entire discovery message was discarded. This incorrect behavior prevented discovery of the entity that sent the discovery message. This issue has been fixed in this release.

[RTI Issue ID MICRO-1270]

HEARTBEAT Not Sent in Response To Initial ACKNACK

In *Connext Micro*, a newly matched reliable DataReader will send an initial ACKNACK submessage to the matching DataWriter in order to expedite reliable communication. The initial ACKNACK is zero-valued, and a DataWriter receiving it will not resend any samples but instead will send a HEARTBEAT that the DataReader will respond with a proper ACKNACK.

In the previous release, however, a DataWriter receiving this initial ACKNACK did not respond with a HEARTBEAT. Consequently, reliable resend of historical samples did not start as soon as it should have, and instead would start with the next HEARTBEAT sent by the DataWriter, either a periodic HEARTBEAT or a piggyback HEARTBEAT sent with newly written samples. This issue has been fixed in this release.

[RTI Issue ID MICRO-1443]

Incorrect Return Code From DataReader's Read or Take APIs When Max_Outstanding_Reads Exceeded

When a DataReader's read or take APIs are called, depending on the input parameters of the sample sequence and sample-info sequence, the DataReader may loan to the caller its memory containing sample and sample-info entries. A resource limit, DATA_READER_RESOURCE_LIMITS max_outstanding_reads, sets the maximum number of samples (and corresponding sample-info entries) that may be loaned.

In previous releases, when max_oustanding_reads was exceeded, the read/take APIs incorrectly returned DDS_RETCODE_NO_DATA instead of DDS_RETCODE_OUT_OF_RESOURCES. This bug has been fixed in this release.

[RTI Issue ID MICRO-1460]

DataReader Did Not Replace Historical Samples When max_samples_per_instance Equaled History Depth

Previously, given a DataReader with RESOURCE_LIMITS max_samples_per_instance equal to HISTORY depth, when the DataReader exceeded its depth (or max_samples_per_instance), it incorrectly did not replace the oldest historical sample with the newest sample. Instead, the oldest historical sample was kept in the queue, and subsequent calls to read() could return it. Note, calls to take() would remove all taken sample from the queue.

This issue has been fixed in this release.

[RTI Issue ID MICRO-1463]

A Disposed Instance Could Be Updated By A DataWriter That Is Not Its Exclusive Owner

When EXCLUSIVE_OWNERSHIP was used, a disposed instance could incorrectly be updated by a DataWriter with a lower strength than the DataWriter that disposed the instance, even if that DataWriter had not unregistered the instance. This has been corrected: when an instance is disposed, a lower strength DataWriter is not allowed to update the instance as long as the DataWriter that disposed the instance is still registered as an updater for the instance. Only when the DataWriter unregisters from the instance can a lower strength DataWriter update the instance again.

[RTI Issue ID MICRO-1464]

Fixed code generation for user-defined enum constants.

The previous version of rtiddsgen shipped with *Connext Micro* contained a bug which prevented the numerical constants assigned to an enum's values to be correctly handled in the generated code.

This error has been fixed and IDL enum types are now correctly translated into C/C++ data types with the correct constants.

[RTI Issue ID MICRO-1483]

Hostname is verified as specified in RFC-952 and RFC-1123

Connext Micro relied on gethostbyname() to resolve hostnames. However, if a name resolver was not available it was possible to specify illegal names.

This has been corrected and only legal names, as defined by RFC-952 and RFC-1123, are resolved.

[RTI Issue ID MICRO-1489]

DDS_<Foo>Seq APIs Were Missing

The DDS sequence APIs for the built-in DDS types, such as DDS_LongSeq etc, were missing. The workaround was to use CDR_<Foo>Seq instead.

This issue has been corrected in this release, with the missing sequence APIs now included.

[RTI Issue ID MICRO-1493]

DataReader Could Reject All Subsequent Samples From a DataWriter

In the previous release, given a DataReader receiving samples from a DataWriter, after the DataWriter had written approximately (2^32) - max_samples_per_remote_writer number of samples, no more samples from that DataWriter would be received by the DataReader. Instead, every subsequent sample from the DataWriter would be rejected. This was caused by an incorrect update of an internal counter of the DataReader.

[RTI Issue ID MICRO-1500]

POSIX Thread Priorities Not Changeable

It was not possible to change the priority of POSIX threads created in previous releases of *Connext Micro*. Instead, a POSIX thread inherited the priority of its parent. This has been fixed in this release.

[RTI Issue ID MICRO-1502]

RTPS DATA Submessages with K-flag Set Were Dropped

Previously, RTPS DATA submessages with the K-flag set (indicating a serialized key payload) were not processed and instead dropped by a DataReader. This has been fixed and such DATA submessages are now processed and accepted.

[RTI Issue ID MICRO-1511]

8.6 Known Issues

8.6.1 Code Generator cannot parse a file preproccesed with GCC 11

GCC 11 produces unexpected output when used as a preproccesor. This unexpected output causes an error in *Code Generator*.

This issue can be worked around with any of the steps below:

- Disable the preprocessor (unless it is required): `rtiddsgen -ppDisable ...`
- Explicitly set a different preprocessor: `rtiddsgen -ppPath /path/to/cpp`
- Set a different PATH, where a different preprocessor is selected first: `PATH=/path/to/cpp:${PATH} rtiddsgen...`
- Disable line markers in your preprocessor, e.g. for GCC: `rtiddsgen -ppOption -P ...`

[RTI Issue ID CODEGENII-1508]

8.6.2 AUTOSAR ErrorHook may create CPU overhead

If enabled during configuration, the AUTOSAR OS Hook `ErrorHook` may be called if *Connext Micro* tries to cancel an alarm that has already been signaled. There is no known workaround for this issue.

[RTI Issue ID MICRO-5367]

8.6.3 Maximum Number of Components Limited to 58

The maximum number of components that can be registered is limited to 58.

8.6.4 CMake version 3.6 or Higher is Required to Build VxWorks with CMake

Limitations in CMake prior to 3.6 required forcing the compiler to a specific path. However, this resulted in warnings from CMake 3.6 and higher that this feature has been deprecated and instead the CMAKE_TRY_COMPILE_TARGET_TYPE should be used to prevent linking.

Unless there are specific needs,there are no plans to support CMake prior to 3.6 when building for VxWorks.

8.6.5 Endpoint Discovery Requires Unique Object IDs Across All Remote Endpoints

When using static endpoint discovery (DPSE), RTI Connext Micro requires that the object_id for statically asserted remote endpoints must be unique across all remote endpoints, as opposed to just between remote endpoints within the same participant. Note, this restriction was incorrectly documented as removed in version 2.4.1.

8.6.6 Compiler warnings on VxWorks

When compiling for VxWorks 6.9 with the -Wconversion flag there are compiler warnings of the type:

```
warning: conversion to 'DDS_Boolean' from 'int' may alter its value
```

These compiler warnings seem to be an issue with GCC for VxWorks and can be ignored. The problem is that returning a value from a expression seems to always be treated as an unbounded int as opposed to an int with a value of 0 or 1 as the C standard dictates.

8.6.7 OSAPI Does Not Always Detect Endianess

osapi_cc_stdc.h detects the CPU endianness by checking GCC predefined macros, such as ___BYTE_ORDER___. However, some versions of GCC does not set these macros, for example GCC for VxWorks. If osapi_cc_stdc.h does not find any of the flags, it incorrectly sets the CPU to little endian.

In this case it is *important* that *one* of the following preprocessor macros are defined:

- RTI_ENDIAN_BIG The CPU is big-endian
- RTI_ENDIAN_LITTLE The CPU is little-endian

NOTE: The VxWorks cmake toolchain file from RTI set these based on CPU type in the target name (–name option).

8.6.8 Missing Checks for max_routes_per reader and max_routes_per_writer

The `DDS_DataReaderQos.reader_resource_limits.max_routes_per_writer` and `DDS_DataWriterQos.writer_resource_limits.max_routes_per_reader` fields are missing a check that the values are in the range [1,2000]. The fields are also missing from the methods `DDS_DataReaderQos_is_equal` and `DDS_DataWriterQos_is_equal`, respectively.

Chapter 9

Benchmarks

The benchmark section provides metrics for *Connext Micro*. The information contained here is only meant as guidance and actual numbers will vary across different hardware and compilers. Please note that the numbers are generated before the final release and the source-code line count and library sizes may vary slightly. Performance numbers are always valid for the final release.

9.1 Latency Benchmarks

Latency measurements are provided on the following environment:

- *Xeon* – End-to-end latency measured with the RTI Connext DDS Performance Test tool on high-performance Xeon machines in a dedicated network .

9.1.1 Xeon

The end-to-end latency is measured between two identical machines, using the test configuration below and running the RTI Connext DDS Performance Test tool.

The test environment consists of the following:

- x86_64 CentOS Linux release 7.1.1503
- RTI Perftest 3.0
- Switch Configuration: D-Link DXS-3350 SR:
  - 176Gbps Switching Capacity
  - Dual 10-Gig stacking ports and optional 10-Gig uplinks
  - Stacks up to 8 units per stack
  - 4MB (Packet Buffer Size)
  - 48 x 10/100/1000BASE-T ports

- Machine:
  - Intel I350 Gigabit NIC
  - Intel Core i7 CPU:
    - 12MB cache
    - 6 Cores (12 threads)
    - 3.33 GHz CPU speed
  - 12GB memory

The latency is measured by sending one *PING* sample and wait for the Echoer to return the *PONG* sample. The sender records the time it took to receive the *PONG* sample and divides the result by 2. The test is repeated a number of times for each size. Note that the *end-to-end* latency is measured.

The following measurements are reported in the tables below:

- **Bytes** - The size of the DDS sample payload in bytes (UDP overhead is *not* included).
- **Ave** - Average latency
- **Std** - Standard deviation
- **Min** - The minimum latency
- **Max** - The maximum latency
- **50%** - The 50th percentile latency
- **90%** - The 90th percentile latency
- **99%** - The 99th percentile latency
- **99.99%** - The 99.99th percentile latency

All values are reported in micro-seconds **(µs)**.

C++ Best Effort keyed 1 Gbps

Table 9.1: C++ Best Effort keyed 1 Gbps

Bytes	Ave (µs)	Std (µs)	Min (µs)	Max (µs)	50% (µs)	90% (µs)	99% (µs)	99.99% (µs)
32	25	0.4	24	80	25	25	27	28
64	25	0.4	24	40	25	26	27	29
128	27	0.4	26	41	27	27	28	30
256	30	0.6	29	40	30	30	31	33
1024	44	0.5	43	56	44	44	45	48
4096	76	0.6	75	345	76	77	78	80
8192	113	0.6	112	231	113	114	115	119
63000	605	0.9	603	622	605	606	607	621

C++ Best Effort Unkeyed 1 Gbps

Table 9.2: C++ Best Effort Unkeyed 1 Gbps

Bytes	Ave (µs)	Std (µs)	Min (µs)	Max (µs)	50% (µs)	90% (µs)	99% (µs)	99.99% (µs)
32	24	0.3	23	35	24	24	26	27
64	24	0.5	23	39	24	25	26	28
128	26	0.3	25	46	26	26	27	29
256	29	0.5	28	334	29	29	30	32
1024	43	0.4	42	54	43	44	45	47
4096	76	0.5	75	169	76	76	78	80
8192	113	0.7	112	272	113	114	115	118
63000	605	0.9	603	622	605	606	608	619
32	24	0.6	24	43	24	25	26	28
64	25	0.6	24	271	25	25	26	29
128	26	0.4	25	267	26	26	28	30
256	28	0.6	28	291	28	29	30	33
1024	43	0.6	42	336	43	44	45	48
4096	76	0.6	75	287	76	76	78	80
8192	113	0.9	112	370	113	114	115	118
63000	605	1.2	603	775	605	606	607	622

C++ Reliable Keyed 1 Gbps

Table 9.3: C++ Reliable Keyed 1 Gbps

Bytes	Ave (µs)	Std (µs)	Min (µs)	Max (µs)	50% (µs)	90% (µs)	99% (µs)	99.99% (µs)
32	28	1.4	26	45	27	31	32	34
64	28	1.4	26	325	27	31	32	34
128	30	1.3	28	39	29	32	33	36
256	33	1.2	31	47	33	36	37	39
1024	47	1.2	46	335	47	49	50	53
4096	80	1.4	77	347	80	83	84	87
8192	117	1.4	114	390	117	119	121	124
63000	609	1.5	606	785	608	610	612	622
32	28	1.2	25	91	27	30	31	35
64	28	1.6	25	311	27	31	32	35
128	30	1.4	28	55	29	32	33	36
256	33	1.2	31	336	33	35	36	40
1024	48	1.2	46	514	47	50	50	53
4096	80	0.9	78	342	79	80	82	86
8192	117	1.5	114	381	117	119	120	124
63000	609	1.1	606	628	609	610	612	624

C++ Reliable Unkeyed 1 Gbps

Table 9.4: C++ Reliable Unkeyed 1 Gbps

Bytes	Ave (µs)	Std (µs)	Min (µs)	Max (µs)	50% (µs)	90% (µs)	99% (µs)	99.99% (µs)
32	27	1.9	25	312	27	30	34	36
64	28	1.3	26	51	28	30	31	35
128	29	1.4	27	42	29	32	32	37
256	32	1.1	30	64	32	34	35	38
1024	48	0.9	45	63	47	49	50	53
4096	80	1.2	77	298	79	82	83	86
8192	117	1.3	115	211	116	119	121	125
63000	609	1.5	607	807	609	611	613	624
32	27	1.3	24	312	27	30	31	34
64	28	1.6	25	322	27	31	32	37
128	28	1.4	26	307	28	31	32	36
256	33	1.3	30	632	32	35	35	38
1024	47	1.1	45	337	46	49	50	52
4096	80	1.4	78	550	79	82	83	85
8192	117	1.2	115	362	116	119	120	123
63000	609	1.7	607	898	609	610	612	628

9.2 Throughput Benchmark

Throughput measurements are provided for the following environment:

- *Xeon* – End-to-snd latency measured with the RTI Connext DDS Performance Test tool on high-performance Xeon machines in a dedicated network.

9.2.1 Xeon

The end-to-end throughput is measured between two identical machines, using the test configuration below and running the RTI Connext DDS Performance Test tool.

The test environment consists of the following:

- x86_64 CentOS Linux release 7.1.1503
- RTI Perftest 3.0
- Switch Configuration: D-Link DXS-3350 SR:
  - 176Gbps Switching Capacity
  - Dual 10-Gig stacking ports and optional 10-Gig uplinks

  - Stacks up to 8 units per stack
  - 4MB (Packet Buffer Size)
  - 48 x 10/100/1000BASE-T ports
- Machine:
  - Intel I350 Gigabit NIC
  - Intel Core i7 CPU:
    * 12MB cache
    * 6 Cores (12 threads)
    * 3.33 GHz CPU speed
  - 12GB memory

Throughput is measured by sending samples from a publisher as fast as possible. A subscriber measures the throughput results.

The following measurements are reported in the tables below:

- **Length** - The size of the DDS sample payload (UDP overhead is not included).
- **Total Samples** - The number of samples written.
- **Ave Samples/s** - The number of samples written per second.
- **Ave Mbps** - The bandwidth utilization for the payload based on **Length** and **Ave Samples/s**.
- **Lost Samples** - On the subscriber side, the number of samples received is counted against what is expected.
- **Lost Samples %** - Percentage of **Lost Samples** compared to the **Total Samples**.

C++ Best Effort Unkeyed 1 Gbps

Table 9.5: C++ Best Effort Unkeyed 1 Gbps

Length	Total Samples	Ave Samples/s	Ave Mbps	Lost Samples	Lost Samples %
32	16333991	272176	69.7	3523614	17.74
64	15991211	266461	136.4	4536872	22.10
128	16457503	274234	280.8	3857153	18.99
256	15627628	260436	533.4	4006886	20.41
1024	6522174	108698	890.5	0	0.00
4096	1776564	29607	970.2	0	0.00
8192	901722	15028	984.9	0	0.00
63000	118062	1967	991.7	0	0.00

C++ Best Effort Keyed 1 Gbps

Table 9.6: C++ Best Effort Unkeyed 1 Gbps

Length	Total Samples	Ave Samples/s	Ave Mbps	Lost Samples	Lost Samples %
32	16744913	279028	71.4	1071377	6.01
64	16480396	274614	140.6	2673204	13.96
128	16440910	273956	280.5	2415054	12.81
256	15457417	257594	527.6	3016783	16.33
1024	6389046	106476	872.3	0	0.00
4096	1766500	29440	964.7	0	0.00
8192	899151	14984	982.0	0	0.00
63000	118016	1966	991.3	0	0.00

C++ Reliable Unkeyed 1 Gbps

Table 9.7: C++ Best Effort Unkeyed 1 Gbps

Length	Total Samples	Ave Samples/s	Ave Mbps	Lost Samples	Lost Samples %
32	13849260	230820	59.1	0	0.00
64	13409644	223493	114.4	0	0.00
128	13749231	229153	234.7	0	0.00
256	13505470	225091	461.0	0	0.00
1024	6503630	108386	887.9	0	0.00
4096	1775045	29582	969.4	0	0.00
8192	901346	15021	984.5	0	0.00
63000	118037	1967	991.5	0	0.00

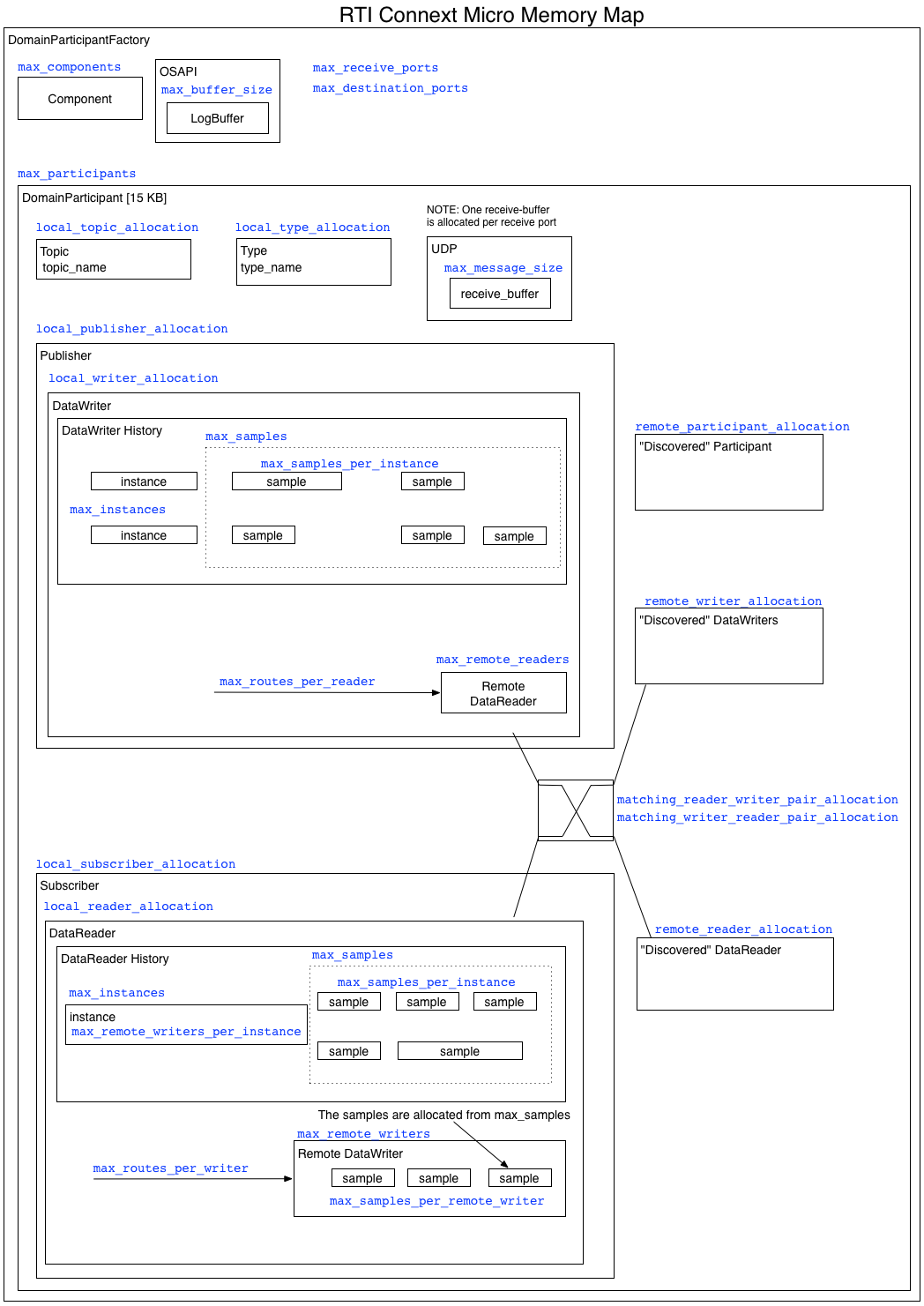
9.3 Heap Benchmarks

The "Heap" section provides information about how much dynamically allocated memory is used by *Connext Micro*. It should be noted that exact numbers are very difficult to estimate and that the numbers are only for guidance. Please refer to ResourceModule for a more information on resource limits and memory usage.

On Linux, for each heap allocation using malloc, malloc_usable_size() is called to determine the actual size of each allocation. The numbers include resources used by the RH_SM, WH_SM, and UDP components, but not the resources used by the dynamic discovery component (DPDE) or the static discovery component (DPSE). In addition, please note that the memory does not include memory for the actual user-data. This must be added according to the resource limits. The numbers are for the release libraries.

The size for entities that are controlled by resource limits are provided. In addition, a formula is provided to estimate the amount of memory used by a data reader and data writer as these are typically the ones that consume most of the memory.

9.3.1 Heap Usage



The following table shows how much memory each resource-limit uses in the memory model for the *armv8QOS2.1_qcc_gpp5.4.0* architecture.

Resource limit	Size in Bytes	Notes
DomainParticipantFactory	3736	
max_participants	21498	This is the memory for an empty participar
max_components	N/A	
local_topic_allocation	140	Add strlen(topic_name) + 1
local_type_allocation	36	Add strlen(type_name) + 1
local_publisher_allocation	268	
local_subscriber_allocation	268	
local_reader_allocation	2285	The sample and instance resources must be
local_writer_allocation	2727	The sample and instance resources must be
matching_writer_reader_pair_allocation	28	
remote_participant_allocation	905	
remote_writer_allocation	about 600	This includes the topic_name.
remote_reader_allocation	about 600	This includes the topic_name.
max_destination_ports	77	
max_receive_ports	376	
(DataReader) max_instances	272	
(DataReader) max_samples	160	
(DataReader) max_remote_writers	391	
(DataReader) max_routes_per_writer	87	
(DataReader) max_samples_per_instance	0	
(DataReader) max_remote_writers_per_instance	0	
(DataReader) max_samples_per_remote_writer	0	
(DataWriter Best Effort) max_instances	80	
(DataWriter Best Effort) max_samples	116	
(DataWriter Best Effort) max_remote_readers	391	
(DataWriter Best Effort) max_routes_per_reader	87	
(DataWriter Reliable) max_instances	79	
(DataWriter Reliable) max_samples	480	
(DataWriter Reliable) max_remote_readers	391	
(DataWriter Reliable) max_routes_per_reader	87	
(DataWriter) max_samples_per_instance	0	
max_locators_per_discovered_participant	83	
max_buffer_size	0	
max_message_size	0	

Calculating Memory Usage for DDS Entities

The following short-hands are used in these formulas:

- `rl_ms` - resource_limits.max_samples
- `rl_mi` - resource_limits.max_instances
- `rl_mrw` - datareader_resource_limits.max_remote_writers
- `rl_mrpw` - datareader_resource_limits.max_routes_per_writer

- `wrl_mrw` - datawriter_resource_limits.max_remote_readers
- `wrl_mrpr` - datawriter_resource_limits.max_routes_per_reader

Type

```
(36) + string.len(type_name) + 1
```

Topic

```
(140) + string.len(topic_name) + 1
```

DDS DataReader

```
(2285) + (rl_ms * 160 ) + (rl_mi * 271) + (rl_mrw * 391) + (rl_mrpw * 87)
```

DDS DataWriter

```
(2727) + (rl_ms * 116) + (rl_mi * 79) + (wrl_mrr * 391) + (wrl_mrpr * 87)
```

RemoteParticipant

```
(remote_participant_allocation) + (16 * 24)
```

RemotePublication

```
(remote_writer_allocation) + string.len(topic_name) + 1 + (16 * 24)
```

RemoteSubscription

```
(remote_reader_allocation) + strlen(topic_name) + 1 + (16 * 24)
```

9.3.2 Dynamic Discovery (DPDE) Heap Usage Information

The DPDE plugin is a DDS application that advertises locally created DDS entities and listens for DDS entities available in the DDS data-space. It is implemented using the DDS APIs supported by *Connext Micro*.

The DPDE plugin creates the following DDS entities:

- One DDS Publisher
- One DDS Subscriber
- Three DDS Topics
- Three DDS DataReaders
- Three DDS DataWriters

The DPDE plugin also registers the following three types:

- DDS_ParticipantBuiltinTopicData
- DDS_PublicationBuiltinTopicData
- DDS_SubscriptionBuiltinTopicData

All heap memory allocated by the DPDE plugin is allocated after the DDS DomainParticipant is created (no additional memory is allocated after the DDS DomainParticipant is enabled).

DPDE Plugin	Release Size(B)
Plugin	66488

9.3.3 Static Discovery (DPSE) Heap Usage Information

The DPSE plugin is a DDS application that only advertises locally created DDS DomainParticipants and listens for other DDS DomainParticipants available in the DDS data-space. It is implemented using the DDS APIs supported by *Connext Micro*.

The DPSE plugin creates the following DDS entities:

- One DDS Publisher
- One DDS Subscriber
- One DDS Topics
- One DDS DataReader
- One DDS DataWriter

The DPSE plugin also registers the following type:

- DDS_ParticipantBuiltinTopicData

All heap memory allocated by the DPSE plugin is allocated after the DDS DomainParticipant is created (no additional memory is allocated after the DDS DomainParticipant is enabled).

DSDE Plugin	Release Size(B)
Plugin	32020

9.4 Source Line Count

This section gives the size of each library in terms off effective lines of source-code (ELOC) and is gathered from the pre-processed files only for the release library. The ELOC number only include lines with source that directly contribute to the object-files. For example, the following are _not_ included:

- comments
- white-space
- lines with only braces
- type, structure, constant definitions

The ELOC number by itself is not very useful, but is provided since it is a frequently asked question.

Library	ELOC
rti_me	30093
discdpde	3399
discdpse	1696
rh_sm + wh_sm	1889

9.5 Library Sizes

The size of each shared library's _text_, and _data_ segment in bytes is determined using the *size* command on 64 bit Darwin. Please note that these numbers can vary significantly between different targets.

Library	Text (B)	Data (B)
rti_me	409600	8192
discdpde	40960	4096
discdpse	28672	4096
rh_sm	20480	4096
wh_sm	12288	4096
rti_me_cpp	65536	12288

9.6 Threads

RTI Connext Micro uses multiple threads. The timer thread is managed by the *DomainParticipant* and cannot easily be removed. All the UDP threads are managed by the UDP transport, and a different UDP transport implementation can choose a different threading model.

The default stack size is determined by the OS, but can be changed with *OSAPI_SystemProperty* and *UDP_InterfaceFactoryProperty*. Please refer to the platform specific sections for details.

Chapter 10

Copyrights

Printed in U.S.A. First printing.
July 2023.

Trademarks

Copy and Use Restrictions

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/

Chapter 11

Contact Support

We welcome your input on how to improve *RTI Connext Micro* to suit your needs. If you have questions or comments about this release, please visit the RTI Customer Portal, https://support.rti.com. The RTI Customer Portal provides access to RTI software, documentation, and support. It also allows you to log support cases.

To access the software, documentation or log support cases, the RTI Customer Portal requires a username and password. You will receive this in the email confirming your purchase. If you do not have this email, please contact license@rti.com. Resetting your login password can be done directly at the RTI Customer Portal.

Chapter 12

Join the Community

RTI Community provides a free public knowledge base containing how-to guides, detailed solutions, and example source code for many use cases. Search it whenever you need help using and developing with RTI products.

RTI Community also provides forums for all RTI users to connect and interact.