RTI Connext DDS

Core Libraries

Getting Started Guide

Addendum for Android Systems

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Technical Support

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

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Chapter 1 Android Systems

This document provides instructions to install and configure *RTI® Connext® DDS* for Android™ development and run *Connext DDS* applications on Android systems. Please refer to the documentation provided by Google® for more information on the Android operating system and Android platform: https://developer.android.com/develop/index.html.

This document will guide you through the process of generating, compiling, and running a Hello World application on an Android system, as well as using *Connext DDS* utilities.

Installing Connext DDS for Android Development (Chapter 2 on page 2) describes how to install and configure *Connext DDS* for Android development.

If you want to use the *Connext DDS* Ping, Spy, or Prototyper utilities, please read Using Connext DDS Utilities on an Android Platform (Chapter 3 on page 3).

These sections will guide you through the steps to generate, modify, build, and run an example HelloWorld application on an Android target:

- Generating Example Code and a Makefile from IDL (Chapter 4 on page 8)
- Building and Running a Hello World Example with C/C++ or Java (Chapter 5 on page 12)

The last section describes some additional considerations for Android development:

- Additional Considerations (Chapter 6 on page 17)

Chapter 2 Installing Connext DDS for Android Development

You will need to install a host archive and a target archive. The host archive contains documentation, header files, and other files you need for development; the target archive contains the libraries and other files you need for deployment. Unpack them as described in the instructions for Linux systems in the RTI Connext DDS Installation Guide.

Chapter 3 Using Connext DDS Utilities on an Android Platform

You can use the *Connext DDS rtiddsspy*, *rtiddsping* and *rtiddsprototyper* utilities either as Android Apps or as command-line programs. When running as Android Apps on a real Android device, there is no command prompt for entering parameters and no shell for outputting data. So to facilitate their use, the utilities come with a simple GUI.

For information on using *rtiddsspy* and *rtiddsping* from the command-line, see the *Connext DDS* API Reference HTML documentation (under **Modules**, select **Programming Tools**). For information on *Prototyper*, see the *Prototyper with Lua Getting Started Guide*.

> Before installing these utilities: The **adb install** command requires that you connect the device to a host machine and enable USB debugging in the device. For details on how to do this, see these instructions (http://developer.android.com/tools/device.html#setting-up).

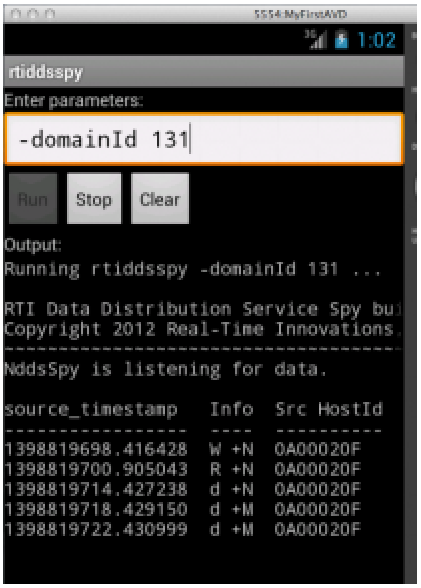
3.1 RTI DDS Spy App

To install and use *rtiddsspy* on an Android device:

1. Install *rtiddsspy* with this command (replace <*arch*> with your architecture name):

   ```
   adb install $NDDSHOME/resource/app/bin/<arch>/rtiddsspy.apk
   ```

2. Touch or click the *rtiddsspy* icon.
3. On the displayed screen, enter parameters exactly as they would be entered on the command line when using *rtiddsspy* on other platforms.



```
-domainId 131
```

```
Running rtiddsspy -domainId 131 ...

RTI Data Distribution Service Spy bu
Copyright 2012 Real-Time Innovations
----------------------------------------
NddsSpy is listening for data.

source_timestamp   Info  Src HostId
-----------------  ----  ----------
1398819698.416428  W +N  0A00020F
1398819700.905043  R +N  0A00020F
1398819714.427238  d +N  0A00020F
1398819718.429150  d +M  0A00020F
1398819722.430999  d +M  0A00020F
```

4. Click or touch **Run**. Data is displayed in the output panel.

   You may need to scroll the panel to the right to see the full output.

   Note that when running *rtiddsspy* as an App on Android, the **-printSample** option is *not* supported.
5. Note that the **Run** button will be disabled until the Spy process is finished (i.e., if you have specified a **-timeout** value in the parameters). To stop a running Spy process gracefully, click or touch the **Stop** button. Once the Spy process is finished, the **Run** button will be enabled again.
6. (Optional) Click or touch the **Clear** button to clear the current output.

To uninstall *rtiddspy* from the Android device through the **adb** shell, use this command:

```
adb uninstall com.rti.dds.rtiddsspy
```

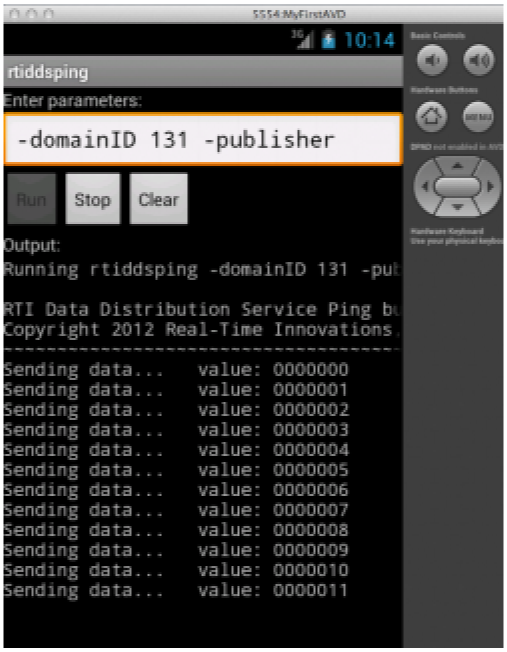
3.2 RTI DDS Ping App

To install and use *rtiddsping* on an Android device:

1. Install *rtiddsping* with this command (replace <*arch*> with your architecture name)

   ```
   adb install $NDDSHOME/resource/app/bin/<arch>/rtiddsping.apk
   ```

2. Touch or click the *rtiddsping* icon.
3. On the displayed screen, enter parameters exactly as they would be entered on the command line when using *rtiddsping* on other platforms.



```
-domainID 131 -publisher
```

```
Running rtiddsping -domainID 131 -pu

RTI Data Distribution Service Ping b
Copyright 2012 Real-Time Innovations
---------------------------------------
Sending data...   value: 0000000
Sending data...   value: 0000001
Sending data...   value: 0000002
Sending data...   value: 0000003
Sending data...   value: 0000004
Sending data...   value: 0000005
Sending data...   value: 0000006
Sending data...   value: 0000007
Sending data...   value: 0000008
Sending data...   value: 0000009
Sending data...   value: 0000010
Sending data...   value: 0000011
```

4. Note that the **Run** button will be disabled until the Ping process is finished (i.e., if you have specified (in the parameters) a **-numSamples** value with the publisher, or a **-timeout** value with the subscriber). To stop a running Ping process gracefully, click or touch the **Stop** button. Once the ping process is finished, the **Run** button will be enabled again.
5. (Optional) Click or touch the **Clear** button to clear the current output.

To uninstall *rtiddsping* from the Android device through the **adb** shell, use this command:

```
adb uninstall com.rti.dds.rtiddsping
```

3.3 RTI DDS Prototyper App

To install and use *rtiddsprototyper* on an Android device:

1. Install *rtiddsprototyper* with this command (replace <*arch*> with your architecture name):

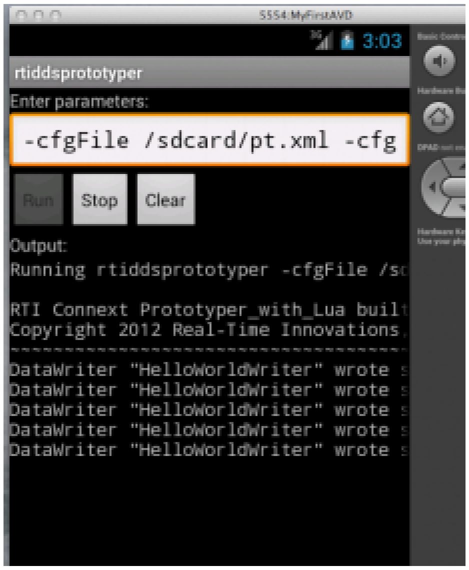
   ```
   adb install $NDDSHOME/resource/app/bin/<arch>/rtiddsprototyper.apk
   ```

2. Enter the following (or you may specify your own configuration file). For example:

   ```
   adb push <path to examples>/prototyper/hello_world/USER_QOS_PROFILES.xml \
      /sdcard/pt.xml
   ```

Note that the configuration file should be put in the Android device's external storage (see 6.3 Loading XML-Specified QoS Settings on page 21).

3. Touch or click the *rtiddsprototyper* icon.
4. On the displayed screen, enter parameters exactly as they would be entered on the command line when using *rtiddsprototyper* on other platforms. Note that **-cfgFile** must indicate a file pushed to the device with **adb**, and **-cfgName** must indicate a configuration within that file. If **-cfgName** is not given and there is more than one configuration in the file, all available configurations will be displayed to the output. (Please note that the interactive manner for selecting the configuration is not supported when used as an Android App.)



```
-cfgFile /sdcard/pt.xml -cfg
```

```
Running rtiddsprototyper -cfgFile /s

RTI Connext Prototyper_with_Lua buil
Copyright 2012 Real-Time Innovations
--------------------------------------------
DataWriter "HelloWorldWriter" wrote
DataWriter "HelloWorldWriter" wrote
DataWriter "HelloWorldWriter" wrote
DataWriter "HelloWorldWriter" wrote
DataWriter "HelloWorldWriter" wrote
```

For example, enter the following as the parameters:

```
-cfgFile /sdcard/pt.xml
-cfgName MyParticipantLibrary::PublicationParticipant
```

5. Touch or click **Run**. Data is displayed in the output panel.
6. Note that the **Run** button will be disabled until the Prototyper process is finished (i.e., if you have specified the **-runDuration** value in the parameters). To stop a running Prototyper process gracefully, click or touch the **Stop** button. Once the Prototyper process is finished, the **Run** button will be enabled again.
7. Touch or click the **Clear** button to clear the current output.

> When running *rtiddsprototyper* as an App on Android, the value of the sample that is received by the reader will *not* be printed (not in the UI and not in **logcat**).

To uninstall *rtiddsprototyper* from the Android device through the **adb** shell, use this command:

```
adb uninstall com.rti.dds.rtiddsprototyper
```

Chapter 4 Generating Example Code and a Makefile from IDL

This section describes how to generate example code and a makefile from IDL using *RTI Code Generator* (*rtiddsgen*). The generated code will run without modification. The generated makefiles contain recipes for performing various Android SDK and NDK tasks to simplify the process of building and running a HelloWorld example. They also contain default settings for certain variables. These defaults are chosen to get the Hello World examples to run out of the box for as wide a range of SDK and NDK configurations as possible. However for real development, these default values should be reviewed.

To create the example applications:

1. Set up the environment on your development machine: set the NDDSHOME environment variable and update your PATH as described in Set Up Environment Variables (rtisetenv), in "Hands-On 1" of *Introduction to Publish/Subscribe*, in the RTI Connext DDS Getting Started Guide.
    - The PATH environment variable should also include the SDK's tools, build-tools and platform-tools directories. For example:

      ```
      setenv ANDROID_SDK_HOME <path where Android SDK is installed>
      setenv PATH $(ANDROID_SDK_HOME)/tools:$(ANDROID_SDK_HOME)/
          build-tools/<build tool version>:$(PATH)
      ```

      (Replace <*build tool version*> to match the one in your installation.)
    - When building Android Apps (***.apk**), the PATH should include the **bin** directory of Ant 1.8.2. For example:

      ```
      setenv ANT_HOME <path where Ant is installed>
      ```

```
setenv PATH <ANT_HOME>/bin:$(PATH)
```

- Check to make sure that you have executable permission to **ant** in **<ANT_HOME>/bin/ant** or **<ANT_HOME>/bin/ant.bat**
- When building Java examples or Android Apps, the **PATH** should include JDK 11. For example:

```
setenv JAVA_HOME <path where Java is installed>
setenv PATH $(JAVA_HOME)/bin:$(PATH)
```

- When building C and C++ examples, both as executables and as Android Apps, the PATH should include the Android NDK. For example:

```
setenv ANDROID_NDK_PATH <path where Android NDK is installed>
setenv ANDROID_NDK_TOOLCHAIN_PATH <path where Android NDK toolchain is
installed>
setenv PATH $(ANDROID_NDK_TOOLCHAIN_PATH)/bin:${PATH}
```

(Replace <*tool chain name*> and <*host name*> to match those in your installation.)

- Note that the Dalvik VM (used by the Android operating system) is partially Java 1.6 compliant. Using Java 1.7 or 1.8 tools to compile class files may lead to problems if the Java code uses language features that are not supported by the Dalvik VM. (See Android documentation for further and up-to-date information).

2. Create a directory to work in. In this example, we use a directory called **myhello**.
3. In the **myhello** directory, create a file called **HelloWorld.idl** that contains a user-defined data type. For example:

```
// Temperature data type
struct Temperature {
    // ID of the sensor sending the temperature
    string<256> sensor_id;
    // Degrees in Celsius
    int32 degrees;
};
```

4. Use *RTI Code Generator* to generate sample code and a makefile. Choose Java, C, or C++. For example:

```
$(NDDSHOME)/bin/rtiddsgen -language C -example <arch> HelloWorld.idl
$(NDDSHOME)/bin/rtiddsgen -language C++ -example <arch> HelloWorld.idl
```

```
$(NDDSHOME)/bin/rtiddsgen -language Java -example <arch>
    -package com.rti.hello.idl HelloWorld.idl
```

Replace <*arch*> (following **-example**) with a supported Android architecture name. For example, <*arch*> may be **armv7Android9clang8.0ndkr19b**. See the *RTI Connext DDS Core Libraries Platform Notes* for the supported Android architectures for each language.

Note that Android Apps (***.apk**) require the Java code generated by *rtiddsgen* to be in a package. You can achieve this by using either the **modules** keyword in IDL or the **-package** command-line option with *rtiddsgen*. The IDL used here does not have modules, so the **–package** option is used instead.

5. See if you need to change any of the default settings in the generated makefile:
    - DEVICE

      The generated makefile assumes that computer on which you building and running these examples only has a single Android device or emulator attached. If this is not the case, you will need to set the DEVICE variable in the makefile. By default, this variable is not set. To see what devices are attached and what value to set DEVICE to, execute "**adb devices**" from the command line.
    - TARGET_ID

      If you are building an Android App (***.apk**), TARGET_ID should be set to the "build target" for your application. It corresponds to an Android platform library that you would like to build your project against. Execute "**android list targets**" to print a list of available Android platforms that you have downloaded for your SDK and the corresponding ID. By default, this is set to 1.
    - ANDROID_PACKAGE_PREFIX

      If you are building an Android App (***.apk**), this should be set to the Android package name prefix for the application. By default, this is set to **com.rti.example<language>.<IDL filename>**, which will eventually be used to generate two Android applications: one with package name **com.rti.<IDL filename>example.publisher** and another one with the package name **com.rti.<IDL filename>example.subscriber** (where <*language*> is Java, C, or C++; <*IDL filename*> is the name of the IDL file that you used for your example).

      If you change the **ANDROID_PACKAGE_PREFIX** value, you will need to update the package name in these generated files:
        - **objs/<arch>/publisher/src/com/rti/example<language>/<IDL filename>/publisher/<IDL filename>PublisherActivity.java**
        - **objs/<arch>/subscriber/src/com/rti/example<language>/<IDL filename>/subscriber/<IDL filename>SubscriberActivity.java**

    - **objs/<arch>/publisher/AndroidManifest.xml**
    - **objs/<arch>/subscriber/AndroidManifest.xml**
  - ANDROID_PUSH_DEST

    If you want to run the example directly on the emulator or device shell, this should be set to the location where files are copied to. By default, this is set to **/data/data/-com.rti.example<language>.<IDL filename>**, where <*IDL filename*> is the name of the IDL file that you are using.

6. If you modify the publisher or subscriber code, the makefile, or QoS file, be careful if you re-run *rtiddsgen:* do not use **–replace** in conjunction with **–example**, as that would overwrite those modifications.

Chapter 5 Building and Running a Hello World Example with C/C++ or Java

This section will guide you through the steps required to successfully run an *rtiddsgen*-generated example application written in C/C++ or Java on an Android target, as an Android App (***.apk**).

Note that the C and C++ Android App examples use a Java wrapper class with JNI. It is also possible to write pure C and C++ native code to build Android Apps; see the Android documentation for details (https://developer.android.com/tools/sdk/ndk/index.html).

1. Compile the generated C/C++ or Java code. The auto-generated makefile will create the executables **HelloWorld_publisher** and **HelloWorld_subscriber** in the **objs/<arch>/** directory for C/C++, or it will generate Java code and archive it into **HelloWorld.jar**.

   On Android 9, you should link with **libc++_shared.so**.
2. See Chapter 4 Generating Example Code and a Makefile from IDL on page 8 regarding the ANDROID_ PACKAGE_PREFIX and TARGET_ID variables; if you want to change these variables in the makefile,do so now.
3. Create shared libraries (***.so**) and build the Android projects with the resulting shared libraries. For example (all on one line):

   ```
   gmake -f makefile_HelloWorld_armv7aAndroid2.3gcc4.8 HelloWorld.so
   ```

   The above command generates separate shared libraries for the publisher and subscriber examples. This also generates separate JNI source code files for both the publisher and subscriber; it also compiles and links the JNI code into separate jni shared libraries, one for the publisher and one for the subscriber. These shared libraries are packaged into Android Apps along with a **classes.dex** file for the Java Activity class.

4. Create the Android project directory structure:

```
gmake -f makefile_HelloWorld_armv7aAndroid2.3gcc4.8 HelloWorld.projects
```

5. Create the apk files that will contain the applications. By running the following command, you will build an APK for the publisher and an APK for the publisher. This apks will be used later to deploy the app:

```
gmake -f makefile_HelloWorld_armv7Android9.0clang8.0ndkr19b HelloWorld.apks
```

6. Install (via **adb**) the two Apps on a connected consumer device or an emulator. For example (all on one line):

```
gmake -f makefile_HelloWorld_armv7Android9.0clang8.0ndkr19b
HelloWorld.installapks
```

7. Run the example on an emulator with a GUI (i.e., not started with the **–no-window** flag) or on a consumer device:
    a. Navigate to the Apps screen displaying icons, it should show **HelloWorld_publisher** and **HelloWorld_subscriber**.

    b. Touch (on a device) or click (on an emulator) the **HelloWorld_subscriber** icon.
    c. Optionally, enter a single number for the DDS Domain ID as a parameter.
    d. Touch or click **Run**.

```
Running HelloWorld_subscriber 131 ...
HelloWorld subscriber sleeping for 4
HelloWorld subscriber sleeping for 4
```

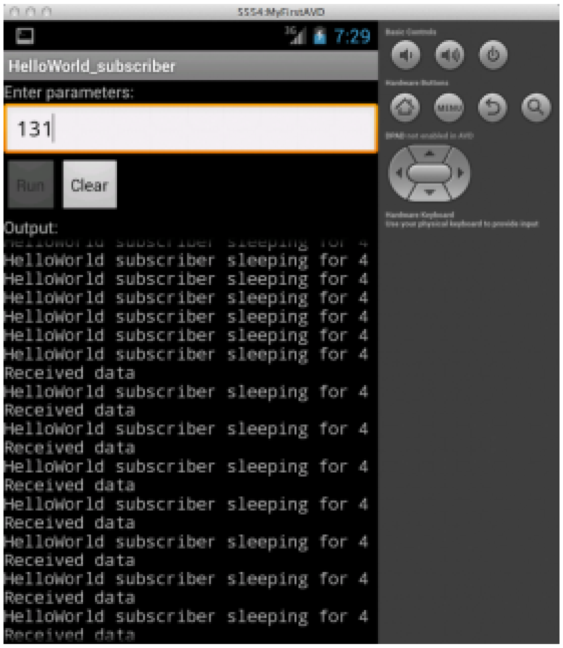
e. Navigate to the Apps icons (via the **Home** button) and launch **HelloWorld_publisher**

f. Optionally, for parameters, enter the DDS Domain ID (use the same ID you entered for the subscriber) as the first number. Optionally, you can enter the number of samples to be published as the second parameter.

g. Touch or click **Run**.

```
Running HelloWorld_publisher 131 99 .
Writing HelloWorld, count 0
Writing HelloWorld, count 1
Writing HelloWorld, count 2
```

h. Navigate to the Apps icons and return to **HelloWorld_subscriber**. Note the samples received.



HelloWorld_subscriber

Enter parameters:

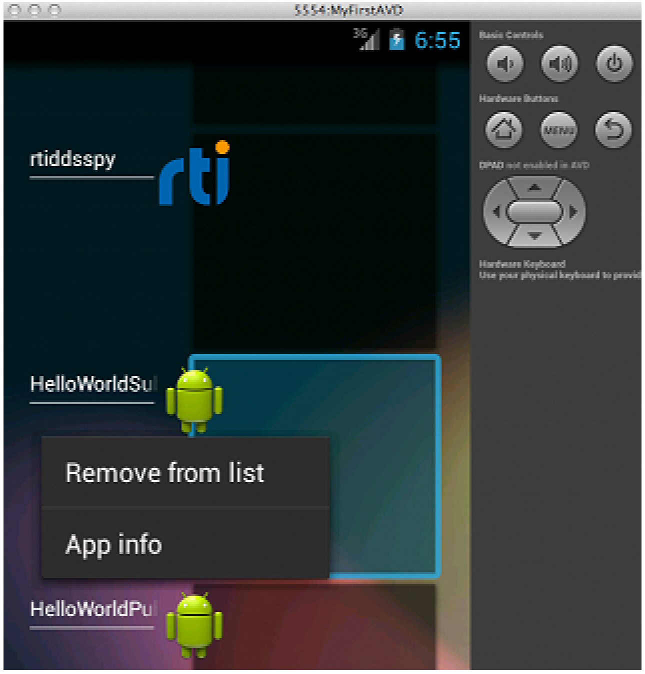
131

Output:

```
HelloWorld subscriber sleeping for 4
HelloWorld subscriber sleeping for 4
HelloWorld subscriber sleeping for 4
HelloWorld subscriber sleeping for 4
HelloWorld subscriber sleeping for 4
HelloWorld subscriber sleeping for 4
HelloWorld subscriber sleeping for 4
Received data
HelloWorld subscriber sleeping for 4
Received data
HelloWorld subscriber sleeping for 4
Received data
HelloWorld subscriber sleeping for 4
Received data
HelloWorld subscriber sleeping for 4
Received data
HelloWorld subscriber sleeping for 4
Received data
HelloWorld subscriber sleeping for 4
Received data
HelloWorld subscriber sleeping for 4
Received data
```

8. An Android App will continue to run in the background when the focus is given to another App. How to stop a running Android App without uninstalling it depends on the device or the virtual device within the emulator. For example, on the emulator hold the **Home** button until a list of applications is shown. Stop an App by swiping it left or right. For example, on a Nexus 7 tablet, touch the **Recent Apps** button (a soft key with an over-lapping rectangle) and swipe the App you want to stop. Alternatively, open **Settings**, choose **Apps**, in the subheadings swipe to **Running**, select **Show cached processes**, and lastly touch and **Stop** the App.

On an emulator, press the Home button to see a list of running apps.



Touch the desired app, then select Remove from list.

9. If you want to see DDS log messages or values of the samples being printed on the subscriber, run adb logcat with a filter in a host machine shell. For example:

```
adb logcat -v tag RTIConnextLog:I *:S
```

Chapter 6 Additional Considerations

6.1 Output when Running Connext DDS Applications on Android Devices and Emulators

6.1.1 DDS Log Messages from Core Libraries

All DDS log messages from the provided core C and C++ libraries are printed using the Android logging system as "information" using the **RTIConnextLog** tag. Log messages from the *Connext DDS* Java files are printed to **System.out** and **System.err**. The **adb logcat** command without the **-v** option will print all logged messages. To view any of the DDS log messages in real time, use the Android **logcat** tool with the appropriate filter through **adb**. For example:

```
adb logcat -v tag RTIConnextLog:I System.out:I System.err:I *:S
```

Note that if you are calling the **TypeSupport_print_data()** method of any of the *rtiddsgen*-generated data types in C or C++, the value of the samples will also be logged using the Android logging system as stated above.

Refer to the Android documentation for details:

- http://developer.android.com/tools/debugging/debugging-log.html

6.1.2 Output from rtiddsgen-Generated Examples or User Applications

For the *rtiddsgen*-generated Java publisher/subscriber examples, **System.out.println()** is used for printing output.

For the *rtiddsgen*-generated C/C++ examples, **printf()** is used for printing output.

By default, Android systems send stdout and stderr output to **/dev/null**. If you are running the generated publisher/subscriber with the **adb** shell (typically on a device on which you have root access), you should be able to see the example output directly in the shell.

If you are using the Android project files generated by the *rtiddsgen*-generated makefile to compile the publisher and subscriber examples as Android Apps, the generated source code for the application is doing something special to redirect the output to allow them to show up in the Android App.

For the Java example scenario, all the **System.out** output is redirected to the TextView in the GUI of the Android App. Refer to the generated Java Activity class source code under the project **src** directory for details on how this is done.

For the C/C++ example scenario, a special **RTIAndroid_registerOnPrintf()** method can be found in the generated publisher and subscriber example source code to redirect all **printf()** calls to a function callback. The **RTIAndroid_registerOnPrintf()** method is called when the example is run for the first time. Each time **printf()** is called from the generated publisher and subscriber example source code, the registered function callback, implemented in JNI, will be called. In the JNI method, we first attach the current thread to the Dalvik VM if it has not been done, then we call a method in the Java Activity class to display the message in the TextView UI. The native thread will be detached from the Dalvik VM, if necessary, before we return to the native publisher/subscriber example code. Refer to the generated Java Activity class source code under the project **src** directory, JNI code, and publisher/subscriber C/C++ code in the example's main directory for details on how this is done.

Note that when running the *rtiddsgen*-generated examples as an Android App, DDS logging messages and the printing of the Samples in the C or C++ subscriber will still need to be viewed using **logcat**—they will not show up in the GUI of the Android App.

Alternatively, you can change the generated example code to cause all the output to go to **logcat**. For C and C++, replace all calls to **printf()** with **__android_log_print()** with your desired priority and tag. For Java, use methods in the **android.util.Log** class instead of the **System.out** class.

Refer to Android SDK documentation for details:

- http://developer.android.com/tools/debugging/debugging-log.html

6.1.3 Output from Connext DDS Utilities

The *Connext DDS rtiddsspy*, *rtiddsping* and *rtiddsprototyper* utilities are implemented with *Connext DDS* core libraries. As a result, DDS log messages must be viewed with **logcat**.

If you run *rtiddsping, rtiddsspy*, and *rtiddsprototyper* in a shell, all the output from the utility will show up in the shell (even though DDS log messages still need to be viewed with **logcat**).

If you run *rtiddsping, rtiddsspy*, and *rtiddsprototyper* as Android Apps, most of the utility output will show up on the App UI, with the following exceptions. When running *rtiddsspy* with the **-printSample** option as an Android App, and when running *rtiddsprototyper* as an Android App, the value of the received sample is printed to stdout and therefore will not show up in either the UI or in **logcat**. The rest of the output from the utility itself will show up in the App UI as expected. DDS log messages still need to be viewed with **logcat**.

6.2 Communication between Connext DDS Applications on Emulator and Host

The emulator has its own virtual LAN: 10.0.2.*. In particular, 10.0.2.15 is the emulator's address for the host's NIC and 10.0.2.2 is the emulator's address for the host's loopback interface (localhost). To reach addresses outside of its virtual LAN, the emulator will route packets through its virtual network interface, 10.0.2.15 (the host's NIC). For communication from host to emulator, packets must be sent to the host's loopback interface, 127.0.0.1. The emulator can be directed to open ports on the host 127.0.0.1.

The emulator does not (for the version used at time of writing) support multicast. Therefore, discovery will be over unicast UDP. The number of participants within the host + emulator is limited due to the need to allocate ports for each participant. By default, that limit is five participants. In normal *Connext DDS* usage, the participants would acquire ports automatically. (The assignment would be implicitly based on the order of start up). The emulator that encapsulates one or more participants needs to explicitly acquire the ports that its contained participants will use. Therefore, it is necessary to explicitly manage the ports used.

Connext DDS determines ports for unicast communication based on Domain and Participant IDs. (For the algorithm used to calculate port numbers, see Ports Used for Discovery, in the *Discovery* chapter of the RTI Connext DDS Core Libraries User's Manual.

Consider the following example: A **Hello_simple** subscriber on the host is communicating with a **Hello_simple** publisher (Android) on an emulator.

Assuming Domain ID 0, the subscriber is given a Participant ID of 3. As there will be no contention, the publisher can assume the Participant ID is 0. The publisher will use ports 7410 for meta-traffic and 7411 for user-traffic. The subscriber will use ports 7416 for meta-traffic and 7417 for user-traffic.

To cause the emulator to open ports 7410 and 7411 on behalf of the publisher, it is necessary to set up some redirections. Use the "**adb devices**" command on the host to get the name of the emulator (e.g., "emulator-5554") and determine its control port (5554).

If the control port is 5554, enter this at the host to determine that no redirections are currently in place:

```
telnet localhost 5554
redir list
```

Then enter the following to set up redirections:

```
redir add udp:7410:7410
redir add udp:7411:7411
```

These redirections apply for 127.0.0.1 on the host, redirected to 10.0.2.2 in the emulator. The **redir** command causes the emulator to open the host port (the first of the two ports specified in the command) on the 127.0.0.1 interface. If another process already has that port, **redir** will report an error.

The publisher, running in the emulator, requires the following settings, shown below in a snippet of a QoS file’s **domain_participant_qos** section:

```
<discovery>
       <initial_peers>
               <element>builtin.udpv4://10.0.2.2</element>
       </initial_peers>
</discovery>
<property>
       <value>
               <element>
                       <name>dds.transport.UDPv4.builtin.public_address</name>
                       <value>127.0.0.1</value>
               </element>
       </value>
</property>
```

The above sets the locators provided by the publisher; these locators instruct the subscriber to direct traffic to the host's loopback interface. The virtual LAN address that would otherwise be used is not accessible to the subscriber running on the host.

Set the environment for the publisher (on the emulator) so that NDDS_QOS_PROFILES points to the QoS file. Note that the **initial_peers** can alternatively be set via the NDDS_DISCOVERY_PEERS environment variable.

Note that for an Android App (***.apk**), these settings can be made programmatically.

The subscriber, running on the host, requires the following settings, shown below in a snippet of a QoS file’s **domain_participant_qos** section:

```
<discovery>
       <initial_peers>
               <element>builtin.udpv4://127.0.0.1</element>
       </initial_peers>
</discovery>
<transport_builtin>
       <mask>UDPv4</mask>
</transport_builtin>
<wire_protocol>
       <participant_id>3</participant_id>
</wire_protocol>
```

Explicitly attempting to communicate the participant ID prevents the subscriber from implicitly using participant ID 0 (which would cause a later attempt to set redirections for the emulator to fail). Explicitly setting the builtin transport to be UDPv4 only will prevent the host from communicating with the emulator via shared memory.

Set the environment for the subscriber (on the host) so that NDDS_QOS_PROFILES points to the QoS file. Note that you can also set **initial_peers** via the NDDS_DISCOVERY_PEERS environment variable. All these settings can also be made programmatically.

Finally, if you need to run *rtiddsspy* on the host to communicate with DDS applications running on the emulator, be careful when specifying its transports, discovery addresses, and participant ID. For example:

```
$(NDDSHOME)/bin/rtiddsspy -peer 127.0.0.1 -transport 1 -index 1
```

There are many variation on this theme to achieve communication between host and emulator. This example illustrates the issues that need to be addressed.

6.3 Loading XML-Specified QoS Settings

If you have root access to the device or you are running on an emulator, you can run your *Connext DDS* application in the Android shell and set up environment variables in the shell just as you would for any other Linux system. In this scenario, XML QoS profiles can be loaded in the usual ways.

If you want to run *Connext DDS* through an Android App, there is no support for environment variables, which limits the ways that can be used to load XML-specified QoS settings. However, it can still be done by specifying one of the following fields in the ProfileQosPolicy in DomainParticipantFactoryQos:

- **url_profile**
- **string_profile**

See the *RTI Connext DDS Core Libraries User's Manual* for details.

When running an Android App on a non-rooted consumer device, if you want to use **url_profile** to specify the location of the file that contains the XML-specified QoS settings, it will work only if the file is in Android external storage (for example, under **/sdcard**). You will also need to make sure the **AndroidManifest.xml** file of the project has specified the correct permission to allow reading from external storage.

For example, use the following command to put the file in external storage:

```
adb push <host-qos-file> /sdcard/<target-qos-file>
```

In the *Connext DDS* source code, specify the location of the file in the external storage in the **url_profile** field of **ProfileQosPolicy** in **DomainParticipantFactoryQos**. For example, in Java, you can do the following before creating DDS entities:

```
DomainParticipantFactoryQos factoryQos = new DomainParticipantFactoryQos();
```

```
DomainParticipantFactory factory = DomainParticipantFactory.get_instance();
factory.get_qos(factoryQos);
factoryQos.profile.url_profile.add("file:///sdcard/USER_QOS_PROFILES.xml");
factory.set_qos(factoryQos);
```

In the **AndroidManifest.xml** file of the project, add the following permission:

```
<uses-permission android:name="android.permission.READ_EXTERNAL_STORAGE" />
```

Refer to Android documentation for details regarding Android external storage.

6.4 Using DDS C++ Libraries for Android Applications

The *Connext DDS* C++ libraries are built and linked against the *C++ runtime*. The *Connext DDS* libraries for Android 9 systems require the shared version of the *C++ runtime*. This is due to the way *Connext DDS* libraries are built.

The *rtiddsgen*-generated makefile for C++ examples builds a shared library (**.so**) that is used by the Android App. When building this shared library, we are also linking against the *C++ runtime*. The *C++ runtime* is not included as part of the *Connext DDS* bundles. You can obtain these libraries as part of the Android NDK.

The static *C++ runtime* can be used only if it is linked into a single binary. If your project contains multiple shared libraries that are linked with the *C++ runtime*, you should use the shared version of the *C++ runtime*. Note that if you use the shared version of the *C++ runtime* in the project for your Android App, you will not be able to write pure native code by just using the Android Native Activity class in your App's manifest file. Instead, you will need to write Java code and call **System.loadLibrary()** to explicitly load the *C++ runtime* first, before loading the shared library of your project. For example, for Android 9:

```
static {
System.loadLibrary(“c++_shared”);
System.loadLibrary(“HelloWorld_publisher”);
}
```

Please, also pay attention to the license for LLVM libc++ libraries before using that in your project. Refer to the Android NDK documentation under "C++ Library Support" for more details: https://developer.android.com/ndk/guides/cpp-support.

6.5 Android Threads

When an Android application is launched, the system creates a thread of execution for the application, called "main." This main thread is also sometimes called the UI thread. Due to Android's single thread model, one should never block the UI thread and one should not access the Android UI toolkit from outside the UI thread.

The project files generated by the *rtiddsgen*-generated makefile has taken care of this for you. If you click the **Run** button to run the publisher/subscriber example, a new thread is created to handle the execution of the example, so that the UI thread will not be blocked. Similarly, if the Android UI needs to be updated (for example, to display output of the publisher/subscriber example in the TextView UI), **runOnUiThread()** is called to make sure the display is always updated in the UI thread. See the generated Java Activity class source code under the project **src** directory for details.

6.6 Setting Permission in App Manifest

When using *Connext DDS* on an Android platform as an App, you need to grant the proper permissions for networking in **AndroidManifest.xml** for your project:

```
<uses-permission android:name="android.permission.INTERNET" />
<uses-permission android:name="android.permission.CHANGE_WIFI_MULTICAST_STATE"
/>
<uses-permission android:name="android.permission.CHANGE_WIFI_STATE" />
```

If you want to use Android external storage to load XML-specified QoS settings for your *Connext DDS*-based Android App, you also need to grant the proper permissions to read the external storage:

```
<uses-permission android:name="android.permission.READ_EXTERNAL_STORAGE" />
```

Refer to Android documentation for more details:

- http://developer.android.com/reference/android/Manifest.permission.html

Chapter 7 Third-Party Licenses

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Developed by:

LLVM Team

University of Illinois at Urbana-Champaign

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