Freescale Semiconductor
Application Note

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AIOP SDK Applications Debug

1 Overview

This application note describes how to debug an AIOP SDK application with CodeWarrior for APP. The application targeted by this document is AIOP Packet reflector.

AIOP packet reflector provides an entry-level demonstration about how to use and program an AIOP. It has no predefined Freescale infrastructure that is required to be used by the end user. It uses the AIOP SL-Service Layer routines only.

The purpose of this sample application is to demonstrate a simple application data path on AIOP. The application is available in these two flavors:

- A basic reflector for every IPv4 frame (further referenced as *Reflector*). It works much like the NADK Packet Reflector application, except that it runs on AIOP.
- The second one applies an extra classification and only accepted frames are further reflected (further referenced as *Reflector-Classifier*).

For more details about this application, see the *AIOP 'packet reflector' sample application* chapter of the *LS2085 SDK Quick Start Guide*.

This application note focuses on the *Reflector* flavor.

An updated version of the Application Note is available on CodeWarrior Development Studio for Advanced Packet Processing Product Summary Page.

Contents

2 Prerequisites

This application note is intended to be used on a Linux 64-bit host machine for simulator.

NOTE

You can use either Linux or Windows hardware.

The table below shows the requisite components.

Component	Version
CodeWarrior for APP	10.2.0 or later
SDK	EAR6.0 or later

3 Getting AIOP reflector source files

To get the AIOP APP source files, follow these steps:

1. Install the SDK .iso image from here on a 64-bit machine using the commands listed below:
   a. `mount -o loop <image>.iso dir_to_mount`
   b. `cd <dir_to_mount>`
   c. `./install`
   d. `cd <install_dir>`
   e. `./poky/scripts/host-prepare.sh`
   f. `source ./poky/fsl-setup-poky -m <target>`

   Where target can be `ls2085ardb` or `ls2085a-simu`, in case you want to use a hardware board or a simulator, respectively.
2. Prepare to build and deploy the aiopapp projects and images, set CW PATH in Yocto
   a. `vim conf/local.conf`
   b. add next line: `CW_PATH="path to your CW for APP"` as listed below:

```
CW_PATH = "/home/b32331/Desktop/CW_NetApps_v2014.11/CW_APP"
```

3. Build the AIOP reflector using this command:

```
bitbake aiop-refapp
```

4. Build the rest of images needed by AIOP reflector as follows:
   a. `bitbake fsl-image-kernelitb`
   b. `bitbake dpl-examples`

4 Hardware setup

To demonstrate the *reflected* traffic, you can use only one board with two ports connected back-to-back, as the following figure shows (in the example below, the copper ports 5 and 6 are connected):

Figure 1. Hardware setup using one board with two ports connected back-to-back

The Linux container role is played by the port 5 and the AIOP container role is played by the port 6.

```
LINUX                                                          AIOP
dpni.0  <-> dpmac.5 <--------------------------------> dpmac.6 <-> dpni.1
(ni0)
```

After you get a U-Boot prompt on the board, use these commands:

Bring up the board via tftp from U-Boot (or you can write the images to the flash using the flash programmer from CodeWarrior for ARMv8).

```
setenv filesize; setenv myaddr 0x580100000; tftp 0x80000000 u-boot-nor.bin; protect off
$myaddr +$filesize; erase $myaddr +$filesize; cp.b 0x80000000 $myaddr $filesize; protect on
$myaddr +$filesize

setenv filesize; setenv myaddr 0x580000000; tftp 0x80000000 PBL.bin; protect off $myaddr +
$filesize; erase $myaddr +$filesize; cp.b 0x80000000 $myaddr $filesize; protect on $myaddr +
$filesize

setenv filesize; setenv myaddr 0x580300000; tftp 0x80000000 mc.itb; protect off $myaddr +
$filesize; erase $myaddr +$filesize; cp.b 0x80000000 $myaddr $filesize; protect on $myaddr +
$filesize

setenv filesize; setenv myaddr 0x580700000; tftp 0x80000000 dpl-eth.0x2A_0x41.dtb; protect
off $myaddr +$filesize; erase $myaddr +$filesize; cp.b 0x80000000 $myaddr $filesize; protect
on $myaddr +$filesize

setenv filesize; setenv myaddr 0x580800000; tftp 0x80000000 dpc-0x2a41.dtb; protect off
$myaddr +$filesize; erase $myaddr +$filesize; cp.b 0x80000000 $myaddr $filesize; protect on
```

```
$myaddr +$filesize

fsl_mc start mc 580300000 580800000 && fsl_mc apply dpl 580700000
tftp a0000000 kernel-ls2085ardb.itb
bootm a0000000
```

Configure the ni0 interface and create a static ARP entry. Set the destination MAC as the ARP hardware address for all the IP flows on which the packet needs to be sent:

```
$ ifconfig ni0 6.6.6.1 up
$ arp -s 6.6.6.10 000000000006
```

Prepare the AIOP container using the following steps:

1. Edit the following script:

   `<yocto_path>/build_ls2085ardb_release/tmp/work/aarch64-fsl-linux/aiopapp-refapp/scripts/dynamic_aiop_root.sh`
2. Delete the lines between 205 and 225 and update `DPMAC1="dpmac.6"`.
3. Copy the script and `aiop_reflector.elf` on the Linux target using `scp` from the Linux host and the `eth0` (connected to e1000#0 PCI card) interface.

On the linux target:

```
$ ifconfig eth0 192.168.1.2 up
```

On the linux host:

```
$ ifconfig eth0 192.168.1.1 up
$ scp <yocto_path>/build_ls2085ardb_release/tmp/work/aarch64-fsl-linux/aiopapp-refapp/
scripts/dynamic_aiop_root.sh root@192.168.1.2:.
$ scp <yocto_path>/build_ls2085ardb_release/tmp/work/aarch64-fsl-linux/aiopapp-refapp/demos/
reflector/out/aiop_reflector.elf root@192.168.1.2:.
```

On the linux target:

```
root@ls2085ardb:~# chmod +x dynamic_aiop_root_test.sh
root@ls2085ardb:~# ./dynamic_aiop_root_test.sh
Creating AIOP Container
Assigned dpbp.1 to dprc.2
Assigned dpbp.2 to dprc.2
Assigned dpbp.3 to dprc.2
Assigned dpni.1 to dprc.2
Connecting dpni.1<------->dpmac.6
AIOP Container dprc.2 created
----- Contents of AIOP Container: dprc.2 -----
dprc.2 contains 4 objects:
object          label           plugged-state
dpni.1                          plugged
dpbp.3                          plugged
dpbp.2                          plugged
dpbp.1                          plugged
-----
====================================================
Creating AIOP Tool Container
Assigned dpaiop.0 to dprc.3
Assigned dpmcp.22 to dprc.3
AIOP Tool Container dprc.3 created
----- Contents of AIOP Tool Container: dprc.3 -----
dprc.3 contains 2 objects:
object          label           plugged-state
dpaiop.0                        plugged
dpmcp.22                        plugged
-----
====================================================
Performing VFIO mapping for AIOP Tool Container (dprc.3)
Performing vfio [  234.804575] vfio-fsl-mc dprc.3: Binding with vfio-fsl_mc driver
mapping for dprc.3
```

```
[  234.814384] vfio-fsl-mc dpaiop.0: Binding with vfio-fsl_mc driver
[  234.821209] vfio-fsl-mc dpmcp.22: Binding with vfio-fsl_mc driver
========== Summary ================================
 AIOP Container: dprc.2
 AIOP Tool Container: dprc.3
====================================================
```

Load the AIOP application using `aiop_tool`.

Initiate ping on the interface to forward packets to the *Reflector* application running on the AIOP container board. Basically, this is a ping from ni0 interface (dpni.0 – dpmac.5) to dpni.1 – dpmac.6.

```
$ aiop_tool load -f aiop_reflector.elf -g dprc.3
AIOP Image (aiop_reflector.elf) loaded successfully.
$ ping 6.6.6.10
```

To check if the AIOP reflector application loaded successfully, execute the following command in the Linux command shell:

```
$ root@ls2085ardb:~# cat /dev/fsl_aiop_console
```

The command output displays the number of DPNIs that are successfully configured, together with the DPNIs that are provided to the AIOP Reflector Application:

```
REFLECTOR : Successfully configured ni0 (dpni.1)
REFLECTOR : dpni.1 <---connected---> dpmac.6 (MAC addr: 00:00:00:00:00:06)
> TRACE [CPU 0, dpci_drv.c:524 dpci_event_handle_removed_objects]: Exit
> INFO [CPU 0, init.c:289 core_ready_for_tasks]: AIOP core 0 completed boot sequence
> INFO [CPU 0, init.c:295 core_ready_for_tasks]: AIOP boot finished; ready for tasks...
```

The AIOP Logger prints a brief information about every frame that is reflected, as listed below. You can also view these logs in the CodeWarrior IDE in a simple manner using the Debug Print feature. For more information about the Debug Print feature, see the *Debug Print Application Note*.

```
$ root@ls2085ardb:~# tail -f /dev/fsl_aiop_console


RX on DPNI 1 | CORE:15
  MAC_SA: 02-00-c0-a8-48-01 MAC DA: 00-00-00-00-00-06
  IP SRC: 6.6.6.1 IP DST: 6.6.6.10

RX on DPNI 1 | CORE:15
  MAC_SA: 02-00-c0-a8-48-01 MAC DA: 00-00-00-00-00-06
  IP SRC: 6.6.6.1 IP DST: 6.6.6.10

RX on DPNI 1 | CORE:15
  MAC_SA: 02-00-c0-a8-48-01 MAC DA: 00-00-00-00-00-06
  IP SRC: 6.6.6.1 IP DST: 6.6.6.10

RX on DPNI 1 | CORE:15
  MAC_SA: 02-00-c0-a8-48-01 MAC DA: 00-00-00-00-00-06
  IP SRC: 6.6.6.1 IP DST: 6.6.6.10
```

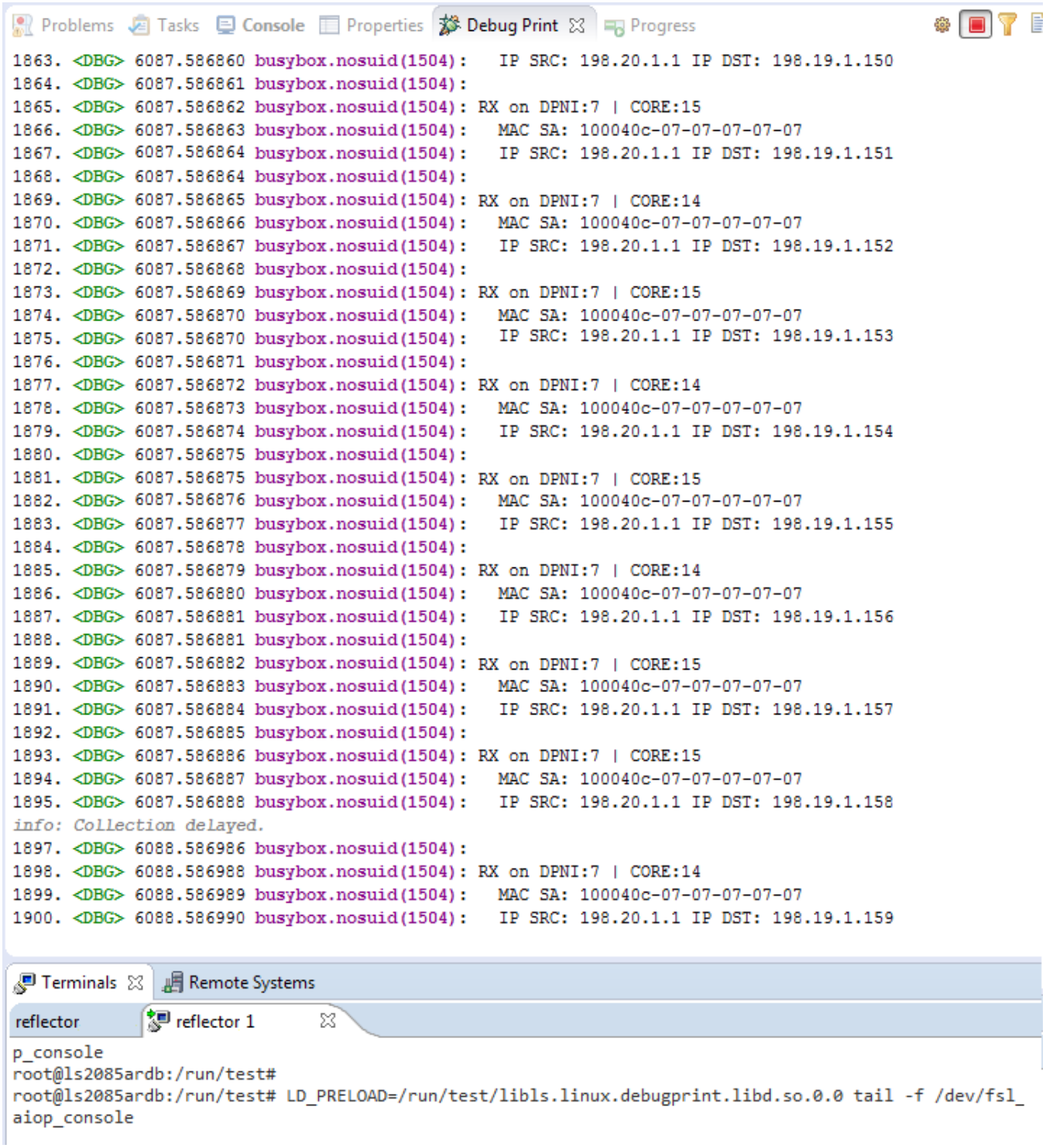


Figure 2. Debug print

5 Importing and building AIOP reflector project in CodeWarrior

To import and build the AIOP reflector project, follow these steps:

1. Start the CodeWarrior and create a new workspace.
2. Import (**File > Import > General > Existing Projects Into Workspace**) the **reflector** and **aiop_sl** projects from this location: `<yocto_path>/build_ls2085ardb_release\tmp\work\aarch64-fsl-linux\aiop-refapp`

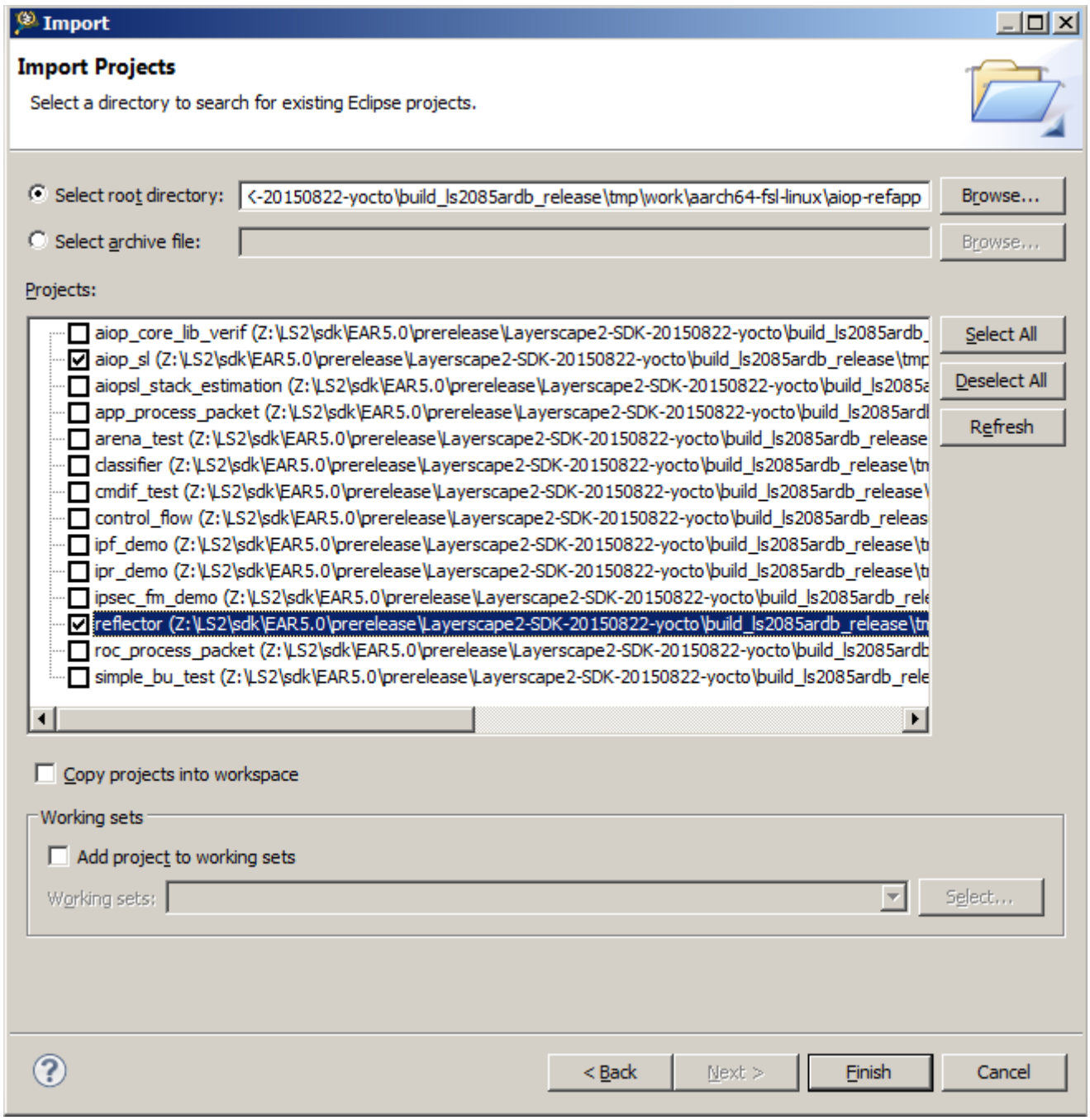


Figure 3. Import dialog - Import Projects page

3. The aiop reflector project (`aiop_reflector.elf`) is already built by Yocto, but if you want you can edit the sources and build the project directly from the CodeWarrior. To do this, right-click on the project in the **CodeWarrior Projects** view and select **Build Project**. The IDE also rebuilds the `aiop_sl` library project that is linked to the reflector project. It is recommended to use –O0 level optimization for improved debugging. To access **Optimization Level**, select **Project Properties > C/C++ Build > Settings > Compiler > Optimization > Optimization Level**.

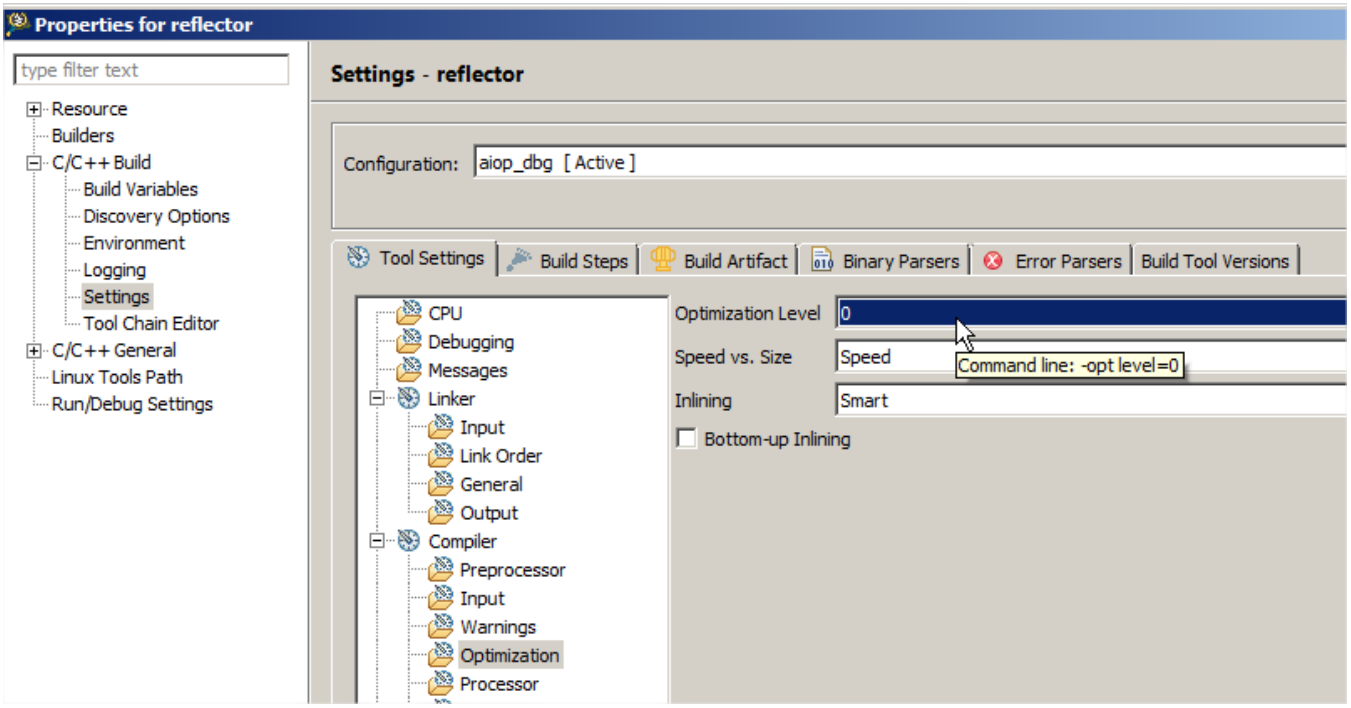


Figure 4. Properties for reflector project - Settings window

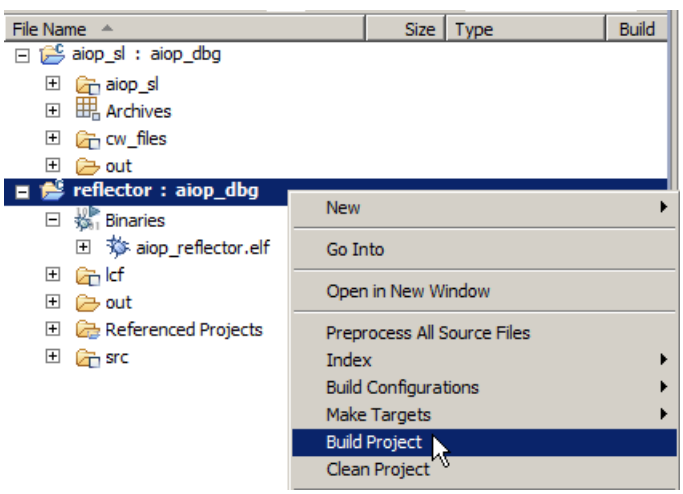


Figure 5. CodeWarrior Projects view - Build Project option

6 Debugging AIOP APP using CodeWarrior

To debug the AIOP using the CodeWarrior for APP IDE, follow these steps:

1. Copy the new `aiop_reflector.elf` just compiled with CodeWarrior or yocto to the linux board. To locate the elf, expand the **Binaries** group from reflector project, right click on the `aiop_app.elf` and select **Show in Windows Explorer** for Windows, or **Show in File Manager** for Linux.

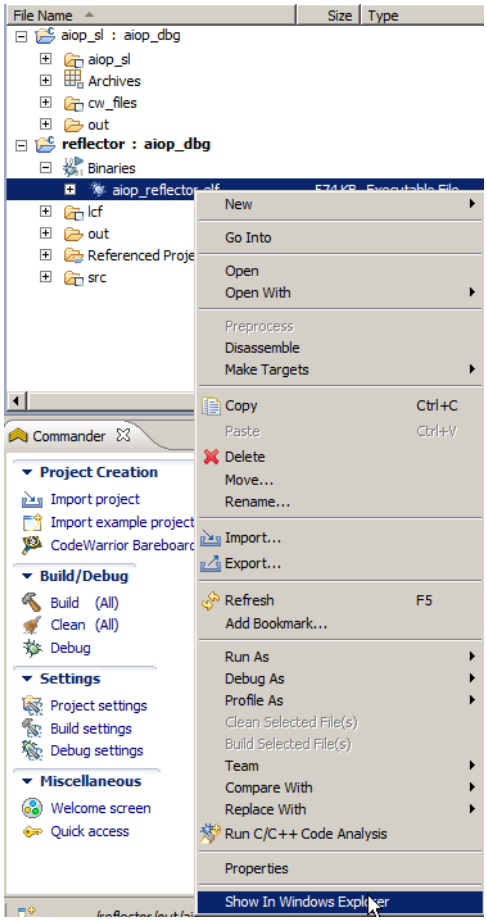


Figure 6. Show in Windows Explorer option

2. Select **Run > Debug Configurations** from the IDE menu bar.

   The **Debug Configuration** dialog appears.

3. Select the reflector project.
4. Select **aiop_dbg** launch configuration from the left panel.
5. Click **Edit** from **Connection**.
6. Specify the **Hostname/IP**.

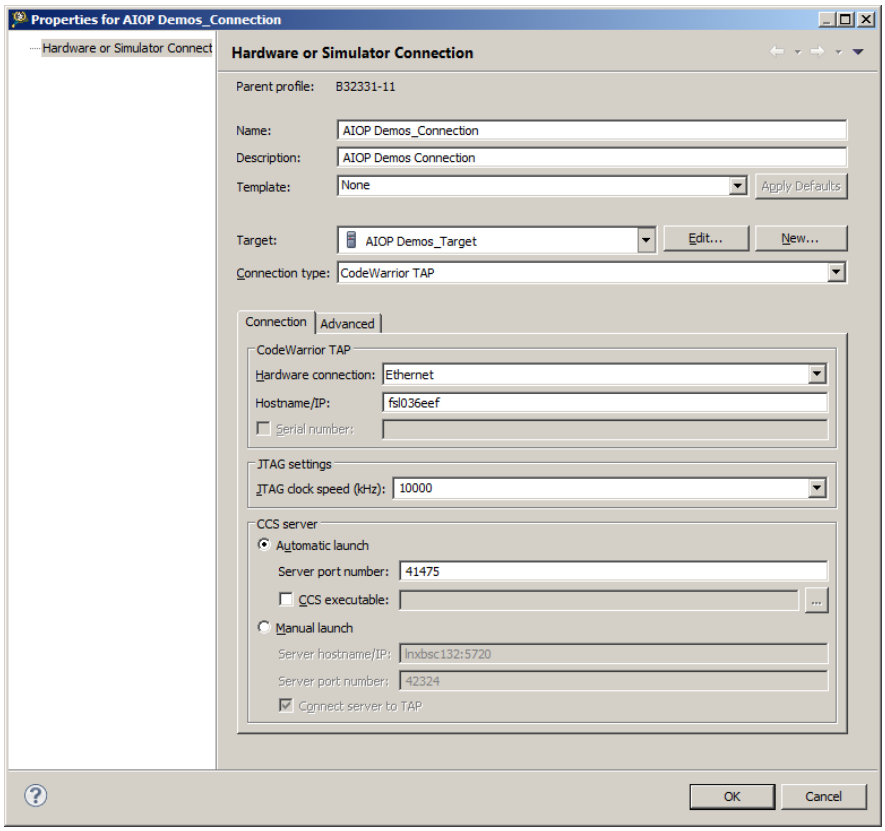


Figure 7. Properties for <connection> dialog - Hostname/IP option

7. Click **OK**.
8. Ensure that the AIOP OS awareness is enabled. To do this, open the **Debugger > OS Awareness** tabs and ensure that the **AIOP** is selected in the **Target OS** group.

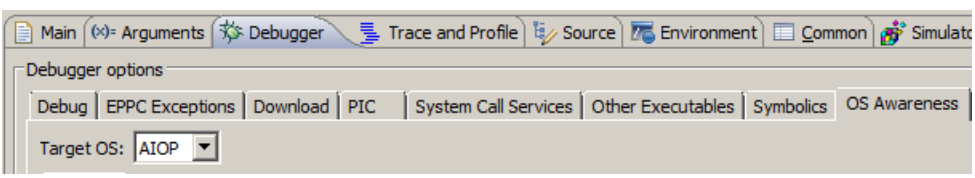


Figure 8. Selecting AIOP Target OS

9. Click **Debug** for attaching to the AIOP.

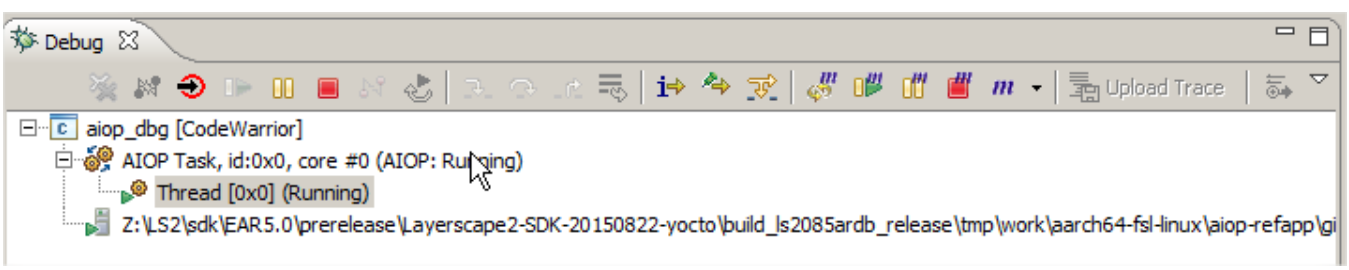


Figure 9. Debug view - Attaching AIOP

You can debug the AIOP APP using the following two methods:

- Debugging AIOP from system entry point
- Debugging AIOP from application entry point

6.1 Debugging AIOP from system entry point

1. To access the very first AIOP instruction (the entry point), you need to control the entire system booting process (U-Boot/GPP > MC > AIOP) and have run-control on the GPP core side.
2. Click Reset.

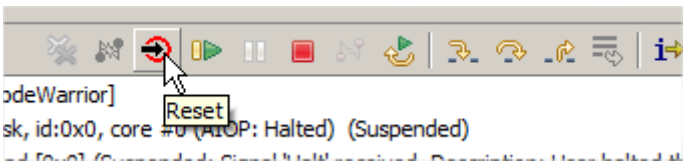


Figure 10. Debug view showing Reset button

The AIOP debugging halts.

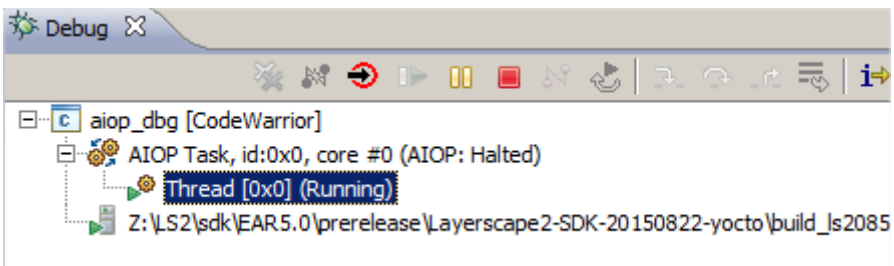


Figure 11. Debug view

3. Open the *CodeWarrior for APP* IDE.
4. Set a breakpoint at `__sys_start`.

NOTE

This is possible from both the source file and the **Debugger Shell** view. The breakpoint from the `__sys_start init` hits just after the AIOP tool loads the AIOP application.

Figure 12. CodeWarrior for APP - Editor view

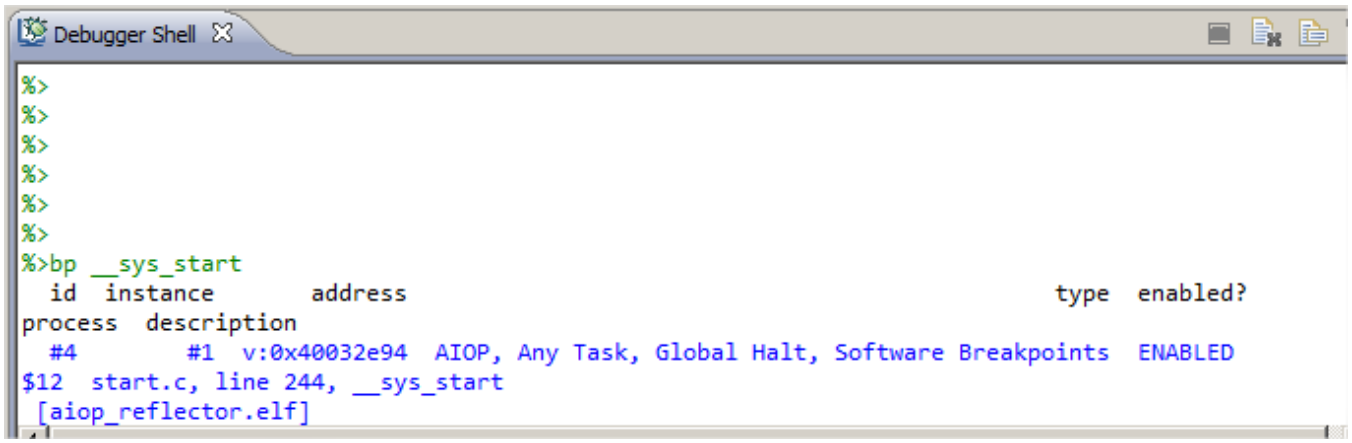


Figure 13. CodeWarrior for APP - Debugger Shell view

5. Click **Resume** to boot the entire eco-system (*u-boot/GPP* > *MC* > *Linux* > *AIOP*) using the Debugger Shell view. Write the following command in the Debugger Shell view `<protocol ccs::run_core 288>`

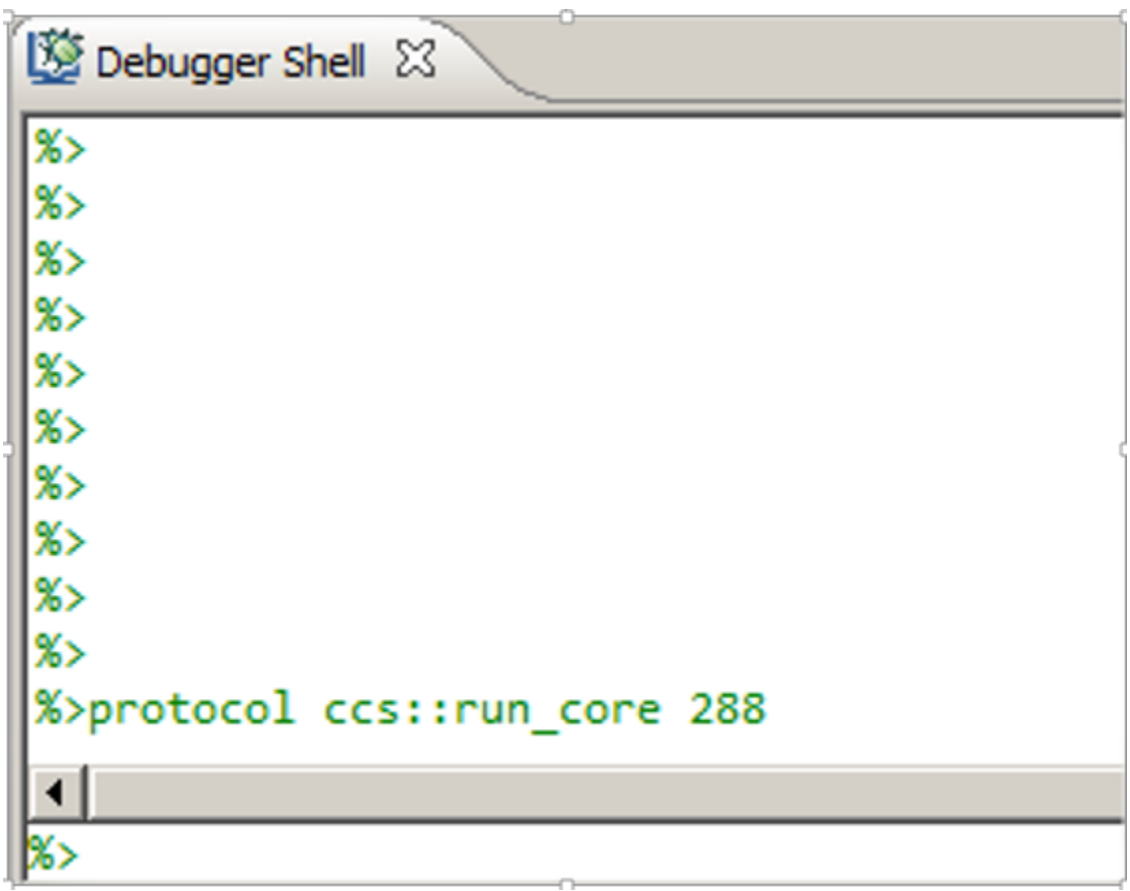


Figure 14. CodeWarrior for APP - Debug Shell view

6. The debugger hits the break point `__sys_start` after the `aiop_tool` loads the AIOP application from the linux target. For more details, see Hardware setup.

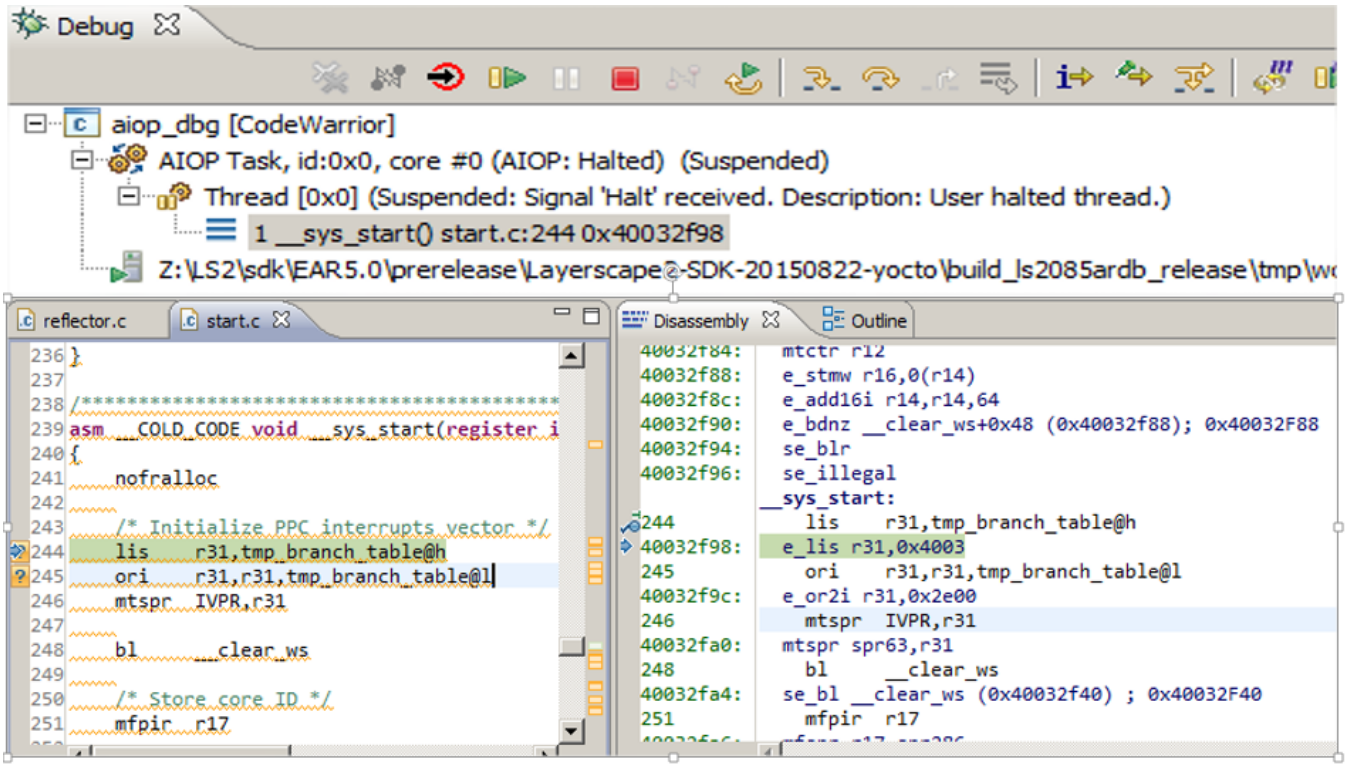


Figure 15. CodeWarrior for APP - Debug perspective

6.2 Debugging AIOP from application entry point

The entry point function executed by a triggered AIOP task is `app_reflector`. A breakpoint in this function hits when you generate traffic using the ping command (see Hardware setup). To debug AIOP from the application entry point, follow the steps below:

1. Set up a breakpoint at `app_reflector` symbol using either the source file or the **Debugger Shell** view.

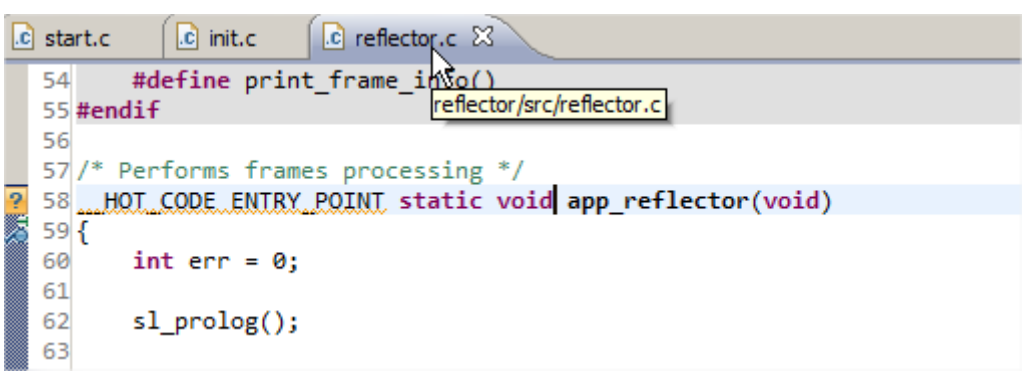


Figure 16. Setting breakpoint using source file

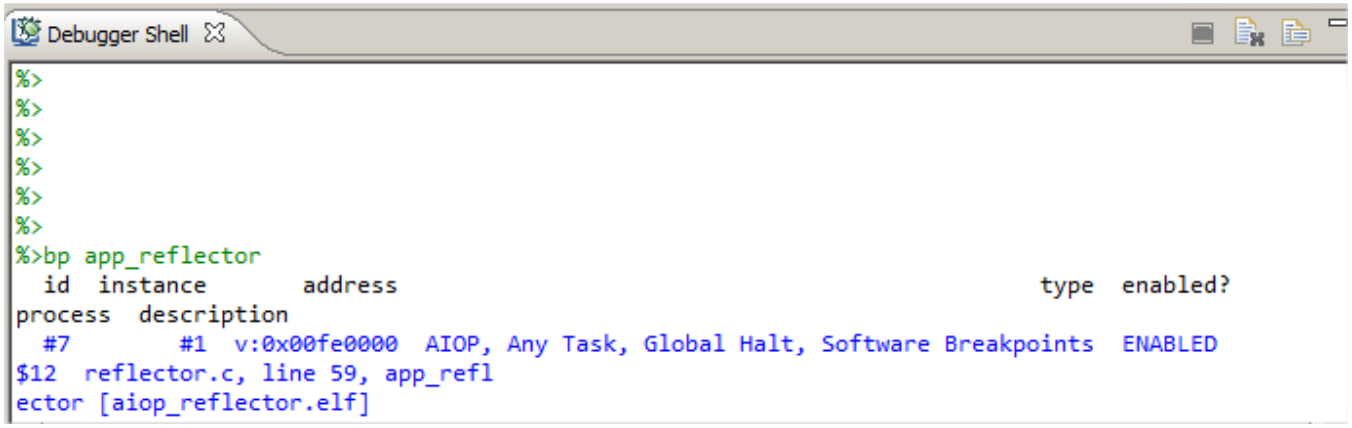


Figure 17. Setting breakpoint using Debugger Shell view

2. Click **Resume** from the **Debug** view.
   The figure below shows the AIOP task suspended in `core_ready_for_tasks()` function.

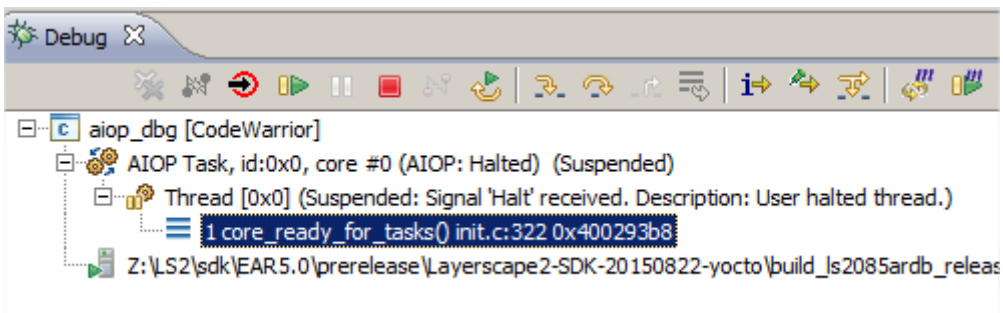


Figure 18. Debug view displaying core_ready_for_tasks() function

3. The core finishes to boot and waits for the tasks to be triggered.
4. Now, follow the AIOP reflector demonstration steps listed in the Hardware setup chapter.

NOTE

You need to load the kernel via the `tftp` and `bootm` commands. Sending the packets (with ping) to the AIOP interfaces generate tasks that can be observed/debugged in the **System Browser** view and also hits the breakpoint from the `app_reflector` symbol. For full debugging capabilities of the System Browser and the AIOP Task Aware features, see the *AIOP Task Aware Debug* (document AN5044) application note.

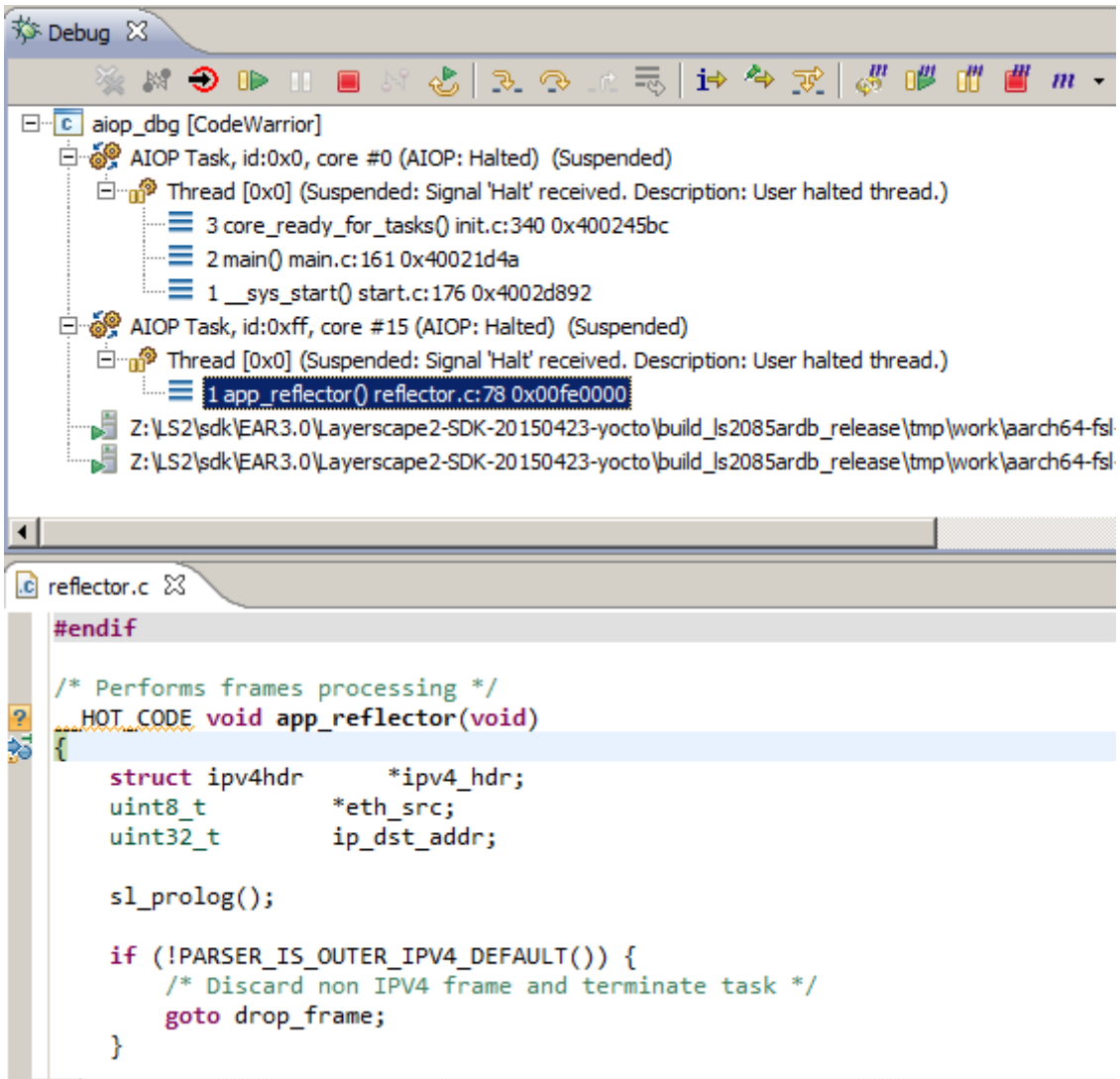
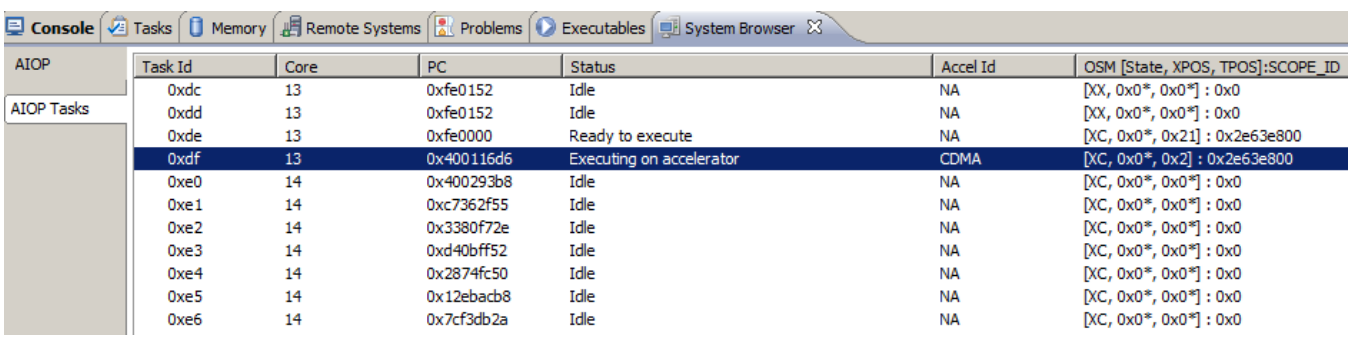


Figure 19. Debug view - app_reflector breakpoint



Task Id	Core	PC	Status	Accel Id	OSM [State, XPOS, TPOS]:SCOPE_ID
0xdc	13	0xfe0152	Idle	NA	[XX, 0x0*, 0x0*] : 0x0
0xdd	13	0xfe0152	Idle	NA	[XX, 0x0*, 0x0*] : 0x0
0xde	13	0xfe0000	Ready to execute	NA	[XC, 0x0*, 0x21] : 0x2e63e800
0xdf	13	0x400116d6	Executing on accelerator	CDMA	[XC, 0x0*, 0x2] : 0x2e63e800
0xe0	14	0x400293b8	Idle	NA	[XC, 0x0*, 0x0*] : 0x0
0xe1	14	0xc7362f55	Idle	NA	[XC, 0x0*, 0x0*] : 0x0
0xe2	14	0x3380f72e	Idle	NA	[XC, 0x0*, 0x0*] : 0x0
0xe3	14	0xd40bff52	Idle	NA	[XC, 0x0*, 0x0*] : 0x0
0xe4	14	0x2874fc50	Idle	NA	[XC, 0x0*, 0x0*] : 0x0
0xe5	14	0x12ebacb8	Idle	NA	[XC, 0x0*, 0x0*] : 0x0
0xe6	14	0x7cf3db2a	Idle	NA	[XC, 0x0*, 0x0*] : 0x0

Figure 20. System Browser view

7 Collecting hardware trace

To collect the hardware trace, follow the steps listed below:

1. Open **Run > Debug Configurations > Trace and Profile** tab.
2. Check the **Enable Trace and Profile** checkbox. For customizing the trace options, click **Edit**.

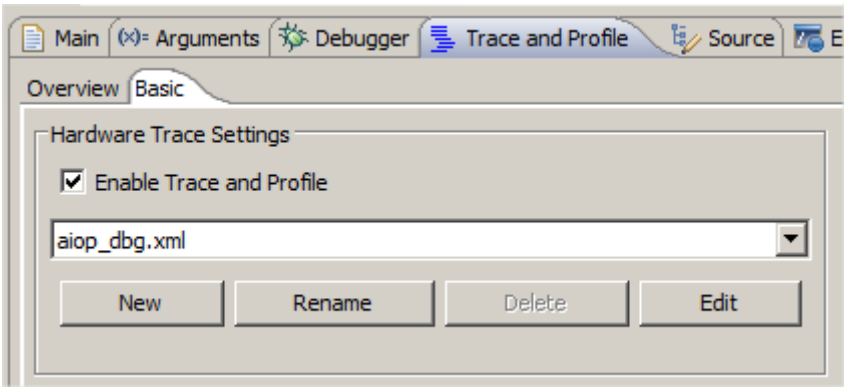


Figure 21. Trace and Profile tab

3. Click **Debug**.
   The trace gets collected between the two suspended events.

NOTE

After the *attach* is completed, it is mandatory for the task to process the suspend operation first.

4. Ensure that you set up the breakpoints in the `app_reflector` entry point.
5. Click **Resume**.
6. Send the ping traffic as suggested in the Hardware setup chapter.
7. The debugger hits the breakpoint.
8. Click **Resume** again for executing the entry point function and for generating the trace for your entry point function.
9. The debugger hits the breakpoint again.
10. Click **Upload Trace** to collect the trace.

Figure 22. Debug view - Collect Trace option

11. The collected trace appears in the **Analysis Results** view.

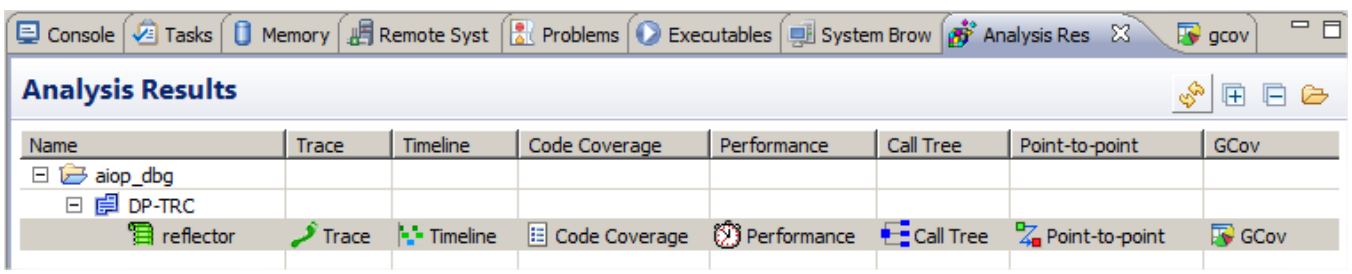


Figure 23. Analysis Results view

12. It is mandatory to open the **Trace** item first for letting the CodeWarrior IDE to decoding the gathered hardware trace.

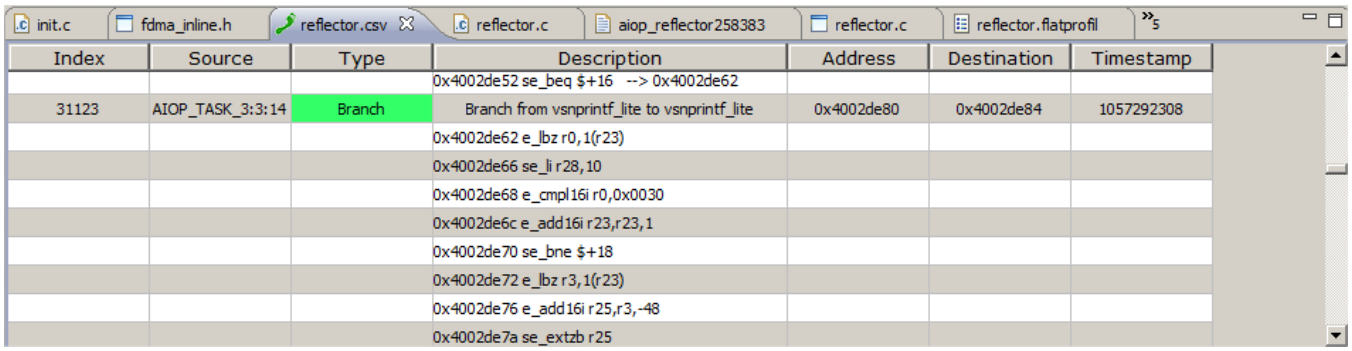


Figure 24. Hardware trace

For the rest of the items, ensure that you select the last task because the app reflector is enabling the tasks in a round-robin manner starting from the last task.

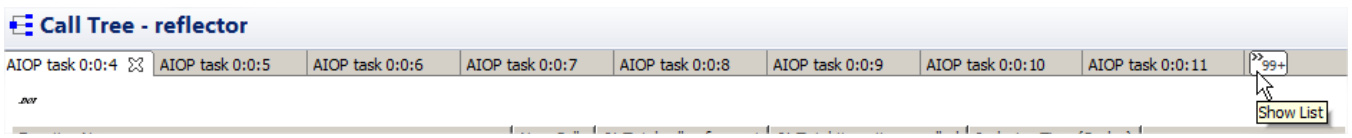


Figure 25. Call Tree view

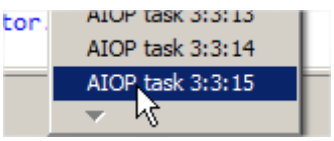


Figure 26. Selecting task

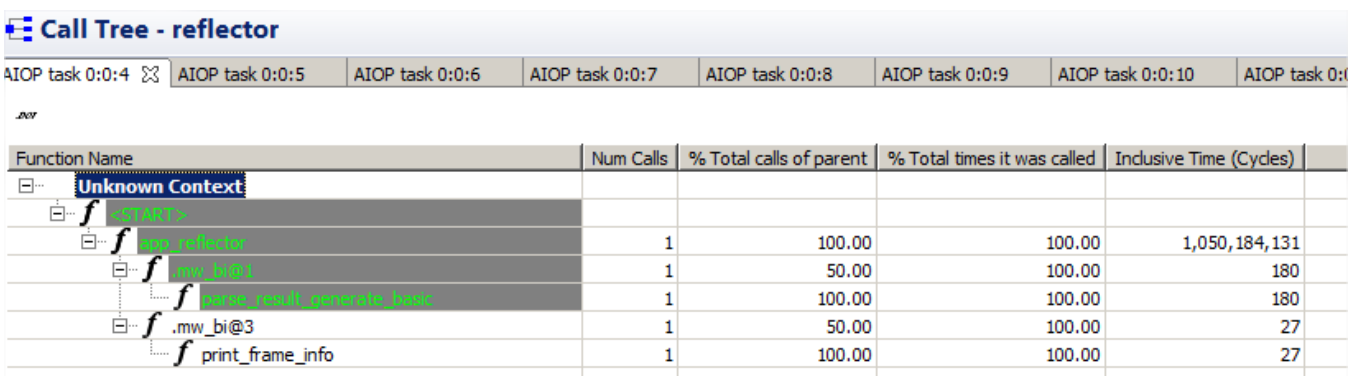


Figure 27. Collected trace

7.1 GCov code coverage

To enable GCov code coverage for reflector, follow the steps below:

1. Enable the **Generate Code Coverage File** option from the **Project > Properties > Settings > Tool Settings > Compiler > Processor** and re-build the project.

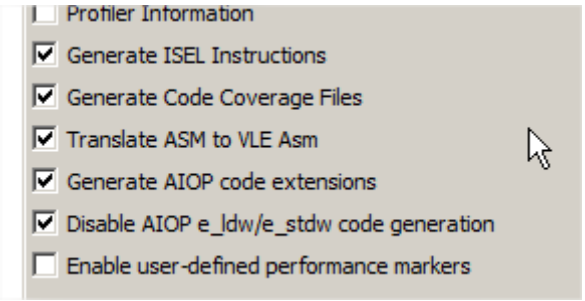


Figure 28. Generate Code Coverage File option

2. Follow the steps from Collecting hardware trace section to have the gcov results.

   For more details, see the section *6.3 GCov* of the *CodeWarrior Development Studio for Advanced Packet Processing Targeting Manual* (document CWAPPTM).

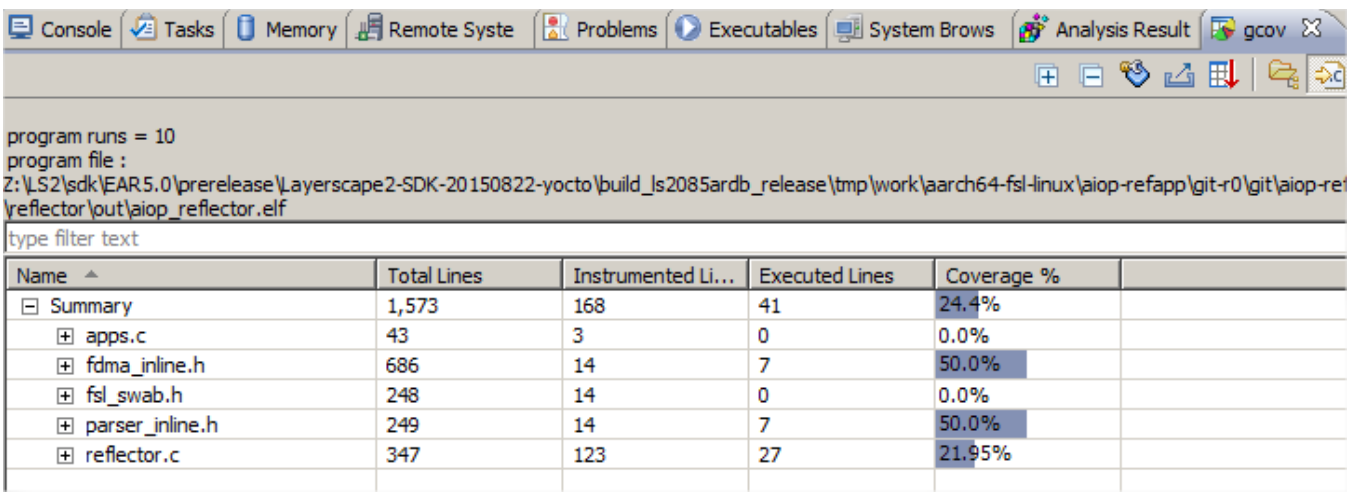


Figure 29. gcov view

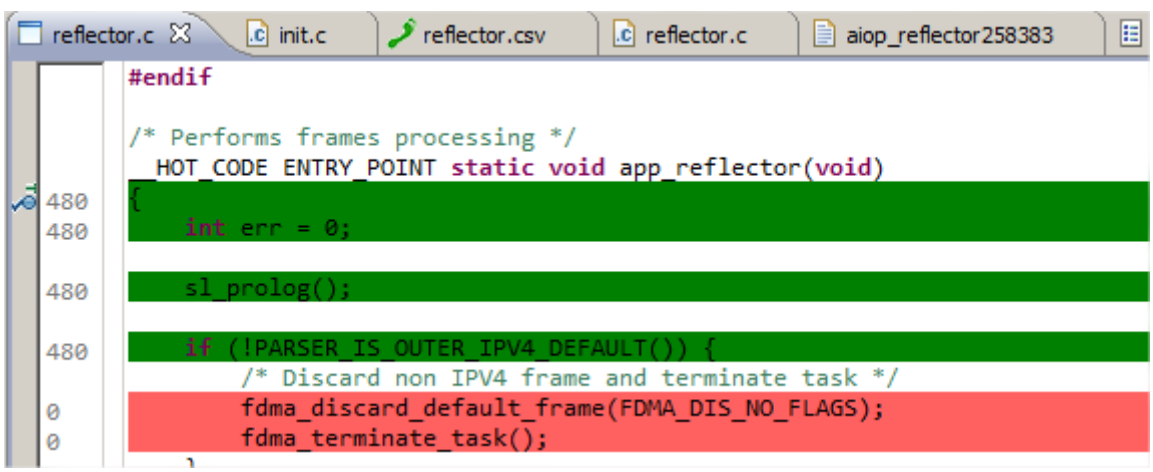


Figure 30. Editor view - reflector.c file

8 Simulator setup

To setup the LS software simulator, you have to:

- Complete the CSAM registration (only for the Freescale internal users)
- Configure and start the simulator

8.1 Configuring and starting simulator

To configure and start the simulator, perform these steps:

1. If you are running the CodeWarrior on a Linux machine, the simulator is available unpacked under `Common/CCSSim` folder, therefore, you may skip to *step 4*.
2. For running CodeWarrior software on a Windows machine, the simulator is available in the CodeWarrior layout at this location: `<CW_Layout>/Common/CCSSim/LS_SIM_RELEASE_0_x_0_xxxx_xxxxxx.tgz`
3. Copy the file to the Linux x86_64 machine and untar it.
4. To enable the **AIOP debug in parallel with the u-boot/Linux** option, follow the steps listed below:
    a. On top of the simulator start-up scripts, there is a package consisting of a set of SDK binary images (U-Boot, Linux kernel) and a start-up script `run-sim.sh`, which loads all the mentioned images and begins execution on the primary GPP core. For details, see *Using ls2-sim-support scripts (run-sim.sh) and CodeWarrior* section of the *Layerscape Simulator User Guide*.
    b. If you have your custom SDK images, copy all of them in the images folder from ls2-sim-support package (see step 1 Debugging AIOP APP using CodeWarrior)
    c. In a console, set the `LS2_SIM_BASE_DIR` variable to the simulator path `<Layout>/Common/CCSSim/`
    d. In the same console, navigate to the `ls2-sim-support` folder and run the command listed below (using this command you can debug only the APP – AIOP side and triggers the U-boot to boot up)

    ```
    ./run-sim.sh -G -i images/aiop_reflector.elf -d images/dpl-reflector.dtb
    ```

    e. If you also need to see the MC firmware and AIOPAPP consoles during booting, you can use this command:

    ```
    ./run-sim.sh -G -m -a-i images/aiop_reflector.elf -d images/dpl-reflector.dtb
    ```

    f. If you need a custom debugging port (a set up in CodeWarrior Connection settings), you can use `-e '-port xxxxx'`. Also, you can change the default tio port (very useful for example when multiple users are using the same Linux machine) as listed below, using the `-p` option:

    ```
    ./run_sim.sh -p 47178 -G -e '-port 41976' -i images/aiop_reflector.elf -d images/
    dpl-reflector.dtb
    ```

    g. For closing the simulator during the booting, press *Ctrl+D* followed by *Ctrl+C*.
    h. For more details about `run-sim.sh` parameters, use the `./run-sim.sh -h` command.

8.2 GCov code coverage

The CodeWarrior for APP also supports the GCov code coverage for the simulator side. To gather the gcov information, you need to execute the steps listed in the GCov code coverage and enable the **Enable Code Coverage** option from the **Trace and Profile** tab.

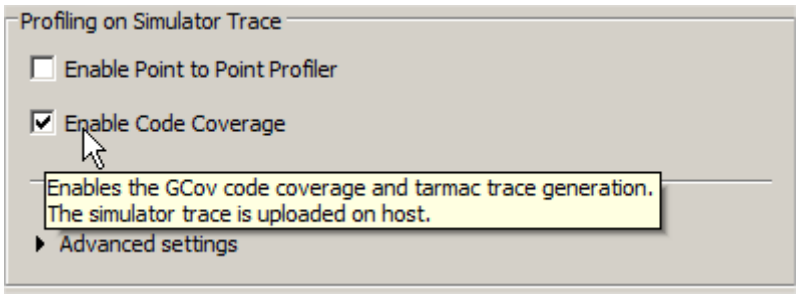


Figure 31. Enable Code Coverage option

8.3 Point to Point Profiler

Point to Point Profiler is a user-friendly and flexible way to gather the statistics and visualize reports in the CodeWarrior IDE for the supported AIOP counters. For more details, see section *6.4 Point to Point Profiler* of the *CodeWarrior Development Studio for Advanced Packet Processing Targeting Manual* (document CWAPPTM).

The Point to Point Profiler markers are employed to gather the statistics for certain regions of the code. These markers are added by the user into the code and are taken into account by the compiler only if the `-perfmarks` flag is set. To enable the flag in a project, select the **Enable user-defined performance markers** option in the **Properties > Settings > Tool Settings > Compiler > Processor** page and re-build the poject.

Also, you need to enable the **Enable Point to Point Profiler** option in the **Trace and Profile** tab for sending the simulator trace back to the CodeWarrior host.

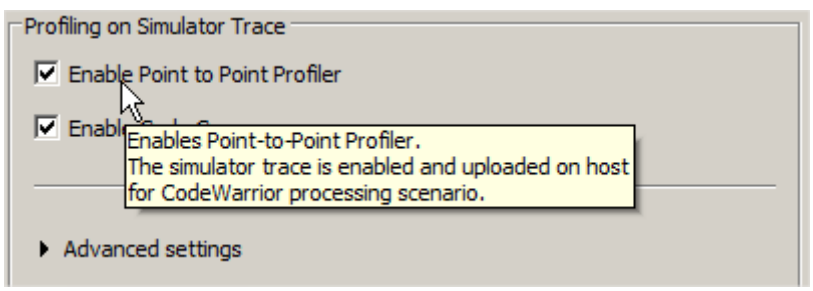


Figure 32. Enable Point to Point Profiler option

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