RTI Recording Service

User's Manual

Version 7.7.0

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Welcome to *RTI® Recording Service*, an *RTI Connext®* application that records and replays DDS Topics and discovery data.

Chapter 1

Introduction

RTI® Recording Service includes the following tools:

- *Recording Service*, an *RTI Connext®* application that records Topics and discovery data. *Recording Service* records updates to data along with a timestamp, so you can view or replay updates to data in your system as they occur over time. Recorded data is stored in SQLite® files by default. *Recording Service* also has an API to record to a custom data store.
- *Replay Service*, an application that can play back data recorded by *Recording Service*. *Replay Service* also has an API to allow plugging in custom storage.
- *Converter*, an application that converts binary (serialized) recorded data to deserialized data that can be viewed and queried. The most efficient way to record data is in serialized form. *Converter* allows data to be recorded efficiently, then post-processed into a queryable form. *Converter* also provides APIs to plug in custom storage.

1.1 The Basics

Recording Service is used when you need to record updates to system data over a period of time, and to access that data by time. One example of when you might use the *Recording Service:* if you are testing your system, you can use *Recording Service* to record all DDS data updates that occur during a particular test run. Then you can use a database tool or *Replay Service* to view what happened at specific times during your test.

Recording Service's builtin database is a SQLite file. *Recording Service* can store data in the SQLite database in two formats:

- CDR serialized format: This is the format in which data is sent over the network, so it is the most efficient way to store data. It is binary, so it is not queryable.
- JSON format: To store data this way, *Recording Service* must convert between the network format and the JSON format. This is queryable, but comes at a performance cost.

Recording Service also provides an API that allows you to implement your own storage backend. You will receive the data in serialized format, then use *Connext* dynamic-data APIs to deserialize the data.

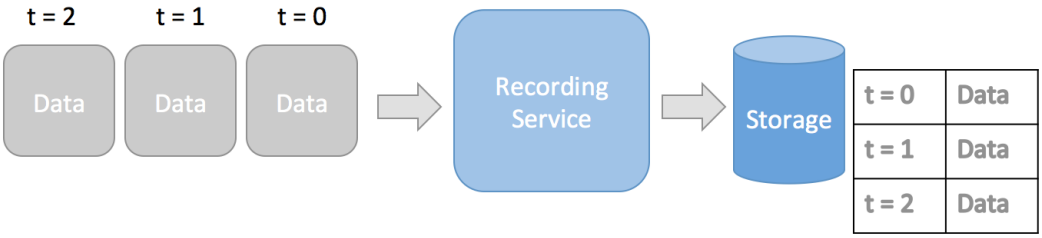

Figure 1.1: *Recording Service* receives DDS samples over the network and records them to storage, based on their timestamps

Replay Service works with data recorded by *Recording Service*. It uses the timestamps of the recorded data to replay the data back into a DDS system at the original offsets between recorded timestamps. *Replay Service* also offers an API to retrieve your data from the storage of your choice to be replayed.

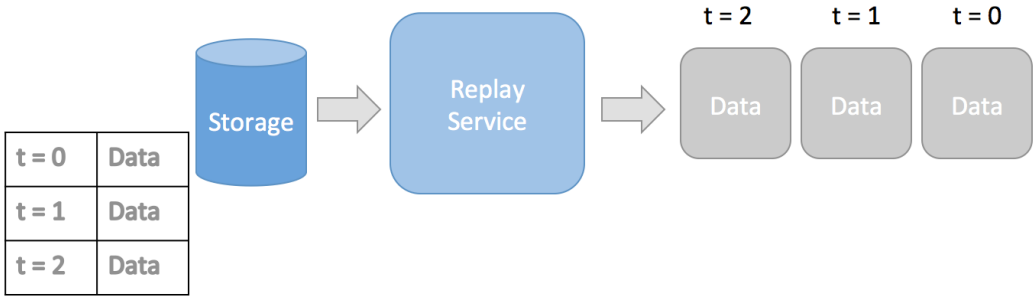

Figure 1.2: *Replay Service* retrieves stored data samples from storage and replays it over DDS, maintaining the original timing of the data

Converter is a tool that can convert between the data formats used by *Recording Service*. Currently, the only builtin formats supported by *Recording Service* are the CDR and JSON formats described above, within a SQLite database. *Converter* allows you to record data in the efficient CDR format and later convert to a queryable JSON format.

1.2 Paths Mentioned in Documentation

This documentation refers to:

- `<NDDSHOME>` This refers to the installation directory for *Connext*.

  The default installation paths are:

  - macOS® systems: `/Applications/rti_connext_dds-version`
  - Linux® systems, non-root user: `/home/your user name/rti_connext_dds-version`
  - Linux systems, root user: `/opt/rti_connext_dds-version`

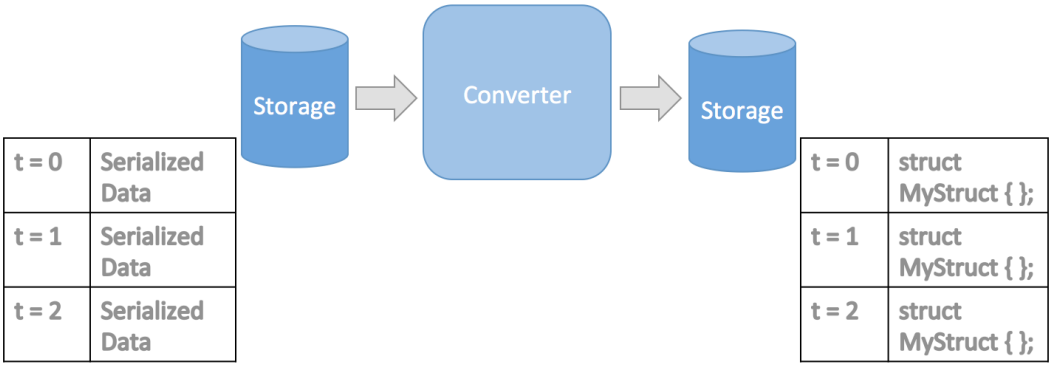

Figure 1.3: *Converter* takes serialized (binary) data and converts it to deserialized JSON data

  - Windows® systems, user without Administrator privileges: `<your home directory>\rti_connext_dds-version`
  - Windows systems, user with Administrator privileges: `C:\Program Files\rti_connext_dds-version`

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

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

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

  Or if you have defined the `NDDSHOME` environment variable: `"%NDDSHOME%\bin\rticlouddiscoveryservice.bat"`

- API Reference HTML documentation: `<NDDSHOME>/doc/api/<product>/api_<language>`
- `<path to examples>` By default, examples are copied into your home directory the first time you run *RTI Launcher* or any script in `<NDDSHOME>/bin`. This document refers to the location of the copied examples as `<path to examples>`.

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

  Default path to the examples:

  - macOS systems: `/Users/your user name/rti_workspace/version/examples`
  - Linux systems: `/home/your user name/rti_workspace/version/examples`
  - Windows systems: `your Windows documents folder\rti_workspace\version\examples`. Where `'your Windows documents folder'` depends on your version of Windows. For example, on Windows 11 systems, the folder is `C:\Users\your user name\Documents`.

Chapter 2

Installation

RTI Recording Service is pre-installed as part of *Connext Professional*. *Recording Service* and *Replay Service* are also available as standalone container-based deployments on RTI's Docker Hub registry.

For details on installing *Connext Professional*, see the RTI Connext Installation Guide.

2.1 Third-party Dependency

To use the *Recording Service* `rtirecordingservice_list_tags` command-line utility, you must install the SQLite3 executable and include it in the `PATH` environment variable. SQLite3 is not included in RTI installers; to download, go to the SQLite download page. To learn more about SQLite3, go to the SQLite CLI page.

Chapter 3

Recording Service

3.1 Usage

This section explains how to run *Recording Service* from a command line. In particular, it describes:

- How to Start *Recording Service* (Section 3.1.1)
- How to Stop *Recording Service* (Section 3.1.2)
- *Recording Service* command-line parameters (Section 3.1.3)

Recording Service can also be deployed as a native library linked into your application on select architectures. For details on using *Recording Service* as a library, see Section 3.6.3.

3.1.1 Starting Recording Service

Recording Service runs as a separate application. The script to run the executable is in `<NDDSHOME>/bin`. (See Section 1.2 for the path to NDDSHOME.)

To start *Recording Service* with a default configuration, enter:

```
rtirecordingservice
```

This command will run *Recording Service* indefinitely until you stop it.

You can run *Recording Service* using the command-line parameters defined below.

Recording Service is pre-loaded with a builtin configuration that has default settings. See Section 3.3.15.

Recording Service is provided for both the *host* platform and, for certain architectures, the *target* platform. By default, *Recording Service* runs for the host platform (located in `resource/app/bin/<host>`). To configure the script to run *Recording Service* for a target platform (located in `resource/app/bin/<target>`), specify the target architecture in either of the following variables:

- The environment variable `CONNEXTDDS_ARCH`.

- The variable `connextdds_architecture` in the file `rticommon_config.[sh/bat]`. (The file is `resource/scripts/rticommon_config.sh` on Linux or macOS systems, `resource/scripts/rticommon_config.bat` on Windows systems.)

These instructions (configuring the script to run *Recording Service* for a target platform) do not apply to embedded systems; for those, see the "Building and Running" section for your platform in the Getting Started Guide Addendum for Embedded Systems. Follow the instructions for loading and running your application. (The `rtirecordingservice` application is already compiled; you do not need to compile it.) Copy `rtirecordingservice` from `/resource/app/bin/<target_architecture>/rtirecordingservice` to your target platform.

3.1.2 Stopping Recording Service

To stop *Recording Service*, press Ctrl-c. *Recording Service* will perform a clean shutdown.

3.1.3 Recording Service Command-Line Parameters

The following table describes all the command-line parameters available in *Recording Service*. To list the available parameters, run `rtirecordingservice -help`.

All command-line parameters are optional; if specified, they override the values of any corresponding settings in the loaded XML configuration. See Section 3.3.2 for the XML elements that can be overridden with command-line parameters.

Table 3.1: *Recording Service* Command-Line Parameters

Parameter	Description
-appName <string>	Application name used to identify this execution for remote administration and to name the *Connext* participant.
-cfgFile <string>	Semicolon-separated list of configuration file paths. **Default:** unspecified
-cfgName	Configuration name used to find a `<recording_service>` matching tag in the configuration file.
-domainIdBase <int>	This value is added to the domain IDs in the `<domain_participant>` tag in the configuration file. For example, if you set -domainIdBase to 50 and use domain IDs 0 and 1 in the configuration file, then *Recording Service* will use domains 50 and 51 for recording (though the recorded data will appear as though it was recorded in domains 0 and 1). **Default:** 0
-D<name>=<value>	Defines a variable that can be used as an alternate replacement for XML environment variables, specified in the form $(VAR_NAME). Note that definitions in the environment take precedence over these definitions.
-help	Shows this help.

continues on next page

Table 3.1 – continued from previous page

Parameter	Description
-heapSnapshotDir	Output directory where the heap monitoring snapshots are dumped. The filename format is: RTI_heap_<appName>_<processId>_<index>.log
-heapSnapshotPeriod <sec>	Period at which heap monitoring snapshots are dumped. Enables heap monitoring if > 0. **Default:** 0 (disabled)
-logFormat <format>	A mask to configure the format of the log messages for both *Recording Service* and *Connext*: • DEFAULT - Print message, method name, log level, activity context, and logging category • TIMESTAMPED - Print message, method name, log level, activity context, logging category, and timestamp • MINIMAL - Print only message number and message location • MAXIMAL - Print all available fields **Default:** DEFAULT
-maxObjectsPerThread <int>	Maximum number of thread-specific objects that can be created. **Default**: Same as the *Connext* default for max_objects_per_thread
-remoteAdministrationDomainId <int>	Enables remote administration and sets the domain ID for communication. **Default**: Remote administration is not enabled.
-remoteMonitoringDomainId <int>	Enables remote monitoring and sets the domain ID for status publication. **Default**: Remote monitoring is not enabled.
-verbosity <service_level>[:<dds_level>]	Controls what type of messages are logged. <service_level> is the verbosity level for the service logs and <dds_level> is the verbosity level for the DDS logs. Both can take any of the following values: • `SILENT` • `ERROR` • `WARN` • `LOCAL` • `REMOTE` • `ALL` **Default:** `ERROR:ERROR`
-version	Prints the program version and exits.

3.1.4 Controlling Recording Service's Operation Mode

Recording Service can operate in different modes, regarding when data are written into disk.

In standard operation mode, *Recording Service* will store samples as they arrive. This is a purely reactive model. This mode is the default mode and is the best mode for scalability. To further improve performance and scalability, standard operation mode can be used in combination with the <thread_pool> settings for Sessions (see Section 3.3.8 for more information). These settings allow you to control the number of worker threads that process the data events, as well as the thread priorities, mask, etc.

Note: The default SQLite storage plugin requires sequential access. Because of this, setting the thread pool **size** to a value greater than **1** has no practical effect on performance when using the built-in SQLite plugin. Increasing the thread pool size only improves performance when using a custom storage plugin that supports concurrent writes.

In flush mode, you can define a flush period (see Section 3.3.6 for more information on how to enable it). When a flush period is defined, *Recording Service* will operate in a periodic fashion. This means that user-data samples will be written to disk only every time the flush period elapses.

The third operation mode is called buffering mode. This mode is controlled by setting the <enable_buffering_mode> in the storage configuration of the service (see Section 3.3.6). Unlike the other modes above, when operating in buffering mode, *Recording Service* will not do any writing to disk automatically. Instead, it will buffer samples in memory and wait for remote administration *flush()* commands to actually write them to disk.

Controlling Buffer Size in Buffering Mode

As mentioned above, there is an operation mode in *Recording Service* called *buffering mode*. This mode will not perform any automatic writing of samples to disk. Instead, this mode will wait for the reception of remote *flush()* commands that you send on demand.

Note: *Recording Service* will still write DDS discovery information automatically, even if buffering mode is enabled. This is done to ensure compatibility with *Replay Service* and *Converter*, by making sure no discovery samples are missing in the database files. *Replay Service* and *Converter* rely on this information to be able to function properly.

In between reception of *flush* commands, *Recording Service* will buffer samples in RAM memory, using the sample caches in its DataReaders. This buffering can lead to situations of unlimited memory growth. To avoid this problem, there are two options:

- Issue remote *flush* commands at a rate that allows Recorder's writing to disk to keep up with the sample read rate. This rate is complex to calculate in many scenarios; if you find that you are sending flushing commands periodically, then it's better to just use the <flush_period> setting and operate in periodic mode.
- Limit the size of the DataReader caches. This will allow the caches to work as a configurable, finite circular buffer with a fixed, immutable, oldest-first replacement policy. The following section explains the QoS properties used to control the DataReader's cache.

Configuring In-Memory Buffer Size

The most important policy to work with is the History QoS policy. There are optional settings that can help improve the performance or that can affect the History QoS. Assuming that the intent is to configure *Recording Service* to keep a buffer of size N, the following table shows the DataReader QoS settings that should be used or are desirable (defined as optional):

Table 3.2: *Recording Service* Buffer Size Control

QoS Policy	Value
`History.kind`	KEEP_LAST
`History.depth`	N
(Optional) `ResourceLimits.max_samples`	N
(Optional) `ResourceLimits.max_instances`	N
(Optional) `ResourceLimits.max_samples_per_instance`	N
(Optional) `ResourceLimits.initial_samples`	N
(Optional) `ResourceLimits.initial_instances`	N

Setting initial samples and instances is optional but recommended for performance because setting these properties will force the DataReader queue to start with a size of N samples directly, avoiding memory allocations during *Recording Service*'s operation.

Another important setting to take into account is `ReaderResourceLimits.max_samples_per_read`. This setting defines the maximum number of samples that a single read or take operation can return in one go. This setting will interact with the size of the buffer when a *flush* remote command is issued. When this setting is smaller than the buffer's size, N, then *Recording Service* will need to generate several writing events, until N is reached or until there are no more samples to read.

See the following sections in the *RTI Connext Core Libraries User's Manual* for more information on these settings:

- History QoS Policy
- Resource Limits QoS Policy
- Reader Resource Limits QoS Policy

3.2 Operating System Daemon

See generic instructions in *How to Run as an Operating System Daemon*.

3.3 Configuration

This section provides a reference for the XML elements that comprise a *Recording Service* configuration. For details on how to provide XML configurations to *Recording Service*. refer to *Configuring RTI Services*. This chapter describes how to compose an XML configuration.

Note: *Recording Service* makes use of XSD files to validate the XML configuration files used to configure *Recording Service*. Due to the restrictions imposed by XSD schemas for XML 1.0, some of the tags used in the

configuration must be grouped in order. This behavior is intended; *Recording Service* validates the XML files before parsing them to catch as many parsing errors as possible beforehand.

3.3.1 Builtin Configuration of Recording Service

Recording Service is pre-configured with a builtin configuration. See Section 3.3.15 for more details.

3.3.2 XML Tags for Configuring Recording Service

This section describes the XML tags you can use in a *Recording Service* configuration file. The following diagram and table describe the top-level tags allowed within the root `<dds>` tag.

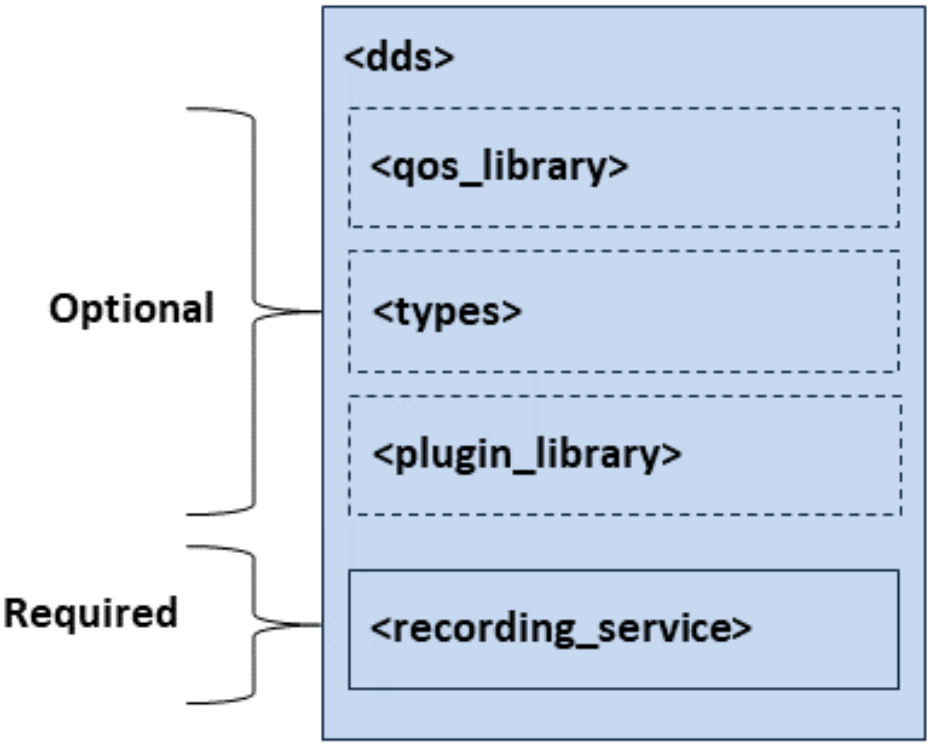

Figure 3.1: Top-level Tags in Recording Service's Configuration File

Table 3.3: Top-level Tags in Recording Service's Configuration File

Tags within <dds>	Description	Multiplicity
<qos_library>	Specifies a QoS library and profiles. The contents of this tag are specified in the same manner as for the *Connext* QoS profile file—see Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.	0..*
<types>	Defines types that can be used by *Recording Service*. This is needed if data types are not available through discovery, or when using a transformation. The type description is done using the *Connext* XML format for type definitions. See Creating User Data Types with Extensible Markup Language (XML) in the *RTI Connext Core Libraries User's Manual*.	0..*
<plugin_library>	Contains a list of libraries that can be used to: • Plug in custom storage, such as custom databases. For more information, see Section 3.6.4. • Transform data after it is received from *Connext* and before it is stored. For more on using transformations, see Data Transformation, in the RTI Routing Service User's Manual. See Section 3.3.12	0..*

<recording_service>	**Required.** Specifies a *Recording Service* configuration. See Section 3.3.3.
	Attributes
	• `name`: Uniquely identifies a service configuration. **Required**.
	Example
	`<recording_service name="RecordAll">`
	`<!-- your service settings ... -->`
	`</recording_service>`
		1..*

3.3.3 Recording Service Tag

A configuration file must have at least one `<recording_service>` tag. This tag is used to configure an execution of *Recording Service*.

A configuration file may contain multiple `<recording_service>` tags. When you start *Recording Service*, you can use the `-cfgName` command-line parameter to specify which `<recording_service>` tag to use to configure the service. This means one file can be used to configure multiple *Recording Service* executions.

The following diagram and Table 3.4 describe the tags allowed within a `<recording_service>` tag.

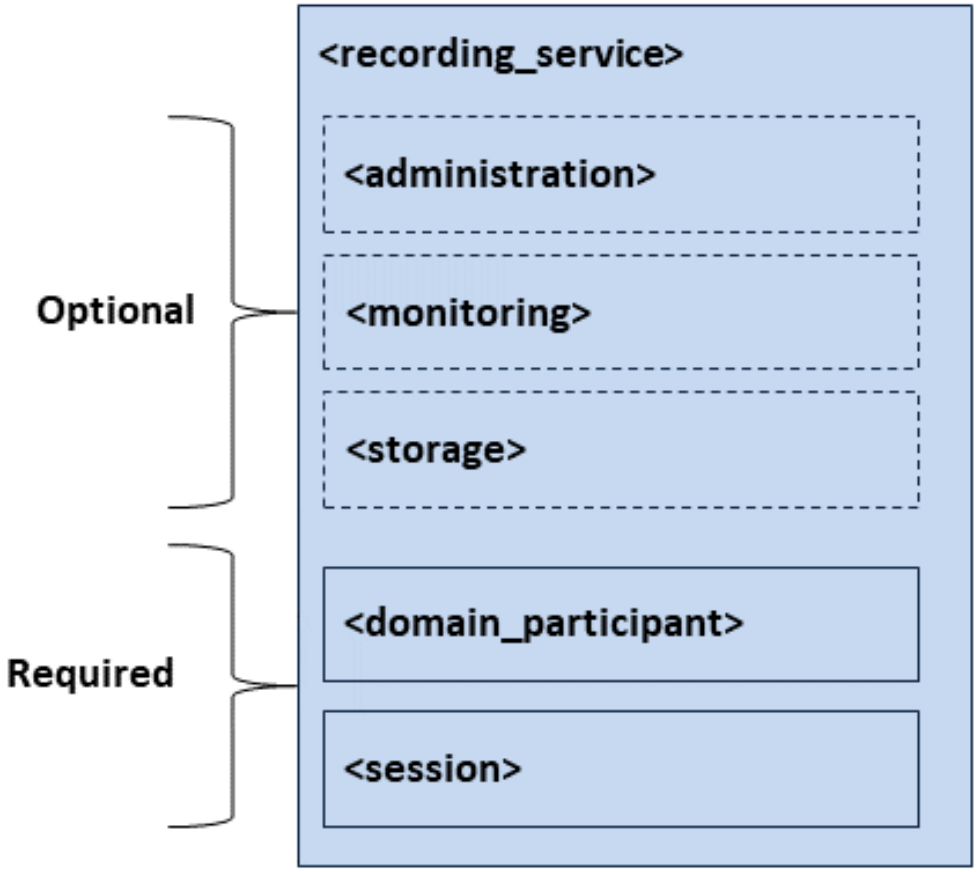

Figure 3.2: Tags used to configure a *Recording Service* instance

Table 3.4: Recording Service Tags in Recording Service's Configuration File

Tags within <recording_service>	Description	Multiplicity
<administration>	Enables remote administration. When administration is enabled, monitoring is also enabled by default. If no domain ID is specified for monitoring, *Recording Service* will use the same domain as administration by default. See Section 3.3.4.	0..1
<monitoring>	Enables monitoring for the recording service, including statistics. See Section 3.3.5.	0..1
<storage>	Describes how the data will be stored. If this is not specified, data will be stored in a SQLite file using the default name "rti_recorder_default.db". See Section 3.3.6.	0..1

<domain_participant>	**Required**. Specifies a DomainParticipant to use to record data.
	Attributes
	• `name`: Uniquely defines a DomainParticipant. **Required**.
	Example
	`<domain_participant name="Participant3">`
	`  <domain_id>3</domain_id>`
	`  <!-- Participant QoS -->`
	`</domain_participant>`
	See Section 3.3.7.
		1..*

<session>	**Required**. Active component of *Recording Service* for recording data. Contains one or more threads that can be used for recording.
	Attributes
	• `name`: Uniquely defines a recording session. **Required**.
	• `default_participant_ref`: Specifies a default DomainParticipant to be used by children of this recording session. Children can override this by specifying their own participant.
	Example
	`<session name="Session" default_participant_ref="Participant3">`
	`  <!-- ... topics / groups of topics to record -->`
	`</session>`
	See Section 3.3.8.
		1..*

Example: Specify a Recording Service Configuration in XML

```
<dds>
    <recording_service name="MyRecorderService">
        <!-- ... Required entities -->
    </recording_service>
</dds>
```

Starting a *Recording Service* instance with the following command will use the `<recording_service>` tag with the name "MyRecorderService":

```
$NDDSHOME/bin/rtirecordingservice -cfgFile file.xml -cfgName MyRecorderService
```

3.3.4 Administration

The `<administration>` tag allows you to enable and configure remote administration of *Recording Service*, including stopping, starting, and pausing recording.

See Section 3.4 for details on using remote administration.

Table 3.5: Administration Tags in Recording Service's Configuration File

Tags within <administration>	Description	Multiplicity
<domain_id>	Domain ID used for remote administration. Also used for monitoring by default.	0..1
<domain_participant_qos>	QoS used by the administration DomainParticipant. If the tag is not defined, *Connext* defaults will be used.	0..1
<publisher_qos>	QoS used by the administration Publisher. If the tag is not defined, *Connext* defaults will be used.	0..1
<subscriber_qos>	QoS used by the administration Subscriber. If the tag is not defined, *Connext* defaults will be used.	0..1
<datawriter_qos>	QoS used by administration DataWriter(s). If the tag is not defined, *Connext* defaults will be used, with the following changes: • history.kind = DDS_KEEP_ALL_HISTORY_QOS • resource_limits.max_samples = 32	0..1
<datareader_qos>	Quality of Service (QoS) used by administration DataReader(s). If the tag is not defined, the *Connext* defaults will be used, with the following changes: • reliability.kind = DDS_RELIABLE_RELIABILITY_QOS (this value cannot be changed) • history.kind = DDS_KEEP_ALL_HISTORY_QOS • resource_limits.max_samples = 32	0..1

continues on next page

Table 3.5 – continued from previous page

Tags within <administration>	Description	Multiplicity
<distributed_logger>	When you enable *Distributed Logger*, *Recording Service* will publish its Log messages to *Connext*. See Section 3.3.13.	0..1

The contents of the tags for configuring QoS are specified in the same manner as for the *Connext* QoS profile file. See Configuring QoS with XML, in the *RTI Connext Core Libraries User's Manual*.

3.3.5 Monitoring

The `<monitoring>` tag allows you to enable and configure remote monitoring of *Recording Service*. See Section 3.5.

Table 3.6: Monitoring Tags in Recording Service's Configuration File

Tags within <monitoring>	Description	Multiplicity
<enabled>	Whether to enable monitoring of the service. Default: Disabled, unless administration is enabled.	0..1
<domain_id>	Domain ID used for monitoring. Default: The domain ID specified for monitoring.	0..1
<datawriter_qos>	QoS used by monitoring DataWriter(s)	0..1
<publisher_qos>	QoS used by monitoring Publisher(s)	0..1
<domain_participant_qos>	QoS used by monitoring DomainParticipant	0..1
<statistics_sampling_period>	How frequently to sample the service's statistics, using the tags <sec> or <nanosec>. For example, <sec>1</sec> samples the service's statistics every second. Default: 1 second.	0..1
<status_publication_period>	How frequently to publish the service status, using the tags <sec> or <nanosec>. For example, <sec>1</sec> publishes the service's status every second. Default: 5 seconds	0..1

The contents of the tags for configuring QoS are specified in the same manner as for the *Connext* QoS profile file. See Configuring QoS with XML, in the *RTI Connext Core Libraries User's Manual*.

3.3.6 Storage

The <storage> tag allows you to configure the storage to which data will be written. You can choose between using the builtin SQLite storage or implementing your own storage plugin. You can also specify the *flush period* of the service, defined as the time interval between consecutive writings of samples to disk. Within <storage>, *Recording Service* can also be set in *buffering mode*. This mode disables all automatic storage to disk and just writes the data to disk upon reception of a remote *flush()* command.

Table 3.7: Storage Tags in Recording Service's Configuration File

Tags within <storage>	Description	Multiplicity
<sqlite>	Enables storing data in a SQLite database file. See Section 3.3.6.	0..1
<plugin>	Enables storing data in an external library that you specify. Attributes • `plugin_name`: Name of the plug-in that creates a storage plugin object. This name shall refer to a registered storage plug-in. See Section 10.5 for details on how the options of how to register plug-ins). See Section 3.3.6 for more about using this tag. See Section 3.6.4 for a tutorial on plugging in custom storage.	0..1
<flush_period>	Defined as a duration (seconds and nanoseconds), <flush_period> represents the rate at which user-data samples will be written to disk. When this tag is present, *Recording Service* will work in a purely periodic fashion. If no remote *flush()* command is received, data will be written to disk only when this period elapses. This tag cannot be used at the same time as the <enable_buffering_mode> tag. Default: no default. If not set, *Recording Service* will work in a purely reactive way.	0..1
<enable_buffering_mode>	When set to true, *Recording Service* will run in buffering mode. This mode is a listening-only mode and will not output data to disk automatically. Instead, *Recording Service* will wait continously for remote *flush()* commands to trigger the storage to disk (see Section 3.4.5 for more information about the remote *flush* command). *Recording Service* will buffer samples using the caches in the DataReaders it creates, so it is important that the size of the caches is controlled so memory doesn't grow indefinitely. The size can be controlled by controlling the size of the queue (see Section 3.1.4) or by ensuring that the rate at which *flush* remote commands are sent matches the sample rate. The general recommendation is to define a buffer size for all Topics and Topic Groups in the configuration. This tag cannot be used at the same time as the <flush_period> tag. This feature *requires* remote administration to be enabled. If remote administration isn't enabled in the configuration, *Recording Service* will enable it automatically. Default: false (service will start in normal operation mode).	0..1
<instance_indexing>	When this setting is enabled, *Recording Service* will keep an internal index about instances and their values. It will also store this instance to disk once *Recording Service* shuts down. This can affect the recording performance. However, *Replay Service* startup time will be improved when the Instance History Replay setting is enabled (see Section 4.3.9). If this setting is not enabled, Replay will build the indexes while starting up, delaying the startup process. Indexing can also be done offline, see Section 8. See Section 3.3.6 for more details on instance indexing configuration.	0..1

SQLite

The <sqlite> tag allows you to specify the name and file extension of a SQLite file in which to write data. It also allows you to choose the storage format in which to store the data. The default format, XCDR_AUTO, records data without deserializing it from the network format, so it is the most efficient way to store data; however, it is a binary format that cannot be queried without using *Converter* to convert it to a readable JSON_SQLITE format. The JSON_SQLITE format is slower to record, because it requires deserializing the data, but it can be queried using SQLite tools.

Table 3.8: SQLite Tags in Recording Service's Configuration File

Tags within <sqlite>	Description	Multiplicity
<fileset>	Set of files to write to, and parameters for creating files and directories in that set. See Section 3.3.6.	0..1
<file>	File to write to. Default: rti_recorder_default	0..1
<file_suffix>	Allows you to add a suffix to the end of a filename.	0..1
<overwrite_policy_kind>	Whether *Recording Service* is allowed to overwrite files. The options are OVERWRITE or DO_NOT_TOUCH. When DO_NOT_TOUCH is selected, *Recording Service* cannot overwrite an existing file, even if the rollover functionality is enabled. Default: OVERWRITE	0..1
<storage_format>	Specifies what format the data is stored in. The options are: • XCDR_AUTO: This is the binary format used by *Connext* when sending data over the network. This has the highest performance for recording, but can only be viewed by using *Converter* to convert the data to a readable format, or by using *Replay* to replay the data. This will internally store data in XCDR or XCDR2 depending on the format received. • JSON_SQLITE: This format can be queried, but recording in this format has lower performance because data must be deserialized before it can be stored. • XCDR: The format to use when communicating with *Connext* before 6.0.0. • XCDR2: More efficient than XCDR, used by *Connext* 6.0.0 and later. Default: XCDR_AUTO	0..1

continues on next page

Table 3.8 – continued from previous page

Tags within <sqlite>	Description	Multiplicity
<sql_initialization_string>	Specifies a SQLite SQL expression to use when establishing sqlite connections using this plugin. This can be used to change the pragmas used by SQLite, or to do other database operations. **Note**: when using *Recording Service* and another application (either *Replay Service* or another SQLite application) at the same time to access the same database files, we recommend using SQLite's WAL (write-ahead logging) mode. This can be done by adding `PRAGMA JOURNAL_MODE = WAL;` to this configuration setting. More information about SQLite's WAL mode can be found here. This scenario is not fully supported. Please be aware that the WAL file will grow without bounds during the replay operation. This implies that the database file will not be updated with the WAL contents until all the Replay instances finish executing. Default: PRAGMA SYNCHRONOUS = OFF; PRAGMA JOURNAL_MODE = MEMORY;	0..1

Fileset

The `<fileset>` tag allows you to specify a set of files for *Recording Service* to write to. This lets you specify behaviors such as "create a new directory with each run of *Recording Service* based on the timestamp when the tool was started" or "create a new file every time *Recording Service* is started, incrementing an integer in the filename."

The `<fileset>` tag is also where the rollover behavior is specified.

Table 3.9: Fileset Tags in Recording Service's Configuration File

Tags within <fileset>	Description	Multiplicity
<workspace_dir>	Base directory where the database files for an instance of *Recording Service* (including discovery and user data files) will be stored. Depending on the value of the <execution_dir_expression> tag, this will either contain a set of files or a set of directories. Default: The current working directory.	0..1

continues on next page

Table 3.9 – continued from previous page

Tags within <fileset>	Description	Multiplicity

<execution_dir_expression>	When *Recording Service* starts, it will use this expression to create the directory where output files will be stored. Every time *Recording Service* starts, it will evaluate this expression to decide on its output directory. Stopping and restarting remotely will cause *Recording Service* to re-evaluate this expression and possibly change its output directory.
	This execution directory is a parameterisable expression. In it, it accepts text and any combination of the following:
	• Autonumeric. **Format: %auto:M-N%.** This parameter describes an integer that auto-increments every time *Recording Service* starts. The numeric sequence is restarted when *Recording Service* is manually shut down and restarted. M must be lower than N; together they define a numeric range, both inclusive. N can be omitted (%auto:M%), resulting in an unlimited sequence of numbers starting at M.
	Example:
	`<execution_dir_expression>`
	`test_run_%auto:0-3%`
	`</execution_dir_expression>`
	This example will create directories named test_run_0, test_run_1, test_run_2, and test_run_3.
	• Timestamp. **Format: %ts%.** This parameter will take the current timestamp in the system (the time represented as number of seconds since Epoch).
	• Time. **Format: %T%.** Current time expressed in ISO 8601 time format (THHMMSS). Example: T145502 This parameter uses the strftime() parameter %T.
	• Short date. **Format: %F%**. Short date in YYYY-MM-DD format. Example: 2001-08-23. This parameter uses the strftime() parameter %F.
	• Date and time. **Format: %c%**. Date and time representation, locale-dependent. This parameter is based on the strftime() parameter %c but we use the time expressed in ISO 8601 format (THHMMSS). Example: Thu Aug 23 T145502 2001
	Note: Using parameters, *Recording Service* will check if the possible execution directories exist before overwriting any directory. If the execution directories exist, *Recording Service's* behavior will be affected by the value of the <overwrite_policy_kind> tag. If <overwrite_policy_kind> is set to OVERWRITE, *Recording Service* will overwrite the first directory. Otherwise, *Recording Service* will not delete any of the old directories and will just exit.
	Using no parameters will yield the same execution directory every time the service is started. In this case, if the directory already contains database files, they may be overwritten (see the <overwrite> tag).
	Default: %ts% (current timestamp number since Epoch).
		0..1

continues on next page

Table 3.9 – continued from previous page

Tags within <fileset>	Description	Multiplicity

<filename_expression>	Once *Recording Service* knows the exact directory in which to put the database files, it will use this parameter to determine the name(s) of the user data file(s) to be created. Right before the recording starts and every time *Recording Service* has to change its current file to a new one, it will use this parameterisable expression to generate the next file's name. This setting accepts text and any combination of the following parameters:
	• Autonumeric. **Format: %auto:M-N%.** This parameter describes an integer that auto-increments every time *Recording Service* is started. However, the numeric sequence is restarted with every execution of the *Recording Service* application. M must be lower than N; together M and N define a numeric range, both inclusive. N may be omitted (%auto:M%), resulting in an unlimited sequence of numbers starting at M.
	Example:
	`<filename_expression>`
	`test_files_%auto:0-2%.db`
	`</filename_expression>`
	This will create files named test_files_0.db, test_files_1.db, and test_files_2.db. When a rollover event occurs, *Recording Service* will either create one of these files, or overwrite the next file in the sequence. When *Recording Service* is restarted, this will start over with overwriting test_files_0.db.
	• Timestamp. **Format: %ts%.** This parameter will take the current timestamp in the system (the time represented as number of seconds since Epoch).
	• Time. **Format: %T%.** Current time expressed in ISO 8601 time format (THHMMSS). Example: T145502. This parameter uses the strftime() parameter %T.
	• Short date. **Format: %F%.** Short date in YYYY-MM-DD format. Example: 2001-08-23. This parameter uses the strftime() parameter %F. **Note:** This parameter will not vary in 24 hours, so use with caution in combination with the rollover time limit feature (time limit should be greater than 1 day; otherwise, you may overwrite the same file continously).
	• Date and time. **Format: %c%.** Date and time representation, locale-dependent. This parameter is based on the strftime() parameter %c but we use the time expressed in ISO 8601 format (THHMMSS). Example: Thu Aug 23 T145502 2001
	Note: Using no parameters will yield the same file name every time. Therefore, if a file rollover command is received or scheduled, *Recording Service* will be stopped (no more data can be stored without overwriting the current, and only, file). Default: rti_recorder_default_%auto:0%.db (auto-numeric starting at zero, unlimited).
		0..1

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Table 3.9 – continued from previous page

Tags within <fileset>	Description	Multiplicity
<rollover>	Configuration for rolling over the file after a size or time limit is reached. See Section 3.3.6.	0..1

Rollover

Rollover enables *Recording Service* to overwrite the oldest data file created by the current execution of the service when the last file in the set has reached a maximum size, or when a time limit is reached.

Note: In this release, rollover is only supported when the <filename_expression> tag specifies an auto-numeric filename. (See example below.)

```
<recording_service name="RolloverExample">
    <storage>
        <sqlite>
            <storage_format>JSON_SQLITE</storage_format>
            <fileset>
                <workspace_dir>cdr_recording</workspace_dir>
                <execution_dir_expression></execution_dir_expression>
                <!-- Files will be numbered 0-9. -->
                <filename_expression>file_rollover_%auto:0-9%.db</filename_
↪expression>
                <rollover>
                    <enabled>true</enabled>
                    <!-- Rollovers have been enabled, but the first one won't␣
↪happen -->
                    <!-- until the local time passes 11:30. After that, they␣
↪will -->
                    <!-- happen when one of two conditions is met first: -->
                    <time_limit start_time="11:30:00">
                        <!-- (1) When five seconds pass since the latest␣
↪rollover -->
                        <seconds>5</seconds>
                    </time_limit>
                    <!-- (2) When the current recording file size reaches␣
↪256KB -->
                    <file_size_limit unit="KILOBYTES">256</file_size_limit>
                </rollover>
            </fileset>
        </sqlite>
    </storage>
</recording_service>
```

Table 3.10: Rollover Tags in Recording Service's Configuration File

Tags within <rollover>	Description	Multiplicity
<enabled>	Whether *Recording Service* will roll over files when a limit is reached. Default: False.	0..1
<file_size_limit>	The maximum allowed size for a file in a set. Note that setting this to a very low value (e.g., 1 KB) may yield unexpected behavior, because SQLite will take up more than that for even the simplest file. **Note:** The unit refers to the decimal prefix and not the binary prefix of the number, meaning 1 MEGABYTES = 1000 KB (and not 1024 KB). This is usually the standard way to refer to storage size. **Attributes:** • unit: (Optional) The unit in which the size is expressed. The following values are allowed (Default: `KILOBYTES`): – `BYTES` – `KILOBYTES` – `MEGABYTES` – `GIGABYTES`	0..1
<time_limit>	The maximum amount of time *Recording Service* can record to a file in a set. Specified with tags <days>, <hours>, <minutes>, <seconds>. **Attributes:** • start_time: The time to do the first rollover. After that, rollover will be done when the time_limit or file_size_limit is reached.	0..1

Plugin

Table 3.11: Storage plugin Tag in the Configuration File

Tags within <plugin>	Description	Multiplicity

<property>	Name/value pairs of properties to pass to a storage plugin.
	Example:
	`<property>`
	`  <value>`
	`  <element>`
	`  <name>Name</name>`
	`  <value>Value</value>`
	`  </element>`
	`  </value>`
	`</property>`
		0 or 1

Instance Indexing

Table 3.12: Instance Indexing Tag in the Configuration File

Tags within <instance_indexing>	Description	Multiplicity
<enabled>	Set this to true to enable instance indexing. It's recommended to enable instance indexing only when *Replay Service* is going to use Instance History Replay mode. You can also perform instance indexing offline, see Section 8. Default: false.	0 or 1
<timestamps>	The type of timestamp (reception, source or both) to use when building the instance history index. The options are: • `RECEPTION`: Create the index based on the time the DDS sample was received by the DataReader. • `SOURCE`: Create the index based on the time the DDS sample was written by the DataWriter. • `BOTH`: Create the index based on both the source timestamp and the reception timestamp. Default: RECEPTION.	0 or 1

3.3.7 DomainParticipant

Table 3.13: DomainParticipant Tags in Recording Service's Configuration File

Tags within <domain_participant>	Description	Multiplicity
<domain_id>	**Required**. DDS domain ID used for recording.	1
<domain_participant_qos>	QoS used by this DomainParticipant. See Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.	0..1s

continues on next page

Table 3.13 – continued from previous page

Tags within <domain_participant>	Description	Multiplicity

<memory_management>	Configures certain aspects of how *Connext* allocates internal memory. The configuration is per DomainParticipant and therefore affects all the contained DDS entities.
	Example:
	`<memory_management>`
	`  <sample_buffer_min_size>`
	`  1024`
	`  </sample_buffer_min_size>`
	`  <sample_buffer_trim_to_size>`
	`  true`
	`  </sample_buffer_trim_to_size>`
	`</memory_management>`
	Tags within this tag:
	• <sample_buffer_min_size>: For all DataWriters and DataReaders, the way *Connext* allocates memory for samples is as follows: *Connext* pre-allocates space for samples up to size X in the DataWriter and DataReader queues. If a sample has an actual size greater than X, the memory is allocated dynamically for that sample. The default size is 64KB. This is the maximum amount of pre-allocated memory. Dynamic memory allocation may occur when necessary if samples require a bigger size.
	• <sample_buffer_trim_to_size>: If set to true, after allocating dynamic memory for very large samples, that memory will be released when possible. If false, that memory will not be released but kept for future samples if needed. The default is false.
	This feature is useful when a data type has a very high maximum size (e.g., megabytes) but most of the samples sent are much smaller than the maximum possible size (e.g., kilobytes). In this case, the memory footprint is reduced dramatically, while still correctly handling the rare cases in which very large samples are published.
		0..1

continues on next page

Table 3.13 – continued from previous page

Tags within <domain_participant>	Description	Multiplicity
<register_type>	Registers a type name and associates it with a type representation. When you define a type in the configuration file, you have to register the type in order to use it in a `<topic>`. **Attributes:** • `name`: Name that the data type is registered with if no <registered_name> is specified. The same data type may be registered with different names. **Required**. • `type_ref`: Definition of this data type. It must refer to one of the defined types in the `<types>` section by specifying the fully qualified name. **Tags within this tag:** • <registered_name>: Name the data type is registered with. The same data type may be registered with different names. Not required.	0..*

3.3.8 Session

The `<session>` tag configures the threads that will be used to record data. You also specify the Topics and groups of Topics to record inside the `<session>` tag.

Table 3.14: Session Tags in Recording Service's Configuration File

Tags within <session>	Description	Multiplicity
<subscriber_qos>	Specifies the QoS of DDS subscribers that will be used by the contained `<topic>` and `<topic_group>`. See Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.	0..1

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Table 3.14 – continued from previous page

Tags within <session>	Description	Multiplicity

<thread_pool>	Defines the number of threads used by this session to process Topics and Topic Groups and allows you to set the mask, priority, and stack size of each thread.
	This setting can improve the reactiveness and scalability of the running *Recording Service* when there are multiple Topics and Topic Groups associated with the same session.
	Note: The default SQLite storage plugin requires sequential access. Because of this, setting the thread pool **size** to a value greater than **1** has no practical effect on performance when using the built-in SQLite plugin. Increasing the thread pool size only improves performance when using a custom storage plugin that supports concurrent writes.
	Example:
	`<thread_pool>`
	`<mask>MASK_DEFAULT</mask>`
	`<priority>THREAD_PRIORITY_DEFAULT</priority>`
	`<stack_size>`
	`THREAD_STACK_SIZE_DEFAULT`
	`</stack_size>`
	`</thread_pool>`
	Default values:
	• **size**: 1
	• **mask**: MASK_DEFAULT
	• **priority**: THREAD_PRIORITY_DEFAULT
	• **stack_size**: THREAD_STACK_SIZE_DEFAULT
		0..1

<topic>	Specifies an individual Topic to record. **Attributes:** • name: The name of the Topic to record. This name is also used when monitoring and administering each Topic. • participant_ref: A DomainParticipant to use when recording this Topic. If the parent `<session>` specifies a default_participant_ref, this attribute is optional. See Section 3.3.10.	0..*

continues on next page

Table 3.14 – continued from previous page

Tags within <session>	Description	Multiplicity
<topic_group>	Specifies a group of Topics to record. **Attributes:** • name: The name of the Topic group. This name is also used when monitoring and administering each Topic group. • participant_ref: Specifies a DomainParticipant to use when recording this topic group. If the parent `<session>` specifies a default_participant_ref, this attribute is optional. See Section 3.3.9.	0..*

3.3.9 Topic Group

You can record a group of Topics, using regular expressions to describe which Topics to record.

Table 3.15: Topic Group Tags in Recording Service's Configuration File

Tags within <topic_group>	Description	Multiplicity

<allow_topic_name_filter>	A regular expression (fnmatch) describing which Topics are allowed to be recorded. You may use a comma-separated list to specify more than one filter.
	Example:
	`<topic_group name="RecordAll">`
	`  <allow_topic_name_filter>CONTROL_*,DATA_*</allow_topic_name_filter>`
	`</topic_group>`
		0..1

<deny_topic_name_filter>	A regular expression (fnmatch) describing which Topics are not allowed to be recorded. This tag is applied after the `allow_topic_name_filter` tag. You may use a comma-separated list to specify more than one filter.	0..1
<allow_type_name_filter>	A regular expression (fnmatch) describing the names of data types that are allowed to be recorded. You may use a comma-separated list to specify more than one filter.	0..1
<deny_type_name_filter>	A regular expression (fnmatch) describing the names of data types that are not allowed to be recorded. This tag is applied after the `allow_type_name_filter` tag. You may use a comma-separated list to specify more than one filter.	0..1
<datareader_qos>	The DataReader's QoS to use when recording data.	0..1

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Table 3.15 – continued from previous page

Tags within <topic_group>	Description	Multiplicity

<content_filter>	A ContentFilteredTopic to use when recording data. See ContentFilteredTopics in the *RTI Connext Core Libraries User's Manual*.
	This allows you to record data samples only if their contents pass a filter that you specify in your configuration. The filter looks like a SQL WHERE clause. Note that XML reserved characters must be converted to their escape values; for example, > and < (greater than and less than signs) must be converted to < and > as shown in the example below.
	Example:
	`<topic_group name="RecordAll">`
	`  <content_filter>`
	`  <!-- Data will only be recorded when x is greater than 100 -->`
	`  <expression>x > 100</expression>`
	`  </content_filter>`
	`</topic_group>`
		0..1

3.3.10 Topic

The `<topic>` tag specifies an individual Topic to record.

Table 3.16: Topic Tags in Recording Service's Configuration File

Tags within <topic>	Description	Multiplicity
<topic_name>	The name of the DDS topic to be recorded. If this tag is not present, the name attribute of the <*topic*> will be used. *Note*: we recommend using this tag to define the topic name. There may be characters that cause the XML validation to fail if they are part of the topic name attribute. Also, the '/' character and '::' separator may cause Recorder to fail when found in the topic name attribute.	0..1
<registered_type_name>	**Required**. The name of the data type that will be recorded for this topic.	1

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Table 3.16 – continued from previous page

Tags within <topic>	Description	Multiplicity

<transformation>	The transformation library to be applied to this Topic's data when recording. This is a user library that can modify the data after it is received by *Connext* and before it is stored in the database. Transformations implement APIs identical to *Routing Service*'s transformations.
	For more on using transformations, see these sections in the *RTI Routing Service User's Manual*:
	• Data Transformation
	• Tutorials
	Attributes:
	• plugin_name: The name of the plugin to load, qualified by the plugin library name.
	Example:
	`<dds>`
	`  <plugin_library name="RecordTransformations">`
	`  <transformation_plugin name="ModifyTestID">`
	`  <create_function>ModifyTestID_create</create_function>`
	`  <dll>modify_test_id_library</dll>`
	`  </transformation_plugin>`
	`  </plugin_library>`
	`  <!-- ... -->`
	`  <recording_service>`
	`  <!-- ... -->`
	`  <topic name="TestTopic">`
	`  <transformation plugin_name="RecordTransformations::ModifyTestID" />`
	`  </topic>`
	`  </recording_service>`
	`</dds>`
		0..1

<datareader_qos>	The DataReader QoS to use when recording this data.	0..1

<content_filter>	A ContentFilteredTopic to use when recording data. See ContentFilteredTopics, in the *RTI Connext Core Libraries User's Manual*.
	Example of how to set a content filter expression:
	`<topic_group name="RecordAll">`
	`  <content_filter>`
	`  <!-- Data will only be recorded when x is greater than 100 -->`
	`  <expression>x > 100</expression>`
	`  </content_filter>`
	`</topic_group>`
		0..1

3.3.11 Support for RTI FlatData and Zero Copy Transfer Over Shared Memory

Recording Service supports communication with applications that use RTI FlatData™ and Zero Copy transfer over shared memory. You can configure *Recording Service* to enable these capabilities for data reception, *while actively recording*.

> **Warning:** *Recording Service* cannot replay data recorded with RTI FlatData™ and Zero Copy. For further information about this constraint, see the Support for RTI FlatData and Zero Copy Transfer Over Shared Memory section in the *RTI Routing Service User's Manual*.

Recording Service can work with RTI FlatData and Zero Copy transfer over shared memory for discovered types and types declared in the XML configuration. If the types are declared in XML, they must be properly annotated and then registered in each *DomainParticipant*. You can use each of these features separately or together.

For further information about these features, see Sending Large Data in the *RTI Connext Core Libraries User's Manual*.

Example: Configuration to enable both FlatData and Zero Copy transfer over shared memory

```
<dds>
    <types>
        <struct name="Point"
                transferMode="shmem_ref"
                languageBinding="flat_data"
                extensibility= "final">
            <member name="x" type="long"/>
            <member name="y" type="long"/>
        </struct>
    </types>

    <qos_library name="MyQosLib">
        <qos_profile name="ShmemOnly">
            <domain_participant_qos>
                <discovery>
                    <initial_peers>
                        <element>shmem://</element>
                    </initial_peers>
                </discovery>
                <transport_builtin>
                    <mask>SHMEM</mask>
                </transport_builtin>
            </domain_participant_qos>
        </qos_profile>
    </qos_library>

    <recording_service name="FlatDataWithZeroCopy">
```

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```
        <domain_participant name="RecordDomain">
            <domain_id>0</domain_id>
            <domain_participant_qos base_name="MyQosLib::ShmemOnly"/>
            <register_type name="Point" type_ref="Point"/>
        </domain_participant>

        <session default_participant_ref="RecordDomain">
            <topic name="PointTopic">
                <registered_type_name>Point</registered_type_name>
            </topic>
        </session>
    </recording_service>

</dds>
```

3.3.12 Plugins

All the pluggable components specific to *Recording Service* are configured within the `<plugin_library>` tag. Table 3.17 describes the available tags.

Plug-ins are categorized and configured based on the source language. *Recording Service* supports C/C++ plug-ins.

Table 3.17: Configuration tags for plug-in libraries

Tags within <plugin_library>	Description	Multiplicity
<storage_plugin>	Specifies a C/C++ *Storage* plug-in. See Table 10.18 and Section 3.3.6.	0..*
<transformation_plugin>	Specifies a C/C++ *Transformation* plug-in. See Table 10.18 and Section 3.3.10.	0..*

3.3.13 Enabling Distributed Logger

Distributed Logger is included in *Connext*, but it is not supported on all platforms; see the RTI Connext Core Libraries Platform Notes to see which platforms support *Distributed Logger*.

When you enable *Distributed Logger*, the Service will publish its log messages to *Connext*. Then you can use *RTI Admin Console* to visualize the log message data. Since the data is provided in a topic, you can also use *rtiddsspy* or even write your own visualization tool.

To enable *Distributed Logger*, use the tag `<distributed_logger>` within `<adminstration>`. For example:

```
<recording_service name="RecordAll">
      <administration>
            ...
```

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```
            <distributed_logger>
                <enabled>true</enabled>
            </distributed_logger>
        </administration>
        ...
</recording_service>
```

For more details, see Enabling Distributed Logger in RTI Services in the *RTI Connext Core Libraries User's Manual*.

3.3.14 Support for Security Plugins (RTI Security Plugins)

Recording Service supports configuring and using Security Plugins. To configure *Recording Service* securely, you need to configure the appropriate QoS settings in the XML configuration. For more information, see the RTI Security Plugins User's Manual.

Example: Configuring a Recorder Instance using Security

The following example in XML demonstrates how to configure *Recording Service* to load and use the Security Plugins. The example assumes a path where the user has created the necessary security artifacts (such as permissions files, certificates, and certificate authorities). This path is represented by the `SECURITY_ARTIFACTS_PATH` environment variable.

Note: The `SECURITY_ARTIFACTS_PATH` environment variable must include the `file:` prefix to make sure paths are properly loaded by the Security Plugins.

```
<dds>
    <qos_library name="SecureQosLibrary">
        <qos_profile name="SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>com.rti.serv.load_plugin</name>
                            <value>com.rti.serv.secure</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.library</name>
                            <value>nddssecurity</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.create_function</name>
                            <value>RTI_Security_PluginSuite_create</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_ca</name>
```

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```
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_certificate</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01RecordingServiceCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.private_key</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01RecordingServiceKey.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.governance</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪Governance.p7s</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪PermissionsA.p7s</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
    </qos_library>

    ...

    <recording_service name="SecuredRecorderService">
        <!--  Top-level storage settings -->
        <storage>
            <sqlite>
                <file>rti_recorder_secure</file>
                <file_suffix>dat</file_suffix>
                <storage_format>XCDR_AUTO</storage_format>
            </sqlite>
        </storage>

        <!--  Top-level domain settings -->
        <domain_participant name="Participant0">
            <!-- Domain Participant in Domain 0 is secured -->
            <domain_id>0</domain_id>
                <domain_participant_qos base_name=
↪"SecureQosLibrary::SecureParticipantQos" />
```

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```
            </participant>
        </domain_participant>

        <session name="DefaultSession">
            <topic_group name="RecordAll" participant_ref="Participant0">
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
            </topic_group>
        </session>
    </recording_service>

</dds>
```

The above XML example configures a *Topic Group* that records all data (except RTI topics) from a secured *DomainParticipant*. The security settings are encapsulated in a QoS Profile called SecureParticipantQos. When secured data reaches the secured endpoint, the *Recording Service* instance performs all security operations that will be incorporated in the cleartext sample moving into storage. In the current version of the default storage plugins, storage is unsecure.

Example: Configuring Recording Service to use a Certificate Revocation List (CRL)

Recording Service can remove a *DomainParticipant* from the system when its certificate has been revoked. Use Security Plugins to specify a CRL (certificate revocation list) file to track via the `authentication.crl` property; when the `files_poll_interval` property is configured in Security Plugins, *Recording Service* can banish revoked participants by checking the CRL file periodically. For more information, see Properties for Configuring Authentication in the *RTI Security Plugins User's Manual*. The following example XML configuration file uses a CRL file to enable *Recording Service* to remove participants with revoked certificates.

```
<dds>
    <qos_library name="SecureQosLibrary">
        <qos_profile name="SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>com.rti.serv.load_plugin</name>
                            <value>com.rti.serv.secure</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.library</name>
                            <value>nddssecurity</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.create_function</name>
                            <value>RTI_Security_PluginSuite_create</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
```

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```
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_certificate</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01RecordingServiceCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.private_key</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01RecordingServiceKey.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.governance</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪Governance.p7s</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪PermissionsA.p7s</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
        <qos_profile name="SecureParticipantQosWithCrl" base_name=
↪"SecureQosLibrary::SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>dds.sec.auth.crl</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/
↪RecordingServiceRevoked.crl</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.files_poll_interval</
↪name>
                            <value>1</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
    </qos_library>
```

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```
    ...

    <recording_service name="SecuredRecorderServiceWithCrl">
        <!--  Top-level storage settings -->
        <storage>
            <sqlite>
                <file>rti_recorder_secure</file>
                <file_suffix>dat</file_suffix>
                <storage_format>XCDR_AUTO</storage_format>
            </sqlite>
        </storage>

        <!--  Top-level domain settings -->
        <domain_participant name="Participant0">
            <!-- Domain Participant in Domain 0 is secured and tracks a CRL␣
↪file -->
            <domain_id>0</domain_id>
                <domain_participant_qos base_name=
↪"SecureQosLibrary::SecureParticipantQosWithCrl" />
            </participant>
        </domain_participant>

        <session name="DefaultSession">
            <topic_group name="RecordAll" participant_ref="Participant0">
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
            </topic_group>
        </session>
    </recording_service>

</dds>
```

The above configuration in *Recording Service* reads the CRL file `$SECURITY_ARTIFACTS_PATH/RecordingServiceRevoked.crl`. In addition, the `files_poll_interval` element instructs the service to track the file for changes so that participants can be removed dynamically. In this example, the polling of the file happens every 1s.

Note: If the poll period is zero, *Recording Service* will not track the file continuously.

Example: Configuring Recording Service for Dynamic Certificate Renewal

Recording Service can dynamically renew its certificate if it was revoked or it expired. Use SECURITY PLUGINS to specify a periodic check of the certificate file; when the `files_poll_interval` property is configured in SECURITY PLUGINS, *Recording Service* reloads the certificate if the certificate file changes. For more information, see Properties for Configuring Authentication in the *RTI Security Plugins User's Manual*.

The following example XML configuration file defines a 1s period for checking the certificate file for changes.

```
<dds>
    <qos_library name="SecureQosLibrary">
        <qos_profile name="SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>com.rti.serv.load_plugin</name>
                            <value>com.rti.serv.secure</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.library</name>
                            <value>nddssecurity</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.create_function</name>
                            <value>RTI_Security_PluginSuite_create</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_certificate</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01RecordingServiceCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.private_key</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01RecordingServiceKey.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.governance</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪Governance.p7s</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪PermissionsA.p7s</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
```

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```
        <qos_profile name="SecureParticipantQosDynamicCert" base_name=
↪"SecureQosLibrary::SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>com.rti.serv.secure.files_poll_interval</
↪name>
                            <value>1</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
    </qos_library>

    ...

    <recording_service name="SecuredRecorderServiceDynamicCert">
        <!--  Top-level storage settings -->
        <storage>
            <sqlite>
                <file>rti_recorder_secure</file>
                <file_suffix>dat</file_suffix>
                <storage_format>XCDR_AUTO</storage_format>
            </sqlite>
        </storage>

        <!--  Top-level domain settings -->
        <domain_participant name="Participant0">
            <!-- Domain Participant in Domain 0 is secured and tracks a CRL␣
↪file -->
            <domain_id>0</domain_id>
                <domain_participant_qos base_name=
↪"SecureQosLibrary::SecureParticipantQosDynamicCert" />
            </participant>
        </domain_participant>

        <session name="DefaultSession">
            <topic_group name="RecordAll" participant_ref="Participant0">
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
            </topic_group>
        </session>
    </recording_service>

</dds>
```

The above configuration in *Recording Service* checks the *DomainParticipant* certificate file `$SECURITY_ARTIFACTS_PATH/ecdsa01/identities/ecdsa01RecordingServiceCert.pem` for changes every 1s.

Note: If the poll period is zero, *Recording Service* will not track the file continuously.

3.3.15 Recording Service Builtin Configuration Details

The *Recording Service* builtin configuration specifies:

- Recording all non-RTI Topics
- In domain 0
- Into a SQLite file named rti_recorder_default.db
- In the efficient XCDR format

```
<?xml version="1.0" encoding="UTF-8"?>

<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:noNamespaceSchemaLocation="../schema/rti_recording_service.xsd">

    <!-- Qos Library -->
    <qos_library name="QosLib">
        <qos_profile name="ReliableQos" >
            <datareader_qos>
                <reliability>
                    <kind>RELIABLE_RELIABILITY_QOS</kind>
                </reliability>
                <history>
                    <kind>KEEP_ALL_HISTORY_QOS</kind>
                </history>
            </datareader_qos>
        </qos_profile>
    </qos_library>

    <recording_service name="RecorderService">
        <!--  Top-level storage settings -->
        <storage>
            <sqlite>
                <file>rti_recorder_default</file>
                <file_suffix>dat</file_suffix>
                <storage_format>XCDR_AUTO</storage_format>
            </sqlite>
        </storage>

        <!--  Top-level domain settings -->
        <domain_participant name="Participant0">
            <domain_id>0</domain_id>
        </domain_participant>

        <session name="DefaultSession">
            <topic_group name="RecordAll" participant_ref="Participant0">
```

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```
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
                <datareader_qos base_name="QosLib::ReliableQos" />
            </topic_group>
        </session>
    </recording_service>

</dds>
```

3.4 Remote Administration

A control client (such as *RTI Admin Console*) can use this interface to remotely control *Recording Service*.

Note: *Recording Service* remote administration is based on the *RTI Remote Administration Platform* described in Section 10.3. Please refer to that manual for a detailed discussion on the workings of remote administration in *Recording Service*.

Below you will find an API reference for all the supported operations.

3.4.1 Enabling Remote Administration

By default, remote administration is disabled in *Recording Service*.

To enable remote administration you can use the `<administration>` XML tag (see Section 3.3.4) or the `-remoteAdministrationDomainId` command-line parameter (see Section 3.1.3). Both of these methods enable remote administration and set the domain ID for remote communication.

3.4.2 Available Service Resources

Table 3.18 lists the public resources specific to *Recording Service*. Each resource identifier is expressed as a hierarchical sequence of identifiers, including parent and target resources. (See Section 10.2.2 for details.)

In the table below, the elements `(rs)`, and `(st)` refer to the name of an entity of the corresponding class as specified in the configuration in the `name` attribute. For example, in the following configuration:

```
<recording_service name="MyRecorder">...</recording_service>
```

The resource identifier is:

```
/recording_services/MyRecorder
```

In the table below, the resource identifier is written as /recording_services/(rs), where (rs) is the service name. (st) is the storage name, and so on. This nomenclature is used in the table to give you an idea of the structure of the resource identifiers. For actual (example) resource identifier names, see the example section that follows.

Table 3.18: Resources and Their Identifiers in *Recording Service*

Resource	Resource Identifier
Recording Service	/recording_services/(rs)
Storage	/recording_services/(rs)/storage/(st)

Example

This example shows you how to address a resource of each possible resource class in *Recording Service*.

Recording Service

Entity with name "MyRecorder":

```
<recording_service name="MyRecorder">...</recording_service>
```

Resource identifier:

```
/recording_services/MyRecorder
```

Storage

Entity with name "sqlite" (implicit name of the builtin storage):

```
<recording_service name="MyRecorder">
    <sqlite>...</sqlite>
</recording_service>
```

Resource identifier:

```
/recording_services/MyRecorder/storage/sqlite
```

3.4.3 Remote API Overview

Table 3.19: Remote Interface Overview

Resource	Operation	Description
RecordingService	*DELETE /recording_services/(rs)*	Shuts down a running *Recording Service* instance.
RecordingService	*UPDATE /recording_services/(rs):flush*	Flushes all buffered data in memory into disk.
	UPDATE /recording_services/(rs)/state	Sets a *Recording Service* state.
builtin SQLite *Storage*	*UPDATE /recording_services/(rs)/storage/sqlite:rollover*	Continues the current recording in a new file (also known as a "shard" or file segment). Note: Only valid for builtin SQLite plugin.
	UPDATE /recording_services/(rs)/storage/sqlite:tag_timestamp	Associates a symbolic name with the current time (with an optional offset) in the recording. Note: Only valid for builtin SQLite plugin.

3.4.4 Recording Service

`DELETE /recording_services/(rs)`

Operation `shutdown`

This operation will cause *Recording Service* to shutdown.

`UPDATE /recording_services/(rs):flush`

Operation `flush`

This operation will cause Recording Service to flush contents of all topics and topic groups into permanent storage. This operation can be used with any of Recording Service's modes of operation, but is crucial when running in buffering mode, because it's the only way to flush buffered samples into permanent storage.

This operation will store a total of N samples into storage, N being the depth of the History QoS policy. If there are fewer samples in the buffer, this operation will store all of them.

This operation will affect the whole service, meaning that all Topics and Topic Groups will be affected by it.

Request Field	Value
`action`	UPDATE
`resource_identifier`	/recording_services/MyRecorder:flush

Request body

- Empty.

`UPDATE /recording_services/(rs)/state`

Operation `set_state`

Sets the state of a *Recording Service* object. The action is parametrized on octet_body, which could have the following values:

See *Set Resource State* (Section 10.3.3).

Valid requested states:

- `STARTED`
- `STOPPED`
- `PAUSED`
- `RUNNING`

- Example

  To pause an instance of *Recording Service* with the name "MyRecorder":

Request Field	Value
`action`	UPDATE
`resource_identifier`	/recording_services/MyRecorder/state
`octet_body`	`to_cdr_buffer(RTI::Service::EntityStateKind::PAUSED)`

3.4.5 Storage

`UPDATE /recording_services/(rs)/storage/sqlite:rollover`

Operation `rollover`

If the storage plugin being used is the builtin SQLite plugin, this operation will cause the recording to switch to a new file segment (also known as a "shard") in the fileset.

Request Field	Value
`action`	UPDATE
`resource_identifier`	/recording_services/MyRecorder/storage/sqlite:rollover

Request body

- Empty.

UPDATE /recording_services/(rs)/storage/sqlite:tag_timestamp

Operation `tag_timestamp`

If the storage plugin being used is the builtin SQLite plugin, this operation will introduce a new entry in the symbolic timestamps table, using the tag name, textual description, and offset time specified in the arguments to the operation (CDR-serialized in the octet-body with the `RTI::RecordingService::DataTagParams` data type). The `timestamp_offset` field represents an offset in **seconds** from the moment the command is received. If the offset is negative, the tag will be associated with a moment in the past. For example, an offset of 20.3 represents a time ~20.3 seconds in the future, while an offset of -10.1 represents a time ~10.1 seconds in the past.

- Example

  To tag a moment with the name "/example/test1/tag1", representing a moment that is 123 seconds in the past:

Request Field	Value
`action`	UPDATE
`resource_identifier`	/recording_services/MyRecorder/storage/sqlite:tag_timestamp
`octet_body`	

```
std::string tag_name_1("/example/test1/tag1");
std::string tag_description_1("start of test");
RTI::RecordingService::DataTagParams data_tag_arguments;
data_tag_arguments.tag_name(tag_name_1);
data_tag_arguments.tag_description(tag_description_1);
data_tag_arguments.timestamp_offset(-123);
std::vector<char> data_tag_arguments_buffer;

dds::topic::topic_type_support<RTI::RecordingService::DataTagParams>
    ::to_cdr_buffer(
        data_tag_arguments_buffer,
        data_tag_arguments);
```

3.5 Monitoring

This section provides documentation on *Recording Service* remote monitoring.

Note: *Recording Service* monitoring is based on the *Monitoring Distribution Platform* described in Section 10.4. We recommend that you read Section 10.4 before using *Recording Service* monitoring.

3.5.1 Overview

Enabling Service Monitoring

By default, monitoring is disabled in *Recording Service*. To enable monitoring you can use the `<monitoring>` tag (see Section 3.3.3) or the `-remoteMonitoringDomainId` command-line parameter, which enables remote monitoring and sets the domain ID for data publication (see Section 3.1.3).

Monitoring Types

The available *Keyed Resource* classes and their types that can be present in the distribution monitoring topics are listed in Table 3.20. The complete type relationship is shown in Figure 3.3.

Table 3.20: *Recording Service Keyed Resources*

Keyed Resource Class	Config	Event	Periodic
Service	`ServiceConfig`	`ServiceEvent`	`ServicePeriodic`
Session	`SessionConfig`	`SessionEvent`	`SessionPeriodic`
TopicGroup	`TopicGroupConfig`	`TopicGroupEvent`	`TopicGroupPeriodic`
Topic	`TopicConfig`	`TopicEvent`	`TopicPeriodic`

All the type definitions for *Recording Service* monitoring information are in `[NDDSHOME]/resource/idl/ServiceCommon.idl` and `[NDDSHOME]/resource/idl/RecordingServiceMonitoring.idl`.

Recording Service creates a *DataWriter* for each distribution *Topic*. All *DataWriters* are created from a single *Publisher*, which is created from a dedicated *DomainParticipant*. See Section 3.3.3 for details on configuring the QoS for these entities.

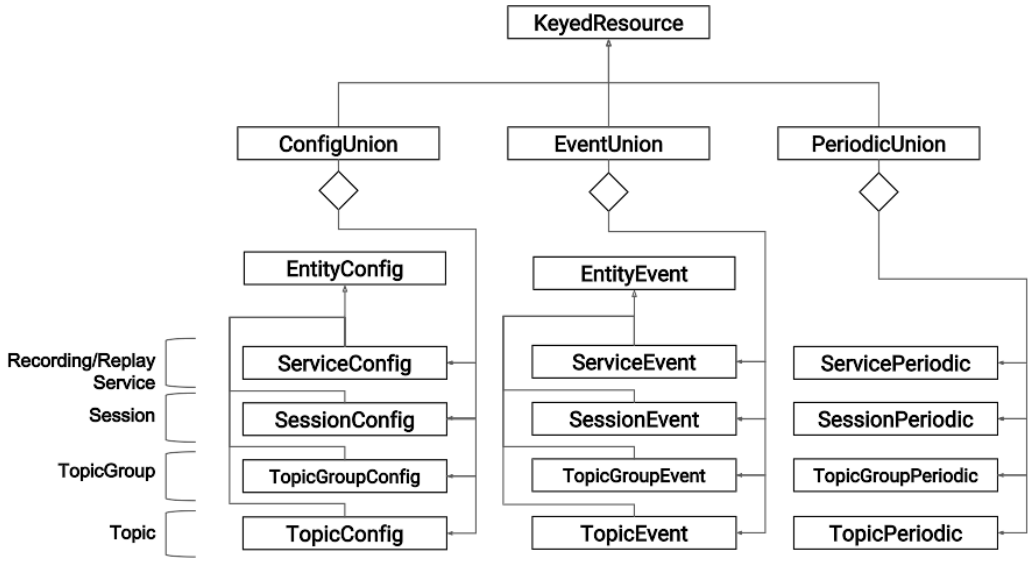

Figure 3.3: Keyed Resource Types for *Recording Service* monitoring

3.5.2 Monitoring Metrics Reference

This section provides a reference to all the monitoring metrics *Recording Service* distributes, organized by service resource class.

Service

Listing 3.1: *Recording Service* Types

```
@mutable @nested
struct SqliteDatabaseConfig {
    Service::FilePath db_directory;
    @optional Service::FilePath execution_directory_expression;
    @optional Service::FilePath user_data_file_expression;
};
@mutable @nested
struct SqliteDatabaseEvent {
    @optional Service::FilePath current_db_directory;
    @optional Service::FilePath current_file;
    @optional int32 rollover_count;
};
@mutable @nested
struct SqliteDatabasePeriodic {
    @optional Service::FilePath current_file;
```

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```
                @optional uint64 current_file_size;
                // These fields are no longer supported and carry no␣
↪information.
                // Kept only to support older version.
                @deprecated int32 current_timestamp_sec;
                @deprecated uint32 current_timestamp_nanosec;
            };

            @mutable @nested
            struct ParticipantInfo {
                Service::BoundedString name;
            };

            @mutable @nested
            struct ServiceConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString application_name;
                Service::Monitoring::ResourceGuid application_guid;
                @optional Service::Monitoring::HostConfig host;
                @optional Service::Monitoring::ProcessConfig process;
                @optional SqliteDatabaseConfig builtin_sqlite;
                @optional sequence<ParticipantInfo> participants;
            };
            @mutable @nested
            struct ServiceEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                @optional SqliteDatabaseEvent builtin_sqlite;
            };
            @mutable @nested
            struct ServicePeriodic {
                @optional Service::Monitoring::HostPeriodic host;
                @optional Service::Monitoring::ProcessPeriodic process;
                int64 current_timestamp_nanos;
                @optional SqliteDatabasePeriodic builtin_sqlite;
            };
```

Table 3.21: `ServiceConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
application_name	Name of the *Recording Service* instance. The application name is provided through: • `appName` command-line option when run as executable. • `ServiceProperty::application_name` field when run as a library.
application_guid	GUID of the *Recording Service* instance. Unique across all service instances.
host	See Table 10.10.
process	See Table 10.12.
builtin_sqlite	See Table 3.22
participants	Sequence of `ParticipantInfo` objects, one for each *DomainParticipant* inside the *Recording Service*. See Table 3.23.

Table 3.22: `SqliteDatabaseConfig`

Field Name	Description
db_directory	Path to the base directory where the database files will live. This is the prefix directory, and still the execution directory expression below will be appended to it to determine the final directory.
execution_directory_expression	The expression used to generate the directory where the database files live. Note: this value is not set when running *Replay Service*. See Section 3.3.6
user_data_file_expression	The expression used to generate the names of the database files. Note: this value is not set when running *Replay Service*. See Section 3.3.6

Table 3.23: `ParticipantInfo`

Field Name	Description
name	Name of the *DomainParticipant* instance, as specified in the `name` attribute of the corresponding configuration tag.

Table 3.24: `ServiceEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.
builtin_sqlite	See Table 3.25

Table 3.25: `SqliteDatabaseEvent`

Field Name	Description
current_db_directory	Path to the current directory where files are being stored to. This is the actual final directory once the base directory and any execution directory expressions have been applied.
current_file	Path to the current file where data is being stored to. Note: this value is not set when running *Replay Service*.
rollover_count	The total number of file rollover events that have happened to this moment. Note: this value is not set when running *Replay Service*.

Table 3.26: `ServicePeriodic`

Field Name	Description
host	See Table 10.11.
process	See Table 10.13.
current_timestamp_nanos	Time in nanoseconds *Recording Service* has been running.
builtin_sqlite	See Table 3.27

Table 3.27: `SqliteDatabasePeriodic`

Field Name	Description
current_file_size	The size in bytes of the current file where data is being stored. Note: this value is not set when running *Replay Service*.

Session

Listing 3.2: *Session* Types

```
            @mutable @nested
            struct SessionConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString default_participant_name;
            };
            @mutable @nested
            struct SessionEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                int32 _dummy;
            };
            @mutable @nested
            struct SessionPeriodic {
                @optional Service::Monitoring::NetworkPerformance network_
↪performance;
                @optional @optional Service::Monitoring::ThreadPoolPeriodic␣
↪thread_pool;
            };
```

Table 3.28: `SessionConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
default_participant_name	The name of the default participant configuration.

Table 3.29: `SessionEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.

Table 3.30: `SessionPeriodic`

Field Name	Description
network_performance	Provides network performance metric as an aggregation of the same metric across the contained *Topics* and *TopicGroups*. See Section 10.4.4.

TopicGroup

Listing 3.3: *TopicGroup* Types

```
            @mutable @nested
            struct TopicGroupConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString participant_name;
            };
            @mutable @nested
            struct TopicGroupEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                int32 _dummy;
            };
            @mutable @nested
            struct TopicGroupPeriodic {
                @optional Service::Monitoring::NetworkPerformance network_
↪performance;
                int64 topic_count;
            };
```

Table 3.31: `TopicGroupConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
participant_name	Name of the *DomainParticipant* from which the *Topic* is created.

Table 3.32: `TopicGroupEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.

Table 3.33: `TopicGroupPeriodic`

Field Name	Description
network_performance	Provides network performance metric as an aggregation of the same metric across the contained *Topics*. See Section 10.4.4.
topic_count	Current number of *Topics* created from this *TopicGroup*.

Topic

Listing 3.4: *Topic* Types

```
            @mutable @nested
            struct TopicConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString topic_name;
                Service::BoundedString registered_type_name;
                Service::BoundedString participant_name;
                Service::Monitoring::ResourceGuid topic_group;
            };
            @mutable @nested
            struct TopicEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                int32 _dummy;
            };
            @mutable @nested
            struct TopicPeriodic {
                @optional Service::Monitoring::NetworkPerformance network_
↪performance;
                @optional Service::Monitoring::CountStatus matched_status;
            };
```

Table 3.34: `TopicConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
topic_name	Topic name as specified in the configuration.
registered_type_name	Topic registered type name as specified in the configuration.
paritcipant_name	Name of the *DomainParticipant* from which the *Topic* is created.
topic_group	GUID of the *TopicGroup* from which this *Topic* was created. This field is set to zero for standalone *Topics*.

Table 3.35: `TopicEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.

Table 3.36: `TopicPeriodic`

Field Name	Description
network_performance	Provides network performance metric as an aggregation of the same metric across the contained *Topics*. See Section 10.4.4.
matched_status	Provides information about the matched endpoints associated with this *Topic*.

3.6 Tutorials

3.6.1 Getting Started with Recording Service and Shapes Demo

In this tutorial, you will edit a *Recording Service* configuration file to record only specific topics. Then you will start the *Shapes Demo* application and publish multiple topics. You will then inspect the database to see that only the specified topics were recorded.

Edit the Configuration

The first time you run any RTI tools, an `rti_workspace` directory is created in your home directory. (See Section 1.2 for the path to your workspace).

Inside the workspace, you will find a directory called `user_config/recording_service`. Open the `USER_RECORDING_SERVICE.xml` file in an editor. Notice that there are two `<recording_service>` tags in this file, one named **UserRecorderService** and one named **UserRecorderServiceJson**. The **UserRecorderServiceJson** configuration is shown below.

```
<recording_service name="UserRecorderServiceJson">
    <!--  Top-level storage settings -->
    <storage>
        <sqlite>
            <storage_format>JSON_SQLITE</storage_format>
            <fileset>
                <workspace_dir></workspace_dir>
                <execution_dir_expression>json_recording</execution_dir_
↪expression>
                <filename_expression>rti_recorder_default_json.db</filename_
↪expression>
            </fileset>
        </sqlite>
```

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```
    </storage>

    <!--  Top-level domain settings -->
    <domain_participant name="Participant0">
        <domain_id>0</domain_id>
    </domain_participant>

    <session name="DefaultSession">
        <topic_group name="RecordAll" participant_ref="Participant0">
            <allow_topic_name_filter>*</allow_topic_name_filter>
            <deny_topic_name_filter>rti/*</deny_topic_name_filter>
        </topic_group>
    </session>
</recording_service>
```

This configuration is recording all topics in domain 0 into a database file named `rti_recorder_default_json.db`. It is recording in deserialized (JSON_SQLITE) mode. In the configuration, change the value in `<allow_topic_name_filter>` from `*` to `Square`. Now it will record only the Square topic.

```
<recording_service name="UserRecorderServiceJson">
    <!--  Top-level storage settings -->
    <storage>
        <sqlite>
            <storage_format>JSON_SQLITE</storage_format>
            <fileset>
                <workspace_dir></workspace_dir>
                <execution_dir_expression>json_recording</execution_dir_
↪expression>
                <filename_expression>rti_recorder_default_json.db</filename_
↪expression>
            </fileset>
        </sqlite>
    </storage>

    <!--  Top-level domain settings -->
    <domain_participant name="Participant0">
        <domain_id>0</domain_id>
    </domain_participant>

    <session name="DefaultSession">
        <topic_group name="RecordAll" participant_ref="Participant0">
            <allow_topic_name_filter>Square</allow_topic_name_filter>
            <deny_topic_name_filter>rti/*</deny_topic_name_filter>
        </topic_group>
    </session>
</recording_service>
```

Start Shapes Demo

Use *Launcher* to start *Shapes Demo*.

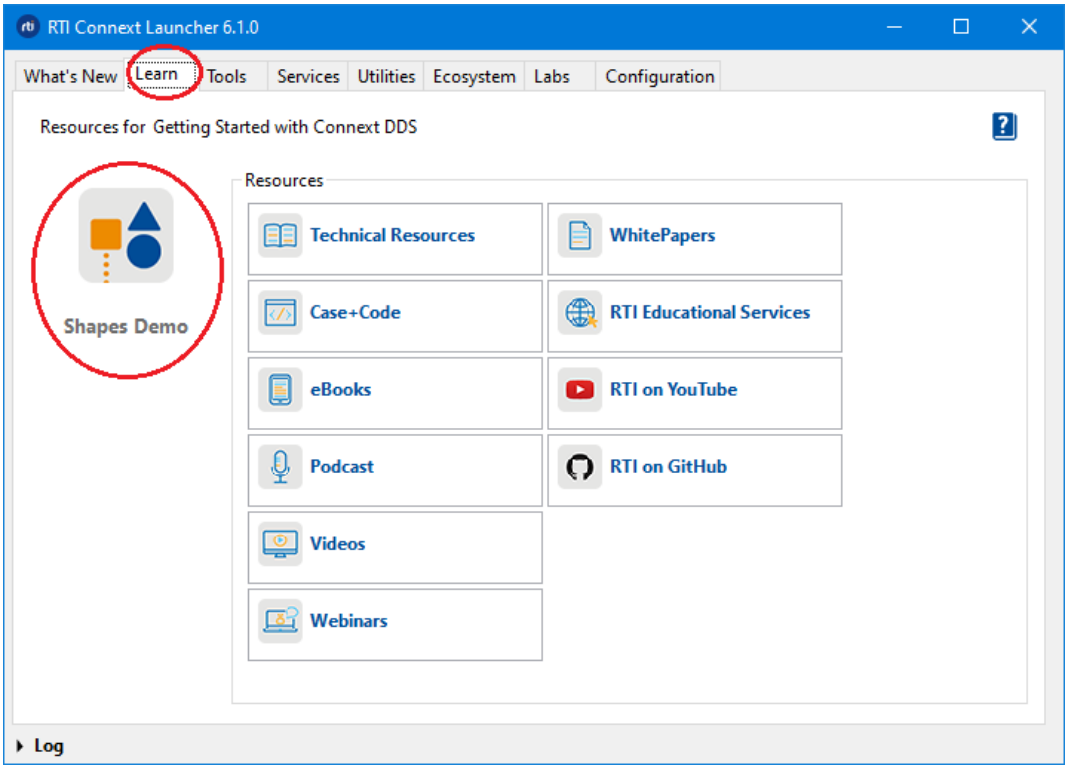

Figure 3.4: Open Shapes Demo from Launcher

In *Shapes Demo*, start two publishers: one Square publisher and one Circle publisher.

Start Recording Service

Start *Recording Service* with the **UserRecorderServiceJson** configuration and with verbosity level 3 by entering the following in a command shell:

```
cd <RTI_WORKSPACE>/user_config/recording_service
<NDDSHOME>/bin/rtirecordingservice -cfgName UserRecorderServiceJson -
↪verbosity 3
```

See Section 1.2 for the path to your workspace and NDDSHOME.

You should see output indicating that the Square topic is being recorded:

```
[/recording_services/UserRecorderServiceJson/domain_participants/
↪Participant0|STREAM_DISCOVERED name=Square|../../sessions/DefaultSession/
↪topics/RecordAll@Square|CREATE]
[/recording_services/UserRecorderServiceJson/domain_participants/
↪Participant0|STREAM_DISCOVERED name=Square|../../sessions/DefaultSession/
```

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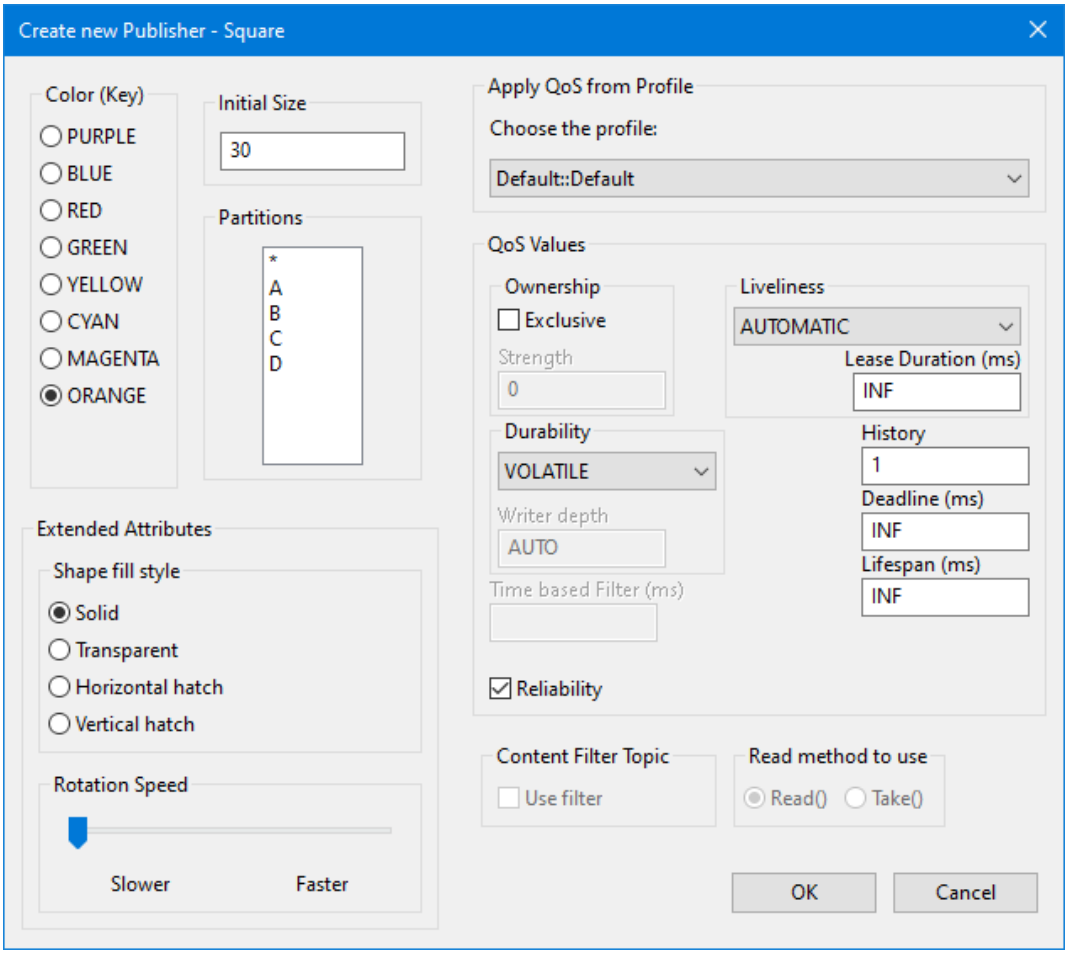

Figure 3.5: Create a new publisher in Shapes Demo

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```
↪topics/RecordAll@Square|ENABLE]
RTI Recording Service started
[/recording_services/UserRecorderServiceJson/sessions/DefaultSession/topics/
↪RecordAll@Square|START]
[/recording_services/UserRecorderServiceJson/sessions/DefaultSession/topics/
↪RecordAll@Square|RUN]
```

View the Data in Sqlite3

First, download the sqlite3 command-line browser from the SQLite download page. (If you are using a Linux or macOS system, you may already have this installed.)

Then open a command prompt and run the application:

```
sqlite3 json_recording/rti_recorder_default_json.db
```

Type the command `.tables` and you should see recorded data for topic Square:

```
sqlite> .tables
Square@0
```

Then you can view your recorded Square data by typing:

```
sqlite> select rti_json_sample from "Square@0";

{"color":"ORANGE","x":120,"y":195,"shapesize":30,"fillKind":"SOLID_FILL",
↪"angle":0}
{"color":"ORANGE","x":120,"y":197,"shapesize":30,"fillKind":"SOLID_FILL",
↪"angle":0}
{"color":"ORANGE","x":120,"y":199,"shapesize":30,"fillKind":"SOLID_FILL",
↪"angle":0}
{"color":"ORANGE","x":120,"y":201,"shapesize":30,"fillKind":"SOLID_FILL",
↪"angle":0}
```

3.6.2 Using Recording Service and Admin Console

You can use *RTI Admin Console* to monitor, pause and resume *Recording Service*.

Configuration

To use *Recording Service* with *Admin Console*, make sure that administration is enabled in the configuration. For example:

```
<recording_service name="AdminExample">
    <administration>
        <domain_id>0</domain_id>
```

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```
    </administration>
    ...
</recording_service>
```

Note that enabling administration will also enable monitoring in the same domain by default. *Admin Console* cannot control the *Recording Service* instance unless monitoring is enabled.

Start Recording Service

Admin Console cannot start a new instance of *Recording Service*. It can only monitor and administer a instance of *Recording Service* that is already running.

To begin, start *Recording Service* with administration enabled:

```
<NDDSHOME>/bin/rtirecordingservice -cfgName AdminExample
```

Start Shapes Demo

Start *Shapes Demo* and publish Squares and Circles as described in Section 3.6.1.

Viewing with Admin Console

Use *Launcher* to start *Admin Console* (from the Tools tab).

You will see the Recording Service appear in *Admin Console's* Physical View and Processes View. Click on the Recording Service in either view and a Recording Service tab will appear.

The first tab, **RTI Recording Service Entities**, shows your Recording Service, the session(s) it is running, the topics and topic groups it is configured to record, and which topics are being recorded.

Note that topics that are being recorded as part of a topic_group will appear side-by-side with topics that were configured individually. You can tell they are part of a topic_group because the name of the topic_group will appear along with the topic, such as `RecordAll@Square`.

The second tab, **RTI Recording Service Configuration**, displays the configuration that was used to configure the running Recording Service instance.

The third tab, **Graphical view**, displays the system in a graph. This allows you to visualize the entire system. You can see the DDS Entities that were discovered by Admin Console, including how they are connected and their matching endpoints.

The fourth tab, **DDS Entities**, displays the DDS entities that have been created by the Recording Service. If you click on individual DataReaders, you can view their QoS in the DDS QoS view.

The fifth tab, **RTI Recording Service Information**, shows details about the recording, such as:

- The *Connext* version number
- The name of the database file it is recording (if you are using the builtin SQLite storage)

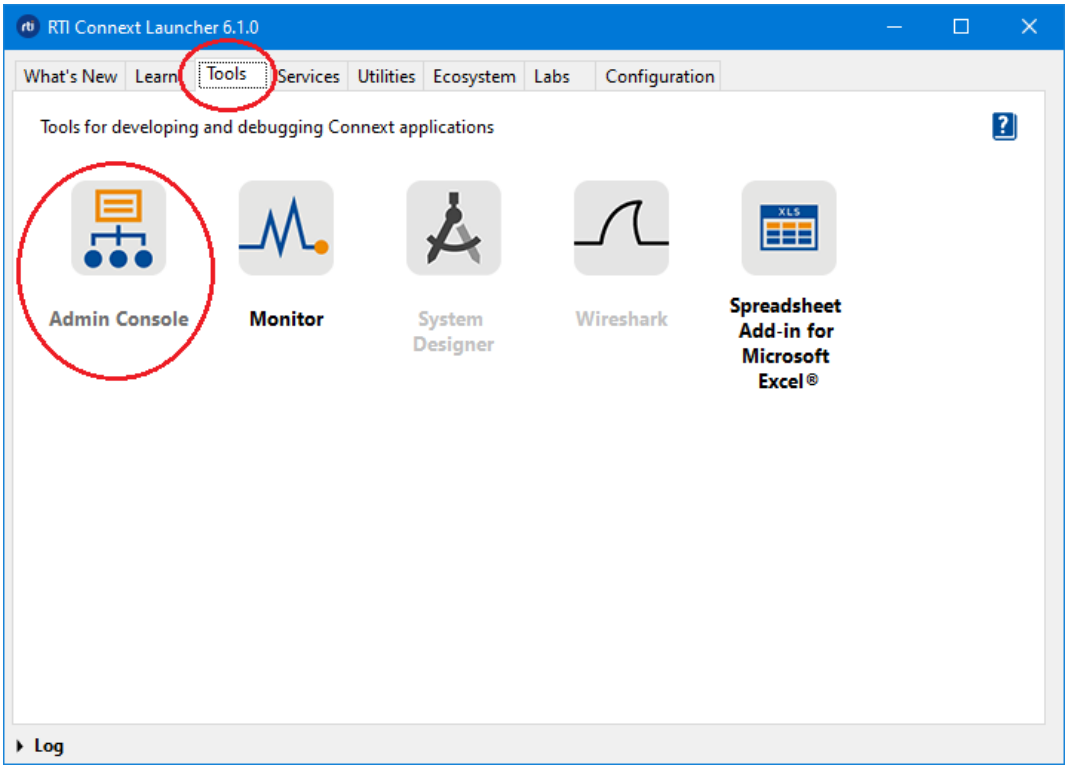

Figure 3.6: Open Admin Console from Launcher

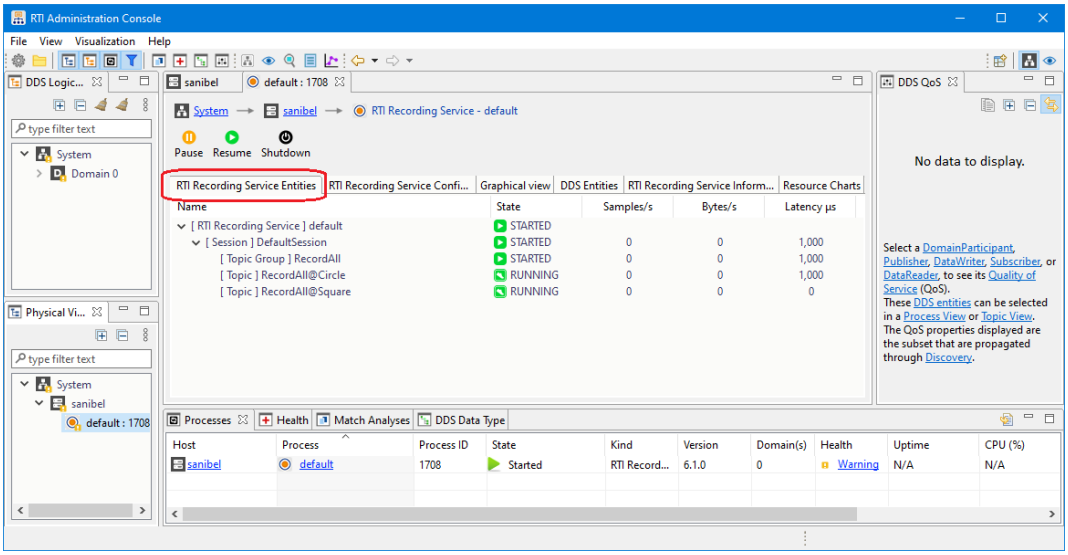

Figure 3.7: View the Recording Service information in Admin Console

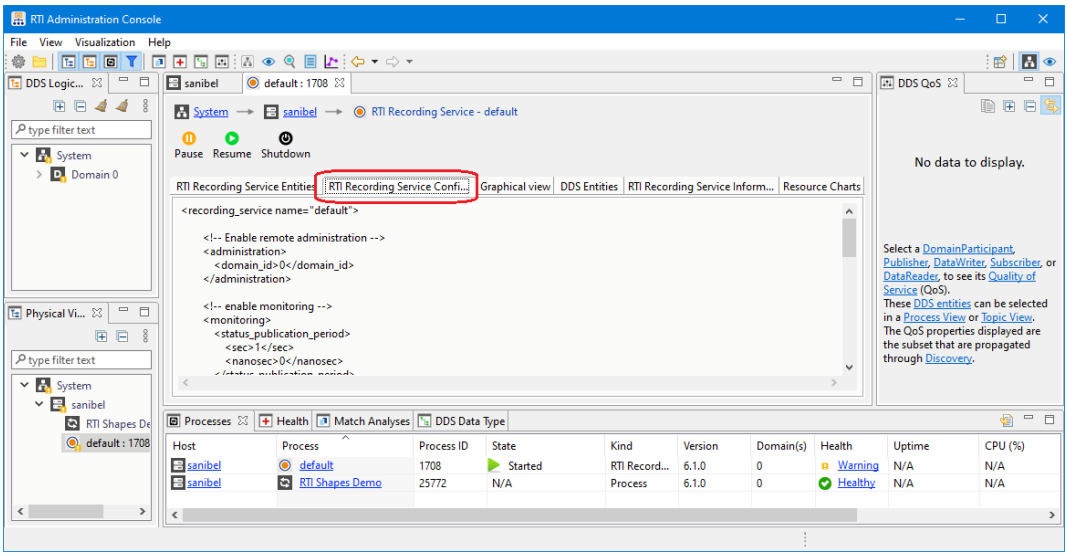

Figure 3.8: View the Recording Service Configuration tab in Admin Console

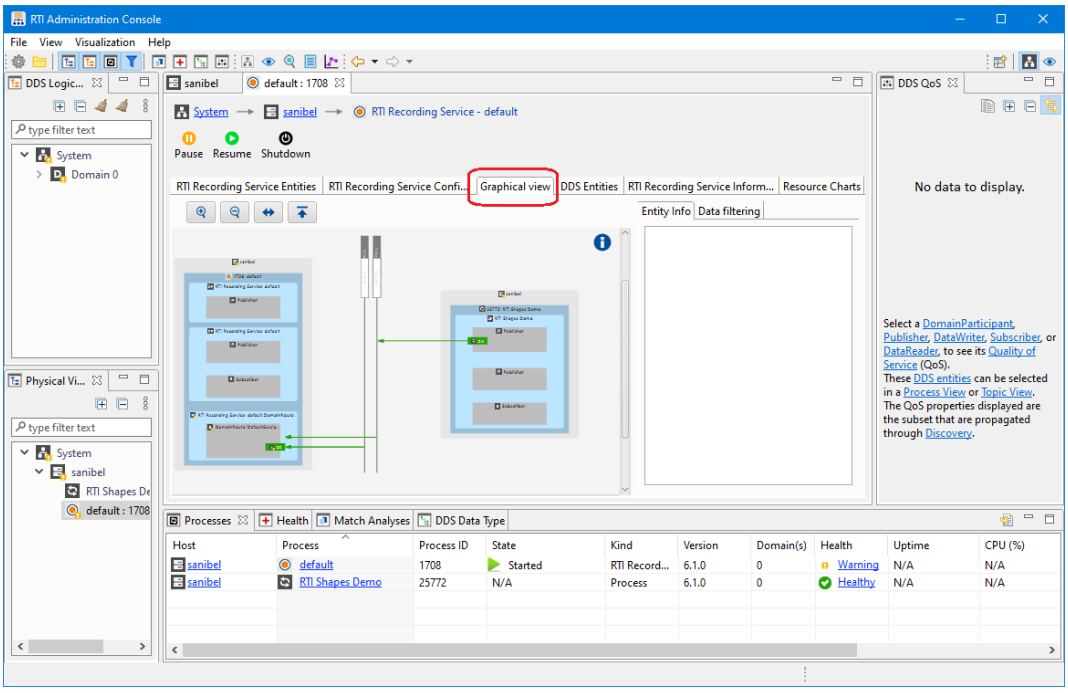

Figure 3.9: View the Graphical View tab in Admin Console

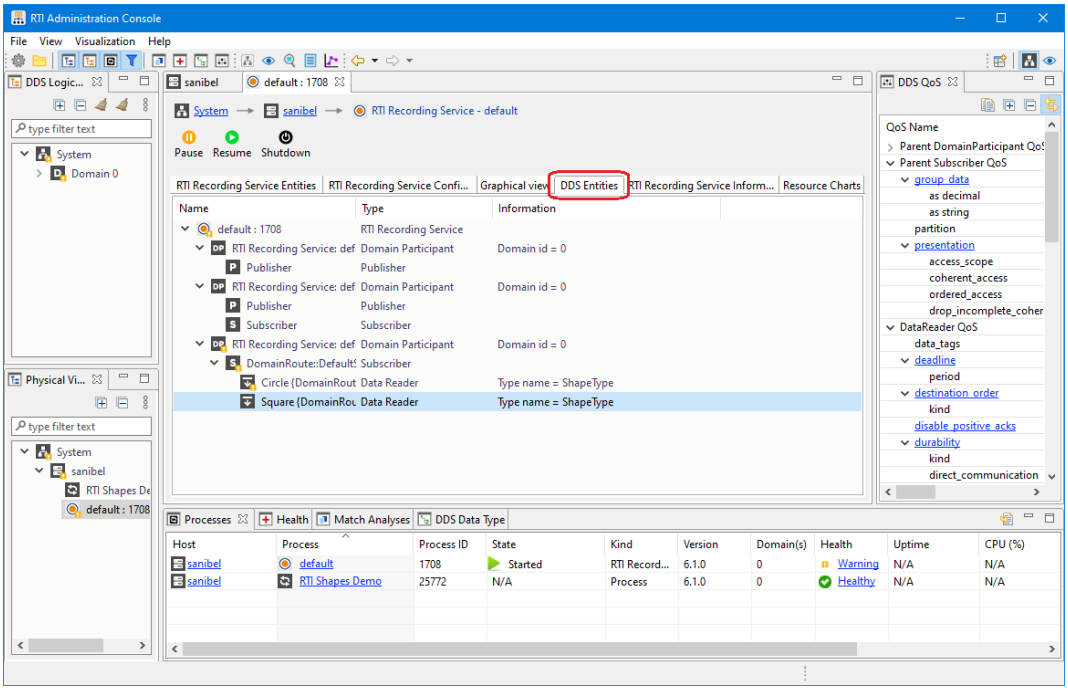

Figure 3.10: View the DDS Entities tab in Admin Console

- The current size of the database file you are recording (if you are using the builtin SQLite storage)

The final tab, **Resource Charts**, allows you to monitor *Recording Service's* CPU and memory usage.

Administering with Admin Console

***Recording Service* allows the following commands:**

- Pause: This pauses all the topics in a running service.
- Resume: This restarts the sessions and topics in a *Recording Service* application.
- Shut down: This shuts down the *Recording Service* application. To restart the application, you must re-run from *Launcher* or the command line.

3.6.3 Using Recording Service as a Library

It is possible to use *Recording Service* as a library in your application. All the necessary tools are included in the library `rtirecordingservice` (`librtirecordingservicecore.so` on Linux systems, `librtirecordingservice.dylib` on macOS systems, and `rtirecordingservice.dll` on Windows systems). The library can be used in any of the modes provided by *Recording Service*: recording data, replaying data or converting data. For more information, see: Recording Service C++ API.

A simple C++ example of how to link the Recording Service library into your application is available here: RTI Community Recording Service examples: Service as a Library.

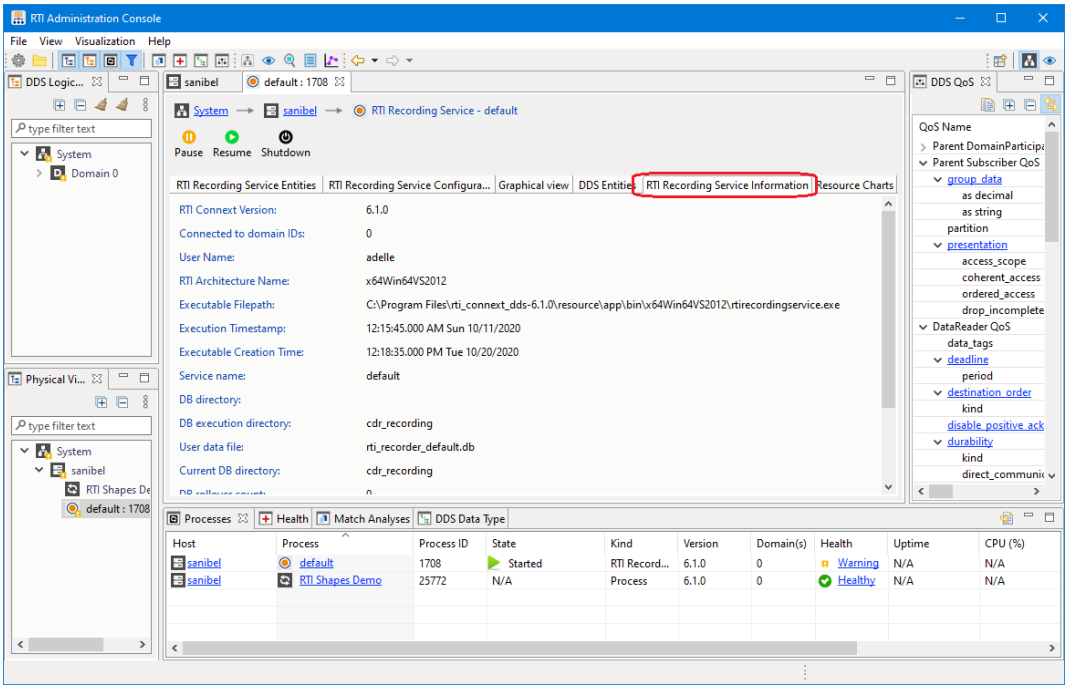

Figure 3.11: View the Recording Service Information tab in Admin Console

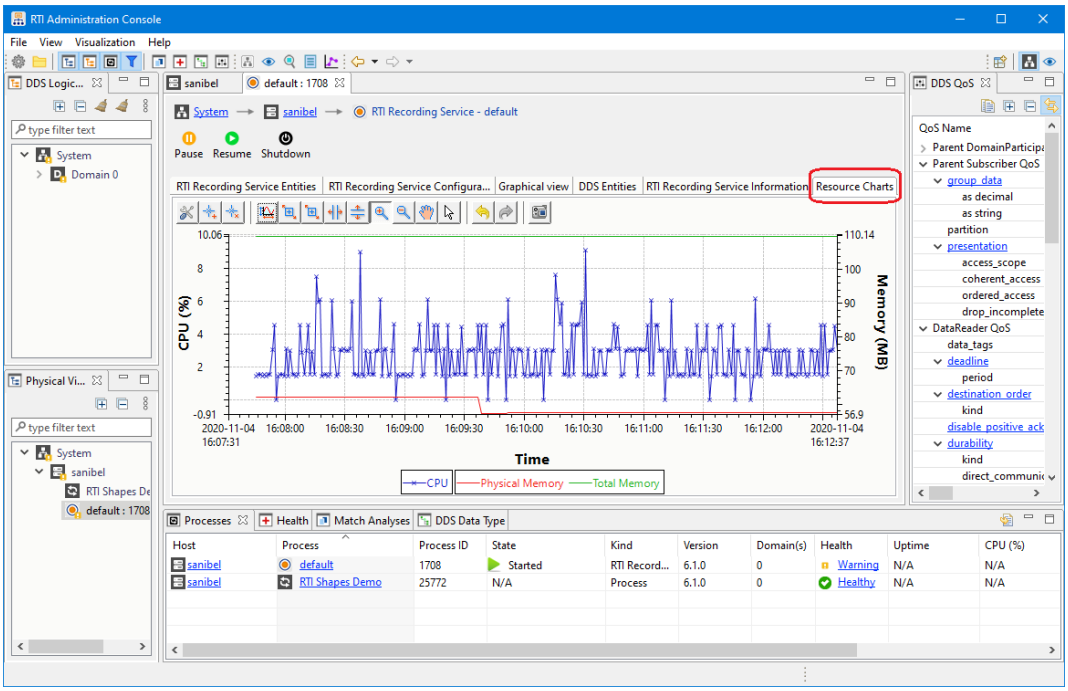

Figure 3.12: View the Resource Charts tab in Admin Console

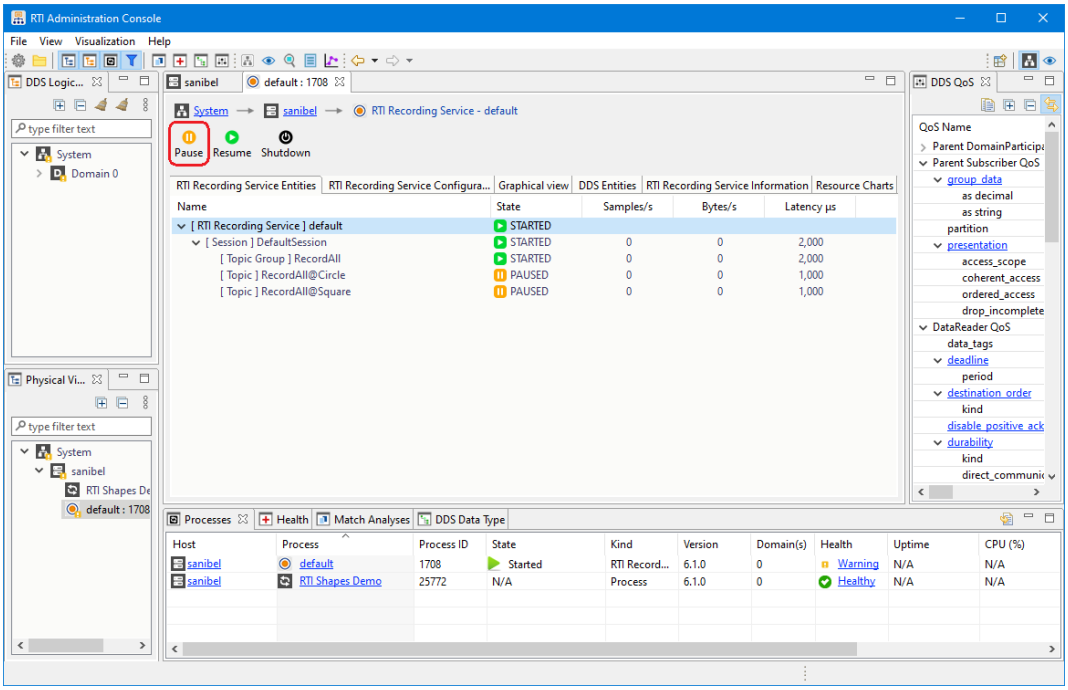

Figure 3.13: Pause the Recording Service in Admin Console

Include files

When using *Recording Service* as a library, you should include the following header in your application code:

```
#include <rti/recording/RecordingService.hpp>
```

Using the RecordingService class

The main class used to instantiate *Recording Service* as a library is called `RecordingService`. To instantiate it, you need to define the properties to be used by the service for its configuration. The class used to define these properties is called `ServiceProperty`. Among the parameters that can be set to control the service's execution, you can find:

- Application role: record, replay or convert.
- Configuration control: configuration file as well as configuration name (service name).
- Remote administration control: flag to enable or disable it as well as the domain ID to use.
- Monitoring control: flag to enable or disable it as well as the domain ID to use.
- DDS Domain ID control: the domain ID base parameter allows the user to apply an offset to the domain IDs specified in the XML configuration to be loaded.
- XML control: whether to load the default Connext XML files or not or whether to enforce XSD validation of the supplied configuration file.

The following code snippet shows how to launch a *Recording Service* instance in record mode. This instance will use an XML configuration called `MyRecorderConfig` that can be found in file `my_recording_service.xml`. Administration and monitoring will be enabled and attached to domain ID 5. By using the domain ID base as well, all the domain IDs specified in the aforementioned XML configuration will be offset by 6.

```
using namespace rti::recording;

// ...

ServiceProperty service_property;
service_property.application_role(ApplicationRoleKind::RECORD_APPLICATION).
        enable_administration(true).
        administration_domain_id(5).
        enable_monitoring(true).
        monitoring_domain_id(5).
        domain_id_base(6).
        cfg_file("my_recording_service.xml").
        service_name("MyRecorderConfig");
RecordingService recorder(service_property);
recorder.start();

// ...

// When it's time to stop the Recording Service instance, call the method
// below. The ``stop()`` method will also be called automatically by the
// RecordingService class destructor, so it will be called when the
// instance goes out of scope.
recorder.stop();
```

3.6.4 Plugging in Custom Storage

To configure a custom storage library, you must add the `<plugin_library>` tag inside the `<dds>` tag. This allows you to define one or more storage libraries that can be used to plug in custom storage.

In addition, you must associate the storage library with your *Recording Service* instance by specifying the plugin and its name in the `<storage>` tag.

You can pass custom properties to your plugin inside the `<plugin>` tag.

There are full examples written in C and C++ about plugging in custom storage in *Recording Service*, in: RTI Community Recording Service examples: C storage plugin and RTI Community Recording Service examples: C++ storage plugin.

Custom Storage API Overview

To store data, you must implement the following APIs:

- RecordingServiceStorageWriter create function: A creation function for the StorageWriter structure or class. This allocates a StorageWriter object, which is used to allocate StorageStreamWriters.
- **StorageWriter:**
  - A function for creating StorageStreamWriters for user-data topics when *Recording Service* notifies the plugin about a new stream. The user-data streams represent samples as Dynamic Data objects.
  - Three functions for creating StorageStreamWriters for the builtin discovery topics: `DCPSParticipant`, `DCPSPublication` and `DCPSSubscription`. These topics are represented by their specific types (e.g., `DDS_ParticipantBuiltinTopicData` type for `DCPSParticipant`). These functions are not required, thus when one of them is not implemented, no samples will be stored for that builtin topic.
  - A function for deleting user-data StorageStreamWriters. *Recording Service* expects this function to be able to work with streams writers created for user-data samples only.
  - Three functions to delete the StorageStreamWriters representing the DDS builtin topics. These functions are not required, but if the creation function was defined for a topic, the deletion function must also be defined.
  - A function for deleting the StorageWriter instance.
- **StorageStreamWriter:**
  - A function for storing data associated with a stream. For the stored data to be compatible with *Replay Service*, the reception timestamp of every sample should be stored with the data. It is also recommended that the valid data flag is recorded. For *Replay Service* to be able to replay instance states, it's also necessary for *Recording Service* to store the instance state and instance handle fields.
  - There are three specific classes for the three different builtin discovery topics: `StorageParticipantWriter`, `StoragePublicationWriter` and `StorageSubscriptionWriter`. Each of them includes a `store()` function that is strongly typed to the topic's type.

The C++ APIs provide a mechanism to have strongly typed `StorageStreamWriter` classes. There are four specific builtin `StorageStreamWriter` definitions to work with the different types of streams:

- A definition based on `dds::core::xtypes::DynamicData`, which should be used to store samples for user-data topics.
- A definition based on `dds::topic::ParticipantBuiltinTopicData`, which can be used to store samples of the builtin DDS discovery stream `DCPSParticipant`.
- A definition based on `dds::topic::PublicationBuiltinTopicData`, which can be used to store samples of the builtin DDS discovery stream `DCPSPublication`.
- A definition based on `dds::topic::SubscriptionBuiltinTopicData`, which can be used to store samples of the builtin DDS discovery stream `DCPSSubscription`.

More detailed API documentation is here:

- Recording Service C API documentation
- Recording Service C++ API documentation

3.6.5 Accessing JSON samples through SQL

When using the builtin SQLite JSON storage format, data samples are stored in the column called `rti_json_sample` using SQLite's JSON extensions. The sample can thus be accessed using these extensions, namely, the `json_extract()` function.

As an example, suppose we have the following IDL type:

```
struct BasicStruct {
    double member1;
    string member2;
};
```

We could access the sample's data with a SQL query like this:

```
SELECT json_extract(rti_json_sample, '$.member2') FROM [MyTableName]
WHERE json_extract(rti_json_sample, '$.member1') > 2.0
```

3.6.6 Controlling Recording Service Remotely from an Application

Apart from the ability to use *Admin Console* to control a *Recording Service* instance, it is possible to control it using an application that issues command requests programmatically, using the Remote Administration Platform.

There is a C++ example in the RTI Community that provides an application that can produce command requests for *Recording Service* (or in general, for any RTI service that uses the common Remote Administration Platform): RTI Community Examples: C++ Service Administration.

3.6.7 Listing the Timestamp Tags in a Recording

If you are using the builtin SQLite plugin in *Recording Service*, and remote administration is enabled, then the remote administration exposes a command that allows you to *tag* timestamps with a symbolic name and description. These *timestamp tags* allow you to associate points in time in the recording with external events. The tags can be used later with *Replay Service* or *Converter* in place of timestamps to select what data to replay or convert.

The use case for timestamp tags is that they allow you to record, in a human-readable way, the time at which interesting events occur in your business processes along with the database that *Recording Service* is recording into. Later you can use these markers to replay data from (or up to) that point, instead of expressing start and end times in a numeric way.

For example, suppose you use *Recording Service* to record data while you are doing some business process. Then some event happens during the process that you want to somehow mark in the database. (Maybe this

event marks the time at which some device starts behaving strangely during a troubleshooting session). If you create a custom GUI application that an operator can use, or any kind of application, you can use the timestamp tagging command described in this section. Then when that application sends the command, *Recording Service* will store in the database a record in which you can give the event a name and description. Later you can replay the recorded data starting (or ending) at that named event.

Note that you can use a time offset when submitting the timestamp tagging command. This allows you to create tags that refer to a time in the past or the future, relative to the time when you sent the tagging command.

Once you have a recorded database, you can list the timestamp tags that are in the recording. Use the command `rtirecordingservice_list_tags` and point it to the directory that contains your recorded database with the `-d` argument.

For example:

```
<NDDSHOME>/bin/rtirecordingservice_list_tags -d /database/directory/
```

This command will analyze the recording in `/database/directory/` and list the details of any timestamp tags in the recording, including the tag names, descriptions, and associated timestamps. For example:

```
tag_name                    timestamp_ms   tag_description
--------------------------  -------------  ------------------------
/my_example/my_events/tag1  1546484663309  first tag description
/my_example/my_events/tag2  1546484703360  a second tag description
```

Note: The `rtirecordingservice_list_tags` command-line utility requires the SQLite3 executable to be installed and in the path (not provided by RTI installers). See the SQLite download page and SQLite CLI page for more information.

For information on using timestamp tags with *Replay Service*, see Section 4.6.4. They can also be used with *Converter*, see Section 5.3.1.

A simple C++ example of how to use timestamp tags using remote administration is available here: RTI Community Examples: C++ Service Administration.

3.7 Troubleshooting

3.7.1 Verbosity

Increase the verbosity from the command line to view information about which Topics have been discovered. For example, running with `-verbosity 4` shows that *Recording Service* has discovered a Square Topic.

```
[/recording_services/RecorderService/domain_participants/Participant0|STREAM_
↪DISCOVERED name=Triangle] type_name=ShapeType
[/recording_services/RecorderService/domain_participants/Participant0|STREAM_
↪DISCOVERED name=Triangle|../../sessions/DefaultSession/topics/
↪RecordAll@Triangle|CREATE]
[/recording_services/RecorderService/domain_participants/Participant0|STREAM_
```

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```
↪DISCOVERED name=Triangle|../../sessions/DefaultSession/topics/
↪RecordAll@Triangle|ENABLE]
[/recording_services/RecorderService/sessions/DefaultSession/topics/
↪RecordAll@Triangle|START]
[/recording_services/RecorderService/sessions/DefaultSession/topics/
↪RecordAll@Triangle|RUN]
```

At verbosity level 4, it is also possible to see incompatible QoS.

```
[/recording_services/RecorderService/sessions/DefaultSession/topics/
↪RecordAll@Triangle|START]
[/recording_services/RecorderService/sessions/DefaultSession/topics/
↪RecordAll@Triangle|RUN]
PRESPsService_isRemoteWriterLocalReaderCompatible:incompatible ownership:␣
↪writer 1 reader 0
[/routing_services/RecorderService/domain_routes/DomainRoute/sessions/
↪DefaultSession/routes/RecordAll@Circle/inputs/DdsInput1] requested␣
↪incompatible qos: policy id=6, name=Ownership
```

Chapter 4

Replay Service

4.1 Usage

This section explains how to run *Replay Service* from a command line. In particular, it describes:

- How to Start *Replay Service* (Section 4.1.1).
- How to Stop *Replay Service* (Section 4.1.2).
- *Replay Service* command-line parameters (Section 4.1.3).

4.1.1 Starting Replay Service

Replay Service runs as a separate application. The script to run the executable is in <NDDSHOME>/bin. (See Section 1.2 for the path to NDDSHOME.)

```
rtireplayservice [options]
```

To start *Replay Service* with a default configuration, enter:

```
$NDDSHOME/bin/rtireplayservice
```

This command will run *Replay Service* indefinitely until you stop it.

Replay Service is pre-loaded with a built-in configuration that has default settings.

Replay Service is provided for both the *host* platform and, for certain architectures, the *target* platform. By default, *Replay Service* runs for the host platform (located in `resource/app/bin/<host>`). To configure the script to run *Replay Service* for a target platform (located in `resource/app/bin/<target>`), specify the target architecture in either of the following variables:

- The environment variable `CONNEXTDDS_ARCH`.
- The variable `connextdds_architecture` in the file `rticommon_config.[sh/bat]`. (The file is `resource/scripts/rticommon_config.sh` on Linux or macOS systems, `resource/scripts/rticommon_config.bat` on Windows systems.)

These instructions (configuring the script to run *Replay Service* for a target platform) do not apply to embedded systems; for those, see the "Building and Running" section for your platform in the Getting Started Guide Addendum for Embedded Systems. Follow the instructions for loading and running your application. (The `rtireplayservice` application is already compiled; you do not need to compile it.) Copy `rtireplayservice` from `/resource/app/bin/<target_architecture>/rtireplayservice` to your target platform.

4.1.2 Stopping Replay Service

To stop *Replay Service*, press Ctrl-c. *Replay Service* will perform a clean shutdown.

4.1.3 Replay Service Command-Line Parameters

The following table describes all the command-line parameters available in *Replay Service*. To list the available parameters, run `rtireplayservice -help`.

All command-line parameters are optional; if specified, they override the values of any corresponding settings in the loaded XML configuration. See Section 4.3.1 for the XML elements that can be overridden with command-line parameters.

Table 4.1: Replay Service Command-Line Parameters

Parameter	Description
-appName <string>	Application name used to identify this execution for remote administration, and to name the *Connext* participant.
-cfgFile <string>	Semicolon-separated list of configuration file paths. **Default**: Unspecified
-cfgName	Configuration name Used to find a `<replay_service>` matching tag in the configuration file.
-debugMode	Enables debug mode. **Default**: Debug mode is not enabled.
-reverseMode	Enables reverse playback. **Default**: Reverse mode is not enabled.
-domainIdBase <int>	This value is added to the domain IDs in the `<domain_participant>` tag in the configuration file. For example, if you set `-domainIdBase` to 50 and use domain IDs 0 and 1 in the configuration file, *Replay Service* will read domains 0 and 1 from the database, but will replay that data into domains 50 and 51. **Default**: 0
-D<name>=<value>	Defines a variable that can be used as an alternate replacement for XML environment variables, specified in the form $(VAR_NAME). Note that definitions in the environment take precedence over these definitions.
-help	Shows this help.
-heapSnapshotDir	Output directory where the heap monitoring snapshots are dumped. The filename format is: RTI_heap_<appName>_<processId>_<index>.log

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Table 4.1 – continued from previous page

Parameter	Description
-heapSnapshotPeriod <sec>	Period at which heap monitoring snapshots are dumped. Enables heap monitoring if > 0. **Default**: 0 (disabled)
-logFormat <format>	A mask to configure the format of the log messages for both *Replay Service* and *Connext*. • DEFAULT - Print message, method name, log level, activity context, and logging category • TIMESTAMPED - Print message, method name, log level, activity context, logging category, and timestamp • MINIMAL - Print only message number and message location • MAXIMAL - Print all available fields **Default**: DEFAULT
-maxObjectsPerThread <int>	Maximum number of thread-specific objects that can be created. **Default**: Same as the *Connext* default for max_objects_per_thread
-remoteAdministrationDomainId <int>	Enables remote administration and sets the domain ID for communication. **Default**: Remote administration is not enabled.
-remoteMonitoringDomainId <int>	Enables remote monitoring and sets the domain ID for status publication. **Default**: Remote monitoring is not enabled.
-verbosity <service_level>[:<dds_level>]	Controls what type of messages are logged. <service_level> is the verbosity level for the service logs and <dds_level> is the verbosity level for the DDS logs. Both can take any of the following values: • `SILENT` • `ERROR` • `WARN` • `LOCAL` • `REMOTE` • `ALL` **Default:** `ERROR:ERROR`
-version	Prints the program version and exits.

4.1.4 Replay Service Runtime Behavior

Replay Service currently does not delete *DataWriters*, even if all original *DataWriters* were deleted in the recorded database.

4.1.5 Working With Large Data

The built-in SQLite plugin implementation available in *Replay Service* is prepared to handle any type size and storage format. In order to improve the fidelity of the samples published with respect to the timestamps of the original samples in the database, *Replay Service* internally caches the next sample to be published, so that it can be accessed more quickly when it's time to publish. This behavior is particularly useful when replaying large data.

However, when working with large data types and massive files (or filesets), *Replay Service* may take a while to prepare SQL statements to work with the data, resulting in a delay in publishing the first samples for any large data topics.

Because of this delay, it is recommended that you index the user data tables for those large topics before running *Replay Service* on them. Indexing can massively improve *Replay Service*'s startup time for those topics. You can create the indexes offline, after *Recording Service* has finished recording all the data. Index the tables on the `SampleInfo_reception_timestamp` field. For example, imagine a table, `VeryLargeTopic@0`, has been created by *Recording Service*; you can use the following index creation statement:

```
CREATE INDEX IF NOT EXISTS [VeryLargeTopic@0_idx_rt]
        ON [VeryLargeTopic@0] (SampleInfo_reception_timestamp)
```

4.1.6 Choosing the Sample Order for Replaying Data

Replay Service has the capability to replay data ordered by reception timestamp or by source timestamp. Reception timestamp represents a monotonic ascending time series and the source timestamp comes from every recorded participant's system clock, hence it can behave in non-monotonic fashion. The source timestamp can differ between one record and another with the same information.

Furthermore, it is important to consider the DDS_DestinationOrderQosPolicy, which can create "eventual consistency" between the different Recording Service instances. For more details, please see DESTINATION_ORDER QosPolicy in the *RTI Connext Core Libraries User's Manual*.

That being said, *Replay Service's* built-in SQLite plugin implementation will sort the database by using the chosen sample_order before it replays the data.

4.1.7 Recreating the State of the World when Replaying (Replaying Instance History)

Replay Service has the ability to replay what can be called the *state of the world* given a starting timestamp. The state of the world is the latest value for every alive instance at a certain timestamp. That's why we also refer to this feature as Instance History Replay. When this feature is enabled, *Replay Service* will read the latest value for every instance that was alive, and publish it with the first batch of samples to be published for a topic. Of course this feature relates to keyed types and topics, for unkeyed types and topics it has no effect.

As an example, imagine a keyed topic *T1* was recorded, and that there are three instances for the topic, define by IDs 1, 2 and 3. The following table shows the instances and values recorded for it during a certain period of time:

Time	Instance ID	Value
1	ID=1	100
2	ID=2	200
3	ID=3	300
4	ID=1	110
5	ID=3	310
6	ID=1	disposed
7	ID=2	210
8	ID=3	320
9	ID=1	120
10	ID=2	220

If the Instance History Replay feature is enabled, *Replay Service* will publish the instance values that compose the state of the world at the start time provided by the user. For example, for start time T=4, *Replay Service* will publish, ahead of any normal replay activity, samples `{ID=1,100}`, `{ID=2,200}` and `{ID=3,300}`. It will then start publishing samples normally, `{ID=1,110}`, etc. If start time is T=7, then the state of the world will be composed of two samples, because the sample with ID=1 was disposed at time T=6. Hence, *Replay Service* will publish samples `{ID=2,200}` and `{ID=3,310}` as the state of the world. Of course, if the start time is not provided (T=0) then there is no history to replay.

An important note about how the instance history is replayed is that it's published in a burst. This means that time separation between different values is not preserved. The goal of the feature is to publish a whole picture for the topic *before* starting with normal, time-preserving replay.

This feature can be useful in situations where very large databases are being replayed partially (this is, with a specific time range). When this is done, and this feature is not enabled, instances that were alive at the specified start time are just not present in the replay. By enabling this feature, *Replay Service* will publish a value for each instance that was alive at the start time provided, hence completing the whole picture for the topic before normal replay activity starts.

Under the hood, this feature uses a custom instance history index that is created by *Recording Service* (although the creation is disabled by default, as it can affect performance), or it can also be created offline. See Section 3.3.6 on how to enable this feature while recording, or Section 8 for how to index the database offline. If the index was not created while recording, or offline ahead of replaying, then *Replay Service* **will create the index during startup**, which can take some time in huge databases. So our general recommendation is to plan ahead whether this feature is going to be used when replaying your data and either use online indexing with *Recording Service* (by enabling the `<instance_indexing` tag) or save some time for the offline indexing of the database. It's interesting to note that indexing, even when done by *Replay Service*, will only happen once, as it can be expected.

The searching for the instance history is quite optimized, but it takes some time. This delay can manifest during *Replay Service* startup, but no more searching will be needed after that during normal replay of samples. If if the looping feature is enabled, *Replay Service* will search for instance history again and re-publish it. This will *restore* the original state of the world ahead of replaying samples of the next loop.

This feature is integrated with replaying by source timestamp and other features, like jumping between timestamps. Take into account that if instance indexing was done, for example, based only for reception timestamp, but you want to Replay with instance history based on source timestamp, then *Replay Service* will proceed to indexing the database by source timestamp, incurring in the indexing delay. So planning ahead of time what

sort of indexing and replay (source, timestamp) is going to be needed can also save time.

For more details on how to configure this feature, see Section 4.3.9.

4.1.8 Jumping in Time while Replaying

Replay Service has the capability of jumping in time. With this jump action, *Replay Service* will move the current replay position forward or backward in time.

For example, suppose you have a recording and in the middle there are some important events. During the replay, you can jump ahead to those events, skipping the unrelated events that came before.

When the jump in time is to the future, *Replay Service* will burst all the discovery samples between your previous position and your new position. This discovery phase can take some time depending on the amount of discovery between both positions. To improve the performance of the jump, you can enable Instance History Replay to obtain the discovery state of the world and create all the new StreamReaders. For more information, see Section 4.1.7.

In order to jump in time, you have to enable the remote administration. Remote administration exposes some commands that allow you to perform this action. See Section 4.4.3 for details.

4.1.9 Using Debug Mode while Replaying

Replay Service has a secondary mode to start in a debug way. This mode will allow you to add breakpoints in the replay. The replay will be paused once it hits a breakpoint and the user will have the capability to decide the behavior of the replay.

For example, suppose you have a recording and in the middle there are some important events. During the replay, you can replay that section of events adding breakpoints at the beginning and at the end of the replay section. Once, the replay hits the end breakpoint you will be able to jump to the first breakpoint and reproduce that important event again.

If the Debug mode feature is enabled, *Replay Service* will first hit an initial breakpoint, which is a permanent breakpoint labeled "default_breakpoint". This initial breakpoint is set to the start timestamp of the recorded database.

In this mode, you can continue the replay until hit a breakpoint or continue the replay for a period of time and then stop the replay without hitting a real breakpoint.

Under the hood, *Replay Service* will create a virtual breakpoint at the end of that period of time. The virtual breakpoint will be removed internally after it was hit or we jump to another breakpoint. This period of time can be a custom time set by the user or a fixed time that we call slice period. The slice period can be set inside the XML configuration and it can't be changed during the replay.

The debug mode use the remote administration system to receive the user's order due to that you have to enable the remote administration to control this mode. See Section 4.4.3 for details.

4.2 Operating System Daemon

See generic instructions in *How to Run as an Operating System Daemon*.

4.3 Configuration

This section provides a reference for the XML elements that comprises a *Replay Service* configuration. For details on how to provide XML configurations to *Replay Service*. refer to *Configuring RTI Services*. This chapter describes how to compose an XML configuration.

Note: *Replay Service* makes use of XSD files to validate the XML configuration files used to configure *Replay Service*. Due to the restrictions imposed by XSD schemas for XML 1.0, some of the tags used in the configuration must be grouped in order. This behavior is intended; *Replay Service* validates the XML files before parsing them to catch as many parsing errors as possible beforehand.

4.3.1 XML Tags for Configuring Replay Service

This section describes the XML tags you can use in a *Replay Service* configuration file. Figure 4.1 and Table 4.2 describe the top-level tags allowed within the root `<dds>` tag.

Table 4.2: Top-Level Tags in Replay Service's Configuration File

Tags within <dds>	Description	Multiplicity
<qos_library>	Specifies a QoS library and profiles. The contents of this tag are specified in the same manner as for a *Connext* QoS profile file — see Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.	0..*
<types>	Defines types that can be used by *Replay Service*. This tag is needed if data types are not available through discovery, or when using a transformation. The type description is done using the *Connext* XML format for type definitions. See Creating User Data Types with Extensible Markup Language (XML) in the *RTI Connext Core Libraries User's Manual*.	0..*
<plugin_library>	Contains a list of libraries that can be used to: • Plug in custom storage, such as custom databases. For more information, see Section 4.6.3. • Transform data after it is received from *Connext* and before it is placed in storage. For more information, see Data Transformation in the *RTI Routing Service User's Manual*. See Section 3.3.12	0..*

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Table 4.2 – continued from previous page

Tags within <dds>	Description	Multiplicity

<replay_service>	**Required.** Specifies a *Replay Service* configuration. See Section 4.3.2.
	Attributes
	• `name`: uniquely identifies a service configuration. **Required**.
	Example
	`<replay_service name="ReplayAll">`
	`<!-- your service settings ... -->`
	`</replay_service>`
		1..*

4.3.2 Replay Service Tag

A configuration file must have at least one `<replay_service>` tag. This tag is used to configure an execution of *Replay Service*.

A configuration file may contain multiple `<replay_service>` tags. When you start *Replay Service*, you can specify which `<replay_service>` tag to use to configure the service using the -cfgName command-line parameter. This means one file can be used to configure multiple *Replay Service* executions.

Figure 4.2 and Table 4.3 describe the tags allowed within a `<replay_service>` tag.

Table 4.3: Replay Service Tags in Replay Service's Configuration File

Tags within <replay_service>	Description	Multiplicity
<administration>	Enables remote administration. When administration is enabled, monitoring is also enabled by default. See Section 4.3.3.	0..1
<monitoring>	Enables monitoring for *Replay Service*, including statistics. See Section 4.3.4.	0..1
<storage>	Describes how the data will be loaded from storage. See Section 4.3.5. If this is not specified, data will be loaded from the current working directory.	0..1
<playback>	Specifies the timing rules for how data is played back. See Section 4.3.9.	0..1
<data_selection>	Enables selection of a subset of data to replay. Supports selecting replay data by time (or tagged time). See Section 4.3.10.	0..1

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Table 4.3 – continued from previous page

Tags within <replay_service>	Description	Multiplicity

<domain_participant>	**Required**. Specifies a DomainParticipant to use to replay data. The domain ID specified for the DomainParticipant will be used to determine which domains to select from the database and (combined with the domainIdBase) which domains to replay the data into. For example, if data was originally recorded in domains 0 and 1, and you want to replay in domains 50 and 51, you must:
	• Specify `<domain_participant>` tags with `<domain_id>` tags set to 0 and 1 in your configuration file.
	• Use `-domainIdBase 50` to specify that the domain IDs the data will actually be written into is offset by 50.
	See Section 4.3.8.
	Attributes:
	• `name`: Uniquely defines a DomainParticipant. **Required**.
	Example
	`<domain_participant name="Participant3">`
	`  <domain_id>3</domain_id>`
	`  <!-- Participant QoS -->`
	`</domain_participant>`
		1..*

<session>	**Required**. Active component of *Replay Service* for replaying data. Contains one or more threads that can be used for replay. See Section 4.3.12.
	Attributes
	• `name`: Uniquely defines a replay session. **Required**.
	• `default_participant_ref`: Specifies a default DomainParticipant to be used by topics and topic groups belonging to this replay session. Children can override this by specifying their own participant.
	Example
	`<session name="Session" default_participant_ref="Participant3">`
	`  <!-- ... topics / groups of topics to record -->`
	`</session>`
		1..*

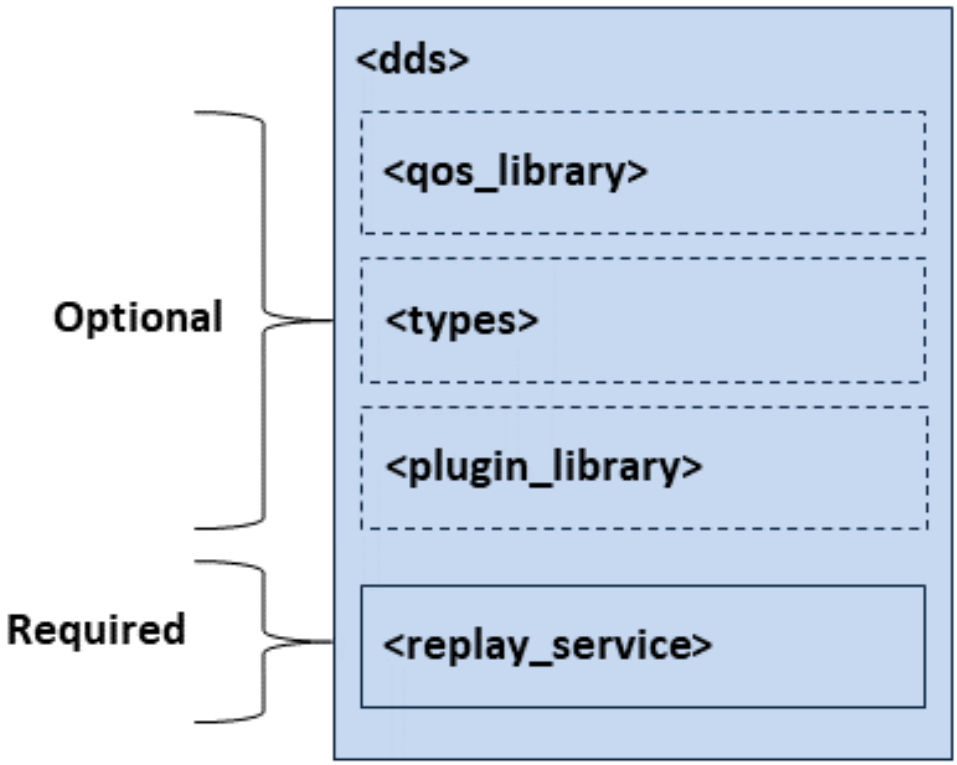

Figure 4.1: Top-level Tags in the *Replay* Configuration File

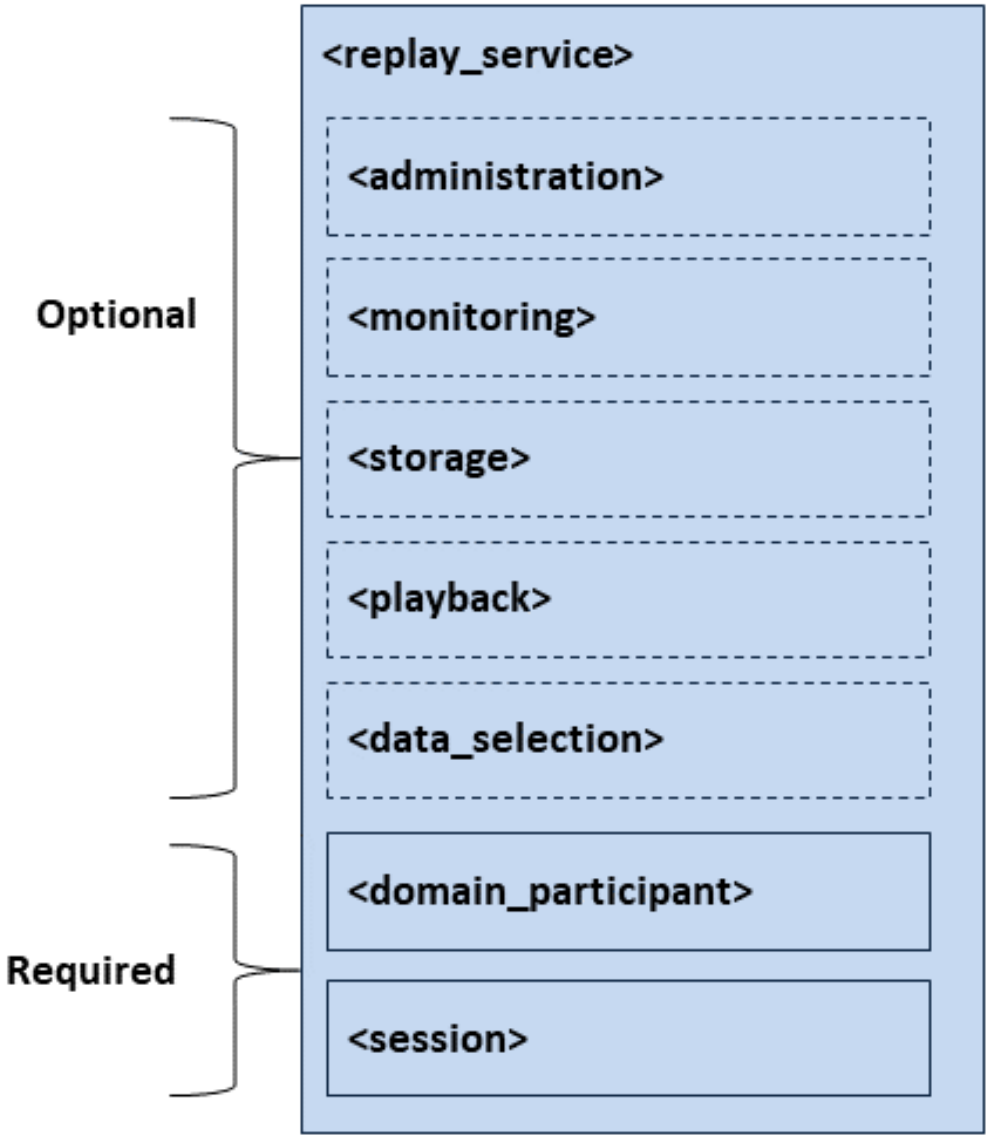

Figure 4.2: Tags used to configure a *Replay Service* instance

Example: Specify a Replay Service Configuration in XML

```
<dds>
    <replay_service name="MyReplayService">
        <!-- ... Required entities -->
    </replay_service>
</dds>
```

Starting a *Replay Service* with the following command will use the `<replay_service>` tag with the name "MyReplayService".

```
$NDDSHOME/bin/rtireplayservice -cfgFile file.xml -cfgName MyReplayService
```

Replay Service uses the Topic names and domain IDs specified in the configuration file to determine which data to replay. To replay data into a different domain than the one it was recorded from, use the `-domainIdBase` command-line parameter to change the output domain ID.

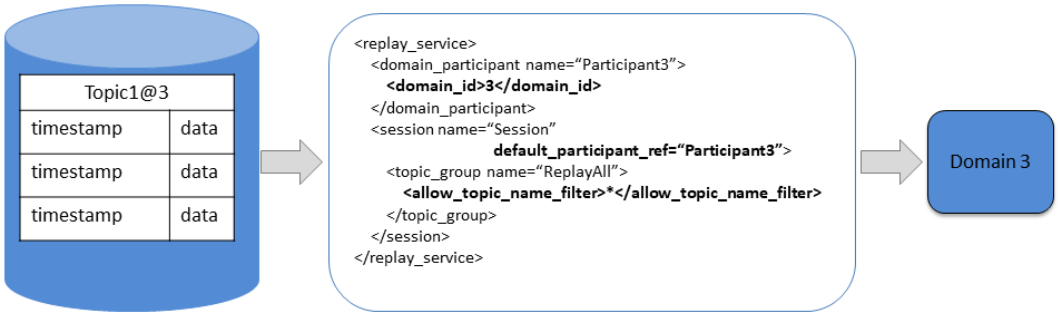

Figure 4.3: The domain ID specified inside a DomainParticipant, in combination with the Topic name, is used to load data from recorded tables. In this case, the DomainParticipant's domain ID is set to 3. The `topic_group` specifies all topics.

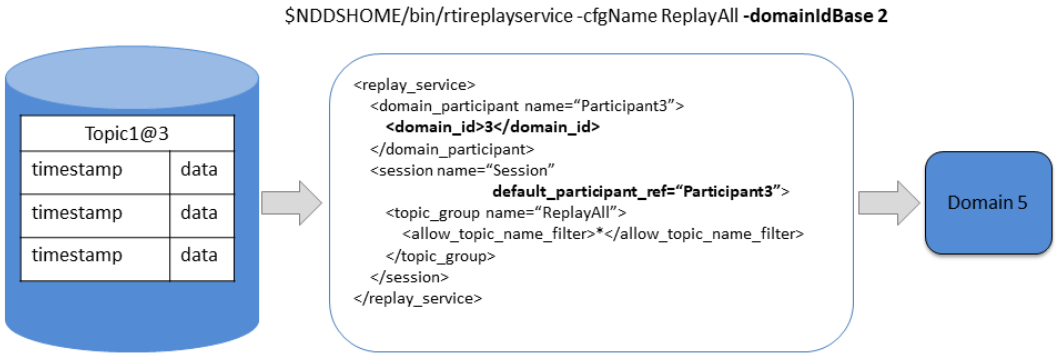

Figure 4.4: To replay data in a different domain than where it was recorded, use the `-domainIdBase` command-line parameter to specify a base ID for the replay domain. Here, by specifying a domainIdBase of 2, all Topics will be replayed in their original domain, plus 2.

4.3.3 Administration

The `<administration>` tag allows you to enable and configure remote administration of *Replay Service*, including stopping, starting, and pausing replay.

See Section 4.4 for details on using remote administration.

Table 4.4: Administration Tags in Replay Service's Configuration File

Tags within <administration>	Description	Multiplicity
<domain_id>	Domain ID used for remote administration. Also used for monitoring by default.	0..1
<domain_participant_qos>	QoS used by the administration DomainParticipant. If the tag is not defined, *Connext* defaults will be used.	0..1
<publisher_qos>	QoS used by the administration Publisher. If the tag is not defined, *Connext* defaults will be used.	0..1
<subscriber_qos>	QoS used by the administration Subscriber. If the tag is not defined, *Connext* defaults will be used.	0..1
<datawriter_qos>	QoS used by administration DataWriter(s). If the tag is not defined, *Connext* defaults will be used, with the following changes: • history.kind = DDS_KEEP_ALL_HISTORY_QOS • resource_limits.max_samples = 32	0..1
<datareader_qos>	Quality of Service (QoS) used by administration DataReader(s). If the tag is not defined, the *Connext* defaults will be used, with the following changes: • reliability.kind = DDS_RELIABLE_RELIABILITY_QOS (this value cannot be changed) • history.kind = DDS_KEEP_ALL_HISTORY_QOS • resource_limits.max_samples = 32	0..1
<distributed_logger>	When you enable *Distributed Logger*, *Replay Service* will publish its Log messages to *Connext*. See Section 3.3.13.	0..1

The contents of the tags for configuring QoS are specified in the same manner as for the *Connext* QoS profile file. See Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.

4.3.4 Monitoring

The `<monitoring>` tag allows you to enable and configure remote monitoring of *Replay Service*.

Table 4.5: Monitoring Tags in Replay Service's Configuration File

Tags within <monitoring>	Description	Multiplicity
<enabled>	Whether to enable monitoring of the service. **Default**: Disabled unless administration is enabled	0..1
<domain_id>	Domain ID used for monitoring. **Default**: Use the domain ID specified for monitoring	0..1
<datawriter_qos>	QoS used by monitoring DataWriter(s)	0..1
<publisher_qos>	QoS used by monitoring Publisher(s)	0..1
<domain_participant_qos>	QoS used by monitoring DomainParticipant	0..1
<statistics_sampling_period>	How frequently to sample the service's statistics, using the tags <sec> or <nanosec>. For example, <sec>1</sec> samples the service's statistics every second. **Default**: 1 second.	0..1
<status_publication_period>	How frequently to publish the service status, using the tags <sec> or <nanosec>. For example, <sec>1</sec> publishes the service's status every second. **Default**: 5 seconds	0..1

The contents of the tags for configuring QoS are specified in the same manner as for the *Connext* QoS profile file. See Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.

4.3.5 Storage

The `<storage>` tag allows you to configure the storage from which data will be read. You can choose between using the builtin SQLite storage or implementing your own storage plugin.

Table 4.6: Storage Tags in Replay Service's Configuration File

Tags within <storage>	Description	Multiplicity
<sqlite>	Enables replaying data from an SQLite database file See Section 4.3.5.	0..1
<plugin>	Enables storing data in an external library that you specify. Attributes • `plugin_name`: Name of the plugin that creates a storage plugin object. This name shall refer to a registered storage plugin. See Section 10.5 for details on how to register plugins). See Section 4.3.5 for more about using this tag. See Section 4.6.3 for a tutorial on plugging in custom storage.	0..1

SQLite

The `<sqlite>` tag allows you to specify a SQLite formatted file to read data from for replay.

Table 4.7: SQLite Tags in Replay Service's Configuration File

Tags within <sqlite>	Description	Multiplicity
<storage_format>	The storage format of the user data files found in the database directory. If not specified, XCDR_AUTO is assumed. The options are: • XCDR_AUTO: This is the binary format used by *Connext* when sending data over the network. This has the highest performance for recording, but can only be viewed by using *Converter* to convert the data to a readable format, or by using *Replay* to replay the data. This will internally store data in XCDR or XCDR2 depending on the format received. • JSON_SQLITE: This format can be queried, but recording in this format has lower performance because data must be deserialized before it can be stored. • XCDR: The format to use when communicating with *Connext* before 6.0.0. • XCDR2: More efficient than XCDR, used by *Connext* 6.0.0 and later. **Default**: XCDR_AUTO.	0..1
<database_dir>	The directory where to look for a recorded database. The directory must contain a valid metadata file, as well as a discovery file and one or many user data files. This field is optional. When not included, the current directory will be used. **Default**: the current directory.	0..1

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Table 4.7 – continued from previous page

Tags within <sqlite>	Description	Multiplicity

<sql_initialization_string>	Allows configuring an SQLite SQL expression to use when establishing SQLite connections using this plugin. You can add an index to a table to speed up replay, but this must be done for each table you want to index. Note that you can perform this step using an SQLite client.
	Example:
	`<sql_initialization_string>`
	`CREATE INDEX IF NOT EXISTS pingtopic_0_by_rcp_timestamp ON 'PingTopic@0' (SampleInfo_reception_timestamp);`
	`</sql_initialization_string>`
	Note: when using Recorder and Replay at the same time for the same DB file(s), or for that matter, any other SQLite application accessing the data, we recommend using SQLite's WAL (write-ahead logging) mode. This can be done by adding `PRAGMA JOURNAL_MODE = WAL;` to this configuration setting. More information about SQLite's WAL mode can be found here.
	This scenario is not fully supported. Please be aware that the WAL file will grow without bounds during the replay operation. This implies that the database file will not be updated with the WAL contents until all the Replay instances finish executing.
	Default: `PRAGMA SYNCHRONOUS = OFF; PRAGMA JOURNAL_MODE = MEMORY;`
		0..1

Plugin

Table 4.8: Storage plugin Tag in the Configuration File

Tags within <plugin>	Description	Multiplicity

<property>	Name/value pairs of properties to pass to a storage plugin.
	Example:
	`<property>`
	`<value>`
	`<element>`
	`<name>Name</name>`
	`<value>Value</value>`
	`</element>`
	`</value>`
	`</property>`
		0 or 1

4.3.6 Legacy

Table 4.9: Legacy Tags in the Configuration File

Tags within <legacy>	Description	Multiplicity
<file_path>	Path to the legacy format recorded file. File set and version properties will be obtained automatically from the file itself.	0..1
<domain_mapping>	This tag allows you to link legacy domain names with domain IDs. See Section 4.3.7.	0..1

4.3.7 Domain Mapping

When converting a legacy database, the domain may not have been recorded. This tag provides a way to map a table with a domain ID.

Later versions of the old Recorder database allowed you to use field filters. By default, the domain ID field was not recorded (it was filtered out by default). Thus, there is no information available in these legacy databases to relate the domain name used to record the data with a domain ID. This tag allows you to link legacy domain names with domain IDs.

Table 4.10: Domain Mapping Tags in the Configuration File

Tags within <domain_mapping>	Description	Multiplicity
<domain_map>	**Required**. A link between a recorded legacy domain name and a domain ID. **Attributes:** • `legacy_domain_name`: Name of the recorded domain name as specified in the old Recording Service domain tag, for example: <domain name="domain0">. • `participant_ref`: The name of a DomainParticipant specified below using a `<domain_participant>` tag. This DomainParticipant will be used to replay data specified by the legacy domain name.	1..*

4.3.8 DomainParticipant

The `<domain_participant>` tag allows you to specify the DomainParticipants and domain IDs you want to query from the database for replay. You can replay in the same domain you used to record, or you can use the `-domainIdBase` command-line parameter to replay in a different domain.

The contents of the tags for configuring QoS are specified in the same manner as for the *Connext* QoS profile file. See Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.

Table 4.11: DomainParticipant Tags in Replay Service's Configuration File

Tags within <domain_participant>	Description	Multiplicity
<domain_id>	The domain ID of tables loaded from the database. This is used (in conjunction with the `-domainIdBase` command-line parameter) to choose which domain to replay into.	1
<domain_participant_qos>	QoS used by this DomainParticipant.	0..1

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Table 4.11 – continued from previous page

Tags within <domain_participant>	Description	Multiplicity

<memory_management>	Configures certain aspects of how *Connext* allocates internal memory. The configuration is per DomainParticipant and therefore affects all the contained DDS entities.
	Example:
	`<memory_management>`
	`  <sample_buffer_min_size>`
	`  1024`
	`  </sample_buffer_min_size>`
	`  <sample_buffer_trim_to_size>`
	`  true`
	`  </sample_buffer_trim_to_size>`
	`</memory_management>`
	This tag includes the following tags:
	• <sample_buffer_min_size>: For all DataWriters and DataReaders, the way *Connext* allocates memory for samples is as follows: *Connext* pre-allocates space for samples up to size X in the DataWriter and DataReader queues. If a sample has an actual size greater than X, the memory is allocated dynamically for that sample. The default size is 64KB. This is the maximum amount of pre-allocated memory. Dynamic memory allocation may occur when necessary if samples require a bigger size.
	• <sample_buffer_trim_to_size>: If set to true, after allocating dynamic memory for very large samples, that memory will be released when possible. If false, that memory will not be released but kept for future samples if needed. The default is false.
	This feature is useful when a data type has a very high maximum size (e.g., megabytes) but most of the samples sent are much smaller than the maximum possible size (e.g., kilobytes). In this case, the memory footprint is reduced dramatically, while still correctly handling the rare cases in which very large samples are published.
		0..1

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Table 4.11 – continued from previous page

Tags within <domain_participant>	Description	Multiplicity
<register_type>	Registers a type name and associates it with a type representation. When you define a type in the configuration file, you have to register the type in order to use it in a `<topic>`. **Attributes:** • `name`: Name that the data type is registered with if no <registered_name> is specified. The same data type may be registered with different names. **Required**. • `type_ref`: Definition of this data type. It must refer to one of the defined types in the `<types>` section by specifying the fully qualified name. **Tags within this tag:** • <registered_name>: Name the data type is registered with. The same data type may be registered with different names. Not required.	0..*

4.3.9 Playback

The `<playback>` tag allows you to specify the timing rules for how the data is played back, such as the time on the local machine to start the replay, if it is not started immediately. Its tags must follow the same order in which they appear in the following table.

Table 4.12: Playback Tags in Replay Service's Configuration File

Tags within <playback>	Description	Multiplicity
<fidelity>	Specifies the fidelity of the replayed data. Samples whose timestamp distance is less than the fidelity period may be published together in the same batch. For example, if your fidelity is 100 ms, data stored in your database within a 100 ms time period may be published together. **Tags within this tag:** • <sampling_period>: the duration (in seconds and nanoseconds) that represents the maximum time period during which samples with different timestamps may be published together. **Default**: 1 ms	0..1
<rate>	Specifies the rate to replay data, as a double. For example, to play data at half speed, use 0.5. **Default**: 1 (normal speed)	0..1

continues on next page

Table 4.12 – continued from previous page

Tags within <playback>	Description	Multiplicity
<enable_looping>	Plays the data in a repeating loop, until *Replay Service* is stopped. Note that this means that only a termination signal or a remote shutdown command will make it stop replaying data. When no time range data selection has been specified (see Section 4.3.10) then Replay will replay the whole contents of the database file(s) and when it's time to loop, it will start from the very beginning of the file or files. However, when a specific time range has been specified for replay, the looping will respect the time range and will restart at the specified start time and end at the specified end time. **Note**: in our default SQLite implementation, Replay is able to check if new data has been written by Recorder (or any application) for every given stream being replayed, since the start of the service. This feature is generally not supported when looping without specifying a time range and may yield unexpected results. **Default**: false.	0..1
<debug_mode>	Enables debug mode for *Replay Service's* playback feature. See Section 4.3.9 for more information on the configuration tags available in this mode.	0..1
<reverse_mode>	Plays the data in reverse, while maintaining the fidelity of the recorded database. *Replay Service* will start its replay with the last sample recorded and it will finish with the first sample recorded. *Replay Service* will discover all the StreamReaders at the beginning of the Replay in this mode. **Note**: Replay in reverse mode will not replay stored dispose samples. **Note**: Instance History Replay is not available when reverse mode is enabled. **Default**: false.	0..1
<sample_order>	Specifies the timestamp kind to replay data. If not specified, RECEPTION_TIMESTAMP is assumed. The options are: • RECEPTION_TIMESTAMP: Time stored when the DDS sample was received by the DataReader. For more details, please see DESTINATION_ORDER QosPolicy in the *RTI Connext Core Libraries User's Manual*. • SOURCE_TIMESTAMP: Time stored by the DataWriter when the DDS sample was written. **Note**: For more information about source timestamp and reception timestamp, please see Section 4.1.6. **Default**: RECEPTION_TIMESTAMP.	0..1

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Table 4.12 – continued from previous page

Tags within <playback>	Description	Multiplicity

<start_replay_local_time>	Selects the local time when *Replay Service* should start publishing samples. Specified in hours, minutes, and seconds. Specifying a full date is not currently supported, so if you specify a time that happened in the past (which *Replay Service* interprets as in the past *today*), replay will start immediately.
	Example:
	`<start_replay_local_time>`
	`  <hour>14</hour>`
	`  <minute>30</minute>`
	`  <second>0</second>`
	`</start_replay_local_time>`
	The example above indicates that *Replay Service* will will start the replay at 14:30 pm.
	Default: Replay will start immediately
		0..1

<instance_history_replay>	Specifies whether Instance History Replay (state of the world publication) is enabled. See Section 4.1.7 for a description of the feature. **Tags within this tag:** • `<enabled>`: Whether to enable or disable the feature. When enabled, *Replay Service* will publish an initial value (or more, depending on the depth setting) for every alive instance before the specified start timestamp. After this startup publication, *Replay Service* will start normal replay. **Default**: false.	0..1

Debug mode

The `<debug_mode>` tag allows you to enable the debug mode, such as set the slice period and the initial list of breakpoints.

Table 4.13: Debug Mode Tags in Replay Service's Configuration File

Tags within <debug_mode>	Description	Multiplicity
<enabled>	Enables debug mode.	0..1
<slice_period>	Specifies the slice period of the replay. It will determine the replay period when you use a next_slice or continue operation. After that period of time *Replay Service* will pause the replay. **Default**: 1 s	0..1

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Table 4.13 – continued from previous page

Tags within <debug_mode>	Description	Multiplicity

<initial_breakpoints>	Specifies an initial list of breakpoints. Those breakpoints will be set once the replay start.
	Tags within this tag:
	• <element>: the timestamp (in nanoseconds) that will have the breakpoint. You can assign a label to the breakpoint as an identifier. Multiplicity: 1..*
	Attributes:
	– `label`: Breakpoint identifier.
	Example:
	`<debug_mode>`
	`<enabled>true</enabled>`
	`<initial_breakpoints>`
	`<element>`
	`↪1600635588280996383</element>`
	`<element label=`
	`↪"MyBreakpoint">`
	`↪1600635598310952678</element>`
	`</initial_breakpoints>`
	`</debug_mode>`
		0..1

4.3.10 Data Selection

Selection of data to replay from the database. Currently only supports selection using a time range.

Table 4.14: Data Selection Tags in Replay Service's Configuration File

Tags within <data_selection>	Description	Multiplicity
<time_range>	Select data to replay from the database, based on start and end times. See Section 4.3.11.	0..1

4.3.11 Time Range

The `<time_range>` tag allows you to specify the begin and end times of the data you want to replay. This can be specified either as timestamps or as symbolic timestamps called "timestamp tags." These tags may have been added to the recording through remote administration, and can be viewed using the script `rtirecordingservice_list_tags` (see Section 3.6.7).

Table 4.15: Time Range Tags in Replay Service's Configuration File

Tags within <time_range>	Description	Multiplicity
<begin_time>	Select data to replay from the database, with a timestamp beginning at this time. Specify the time in seconds and nanoseconds. **Default**: 0, start at beginning of the file.	0..1
<begin_tag>	Can be used instead of begin_time. Select data to start replaying from the database by specifying the string name of a timestamp tag. Timestamp tags associate a timestamp with a name. Then you can refer to a timestamp by that name. The timestamp must have been tagged with that name during recording. See Section 3.6.6. **Default**: Start at beginning of the file.	0..1
<end_time>	Select data to replay from the database, with a timestamp ending at this time. Specify the time in seconds and nanoseconds. **Default**: Stop at end of file.	0..1
<end_tag>	Can be used instead of end_time. Select when to stop replaying data by specifying the string name of a timestamp tag. Timestamp tags associate a timestamp with a name. Then you can refer to a timestamp by that name. The timestamp must have been tagged with that name during recording. See Section 3.6.6. **Default**: Stop at end of file.	0..1

4.3.12 Session

The `<session>` tag configures the threads that will be used to replay data. You also specify the Topics and groups of Topics to replay inside the <session> tag.

Table 4.16: Session Tags in Replay Service's Configuration File

Tags within <session>	Description	Multiplicity
<publisher_qos>	Specifies the QoS of the Publisher that will be used by the contained `<topic>` and `<topic_group>`. For information on configuring Pubscriber QoS with XML, see Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual*.	0..1

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Table 4.16 – continued from previous page

Tags within <session>	Description	Multiplicity

<thread_pool>	Defines the number of threads used by this session to process Topics and Topic Groups and sets the mask, priority, and stack size of each thread.
	
	Note: The default SQLite storage plugin requires sequential access. Because of this, setting the thread pool **size** to a value greater than **1** has no practical effect on performance when using the built-in SQLite plugin. Increasing the thread pool size only improves performance when using a custom storage plugin that supports concurrent reads.
	Example:
	`<thread_pool>`
	`  <mask>MASK_DEFAULT</mask>`
	`  <priority>THREAD_PRIORITY_DEFAULT</priority>`
	`  <stack_size>`
	`  THREAD_STACK_SIZE_DEFAULT`
	`  </stack_size>`
	`</thread_pool>`
	Default values:
	• **size**: 1
	• **mask**: MASK_DEFAULT
	• **priority**: THREAD_PRIORITY_DEFAULT
	• **stack_size**: THREAD_STACK_SIZE_DEFAULT
		0..1

<topic>	Specifies an individual Topic to replay. See Section 4.3.14. **Attributes:** • `name`: The name of the Topic to replay. This name is also used when monitoring and administering each Topic. • `participant_ref`: A DomainParticipant to use when replaying this Topic. If the parent `<session>` specifies a `default_participant_ref`, this attribute is optional.	0..*

continues on next page

Table 4.16 – continued from previous page

Tags within <session>	Description	Multiplicity
<topic_group>	Specifies a group of Topics to replay. See Section 4.3.13. **Attributes:** • `name`: The name of the topic group. This name is used when monitoring and administering each topic group. • `participant_ref`: A DomainParticipant to use when replaying this topic group. If the parent `<session>` specifies a `default_participant_ref`, this attribute is optional.	0..*

4.3.13 Topic Group

The `<topic_group>` tag allows you to replay a group of Topics, using regular expressions to describe which Topics to replay.

Table 4.17: Topic Group Tags in Replay Service's Configuration File

Tags within <topic_group>	Description	Multiplicity
<publish_with_original_info>	Writes the data sample as if it came from its original writer. Setting this option to true allows having redundant recording services and prevents the applications from receiving duplicate samples. **Default**: false	0..1
<publish_with_original_timestamp>	Indicates if the data samples are written with their original source timestamp. **Default:** false	0..1

<allow_topic_name_filter>	A regular expression (fnmatch) describing which Topics are allowed to be replayed. You may use a comma-separated list to specify more than one filter.
	Example:
	`<topic_group name="ReplayAll">`
	`  <allow_topic_name_filter>CONTROL_*,DATA_*</allow_topic_name_filter>`
	`</topic_group>`
		0..1

<deny_topic_name_filter>	A regular expression (fnmatch) describing which Topics are not allowed to be replayed. This is applied after the `allow_topic_name_filter`. You may use a comma-separated list to specify more than one filter.	0..1
<allow_type_name_filter>	A regular expression (fnmatch) describing the names of data types that are allowed to be replayed. You may use a comma-separated list to specify more than one filter.	0..1

continues on next page

Table 4.17 – continued from previous page

Tags within <topic_group>	Description	Multiplicity
<deny_type_name_filter>	A regular expression (fnmatch) describing the names of data types that are not allowed to be replayed. This is applied after the `allow_type_name_filter`. You may use a comma-separated list to specify more than one filter.	0..1

<on_delete_wait_for_ack_timeout>	Specifies a period for which the StreamWriter will wait for acknowledgment before its elimination. See Waiting for Acknowledgments in a DataWriter in the *RTI Connext Core Libraries User's Manual*. **Default:** 0 (no wait for acknowledgment)
	Example:
	`<on_delete_wait_for_ack_timeout>`
	`  <sec>1</sec>`
	`  <nanosec>0</nanosec>`
	`</on_delete_wait_for_ack_timeout>`
	The example above indicates that StreamWriter will wait one second for acknowledgment of the samples.
		0..1

<datawriter_qos>	The DataWriter's QoS to use when replaying this data. For information on configuring QoS with XML, see Configuring QoS with XML, in the *RTI Connext Core Libraries User's Manual*.	0..1

4.3.14 Topic

The `<topic>` tag specifies an individual Topic to replay.

Table 4.18: Topic Tags in Replay Service's Configuration File

Tags within <topic>	Description	Multiplicity
<topic_name>	The name of the DDS topic to be replayed. If this tag is not present, the name attribute of the *<topic>* will be used. *Note*: we recommend using this tag to define the topic name. There may be characters that cause the XML validation to fail if they are part of the topic name attribute. Also, the '/' character and '::' separator may cause Replay to fail when found in the topic name attribute.	0..1
<registered_type_name>	The name of the data type that will be replayed for this topic. **Required**.	1
<publish_with_original_info>	Writes the data sample as if it came from its original writer. Setting this option to true allows having redundant recording services and prevents the applications from receiving duplicate samples. **Default**: false	0..1
<publish_with_original_timestamp>	Indicates if the data samples are written with their original source timestamp. **Default:** false	0..1

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Table 4.18 – continued from previous page

Tags within <topic>	Description	Multiplicity

<on_delete_wait_for_ack_timeout>	Specifies a period for which the StreamWriter will wait for acknowledgment before its elimination. See Waiting for Acknowledgments in a DataWriter in the *RTI Connext Core Libraries User's Manual*. **Default:** 0 (no wait for acknowledgment)
	Example:
	`<on_delete_wait_for_ack_timeout>`
	`  <sec>1</sec>`
	`  <nanosec>0</nanosec>`
	`</on_delete_wait_for_ack_timeout>`
	The example above indicates that StreamWriter will wait one second for acknowledgment of the samples.
		0..1

<transformation>	The transformation library to be applied to this Topic's data when replaying. This is a user library that can modify the data after it is received from storage and before it is sent via *Connext*.
	Transformations implement APIs identical to *Routing Service's* transformations. For more on using transformations, see these sections in the *RTI Routing Service User's Manual*:
	• Data Transformation
	• Tutorials
	Attributes:
	• `plugin_name`: The name of the plugin to load, qualified by the plugin library name.
	Example:
	`<dds>`
	`  <plugin_library name="ReplayTransformations ↪">`
	`  <transformation_plugin name= ↪"ModifyTestID">`
	`  <create_function>ModifyTestID_create ↪</create_function>`
	`  <dll>modify_test_id_library</dll>`
	`  </transformation_plugin>`
	`  </plugin_library>`
	`  <!-- ... -->`
	`  <replay_service>`
	`  <!-- ... -->`
	`  <topic name="TestTopic">`
	`  <transformation plugin_name= ↪"ReplayTransformations::ModifyTestID" />`
	`  </topic>`
	`  </replay_service>`
	`</dds>`
		0..1

continues on next page

Table 4.18 – continued from previous page

Tags within <topic>	Description	Multiplicity
<datawriter_qos>	The DataWriter QoS to use when replaying this data. For information on configuring QoS with XML, see Configuring QoS with XML, in the *RTI Connext Core Libraries User's Manual*.	0..1

4.3.15 Plugins

All the pluggable components specific to *Recording Service* are configured within the `<plugin_library>` tag. Table 4.19 describes the available tags.

Plug-ins are categorized and configured based on the source language. *Replay Service* supports C/C++ plugins.

Table 4.19: Configuration tags for plugin libraries

Tags within <plugin_library>	Description	Multiplicity
<storage_plugin>	Specifies a C/C++ *Storage* plugin. See Table 10.18 and Section 3.3.6.	0..*
<transformation_plugin>	Specifies a C/C++ *Transformation* plugin. See Table 10.18 and Section 3.3.10.	0..*

4.3.16 Support for Security Plugins

Replay Service supports configuring and using Security Plugins. To configure *Replay Service* securely, you need to configure the appropriate QoS settings in the XML configuration. For more information, see the RTI Security Plugins User's Manual.

Example: Configuring a Replay Instance using Security

The following example in XML demonstrates how to configure Replay to load and use the Security Plugins. The example assumes a path where the user has created the necessary security artifacts (such as permissions files, certificates, and certificate authorities). This path is represented by the `SECURITY_ARTIFACTS_PATH` environment variable.

Note: The `SECURITY_ARTIFACTS_PATH` environment variable must include the `file:` prefix to make sure paths are properly loaded by the Security Plugins.

```
<dds>
    <qos_library name="SecureQosLibrary">
        <qos_profile name="SecureParticipantQos">
            <domain_participant_qos>
                <property>
```

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```
                    <value>
                        <element>
                            <name>com.rti.serv.load_plugin</name>
                            <value>com.rti.serv.secure</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.library</name>
                            <value>nddssecurity</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.create_function</name>
                            <value>RTI_Security_PluginSuite_create</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_certificate</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01ReplayServiceCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.private_key</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01ReplayServiceKey.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.governance</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪Governance.p7s</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪PermissionsA.p7s</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
    </qos_library>

    ...

    <replay_service name="SecuredReplayService">
```

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```
        <!--  Top-level storage settings -->
        <storage>
            <sqlite>
                <storage_format>XCDR_AUTO</storage_format>
                <database_dir>cdr_recording</database_dir>
            </sqlite>
        </storage>

        <!--  Top-level domain settings -->
        <domain_participant name="Participant0">
            <!-- Domain Participant in Domain 0 is secured -->
            <domain_id>0</domain_id>
                <domain_participant_qos base_name=
↪"SecureQosLibrary::SecureParticipantQos" />
            </participant>
        </domain_participant>

        <session name="DefaultSession">
            <topic_group name="ReplayAll" participant_ref="Participant0">
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
            </topic_group>
        </session>
    </replay_service>

</dds>
```

The above XML example configures a *Topic Group* that replays all data (except RTI topics) from a secured *DomainParticipant*. The security settings are encapsulated in a QoS Profile called SecureParticipantQos. In the current version of the default storage plugins, storage is unsecure.

Example: Configuring Replay Service to use a Certificate Revocation List (CRL)

Replay Service can remove a *DomainParticipant* from the system when its certificate has been revoked. Use Security Plugins to specify a CRL (certificate revocation list) file to track via the `authentication.crl` property; when the `files_poll_interval` property is configured in Security Plugins, *Replay Service* can banish revoked participants. For more information, see Properties for Configuring Authentication in the *RTI Security Plugins User's Manual*. The following example XML configuration file uses a CRL file to enable *Replay Service* to remove participants with revoked certificates.

```
<dds>
    <qos_library name="SecureQosLibrary">
        <qos_profile name="SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>com.rti.serv.load_plugin</name>
                            <value>com.rti.serv.secure</value>
```

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```
                        </element>
                        <element>
                            <name>com.rti.serv.secure.library</name>
                            <value>nddssecurity</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.create_function</name>
                            <value>RTI_Security_PluginSuite_create</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_certificate</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01ReplayServiceCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.private_key</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01ReplayServiceKey.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.governance</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪Governance.p7s</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪PermissionsA.p7s</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
        <qos_profile name="SecureParticipantQosWithCrl" base_name=
↪"SecureQosLibrary::SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>dds.sec.auth.crl</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/
↪ReplayServiceRevoked.crl</value>
```

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```
                        </element>
                        <element>
                            <name>com.rti.serv.secure.files_poll_interval</
↪name>
                            <value>1</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
    </qos_library>

    ...

    <replay_service name="SecuredReplayServiceWithCrl">
        <!--  Top-level storage settings -->
        <storage>
            <sqlite>
                <storage_format>XCDR_AUTO</storage_format>
                <database_dir>cdr_recording</database_dir>
            </sqlite>
        </storage>

        <!--  Top-level domain settings -->
        <domain_participant name="Participant0">
            <!-- Domain Participant in Domain 0 is secured and tracks a CRL␣
↪file -->
            <domain_id>0</domain_id>
                <domain_participant_qos base_name=
↪"SecureQosLibrary::SecureParticipantQosWithCrl" />
            </participant>
        </domain_participant>

        <session name="DefaultSession">
            <topic_group name="ReplayAll" participant_ref="Participant0">
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
            </topic_group>
        </session>
    </replay_service>

</dds>
```

The above configuration in *Replay Service* reads the CRL file `$SECURITY_ARTIFACTS_PATH/ReplayServiceRevoked.crl`. In addition, the `files_poll_interval` element instructs the service to track the file for changes so that participants can be removed dynamically. In this example, the polling of the file happens every 1s.

Note: If the poll period is zero, *Replay Service* will not track the file continuously.

Example: Configuring Replay Service for Dynamic Certificate Renewal

Replay Service can dynamically renew its certificate if it was revoked or it expired. Use SECURITY PLUGINS to specify a periodic check of the certificate file; if the `files_poll_interval` property is configured in SECURITY PLUGINS, *Replay Service* reloads the certificate if the file changes. For more information, see Properties for Configuring Authentication in the *RTI Security Plugins User's Manual*.

The following example XML configuration file defines a 1s period for checking the certificate file for changes.

```
<dds>
    <qos_library name="SecureQosLibrary">
        <qos_profile name="SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>com.rti.serv.load_plugin</name>
                            <value>com.rti.serv.secure</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.library</name>
                            <value>nddssecurity</value>
                        </element>
                        <element>
                            <name>com.rti.serv.secure.create_function</name>
                            <value>RTI_Security_PluginSuite_create</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.identity_certificate</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01ReplayServiceCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.auth.private_key</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/
↪identities/ecdsa01ReplayServiceKey.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.permissions_ca</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/ecdsa01/ca/
↪ecdsa01RootCaCert.pem</value>
                        </element>
                        <element>
                            <name>dds.sec.access.governance</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪Governance.p7s</value>
                        </element>
                        <element>
```

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```
                            <name>dds.sec.access.permissions</name>
                            <value>$(SECURITY_ARTIFACTS_PATH)/signed_
↪PermissionsA.p7s</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
        <qos_profile name="SecureParticipantQosDynamicCert" base_name=
↪"SecureQosLibrary::SecureParticipantQos">
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>com.rti.serv.secure.files_poll_interval</
↪name>
                            <value>1</value>
                        </element>
                    </value>
                </property>
            </domain_participant_qos>
        </qos_profile>
    </qos_library>

    ...

    <replay_service name="SecuredReplayServiceDynamicCert">
        <!--  Top-level storage settings -->
        <storage>
            <sqlite>
                <storage_format>XCDR_AUTO</storage_format>
                <database_dir>cdr_recording</database_dir>
            </sqlite>
        </storage>

        <!--  Top-level domain settings -->
        <domain_participant name="Participant0">
            <!-- Domain Participant in Domain 0 is secured and tracks a CRL␣
↪file -->
            <domain_id>0</domain_id>
                <domain_participant_qos base_name=
↪"SecureQosLibrary::SecureParticipantQosDynamicCert" />
            </participant>
        </domain_participant>

        <session name="DefaultSession">
            <topic_group name="ReplayAll" participant_ref="Participant0">
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
            </topic_group>
        </session>
    </replay_service>
```

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```
</dds>
```

The above configuration in *Replay Service* checks the *DomainParticipant* certificate file `$SECURITY_ARTIFACTS_PATH/ecdsa01/identities/ecdsa01ReplayServiceCert.pem` for changes every 1s.

Note: If the poll period is zero, *Replay Service* will not track the file continuously.

4.4 Remote Administration

This section provides documentation on *Replay Service* remote administration. A control client (such as *RTI Admin Console*) can use this interface to remotely control a *Replay Service*.

Note: *Replay Service* remote administration is based on the *RTI Remote Administration Platform* described in Section 10.3. Please refer to that manual for a detailed discussion on the workings of remote administration in *Replay Service*.

Below you will find an API reference for all the supported operations.

4.4.1 Enabling Remote Administration

By default, remote administration is disabled in *Replay Service*.

To enable remote administration you can use the `<administration>` XML tag (see Section 4.3) or the `-remoteAdministrationDomainId` command-line parameter (see Section 4.1). Both of these methods enable remote administration and set the domain ID for remote communication.

4.4.2 Available Service Resources

Table 4.20 lists the public resources specific to *Replay Service*. Each resource identifier is expressed as a hierarchical sequence of identifiers, including parent and target resources. (See Section 10.2.2 for details.)

In the table below, the elements `(rs)`, and `(st)` refer to the name of an entity of the corresponding class as specified in the configuration in the `name` attribute. For example, in the following configuration:

```
<replay_service name="MyReplay">...</replay_service>
```

The resource identifier is:

```
/replay_service/MyReplay
```

In the table, the resource identifier is written as /replay_service/(rs), where (rs) is the service name. This nomenclature is used in the table to give you an idea of the structure of the resource identifiers. For actual (example) resource identifier names, see the example section that follows.

Table 4.20: Resources and Their Identifiers in *Replay Service*

Resource	Resource Identifier
Replay Service	/replay_service/(rs)

4.4.3 Remote API Overview

Table 4.21: Remote Interface Overview

Resource	Operation	Description
ReplayService	*DELETE /replay_services/(rs)*	Shuts down a running *Replay Service*
	UPDATE /replay_services/(rs)/state	Sets a *Replay Service* state
	UPDATE /replay_services/(rs)/playback/rate	Change the rate of the replay
	UPDATE /replay_services/(rs)/playback/current_timestamp	Jump to a specific timestamp and continue the replay
	UPDATE /replay_services/(rs)/playback/current_tag	Jump to a specific timestamp tag and continue the replay
	GET /replay_services/(rs)/playback/state	Provide the current *Replay Service* state. It will allow us to detect when *Replay Service* hit a breakpoint.
	UPDATE /replay_services/(rs)/playback:add_breakpoint	Add a new breakpoint
	UPDATE /replay_services/(rs)/playback:remove_breakpoint	Remove an existing breakpoint
	UPDATE /replay_services/(rs)/playback:goto_breakpoint	Jump to a specific breakpoint and stop the replay
	UPDATE /replay_services/(rs)/playback:next_breakpoint	Jump to the next breakpoint and stop the replay
	UPDATE /replay_services/(rs)/playback:continue	Continue the replay leaving the current breakpoint
	UPDATE /replay_services/(rs)/playback:next_slice	Continue the replay for a slice of period

4.4.4 Replay Service

`DELETE /replay_services/(rs)`

Operation `shutdown`

Causes *Replay Service* to shutdown.

`UPDATE /replay_services/(rs)/state`

Operation `set_state`

See *Set Resource State* (Section 10.3.3).

Valid requested states:

- `STARTED`
- `STOPPED`
- `PAUSED`
- `RUNNING`

- Example

  To pause a replay service with the name "MyReplay":

Request Field	Value
`command_action`	UPDATE
`resource_identifier`	/replay_services/MyReplay/state
`octet_body`	`to_cdr_buffer(RTI::Service::EntityStateKind::PAUSED)`

`UPDATE /replay_services/(rs)/playback/rate`

Operation `set_rate`

This operation will cause *Replay Service* to change its rate.

Request body

- The new rate of the replay.

`UPDATE /replay_services/(rs)/playback/current_timestamp`

Operation `current_timestamp`

This operation will cause *Replay Service* to change its current timestamp, modifying the replay location backward or forward in time.

It will affect the whole service, meaning that all StreamReaders will be affected by it.

- Example

To change the current timestamp in a replay service named "MyReplay":

Request Field	Value
`command_action`	UPDATE
`resource_identifier`	/replay_services/MyReplay/playback/current_timestamp

`octet_body`	`RTI::RecordingService::TimestampHolder timestamp_holder;`
	`timestamp_holder.timestamp_nanos(1600635588280996383);`
	`std::vector<char> timestamp_holder_buffer;`
	
	`dds::topic::topic_type_support<RTI::RecordingService::TimestampHolder>::to_cdr_buffer(`
	`timestamp_holder_buffer,`
	`timestamp_holder);`

`UPDATE /replay_services/(rs)/playback/current_tag`

Operation `current_tag`

This operation will cause *Replay Service* to change its current timestamp, modifying the replay location backward or forward in time. The replay will jump to the timestamp of the selected timestamp tag.

It will affect the whole service, meaning that all StreamReaders will be affected by it.

Request body

- Tag name of a specific recorded timestamp tag.

`GET /replay_services/(rs)/playback/state`

Operation `get_state`

This operation will provide the current debug state of the *Replay Service* related to the debug mode. It will allow you to detect when *Replay Service* stop in a breakpoint

Valid provided states:

- `BREAKPOINT`
- `WORKING`

Request body

- Empty.

Reply body

- `octet_body`: CDR representation of the DebugStatus.

UPDATE /replay_services/(rs)/playback:add_breakpoint

Operation `add_breakpoint`

This operation will create a new breakpoint. *Replay Service* will only accept as proper breakpoint those which timestamp is not out of the recorded timestamp period.

Also, we can use a recorded timestamp tag to create a breakpoint with it.

- Examples

  To create a new breakpoint in a replay service named "MyReplay":

Request Field	Value
`command_action`	UPDATE
`resource_identifier`	/replay_services/MyReplay/playback:add_breakpoint

`octet_body`	`RTI::RecordingService::BreakpointParams breakpoint_arguments;`
	`::dds::core::optional<std::string> optional_label_value("breakpoint_1");`
	`breakpoint_arguments.label(optional_label_value);`
	`breakpoint_arguments.value().timestamp_nanos(1600635588280996383);`
	`dds::topic::topic_type_support<RTI::RecordingService::BreakpointParams>`
	`::to_cdr_buffer(`
	`reinterpret_cast<std::vector<char> &> (request.octet_body()),`
	`breakpoint_arguments);`

  To create a new breakpoint using a timestamp tag:

Request Field	Value
command_action	UPDATE
resource_identifier	/replay_services/MyReplay/playback:add_breakpoint

octet_body	RTI::RecordingService::BreakpointParams breakpoint_arguments;
	::dds::core::optional<std::string> optional_label_value("breakpoint_tag");
	breakpoint_arguments.label(optional_label_value);
	breakpoint_arguments.value().tag_name("example/tag1");
	dds::topic::topic_type_support<RTI::RecordingService::BreakpointParams>
	::to_cdr_buffer(
	reinterpret_cast<std::vector<char> &> (request.octet_body()),
	breakpoint_arguments);

UPDATE /replay_services/(rs)/playback:remove_breakpoint

Operation remove_breakpoint

This operation will remove an existing breakpoint for the replay. A breakpoint can be removed by label or by timestamp.

In order to clean the complete list of breakpoints (except the default one) you can use the special character "*" as label value.

If *Replay Service* is hitting the breakpoint to be removed, It won't resume the replay.

- Examples

  To remove the breakpoint with label "MyBreakpoint" in a replay service named "MyReplay":

Request Field	Value
command_action	UPDATE
resource_identifier	/replay_services/MyReplay/playback:remove_breakpoint

octet_body	RTI::RecordingService::BreakpointParams breakpoint_arguments;
	::dds::core::optional<std::string> optional_label_value("MyBreakpoint");
	breakpoint_arguments.label(optional_label_value);
	breakpoint_arguments.value().timestamp_nanos(0);
	dds::topic::topic_type_support<RTI::RecordingService::BreakpointParams>
	::to_cdr_buffer(
	reinterpret_cast<std::vector<char> &> (request.octet_body()),
	breakpoint_arguments);

UPDATE /replay_services/(rs)/playback:goto_breakpoint

Operation goto_breakpoint

This operation will cause *Replay Service* to jump to a specific breakpoint. You can specifie the jumping breakpoint by label or by timestamp.

It will affect the whole service, meaning that all StreamReaders will be affected by it.

-Example:

To jump to breakpoint with timestamp "1600635588280996383" in a replay service named "MyReplay":

Request Field	Value
command_action	UPDATE
resource_identifier	/replay_services/MyReplay/playback:goto_breakpoint
octet_body	RTI::RecordingService::BreakpointParams breakpoint_arguments; breakpoint_arguments.value().timestamp_nanos(1600635588280996383); dds::topic::topic_type_support<RTI::RecordingService::BreakpointParams>::to_cdr_buffer(reinterpret_cast<std::vector<char> &> (request.octet_body()), breakpoint_arguments);

UPDATE /replay_services/(rs)/playback:next_breakpoint

Operation next_breakpoint

This operation will cause *Replay Service* to jump to the next breakpoint on the list. if *Replay Service* was on the last breakpoint of the list It will throw an exception.

It will affect the whole service, meaning that all StreamReaders will be affected by it.

Request body

- Empty.

UPDATE /replay_services/(rs)/playback:continue

Operation continue

This operation will cause *Replay Service* to continue the replay after it hit a breakpoint. If you do not add any CDR representation to the request, it will continue until it hits a new breakpoint or the replay end. Otherwise, this operation will continue the replay for the period of time specified by you. *Replay Service* has to be on BREAKPOINT state in order to make this action.

It will affect the whole service, meaning that all StreamReaders will be affected by it.

-Examples:

To continue the replay for 1 second in a replay service named "MyReplay":

Request Field	Value
command_action	UPDATE
resource_identifier	/replay_services/MyReplay/playback:continue
octet_body	RTI::RecordingService::ContinueParams continue_arguments; continue_arguments.value().offset(1000000000); dds::topic::topic_type_support<RTI::RecordingService::ContinueParams>::to_cdr_buffer(reinterpret_cast<std::vector<char>&> (request.octet_body()), continue_arguments);

To continue the replay for 2 slices periods in a replay service named "MyReplay":

Request Field	Value
command_action	UPDATE
resource_identifier	/replay_services/MyReplay/playback:continue
octet_body	RTI::RecordingService::ContinueParams continue_arguments; continue_arguments.value().slices(2); dds::topic::topic_type_support<RTI::RecordingService::ContinueParams>::to_cdr_buffer(reinterpret_cast<std::vector<char>&> (request.octet_body()), continue_arguments);

UPDATE /replay_services/(rs)/playback:next_slice

Operation next_slice

This operation will cause *Replay Service* to resume the replay for the duration of a slice period. *Replay Service* has to be on BREAKPOINT state in order to make this action.

It will affect the whole service, meaning that all StreamReaders will be affected by it.

Request body

- Empty.

4.5 Monitoring

This section provides documentation on *Recording Service* remote monitoring.

Note: *Recording Service* monitoring is based on the *Monitoring Distribution Platform* described in Section 10.4. We recommend that you read Section 10.4 before using *Recording Service* monitoring.

4.5.1 Overview

Enabling Service Monitoring

By default, monitoring is disabled in *Recording Service*. To enable monitoring you can use the `<monitoring>` tag (see Section 3.3.3) or the `-remoteMonitoringDomainId` command-line parameter, which enables remote monitoring and sets the domain ID for data publication (see Section 3.1.3).

Monitoring Types

The available *Keyed Resource* classes and their types that can be present in the distribution monitoring topics are listed in Table 4.22. The complete type relationship is shown in Figure 4.5.

Table 4.22: *Recording Service Keyed Resources*

Keyed Resource Class	Config	Event	Periodic
Service	`ServiceConfig`	`ServiceEvent`	`ServicePeriodic`
Session	`SessionConfig`	`SessionEvent`	`SessionPeriodic`
TopicGroup	`TopicGroupConfig`	`TopicGroupEvent`	`TopicGroupPeriodic`
Topic	`TopicConfig`	`TopicEvent`	`TopicPeriodic`

All the type definitions for *Recording Service* monitoring information are in `[NDDSHOME]/resource/idl/ServiceCommon.idl` and `[NDDSHOME]/resource/idl/RecordingServiceMonitoring.idl`.

Recording Service creates a *DataWriter* for each distribution *Topic*. All *DataWriters* are created from a single *Publisher*, which is created from a dedicated *DomainParticipant*. See Section 3.3.3 for details on configuring the QoS for these entities.

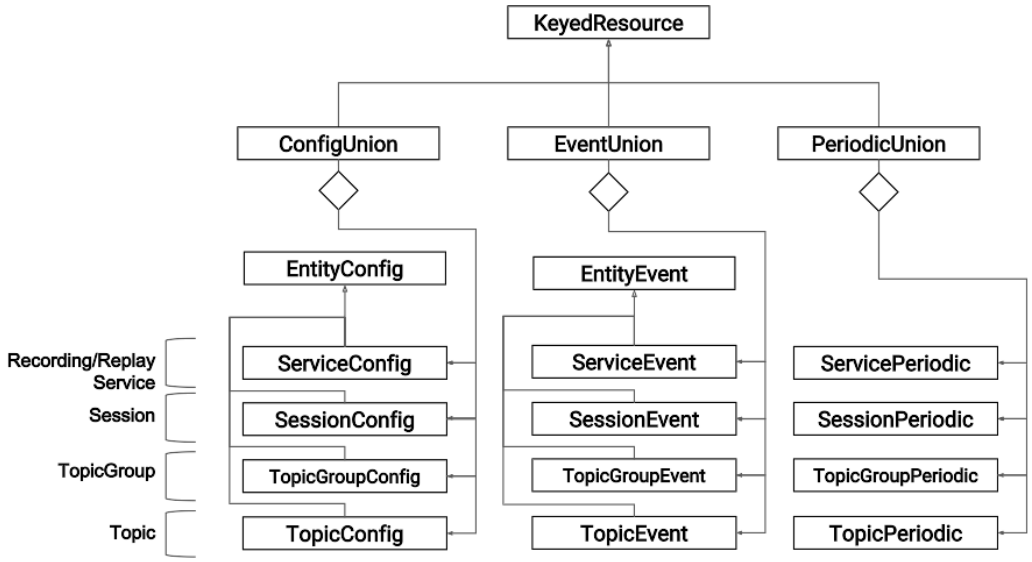

Figure 4.5: Keyed Resource Types for *Recording Service* monitoring

4.5.2 Monitoring Metrics Reference

This section provides a reference to all the monitoring metrics *Recording Service* distributes, organized by service resource class.

Service

Listing 4.1: *Recording Service* Types

```
@mutable @nested
struct SqliteDatabaseConfig {
    Service::FilePath db_directory;
    @optional Service::FilePath execution_directory_expression;
    @optional Service::FilePath user_data_file_expression;
};
@mutable @nested
struct SqliteDatabaseEvent {
    @optional Service::FilePath current_db_directory;
    @optional Service::FilePath current_file;
    @optional int32 rollover_count;
};
@mutable @nested
struct SqliteDatabasePeriodic {
    @optional Service::FilePath current_file;
```

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```
                @optional uint64 current_file_size;
                // These fields are no longer supported and carry no␣
↪information.
                // Kept only to support older version.
                @deprecated int32 current_timestamp_sec;
                @deprecated uint32 current_timestamp_nanosec;
            };

            @mutable @nested
            struct ParticipantInfo {
                Service::BoundedString name;
            };

            @mutable @nested
            struct ServiceConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString application_name;
                Service::Monitoring::ResourceGuid application_guid;
                @optional Service::Monitoring::HostConfig host;
                @optional Service::Monitoring::ProcessConfig process;
                @optional SqliteDatabaseConfig builtin_sqlite;
                @optional sequence<ParticipantInfo> participants;
            };
            @mutable @nested
            struct ServiceEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                @optional SqliteDatabaseEvent builtin_sqlite;
            };
            @mutable @nested
            struct ServicePeriodic {
                @optional Service::Monitoring::HostPeriodic host;
                @optional Service::Monitoring::ProcessPeriodic process;
                int64 current_timestamp_nanos;
                @optional SqliteDatabasePeriodic builtin_sqlite;
            };
```

Table 4.23: `ServiceConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
application_name	Name of the *Recording Service* instance. The application name is provided through: • `appName` command-line option when run as executable. • `ServiceProperty::application_name` field when run as a library.
application_guid	GUID of the *Recording Service* instance. Unique across all service instances.
host	See Table 10.10.
process	See Table 10.12.
builtin_sqlite	See Table 4.24
participants	Sequence of `ParticipantInfo` objects, one for each *DomainParticipant* inside the *Recording Service*. See Table 4.25.

Table 4.24: `SqliteDatabaseConfig`

Field Name	Description
db_directory	Path to the base directory where the database files live.
execution_directory_expression	This value is not set when running *Replay Service*. See Section 3.3.6
user_data_file_expression	This value is not set when running *Replay Service*.

Table 4.25: `ParticipantInfo`

Field Name	Description
name	Name of the *DomainParticipant* instance, as specified in the `name` attribute of the corresponding configuration tag.

Table 4.26: `ServiceEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.
builtin_sqlite	See Table 4.27

Table 4.27: `SqliteDatabaseEvent`

Field Name	Description
current_db_directory	Path to the current directory where files are being replayed from.
current_file	This value is not set when running *Replay Service*.
rollover_count	This value is not set when running *Replay Service*.

Table 4.28: `ServicePeriodic`

Field Name	Description
host	See Table 10.11.
process	See Table 10.13.
current_timestamp_nanos	Timestamp in nanoseconds at which data is being replayed, relative to recorded time.
builtin_sqlite	See Table 4.29

Table 4.29: `SqliteDatabasePeriodic`

Field Name	Description
current_file_size	This value is not set when running *Replay Service*.

Session

Listing 4.2: *Session* Types

```
            @mutable @nested
            struct SessionConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString default_participant_name;
            };
            @mutable @nested
            struct SessionEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                int32 _dummy;
            };
            @mutable @nested
            struct SessionPeriodic {
                @optional Service::Monitoring::NetworkPerformance network_
↪performance;
                @optional @optional Service::Monitoring::ThreadPoolPeriodic␣
↪thread_pool;
            };
```

Table 4.30: `SessionConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
default_participant_name	The name of the default participant configuration.

Table 4.31: `SessionEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.

Table 4.32: `SessionPeriodic`

Field Name	Description
network_performance	Provides network performance metric as an aggregation of the same metric across the contained *Topics* and *TopicGroups*. See Section 10.4.4.

TopicGroup

Listing 4.3: *TopicGroup* Types

```
            @mutable @nested
            struct TopicGroupConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString participant_name;
            };
            @mutable @nested
            struct TopicGroupEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                int32 _dummy;
            };
            @mutable @nested
            struct TopicGroupPeriodic {
                @optional Service::Monitoring::NetworkPerformance network_
↪performance;
                int64 topic_count;
            };
```

Table 4.33: `TopicGroupConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
participant_name	Name of the *DomainParticipant* from which the *Topic* is created.

Table 4.34: `TopicGroupEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.

Table 4.35: `TopicGroupPeriodic`

Field Name	Description
network_performance	Provides network performance metric as an aggregation of the same metric across the contained *Topics*. See Section 10.4.4.
topic_count	Current number of *Topics* created from this *TopicGroup*.

Topic

Listing 4.4: *Topic* Types

```
            @mutable @nested
            struct TopicConfig : Service::Monitoring::EntityConfig {
                Service::BoundedString topic_name;
                Service::BoundedString registered_type_name;
                Service::BoundedString participant_name;
                Service::Monitoring::ResourceGuid topic_group;
            };
            @mutable @nested
            struct TopicEvent : Service::Monitoring::EntityEvent {
                //to avoid unused variable warnings
                int32 _dummy;
            };
            @mutable @nested
            struct TopicPeriodic {
                @optional Service::Monitoring::NetworkPerformance network_
↪performance;
                @optional Service::Monitoring::CountStatus matched_status;
            };
```

Table 4.36: `TopicConfig`

Field Name	Description
Inherited fields from `EntityConfig`	See Table 10.14.
topic_name	Topic name as specified in the configuration.
registered_type_name	Topic registered type name as specified in the configuration.
paritcipant_name	Name of the *DomainParticipant* from which the *Topic* is created.
topic_group	GUID of the *TopicGroup* from which this *Topic* was created. This field is set to zero for standalone *Topics*.

Table 4.37: `TopicEvent`

Field Name	Description
Inherited fields from `EntityEvent`	See Table 10.15.

Table 4.38: `TopicPeriodic`

Field Name	Description
network_performance	Provides network performance metric as an aggregation of the same metric across the contained *Topics*. See Section 10.4.4.
matched_status	Provides information about the matched endpoints associated with this *Topic*.

4.6 Tutorials

4.6.1 Example: Getting Started with Replay and Shapes Demo

Start by recording Square data, as described in Section 3.6.1.

Start Shapes Demo and Subscribe to Squares

If you have any *Shapes Demo* windows publishing data, delete them.

Start *Shapes Demo* from *Launcher* and create a Square subscriber as described in Section 3.6.1.

Start Replay Service

Start *Replay Service*:

```
<NDDSHOME>/bin/rtireplayservice -cfgName UserReplayServiceJson -verbosity 3
```

You should see Square data replayed in *Shapes Demo*.

4.6.2 Example: Replaying Data at a Different Rate

To replay data at a faster or slower rate than it was recorded, you can edit the configuration file to specify a playback rate.

Start by recording Square data as described in Section 3.6.1.

Edit the Replay Configuration

In your `<RTI_WORKSPACE>/user_config/recording_service` directory, edit the `USER_REPLAY_SERVICE.xml` file. Add a playback rate, as seen in the following XML:

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- All of our files start with a dds tag -->
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:noNamespaceSchemaLocation="../../resource/schema/rti_replay_service.xsd">
```

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```
  <replay_service name="UserReplayServiceJson">
      <!-- This will look for files in the directory 'json_recording' in the
           current working directory. This is integrated with the Recording
           Service configuration 'UserRecorderServiceJson' in the file
           USER_RECORDING_SERVICE.xml -->
      <storage>
          <sqlite>
              <storage_format>JSON_SQLITE</storage_format>
              <database_dir>json_recording</database_dir>
          </sqlite>
      </storage>

      <!-- Optionally select the begin and end times for the data to be
           replayed -->
      <!--data_selection>
          <time_range>
              <begin_time>
                  <sec>0</sec>
                  <nanosec>0</nanosec>
              </begin_time>
          </time_range>
      </data_selection-->

      <!-- Specify playback behavior, including what local time to start -->
      <playback>
          <rate>2</rate>
      </playback>

      <domain_participant name="DefaultParticipant">
          <domain_id>0</domain_id>
      </domain_participant>

      <session name="DefaultSession"
               default_participant_ref="DefaultParticipant">
          <!-- Topics to replay in this session -->
          <topic_group name="DefaultTopicGroup">
              <!-- Topics to replay -->
              <allow_topic_name_filter>*</allow_topic_name_filter>
              <deny_topic_name_filter>rti/*</deny_topic_name_filter>
          </topic_group>
      </session>
  </replay_service>
</dds>
```

Start Shapes Demo

Use *Launcher* to start *Shapes Demo*, then create a Square subscriber.

Start Replay Service

Start *Replay Service*:

```
<NDDSHOME>/bin/rtireplayservice -cfgName UserReplayService -verbosity 3
```

You should see Square data replayed in *Shapes Demo* twice as fast as it was originally recorded.

4.6.3 Example: Plugging in Custom Storage

If you created a storage plugin to record data into your own custom storage, you can also create a plugin to replay from that same storage.

There are full examples written in C and C++ about plugging in custom storage in *Recording Service*, in the RTI Community Recording Service examples: C storage plugin and RTI Community Recording Service examples: C++ storage plugin.

Custom Storage API Overview

To retrieve data for replay, you must implement the following APIs:

- **A create storage reader API:**
  - This is used to create a StorageReader object.
  - This API is a C function. In C++, you can use macros to declare and define the C function for your class. For example:
    - `RTI_RECORDING_STORAGE_READER_CREATE_DECL(FileStorageReader)`
    - `RTI_RECORDING_STORAGE_READER_CREATE_DEF(FileStorageReader)`
  - The StorageReader is used to create and delete StorageStreamInfoReaders and StorageStreamReaders.
- **StorageReader:**
  - A create stream info reader API, where you create a stream reader that provides information about what streams (topics) are in your storage.
  - A delete stream info reader API, where you delete a stream info reader
  - A create stream reader API, where you create a stream reader
  - A delete stream reader API, where you delete a stream reader

- **StorageStreamInfoReader:**
  - Read: An API to retrieve discovery data from the storage. It uses a selector object to determine the kind of samples (not read or any kind) to be returned, as well as the time range. The samples should be returned in increasing time-stamp order.
  - Return loan: An API that notifies the plugin that it can release resources associated with the data passed to the read API
  - Get service start time: An API to query the recorded time from which to start replaying
  - Get service stop time: An API to query the recorded time at which to stop replaying
  - Finished: An API to tell *Replay Service* and *Converter* that there are no more stream infos to read.
  - Reset: An API called by the *Replay Service* to tell the plug-in to reset its state because it is looping. After this method is called, the stream reader should be ready to start reading data from the beginning of the stream, again.
- **StorageStreamReader**
  - Read: An API to retreive data from storage. It uses a selector object to determine the kind of samples (not read or any kind) to be returned, as well as the time range. The samples should be returned in increasing timestamp order.
  - Return loan: An API that notifies the plugin that it can release resources associated with the data passed to the take API
  - Finished: An API that notifies the plugin that there is no more data in this data stream

The APIs provide a mechanism to have strongly typed StorageStreamReader classes. A builtin one is provided, based on `dds::core::xtypes::DynamicData`.

More detailed API documentation is in:

- Recording Service C API documentation
- Recording Service C++ API documentation

4.6.4 Using Timestamp Tags with Replay Service

If your recording was originally made with the builtin SQLite storage plugin, and you used the `tag_timestamp` remote command to tag certain events, then your recording contains timestamp tags: symbolic timestamp names you can use in place of timestamps expressed in units of time. For more information on timestamp tags, see Section 3.6.6.

You can list the timestamp tags that are in your recorded database by using the `rtirecordingservice_list_tags` script. Use the `-d` argument to point to the directory that contains your recorded database, as follows:

```
<NDDSHOME>/bin/rtirecordingservice_list_tags -d /database/directory/
```

Note: The `rtirecordingservice_list_tags` command-line utility requires the SQLite3 executable to be installed and in the path (not provided by RTI installers). See the SQLite download page and SQLite CLI page for more information.

This command will analyze the recording in `/database/directory/` and list the details of any timestamp tags in the recording, including the tag names, descriptions, and associated timestamps.

You can use the tag_name of the timestamp tags you find in a recording when you are creating an XML configuration file for *Replay Service* by using the `<data_selection>` tag.

For example, if after running `rtirecordingservice_list_tags`, you see output such as:

```
tag_name                    timestamp_ms   tag_description
--------------------------  -------------  ------------------------
/my_example/my_events/tag1  1546484663309  first tag description
/my_example/my_events/tag2  1546484703360  a second tag description
```

Then you can have a `<data_selection>` tag in your XML for *Replay Service*, after the `<storage>` tag, that looks like the following:

```
<data_selection>
    <time_range>
        <begin_tag>/my_example/my_events/tag1</begin_tag>
        <end_tag>/my_example/my_events/tag2</end_tag>
    </time_range>
</data_selection>
```

Replay Service will replay data between those tags. Note that when expressing a `<time_range>` tag, you can mix and match timestamps and timestamp tags. For example, you can use a `<begin_tag>` (by referring to a tag_name) to express the time when replay should begin, and an `<end_tag>` with an end time timestamp (expressed in time units) to express when replay should end. If you do not provide one of the bounds, then the start of recording is the default begin bound and the end of recording is the default end bound.

4.6.5 Jump in time in Replay Service

This section shows a possible scenario where the jump in time operation can be useful. This scenario will be based on the following recorded database:

```
sqlite3 json_recording/rti_recorder_default_json.db
sqlite> select ROWID, SampleInfo_reception_timestamp, rti_json_sample from
↪"Square@0";

1|1600635598310952678|{"color":"ORANGE","x":120,"y":195,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
2|1600635598460562312|{"color":"ORANGE","x":121,"y":197,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
3|1600635599612452987|{"color":"ORANGE","x":122,"y":199,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
4|1600635601310952678|{"color":"ORANGE","x":123,"y":201,"shapesize":30,
```

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```
↪"fillKind":"SOLID_FILL","angle":0}
....
1000|1600637901310952678|{"color":"ORANGE","x":129,"y":199,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
```

In order to reproduce this scenario, see Section 3.6.1.

Suppose you want to replay for some seconds, then you want to replay again samples 4 to 10, because they contain important events and continue the replay until the end. To do this, you need to use the jump in time operation to change the replay position, like this.

```
CommandRequest request;

// Fill the request
request.action(CommandActionKind::UPDATE_ACTION);
request.application_name(service_property.application_name());
request.resource_identifier("/playback/current_timestamp");

// Set TimestampHolder
RTI::RecordingService::TimestampHolder timestamp_arguments;
timestamp_arguments.timestamp_nanos(1600635601310952678);

// Seralization of the TimestampHolder
dds::topic::topic_type_support<RTI::RecordingService::TimestampHolder>
        ::to_cdr_buffer(
                reinterpret_cast<std::vector<char> &> (request.octet_body()),
                timestamp_arguments);

// Send command
command_requester->send_request(request);
```

Once *Replay Service* has jumped to sample 4, it will replay those important samples again.

A simple C++ example of how to use the remote administration API is available here: RTI Community Recording Service examples: Service Administration. If you want to reproduce this scenario using this example you can run the following command:

```
./Requester UPDATE /replay_services/remote_admin/playback/current_timestamp --
↪current-timestamp 1600635601310952678
```

4.6.6 Using Debug mode in Replay Service

In this section you can see a possible scenario where the debug mode can be useful. This scenario will be based on the following recorded database:

```
sqlite3 json_recording/rti_recorder_default_json.db
sqlite> select ROWID, SampleInfo_reception_timestamp, rti_json_sample from
↪"Square@0";

1|1600635598310952678|{"color":"ORANGE","x":120,"y":195,"shapesize":30,
```

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```
↪"fillKind":"SOLID_FILL","angle":0}
2|1600635598460562312|{"color":"ORANGE","x":121,"y":197,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
3|1600635599612452987|{"color":"ORANGE","x":122,"y":199,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
4|1600635601310952678|{"color":"ORANGE","x":123,"y":201,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
....
100|1600637398330952678|{"color":"ORANGE","x":126,"y":199,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
101|1600637498460562312|{"color":"ORANGE","x":127,"y":199,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
102|1600637799612452987|{"color":"ORANGE","x":128,"y":199,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
103|1600637901310952678|{"color":"ORANGE","x":129,"y":199,"shapesize":30,
↪"fillKind":"SOLID_FILL","angle":0}
```

In order to reproduce this scenario, see Section 3.6.1.

Suppose you want to replay samples 1-4, then you want to skip samples 5-99 and continue the replay at sample 100. To do this, you need to add some breakpoints to stop *Replay Service* before it replays specific samples. So you need to add two breakpoints: one after the 4th sample and another before the 100th sample.

To add those breakpoints you can use the <initial_breakpoint> tags. For example:

```
<debug_mode>
    <enabled>true</enabled>
    <initial_breakpoints>
        <element label="breakpoint_afterSample4">1600635601320000000</element>
        <element label="breakpoint_beforeSample100">1600637398330000000</
↪element>
    </initial_breakpoints>
</debug_mode>
```

Also, you can add those breakpoints by code using the remote administration system. See Section 4.4.3 for more details about the different debug mode operations.

Once the replay starts, it will hit the default breakpoint. This breakpoint is always added by *Replay Service* at the start timestamp of the replay.

To start the replay, we should execute the operation "continue" using remote administration. *Replay Service* will publish the first 4 samples, then it will stop when it hits breakpoint_afterSample4. You can run the operation "continue" like this:

```
CommandRequest request;

// Fill the request
request.action(CommandActionKind::UPDATE_ACTION);
request.application_name(service_property.application_name());
request.resource_identifier("/playback:continue");
```

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```
// Send command
command_requester->send_request(request);
```

Once it hits this breakpoint, we don't want to replay the 5th sample. Instead, we want to jump to the breakpoint "breakpoint_beforeSample100", which is just before sample 100. To do this, we have to execute the operation "goto_breakpoint" like this:

```
CommandRequest request;

// Fill the request
request.action(CommandActionKind::UPDATE_ACTION);
request.application_name(service_property.application_name());
request.resource_identifier("/playback:goto_breakpoint");

// Set BreakpointParams
RTI::RecordingService::BreakpointParams breakpoint_arguments;
breakpoint_arguments.value().labels("breakpoint_beforeSample100");

// Seralization of the BreakpointParams
dds::topic::topic_type_support<RTI::RecordingService::BreakpointParams>
        ::to_cdr_buffer(
                reinterpret_cast<std::vector<char> &> (request.octet_body()),
                breakpoint_arguments);

// Send command
command_requester->send_request(request);
```

Once *Replay Service* has jumped to "breakpoint_beforeSample100", we need to execute the "continue" operation to resume replaying from sample 100 until the end.

A simple C++ example of how to use the remote administration API is available here: RTI Community Recording Service examples: Service Administration. If you want to reproduce this scenario using this example you can run the following command:

```
./Requester UPDATE /replay_services/remote_admin/playback:continue
./Requester UPDATE /replay_services/remote_admin/playback:goto_breakpoint --
↪goto-breakpoint "breakpoint_beforeSample100"
./Requester UPDATE /replay_services/remote_admin/playback:continue
```

4.6.7 Instance History replay

In this section, you will see instance history replay in action. For this scenario, we will need to record a database with a keyed type with only one instance. To do that, we will create an example from the following IDL:

```
struct Hello {
    long id; //@key
    long sample_number;
};
```

In order to generate the example, you need to run rtiddsgen like this:

```
>$NDDSHOME/bin/rtiddsgen -language C++11 -example <ARCH> Hello.idl
```

After generating the code, we need to make a small change in Hello_publisher.cxx, so that it only creates an instance. To do that, set `data.id` to 0, instead of to `sample_written`.

```
// Instance history example: Set data.id to 0.
data.id(0);
for (unsigned int samples_written = 0;
        !application::shutdown_requested && samples_written < sample_count;
        samples_written++) {
    // Modify the data to be written here
    // Instance history example: Remove this data.id set line.
    // data.id(static_cast<int32_t>(samples_written));
....
```

To record the scenario, we need to enable Instance indexing. Please see Section 3.3.6 for more information.

Once we have the recorded database, we can move to the replay side. We will base the scenario on the following recorded database:

```
sqlite3 json_recording/rti_recorder_default.db
sqlite> select ROWID, SampleInfo_reception_timestamp from "Example Hello@0";

1|1600635598310952678
2|1600635598460562312
3|1600635599612452987
4|1600635601310952678
....
10|1600636398330952678
```

We need to make some changes in the replay configuration to start at sample 4 and to enable instance history replay. To do that, add the following tags:

```
<data_selection>
    <time_range>
        <begin_time>
            <sec>1600635600</sec>
            <nanosec>310952678</nanosec>
        </begin_time>
    </time_range>
</data_selection>

<playback>
    <instance_history_replay>
        <enabled>true</enabled>
    </instance_history_replay>
</playback>
```

Also, the DataReader and the *Replay Service* DataWriter need to have their Durability QoS set to TRANSIENT_LOCAL in order to receive the historical sample. See Configuring QoS with XML in the *RTI Connext Core Libraries User's Manual* for more information.

Once everything was set, we can run the replay scenario. The expected output is:

```
> ./objs/<ARCH>/Hello_subscriber
[id: 0, sample_number: 3]
[id: 0, sample_number: 4]
[id: 0, sample_number: 5]
[id: 0, sample_number: 6]
.....
[id: 0, sample_number: 10]
```

Notice that you also received sample 3, which was before the start timestamp. This sample was received as part of the state of the world. If we have more than one instance, we will receive one sample per instance (if they have a valid state on that start timestamp).

4.7 Troubleshooting

4.7.1 No Input File

If *Replay Service* is started but there is no file for it to read from, it will print error messages like the ones below and then exit. It is looking for a database located in a cdr_recording directory inside your current working directory. You can fix this by creating a configuration file that specifies the correct location of your database to replay, or by changing directories to a location that contains your cdr_recording directory that contains a recording.

```
[/replay_services/default|START] create_connection:caught exception from:
    set_properties:!No valid metadata file found in directory: cdr_recording
[/replay_services/default|START] ROUTERConnection_
↪enable:(adapter=StorageAdapterPlugin, retcode=0: set_properties:!No valid␣
↪metadata file found in directory: cdr_recording
)
[/replay_services/default|START] ROUTERDomainRoute_start:!enable Connection
[/replay_services/default|START] ROUTERService_startDomainRoute:!start domain␣
↪route
[/replay_services/default|START] ROUTERService_createDomainRoute:!start␣
↪domain route
[/replay_services/default|START] ROUTERService_start:!create domain route
[/replay_services/default|START] RTI_RoutingService_start:!start routing␣
↪service
main:!!start RoutingService error
```

4.7.2 Table Not Found Errors

When recording a database with *Recording Service*, there may be topics that have no associated table, because they were discovered but were filtered out by using the `<allow_topic_name_filter>` or `<deny_topic_name_filter>` tags in Topic Group or by defining Topics (that target specific topic names). While the topic will be present in the `DCPSPublication` table in the discovery file, it won't have a corresponding table in the user-data files.

If the same topics are not filtered in *Replay Service* (by using the same `<allow_topic_name_filter>` or `<deny_topic_name_filter>` tags, or Topics), then when *Replay Service* starts it will discover the

topics without a table because they are available in the discovery information. When *Replay Service* attempts to create a stream reader for these topic(s), a failure message will be printed:

```
ROUTERConnection_createStreamReaderAdapter:(adapter=StorageAdapterPlugin,␣
↪retcode=0: Function returned NULL)
ROUTERStreamReader_enable:!create stream reader adapter
ROUTERTopicRoute_enableInput:!enable stream reader
ROUTERTopicRoute_processEvent:!enable route input
ROUTERTopicRoute_onConditionTriggered:!process event
create_stream_reader_fwd:SQLiteStorageStreamReader:!Table not found in␣
↪database files: TopicNotRecorded@0
```

These messages are harmless, they are just informing you that a table could not be found for the topic (in the example above, `TopicNotRecorded`).

To get rid of the messages, use the same Topic Group filter expressions or Topics used in *Recording Service*.

4.7.3 Receiving the data twice

When a Subscriber uses a different typename than the current typename recorded, *Replay Service* will create two sessions for the same topic.

Since TypeObject is being used, discovery completes correctly, even though there are two different type names.

The behavior in this scenario is that the data for that topic will be received twice. To prevent this, make sure the Subscriber uses the same typename that was used in the recording.

Chapter 5

Converter

5.1 Usage

This section explains how to run *Converter* from a command line. In particular, it describes:

- How to Start *Converter* (Section 5.1.1).
- *Converter* command-line parameters (Section 5.1.2).

5.1.1 Starting Converter

Converter runs as a separate application. The script to run the executable is in `<NDDSHOME>/bin`. (See Section 1.2 for the path to NDDSHOME.)

```
rticonverter [options]
```

To start *Converter* with a default configuration, enter:

```
$NDDSHOME/bin/rticonverter
```

Converter is pre-loaded with a builtin configuration that has default settings. See Section 5.2.21.

Converter is provided for both the *host* platform and, for certain architectures, the *target* platform. By default, *Converter* runs for the host platform (located in `resource/app/bin/<host>`). To configure the script to run *Converter* for a target platform (located in `resource/app/bin/<target>`), specify the target architecture in either of the following variables:

- The environment variable `CONNEXTDDS_ARCH`.
- The variable `connextdds_architecture` in the file `rticommon_config.[sh/bat]`. (The file is `resource/scripts/rticommon_config.sh` on Linux or macOS systems, `resource/scripts/rticommon_config.bat` on Windows systems.)

These instructions (configuring the script to run *Converter* for a target platform) do not apply to embedded systems; for those, see the "Building and Running" section for your platform in the Getting Started Guide Addendum for Embedded Systems. Follow the instructions for loading and running your application. (The

`rticonverter` application is already compiled; you do not need to compile it.) Copy `rticonverter` from `/resource/app/bin/<target_architecture>/rticonverter` to your target platform.

5.1.2 Converter Command-Line Parameters

The following table describes all the command-line parameters available in *Converter*. To list the available parameters, run `rticonverter -help`.

All command-line parameters are optional; if specified, they override the values of any corresponding settings in the loaded XML configuration. See Section 5.2.4 for the XML elements that can be overridden with command-line parameters.

Table 5.1: Converter Command-Line Parameters

Parameter	Description
-cfgFile <string>	Semicolon-separated list of configuration file paths. **Default:** Unspecified
-cfgName	Configuration name. This name is used to find a matching `<converter>` tag in the configuration file.
-D<name>=<value>	Defines a variable that can be used as an alternate replacement for XML environment variables, specified in the form $(VAR_NAME). Note that definitions in the environment take precedence over these definitions.
-help	Shows this help.
-verbosity <service_level>[:<dds_level>]	Controls what type of messages are logged. <service_level> is the verbosity level for the service logs and <dds_level> is the verbosity level for the DDS logs. Both can take any of the following values: • `SILENT` • `ERROR` • `WARN` • `LOCAL` • `REMOTE` • `ALL` **Default:** `ERROR:ERROR`
-version	Prints the program version and exits.

5.1.3 Working With Large Data

The built-in SQLite plugin implementation available in *Converter* is prepared to handle any type size and storage format. However, when working with large data types and massive files (or filesets), *Converter* may take a while to prepare SQL statements to work with the data, resulting in a delay when starting the conversion process.

Because of this delay, it is recommended that you index the user data tables for those large topics before running *Converter* on them. Indexing can massively improve *Converter*'s startup time for those topics. You can create the indexes offline, after Recording Service has finished recording all the data. Index the tables on the `SampleInfo_reception_timestamp` field. For example, imagine a table, `VeryLargeTopic@0`, has been created by Recording Service; you can use the following index creation statement:

```
CREATE INDEX IF NOT EXISTS [VeryLargeTopic@0_idx_rt]
        ON [VeryLargeTopic@0] (SampleInfo_reception_timestamp)
```

5.2 Converter Configuration

When you start *Converter*, you can specify a configuration file in XML format. In this file, you can specify the properties that control the behavior of the service. This section describes how to write a configuration file.

Note: *Converter* makes use of XSD files to validate the XML configuration files used to configure *Converter*. Due to the restrictions imposed by XSD schemas for XML 1.0, some of the tags used in the configuration must be grouped in order. This behavior is intended; *Converter* validates the XML files before parsing them to catch as many parsing errors as possible beforehand.

5.2.1 How to Load the XML Configuration

Converter loads its XML configuration from multiple locations. Here are the various sources of configuration files, listed in load order:

1. `[working directory]/USER_CONVERTER.xml` This file is loaded automatically if it exists.
2. `[NDDSHOME]/resource/xml/RTI_CONVERTER.xml` This file is loaded automatically if it exists.
3. One or more files (semicolon-separated) specified using the command-line parameter -cfgFile.

Note: `[working directory]` indicates the path to the current working directory from which you run *Converter*.

`[NDDSHOME]` indicates the path to your *Connext* installation. See Section 1.2.

You may use a combination of the above sources and load multiple configuration files.

Here is an example configuration file. You will learn the meaning of each line as you read the rest of this section.

```
<?xml version="1.0" encoding="UTF-8"?>

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

    <!-- Available types -->
    <types />

    <!--  A definition of a Converter instance to run -->
    <converter name="defaultToJson">
```

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```
        <!--  Input storage settings -->
        <input_storage>
            <sqlite>
                <storage_format>XCDR_AUTO</storage_format>
                <database_dir>cdr_recording</database_dir>
            </sqlite>
        </input_storage>

        <!--  Output storage settings -->
        <output_storage>
            <sqlite>
                <storage_format>JSON_SQLITE</storage_format>
                <fileset>
                    <workspace_dir>converted</workspace_dir>
                    <filename_expression>rti_recorder_default.converted.db</
↪filename_expression>
                </fileset>
            </sqlite>
        </output_storage>

        <!--  Domain selection: assume 0 by default.
              Converter is not a DDS application, so this won't create a
              DDS Domain Participant, but allows you to select which domains
              to convert -->
        <domain_participant name="Domain0">
            <domain_id>0</domain_id>
        </domain_participant>

        <session name="DefaultSession"
                 default_participant_ref="Domain0">
            <!-- Topics to convert in this session -->
            <topic_group name="DefaultTopicGroup">
                <!-- Rules describing the topics to convert -->
                <allow_topic_name_filter>*</allow_topic_name_filter>
                <deny_topic_name_filter>rti/*</deny_topic_name_filter>
            </topic_group>
        </session>

    </converter>
</dds>
```

5.2.2 XML Syntax and Validation

The XML representation of DDS-related resources must follow these syntax rules:

- It shall be a well-formed XML document according to the criteria defined in clause 2.1 of the Extensible Markup Language standard.
- It shall use UTF-8 character encoding for XML elements and values.
- It shall use `<dds>` as the root tag of every document.

To validate the loaded configuration, *Converter* relies on an XSD file that describes the format of the XML content. We recommend including a reference to this document in the XML file that contains the service's configuration; this document provides helpful features in code editors such as Visual Studio®, Eclipse®, and NetBeans®, including validation and auto-completion while you are editing the XML file.

The XSD definitions of the XML elements are in `$NDDSHOME/resources/schema/rti_converter.xsd`.

To include a reference to the XSD document in your XML file, use the attribute `xsi:noNamespaceSchemaLocation` in the `<dds>` tag. For example:

```
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"␣
↪xsi:noNamespaceSchemaLocation="../schema/rti_converter.xsd">
    <!-- ... -->
</dds>
```

5.2.3 Builtin Configuration of Converter

Converter comes pre-configured with a configuration that converts a file called rti_recorder_default.db from XCDR format to a file called rti_recorder_default_converted.db in JSON_SQLITE format. See Section 5.2.21 for details.

5.2.4 XML Tags for Configuring Converter

This section describes the XML tags you can use in a *Converter* configuration file. Figure 5.1 and Table 5.2 describe the top-level tags allowed within the root `<dds>` tag.

Table 5.2: Top-Level Tags in Converter's Configuration file

Tags within <dds>	Description	Multiplicity
<types>	Defines types that can be used by *Converter*. This tag is needed if data types are not available in the discovery table. The type description is done using the *Connext* XML format for type definitions. See Creating User Data Types with Extensible Markup Language (XML) in the *RTI Connext Core Libraries User's Manual*.	0..*
<plugin_library>	Contains a list of storage libraries that you may have implemented to support custom databases. For more information, see Section 3.3.12 and Section 4.3.15.	0..*

<converter>	**Required**. Specifies a *Converter* configuration.
	Attributes
	• `name`: uniquely identifies a *Converter* configuration. **Required**.
	Example
	`<converter name="ConvertAll">`
	`</converter>`
	See Section 5.2.5.
		1..*

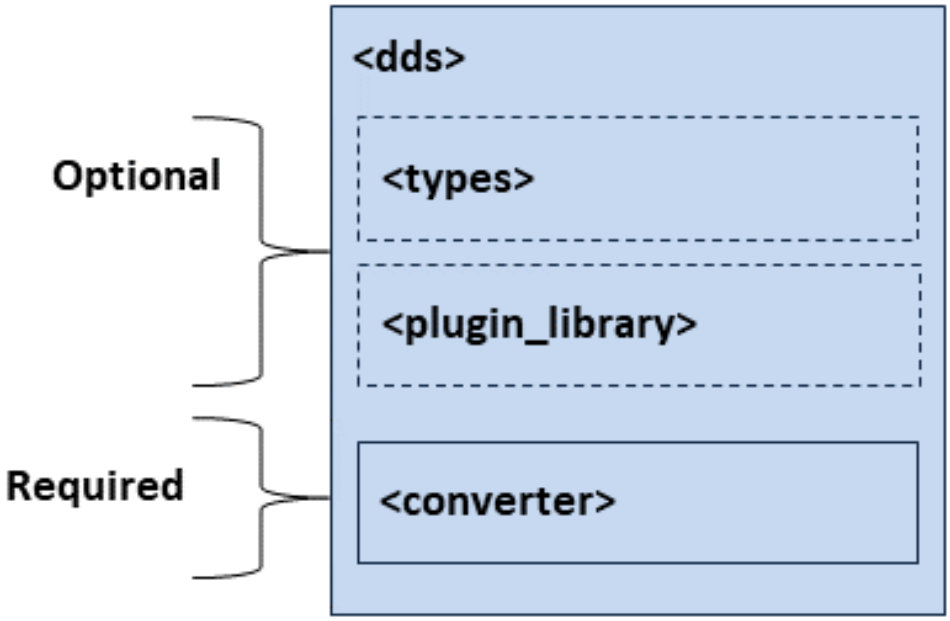

Figure 5.1: Top-level Tags in the *Converter* Configuration File

5.2.5 Converter Tag

A configuration file must have at least one `<converter>` tag. This tag is used to configure an execution of *Converter*.

A configuration file may contain multiple `<converter>` tags. When you start *Converter*, you can specify which `<converter>` tag to use to configure the service using the `-cfgName` command-line parameter. This means one file can be used to configure multiple *Converter* executions.

Figure 5.2 and Table 5.3 describe the tags allowed within a `<converter>` tag.

Table 5.3: Converter Tags in Converter's Configuration File

Tags within <converter>	Description	Multiplicity
<input_storage>	Describes the storage that *Converter* will read as input. *Converter* expects the storage to be in CDR (binary) format. If storage is not specified, data will be stored in a SQLite file using a default name. See Section 5.2.6.	0..1
<output_storage>	Describes the storage that *Converter* will write as output. This output will be in JSON format. If this storage is not specified, data will be stored in a SQLite file using a default name. See Section 5.2.7.	0..1

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Tags within <converter>	Description	Multiplicity
<data_selection>	Enables selection of a subset of data to convert. Supports selecting data for conversion by time (or tagged time). See Section 5.2.15.	0..1
<session>	Allows you to create one or more sessions in which to convert data, which gives you the option of specifying multiple threads for conversion. See Section 5.2.18. **Attributes:** • `name`: Uniquely defines a session. **Required**. • `default_participant_ref`: Refers to a `domain_participant` tag, that specifies the domain ID to use from the database when converting this Topic. Children can override this by specifying their own participant.	0..*
<domain_participant>	**Required.** Describes the domains *Converter* will select for conversion. *Converter* is not a DDS application so this definition will not create a DDS Domain Participant, it just works as a domain ID selection utility. *Note*: the domain ID has to correspond to one of the domain IDs defined in the Recorder configuration. See Section 5.2.17. **Attributes:** • `name`: Uniquely defines a DomainParticipant. **Required**.	1..*

Example: Specify a Configuration in XML

```
<dds>
    <converter name="ConvertToJSON">
        <!-- ... Required entities -->
    </converter>
</dds>
```

Starting *Converter* with the following command will use the `<converter>` tag with the name "ConvertToJSON".

```
$NDDSHOME/bin/rticonverter -cfgFile file.xml -cfgName ConvertToJSON
```

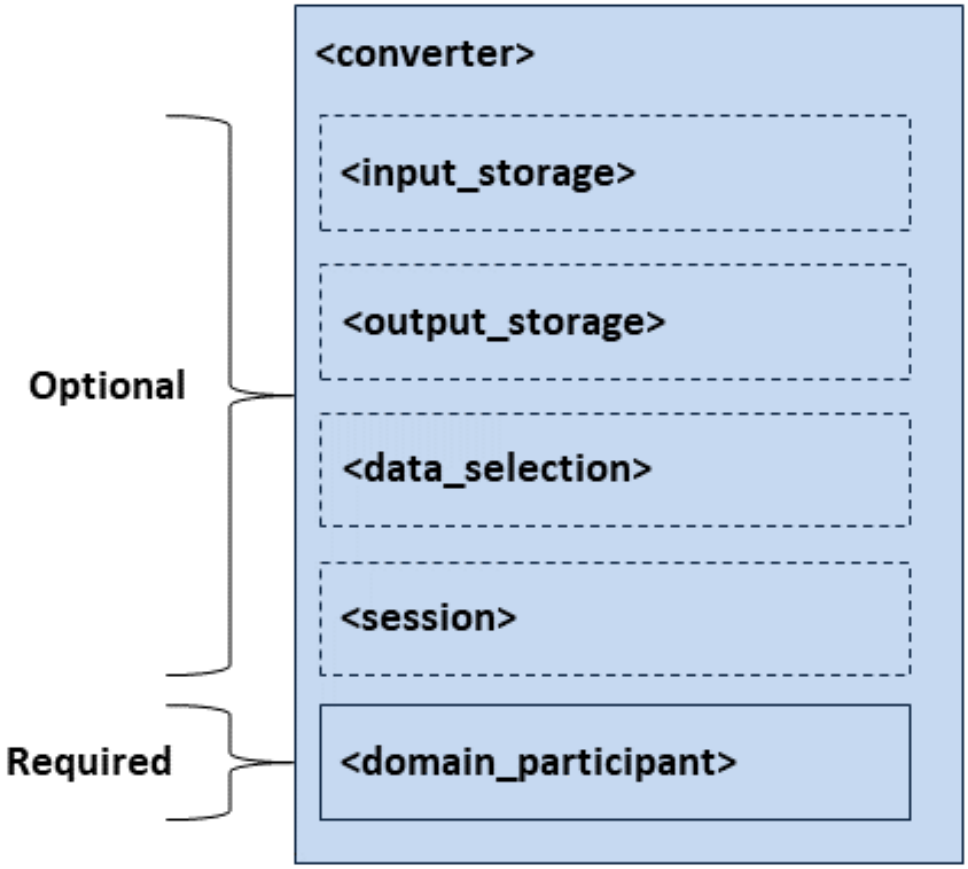

Figure 5.2: Converter Tags in the *Converter* Configuration File

5.2.6 Input Storage

The `<input_storage>` tag allows you to configure the storage from which data will be read. You can choose between using the builtin SQLite storage or implementing your own storage plugin.

Table 5.4: Input Storage Tags in Converter's Configuration File

Tags within <input_storage>	Description	Multiplicity
<sqlite>	Enables converting data from an SQLite database file. See Section 5.2.8.	0..1
<legacy>	Enables converting data from a legacy version of *Recording Service* to a database usable by this version. See Section 5.2.12.	0..1
<plugin>	Enables converting data from storage using an external library that you specify. See Section 5.2.14.	0..1
<max_samples_per_read>	Specifies the maximum number of samples to be returned by the read() operation. When the recorded tables contain huge amounts of samples, this setting can help improve the responsiveness of *Converter*, because the tool won't - for each table - attempt to get all samples at once. If not specified, the default value is 1024 samples. A negative value means an unlimited number of samples.	0..1

5.2.7 Output Storage

The `<output_storage>` tag allows you to configure the storage into which converted data will be written. You can choose between using the builtin SQLite storage, CSV storage utility plugin or implementing your own storage plugin.

Table 5.5: Output Storage Tags in Converter's Configuration File

Tags within <output_storage>	Description	Multiplicity
<sqlite>	Enables writing converted data into an SQLite database file. See Section 5.2.8.	0..1
<csv>	Enables writing converted data with CSV format into a text file. See Section 5.2.9.	0..1
<plugin>	Enables writing converted data into storage of your choosing, using a plugin library that you specify. See Section 5.2.14.	0..1

5.2.8 SQLite

The <sqlite> tag allows you to specify the name and file extension of a SQLite file to read data from, or write data to. Currently, the only storage format supported for input is CDR, and the only format supported for output is JSON.

Table 5.6: SQLite Tags in Converter's Configuration File

Tags within <sqlite>	Description	Multiplicity
<fileset> (output only)	Set of files to write to, and parameters for creating files and directories in that set. Used when creating more than one output file. See Section 5.2.10.	0..1
<file> (output only)	Name of file to write converted database file(s) to. Used when creating only a single output file. Default: rti_recorder_default_converted	0..1
<file_suffix> (output only)	Suffix of the output file. Used when creating only a single output file. Default: dat	0..1
<database_dir> (input only)	Directory containing file(s) to convert. Default: Current working directory.	0..1
<storage_format>	Specifies what format the data is stored in. The options are: • [Input Default] XCDR_AUTO: This is the binary format used by *Connext* when sending data over the network. This has the highest performance for recording, but can only be viewed by using *Converter* to convert the data to a readable format, or by using *Replay* to replay the data. This will internally store data in XCDR or XCDR2 depending on the format received. • JSON_SQLITE: This format can be queried, but recording in this format has lower performance because data must be deserialized before it can be stored. • XCDR: The format to use when communicating with *Connext* before 6.0.0. • XCDR2: More efficient than XCDR, used by *Connext* 6.0.0 and later.	0..1
<overwrite_policy_kind>	Defines what to do when database files are already present in the current Converter execution directory. **There are two options:** • OVERWRITE: delete old files and replace them with newly created ones. • DO_NOT_TOUCH: do not delete any old files and just exit. Default: OVERWRITE	0..1

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Table 5.6 – continued from previous page

Tags within <sqlite>	Description	Multi-plicity

<sql_initialization_string>	Configures a SQL expression to use when establishing SQLite connections using this plugin. You can use this to add an index to a table to speed up replay, but this must be done for each table you want to index.
	Example:
	`<sql_initialization_string>`
	`DROP INDEX IF EXISTS pingtopic_0_by_src_timestamp;`
	`CREATE INDEX pingtopic_0_by_src_timestamp ON 'PingTopic@0' (SampleInfo_source_timestamp);`
	`</sql_initialization_string>`
	Default: PRAGMA SYNCHRONOUS = OFF; PRAGMA JOURNAL_MODE = MEMORY;
		0..1

5.2.9 CSV

The CSV storage utility plugin allows you to specify where to output the converted files, whether to merge them, the basename prefix, and other conversion settings. The table below describes the various configuration tags.

Note: Exporting to CSV and unbounded sequences

The CSV storage plugin creates a set of columns for every field in the exported type. When the type contains unbounded sequences, an infinite number of columns may be exported. To avoid this issue, the CSV storage plugin limits the number of elements printed for unbounded sequences. By default, the limit is set to 1000 elements. If the number of elements in the sequence exceeds this limit, the plugin prints the first 1000 elements. To change the limit, use the `<unbounded_seq_size_limits>` tag.

Table 5.7: CSV storage utility tags in Converter's Configuration File

Tags within <fileset>	Description	Multiplicity
<workspace_dir>	Absolute or relative path to where generated file(s) are placed. Default: **.** (working directory)	0..1
<file_basename>	Prefix for the name of the generated file(s). The file generated for each topic has the following name: `[file_basename]-[TOPIC_NAME].csv` If <merge_files> is set to true, then the final file name is equal to `[file_basename].csv`. Default: **csv_converted**	0..1
<merge_files>	Specifies whether the generated files shall be consolidated into a single file. Default: **false**	0..1
<default_member_value>	Sets the value used for data members that are not present or empty. Default: **nil**	0..1
<enum_as_string>	Indicates whether values for enumeration members are printed as their corresponding label string or as an integer. Default: **true**	0..1
<include_source_timestamp>	Indicates whether the source timestamp shall be included in the output file. Default: **false**	0..1

<unbounded_seq_size_limits>	Specifies a collection of expressions with the maximum number of elements to be printed for unbounded sequences.
	Example:
	`<unbounded_seq_size_limits>`
	`<!-- Will match myStruct.mySequence -->`
	`<field_name_expr max_size="10">*mySequence</field_name_expr>`
	`<!-- Will match myStruct.vectorOfSequences[0], myStruct.vectorOfSequences[1], etc -->`
	`<field_name_expr max_size="20">*vectorOfSequences\[*\]</field_name_expr>`
	`</unbounded_seq_size_limits>`
	Subtags:
	• `<field_name_expr>`
	• Defines a POSIX® fnmatch pattern. The size of unbounded sequence fields that match this pattern is limited to the value specified in the `max_size` attribute (integer, required).
	• Multiplicity: 1..*
	• Default max size for unbounded sequence fields that don't match any expressions is **1000**.
		0..1

To learn more about the CSV storage utility plugin see Section 7.1.1.

5.2.10 Fileset

The `<fileset>` tag allows you to specify a set of files for *Converter* to write to.

The behavior allowed by *Converter* is more limited than the behavior allowed by *Recording Service*.

Table 5.8: Fileset Tags in Converter's Configuration File

Tags within <fileset>	Description	Multiplicity
<workspace_dir>	**Required**. Base directory where *Converter* should output files. Must be different from the input `database_dir` directory. Default: The current working directory	1

<filename_expression>	**Required**. The file name *Converter* will use for the generated user data file(s). This expression in combination with the rollover configuration will determine how many (and the names of) files *Converter* will output. This setting accepts text and any combination of the following parameters in it:
	• Autonumeric. **Format: %auto:M%.** This parameter describes an integer that auto-increments every time *Converter* has a rollover event due to time or file size.
	Example:
	`<filename_expression>`
	`test_files_%auto:0%.db`
	`</filename_expression>`
	This will create a series of files starting with test_files_0.db, and incrementing each time *Converter* rolls over (due to the file size or time limits being reached).
	• Timestamp. **Format: %ts%.** This parameter will take the current timestamp in the system (the time represented as number of seconds since Epoch).
	• Time. **Format: %T%.** Current time expressed in ISO 8601 time format (THHMMSS). Example: T145502. This parameter uses the strftime() parameter %T.
	• Short date. **Format: %F%.** Short date in YYYY-MM-DD format. Example: 2001-08-23. This parameter uses the strftime() parameter %F. **Note:** this parameter will not vary in 24 hours, so use with caution in combination with the rollover time limit feature (time limit should be greater than 1 day; otherwise, you may overwrite the same file continously).
	• Date and time. **Format: %c%.** Date and time representation, locale-dependent. This parameter is based on the strftime() parameter %c, but we use the time expressed in ISO 8601 format (THHMMSS). Example: Thu Aug 23 T145502 2001
	Default: rti_recorder_default_%auto:0%.db (auto-numeric starting at zero, unlimited)
		1

<rollover>	Configuration for rolling over the file after a size limit is reached. See Section 5.2.11.	0..1

5.2.11 Rollover

Rollover enables *Converter* to write to the next file in a set when a limit is reached. *Converter's* rollover functionality is decoupled from the files that are input, so many files may be merged into one, or one file may be split into many depending on *Converter's* rollover configuration. Currently *Converter* supports rolling over by size.

Table 5.9: Rollover in Converter's Configuration File

Tags within <rollover>	Description	Multiplicity
<file_size_limit>	The maximum allowed size for a file in a set. Units can be specified as an attribute. **Attributes:** • unit: (Optional) The unit in which the size is expressed. The following values are allowed (Default: `KILOBYTES`): – `BYTES` – `KILOBYTES` – `MEGABYTES` – `GIGABYTES` **Example:** `<file_size_limit unit="KILOBYTES">500 </file_size_limit>`	0..1

5.2.12 Legacy

This tag configures how legacy databases are converted to the newer format. (Note: You can continue to use the older format with *Replay*, by specifying "legacy" storage in *Replay's* configuration.)

Table 5.10: Legacy in the Configuration File

Tags within <legacy>	Description	Multiplicity
<file_path>	The path to a legacy file to be converted. File set and version properties will be obtained automatically from the file itself.	0..1
<domain_mapping>	This tag allows you to link legacy domain names with domain IDs. See Section 5.2.13.	0..1

5.2.13 Domain Mapping

When converting a legacy database, the domain may not have been recorded. This tag provides a way to map a table with a domain ID.

Later versions of the old Recorder database allowed you to use field filters. By default, the domain ID field was not recorded (it was filtered out by default). Thus, there is no information available in these legacy databases to relate the domain name used to record the data with a domain ID. This tag allows you to link legacy domain names with domain IDs.

Table 5.11: Domain Mapping in the Configuration File

Tags within <domain_mapping>	Description	Multiplicity
<domain_map>	**Required**. A link between a recorded legacy domain name and a domain ID. **Attributes:** • `legacy_domain_name`: The recorded domain name specified in the old Recording Service domain tag, for example: <domain name="domain0">. • `domain_id`: The domain ID you want to associate with the legacy domain name.	1..*

5.2.14 Plugin

This tag enables you to convert data using an external library that you specify.

Table 5.12: Storage plugin Tag in the Configuration File

Tags within <plugin>	Description	Multiplicity

<property>	Name/value pairs of properties to pass to a storage plugin.
	Example:
	`<property>`
	`  <value>`
	`  <element>`
	`  <name>Name</name>`
	`  <value>Value</value>`
	`  </element>`
	`  </value>`
	`</property>`
		0 or 1

5.2.15 Data Selection

This tag selects what data to convert from the database, based on a time range.

Table 5.13: Data Selection Tags in Converter's Configuration File

Tags within <data_selection>	Description	Multiplicity
<time_range>	Select data to convert from the database, based on start and end times. See Section 5.2.16.	0..1

5.2.16 Time Range

The `<time_range>` tag allows you to specify the begin and end times of the data you want to convert. This can be specified either as timestamps or as symbolic timestamps called "timestamp tags." Tags may have been added to the recording through remote administration, and can be viewed using the script `rtirecordingservice_list_tags` (see Section 3.6.7).

Table 5.14: Time Range Tags in Converter's Configuration File

Tags within <time_range>	Description	Multiplicity
<begin_time>	Select data to convert from the database, with a timestamp beginning at this time. Specify the time in seconds and nanoseconds. Default: 0, start at beginning of the file.	0..1
<begin_tag>	Can be used instead of begin_time. Select data to start converting from the database by specifying the string name of a timestamp tag. Timestamp tags associate a timestamp with a name. Then you can refer to a timestamp by that name. The timestamp must have been tagged with that name during recording. See Section 3.6.6. Default: Start at beginning of the file.	0..1
<end_time>	Select data to convert from the database, with a timestamp ending at this time. Specify the time in seconds and nanoseconds. Default: End at end of file.	0..1
<end_tag>	Can be used instead of end_time. Select when to stop converting data by specifying the string name of a timestamp tag. Timestamp tags associate a timestamp with a name. Then you can refer to a timestamp by that name. The timestamp must have been tagged with that name during recording. See Section 3.6.6. Default: Stop at end of file.	0..1

5.2.17 DomainParticipant

The <domain_participant> tag allows you to specify the domain IDs you want to convert from the database. Specify a name for the DomainParticipant, and the domain_id you want to convert. Associate the DomainParticipant name with a session, topic or topic_group that you want to convert, to convert data within a domain.

This does not create a DDS DomainParticipant.

Table 5.15: DomainParticipant Tags in Converter's Configuration File

Tags within <domain_participant>	Description	Multiplicity
<domain_id>	The domain ID of tables loaded from the database. This is used to determine which domain IDs to convert.	1
<register_type>	Registers a type name and associates it with a type representation. When you define a type in the configuration file, you have to register the type in order to use it in a <topic>. **Attributes:** • name: Name that the data type is registered with if no <registered_name> is specified. The same data type may be registered with different names. **Required**. • type_ref: Definition of this data type. It must refer to one of the defined types in the <types> section by specifying the fully qualified name. **Tags within this tag:** • <registered_name>: Name the data type is registered with. The same data type may be registered with different names. Not required.	0..*

5.2.18 Session

The <session> tag configures the threads that will be used to convert data. You also specify the Topics and groups of Topics to convert inside the <session> tag.

Table 5.16: Session Tags in Converter's Configuration File

Tags within <session>	Description	Multiplicity
<thread_pool>	Specifies the number of threads used by this session, and the settings used when creating them. **Note:** The default SQLite storage plugin requires sequential access. Because of this, setting the thread pool **size** to a value greater than **1** has no practical effect on performance when using the built-in SQLite plugin. Increasing the thread pool size only improves performance when using a custom storage plugin that supports concurrent access.	0..1
<topic>	Specifies an individual Topic to convert. See Section 5.2.20. **Attributes:** • `name`: The name of the Topic to convert. • `participant_ref`: Refers to a `domain_participant` tag, that specifies the domain ID to use from the database when converting this Topic. If the parent `<session>` specifies a `default_participant_ref`, this attribute is optional.	0..*
<topic_group>	Specifies a group of Topics to convert. See Section 5.2.19. **Attributes:** • `name`: The name of the topic group. • `participant_ref`: Refers to a `domain_participant` tag, that specifies the domain ID to use from the database when converting this Topic. If the parent `<session>` specifies a `default_participant_ref`, this attribute is optional.	0..*

5.2.19 Topic Group

The `<topic_group>` tag allows you to convert a group of Topics, using regular expressions to describe which Topics to convert.

Table 5.17: Topic Group Tags in Converter's Configuration File

Tags within <topic_group>	Description	Multiplicity

<allow_topic_name_filter>	A regular expression (fnmatch) describing which Topics should be converted. You may use a comma-separated list to specify more than one filter.
	Example:
	`<topic_group name="ConvertAll">`
	`  <allow_topic_name_filter>CONTROL_*,DATA_*</allow_topic_name_filter>`
	`</topic_group>`
		0..1

<deny_topic_name_filter>	A regular expression (FNMATCH) describing which Topics should not be converted. This is applied after the `allow_topic_name_filter`. You may use a comma-separated list to specify more than one filter.	0..1

5.2.20 Topic

The `<topic>` tag specifies an individual Topic to convert.

Table 5.18: Topic Tags in Converter's Configuration File

Tags within <topic>	Description	Multiplicity
<topic_name>	The name of the DDS topic to be converted. If this tag is not present, the name attribute of the *<topic>* will be used. *Note*: we recommend using this tag to define the topic name. There may be characters that cause the XML validation to fail if they are part of the topic name attribute. Also, the '/' character and '::' separator may cause Converter to fail when found in the topic name attribute.	0..1
<registered_type_name>	The name of the data type that will be converted for this topic. **Required**.	1

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Tags within <topic>	Description	Multiplicity

<transformation>	The transformation library to be applied to this Topic's data when converting. This is a user library that can modify the data after it is received from input storage and before it is sent to output storage.
	Transformations implement APIs identical to *Routing Service's* transformations. For more on using transformations, see these sections in the *RTI Routing Service User's Manual*:
	• Data Transformation
	• Tutorials
	Attributes:
	• `plugin_name`: The name of the plugin to load, qualified by the plugin library name.
	Example:
	`<dds>`
	`  <plugin_library name="ConverterTransformations">`
	`  <transformation_plugin name="ModifyTestID">`
	`  <create_function>ModifyTestID_create</create_function>`
	`  <dll>modify_test_id_library</dll>`
	`  </transformation_plugin>`
	`  </plugin_library>`
	`  <!-- ... -->`
	`  <converter>`
	`  <!-- ... -->`
	`  <topic name="TestTopic">`
	`  <transformation plugin_name="ConverterTransformations::ModifyTestID" />`
	`  </topic>`
	`  </converter>`
	`</dds>`
		0..1

5.2.21 Converter's Builtin Configuration Details

Converter comes with a builtin configuration, which selects the name of an input file to convert from and an output file to convert to. The 'defaultToJson' configuration specifies JSON SQLite format by default as the output format, with 'rti_recorder_default.db' as the input file and 'rti_recorder_default_converted.db' as the output file. It expects to find the file(s) to convert in a directory called 'cdr_recording'. This is the default directory when recording in XCDR format in the default Recorder configuration.

```
<?xml version="1.0" encoding="UTF-8"?>

<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="http://community.rti.com/schema/6.0.0/rti_
↪converter.xsd">
```

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```
    <!-- Available types -->
    <types />

    <!--  A definition of a Converter instance to run -->
    <converter name="defaultToJson">
        <!--  Input storage settings -->
        <input_storage>
            <sqlite>
                <storage_format>XCDR_AUTO</storage_format>
                <database_dir>cdr_recording</database_dir>
            </sqlite>
        </input_storage>

        <!--  Output storage settings -->
        <output_storage>
            <sqlite>
                <storage_format>JSON_SQLITE</storage_format>
                <fileset>
                    <workspace_dir>converted</workspace_dir>
                    <filename_expression>rti_recorder_default_converted.db</
↪filename_expression>
                </fileset>
            </sqlite>
        </output_storage>

        <!--  Domain selection: assume 0 by default -->
        <domain_participant name="Domain0">
            <domain_id>0</domain_id>
        </domain_participant>

    </converter>
</dds>
```

5.3 Tutorials

5.3.1 Using Timestamp Tags with Converter

If your recording was originally made with the builtin SQLite storage plugin, and you used the tag_timestamp remote command to tag certain events, then your recording contains timestamp tags: symbolic timestamp names you can use in place of timestamps expressed in units of time. For more information on timestamp tags, see Section 3.6.6.

You can list the timestamp tags that are in your recorded database by using the `rtirecordingservice_list_tags` script. Use the `-d` argument to point to the directory that contains your recorded database, as follows:

```
<NDDSHOME>/bin/rtirecordingservice_list_tags -d /database/directory/
```

Note: To use the `rtirecordingservice_list_tags` command-line utility, the SQLite3 executable must be installed and included in the `PATH` environment variable. SQLite3 is not included in RTI installers; to download it, go to the SQLite download page. To learn more about SQLite3, go to the SQLite CLI page.

This command will analyze the recording in /database/directory/ and list the details of the timestamp tags in the recording, including the tag names, their descriptions, and associated timestamps.

You can use the tag_name of the tags you find in a recording when you are creating an XML configuration file for *Converter* by using a `<data_selection>` tag.

For example, if after running `rtirecordingservice_list_tags`, you see output such as:

```
tag_name                    timestamp_ms   tag_description
--------------------------  -------------  -----------------------
/my_example/my_events/tag1  1546484663309  first tag description
/my_example/my_events/tag2  1546484703360  a second tag description
```

Then you can have a `<data_selection>` tag in your XML for *Converter*, after the `<output_storage>` tag, that looks like the following:

```
<data_selection>
    <time_range>
        <begin_tag>/my_example/my_events/tag1</begin_tag>
        <end_tag>/my_example/my_events/tag2</end_tag>
    </time_range>
</data_selection>
```

Converter will convert data between those tags. Note that when expressing a `<time_range>` tag, you can mix and match timestamps and tags. For example, you can use a `<begin_tag>` (by referring to a tag_name) to express the time when conversion should begin, and use an `<end_tag>` with an end_time timestamp (expressed in time units) to specify when conversion should end. If you do not provide one of the bounds, the start of recording is the default begin bound, and the end of recording is the default end bound.

5.4 Troubleshooting

5.4.1 Table Not Found Errors

When recording a database with *Recording Service*, there may be topics that have no associated table, because they were discovered but were filtered out by using the `<allow_topic_name_filter>` or `<deny_topic_name_filter>` tags in Topic Group or by defining Topics (that target specific topic names). While the topic will be present in the `DCPSPublication` table in the discovery file, it won't have a corresponding table in the user-data files.

If the same topics are not filtered in *Converter* (by using the same `<allow_topic_name_filter>` or `<deny_topic_name_filter>` tags, or Topics), then when *Converter* starts it will discover the topics without a table because they are available in the discovery information. When *Converter* attempts to create a stream reader for these topic(s), a failure message will be printed:

```
ROUTERConnection_createStreamReaderAdapter:(adapter=StorageAdapterPlugin,␣
↪retcode=0: Function returned NULL)
ROUTERStreamReader_enable:!create stream reader adapter
ROUTERTopicRoute_enableInput:!enable stream reader
ROUTERTopicRoute_processEvent:!enable route input
ROUTERTopicRoute_onConditionTriggered:!process event
create_stream_reader_fwd:SQLiteStorageStreamReader:!Table not found in␣
↪database files: TopicNotRecorded@0
```

These messages are harmless, they are just informing you that a table could not be found for the topic (in the example above, `TopicNotRecorded`).

To get rid of the messages, use the same Topic Group filter expressions or Topics used in *Recording Service*.

Chapter 6

XML Converter

Recording Service includes an application to convert a legacy XML configuration to the current XML configuration format when possible. It can convert a recording XML configuration, as well as a replay XML configuration.

6.1 Running the XML converter

XML Converter runs as a separate application. The script to run the executable is in <NDDSHOME>/bin. (See Section 1.2 for the path to NDDSHOME.)

```
rtixmlconverter record|replay [options]
```

If you are using features that are not available in Recording Service, you will see warnings such as:

```
Warning: Recording Service does not currently support 'verbosity' in
XML. However, you can specify -verbosity at the command-line.
```

6.2 XMLConverter Command-Line Parameters

The following table describes all the command-line parameters available for the *XML Converter*. To list the available parameters, run `rtixmlconverter -help`.

Table 6.1: XML Converter Application Command-Line Parameters

Parameter	Description
record|replay	**Required**. Which application's configuration file to convert.
-cfgFile	**Required**. The legacy configuration file to be converted.
-cfgFileOut	**Required**. The name of the generated configuration file.
-help	Shows help for the command.
-version	Prints the program version and exits.

Chapter 7

Storage Utility Plugins

This module contains information about the various *Recording Service* Storage Plugins that are shipped in a separate library called `rtistorageutils`. This library is meant to be an extension of the capabilities supported by *RTI Recording Service* out-of-the-box. It is located under `<NDDSHOME>/lib` like other *RTI Connext®* libraries.

In this release, there is one plugin for CSV format. Other plugins may be added in future releases.

Note: The different executables shipped with *Recording Service* will perform run-time loading for `rtistorageutils` if you use one of these Storage Utility Plugins in your XML configuration. Thus make sure that `<NDDSHOME>/lib/<architecture>` is included in your system's library search path. See Section 7.2.1.

7.1 Storage Utility Plugins

7.1.1 CSV

This is a type of output storage plugin that stores the data provided to it in comma-separated value (CSV) format. It is meant to be used with *Converter* to perform conversion of a recorded database into CSV output files. Typically, it helps solve use cases like offline analysis or incident investigation. For more information about the configuration tags, see Section 5.2.9.

By default, the plugin generates a separate CSV file for each recorded *Topic*. The content and format of each file is as follows:

Table 7.1: CSV file format

Row 1: Topic Entry	`Topic name: <Name>`				
Row 2: Type Header	`timestamp`	`member1`	`member2`	…	`memberN`
Row 3: Data values	Reception timestamp of the sample (in nanoseconds)	Value for member1	Value for member2	…	Value for memberN

The filename matches the *Topic* name, with a `.csv` extension. All the files are placed in a directory that can be specified in the plugin configuration.

Note: If the *Topic* name contains characters that cannot appear in the file name because they are reserved by the underlying operating system, these characters will be replaced by the token `#`.

Mapping a data sample into columns

General case

As shown in the table above, a data sample is represented in a single row comprised of multiple columns. Each cell holds only a value for a *final* or leaf member in a complex data type. That is, for a member whose type is a *Simple* type (integer, char, short), enumeration, or *String*.

Each data value in a cell corresponds to a member whose name is in the type header. Given a complex data type, the name for a member is constructed as follows:

```
<parent_member1>.<parent_member2>...<parent_memberN>.<final_member>
```

where `<parent_member>` is the name of the parent complex member that contains the subsequent member.

If either `<parent_member>` or `<final_member>` is a *Collection* type (array or sequence), the member name is suffixed with `[<index>]`, and a column for each possible element in the *Collection* is created.

For example, consider the following type described in IDL:

```
struct NestedStruct {
    long m_long;
};

struct TopLevelStruct {
    String m_string;
    long m_array[2];
    NestedStruct m_complex;
    NestedStruct m_complex_array[2];
};
```

The resulting type header row will look like this:

m_string	m_array[0]	m_array[1]	m_complex.a_long	m_complex_array[0].a_long	m_complex_array[1].a_long

Note: Considerations about collection types

Due to the column consistency required by the CSV format, mapping a collection type **requires us to generate as many columns as the number of elements that can be present in the collection**, even if for a given data sample only a few of them are present (such as for a `Sequence` type). If the recorded type has collections with large sizes, the generated file may hit the column limit of some CSV processors.

Sequences

Mapping a `Sequence` type is based on the mapping of a *Collection* type explained above, plus an additional column to indicate the length of the sequence. That is:

```
.<seq_member.length>.<seq_member[0]>...<seq_member[N-1]>
```

where the column `<seq_member.length>` indicates how many elements are set in the sequence (the number of columns with non-null values) and `N` is the maximum length of the sequence.

For example, consider the following type described in IDL:

```
struct StructType {
    sequence<long, 4> m_seq;
};
```

The resulting type header row will look like this:

m_seq.length	m_seq[0]	m_seq[1]	m_seq[2]	m_seq[3]

Note: Compatibility with unbounded sequences

Unbounded sequences cannot be handled by a column-based format like CSV (because infinite columns cannot be exported). Therefore, the size of the exported sequence has to be limited. The configuration offers the option to set the maximum size for any unbounded sequence found while processing the data. For more information, see Section 5.2.9.. ` (tag `<unbounded_seq_size_limits>`). The default maximum size for unbounded sequence fields is 1000.

Unions

The mapping of a `Union` type is similar to a `Struct` type except that a discriminator column with name `_d` is placed before all the members.

For example, consider the following type described in IDL:

```
union UnionType switch (long) {
    case 0:
    long case1;

    case 1:
    StructType case2;

    default:
    long case_default;
};

struct StructType {
    UnionType m_union;
};
```

The resulting type header row will look like this:

m_union._d	m_union.case1	m_union.case2	m_union.default

Data Values

For a given data sample, the value for each member is placed under the corresponding column represented as a `String`, which applies to all primitive types. For primitive types, the output text will correspond to the standard conventions for the type (for example, decimal point for floating point numbers, single quotes around a character, etc.). By default, enumerations are printed with their corresponding text label. This behavior for enums is configurable.

There may not be values for every column in a sample. This may occur for the following situations:

- A Sequence member that does not contain all the possible elements.
- A Union member, which can only set a member at a time.
- An optional member, which may or may not be set.

By default, the value of an empty member is represented as `nil`.

For example, consider the following type described in IDL:

```
struct StructType {
    sequence<long, 2> m_sequence;
    @optional String m_optional;
};
```

And two samples with the following values (represented in JSON):

```
{
    "m_sequence": [1, 2],
    "m_optional": "hello"
}

{
    "m_sequence": [1],
    "m_optional":
}
```

The resulting type header row and the two data value rows will look like this:

m_sequence.length	m_sequence[0]	m_sequence[1]	m_optional
2	1	2	hello
1	1	nil	nil

7.2 Tutorials

7.2.1 Using the CSV storage utility plugin with Converter

If you have a recorded database in any of the binary CDR serialized formats, it is pretty difficult to analyze the recorded data without replaying it. While there is an option to convert the recorded database to JSON (see Section 5.2.21), you can also convert it to CSV format.

The *Converter* can convert an XCDR database to CSV format using a default configuration called `sqlite-ToCsv`.

Setup

We need to make sure `rtistorageutils` can be loaded dynamically by `rticonverter`, set the library search path variable as follows:

Linux

```
export LD_LIBRARY_PATH=$LD_LIBRARY_PATH;<NDDSHOME>/lib/<architecture>
```

macOS

```
export DYLD_LIBRARY_PATH=$DYLD_LIBRARY_PATH;<NDDSHOME>/lib/<architecture>
```

Windows

```
set PATH=%PATH%;<NDDSHOME>\lib\<architecture>
```

Note: `<NDDSHOME>` is described in section Section 1.2.

Execution

To demonstrate the functionality we first need to record some data. Run *Shapes Demo* with the default configuration and publish some Triangles and Circles (using *Shapes Demo* is described in Section 3.6.1). Once *Shapes Demo* has started, run *Recording Service* as follows:

```
<NDDSHOME>/bin/rtirecordingservice
```

The default configuration should record data in a directory called `cdr_recording`.

Now run *Converter* to perform the conversion of the previously generated database into a single text file in `CSV` format:

```
<NDDSHOME>/bin/rticonverter -cfgName sqliteToCsv
```

If you need to customize the behavior of this configuration, you can do so by adding user variables to the command, as shown:

```
<NDDSHOME>/bin/rticonverter -cfgName sqliteToCsv -DCSV_WORKSPACE_DIR=my_
↪custom_dir
        -DCSV_MERGE_FILES=false -DINPUT_DIR=my_cdr_recording_dir
```

Wait until conversion of the entire input database is performed and `rticonverter` exits automatically. Upon successful conversion, you will find a folder in the current directory with the name `csv_output`. That folder will contain a file called `csv_converted.csv` containing topic data for the Triangles and Circles published earlier by the *Shapes Demo* and recorded by `rtirecordingservice`. This can be verified by opening the file using an editor of your choice.

Chapter 8

Indexing Application

Recording Service includes a command-line utility for indexing the database files.

There are two types of indexing: instance indexing and SQLite table indexing.

8.1 Indexing Instances

Instance indexing is used by *Replay Service* for the Instance History Replay (state of the world publication) feature (see Section 4.1.7 for more information). *Replay Service* will perform the indexing if the index is not present. While this may be acceptable in some cases, it can take a long time if the database is large. This command-line option offers offline indexing, which can be done before running *Replay Service*. Recall that *Recording Service* also offers a way to index instances while recording (see Section 3.3.6 for more information).

8.2 Indexing SQLite Tables

Table indexing improves the performance of *Replay Service* and *Converter* when accessing databases recorded with the builtin SQLite plugin. In this case, the indexer will go over all files and all available tables and create two SQLite indexes: one on the reception timestamp column, and another on the source timestamp column.

For a given table named `T1`, the indexer will create an index called `T1_rt_idx` based on the `SampleInfo_reception_timestamp` column, and another index called `T1_st_idx` based on the `SampleInfo_source_timestamp`.

When dealing with very large databases, having indexes on the timestamp column(s) can be extremely important because it can significantly improve performance.

8.3 Running the Indexer

The *Indexer* runs as a separate application. The script to run the executable is in `<NDDSHOME>/bin`. (See Section 1.2 for the path to NDDSHOME.)

```
rtirecordingindexer [options]
```

8.4 Indexer Command-Line Parameters

The following table describes all the command-line parameters available for the *Indexer*. To list the available parameters, run `rtirecordingindexer -help`.

Table 8.1: Indexer Application Command-Line Parameters

Parameter	Description
instances|tables	**Required**. Specifies the mode the command should work in. **Default:** instances
-dbDirectory	**Required**. The directory containing the SQLite database to be indexed.
-help	Shows help for the command.
-verbosity <service_level>[:<dds_level>]	Controls what type of messages are logged. <service_level> is the verbosity level for the service logs and <dds_level> is the verbosity level for the DDS logs. Both can take any of the following values: • `SILENT` • `ERROR` • `WARN` • `LOCAL` • `REMOTE` • `ALL` **Default:** `ERROR:ERROR`
-version	Prints the program version and exits.

Chapter 9

Software Development Kit

You can extend the out-of-the-box behavior of *Recording Service* through its *Software Development Kit* (SDK). The SDK provides a set of public interfaces that allow you to control *Recording Service* execution as well as extend its capabilities.

The SDK is divided into the following modules:

- *RTI Recording Service* Library API: This module offers a set of APIs that allow you to instantiate *Recording Service* instances in your application. This allows you to run *Recording Service* as a library.
- *RTI Recording Service* Storage API: *Storage* is a pluggable component that allows *Recording Service* to write and read data from custom storage. This module offers a set of pluggable APIs to develop custom *StorageWriter* and *StorageReader*, which you can use through shared libraries or through the Library API. By default, *Recording Service* is distributed with a builtin SQLite® storage plugin that is part of the service library.
- *RTI Recording Service* Transformation API: *Transformation*s are data-oriented pluggable components that allow you to perform conversions of the representation and content of the data that goes through *Recording Service*. This module offers a set of pluggable APIs to develop a custom *Transformation*s, which you can use through shared libraries or through the Library API.

Table 9.1 shows which modules are available for each API, along with links to the API documentation.

Table 9.1: API Documentation for the SDK

Language API	Available Modules
RTI Recording Service C API	• Storage • Transformation (see RTI Routing Service C API)
RTI Recording Service C++ API	• Library • Storage • Transformation (see RTI Routing Service C++ API)

Chapter 10

Common Infrastructure

10.1 Configuring RTI Services

RTI Services are configured using XML and offer multiple ways to load the configurations. The loading alternatives are in general standard across all RTI Services. This section covers how you can provide XML configurations to RTI Services, as well as specific behaviors on how the XML is parsed, validated, and interpreted.

10.1.1 How to Load and Select an XML Configuration

To run an RTI Service with a specific configuration you need to provide two pieces:

- **XML content with one or more configurations** This is the actual XML code that contains the service-specific configurations. We refer to this as the input XML document. There are two different input sources: File system or in-memory strings.
- **Configuration name** The name of the actual service configuration to be run. Each RTI Service defines a top-level element that shall contain a `name` attribute that uniquely identifies it.

Loading from Files

RTI Services can receive a list of file paths separated by semicolons (`;`):

```
filepath_1;filepath_2; ... filepath_N
```

File paths can be relative or absolute and files are loaded in order from left to right. How you provide the file path list depends on whether you run the service from the shipped executable or embed it into your application using the Library API[1].

Shipped Executable

Use the `-cfgFile` option.

[1] Library API may not be available for certain RTI Services.

Warning: On some operating systems, `;` is interpreted as a command separator, so you will need to escape the path list with double quotes `"`.

For example on Linux systems:

RTI Routing Service

```
$NDDSHOME/bin/rtiroutingservice -cfgFile "file.xml;/home/file2.xml"
```

RTI Recording Service

```
$NDDSHOME/bin/rtirecordingservice -cfgFile "file.xml;/home/file2.xml"
```

RTI Cloud Discovery Service

```
$NDDSHOME/bin/rticlouddiscoveryservice -cfgFile "file.xml;/home/file2.xml"
```

where `[NDDSHOME]` indicates the path to your *Connext* installation.

Library API

Set the `ServiceProperty::cfg_file` member.

For example in C++:

```
ServiceProperty property;
property.cfg_file("file.xml;/home/file2.xml");
...
Service service(property);
```

Loading from In-Memory Strings

If you are embedding RTI Services into your application using the Library API, the input XML document can be also be provided through a string array object. You can do so by setting the `ServiceProperty::cfg_strings` member.

For example in C++:

```
std::vector<std::string> xml_strings;
xml_strings.resize(2);
/* This sample demonstrates using Routing Service */
xml_strings[0] = "<dds><routing_service name=\"MyService\">";
xml_strings[1] = "</routing_service></dds>";
property.cfg_strings(xml_strings);
...
Service service(property);
```

Selecting which Configuration to Run

As stated earlier, the input XML document may contain one or more service configurations. You will need to select which specific configuration to run by providing its configuration name.

How you provide the configuration name depends on whether you run the service from the shipped executable or by embedding it into your application using the Library API.

For example, consider the following input XML document in a file named `MyService.xml` that contains two configurations.

RTI Routing Service

```
<dds>
    <routing_service name="Service1"> ... </routing_service>

    <routing_service name="Service2"> ... </routing_service>
</dds>
```

RTI Recording Service

```
<dds>
    <recording_service name="Service1"> ... </recording_service>

    <recording_service name="Service2"> ... </recording_service>
</dds>
```

RTI Cloud Discovery Service

```
<dds>
    <cloud_discovery_service name="Service1"> ... </cloud_discovery_service>

    <cloud_discovery_service name="Service2"> ... </cloud_discovery_service>
</dds>
```

You can run the configuration for `Service1` as follows:

Shipped Executable

Use the `-cfgName` option.

For example, on Linux systems:

RTI Routing Service

```
$NDDSHOME/bin/rtiroutingservice -cfgFile MyService.xml -cfgName Service1
```

RTI Recording Service

```
$NDDSHOME/bin/rtirecordingservice -cfgFile MyService.xml -cfgName Service1
```

RTI Cloud Discovery Service

```
$NDDSHOME/bin/rticlouddiscoveryservice -cfgFile MyService.xml -cfgName␣
↪Service1
```

Library API

Set the `ServiceProperty::cfg_name` member.

For example in C++:

```
ServiceProperty property;
property.cfg_file("MyService.xml");
property.cfg_name("Service1");
...
Service service(property);
```

Default Files

In addition to manually providing input XML files, RTI Services also attempt to automatically load a set of files from predefined locations:

Table 10.1: RTI Services Default Files

File	Allowed Content
`[working directory]/USER_[SERVICE].xml`	• Service-specific elements • QoS profiles • Types
`[NDDSHOME]/resource/xml/RTI_[SERVICE].xml`	• Service-specific elements • QoS profiles • Types
`[working directory]/USER_QOS_PRORFILES.xml`	• QoS profiles • Types

where `[SERVICE]` refers to the concrete product name in uppercase. For example:

- `ROUTING_SERVICE` for *RTI Routing Service*
- `RECORDING_SERVICE` for *RTI Recording Service*
- `CLOUD_DISCOVERY_SERVICE` for *RTI Cloud Discovery Service*

These files are loaded only if present.

You can disable the loading of default files by using the proper option:

Shipped Executable

Use the `-skipDefaultFiles` option.

Library API

Set the `ServiceProperty::skip_default_files` member to true.

XML Syntax and Validation

The XML representation of DDS-related resources must follow these syntax rules:

- It shall be a well-formed XML document according to the criteria defined in clause 2.1 of the Extensible Markup Language standard.
- It shall use UTF-8 character encoding for XML elements and values.
- It shall use `<dds>` as the root tag of every document.

To validate the loaded configuration, each RTI Service relies on an XSD document that describes the format of the XML content. The validation of the input XML document occurs after all the files and strings have been parsed. If the validation fails, the RTI Service will fail to load the XML and log an error. For example here is an error in the case of *RTI Cloud Discovery Service*:

```
NDDSHOME/bin/rticlouddiscoveryservice
[/cloud_discovery_services/default|CREATE] line 26: Element 'invalid_example_
↪tag': This element is not expected.
[/cloud_discovery_services/default|CREATE] CDSService_loadConfiguration:!
↪validate configuration
[/cloud_discovery_services/default|CREATE] CDSService_initialize:!load␣
↪configuration
[/cloud_discovery_services/default|CREATE] CDSService_new:!init service
main:!create service
```

You can disable the XSD validation process by using the proper option:

Shipped Executable

Use the `-ignoreXsdValidation` option.

Library API

Set the `ServiceProperty::enforce_xsd_validation` member to false.

We recommend including a reference to this document in the XML file that contains the service's configuration; this provides helpful features in code editors such as Visual Studio®, Eclipse®, and NetBeans®, including validation and auto-completion while you are editing the XML file.

The XSD for the RTI Service configuration elements is in `[NDDSHOME]/resource/schema/rti_[service_name].xsd`, where `[service_name]` refers to product name in lower snake case. For example:

- `routing_service` for *RTI Routing Service*
- `recording_service` for *RTI Recording Service*
- `cloud_discovery_service` for *RTI Cloud Discovery Service*

To include a reference to the XSD document in your XML file, use the attribute `xsi:noNamespaceSchemaLocation` in the `<dds>` tag. For example:

```
<?xml version="1.0" encoding="UTF-8"?>
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="[NDDSHOME]/resource/schema/rti_routing_
↪service.xsd">
    <!-- ... -->
</dds>
```

Warning: The product XSD file provided under `[NDDSHOME]/resource/schema` is to assist you in the process of creating an XML configuration document. RTI Services have the XSD builtin in memory, so making modifications to the reference XSD will not have an impact on the validation process.

Listing Available Configurations

The shipped executables of some RTI Services provide an option to list all the available configurations in the specified input XML document. You can run the service with the `-listConfig` option to list the available configurations and exit. For example, on Linux systems:

RTI Routing Service

```
rtiroutingservice -listConfig
Available configurations:
- default:([NDDSHOME]/resource/xml/RTI_ROUTING_SERVICE.xml)
    Routes all topics from domain 0 to domain 1
- defaultBothWays:([NDDSHOME]/resource/xml/RTI_ROUTING_SERVICE.xml)
    Routes all topics from domain 0 to domain 1 and the other way around
- defaultReliable:([NDDSHOME]/resource/xml/RTI_ROUTING_SERVICE.xml)
    Routes all topics from domain 0 to domain 1 using reliable communication
```

RTI Cloud Discovery Service

```
rticlouddiscoveryservice -listConfig
Available configurations:
- rti.cds.builtin.config.default:(builtin string)
    Empty configuration. Assumes default values.
- rti.cds.builtin.config.default_wan:(builtin string)
    Enables Real-Time WAN Transport.
                XML variables:
                    - RTI_CDS_PORT: CDS public and host port number
                    - RTI_CDS_PUBLIC_ADDR: CDS WAN public address
```

Each listed configuration indicates the input source (file path or string) and the content of the `<documentation>` tag if present. This operation lists all the configurations detected from the specified input XML document from all the locations and files.

Configuration Variables

The builtin XML parser of the RTI Service offers a special mechanism to reuse and customize content at runtime through the concept of *Configuration variables*.

A configuration variable is an RTI-specific construct that you can use in the input XML documents to set placeholders for content that **will be expanded at parsing time**. A variable is specified as follows:

```
$(VAR_NAME)
```

where `VAR_NAME` is the name that identifies the variable. You can use configuration variables in your XML content as an attribute value and element text.

```
<element attribute="$(VAR_ATTR)">my expanded $(VAR_TEXT)</element>
```

The possible ways a variable can be expanded are listed below in precedence order:

1. Process environment.

   ```
   export VAR_NAME=my_value
   ```

2. Using a specific option when running the service.

   Shipped Executable

   Use the `-DVAR_NAME=VALUE` option

   ```
   $<rtiservicename> ... -DVAR_NAME=my_value
   ```

   where `<rtiservicename>` is one of `rtiroutingservice`, `rtirecordingservice` or `rticlouddiscoveryservice`.

   Library API

   Set the `ServiceProperty::user_environment` member

   ```
   ServiceProperty property;
   property.user_environment()["VAR_NAME"] = "var_value";
   ...
   ```

3. `<configuration_variables>` section, which represents an unbounded list of variable name-value value pairs.

   ```
   <configuration_variables>
       <value>
           <element>
               <name>VAR_NAME</name>
               <value>var_value</value>
           </element>
           ...
       </value>
   </configuration_variables>
   ```

All three of these mechanisms can be used in combination or separately. For the above example, you could expand one variable using the process environment and another variable using the command-line option. The following command:

```
export VAR_ATTR=expanded_attr
<rtiservicename> ... -DVAR_TEXT=expanded_text
```

where `<rtiservicename>` is one of `rtiroutingservice`, `rtirecordingservice` or `rticlouddiscoveryservice`, will result in the following actual parsed XML with the expanded variables:

```
<element attribute="expanded_attr">my expanded expanded_text</element>
```

If the RTI Service cannot expand a variable, it will load the XML document and log an error indicating which variable could not be expanded. Here is an example for *RTI Routing Service*:

```
[/routing_services/default|CREATE] RTIXMLUTILSVariableExpansor_
↪expandString:variable with name=ADMIN_DOMAIN_ID not defined
[/routing_services/default|CREATE] RTIXMLUTILSVariableExpansor_visit:!parse␣
↪at line=19 for tag=domain_id: expand environment variable in element text
[/routing_services/default|CREATE] ROUTERXmlVariableExpansor_visit:!parse at␣
↪line=19 for tag=domain_id
...
```

10.1.2 How to Load Default QoS Profiles

Generally, loading a default QoS profile follows the same mechanism as *Connext* applications. The details on how to specify default QoS profiles in XML is explained in the section Overwriting Default QoS in the *RTI Connext Core Libraries User's Manual*.

In short, you will need to mark a profile as the default using the `is_default_qos` attribute. For RTI Services, you will need to do this as part of the default file `USER_QOS_PROFILES.xml` (see *Default Files*). This requirement is necessary since the default QoS profiles are parsed by the underlying *DomainParticipantFactory* and not the service itself.

Warning: Marking as default a QoS profile defined in a different file than `USER_QOS_PROFILES.xml` will have no effect.

10.1.3 How to Set Logging Properties

You can configure different aspects of the logging infrastructure that is part of RTI Services and *Connext*. This section describes different ways to set these logging properties.

Command-Line Options

The shipped executable for an RTI Service typically offers some out-of-the-box options to configure logging. Typically, you will find these options:

- `-verbosity` sets the verbosity level for the messages generated by the service and *Connext*.
- `-logFormat` configures the format of the log messages, such as whether they contain timestamps, thread IDs, etc.
- `-logFile` redirects the logging to a specified text file.

You can refer to the `Usage` section of each individual product user's manual for further details.

Library API

To configure the service-level verbosity, use the `Logger` singleton class part of the Library API. For example, the following sets `WARNING` level for the service logs in *RTI Routing Service*. For other services change the preceding `rti::routing` prefix to match the RTI Service you are working with.

```
rti::routing::Logger::instance().service_verbosity(
        rti::config::Verbosity::WARNING);
```

To configure the *Connext*-level verbosity (for logs generated by the DDS libraries), you can use the *Connext* configuration logger API. For example, the following sets `WARNING` level for the *Connext* logs:

```
rti::config::Logger::instance().verbosity(
        rti::config::Verbosity::WARNING);
```

For the remaining overall logging properties, such as the log format, output file, and so on, you can also use the *Connext* configuration logger API. For example, to redirect the logging to an output file:

```
rti::config::Logger::instance().output_file(my_service_logs.txt);
```

XML Configuration

As an alternative to the previous two methods, you can configure some logging properties through the `LoggingQosPolicy` which can be specified in XML. For more information, see the LOGGING QosPolicy (DDS Extension) in the *RTI Connext Core Libraries User's Manual*.

The Logging QoS is configured within the `<participant_factory_qos>` that is part of a QoS profile. Since multiple profiles can be present in the loaded XML document, to tell *Connext* which one to use, you will need to mark the profile as the default using the `is_default_qos` attribute, or for the DomainParticipantFactory, the `is_default_participant_factory_profile` attribute.

See *How to Load Default QoS Profiles* for details on how to load default QoS profiles with RTI Services. For example, you can set different properties for the logger by placing the XML code seen below in the `USER_QOS_PROFILES.xml` default file:

```
<dds>
    <qos_library name="DefaultLibrary">
        <qos_profile name="DefaultProfile" is_default_participant_factory_
↪profile ="true">
            <participant_factory_qos>
                <logging>
                    <!-- this element affects Connext logs only -->
                    <verbosity>ALL</verbosity>
                    <!-- for all Connext and Service logs -->
                    <category>ENTITIES</category>
                    <print_format>MAXIMAL</print_format>
                    <output_file>LoggerOutput1.txt</output_file>
                </logging>
            </participant_factory_qos>
        </qos_profile>
    </qos_library>
</dds>
```

See also:

Configuring Connext Logging
Describes the types of logging messages and how to use the logger to enable them.

Identifying Threads used by Connext
Describes the logging messages that provide thread-context information.

10.1.4 How to Run as an Operating System Daemon

Certain Operating Systems offer the capability to run processes in the background and non-interactively. On Linux or macOS systems, this is referred to as *daemon* processes. On Windows systems, this is referred to as a *service*.

How to run a process as a daemon depends on the OS and in some cases there are multiple options. This section describes the most common way to run an RTI Service as a daemon of the main OS.

Linux and macOS Systems

The simplest and more portable way requires you to use the Library API to create your own executable that instantiates the RTI Service and sets the running process as a daemon using the `daemon()` API. For example, for *RTI Routing Service*:

```
#include <stdlib.h>
#include "rti/routing/Service.hpp"

int main(int argc, char **argv)
{
    using namespace rti::routing;

    if (daemon(0,0)) {
        Logger::instance().error("Failed to create daemon process\n");
```

(continues on next page)

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```
        return -1;
    }

    // parse arguments and configure ServiceProperty
    ServiceProperty property;
    property.cfg_file(argv[1]);
    ...
    Service service(property);

    service.start();
}
```

The above code generates an executable that runs the process as a daemon with zero-value arguments, indicating that the working directory is `/` and the standard output is redirected to `/dev/null`. You can find more information about the `daemon()` in the user man pages.

Note that if you link the application dynamically, you will need to guarantee that the dependency libraries are available as part of the library path. An alternative is to link the applications statically.

Windows Systems

To run a process as a Windows Service we recommend using the third party tool Non-Sucking Service Manager (NSSM). This tool allows you to run an existing executable as a service, while adjusting environment variables and command-line arguments.

Hence you can use NSSM to run the shipped executable of an RTI Service. For example, for *Routing Service* you can run:

```
nssm install myRouterService <rtiroutingservice> "-cfgName default"
```

The above command will install a service named `myRouterService` on your Windows system that runs *Routing Service* with the default configuration. Then you can manage the service with the `nssm` GUI utility itself or the Windows Services Control Manager (select Control Panel -> Administrative Services -> Services).

The example above causes the service to use the executable directory as the working directory and relies on the default configuration file in `[NDDSHOME]/resource/xml`. You can specify a different working directory as well as different command-line arguments as follows:

```
nssm set myRouterService AppDirectory <my_working_dir>
nssm set myRouterService AppParameters "-cfgFile my_router.xml -cfgName␣
↪MyRoute"
```

Alternatively, you can use the Library API to embed the RTI Service into your own executable and implement the Windows Library APIs to run the executable as a Windows Service. (see How to: Create Windows Services).

Here are some things to consider when running an RTI Service as a Windows Service:

- All `AppParameters` arguments must be enclosed in quotation marks.
- If you specify `-cfgFile` in the Start Parameters field, you must use the full path to the file.

- Some versions of Windows do not allow Windows Services to communicate with other services/applications using shared memory. In such case, you will need to disable the shared memory transport in all *DomainParticipants* created by the RTI Service.
- In some scenarios, you may need to add a multicast address to your discovery peers or simply use *RTI Cloud Discovery Service*.

10.1.5 How to use a License File with RTI Services

If your *RTI Connext* distribution requires a license file and you don't have one, contact RTI at support@rti.com. To install the license file, follow the instructions in Installing RTI Connext in the *RTI Connext Installation Guide*. Alternatively, you can provide the RTI Service with the path to your license file using either the `-licenseFile` command-line argument or the `license_file_name` field in the Service Property of the Library API.

Note: Some RTI Services do not require a license file.

Check the command line arguments list for the RTI Service to see if a `-licenseFile` argument exists. If it doesn't, you can use the RTI Service without a license file.

Each time your RTI Service starts, it looks for the license file in the following locations, in order, until it finds a valid license:

1. The file specified in the environment variable `RTI_LICENSE_FILE`, which you may set to point to the full path of the license file, including the filename. For example, on Linux:

   ```
   export RTI_LICENSE_FILE=/home/username/my_rti_license.dat
   ```

2. The file `rti_license.dat` in the current working directory.
3. The file `rti_license.dat` in the directory specified by the environment variable `NDDSHOME`.

10.1.6 Key Terms

XML document
: The input XML contained within the `<dds>` root, which contains one or more configurations for an RTI Service.

Configuration name
: Unique identification of a service top-level configuration element. Provided with the `name` attribute.

Configuration variable
: An RTI-specific construct to be used in XML to define content that can be expanded at runtime.

Shipped executable
: An RTI-provided command-line executable that runs an RTI Service.

Library API
: Public API that allows you to embed an RTI Service into your custom application.

10.2 Application Resource Model

RTI Services are described through a *hierarchical application resource model*. In this model, an application is composed of a set of *Resources*, each representing a particular component within the application. *Resources* have a parent-child relationship. Figure 10.1 shows a general view of this concept.

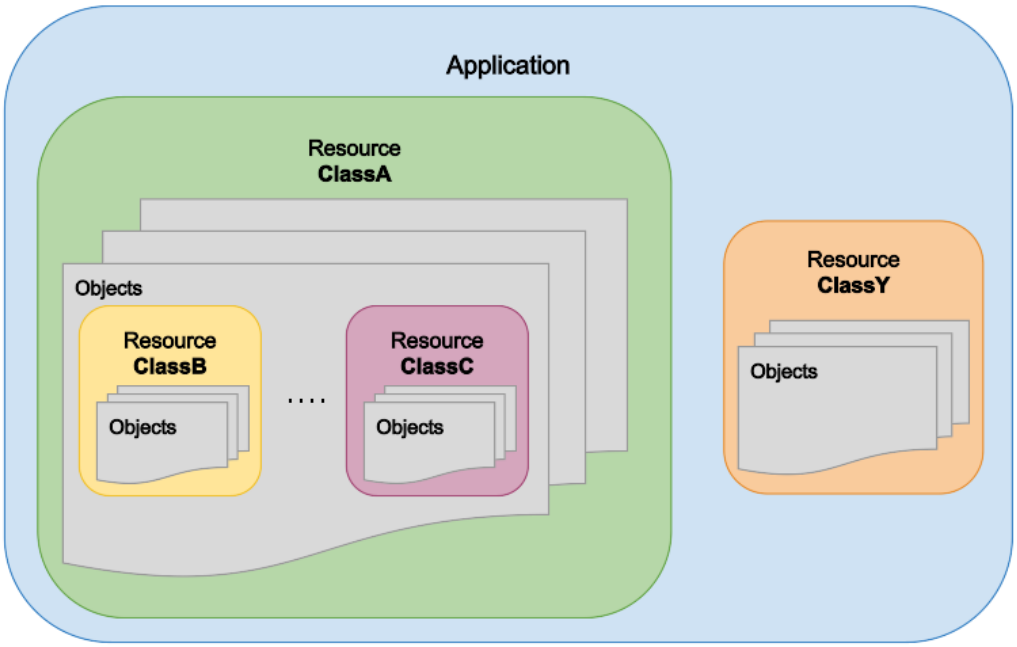

Figure 10.1: Application modeled as a set of related Resources

Each application specifies its resource model by indicating the available resources and their relationship. A *Resource* is determined by its class and a concrete object instance. It can belong to one of the following categories:

- **Simple**–Represents a single object.
- **Collection**–Represents a set of objects of the same class.

A Resource may be composed of one or more Resources. In this relationship, the *parent* Resource is composed of one ore more *child* Resources.

10.2.1 Example: Simple Resource Model of a Connext Application

Figure 10.2 depicts a UML class diagram to provide a generic resource model for *Connext* applications.

In this diagram, the composition relationship is used to denote the parents and children in the hierarchy. The direct relationship denotes a dependency between resources that is not parent-child.

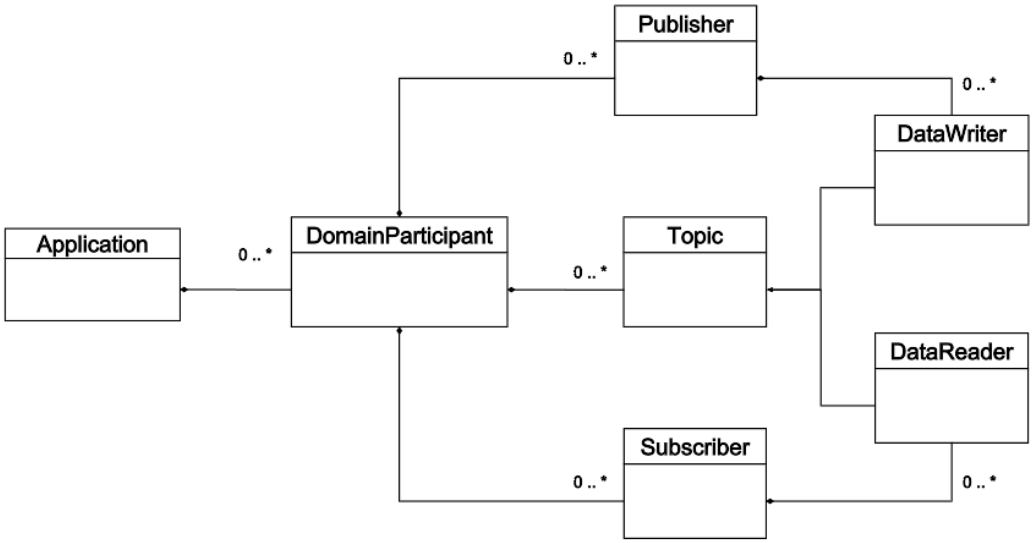

Figure 10.2: Connext application resource model

10.2.2 Resource Identifiers

A resource identifier is a string of characters that uniquely address a concrete resource object within an application. It is expressed as a hierarchical sequence of identifiers separated by /, including all the parent resources and the target resource itself:

$$/resource_id_1/resource_id_2.../resource_id_N$$

where each individual identifier references a concrete resource object *by its name*. The object name is either:

a) Fixed and specified by the resource model of the parent Resource class.

b) Given by the user of the application. This is the case where the parent resource is a collection in which the user can insert objects, providing a name for each of them.

The individual identifier can refer to one of the two kinds of resources, simple and collection resources. For example:

/collection_id$_1$/resource_id$_1$/resource_id$_2$

If the identifier refers to a collection resource, the following child identifier must refer to a simple resource. Both simple and collection resources can be parents (or children). In the previous example, resource_id$_1$ is a simple resource child of collection_id$_1$; it is also the parent of resource_id$_2$.

The hierarchy of identifiers is known as the *full resource identifier path*, where each resource on the left represents a parent resource. The *full resource identifier path* is composed of collection and simple resources. Each child resource identifier is known as the *relative resource* to the parent.

The resource identifier format follows these conventions:

- The first character is /, which represents the root resource and parent of all the available resources across the applications.

- A collection identifier is defined in lower `snake_case`, and it is always specified by the resource class.
- A simple resource identifier is defined in `camelCase` (lower and upper) and may be specified by both the resource class or the user.

Escaped Identifiers

An identifier can be escaped by enclosing it within double quotes (`"`). For example:

/"escaped_identifier"

An escaped identifier is interpreted as a whole and indivisible unit. Escaping a resource identifier is useful; it is also required when the identifier contains the resource separator `/` or the custom method separator `:`.

For example, the following full resource path:

```
/resource_1/"escaped/resource_2"
```

is composed of two relative resources, resource_id$_1$and escaped/resource$_2$. The use of the double quotes to escape the identifier indicates that the enclosing string shall be interpreted as a single identifier, and therefore *Routing Service* ignores the resource separator. If the identifier was not escaped, then *Routing Service* would interpret the resource path as two separate relative resources.

Any time an RTI Service sees a resource separator character (`/`) or the custom method separator `:` in an entity name (such as in the attribute `name`), it automatically escapes the name when it constructs the resource identifier. For example:

```
<service name="A/B">

<service name="A:B">
```

becomes

```
/routing_service/"A/B"

/routing_service/"A:B"
```

in the resource identifier.

Example: Resource Identifiers of a Generic Connext Application

Consider the *Connext* application resource model in *Example: Simple Resource Model of a Connext Application*. The following resource identifier addresses a concrete *DomainParticipant* named "MyParticipant" in a given application:

```
/domain_participants/MyParticipant
```

In this case, "domain_participants" is the identifier of a collection resource that represents a set of *DomainParticipants* in the application and its value is fixed and specified by the application. In contrast, "MyParticipant"

is the identifier of a simple resource that represents a particular *DomainParticipant* and its value is given by the user of the application at *DomainParticipant* creation time.

The following resource identifier addresses the implicit *Publisher* of a concrete *DomainParticipant* in a given application:

```
/domain_participants/MyParticipant/implicit_publisher
```

where "implicit_publisher" is the identifier of a simple resource that represents the always-present implicit *Publisher* and its value is fixed and specified by the *DomainParticipant* resource class.

Example: Resource Identifiers Generated from XML Entity Model

Consider the following XML configuration that models a generic RTI Service:

```
<service name="MyService">
    <entity_class1 name="MyEntity1"> ... </entity_class1>
    <entity_class1 name="Domain/MyEntity2"> ... </entity_class1>
</service>
```

The resulting generated resource identifiers will look as follows:

```
/service/MyService/entity_class1/MyEntity1
/service/MyService/entity_class1/"Domain/MyEntity2"
```

10.3 Remote Administration Platform

This section describes details of the *RTI Remote Administration Platform*, which represents the foundation of the remote access capabilities available in *RTI Routing Service*, *RTI Recording Service, RTI Queuing Service*, *RTI Cloud Discovery Service* and *RTI Observability Collector*. The *RTI Remote Administration Platform* provides a common infrastructure that unifies and consolidates the remote interface to all RTI Services.

Note: Remote administration of RTI Services requires an understanding of the *application resource model*. We recommend that you read *Application Resource Model* (*Application Resource Model*) before continuing with this section.

The *RTI Remote Administration Platform* addresses two areas:

- **Resource Interface:** How to perform operations on a set of resource objects that are available as part of the public interface of the remote service.
- **Communication:** How the remote service receives and sends information.

The combination of these two areas provides the general view of the *RTI Remote Administration Platform*, as shown in Figure 10.3. The *RTI Remote Administration Platform* is defined as a request/reply architecture. In this architecture, the service is modeled as a set of *resources* upon which the requester client can perform operations. Resources represent objects that have both *state* and *behavior*.

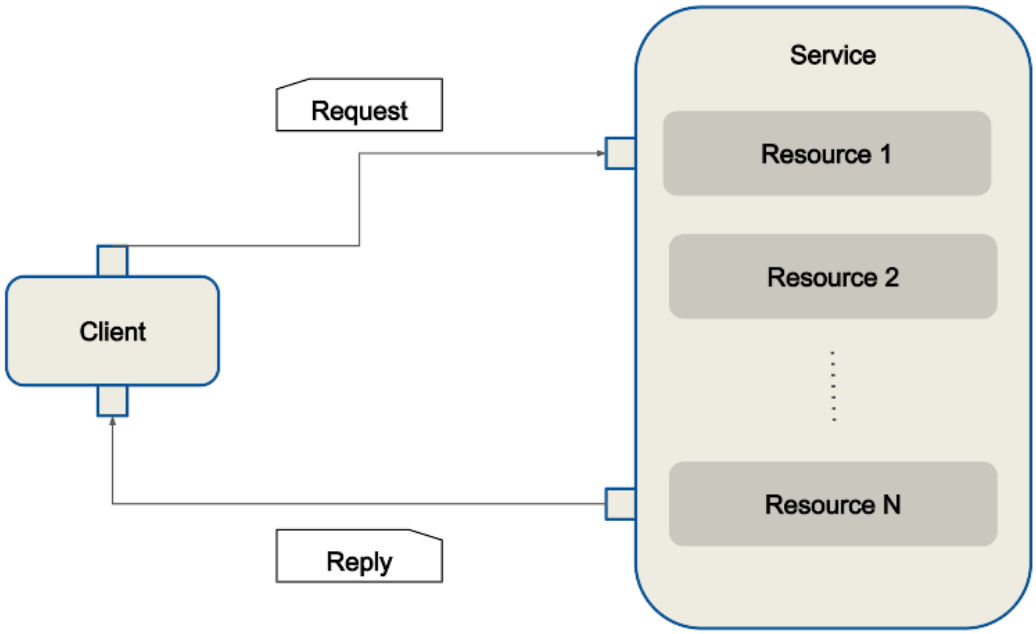

Figure 10.3: General View of the *RTI Remote Administration Platform* Architecture

Clients issue requests indicating the desired operation and receive replies from the service with the result of the requests. If multiple clients issue multiple requests to one or more services, the client will receive only replies to its own requests.

10.3.1 Remote Interface

Services offer their available functionality through their set of resources. The *RTI Remote Administration Platform* defines a Representational State Transfer (REST)-like interface to address service resources and perform operations on them. A resource operation is determined by a REST request and the associated result by a REST reply.

Table 10.2: REST Interface

Element	Description
REST Request	**[method] + [resource_identifier] + [body]** • `method`: Specifies the action to be performed on a service resource. There is only a small subset of methods, known as *standard methods* (see *Standard Methods*). • `resource_identifier`: Addresses a concrete service resource. Each concrete service has its own set of resources (see *Resource Identifiers*). • `body`: Optional request data that contains necessary information to complete the operation.
REST Reply	**[return code] + [body]** • `return code`: Integer indicating the result of the operation. • `body`: Optional reply data that contains information associated with the processing of the request.

Standard Methods

The *RTI Remote Administration Platform* defines the methods listed in Table 10.3.

Table 10.3: Standard Methods

Method	URI	Request Body	Reply Body
`CREATE`	Parent collection resource identifier	Resource representation	N/A
`GET`	Resource identifier	N/A	Resource representation
`UPDATE`	Resource identifier	Resource representation	N/A
`DELETE`	Resource identifier	Undefined	N/A

Custom Methods

There are certain cases in which an operation on a service resource cannot be mapped intuitively to a standard method and resource identifier. *Custom methods* address this limitation.

A custom method can be specified as part of the resource identifier, after the resource path, separated by a `:`.

`UPDATE` + [resource_identifier] **`:`** [custom_verb]

It is up to each service implementation to define which custom methods are available and on what resources they apply. Custom methods follow these conventions:

- They are invoked through the `UPDATE` standard method.

- They are named using lower snake_case.
- They may use the request body and reply body if necessary.

Example: Database Rollover

This example shows the REST request to perform a file rollover operation on a file-based database:

```
UPDATE /databases/MyDatabase:rollover
```

10.3.2 Communication

The information exchange between client and server is based on the DDS request-reply pattern, as shown in Figure 10.4. The client maps to a *Requester*, whereas the server maps to a *Replier*.

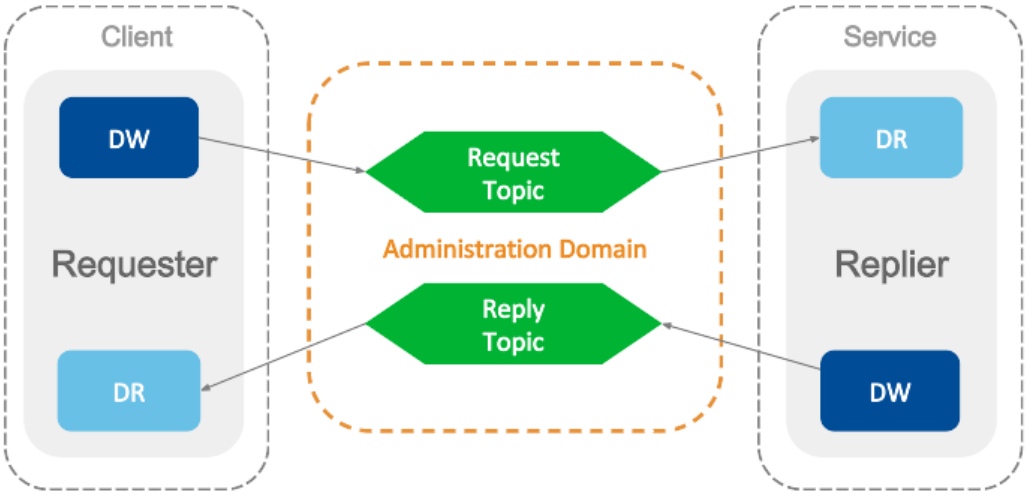

Figure 10.4: Communication in *RTI Remote Administration Platform* is Based on DDS Request-Reply

The communication is performed over a single request-reply channel, composed of two topics:

- **Command Request Topic:** Topic through which the client sends the requests to the server.
- **Command Reply Topic:** Topic through which the server sends the replies to the received requests.

The definition of these topics is shown in Table 10.4:

Table 10.4: Remote Administration *Topic*s

Topic	Name	Top-level Type Name
CommandRequestTopic	rti/service/admin/command_request	`rti::service::admin::CommandRequest`
CommandReplyTopic	rti/service/admin/command_reply	`rti::service::admin::CommandReply`

The definition for each *Topic* type is described below.

Listing 10.1: `CommandRequest` Type

```
@appendable
struct CommandRequest {
    @key int32 instance_id;
    @optional string<BOUNDED_STRING_LENGTH_MAX> application_name;
    CommandActionKind action;
    ResourceIdentifier resource_identifier;
    StringBody string_body;
    OctetBody octet_body;
};
```

Table 10.5: `CommandRequest`

Field Name	Description
`instance_id`	Associates a request with a given instance in the *CommandRequestTopic*. This can be used if your requester application model wants to leverage outstanding requests. In general, this member is always set to zero, so all requests belong to the same *CommandRequestTopic* instance.
`application_name`	Optional member that indicates the target service instance where the request is sent. If `NULL`, the request will be sent to all services.
`action`	Indicates the resource operation.
`resource_identifier`	Addresses a service resource.
`string_body`	Contains content represented as a string.
`octet_body`	Contains content represented as binary.

Listing 10.2: `CommandReply` Type

```
@appendable
struct CommandReply {
    CommandReplyRetcode retcode;
    int32 native_retcode;
    StringBody string_body;
    OctetBody octet_body;
};
```

Table 10.6: `CommandReply`

Field Name	Description
`retcode`	Indicates the result of the operation.
`native_retcode`	Provides extra information about the result of the operation.
`string_body`	Return value of the operation, represented as a string.
`octet_body`	Return value of the operation, represented as binary.

The type definitions for both the *CommandRequestTopic* and *CommandReplyTopic* are in the file `[NDDSHOME]/resource/idl/ServiceAdmin.idl`.

The definition of the request and reply topics is independent of any specific service implementation. In fact, the topic names are fixed, unique, and shared across all services that rely on the *RTI Remote Administration Platform*. Clients can target specific services through two mechanisms:

- Specifying a concrete service instance by providing its *application name*. The application name is a service attribute and can be set at service creation time.
- Specifying the configuration name loaded by the target services. The target service configuration shall be present in the service resource part of the `resource_identifier`.

Reply Sequence

Usually a request is expected to generate a single reply. Sometimes, however, a request may trigger the *generation of multiple replies*, all associated with the same request.

The *RTI Remote Administration Platform* communication architecture allows services to respond to certain requests with a *reply sequence*. All the samples in a reply sequence use the the metadata `SampleFlagBits` to indicate whether it belongs to a reply sequence and whether there are more replies pending.

The `SampleFlagBits` may contain different flags that indicate the status of the reply procedure. For a given reply sequence, the associated sample flags for each reply may contain:

- `SEQUENTIAL_REPLY`: If present, this indicates that the sample is the first reply of a reply sequence and there are more on the way.
- `FINAL_REPLY`: If present, this indicates that the sample is the last one belonging to a reply sequence. This flag is valid only if the `SEQUENTIAL_REPLY` is also set.

For more on SampleFlagBits, see documentation on the DDS_SampleInfo structure in the Connext API Reference HTML documentation.

Example: Controlling services remotely from a Connext Application

The *Connext* GitHub examples repository includes an example that shows how to build and run a requester application that can send commands to a running *RTI Routing Service* instance.

10.3.3 Common Operations

The set of services that use the *RTI Remote Administration Platform* to implement remote administration also share a base remote interface that consolidates and unifies the semantics and behavior of certain common operations.

Services containing resources that implement the common operations conform to the base remote interface, making sure that signatures, semantics, behavior, and conditions are respected.

The following sections describe each of these common operations.

Create Resource

`CREATE [resource_identifier]`

Creates a resource object from its configuration in XML representation.

This operation creates a resource object and its contained entities. The created object becomes a child of the parent specified in the `resource_identifier`.

After successful creation, the resource object is fully addressable for additional remote access, and the associated object configuration is inserted into the currently loaded full XML configuration.

Request body

- `string_body`: XML representation of the resource object provided as `file://` or `str://`.
- Example `str://` request body:

```
str://"<my_resource name="NewResourceObject">
    ...
</my_resource>"
```

- Example `file://` request body:

```
file:///home/rti/config/service_my_resource.xml
```

Reply body

- Empty.

Return codes

The operation may return a reply with error if:

- The specified resource identifier does not exist.
- The specified configuration is schematically invalid.
- There was an error creating the resource object.

Get Resource

`GET [resource_identifier]`

Returns an equivalent XML string that represents the current state of the resource object configuration, including any updates performed during its lifecycle.

Request body

- Empty.

Reply body

- `string_body`: XML representation of the resource object.
- Example reply body:

```
<my_resource name="MyObject">
    ...
</my_resource>
```

Return codes

The operation may return a reply with error if:

- The specified resource identifier does not exist.

Update Resource

UPDATE [resource_identifier]

Updates the specified resource object from its configuration in XML representation.

This operation modifies the properties of the resource object, including the associated configuration. Only the mutable properties of the resource class can be updated while the object is enabled. To update immutable properties, the resource object must be disabled first.

Note: Properties of a child resource cannot be updated as part of a parent resource. Instead, child resources must be addressed and updated independently.

Implementations may validate the received configuration against a scheme (DTD or XSD) that defines the valid set of accepted parameters (for example, only mutable elements).

The update content should only include only the properties to be updated or changed. You are not required to provide the full representation of the object being updated.

For example, consider the XML full representation of an object as follows:

```
<my_resource>
  <nested_resource_A>initial_A</nested_resource_A>
  <nested_resource_B>initial_B</nested_resource_B>
  <nested_resource_C>initial_C</nested_resource_C>
  ...
</my_resource>
```

The update should only contain the content for the properties you want to modify. For example, the following will only update `nested_resource_B` to a new value, leaving the other nested resources unchanged:

```
<my_resource>
  <nested_resource_B>updated_B</nested_resource_B>
  ...
</my_resource>
```

Request body

- `string_body`: XML representation of the resource object provided as `file://` or `str://`.
- Example `str://` request body:

```
str://"<my_resource name="MyResourceObject">
    ...
</my_resource>"
```

- Example `file://` request body:

```
file:///home/rti/config/service_update_my_resource.xml
```

Reply body

- Empty.

Return codes

The operation may return a reply with error if:

- The specified resource identifier does not exist.
- The specified configuration is schematically invalid.
- The specified configuration contains changes in immutable properties.
- There was an error updating the resource object.

Set Resource State

`UPDATE [resource_identifier]/state`

Sends a state change request to the specified resource object.

This operation attempts to change the state of the specified resource object and propagates the request to the resource object's contained entities.

The target state must be one of the resource class's valid accepted states.

Request body

- `octet_body`: CDR representation of an entity state.

Reply body

- Empty.

Return codes

The operation may return a reply with error if:

- The specified resource identifier does not exist.
- The target request is invalid.
- The resource object reported an error while performing the state transition.

Get Resource State

`GET [resource_identifier]/state`

Gets the current state of the specified resource object.

This operation attempts to fetch the state of the specified resource object.

The target's state is returned as a part of the reply.

Request body

- Empty

Reply body

- `octet_body`: CDR representation of an entity's current state.

Return codes

The operation may return a reply with error if:

- The specified resource identifier does not exist.
- The target request is invalid.
- The resource object reported an error while fetching its current state.

Delete Resource

`DELETE [resource_identifier]`

Deletes the specified resource object.

This operation deletes a resource object and its contained entities. The deleted object is removed from its parent resource object.

The associated object configuration is removed from the currently loaded full XML configuration.

After a successful deletion, the resource object is no longer addressable for additional remote access.

Request body

- Empty.

Reply body

- Empty.

Return codes

The operation may return a reply with error if:

- The specified resource identifier does not exist.
- There was an error deleting the resource object.

10.4 Monitoring Distribution Platform

Monitoring refers to the distribution of health status information metrics from instrumented RTI Services. This section describes the architecture of the *monitoring* capability supported in *RTI Routing Service* and *RTI Recording Service*. You will learn what type of information these application can provide and how to access it.

RTI Services provide monitoring information through a *Distribution Topic*, which is a DDS *Topic* responsible for distributing information with certain characteristics about the service resources. An RTI Service provides monitoring information through the following **three distribution topics**:

- *ConfigDistributionTopic*: Distributes metrics related to the description and configuration of a Resource. This information may be immutable or change rarely.
- *EventDistributionTopic*: Distributes metrics related to Resource status notifications of asynchronous nature. This information is provided asynchronously when Resources change after the occurrence of an event.
- *PeriodicDistributionTopic*: Distribute metrics related to periodic, sampling-based updates of a Resource. Information is provided periodically at a configurable publication period.

These three *Topic*s are shared across all services for the distribution of the monitoring information. Table 10.7 provides a summary of these topics.

Table 10.7: Monitoring Distribution *Topic*s

Topic	Name	Top-level Type Name
ConfigDistributionTopic	rti/service/monitoring/config	rti::service::monitoring::Config
EventDistributionTopic	rti/service/monitoring/event	rti::service::monitoring::Event
PeriodicDistributionTopic	rti/service/monitoring/periodic	rti::service::monitoring::Periodic

Figure 10.5 shows the mapping of the monitoring information into the distribution *Topic*s. A distribution *Topic* **is keyed** on service resources categorized as *keyed Resources*. These are resources whose related monitoring information is provided as an instance on the distribution *Topic*.

10.4.1 Distribution Topic Definition

All distribution *Topic*s have a common type structure that is composed of two parts: a base type that identifies a resource object and a resource-specific type that contains actual status monitoring information.

The definition of a distribution *Topic* is shown in Figure 10.6.

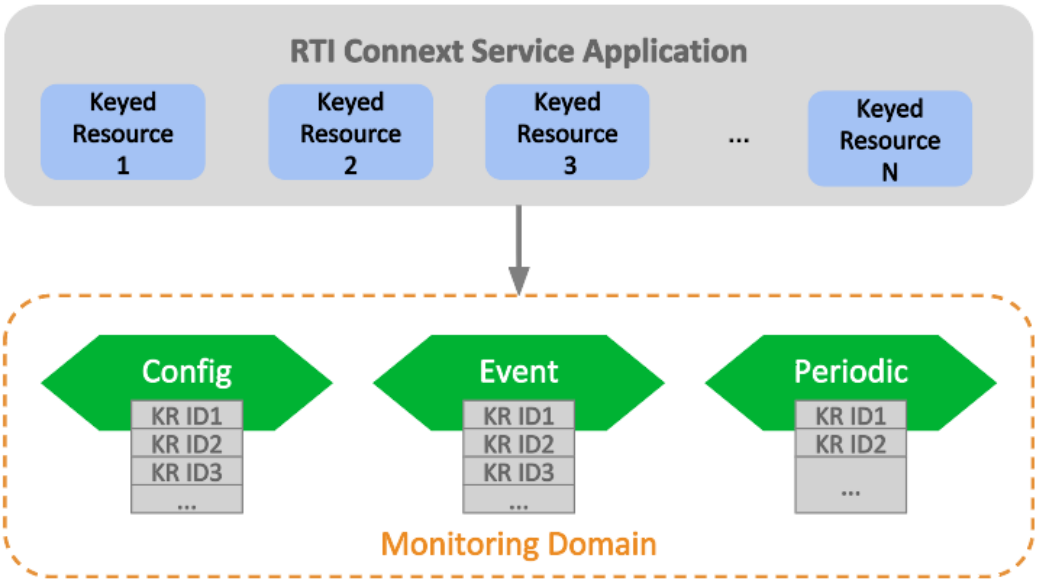

Figure 10.5: Monitoring Distribution *Topic*s of *RTI* Services

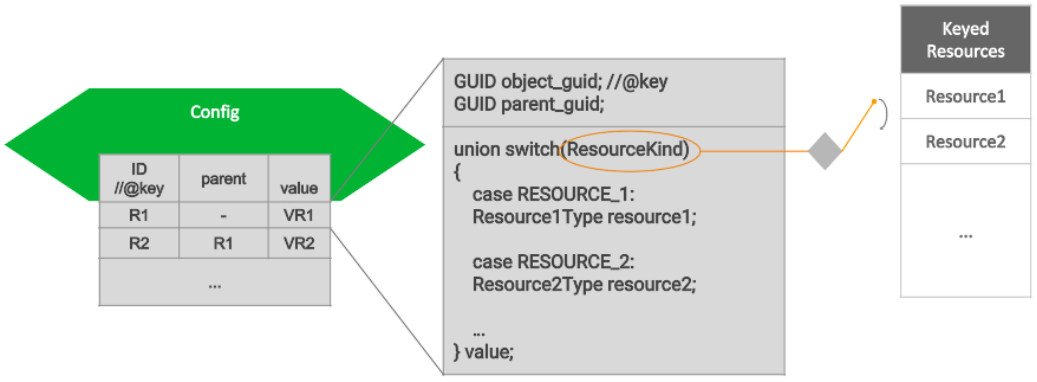

Figure 10.6: Monitoring Distribution *Topic* Definition

Keyed Resource Base Type Fields

This is the base type of all distribution *Topic*s and consists of two fields:

- `object_guid`: Key field. It represents a 16-byte sequence that uniquely identifies a *Keyed Resource* across all the available services in the monitoring domain. Hence, the associated instance handle key hash will be the same for all distribution *Topic*s, allowing easy correlation of a resource. It will also facilitate, as we will discuss later, easy instance data manipulation in a *DataReader*.
- `parent_guid`: It contains the object GUID of the parent resource. This field will be set to all zeros if the object is a top-level resource thus with no parent.

This base type, `KeyedResource`, is defined in `[NDDSHOME]/resource/idl/ServiceCommon.idl`.

Resource-Specific Type Fields

This is the type that conveys monitoring information for a concrete resource object. Since a distribution *Topic* is responsible for providing information about different resource classes, the resource-specific type consists of a single field that is a **Union of all the possible representations** for the keyed resources that provide that on the topic.

As expected, there must be consistency between the two parts of the distribution topic type. That is, a sample for a concrete resource object must contain the resource-specific union discriminator corresponding to the resource object's class.

Example: Monitoring of Generic Application

Assume a generic application that provides monitoring information about the modes of transports `Car`, `Boat` and `Plane`. Each mode is mapped to a keyed resource, each with a custom type that contains metrics specific to each class.

The monitoring distribution *Topic* top-level type, `TransportModeDistribution`, would be defined as follows, using IDL v4 notation:

```
#include "ServiceCommon.idl"

@nested
struct CarType {
    float speed;
    String color;
    String plate_number;
};

@nested
struct BoatType {
    float knots;
    float latitude;
    float longitude;
};
```

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```
@nested
struct PlaneType {
    float ground_speed;
    int32 air_track;
};

enum TransportModeKind {
    CAR_TRANSPORT_MODE,
    BOAT_TRANSPORT_MODE,
    PLANE_TRANSPORT_MODE
};

@nested
union TransportModeUnion switch (TransportModeKind) {
    case CAR_TRANSPORT_MODE:
    CarType car;

    case BOAT_TRANSPORT_MODE:
    BoatType boat;

    case PLANE_TRANSPORT_MODE:
    PlaneType plane;
}

struct TransportModeDistribution : KeyedResource {
    TransportModeUnion value;

};
```

Assume now that in the monitoring domain there are three resource objects, one for each resource class: a `Car` object 'CarA', a `Boat` object 'Boat1', and a `Plane` object 'PlaneX'. They all have unique resource GUIDs and each object represents an instance in the distribution *Topic*. The table shows the example of potential sample values:

Table 10.8: Samples in TransportModeDistribution *Topic*

	CarA	Boat1	PlaneX
`object_guid`	0x0C	0xAB	0xf2
`parent_guid`	0x00	0x00	0x00
`value` discriminator	CAR_TRANSPORT_MODE	BOAT_TRANSPORT_MODE	PLANE_TRANSPORT_MODE

10.4.2 DDS Entities

RTI Services allow you to distribute monitoring information in any domain. For that, they create the following DDS entities:

- A *DomainParticipant* on the monitoring domain.
- A single *Publisher* for all *DataWriter*s.
- A *DataWriter* for each distribution *Topic*.

A service will create these entities with default QoS or otherwise the corresponding service user's manual will specify the actual values. Services allow you to customize the QoS of the DDS entities, typically in the service monitoring configuration under the `<monitoring>` tag. You will need to refer to each service's user's manual.

10.4.3 Monitoring Metrics Publication

How services publish monitoring samples depends on the distribution *Topic*.

Configuration Distribution Topic

There are two events that cause the publication of samples in this topic:

- As soon as a *Resource* object is created. This event generates the first sample in the *Topic* for the resource object just created. Since these first samples are published as resources are created, it is guaranteed to be in hierarchical order; that is, the sample for a parent *Resource* is published before its children. When *Resources* are created depends on the service. Typically, *Resources* are created on service startup. Other cases include manual creation (e.g., through remote administration) or external event-driven creation (e.g., discovery of matching streams, in the case of *AutoRoute* in *Routing Service*).
- On *Resource* object update. This event occurs when the properties of the object change due to a set or update operation (e.g., through remote administration).

Event Distribution Topic

Services publish samples in this *Topic* in reaction to an internal event, such as a *Resource* state change. Which events and their associated information and when they occur is highly dependent on concrete service implementations.

Periodic Distribution Topic

Samples in this *Topic* are published periodically, according to a fixed configurable period. The metrics provided in this *Topic* are generated in two different ways:

- As a snapshot of the current value, taken at the publication time (e.g., current number of matching *DataReaders*). This represents a simple case and the metric is typically represented with an adequate primitive member.
- As a *statistic variable* generated from a set of discreet measurements, obtained periodically. This represents a *continous* flow of metrics, represented with the `StatisticVariable` type (see *Statistic Variable*).

There are two activities involved in the generation of the statistic variables: Calculation and Publication. All the configuration elements for these activities are available under the `<monitoring>` tag.

Calculation

The instrumented service periodically performs measurements on the metric. This activity is also known as *sampling* (don't confuse with data samples). The frequency of the measurements can be configured with the tag `<statistics_sampling_period>`. As a general recommendation, the sampling period should be a few times smaller than the publication period. A small sampling period provides more accurate statistics generation at the expense of increasing memory and CPU consumption.

Publication

The service periodically publishes a data sample containing a snapshot of the statistics generated during the calculation phase. The publication period can be configured with the tag `<status_publication_period>`.The value of a statistic variable corresponds to the time window of a publication period.

10.4.4 Monitoring Metrics Reference

This section describes the types used as common metrics across services. All the type definitions listed here are in `[NDDSHOME]/resource/idl/ServiceCommon.idl`.

Statistic Variable

Listing 10.3: Statistics

```
@appendable @nested
struct StatisticMetrics {
    uint64 period_ms;
    int64 count;
    float mean;
```

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```
        float minimum;
        float maximum;
        float std_dev;
    };

    @appendable @nested
    struct StatisticVariable {
        StatisticMetrics publication_period_metrics;
    };
```

Table 10.9: `StatisticMetrics`

Field Name	Description
period_ms	Period in milliseconds at which the metrics are published.
count	Sum of all the measurement values obtained during the publication period.
mean	Arithmetic mean of all the measurement values during publication period. For aggregated metrics, this value is the mean of all the aggregated metrics means.
min	Minimum of all the measurement values during publication period. For aggregated metrics, this value is the minimum of all the aggregated metrics minimums.
max	Maximum of all the measurement values during publication period. For aggregated metrics, this value is the maximum of all the aggregated metrics minimums.
std_dev	Standard deviation of all the measurement values during publication period. For aggregated metrics, this value is the standard deviation of all the aggregated metrics minimums.

Host Metrics

Listing 10.4: Host Types

```
    @appendable @nested
    struct HostPeriodic {
        @optional StatisticVariable cpu_usage_percentage;
        @optional StatisticVariable free_memory_kb;
        @optional StatisticVariable free_swap_memory_kb;
        int32 uptime_sec;
    };

    @appendable @nested
    struct HostConfig {
        BoundedString name;
        uint32 id;
        int64 total_memory_kb;
        int64 total_swap_memory_kb;
        BoundedString target;
    };
```

Table 10.10: `HostConfig`

Field Name	Description
name	Name of the host where the service is running.
id	ID of the host where the service is running.
total_memory_kb	Total memory in KiloBytes of the host where the service is running. Availability of this value is platform dependent.
total_swap_memory_kb	Total swap memory in KiloBytes of the host where the service is running. Availability of this value is platform dependent.

Table 10.11: `HostPeriodic`

Field Name	Description
cpu_usage_percentage	Statistic variable that provides the global percentage of CPU usage on the host where the service is running. Availability of this value is platform dependent.
free_memory_kb	Statistic variable that provides the amount of free memory in KiloBytes of the host where the service is running. Availability of this value is platform dependent.
free_wap_memory_kb	Statistic variable that provides the amount of free swap memory in KiloBytes of the host where the service is running. Availability of this value is platform dependent.
uptime_sec	Time in seconds elapsed since the host on which the running service started. Availability of this value is platform dependent.

Process Metrics

Listing 10.5: Process Types

```
@appendable @nested
struct ProcessConfig {
    uint64 id;
};
@mutable @nested
struct ProcessPeriodic {
    @optional StatisticVariable cpu_usage_percentage;
    @optional StatisticVariable physical_memory_kb;
    @optional StatisticVariable total_memory_kb;
    int32 uptime_sec;
};
```

Table 10.12: `ProcessConfig`

Field Name	Description
id	Identifies the process where the service is running. The meaning of this value is platform dependent.

Table 10.13: `ProcessPeriodic`

Field Name	Description
cpu_usage_percentage	Statistic variable that provides the percentage of CPU usage of the process where the service is running. The field `count` of the variable contains the total CPU time in ms that the process spent during the publication period. Availability of this value is platform dependent.
physical_memory_kb	Statistic variable that provides the physical memory utilization in KiloBytes of the process where the service is running. Availability of this value is platform dependent.
total_memory_kb	Statistic variable that provides the virtual memory utilization in KiloBytes of the process where the service is running. Availability of this value is platform dependent.
uptime_sec	Time in seconds elapsed since the running service process started. Availability of this value is platform dependent.

Base Entity Resource Metrics

Listing 10.6: Base Entity Types

```
@mutable @nested
struct EntityConfig {
    ResourceId resource_id;
    XmlString configuration;
};
@mutable @nested
struct EntityEvent{
    EntityStateKind state;
};
```

Table 10.14: `EntityConfig`

Field Name	Description
resource_id	String representation of the resource identifier associated with the entity resource.
configuration	String representation of the XML configuration of the entity resource. The XML contains only children elements that are not entity resources.

Table 10.15: `EntityEvent`

Field Name	Description
state	State of the resource entity expressed as an enumeration of type `EntityStateKind`.

Network Performance Metrics

Listing 10.7: Network Performance Type

```
@appendable @nested
struct NetworkPerformance {
    @optional StatisticVariable samples_per_sec;
    @optional StatisticVariable bytes_per_sec;
    @optional StatisticVariable latency_millisec;
};
```

Table 10.16: `NetworkPerformance`

Field Name	Description
samples_per_sec	Statistic variable that provides information about the number of samples processed (received or sent) per second.
bytes_per_sec	Statistic variable that provides information about the number of bytes processed (received or sent) per second.
latency_millisec	Statistic variable that provides information about the latency in milliseconds for the data processed. The latency in a refers to the total time elapsed during the associated processing of the data, which depends on the type of application.

Thread Metrics

Listing 10.8: Thread Metrics Type

```
@mutable @nested
struct ThreadPeriodic {
    uint64 id;
    @optional StatisticVariable cpu_usage_percentage;
};

@mutable @nested
struct ThreadPoolPeriodic {
    @optional sequence<Service::Monitoring::ThreadPeriodic>␣
↪threads;
};
```

Table 10.17: `ThreadPeriodic`

Field Name	Description
id	OS-assigned thread identifier
cpu_usage_percentage	Statistic variable that provides the percentage of CPU usage of the thread belonging to the process where the service is running. The field `count` of the variable contains the total CPU time in ms that the thread spent during the publication period. Availability of this value is platform dependent.

10.5 Plugin Management

Some RTI Services allow for custom behavior through the use of *pluggable* components or *plugins* . The type of plugins is described in *Software Development Kit*. A plugin is represented as a top-level service-owned object whose main role is a factory of other pluggable components, which are responsible for providing the user-defined behavior.

Figure 10.7 shows that for each *class* of pluggable components there is a top-level object with the suffix `Plugin`. This is the object that the *Service* obtains at the moment of loading the plugin. Multiple `Plugin` objects can be registered from the same class, each uniquely identified by its *registered name*.

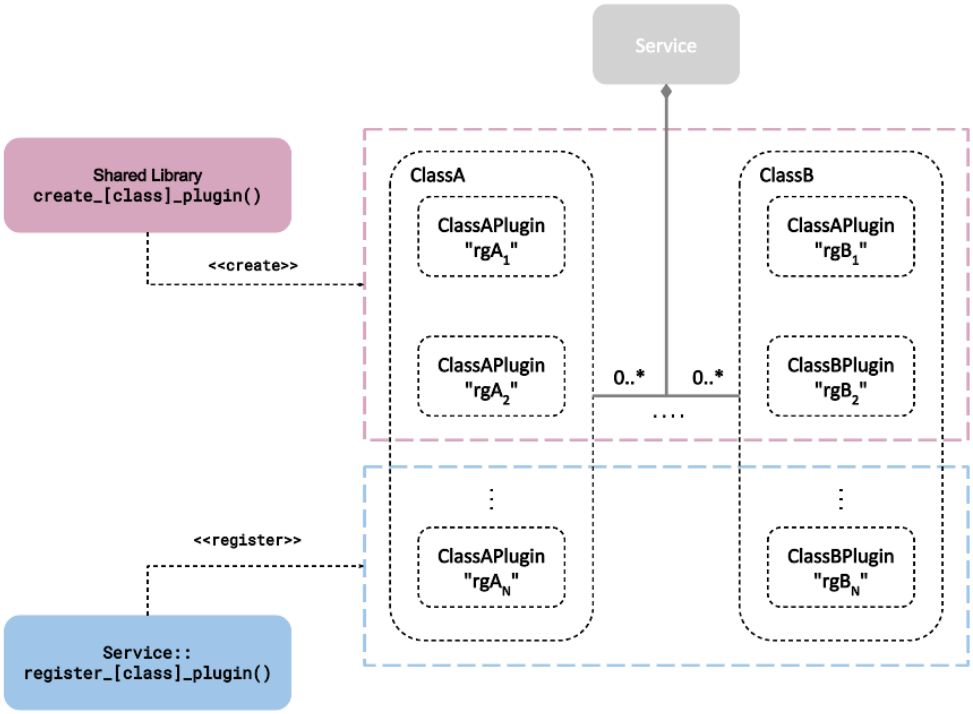

Figure 10.7: Plugin object management

Figure 10.7 also shows that there are two mechanisms through which a *Service* obtains a plugin object: a *shared library* or the Library API. Both mechanisms are complementary and are described with more detail in the next sections.

10.5.1 Shared Library

A plugin object is instantiated through a *create function*, which is included and addressable as part of a shared library. This function is also known as the *entry point* and each RTI Service defines the signature for each plugin class. This method requires specifying the path to the shared library and the name of the entry point (see *Configuration*). The *Service* loads the library the first time an instance of the plugin is needed (lazy initialization) and looks up the specified entry point symbol in the loaded library. The *Service* will always delete the plugin on *Service* stop.

This is the only method suitable when an RTI Service is deployed through an already linked executable, such as the shipped command-line executable (*Usage*).

The plugin lifecycle is as follows:

1. After start, the *Service* creates a plugin object for each registered plugin in the configuration. The plugin object is instantiated through the shared library entry point, specified in the configuration.
2. The *Service* calls operations on the plugin objects as needed and keeps them alive while the *Service* remains started.
3. During stop, the *Service* deletes each plugin object by calling the class abstract deleter.

Configuration

An RTI Service configures the pluggable components within the `<plugin_library>` tag. RTI Services that support plugins will define a set of tags within in the form:

- `<[class]_plugin>` for C/C++ plugins
- `<java_[class]_plugin>` for Java plugins

where `[class]` refers to the name of the plugin class. For example, in *Routing Service* an available tag is `<adapter_plugin>`.

The definition of these tags is the same regardless of the plugin class and is described in the tables below.

Table 10.18 and Table 10.19 describe the configuration of each different plugin language.

Table 10.18: Configuration tags for C/C++ plugins.

Tags within <[class]_plugin>	Description	Multiplicity
<dll>	Shared library containing the implementation of the adapter plugin. This tag may specify the exact path (absolute or relative) of the file (for example, **lib/libmyplugin.so**) or a general name (no file extension). If no extension is provided, the path will be completed based on the running platform. For example, assuming a value for this tag of **dir/myplugin**: • Linux/macOS systems (or similar): **dir/libmyplugin.so** • Windows systems: **dir/myplugin.dll** If the library specified in this tag cannot be loaded (because the environment library path is not pointing to the path where the library is located), *Routing Service* will look for the library in the following locations, in this order: • **[plugin_search_path]**: Provided as part of the service parameters (see *Usage*) • **[executable_dir]**: Directory where the executable lives	1
<create_function>	Entry point. This tag must contain the name of the function used to create the plugin instance. The function symbol must be present in the shared library specified in `<dll>`	1

<property>	A sequence of name-value string pairs that allow you to configure the plugin instance.
	Example:
	`<property>`
	`  <value>`
	`  <element>`
	`  <name>myplugin.user_name</name>`
	`  <value>myusername</value>`
	`  </element>`
	`  </value>`
	`</property>`
		0..1

Table 10.19: Configuration tags for Java plugins

Tags within <java_[class]_plugin>	Description	Multiplicity
<class_name>	Name of the class that implements the plugin. For example: com.myplugins.CustomPlugin The classpath required to run the Java plugin must be part of the RTI Service JVM configuration. See the `<jvm>` tag within the specific service configuration for additional information on JVM creation and configuration.	1

continues on next page

Table 10.19 – continued from previous page

Tags within <java_[class]_plugin>	Description	Multiplicity
<property>	A sequence of name-value string pairs that allow you to configure the plugin instance. **Example:** `<property><value><element><name>myplugin.user_name</name><value>myusername</value></element></value></property>`	0..1

10.5.2 Library API

The user provides the plugin object via the Library API, through one of the available `attach_[class]_plugin()` operations. Upon successful return of the operation, the *Service* takes ownership of the plugin object and will delete it on *Service* stop.

The plugin lifecycle is as follows:

1. The user instantiates plugin objects and provides them to the *Service* through the `attach_[class]_plugin()` operation. This is allowed only before the *Service* starts.
2. After start, the *Service* becomes the owner of the registered plugin objects, calls operations on the plugin objects as needed, and keeps them alive while the *Service* remains started.
3. On stop, the *Service* deletes each registered plugin object by calling the class abstract deleter.

Chapter 11

Release Notes

11.1 Supported Platforms

See the Core Libraries Platform Notes for supported platforms.

Recording Service can also be deployed as a C library linked into your application.

11.2 Compatibility

For backward compatibility information between the current and previous releases of *Recording Service*, please see the *Migration Guide* on the RTI Community portal.

11.3 What's New in 7.7.0

This section describes what's new in *Recording Service* 7.7.0 compared to release *7.6.0*.

Connext 7.7.0 is the first production release in the 7.7 long-term support (LTS) series. It is built upon and combines all of the features in releases 7.4.0, 7.5.0, and 7.6.0 (see *Previous Releases*). See the Connext Versions and Lifecycle page for more information on RTI's software release model.

For what's new in other products in the *Connext* suite, see those products' release notes on the RTI Community Portal or in your installation.

11.3.1 Improved performance when converting to JSON format using Converter

The *Recording Service* Converter tool now converts data to JSON format significantly faster, reducing processing time.

11.3.2 Third-Party Software Changes

The following third-party software used by *Routing Service* has been upgraded:

Table 11.1: Third-Party Software Upgrades

Third-Party Software	Old Version	New Version
libxml2	2.11.4	2.15.1

For information on third-party software used by *Connext* products, see the "3rdPartySoftware" documents in your installation: <NDDSHOME>/doc/manuals/connext_dds_professional/release_notes_3rdparty.

11.4 What's Fixed in 7.7.0

This section describes bugs fixed in *Recording Service* 7.7.0. These are fixes since *7.6.0*.

Connext 7.7.0 is the first production release in the 7.7 long-term support (LTS) series. It is built upon and combines all of the fixes in releases 7.4.0, 7.5.0, and 7.6.0 (see *Previous Releases*). See the Connext Versions and Lifecycle page for more information on RTI's software release model.

For what's fixed in other products in the *Connext* suite, see those products' release notes on the RTI Community Portal or in your installation.

[Critical]: System-stopping issue, such as a crash or data loss. [Major]: Significant issue with no easy workaround. [Minor]: Issue that usually has a workaround. [Trivial]: Small issue, such as a typo in a log.

11.4.1 [Critical] Static memory finalization problems when using Recording Service as library

When using Recording Service as a library embedded in your application, `heap-use-after-free` (UAF) errors could occur when finalizing.

[RTI Issue ID RECORD-1575]

11.4.2 [Critical] Possible crash during rollover process

Recording Service could crash if it attempted to store samples while the rollover mechanism was enabled and the rollover process was active.

[RTI Issue ID RECORD-1550]

[Minor] Recording Service could not use builtin QoS profiles when configured to skip default files

When the *Recording Service* configuration file contained QoS profiles with references to builtin profiles, and the `ignore_default_files` field was set to `TRUE` in the ServiceProperties, *Recording Service* failed to parse the QoS profile.

[RTI Issue ID RECORD-1567]

11.4.3 Vulnerabilities

The following vulnerabilities are fixed in this release.

See also RTI Connext Security Bulletins and Advisories for a complete list of vulnerabilities in RTI releases that have been published through the CVE® Program. That list may be more up-to-date.

[Critical] Potential stack buffer overflow in Recording Service when parsing malicious XML

Recording Service could have been affected by a vulnerability found in the `Libxml2` third-party library. This issue has been resolved by upgrading to a newer version of the third-party library. See the *third-party software changes* in What's New.

User Impact without Security

A vulnerability in *Recording Service* could have resulted in the following:

- Stack buffer overflow when parsing a malicious XML file.
- Exploitable by providing malicious XML code to the applications during startup.
- CVSS v3.1 Base Score: 6.2 LOW
- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:N/UI:N/S:U/C:N/I:N/A:H
- CVSS v4.0 Base Score: 6.9 MEDIUM
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:N/PR:N/UI:N/VC:N/VI:N/VA:H/SC:N/SI:N/SA:N

User Impact with Security

A vulnerability in *Recording Service* could have resulted in the following:

- Stack buffer overflow when parsing a malicious XML file.
- Exploitable by providing malicious XML code to the applications during startup.
- CVSS v3.1 Base Score: 6.2 LOW
- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:N/UI:N/S:U/C:N/I:N/A:H
- CVSS v4.0 Base Score: 6.9 MEDIUM
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:N/PR:N/UI:N/VC:N/VI:N/VA:H/SC:N/SI:N/SA:N

[RTI Issue ID RECORD-1566]

[Critical] Potential unauthorized local file system read in Recording Service when parsing a malicious XML configuration document

Improper restriction of an XML external entity reference vulnerability in *Recording Service* when parsing a malicious XML configuration document could allow unauthorized local file system read access and Data Serialization External Entities Blowup.

User Impact without Security

A vulnerability in *Recording Service* while loading configurations via XML could have resulted in the following:

- Unauthorized local file system read when parsing a malicious XML file.
- Availability of the service affected (denial of service) when parsing a malicious XML file.
- Exploitable by providing malicious XML code to the applications during startup.
- CVSS v3.1 Base Score: 7.7 HIGH
- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:N/UI:N/S:U/C:H/I:N/A:H
- CVSS v4.0 Base Score: 7 HIGH
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:N/PR:N/UI:N/VC:H/VI:N/VA:H/SC:N/SI:N/SA:N

User Impact with Security

A vulnerability in *Recording Service* while loading configurations via XML could have resulted in the following:

- Unauthorized local file system read when parsing a malicious XML file.
- Availability of the service affected (denial of service) when parsing a malicious XML file.
- Exploitable by providing malicious XML code to the applications during startup.
- CVSS v3.1 Base Score: 7.7 HIGH

- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:N/UI:N/S:U/C:H/I:N/A:H
- CVSS v4.0 Base Score: 7 HIGH
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:N/PR:N/UI:N/VC:H/VI:N/VA:H/SC:N/SI:N/SA:N

[RTI Issue ID RECORD-1571]

11.5 Previous Releases

11.5.1 What's New in 7.6.0

This section describes what's new in *Recording Service* 7.6.0 compared to release *7.5.0*.

RTI® Connext® 7.6.0 is an early access release. See the Connext Versions and Lifecycle page for more information on RTI's software release model.

For what's new in other products in the *Connext* suite, see those products' release notes on the RTI Community Portal or in your installation.

Third-Party Software Changes

The following third-party software used by *Recording Service* has been upgraded:

Table 11.2: Third-Party Software Upgrades

Third-Party Software	Old Version	New Version
SQLite	3.39.4	3.50.2

11.5.2 What's Fixed in 7.6.0

This section describes bugs fixed in *Recording Service* 7.6.0. These are fixes since *7.5.0*.

RTI® Connext® 7.6.0 is an early access release. See the Connext Versions and Lifecycle page for more information on RTI's software release model.

For what's fixed in other products in the *Connext* suite, see those products' release notes on the RTI Community Portal or in your installation.

[Critical]: System-stopping issue, such as a crash or data loss. [Major]: Significant issue with no easy workaround. [Minor]: Issue that usually has a workaround. [Trivial]: Small issue, such as a typo in a log.

Performance and Scalability

[Critical] Performance degradation when converting databases to CSV

A performance degradation occurred in *Converter* when converting databases to the CSV format.

[RTI Issue ID RECORD-1536]

Vulnerabilities

Potential out-of-bounds read in RTI Recording Service during its initialization

An out-of-bounds read in *Recording Service* could have occurred during its initialization.

User Impact without Security

A vulnerability in *Recording Service* while initializing could have resulted in the following:

- Out-of-bounds read while executing a malicious SQLite statement.
- Exploitable by providing a malicious XML document to Recording Service during startup. Not remotely exploitable.
- Potential impact on the confidentiality of *Recording Service*.
- Potential crash in *Recording Service*.
- CVSS v3.1 Base Score: 7.7 High
- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:N/UI:N/S:U/C:H/I:N/A:H
- CVSS v4.0 Base Score: 6.9 Medium
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:N/PR:L/UI:N/VC:H/VI:N/VA:H/SC:N/SI:N/SA:N

User Impact with Security

Same impact as described in "User Impact without Security" above.

[RTI Issue ID RECORD-1546]

Potential arbitrary code execution in RTI Recording Service during its initialization

An arbitrary code execution in *Recording Service* could have occurred during its initialization.

User Impact without Security

A vulnerability in *Recording Service* while initializing could have resulted in the following:

- Arbitrary code execution while executing a malicious SQLite statement.
- Exploitable by providing a malicious XML document to Recording Service during startup. Not remotely exploitable.
- Potential impact on the integrity and confidentiality of *Recording Service*.
- Potential crash in *Recording Service*.
- CVSS v3.1 Base Score: 8.4 High
- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H
- CVSS v4.0 Base Score: 8.6 High
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:N/PR:N/UI:N/VC:H/VI:H/VA:H/SC:L/SI:L/SA:L

User Impact with Security

Same impact as described in "User Impact without Security" above.

[RTI Issue ID RECORD-1545]

Potential out-of-bounds write in RTI Recording Service during its initialization

An out-of-bounds write in *RTI Recording Service* could have occurred while initializing the application.

User Impact without Security

A vulnerability in *RTI Recording Service* while initializing could have resulted in the following:

- Out-of-bounds write while executing a malicious SQLite statement.
- Not remotely exploitable.
- Potential impact on the integrity and confidentiality of *RTI Recording Service*.
- Potential crash in *RTI Recording Service*.
- CVSS v3.1 Base Score: 5.8 Medium
- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:H/PR:L/UI:N/S:U/C:L/I:H/A:L

- CVSS v4.0 Base Score: 5.8 Medium
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:H/AT:P/PR:L/UI:N/VC:L/VI:H/VA:L/SC:N/SI:N/SA:N

User Impact with Security

Same impact as described in "User Impact without Security" above.

[RTI Issue ID RECORD-1541]

11.5.3 What's New in 7.5.0

This section describes what's new in *Recording Service* 7.5.0 compared to release 7.4.0.

RTI® Connext® 7.5.0 is an early access release. See the Connext Versions and Lifecycle page for more information on RTI's software release model.

For what's new in other products in the *Connext* suite, see those products' release notes on the RTI Community Portal or in your installation.

Improved performance in Recording Service when converting to CSV

The performance when using the *Recording Service Converter* to convert a recording to CSV format has been improved. Before, the service spent time calculating the necessary string size for storing the sample. Now *Converter* will do this in a greedier way and reuse a string buffer.

11.5.4 What's Fixed in 7.5.0

This section describes bugs fixed in *Recording Service* 7.5.0. These are fixes since 7.4.0.

RTI® Connext® 7.5.0 is an early access release. See the Connext Versions and Lifecycle page for more information on RTI's software release model.

For what's fixed in other products in the *Connext* suite, see those products' release notes on the RTI Community Portal or in your installation.

[Critical]: System-stopping issue, such as a crash or data loss. [Major]: Significant issue with no easy workaround. [Minor]: Issue that usually has a workaround. [Trivial]: Small issue, such as a typo in a log.

Usability

[Critical] Converter slow to start when processing large number of recording files and tables

When trying to process a recording with a large fileset and numerous discovered *Topics*, *Converter Service* took a long time to begin the conversion. The conversion process now starts instantly regardless of the number of files being processed.

[RTI Issue ID RECORD-1502]

Hangs

[Critical] Converter's CSV exporter did not work with unbounded sequences

The CSV utility in *Converter Service* did not work with unbounded sequences. The process entered a loop trying to generate infinite columns and had to be stopped.

Now, the CSV tool will detect when an unbounded sequence is being exported and always apply a limit to the number of columns exported. This limit is configurable via a new XML configuration tag:

```
<csv>
     ...
     <unbounded_seq_size_limits>
         <field_name_expr max_size="1024">mySequence</field_name_expr>
         <field_name_expr max_size="2048">myLongerSequence</field_name_expr>
         ...
     </unbounded_seq_size_limits>
 </csv>
```

If an unbounded sequence field does not match any expressions, a default limit of 1,000 columns will be applied.

[RTI Issue ID RECORD-1058]

Memory Leaks/Growth

[Critical] Memory leaks and errors when using DDS-fragmentation with compression or encryption

Using DDS-fragmentation along with compression or encryption caused a memory leak. This occurred when storing the serialized data from samples received by *Recording Service*. Errors similar to the following were printed:

```
FATAL rCo79661##01Rcv [PARSE MESSAGE|0x01016350,0x5A66C0E7,
↪0x8DA940ED:0x80000004
{Entity=DR,MessageKind=DATA_FRAG}|RECEIVE FROM 0x01018673,0xDB0C9361,
0xB2B4181F:0x80000003] Mx02:/home/user/osapi.1.0/srcC/memory/heap.c:1104:
RTI0x2022004:inconsistent free/alloc: block id 0 being freed with
```

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```
"RTIOsapiHeap_allocateBufferAligned" and was allocated with
"RTIOsapiHeap_unknownFunction"``
```

[RTI Issue ID RECORD-1516]

Vulnerabilities

The following vulnerabilities are fixed in this release.

See also RTI Connext Security Bulletins and Advisories for a complete list of vulnerabilities in RTI releases that have been published through the CVE® Program. That list may be more up-to-date.

[Critical] Potential stack buffer overflow in Recording Service when discovering type or loading XML type with certain characteristics

The stack could have been corrupted when *Recording Service* discovered a malicious type or loaded a malicious XML type.

User Impact without Security

This vulnerability could cause the following in *Recording Service*:

- Stack corruption leading to data corruption or crash.
- Unbounded memory growth.
- Exploitable through malicious RTPS messages.
- Exploitable through a compromised local file system containing a malicious XML file.
- CVSS v3.1 Base Score: 9.1 CRITICAL
- CVSS v3.1 Vector: CVSS:3.1/AV:N/AC:L/PR:N/UI:N/S:U/C:N/I:H/A:H
- CVSS v4.0 Base Score: 8.3 HIGH
- CVSS v4.0 Vector: CVSS:4.0/AV:N/AC:L/AT:P/PR:N/UI:N/VC:N/VI:H/VA:H/SC:N/SI:N/SA:N

User Impact with Security

This vulnerability could cause the following in *Recording Service*:

- Stack corruption leading to data corruption or crash.
- Unbounded memory growth.
- Exploitable through a compromised local file system containing a malicious XML file.
- CVSS v3.1 Base Score: 7.1 HIGH

- CVSS v3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:L/UI:N/S:U/C:N/I:H/A:H
- CVSS v4.0 Base Score: 6.9 MEDIUM
- CVSS v4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:N/PR:L/UI:N/VC:N/VI:H/VA:H/SC:N/SI:N/SA:N

[RTI Issue ID RECORD-1508]

[Critical] Potential out-of-bounds read and write in Recording Service while using file rollover

Recording Service may have read or written out-of-bounds and crashed when recording using the rollover feature.

User Impact without Security

This vulnerability could cause the following in *Recording Service*:

- Memory corruption leading to data corruption or a crash.
- Exploitable only when a race condition was won.
- Potential impact on confidentiality of the *Connext* application.
- When rollover was set up to change files based on size, exploitable through a compromised local file system containing a malicious database file.
- When rollover was set up to change files based on size, exploitable by publishing data over the network.
- CVSS 4.0 Base Score: 7.7 HIGH
- CVSS 4.0 Vector: CVSS:4.0/AV:N/AC:L/AT:P/PR:L/UI:N/VC:H/VI:H/VA:H/SC:N/SI:N/SA:N
- CVSS 3.1 Base Score: 8.8 HIGH
- CVSS 3.1 Vector: CVSS:3.1/AV:N/AC:L/PR:L/UI:N/S:U/C:H/I:H/A:H

User Impact with Security

This vulnerability could cause the following in *Recording Service*:

- Memory corruption leading to data corruption or a crash.
- Exploitable only when a race condition was won.
- Potential impact on confidentiality of the *Connext* application.
- When rollover was set up to change files based on size, exploitable through a compromised local file system containing a malicious database file.
- CVSS 4.0 Base Score: 7.3 HIGH
- CVSS 4.0 Vector: CVSS:4.0/AV:L/AC:L/AT:P/PR:L/UI:N/VC:H/VI:H/VA:H/SC:N/SI:N/SA:N
- CVSS 3.1 Base Score: 7.8 HIGH

- CVSS 3.1 Vector: CVSS:3.1/AV:L/AC:L/PR:L/UI:N/S:U/C:H/I:H/A:H

[RTI Issue ID RECORD-1514]

Other

[Critical] Incomplete documentation for Recording Service's tag_timestamp remote administration command

This issue was fixed in 7.4.0, but not documented at that time.

Recording Service's remote administration command, `tag_timestamp`, had incomplete information; it did not mention that the provided time represents seconds. See 3.4.5 Storage for the corrected documentation.

[RTI Issue ID RECORD-1482]

11.5.5 What's Fixed in 7.4.0

This section describes bugs fixed in *Recording Service* 7.4.0. These are fixes since 7.3.0.

RTI® Connext® 7.4.0 is an early access release. See the Connext Versions and Lifecycle page for more information on RTI's software release model.

For what's new and fixed in other products in the *Connext* suite, see those products' release notes on the RTI Community Portal or in your installation.

[Critical]: System-stopping issue, such as a crash or data loss. [Major]: Significant issue with no easy workaround. [Minor]: Issue that usually has a workaround. [Trivial]: Small issue, such as a typo in a log.

Crashes

[Critical] Converter's CSV plugin failed with double free memory error on some architectures

When running *Converter* with the built-in CSV storage utility plugin, *Converter* could crash with a memory corruption (double free) error. This issue was caused by the definition of symbols loaded by both *Recording Service* and the CSV plugin's dynamic library. When the dynamic library was released, the service incurred a double free attempting to free the same static region in memory.

[RTI Issue ID RECORD-1464]

Data Corruption

[Critical] Overwriting Recording Service database could corrupt its contents and crash (QNX systems only)

When *Recording Service* stored a recording in a path that already contained a recording database, it could corrupt its data when overwriting the previous recording files, resulting in a crash.

[RTI Issue ID RECORD-1445]

[Critical] <content_filter> tags did not work for Topic groups

Recording Service allows the use of `<content_filter>` tags within *Topic* group configurations. These tags were mistakenly ignored by the service.

[RTI Issue ID RECORD-1462]

[Critical] Replay Service did not start when the default internal clock was changed

When the default internal clock was changed in *Replay Service's DomainParticipant* QoS configuration, (as demonstrated in the following snippet), *Replay* could have started with the wrong start timestamp. As a result, the service was unable to replay data.

```
<replay_service name="Replay_InternalClock">
        ...
        <domain_participant name="DefaultParticipant">
            <domain_id>0</domain_id>
            <domain_participant_qos>
                <property>
                    <value>
                        <element>
                            <name>dds.clock.internal_clock</name>
                            <value>realtime</value>
                        </element>
                    ...
```

[RTI Issue ID RECORD-1456]

APIs (Modern C++ API)

[Major] Recording Service as a library did not compile when using the service's constructor as a parameter

The following constructor in the *Recording Service* API had an incorrect `const` qualifier for the Shutdown Hook:

```
template <typename HookFunc>
    explicit Service(
            const ServiceProperty& property,
            const HookFunc& shutdown_hook);
```

The shutdown hook parameter was made const, but the underlying base class constructor did not use const. This prevented applications using the C++ Recording Library API from compiling successfully.

[RTI Issue ID RECORD-1460]

Hangs

[Major] Replay Service did not call the shutdown hook more than once

When using *Replay Service* as a service library, it calls the shutdown hook provided by your application when the replay finishes. However, if the service was run and finished more than once, *Replay Service* did not call the shutdown hook again.

[RTI Issue ID RECORD-1480]

Dynamic Data

[Major] Recording Service did not work with empty structs

Recording Service could have failed to record, replay, or convert a type defined as an empty struct. This issue could have caused *Recording Service* to fail with the following error:

```
DDS_DynamicData2_allocateMembers: Could not reserve buffer of 0 bytes for␣
↪values.
```

[RTI Issue ID RECORD-1463]

Vulnerabilities

[Critical] Stack Overflow could have occurred when using XML configuration file referencing environment variables

An out-of-bounds write on the stack in *Recording Service* could have occurred while parsing XML files containing references to external environment variables.

User Impact without Security

This problem could result in the following:

- Stack buffer overflow when parsing a malicious XML file.
- Exploitable by providing malicious XML code to the applications during startup.
- CVSS 3.1 Score: 6.1 MEDIUM
- CVSS 3.1 Vector: AV:L/AC:L/PR:L/UI:N/S:U/C:N/I:H/A:L

User Impact with Security

Same impact as described in "User Impact without Security," above.

[RTI Issue ID RECORD-1486]

11.6 Known Issues

Note: For an updated list of critical known issues, see the Critical Issues List on the RTI Customer Portal at https://support.rti.com/.

11.6.1 Recording Service may Fail when Current Working Directory in c:\Program Files

Recording Service will try to write to its database in the current working directory. If it does not have permissions to write there, it will fail with a confusing error:

```
[/recording_services/RecorderService|START|/storage|CREATE]
 create_connection:!SQLite - failed to open database file; sqlite
 returned error: out of memory
[SQLite return code = 7]
[File = metadata]
```

This happens most commonly when running the application from within `c:\Program Files` on Windows systems. You can work around this by running *Recording Service* from a command prompt in a directory where you have write permissions.

11.6.2 Some tags in the XML configuration must be grouped in a strict order

The XML validator tools *Recording Service* uses to validate XML configuration files adhere to the XML 1.0 specification, which doesn't offer a way of defining collections of unordered tags that are both bounded and unbounded in occurrences.

This limitation is no longer present in XML 1.1. However, there are no C or C++ validators compliant with the XML 1.1 specification at the time of writing.

[RTI Issue ID CORE-14178]

Chapter 12

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