RTI Code Generator

User's Manual

Version 4.2.0

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Chapter 1 Introduction

RTI® Code Generator creates the code needed to define and register a user data type with *RTI Connext® DDS*. It takes a language-independent specification of the data (in IDL, XML, or XSD notation) and generates supporting classes and code to distribute instances of the data over *Connext*.

Using *Code Generator* is optional if:

- You are using dynamic types (see *Managing Memory for Built-in Types* (Section 3.2.7) in the RTI Connext Core Libraries Users Manual).
- You are using one of the built-in types (see *Built-in Data Types* (Section 3.2) in the RTI Connext Core Libraries Users Manual).

To use *Code Generator*, you will need to provide a description of your data type(s) in an IDL or XML file. You can define multiple data types in the same type-definition file. For details on these files, see the "Data Types and DDS Data Samples" chapter in the RTI Connext Core Libraries User's Manual.

Chapter 2 Paths Mentioned in Documentation

The documentation refers to:

- **<NDDSHOME>**

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

  - macOS® systems:
    /Applications/rti_connext_dds-7.3.0
  - Linux systems, non-*root* user:
    /home/<*your user name*>/rti_connext_dds-7.3.0
  - Linux systems, *root* user:
    /opt/rti_connext_dds-7.3.0
  - Windows® systems, user without Administrator privileges:
    <*your home directory*>\rti_connext_dds-7.3.0
  - Windows systems, user with Administrator privileges:
    C:\Program Files\rti_connext_dds-7.3.0

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

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

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

```
“C:\Program Files\rti_connext_dds-7.3.0\bin\rtiddsgen”
```

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

```
“%NDDSHOME%\bin\rtiddsgen”
```

- ***<path to examples>***

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

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

Default path to the examples:

- macOS systems: **/Users/<*your user name*>/rti_workspace/7.3.0/examples**
- Linux systems: **/home/<*your user name*>/rti_workspace/7.3.0/examples**
- Windows systems: **<*your Windows documents folder*>\rti_workspace\7.3.0\examples**

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

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

Chapter 3 Command-Line Arguments for rtiddsgen

On Windows systems: Before running *rtiddsgen*, run the "vcvars" batch file that is appropriate for your architecture in the same command prompt that you will use to run *rtiddsgen*. For example: **vcvarsall.bat x86**. The location of the "vcvars" batch file varies depending on your version of Visual Studio. Consult the Microsoft Visual Studio documentation for the exact location and parameters for your installation. Alternatively, run *rtiddsgen* from the Visual Studio Command Prompt under the Visual Studio Tools folder. Or, use the command-line argument **-ppDisable**. See -ppDisable in Table 3.1 Options for rtiddsgen on the next page.

If you are generating code for *Connext*, the options are:

```
rtiddsgen   [-help]
        [-allocateWithMalloc]
        [ -allowedDataRepresentation <xcdr1, xcdr2> on the next page]
        [ -allowedEndian <bigEndian, littleEndian> on the next page]
        [-alwaysUseStdVector]
        [-autoGenFiles <architecture>]
        [-constructor]
        [-create <typefiles|   examplefiles|makefiles>]
        [-convertToIdl | -convertToXML | -convertToXsd]
        [-D <name>[=<value>]]
        [-d <outdir>]
        [-disableXSDValidation]
        [-dllExportMacroSuffix <suffix>]
        [-enableEscapeChar]
        [-example <architecture>]
        [-exampleTemplate]
        [-generateIncludeFiles]
        [-I <directory>]
        [[-inputIdl] <IDLInputFile.idl> | [-inputXml] <XMLInputFile.xml>
         |[-inputXsd <IDLInputFile.idl>]]
        [-language  <Ada|C|C++98|C++11|C#|Java|Python>]
        [-namespace]
        [-obfuscate]
        [-optimization <level>]
        [-package <packagePrefix>]
        [-platform <architecture>]
        [-ppDisable]
        [-ppPath <path to preprocessor>]
        [-ppOption <option>]
        [-qualifiedEnumerator]
        [-replace]
        [-sequenceSize <unbounded sequences size>]
        [-sharedLib]
        [-showTemplates]
        [-standard <DDS_PSM_Cxx, IDL4_CPP>]
        [-strict]
        [-stringSize  <unbounded strings size>]
        [-typeSequenceSuffix <suffix>]
        [-typeSizes]
        [-U <name>]
        [-unboundedSupport]
        [-update <typefiles|   examplefiles|makefiles>]
        [-use52Keyhash]
        [-use526Keyhash]
        [-useStdString]
        [-V <name< [=<value>]]
        [-verbosity [1-3]]
        [-version]
        [-virtualDestructor]
```

Table 3.1 Options for rtiddsgen describes the options.

Note: Before using a makefile created by *Code Generator* to compile an application, make sure the **${NDDSHOME}** environment variable is set as described in Set Up Environment Variables (rtisetenv), in "Hands-On 1" of *Introduction to Publish/Subscribe*, in the RTI Connext Getting Started Guide.

Table 3.1 Options for rtiddsgen

Option	Description
-allocateWithMalloc	Use this flag to obtain backward-compatibility when allocating optional members with DDS_Heap_malloc in C++.
-allowedDataRepresentation <xcdr1, xcdr2>	Only applies if **-language C**, **-language C++98**, or **-language C++11** is specified. Generates code for only one data representation. This option may increase performance, because the generated code will not check the data representation during serialization/deserialization.
-allowedEndian <bigEndian, littleEndian>	Only applies if **-language C**, **-language C++98**, or **-language C++11** is specified. Generates code for a specific endianness. This option may improve performance, because the generated code will not check the endianness during serialization/deserialization.
-alwaysUseStdVector	Only applies if **-language C++11** is specified. Generates code that maps all sequences to **std::vector**, even bounded sequences that would otherwise map to **rti::core::bounded_sequence**. Alternatively, the **@use_vector** annotation can be applied to each sequence member.

Table 3.1 Options for rtiddsgen

Option	Description
-autoGenFiles <*architecture*>	Updates the auto-generated files, i.e, the typefiles and makefile/project files. To see the valid options for <*architecture*> per language, run *rtiddsgen* with the **-help** option, or use the string "universal" (**-autoGenFiles universal**) to generate compatible publisher/subscriber code for all supported platforms. The universal architecture will not generate makefiles/project files. This is a shortcut for: `-update typefiles -update makefiles -platform <architecture>`
-constructor	Only applies if **-language C++98** is also specified. Generates the types default constructor, copy constructor, copy assignment operator, and destructor. Using this option will also disable the generation of the following TypeSupport methods: create_data(_ex), delete_data(_ex), initialize_data(_ex), finalize_data(_ex), copy_data.

-create <typefiles|examplefiles|makefiles>	Creates the files indicated (typefiles, examplefiles, or makefiles) if they do not exist. For example:
	`rtiddsgen -language C++11 -create typefiles test.idl`
	If the files already exist, the files are not modified and a warning is printed.
	There can be multiple **-create** options.
	If you specify both **-create** and **-update** for the same file type, only **-update** will be applied.
	If you use -create makefiles, the -platform <arch> option is required. For example:
	`rtiddsgen -language c -create makefiles -platform x64Darwin17clang9.0 test.idl`
	You can specify multiple input (e.g., **.idl**) files or folders. See Chapter 4 Generating Example Code on page 13 for more information.

-convertToIdl	Converts the input type description file into IDL format. This option creates a new file with the same name as the input file and a **.idl** extension.
-convertToXML	Converts the input type description file into XML format. This option creates a new file with the same name as the input file and a **.xml** extension.
-convertToXsd	Converts the input type description file into XSD format. This option creates a new file with the same name as the input file and a **.xsd** extension.
-D <*name*>[=<*value*>]	Defines preprocessor macros. On Windows systems, enclose the argument in quotation marks: **-D "<*name*>[=<*value*>]"**
-d <*outdir*>	Generates the output in the specified directory. By default, *Code Generator* will generate files in the directory where the input type-definition file is found.
-disableXSDValidation	Causes *Code Generator* not to check that the input XSD file is well-formed. The use of *this option is not recommended* in general, as *Code Generator* may receive invalid inputs.
-dllExportMacroSuffix <suffix>	Defines the suffix of the macro that is used to export symbols when building Windows DLLs. The default macro is NDDS_USER_DLL_EXPORT. When this option is specified, the name of the macro is NDDS_USER_DLL_EXPORT_<Suffix>.
-enableEscapeChar	Enables use of the escape character '_' in IDL identifiers. Normally, if you use an identifier that is an IDL keyword, you will see an error (for case-sensitive matches) or a warning (for case-insensitive ones). This option allows you to escape the IDL keywords with an underscore so that they can be used in the IDL.

Table 3.1 Options for rtiddsgen

Option	Description

-example *<architecture>*	Generates type files, example files, and a makefile.
	This is a shortcut for:
	`-create typefiles -create examplefiles -create makefiles -platform <architecture>`
	To see the valid options for <*architecture*> per language, run *rtiddsgen* with the **-help** option, or use the string "universal" (**-example universal**) to generate compatible publisher/subscriber code for all supported platforms. The universal architecture will not generate makefiles/project files.
	For Python, when generating examples, the only available platform is "universal". For example:
	`rtiddsgen -language Python -example -platform universal Hello.idl`

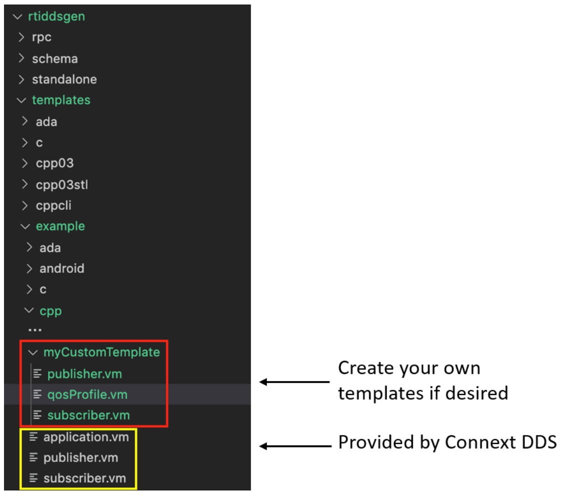
-exampleTemplate	Generates a custom example application using the specified custom publisher and subscriber templates, instead of the default example files. Place your custom templates in **$NDDSHOME/resource/app/app_support/rtiddsgen/templates/example/<language>/<exampleTemplateDirectoryName>/**. Name them **publisher.vm** and **subscriber.vm**; you can also add a QoS template (qosProfile.vm) file to your example template directory (if you don't, *Code Generator* will use the default one, **$NDDSHOME/resource/app/app_support/rtiddsgen/templates/example/qosProfile.vm**). You can base your templates on those that *Connext* provides in **$NDDSHOME/resource/app/app_support/rtiddsgen/templates/example/<language>**.  rtiddsgen rpc schema standalone templates ada c cpp03 cpp03stl cppcli example ada android c cpp ... myCustomTemplate publisher.vm qosProfile.vm subscriber.vm application.vm publisher.vm subscriber.vm Create your own templates if desired Provided by Connext DDS The **-exampleTemplate** option must be used in combination with one of the following command-line options: • **-create examplefiles** • **-update examplefiles** • **-example *<architecture>*** For example: `rtiddsgen -language C++11 -example x64Darwin17clang9.0 -exampleTemplate myCustomTemplate foo.idl` "myCustomTemplate" is your **<exampleTemplateDirectoryName>** in **$NDDSHOME/resource/app/app_support/rtiddsgen/templates/example/<language>/<exampleTemplateDirectoryName>/**. To get a full list of the available custom templates in your *Connext* installation, use the **-showTemplates** option. For C++98, C++11, C#, Python, and Java, you can also use an advanced **-exampleTemplate** option included with *Connext*. See 4.3 Advanced Example on page 16. The **-exampleTemplate** option is not supported in Ada.

Table 3.1 Options for rtiddsgen

Option	Description

-generateIncludeFiles	Generates code for any included file in the inputs. For example:
	`rtiddsgen -language python Foo.idl -generateIncludeFiles`
	Imagine you have the following two files:
	`// File Bar.idl`
	`struct Bar {`
	`...`
	`};`
	
	`// File Foo.idl`
	`#include "Bar.idl"`
	`struct Foo {`
	`Bar b;`
	`};`
	This example will produce the following files:
	• Foo.py
	• Bar.py

-help	Prints out the command-line options for *rtiddsgen.*
-I <*directory*>	Adds to the list of directories to be searched for type-definition files (IDL or XML files). Note: A type-definition file in one format cannot include a file in another format.
-inputIdl	Indicates that the input file is an IDL file, regardless of the file extension. This command-line option is required when the input has one or more directories. See 4.1.4.2 Listing Directories on page 14 for more information.
-inputXml	Indicates that the input file is an XML file, regardless of the file extension. This command-line option is required when the input has one or more directories. See 4.1.4.2 Listing Directories on page 14 for more information.
-inputXsd	Indicates that the input file is an XSD file, regardless of the file extension. This command-line option is required when the input has one or more directories. See 4.1.4.2 Listing Directories on page 14 for more information.
IDLInputFile.idl	A file containing IDL descriptions of your data types. If -inputIdl is not used, the file must have a '**.idl**' extension.
-language <Ada|C|C++98|C++11|C#|Java|Python>	Specifies the language to use for the generated files. Notes: • Use **-language C++98** or **-language C++11** to select the Traditional C++ or Modern C++ API respectively. Note that C++98 and C++11 are the minimum C++ versions required by each API. Applications can use newer C++ standards. • For Python, when generating examples, the only available platform is "universal". For example: `rtiddsgen -language Python -example -platform universal Hello.idl`
-namespace	Specifies the use of C++ namespaces, for traditional C++ only. For modern C++ and C#, it is implied–namespaces are always used.
-obfuscate	Generates an obfuscated IDL file from the input file. Note that even if the input type is XML, this option generates an obfuscated IDL file.

Table 3.1 Options for rtiddsgen

Option	Description
-optimization <level>	Level of optimization of the code: • 0: No optimization. • 1: The compiler generates extra code for typedefs but optimizes its use. If a type that is used is a typedef that can be resolved to a primitive, enum, or aggregated type (struct, union, or value type), the generated code will invoke the code of the most basic type to which the typedef can be resolved. This level can be used if the generated code is not expected to be modified. This is the only optimization level supported for Java and C# languages. • 2: (Default) This optimization level applies only to C, C++, C++11 and higher, and Ada languages. With this optimization level, *rtiddsgen* optimizes the serialization/deserialization of structures and valuetypes by using more aggressive techniques. These techniques include inline expansion of nested types and serialization/deserialization of a set of consecutive members with a single copy function invocation (memcpy) when the memory layout (C, C++ structure layout) is the same as the wire layout (XCDR). See Chapter 7 Optimizing the Code Generation Process on page 29 for more information. 2 is the default for C, C++, C++11 and higher, and Ada languages (but you can change it to 0 or 1). 1 is always used for Java and C# languages, and you cannot change it.
-package <*packagePrefix*>	Specifies the root package into which generated classes will be placed. It applies to Java only. If the type-definition file contains module declarations, those modules will be considered subpackages of the package specified here.
-platform <*architecture*>	Required if **-create makefiles** or **-update makefiles** is used. To see the valid options for <*architecture*> per language, run *rtiddsgen* with the **-help** option, or use the string "universal" (**-platform universal**) to generate compatible publisher/subscriber code for all supported platforms. The universal architecture will not generate makefiles/project files. For Python, when generating examples, the only available platform is "universal". For example: `rtiddsgen -language Python -example -platform universal Hello.idl`
-ppDisable	Disables the preprocessor. *Code Generator* supports the standard preprocessor directives defined by the IDL specification, such as #if, #endif, #include, and #define. To support these directives, *Code Generator* calls an external C preprocessor before parsing the IDL file. On Windows systems, the preprocessor is 'cl.exe.' On other architectures, the preprocessor is 'cpp.' You can change the default preprocessor with the **-ppPath** option. If you do not want to run the preprocessor, use the **-ppDisable** option. The argument **-ppDisable** tells the code generator not to attempt to invoke the C preprocessor on the IDL file prior to generating code. In some cases, the IDL file contains no preprocessor directives, so no preprocessing is necessary. Therefore, you may want to use the **-ppDisable** option to tell *Code Generator* to skip calling the preprocessor. However, if the preprocessor executable is already on your system path (on Windows systems, it will be on your path if you've run the Visual Studio "vcvars" batch file that is appropriate for your architecture), you don't need to use **-ppDisable**. In summary, **-ppDisable** is a useful, quick remedy for simple examples (including HelloWorld examples) for which the IDL is simple and does not need *Code Generator* to invoke the preprocessor. The longterm recommendation, however, is to have the preprocessor in your path (or use the **-ppOption**). Linux architectures often already have the preprocessor in the path; Windows architectures may require you to run a "vcvars" batch file as described at the beginning of this chapter to put the preprocessor in your path.
-ppOption <*option*>	Specifies a preprocessor option. This option can be used multiple times to provide the command-line options for the specified preprocessor. See -ppPath <path to preprocessor>.

Table 3.1 Options for rtiddsgen

Option	Description

-ppPath <*path to preprocessor*>	Specifies the preprocessor. If you only specify the name of an executable (not a complete path to that executable), the executable must be found in your **Path**. The default value is **cpp** for non-Windows architectures and **cl.exe** for Windows architectures.
	If you use **-ppPath** to provide the full path and filename for **cl.exe** or the **cpp** preprocessor, you must also use -ppOption <option> to set the following preprocessor options:
	If you use a non-default path for **cl.exe**, you also need to set:
	`-ppOption /nologo -ppOption /C -ppOption /E -ppOption /X`
	If you use a non-default path for cpp, you also need to set:
	`-ppOption -C`

-qualifiedEnumerator	Uses the fully qualified name for enumerator values including the enum value.
-replace	Deprecated option. Instead, use -update <typefiles| examplefiles|makefiles> for the proper files (typefiles, examplefiles, makefiles). This option is maintained for backwards compatibility. It allows *Code Generator* to overwrite any existing generated files. If it is not present and existing files are found, *Code Generator* will print a warning but will not overwrite them.
-sequenceSize <*unbounded sequences size*>	Sets the size assigned to unbounded sequences. The default value is 100 elements.
-sharedLib	Generates makefiles that compile with the *Connext* shared libraries (by default, the makefile will link with the static libraries)
-showTemplates	Prints and generates an XML file containing a list of the available example templates in your *Connext* installation, organized per language. When you use the -exampleTemplate option, you can specify one of these example templates. *Code Generator* will then generate the example you specified instead of the default one.
-standard <*DDS_PSM_Cxx, IDL4_CPP*>	Defines the mapping for a specific standard. This flag is only supported in C++11. Use the option *DDS_PSM_Cxx* for the default mapping used in versions before 7.2.0. Use the option *IDL4_CPP* for the new IDL4 to CPP Language Mapping defined by the OMG in 2023. The most notable changes in the IDL4-CPP mapping are: • IDL structs map to C++ structs with public fields, instead of classes with getters and setters • IDL unions still map to classes with getters and setters with the following additions: • For members selected by multiple labels, a setter receiving the discriminator value as a second argument is also generated • A method called `_default()` that sets the union to its default discriminator is generated • string and wstring constants map to `std::string_view` and `std::wstring_view` for platforms that support C++17

-strict	Enforces compliance with the OMG 'Extensible and Dynamic Topic Types for DDS' specification, version 1.3 by turning informational (INFO) messages into errors. (Informational messages are described in -verbosity [1-3].)
	Currently in this release, by default, *Code Generator* will report an informational (INFO) message for keyed derived structures when running *rtiddsgen*, but still generate code:
	`INFO com.rti.ndds.nddsgen.antlr.annotation.AnnotationApplier`
	`struct/valuetype derived from a struct/valuetype should not contain @key fields.`
	`This is not compliant with the XTypes specification. You can make this message`
	`an error by using the -strict flag`
	If you want *Code Generator* to enforce the specification, use the **-strict** option. This option will report an error when there are keyed derived structures, and not generate code.
	See the RTI Code Generator Release Notes or the *Migration Guide* on the RTI Community Portal (https://community.rti.com/documentation) for enforcement details that might occur in future releases.

Table 3.1 Options for rtiddsgen

Option	Description
-stringSize <*unbounded strings size*>	Sets the size assigned to unbounded strings, not counting a terminating NULL character. The default value is 255 bytes.
-typeSequenceSuffix <*suffix*>	Assigns a suffix to the name of the implicit sequence defined for IDL types. The option is compatible with languages C, C++, C#, and Java. By default, the suffix is 'Seq'. For example, given the type 'Foo', the name of the sequence would be 'FooSeq'.
-typeSizes	Displays the maximum serialized size, minimum serialized size, and maximum key serialized size of all the complex types in an IDL. If *Code Generator* cannot compute the type sizes, it will display the following: • If there is a recursive type, *Code Generator* will display `Undefined (Recursive Type)`. • If there is a type that is unresolved because you are using `@resolve-name false`, *Code Generator* will display `Undefined (Unresolved Member)`. • If the type is bigger than the maximum serialized size, *Code Generator* will display `Error (Over Max Serialized Size)`. NOTE: Using this option may reduce *Code Generator* performance. We recommend you disable the flag if you just want to generate code and you don't want or need type information.
-U <*name*>	Cancels any previous definition of <*name*>.
-unboundedSupport	Generates code that supports unbounded sequences and strings. When the option is used, the command-line options **-sequenceSize** and **-stringSize** are ignored. This option also affects the way unbounded sequences are deserialized. When a sequence is being received into a sample from the *DataReader's* cache, the old memory for the sequence will be deallocated and memory of sufficient size to hold the deserialized data will be allocated. When initially constructed, sequences will not preallocate any elements having a maximum of zero elements. For more information on using the **-unboundedSupport** option, including some required QoS settings, see these sections in the RTI Connext Core Libraries User's Manual: • *Sequences (Section 3.1.1)* • *Strings and Wide Strings (Section 3.1.2)* • *Sample and Instance Memory Management* chapter in the *RTI Connext Core Libraries User's Manaul*

-update <typefiles|examplefiles|makefiles>	Creates the files indicated if they do not exist. For example:
	`rtiddsgen -language C++11 -update typefiles test.idl`
	If the files already exist, **-update** overwrites the files without printing a warning.
	There can be multiple **-update** options.
	If you specify both **-create** and **-update** for the same file type, only the **-update** will be applied.
	If you use **-update makefiles**, the **-platform <arch>** option is required. For example:
	`rtiddsgen -language c -update makefiles -platform x64Darwin17clang9.0 test.idl`
	You can specify multiple input (e.g., **.idl**) files or folders. See Chapter 4 Generating Example Code on page 13 for more information.

-use52Keyhash	This option should be used when compatibility with 5.2.3 and earlier General Access Releases (GARs) is required when using keyed mutable types (related to RTI Issue IDs CODEGENII-501 and CODEGENII-693).
-use526Keyhash	This option should be used when compatibility with 5.2.6 is required when using keyed mutable types (related to RTI Issue ID CODEGENII-693).

Table 3.1 Options for rtiddsgen

Option	Description
-useStdString	Use 'std::string' instead of 'char *' when generating code for IDL strings when the language option is C++. Using this option will automatically enable constructor generation. Therefore you can use this option with or without **-constructor** and achieve the same result.
-V <*name*< [=<*value*>]	Defines a user variable that can be used in the templates as **$userVarList.name** or **$userVarList.name.equals(value)**. The variables defined with this option are case sensitive.
-verbosity [1-3]	Sets the *Code Generator* verbosity: 1: Exceptions 2: Exceptions and warnings 3: Exceptions, warnings and information (Default)
-version	Displays the version of *Code Generator* being used, such as 2.x.y, as well as the version of the templates being used (xxxx-xxxx-xxxx).
-virtualDestructor	Only applies if **-language C++98** is also specified. Generates a virtual destructor for the generated types in C++. Using this option will automatically enable the -constructor option. Note that using this option will affect filtering performance when using ContentFilteredTopics or QueryConditions.
XMLInputFile.xml	A file containing XML descriptions of your data types. If -inputXml is not used, the file must have an **.xml** extension.

Chapter 4 Generating Example Code

Most *Connext Getting Started Guides* (such as the RTI Connext Getting Started Guide or the RTI Connext Core Libraries Getting Started Guide Addendum for Embedded Systems) have you create a simple "Hello World" application to get started. For example, on macOS:

```
$ rtiddsgen -language c++11 -example x64Darwin17clang9.0 hello_world.idl
```

> **Note:** Before using a makefile created by *Code Generator* to compile an application, make sure the ${NDDSHOME} environment variable is set as described in Set Up Environment Variables (rtisetenv), in "Hands-On 1" of *Introduction to Publish/Subscribe*, in the RTI Connext Getting Started Guide.

4.1 Input Files (IDL, XML, XSD)

For detailed information about IDL, XML, or XSD support in *Connext*, including the mapping between these formats, see the "Data Types and DDS Data Samples" chapter in the RTI Connext Core Libraries User's Manual.

4.1.1 IDL Language

In the IDL language, data types are described in a fashion almost identical to structures in "C." The complete description of the language can be found at the OMG website.

4.1.2 XML Language

Connext provides DTD and XSD files that describe the XML format.

The DTD definition of the XML elements can be found in **rti_dds_topic_types.dtd** under <NDDSHOME>/resource/app/app_support/rtiddsgen/schema.

The XSD definition of the XML elements can be found in **rti_dds_topic_types.xsd** under <NDDSHOME>/resource/app/app_support/rtiddsgen/schema.

The XML validation performed by *rtiddsgen* always uses the DTD definition. If the <!DOCTYPE> tag is not present in the XML file, *rtiddsgen* will look for the DTD document under <NDDSHOME>/resource/app/app_support/rtiddsgen/schema. Otherwise, it will use the location specified in <!DOCTYPE>.

4.1.3 XSD Language

For detailed information about XSD support in *Connext*, see the "Data Types and DDS Data Samples" chapter in the RTI Connext Core Libraries User's Manual.

4.1.4 Specifying Multiple Input Files

You can specify multiple IDL, XML, or XSD input files, either by listing them explicitly on the command line, specifying a directory, or including them in other files with an **#include** directive.

4.1.4.1 Listing Explicit Files

For example, this command will process two input IDL files, **hello_world1.idl** and **hello_world2.idl**:

```
rtiddsgen -language C -create typefiles hello_world1.idl hello_world2.idl
```

Do not mix files with different extensions. For example, this is **NOT** supported:

```
rtiddsgen -language C -create typefiles hello_world1.idl hello_world2.xml
```

4.1.4.2 Listing Directories

You can also pass one or more directories as input. To use directories as inputs, use *one* of the following command-line options: **-inputIDL**, **-inputXML**, or **-inputXSD**. (Do not use more than one of these options in the same command.) *Code Generator* will scan the folder and generate code for the files with the extension indicated by the input flag. For example:

```
rtiddsgen -language C -create typefiles -inputIDL folder folder2
```

You can specify a mix of folders and input files:

```
rtiddsgen -language C -create typefiles -inputIDL folder file1.idl
```

4.1.4.3 Enabling Recursion

The command-line option **-r** will activate a recursive scan of all the input directories. The **-r** option is only valid when one or more folders are used as inputs. For example:

```
rtiddsgen -language C -create typefiles -inputIDL folder folder2 -r
```

In the following example, *Code Generator* will generate code for all the **.idl** files in "folder" when you use **-r** . Without **-r**, *Code Generator* will only generate code for **idl_root1.idl** and **idl_root2.idl**:

```
folder
├──folder1
```

```
│   └──idl_folder1_1.idl
├──folder2
│   └──idl_folder2_1.idl
├──idl_root1.idl
└──idl_root2.idl
```

4.1.4.4 Including Files

The command-line option **-generateIncludeFiles** generates code for any included file(s) in the inputs.

Imagine you have these two files:

```
// File Bar.idl
struct Bar {
...
};

// File Foo.idl
#include "Bar.idl"
struct Foo {
Bar b;
};
```

If you run this command:

```
rtiddsgen -language python Foo.idl -generateIncludeFiles
```

This example will produce the following files:

- Foo.py
- Bar.py

4.2 C++ Example

The following is an example that generates the *Connext* type myDataType:

IDL notation

```
struct myDataType {
    long value;
};
```

XML notation

```
<?xml version="1.0" encoding="UTF-8"?>
<types xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:noNamespaceSchemaLocation="rti_dds_topic_types.xsd">
    <struct name="myDataType">
        <member name="value" type="long"/>
    </struct>
</types>
```

XSD notation

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:dds="http://www.omg.org/dds"
        xmlns:tns="http://www.omg.org/IDL-Mapped/" targetNamespace="http://www.omg.org/IDL-
        Mapped/">
    <xsd:import namespace="http://www.omg.org/dds" schemaLocation="rti_dds_topic_types_
common.xsd"/>
    <xsd:complexType name= "myDataType">
        <xsd:sequence>
            <xsd:element name="value" minOccurs="1" maxOccurs="1" type="xsd:int"/>
        </xsd:sequence>
    </xsd:complexType>
</xsd:schema>
```

4.3 Advanced Example

After you get familiar with the simple Hello World example, you can create a more advanced example by specifying the 'advanced' template option, for traditional C++, modern C++, C#, Python, and Java languages. The advanced template is already included with *Code Generator* (see -exampleTemplate and -showTemplates). For example, on macOS:

```
rtiddsgen -language c++11 -example x64Darwin17clang9.0 -exampleTemplate advanced hello_
world.idl
```

There are a couple of main differences between the simple and advanced examples that *Code Generator* generates, described below: **is_default_qos** and *Listeners*.

> **Note:** The advanced generated example is not supported on Android™ or INTEGRITY® platforms.

4.3.1 is_default_qos (true vs. false)

Connext loads QoS profiles from a file named USER_QOS_PROFILES.xml in your current working directory. (*Connext* may also look for this file in other locations; see *How to Load XML-Specified QoS Settings* in the RTI Connext Core Libraries User's Manual). The simple example sets **is_default_qos=true** in the USER_QOS_PROFILES.xml file. It creates the DDS entities without specifying a profile, so it uses the default from USER_QOS_PROFILES.xml.

The advanced example also loads QoS from the USER_QOS_PROFILES.xml file. However, the advanced example omits the **is_default_qos** setting, which means that *Connext* assumes the default setting of false. Therefore, there is no default QoS provided by the XML. The example explicitly specifies which QoS profile to use from the XML file when creating DDS entities.

Setting **is_default_qos=true** is a convenient way to get you started quickly, but in production applications you should explicitly specify which QoS profile to use, instead of relying on a default. See the *Basic QoS* chapter, in the RTI Connext Getting Started Guide.

> **Note:** The RTI Connext Getting Started Guide example is more complex than the advanced example generated by *Code Generator*; however, it does not use *Listeners* like the *Code Generator* example does.

4.3.2 Listeners vs. WaitSets

Both the simple and advanced examples use *WaitSets* to block a thread until data is available. This is the safest way to get data, because it does not affect any middleware threads (it is blocking the application's main thread until data is available). In the advanced C# example, *TakeAsync()* is used instead of a *WaitSet*, which allows iterating over an asynchronous stream of data samples as they are received.

In addition, the advanced example installs *Listeners* on both the *DataReader* and *DataWriter* with callbacks that you can implement to accomplish a desired behavior. These *Listener* callbacks are triggered for various events, such as discovering a matched *DataWriter* or *DataReader*. *Listener* callbacks are called back from a middleware thread, which you should not block. There are benefits to using *Listeners* for non-data callbacks, because you will not miss events. However, if you block or do slow processing in a *Listener*, it can cause undesired behavior such as data loss. See the *Listeners* chapter, in the RTI Connext Core Libraries User's Manual.

4.4 Using Generated Types Without Connext (Standalone)

You can use the generated type-specific source and header files without linking the *Connext* libraries or even including the *Connext* header files. That is, the generated files for your data types can be used standalone.

The directory <NDDSHOME>resource/app/app_support/rtiddsgen/standalone/include contains the helper files required to work in standalone mode:

- include: header and templates files for C/C++
- src: source files for C/C++
- class: Java jar file

4.4.1 Using Standalone Types in C

The generated files that can be used standalone are:

- <idl file name>.c : Types source file
- <idl file name>.h : Types header file

You *cannot* use the type plug-in (<idl file>Plugin.c <idl file>Plugin.h) or the type support (<idl file>Support.c <idl file>Support.h) code standalone.

To use the *rtiddsgen*-generated types in a standalone manner:

- Include the directory <NDDSHOME>resource/app/app_support/rtiddsgen/standalone/include in the list of directories to be searched for header files.

- Add the source files ndds_standalone_type.c and <idl file name>.c to your project.
- Include the file <idl file name>.h in the source files that will use the generated types in a standalone way.
- Compile the project using the two following preprocessor definitions:
    - NDDS_STANDALONE_TYPE
    - The definition for your platform: RTI_VXWORKS, RTI_QNX, RTI_WIN32, RTI_INTY, RTI_LYNX or RTI_UNIX

4.4.2 Using Standalone Types in C++98

The generated files that can be used standalone are:

- <idl file name>.cxx : Types source file
- <idl file name>.h : Types header file

You *cannot* use the type plugin (<idl file>Plugin.cxx <idl file>Plugin.h) or the type support (<idl file>Support.cxx <idl file>Support.h) code standalone.

To use the generated types in a standalone manner:

- Include the directory <NDDSHOME>resource/app/app_support/rtiddsgen/standalone/include in the list of directories to be searched for header files.
- Add the source files ndds_standalone_type.cxx and <idl file name>.cxx to your project.
- Include the file <idl file name>.h in the source files that will use the generated types in a standalone way.
- Compile the project using the two following preprocessor definitions:
    - NDDS_STANDALONE_TYPE
    - The definition for your platform: RTI_VXWORKS, RTI_QNX, RTI_WIN32, RTI_INTY, RTI_LYNX or RTI_UNIX

4.4.3 Using Standalone Types in C++11

The generated files that can be used standalone are:

- <idl file name>.cxx : Types source file
- <idl file name>.hpp : Types header file

You cannot use the type plugin (<idl file>Plugin.cxx <idl file>Plugin.hpp).

To use the generated types in a standalone manner:

- Include the directories <NDDSHOME>resource/app/app_support/rtiddsgen/standalone/include and <NDDSHOME>resource/app/app_support/rtiddsgen/standalone/include/cpp11 in the list of directories to be searched for header files.
- Add the source files ndds_standalone_type.cxx, Exception.cxx and <idl file name>.cxx to your project.
- Include the file <idl file name>.hpp in the source files that will use the generated types in a standalone way.
- Compile the project using the two following preprocessor definitions:
    - NDDS_STANDALONE_TYPE
    - The definition for your platform: RTI_VXWORKS, RTI_QNX, RTI_WIN32, RTI_INTY, RTI_LYNX or RTI_UNIX

4.4.4 Using Standalone Types in Java

The generated files that can be used standalone are:

- <idl type>.java
- <idl type>Seq.java

You *cannot* use the type code (<idl file>TypeCode.java), the type support (<idl type>TypeSupport.java), the data reader (<idl file>DataReader.java) or the data writer code (<idl file>DataWriter-.java) standalone.

To use the generated types in a standalone manner:

- Include the file ndds_standalone_type.jar in the classpath of your project.
- Compile the project using the standalone types files (<idl type>.java <idl type>Seq.java).

Chapter 5 Generated Files

The following tables show the files that *Code Generator* creates for an example IDL file called **Hello.idl**.

By default, *Code Generator* will not overwrite these files. You must use the **-replace** argument to do that.

Table 5.1 C and Traditional C++ Files Created for Example "Hello.idl"

Generated Files	Description
The following files are required for the user data type. The source files should be compiled and linked with your application. The header files are required to use the data type in source. You should not modify these files unless you intend to customize the generated code supporting your type.	
Hello.[c, cxx] HelloSupport.[c, cxx] HelloPlugin.[c, cxx]	Generated code for the data types. These files contain the implementation for your data types.
Hello.h HelloSupport.h HelloPlugin.h	Header files that contain declarations used in the implementation of your data types.

Table 5.1 C and Traditional C++ Files Created for Example “Hello.idl”

Generated Files	Description
The following optional files are generated when you use the **-example <*architecture*>** command-line option. You may modify and use these files as a way to create simple applications that publish or subscribe to the user data type.	
application.h (traditional C++ only)	Helper code for the Hello_publisher.cxx and Hello_subscriber.cxx applications
Hello_publisher.[c, cxx]	Example code for an application that publishes the user data type. This example shows the basic steps to create all of the DDS objects needed to send data. You will need to modify the code to set and change the values being sent in the data structure. Otherwise, just compile and run.
Hello_subscriber.[c, cxx]	Example code for an application that subscribes to the user data type. This example shows the basic steps to create all of the DDS objects needed to receive data. No modification of this file is required. It is ready for you to compile and run.
Hello-<*architecture*>.sln Hello_publisher-<*architecture*>.v[c, cx]proj Hello_subscriber-<*architecture*>.v[c, cx]proj	Microsoft Visual Studio solution and project files, generated only for Visual Studio-based architectures. (An example <*architecture*> is x64Win64VS2017.) To compile the generated source code, open the workspace file and build the two projects.
makefile_Hello_<*architecture*>	Makefile for non-Visual-Studio-based architectures. An example <*architecture*> is armv8Linux4gcc7.3.0.
USER_QOS_PROFILES.xml	The Quality of Service (QoS) configuration of the DDS entities in the generated example is loaded from this file.

Table 5.2 Modern C++ Files Created for Example “Hello.idl”

Generated Files	Description
The following files are required for the user data type. The source files should be compiled and linked with your application. The header files are required to use the data type in source. You should not modify these files unless you intend to customize the generated code supporting your type.	
Hello.cxx HelloPlugin.cxx	Generated code for the data types. These files contain the implementation for your data types.
Hello.hpp HelloPlugin.hpp	Header files that contain declarations used in the implementation of your data types.
The following optional files are generated when you use the **-example <*architecture*>** command-line option. You may modify and use these files as a way to create simple applications that publish or subscribe to the user data type.	
application.hpp	Helper code for the Hello_publisher.cxx and Hello_subscriber.cxx applications
Hello_publisher.cxx	Example code for an application that publishes the user data type. This example shows the basic steps to create all of the DDS objects needed to send data. You will need to modify the code to set and change the values being sent in the data structure. Otherwise, just compile and run.

Table 5.2 Modern C++ Files Created for Example "Hello.idl"

Generated Files	Description
Hello_subscriber.cxx	Example code for an application that subscribes to the user data type. This example shows the basic steps to create all of the DDS objects needed to receive data. No modification of this file is required. It is ready for you to compile and run.
Hello-<*architecture*>.sln Hello_publisher-<*architecture*>.vcxproj Hello_subscriber-<*architecture*>.vcxproj	Microsoft Visual Studio solution and project files, generated only for Visual Studio-based architectures. (An example <*architecture*> is x64Win64VS2017.) To compile the generated source code, open the workspace file and build the two projects.
makefile_Hello_<*architecture*>	Makefile for non-Visual-Studios-based architectures. An example <*architecture*> is arm-v8Linux4gcc7.3.0.
USER_QOS_PROFILES.xml	The Quality of Service (QoS) configuration of the DDS entities in the generated example is loaded from this file.

Table 5.3 C# Files Created for Example "Hello.idl"

Generated Files	Description
The following files are required for the user data type. The source files should be compiled with your .NET project. You should not modify these files.	
Hello.cs HelloPlugin.cs	Generated code for the data types. These files contain the implementation for your data types.
The following optional files are generated when you use the **-example <*platform*>** command-line option (where <platform> is the .NET platform identifier, such as net5 or netcoreapp3.1). You may modify and use these files as a way to create simple applications that publish or subscribe to the user data type.	
HelloProgram.cs	Code for running the HelloPublisher.cs and HelloSubscriber.cs applications
HelloPublisher.cs	Example code for an application that publishes the user data type. This example shows the basic steps to create all of the DDS objects needed to send data. You will need to modify the code to set and change the values being sent in the data structure. Otherwise, just compile and run.
HelloSubscriber.cs	Example code for an application that subscribes to the user data type. This example shows the basic steps to create all of the DDS objects needed to receive data. No modification of this file is required. It is ready for you to compile and run.
Hello.csproj NuGet.Config	Used to build and run your application. NuGet.Config tells the .NET compiler where to find the Rti.ConnextDds NuGet package.
USER_QOS_PROFILES.xml	The Quality of Service (QoS) configuration of the DDS entities in the generated example is loaded from this file.

Table 5.4 Python Files Created for Example "Hello.idl"

Generated Files	Description
The following files are required for the user data type. You should not modify these files.	
Hello.py	Generated code for the data types. These files contain the definition of your data types.
The following optional files are generated when you use the **-example <*platform*>** command-line option (for Python the only valid value of <platform> is **universal**). You may modify and use these files as a way to create simple applications that publish or subscribe to the user data type.	
Hello_publisher.py	Example code for an application that publishes the user data type. This example shows the basic steps to create all of the DDS objects needed to send data. You can modify the code to set and change the values being sent in the data structure.
Hello_subscriber.py	Example code for an application that subscribes to the user data type. This example shows the basic steps to create all of the DDS objects needed to receive data. No modification of this file is required. It is ready for you to run.
Hello_program.py	Code for running the Hello_publisher.py and Hello_subscriber.py applications. Run "python Hello_program.py <options>".
USER_QOS_PROFILES.xml	The Quality of Service (QoS) configuration of the DDS entities in the generated example is loaded from this file.

Table 5.5 Java Files Created for Example "Hello.idl"

Data Type	Generated Files	Description
Since the Java language requires individual files to be created for each class, *Code Generator* will generate a source file for every IDL construct that translates into a class in Java.		
Constants	Hello.java	Class associated with the constant
Enums	Hello.java	Class associated with enum type
Structures/Unions	Hello.java HelloSeq.java HelloDataReader.java HelloDataWriter.java HelloTypeSupport.java	Structure/Union class Sequence class DDS *DataReader* and *DataWriter* classes Support (serialize, deserialize, etc.) class
Typedef of sequences or arrays	Hello.java HelloSeq.java HelloTypeSupport.java	Wrapper class Sequence class Support (serialize, deserialize, etc.) class

Table 5.5 Java Files Created for Example "Hello.idl"

Data Type	Generated Files	Description
The following optional files are generated when you use the **-example <*architecture*>** command-line option. You may modify and use these files as a way to create simple applications that publish or subscribe to the user data type.		
Last structure/union	HelloPublisher.java HelloSubscriber.java	Example code for applications that publish or subscribe to the user data type. You should modify the code in the publisher application to set and change the value of the published data. Otherwise, both files should be ready to compile and run.
	makefile_Hello_<*architecture*>	Makefile for non-Windows-based architectures. An example <*architecture*> is arm-v8Linux4gcc7.3.0.
	USER_QOS_PROFILES.xml	The Quality of Service (QoS) configuration of the DDS entities in the generated example is loaded from this file.
Structures/Unions/ Typedefs/Enums	HelloTypeCode.java	Type code class associated with the IDL type, Hello

Table 5.6 Ada Files Created for Example "Hello.idl"

Generated Files	Description
Hello[.h,.c]	Generated code for the data types, which contain the implementation for the data types, and header files that contain declarations used in the implementation of the data types.
HelloSupport[.h,.c]	
HelloPlugin[.h,.c]	
hello_idl_file[.adb, .ads]	
hello_idl_file-hello_datawriter.ads	DataReader and DataWriter classes and serialize/deserialize methods.
hello_idl_file-hello_datareader.ads	
hello_idl_file-hello_typesupport[.adb,.ads]	
hello_idl_file-hello_metptypesupport[.adb,.ads]	These files are generated only for types that support Zero Copy transfer over shared memory (that is, are annotated with @transfer_mode(SHMEM_REF) in the IDL file).
hello_idl_file-hello_publisher[.adb,.ads] (in the **samples**/ directory)	Example code for an application that publishes the user data type. You will need to modify the code to set and change the values being sent in the data structure. Otherwise, just compile and run. The subscriberlistener file implements the **on_data_available()** callback.
hello_idl_file-hello_subscriber[.adb,.ads] (in the **samples**/ directory)	
hello_idl_file-hello_subscriberlistener[.adb,.ads] (in the **samples**/ directory)	
hello.gpr	Project files using Ada-like syntax.These files define the build-related characteristics of the application. These characteristics include the list of sources, the location of those sources, the location of the generated object files, the name of the main program, and the options for the various tools involved in the build process. Each of them is for a different set of files (hello-samples is for the examples, hello_c is for the c files and hello is for rest of the ada files.)
hello_c.gpr	
hello-samples.gpr (in the **samples** directory)	

Table 5.6 Ada Files Created for Example “Hello.idl”

Generated Files	Description
The following optional file is generated when you use the **-example <*architecture*>** command-line option. You may modify and use this file as a way to create simple applications that publish or subscribe to the user data type.	
USER_QOS_PROFILES.xml	The Quality of Service (QoS) configuration of the DDS entities in the generated example is loaded from this file.

Chapter 6 Customizing the Generated Code

Code Generator allows you to customize the generated code for different languages by changing the provided templates. This version does not allow you to create new output files.

You can load new templates using the following command in an existing template, where <*pathToTemplate*> is the absolute path to the folder with the customized template:

```
#parse("<pathToTemplate>/template.vm")
```

If that **template.vm** file contains macros, you can use it within the original template. If **template.vm** contains just plain text without macros, that text will be included directly in the original file.

You can also load new templates that contain macros by adding these templates to a folder named "macros," as follows:

```
<NDDSHOME>/resource/app/app_support/rtiddsgen/templates/<lang>/macros/
```

All the templates must have the extension **.vm**. The velocity engine will load them. These macros can then be called from the templates in `<NDDSHOME>/resource/app/app_support/rtiddsgen/templates/<lang>/`.

For example, if you have a template that contains macros to generate Python code called **myMacros.vm**, you could move this template to the following path:

```
<NDDSHOME>/resource/app/app_support/rtiddsgen/templates/py/macros/myMacros.vm
```

You can now use all the macros defined in **myMacros.vm** from the templates **type.vm**, **typeMacros.vm**, and **utils.vm** located in `<NDDSHOME>/resource/app/app_support/rtiddsgen/templates/py/`.

You can customize the behavior of a template by using the predefined set of variables provided with *Code Generator*. For more information, see the tables in **RTI_rtiddsgen_template_variables.xlsx**.

This file contains two different sheets: Language-Templates and Template variables. The Language-Template sheet shows the correspondence between the Velocity Templates used and the generated files for each language. If, for example, we want to add a method in C in the **Hello.c** file, we would need to modify the template **typeBody.vm** under the **templates/c** directory.

The scope of a template can be:

- **type**: If we generate a file with that template for each type in the IDL file. For example in Java, where we generate a TypeSupport file for each type in the IDL.
- **file**: If we generate a file with that template for each IDL file. For example in C, we generate a single plugin file containing all the types Plugin information.
- **lastTopLevelType**: If we generate a file with that template for the last top-level type in the IDL file. This is commonly used for the publisher/subscriber examples.
- **module**: If we generate a file with that template for each module in the IDL file. This is used in Ada, where there are files that contain all the types of a module.
- **topLevelType**: if we generate a file with that template for each type in the idl file. This is used in ADA where the publisher/subscriber files are only generated for top level types

The table also shows the top_level variables that can be used for that templates. These variables are explained in the sheet Template variables. For example in Java, the main unit of variables are the constructMap which is a hashMap of variables that represent a type. In C, we will have as the main unit the constructMapList, which is a List of constructMap. In the Template variables sheet, we can see which variables are contained in each constructMap, the constructKind or type that it is applicable to and the value that it contains depending on the language we use.

One important variable that contains the constructMap for a type is the memberFieldMapList. This list represent the members contained within the type. Each member is also represented as a hashMap whose variables are also described in the Template variables sheet.

Apart from that there are environmental or general variables that are not related with the types that are defined within a hashMap called envMap.

Let’s see how to use these variables with an example. Suppose we want to generate a method in C that prints the members for a structure and, if it is an array or sequence, its corresponding size. For this IDL:

```
module Mymodule{
   struct MyStruct{
       int32 longMember;
       int32 arrayMember [2][100];
       sequence<char,2> sequenceMember;
       sequence <int32, 5> arrayOfSequenceMember[28];
   };
};
```

We want to generate this:

```
void MyModule_MyStruct_specialPrint(){
   printf(" longMember  \n");
   printf(" arrayMember  is an array  [2, 100]  \n ");
   printf(" sequenceMember   is a sequence <2> \n");
   printf(" arrayOfSequenceMember  is an array  [28]  is a sequence <5> ");
}
```

The code in the template would look like this:

```
## We go through all the list of types
#foreach ($node in $constructMapList)
##We only want the method for structs
#*--*##if ($node.constructKind.equals("struct"))
void ${node. nativeFQName}_specialPrint(){
##We go through all the members and call to the macros that check if they are array or
sequences
#*----*##foreach($member in $node.memberFieldMapList)
print("$member.name #isAnArray($member) #isASeq($member) \n");
#*----*##end
}
#*--*##end
#end
```

The **isAnArray** macro checks if the member is an array (i.e, has the variable **dimensionList**) and in that case, prints it:

```
#macro (isAnArray $member)
#if($member.dimensionList) is an array $member.dimensionList #end
#end
```

The **isASeq** macro checks if the member is a sequence (i.e, has the variable seqSize) and in that case, prints it:

```
#macro (isASeq $member)
#if($member.seqSize) is a sequence <$member.seqSize> #end
#end
```

You can add new variables to the templates using the -V <name< [=<value>] command-line option when starting *Code Generator*. This variable will be added to the userVarList hashMap. You can refer to it in the template as **$userVarList.name** or **$userVarList.name.equals(value)**.

For more information on velocity templates, see https://velocity.apache.org/engine/1.5/user-guide.html.

Chapter 7 Optimizing the Code Generation Process

The cost of serialization and deserialization operations increases with type complexity and sample size. It can become a significant contributor to the latency required to send and receive a sample. *Code Generator* provides the command-line option **-optimization**, which can be used to indicate the level of optimization of the serialize/deserialize operations. This command-line option allows selecting one of three different levels.

7.1 Optimization Levels

0: No optimization

1: *rtiddsgen* generates extra code for typedefs but optimizes its use. If a type that is used is a typedef that can be resolved to a primitive, enum, or aggregated type (struct, union, or value type), the generated code will invoke the code of the most basic type to which the typedef can be resolved. This level can be used if the generated code for typedef is not expected to be modified. This is the only optimization level supported for Java and C# languages.

For example:

```
typedef int32 Latitude;
typedef int32 Latitude;

struct Position {
    Latitude x;
    Longitude y;
};
```

With optimization 0, the serialization of a sample with type Position will require calling the serialize methods for Latitude and Longitude. For example:

```
LatitudePlugin_serialize(...) {
    serialize_long(...)
}
```

```
LongitudePlugin_serialize(...) {
    serialize_long(...)
}

Position_serialize(...) {
    LatitudePlugin_serialize(...)
    LongitudePlugin_serialize(...)
}
```

With optimization 1, *rtiddsgen* resolves Latitude and Longitude to their most primitive types for serialization purposes, resulting in a more efficient serialization. In this case, *rtiddsgen* will save two function/method calls.

```
Position_serialize(...) {
    serialize_long(...)
    serialize_long(...)
}
```

2: This optimization level is the default if not specified. (You can also explicitly specify it.) This optimization level applies only to C, C++, C++11, microC, microC++, and Ada languages. With this optimization level, *rtiddsgen* optimizes the serialization/deserialization of structures and valuetypes by using more aggressive techniques. These techniques include inline expansion of nested types and serialization/deserialization of a set of consecutive members with a single copy function invocation (memcpy) when the memory layout (C, C++ structure layout) is the same as the wire layout (XCDR).

7.2 How the Optimizations are Applied

In *Code Generator*, the optimizations (*inline expansion of nested types* and *serialization of consecutive members with a single copy*) are related. Inline expansion of a nested structure is only done when the C/C++ memory layout with standard packing of the structure matches the XCDR layout. (In this case, the structure's members can be serialized with a single memcpy.) If the C/C++ memory layout with standard packing of the structure matches the XCDR layout, then *rtiddsgen* tries first to do the inline expansion, then the serialization of consecutive members with a single copy.

7.2.1 Inline expansion of nested types

Inline expansion is an optimization in which *Code Generator* replaces a type definition with another one in which nested types are flattened out. This is done to remove extra function calls during serialization/deserialization. For example:

```
struct Point {
    int32 x;
    int32 y;
};

struct Dimension {
    int32 height;
    int32 width;
};
```

```
struct Rectangle {
    Point leftTop;
    Dimension size;
};
```

With optimization level 2, *Code Generator* replaces the definition of Rectangle with the following equivalent definition:

```
struct Rectangle {
    int32 leftTop_x;
    int32 leftTop_y;
    int32 size_height;
    int32 size_width;
};
```

This optimization is only done for serialization/deserialization. The generated type in C/C++ continues using Point and Dimension.

7.2.2 Serialization of consecutive members with a single copy

In the previous Rectangle example, *Code Generator*, using optimization level 2, further optimizes the serialization and deserialization by serializing a Rectangle sample with a single copy operation (memcpy) instead of four.

Before optimization:

```
Rectangle_serialize(...) {
    memcpy(..., 4) // leftTop_x
    memcpy(..., 4) // leftTop_y
    memcpy(..., 4) // size_height
    memcpy(..., 4) // size_width
}
```

After optimization:

```
Rectangle_serialize(...) {
    memcpy(..., 16) // leftTop_x
}
```

This optimization is only applicable when the memory layout of the C/C++ structure is equivalent to the serialization layout, which uses the XCDR version 1 or version 2 format.

7.2.3 Rules for Inline Expansion

To be inlinable, a structure 'MyStruct' has to meet the following two requirements:

- It has to have a C/C++-friendly XCDR layout.
- No members of 'MyStruct' should be marked with the @min, @max, or @range annotations.

A struct/valuetype 'MyStruct' has a C/C++-friendly XCDR layout when all of the following conditions apply:

- MyStruct is marked as @final or @appendable when the data representation is XCDR version 1. Mutable structures are not inlinable.
- MyStruct does not have a base type.
- MyStruct contains only primitive members, or complex members composed only of primitive members. A primitive member is a member with any of the following types: int8[1], uint8[2], int16, int32, int64, uint16, uint32, uint64, float, double, octet, and char. The following primitive types are not supported for inlining purposes: long double, wchar, boolean, enum.

```
struct Dimension {
    int32 height;
    int32 width;
}; // Inlinable

struct Dimension {
    string label; // Inlinable structures cannot contain strings
    int32 height;
    int32 width;
}; // Not Inlinable
```

- With any initial alignment (1, 2, 4, 8) greater than the alignment of the first member of the struct, there is no padding between the members that are part of MyStruct. To apply this rule, consider these alignments and sizes for primitive types:

Table 7.1 Alignments and Sizes for Primitive Types

Primitive Type	Alignment (bytes)	Size (bytes)
int8[3]	1	1
uint8[4]	1	1
int16	2	2
uint16	2	2

[0]

[1]This type is supported only at the API level. It is still considered an octet for type matching purposes.

[0]

[2]This type is supported only at the API level. It is still considered an octet for type matching purposes.

[0]

[3]This type is supported only at the API level. It is still considered an octet for type matching purposes.

[0]

[4]This type is supported only at the API level. It is still considered an octet for type matching purposes.

Primitive Type	Alignment (bytes)	Size (bytes)
int32	4	4
uint32	4	4
int64	8	8
uint64	8	8
float	4	4
double	8	8
octet	1	1
char	1	1

```
struct Dimension {
    int32 height;
    int16 width;
}; // Inlinable. Independently of the alignment of the starting memory address (4 or
8), there is no padding between height and width

struct Dimension {
    int16 height;
    int32 width;
}; // Not Inlinable. Starting in a memory address aligned to 4 will require adding a
padding of two bytes between height and width
```

- With any initial alignment (1, 2, 4, 8) greater than the alignment of the first member of the struct, there is no padding between the elements of an array of MyStruct.

```
struct Dimension {
    int32 height;
    int16 width;
}; // Not inlinable. Let's assume an array of two dimensions Dimension[2]. If the
array starts in a memory address aligned to 4, there would be padding between the
first and the second element of the array

struct Dimension {
    int32 height;
    int16 width;
    int16 padding;
}; // Inlinable
```

For serialization and deserialization purposes, *Code Generator* will consider an inlinable structure (according to the previous rules) as a primitive array where the alignment of the primitive type corresponds to the alignment of the first member of the structure. A member with type ‘MyStruct’ will be serialized with a single copy (memcpy) invocation.

When *Code Generator* serializes the members of a data structure, it will also try to coalesce the serialization of consecutive primitive members into a single copy operation if possible. *Code Generator* only applies this optimization when the alignment of the next member is equal to or smaller than the alignment of the current member.

```
struct Dimension {
    int16 height;
    int32 width;
}; // Coalescing not possible because the alignment of width 4 is greater than the alignment
of height 2

struct Dimension {
    int32 width;
    int16 height;
}; // Coalescing is possible because the alignment of width 4 is greater than the alignment
of height 2
```

7.2.4 Guidelines

As a rule of thumb, to take advantage of optimization level 2 for types containing only primitive types:

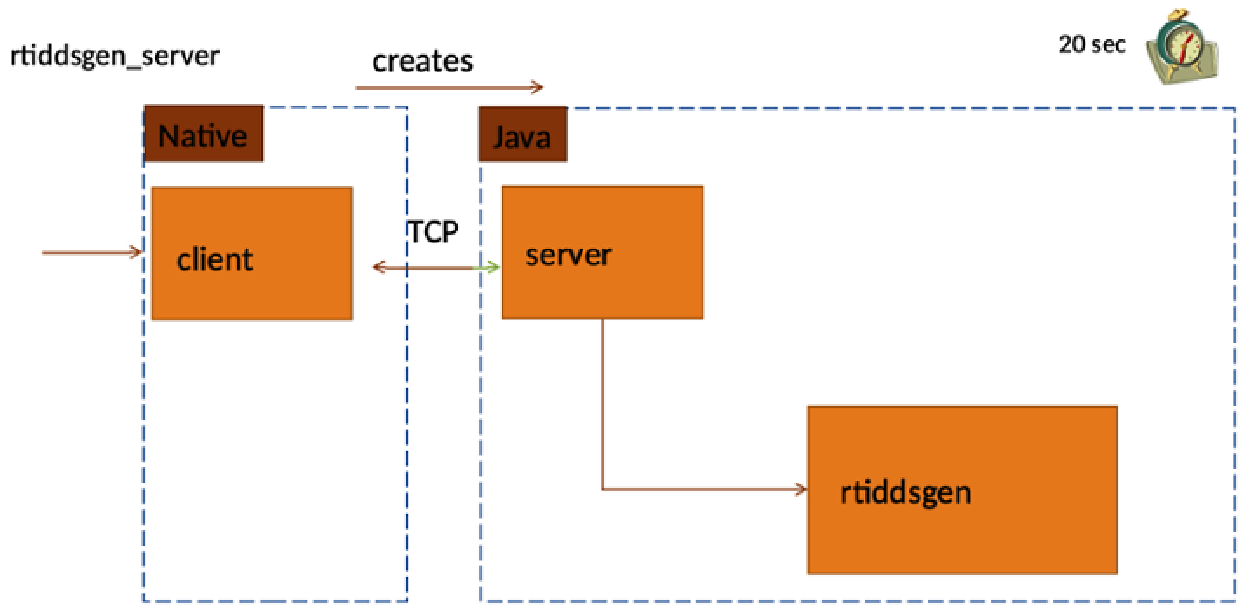
- Order the members in descending alignment order (this will help with copy coalescing).
- For XCDR version 2 encapsulation, use @final extensibility if your types will not evolve. For XCDR version 1 encapsulation, use @final or @appendable if possible (this will help with inline expansion).
- If you use ContentFilteredTopics, it is recommended that fields that appear in the filter expression are placed at the beginning of the type.

Chapter 8 Boosting Performance

If you need to invoke *Code Generator* multiple times with different parameters and/or type files, there will be a performance penalty derived from loading the Java Virtual Machine (JVM) and compiling the velocity templates every time you invoke *Code Generator*. If this is your scenario, you can run *Code Generator* in server mode to avoid doing this process multiple times. Or, if you would like to reduce the JVM startup and execution time, use the JVM optimization provided with *Code Generator*, for a reduced time in code generation. These two options (server mode and JVM optimization) cannot be used together.

8.1 Using Server Mode

One way to boost performance is to run *Code Generator* in server mode. Server mode runs a native executable that opens a TCP connection to a server instance of the code generator that is spawned the first time the executable is run, as depicted below:



To invoke *Code Generator* in server mode, use the script **rtiddsgen_server(.bat)**, which is in the **scripts** directory.

The default port *Code Generator* server attaches to is 14662. If you want to modify the port *Code Generator* server is attached to, use the **-n_serverport <port>** argument. Note that the *Code Generator* server can use up to three ports; make sure you have two free ports after the specified one.

The *Code Generator* server offers a log-to-file option that you can enable by using the argument **-n_logfilepath <log directory>**. In the specified log directory, the *Code Generator* server will create a file named **CodegenServerLog<portNumber>.txt** containing all logging messages from the server side.

Code Generator server comes with builtin timeouts, some of which you can change:

- When *Code Generator* is used in server mode, JVM is loaded a single time when the server is started; the velocity templates are also compiled a single time. The server will wait up to 5 seconds for *Code Generator* to initialize. You can change this value by specifying the number of milliseconds using the argument **-n_connectiontimeout<time in milliseconds>**.
- The *Code Generator* server will automatically stop if it is not used (that is, if it does not receive any calls) for a certain amount of time. The default value is 20 seconds; you can change this by editing the **rtiddsgen_server** script and adjusting the value of the argument **-n_servertimeout <time in milliseconds>**.

- *Code Generator* server sends a handshake message to the client after accepting the connection. In the client, there is a timeout when waiting for the handshake message. If this message is not received in the client in a short amount of time (10 seconds, an internal value that cannot be changed), the *Code Generator* client will time out. This timeout might mean that there was another application running in the port.

Notes:

- Mixing different versions of *Code Generator* server is not supported. See *Limitations* in the RTI Code Generator Release Notes.
- *Code Generator* server cannot be parallelized. Each execution of *Code Generator* server is attached to a port where it receives requests, and it can only generate code for one request at a time. Therefore, if you try to send multiple requests simultaneously, *Code Generator* server will process them sequentially.

8.2 Using JVM Optimization

Java Virtual Machine (JVM) offers different options that help improve its performance. RTI applies some of these options when creating the *Code Generator* JVM, resulting in an improvement in the *Code Generator* execution time. Because these options are non-standard, they are disabled by default. If you are using the JRE shipped with *Connext*, you can enable these options; otherwise, enabling these options is at your own risk.

The options applied to *Code Generator* JVM are as follows:

- -XX:+TieredCompilation
- -XX:TieredStopAtLevel=1
- -XX:CICompilerCount=4
- -Xverify:none
- -XX:+UseParallelGC
- -XX:+OptimizeStringConcat
- -XX:CompileThreshold=5000

For more information on these options, see the JDK documentation: https://docs.oracle.com/en/java/javase/11/. (Currently, you can find most of the options described in the Tools Reference, in "Main Tools to Create and Build Applications" > "java").

To enable the performance improvement associated with the *Code Generator* JVM options, set the RTIDDSGEN_JVM_OPTIMIZATION environment variable to true. To disable the improvement, unset the environment variable. (By default, it is not set.)