SDK Application debug on Linux/QEMU Training

This training is broken into two sections; Hardware Debug, and QEMU Debug.

In the Hardware debug, we shall build a Zynq Hardware design in the Vivado 2015.2 IP Integrator, build a Linux image with a TCF Agent running on the board and connect to this from SDK in order to debug a Linux Application.

In the QEMU section, we shall debug an application using both GDB debugger, and Xilinx System Debugger that is remotely connected to a QEMU. We shall test this for both Zynq CortexA9, and MPSoC A53 and R5 processors.

Pre-requisite:

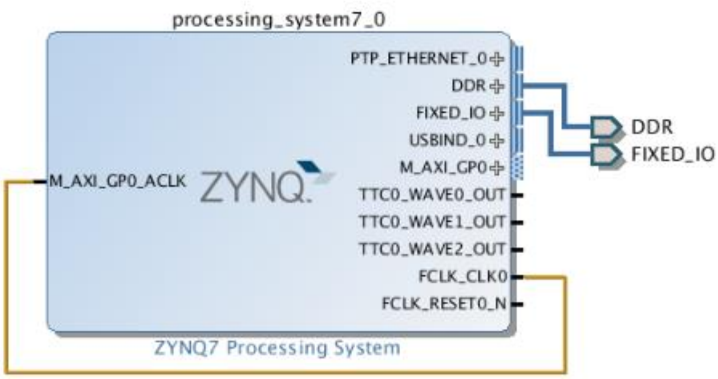
Vivado 2015.2, and Petalinux 2015.2.1 (or 2015.2 installed)

Section 1: Hardware Debug

Step 1: Build the HW:

Here, I am using Vivado 2015.2 to build a very simple Block Design (BD) in Vivado IP Integrator (IPI) targeting the ZC702.

I let the tools run the automation to create the HW project. This will result in the ps (Processing Sub-System) consisting of (amongst others) uart, gem, qspi..



Generate Output Products, Create HDL wrapper, and export to SDK. You can launch SDK and keep it open as we will be coming back to this later.

Step 2: Create Linux Image:

Here, we shall be using the Petalinux tool to create the linux image.

In a new terminal, Navigate to the SDK folder (that was created when we exported to SDK in step 1).

Use the Petalinux Commands below:

- *petalinux-create --type project --template zynq --name demo*
- *petalinux-config --get-hw-description -p demo*

This will pop up the config GUI. User, can explore this. However, for this demo all the defaults will be kept. Select <Exit> to exit.

User can explore the rootfs config to add the tcf-agent and netcat using the command below:

- *cd demo*
- *petalinux-config –c rootfs*
    - *Filesystem Packages -> base -> tcf-agent -> [*] tcf-agent*
    - *Filesystem Packages -> console/network -> [*] netcat*
    - *<Save> and <Exit>*

User can explore the kernel config using the command below:

- *cd demo*
- *petalinux-config –c kernel*

Next, we will need to update the device tree to connect the GEM to the external PHY node. The Devicetree Generator (DTG) will only build the internal system to the chip. However, this is straight forward to achieve.

Open *demo\subsystems\linux\configs\device-tree\system-top.dts* and replace it with the content below:

```
/dts-v1/;
/include/ "system-conf.dtsi"
/ {
};
&gem0 {
  local-mac-address = [00 0a 35 00 c0 12];
  phy-handle = <&phy0>;
  phy-mode = "rgmii-id";
  mdio {
    #address-cells = <1>;
    #size-cells = <0>;
    phy0: phy@7 {
      compatible = "marvell,88e1116r";
      device_type = "ethernet-phy";
      reg = <7>;
    };
  };
};
```

Finally, to build the image. Use the command below (this may take awhile)

- petalinux-build

Tip: to verify that the devicetree DTB was created correctly. Use the command below:

- cd images/linux/
- ../../build/linux/kernel/xlnx-3.19/scripts/dtc/dtc -I dtb -O dts -o system.dts system.dtb
- cd ../..

This will create a system.dts in the images/linux folder. You can investigate he devicetree here.

Next, create the boot image using the command below:

- petalinux-package --boot --fsbl images/linux/zynq_fsbl.elf --fpga ../design_1_wrapper_hw_platform_0/design_1_wrapper.bit --uboot

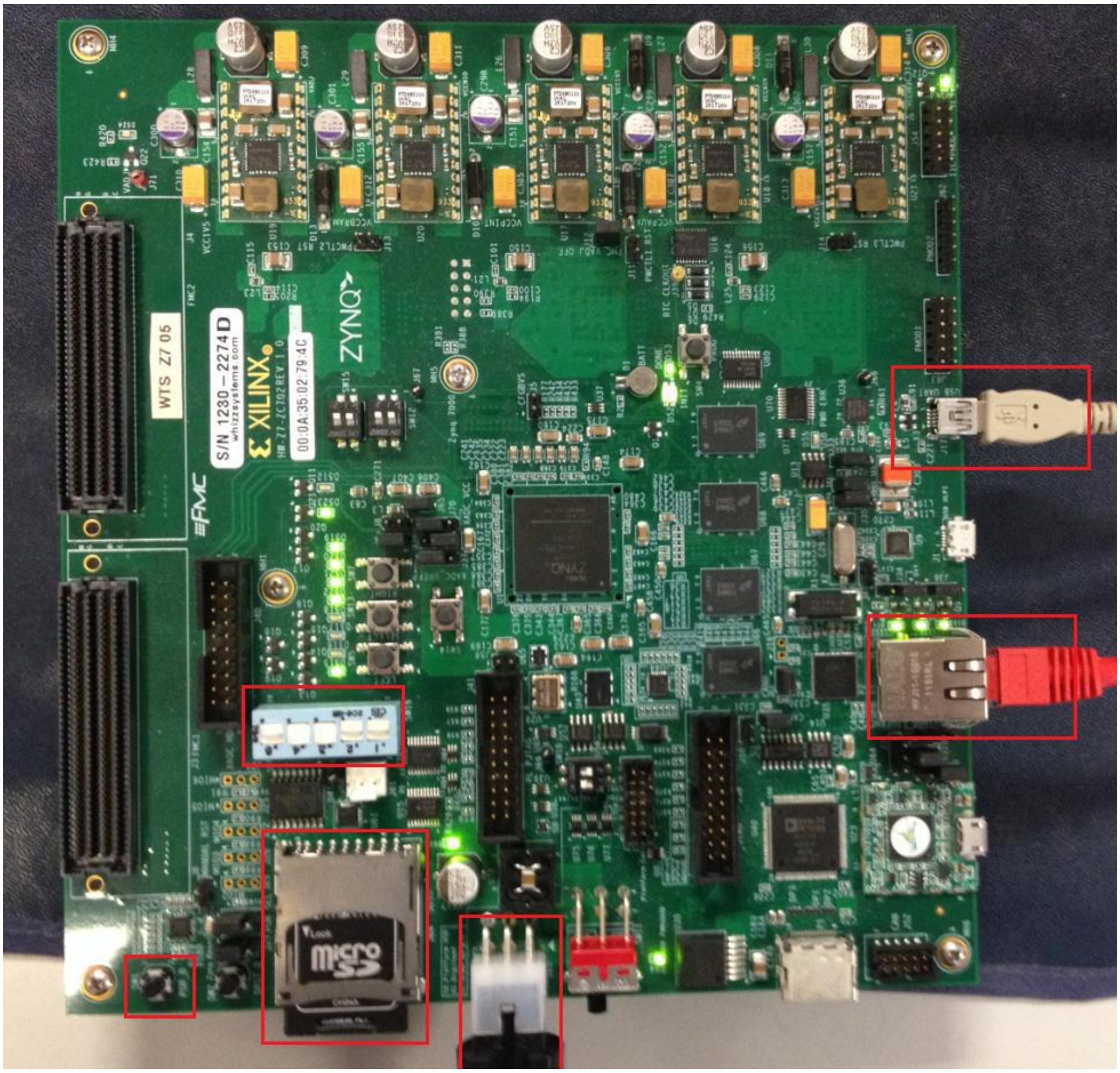
This will create the two files needed for the SD card:

- images/linux/image.ub
- images/linux/BOOT.BIN

Step 3: Test on HW

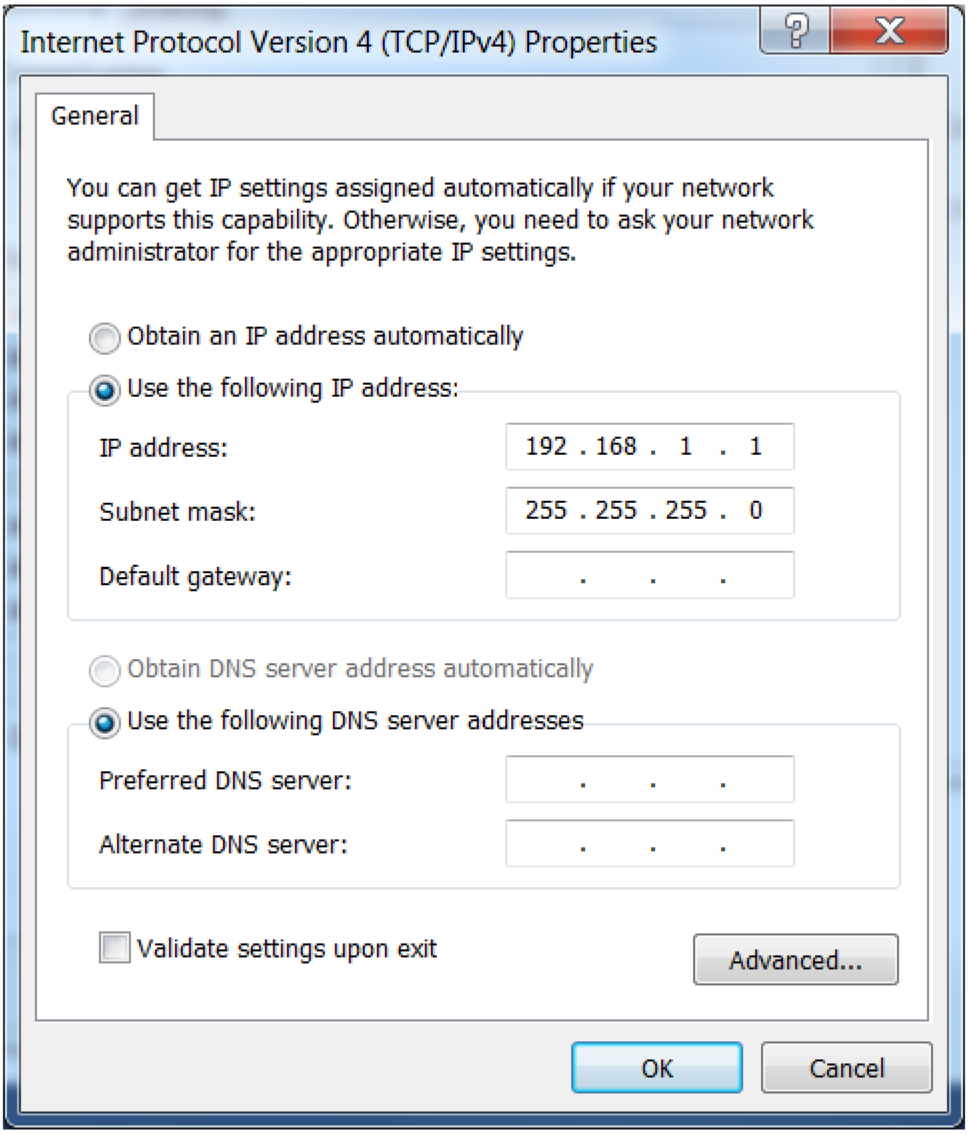
You will need the following:

- ZC702 board with M1:5 boot mode set to 00110
- USB UART (BAUD rate set to 115200)
- PHY cable
- SD Card (with the files created in step 2 on it)

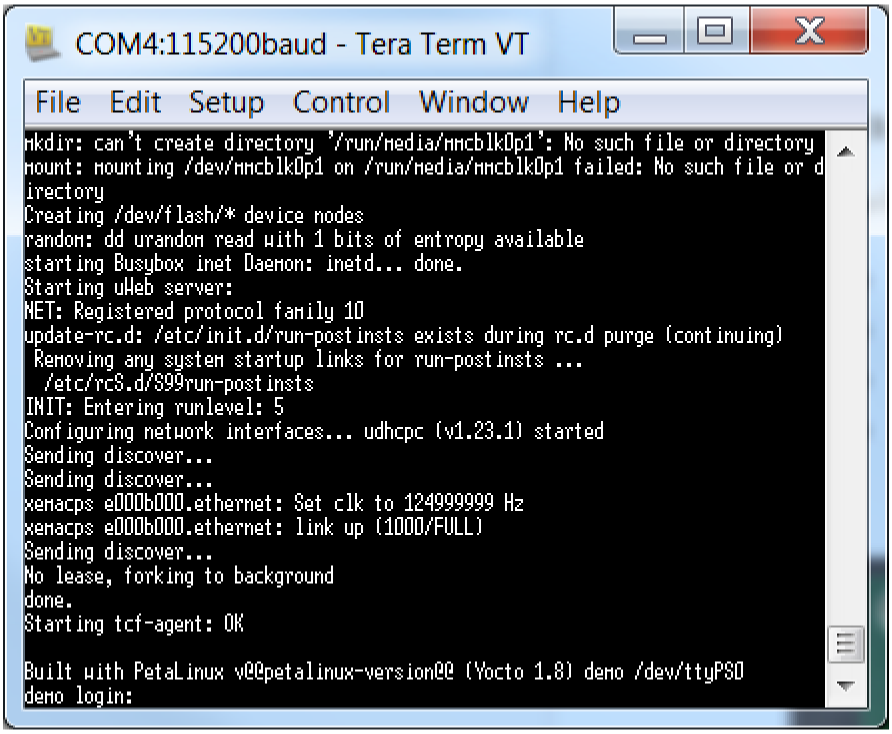


Host Set-up.

Set up your host as follows:



Next, power on the board. You should see the following:



Note: we can see the TCF agent has been started. If you don't see this, then go back and make sure you have enabled it in step 2. Also, the GEM0 (at address 0xe00b000) is setup correctly, if this is not the case then you will need to re-visit your devicetree.

Next, login *root*, and password *root*

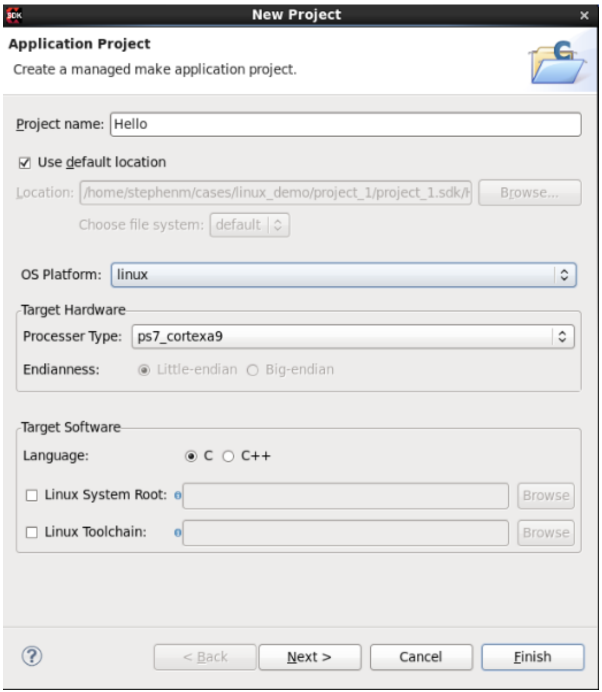
Connect the board to the local host:

- *Ifconfig eth0 192.168.1.10 netmask 255.255.255.0*
- *To test, we can ping the host:*
    - *Ping 192.168.1.1*

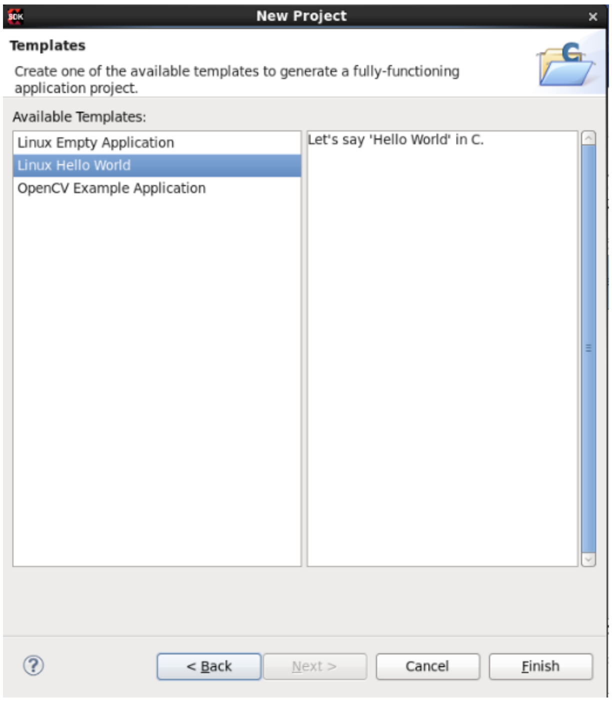
Step 4: Create SDK Hello world application:

Return to SDK, and create a simple Hello World

File -> New -> Application Project:

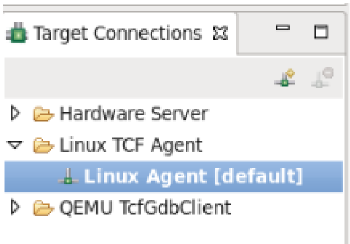


Next:

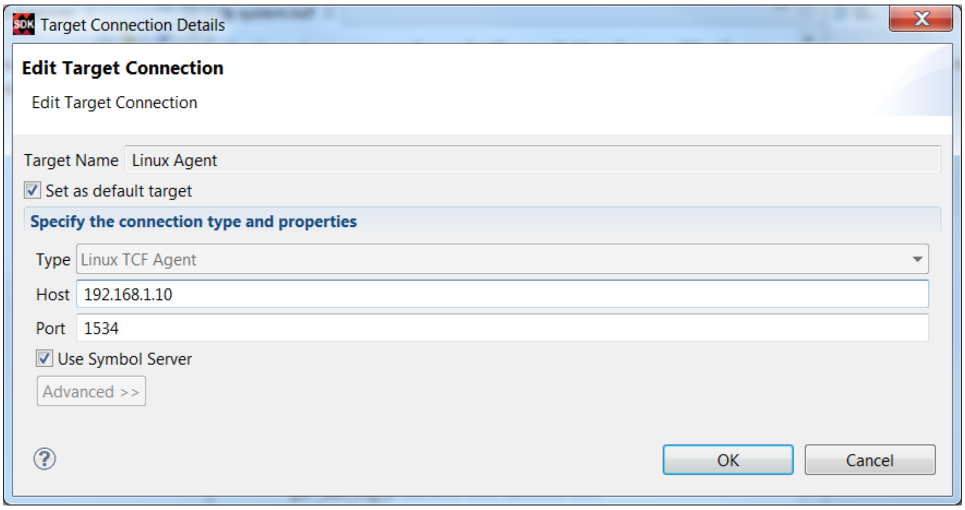


Finish to continue.

Next, we need to make the remote connection to the tcf-agent running on the Linux. To do this, go to the Target Connections and drop down the Linux TCF Agent:



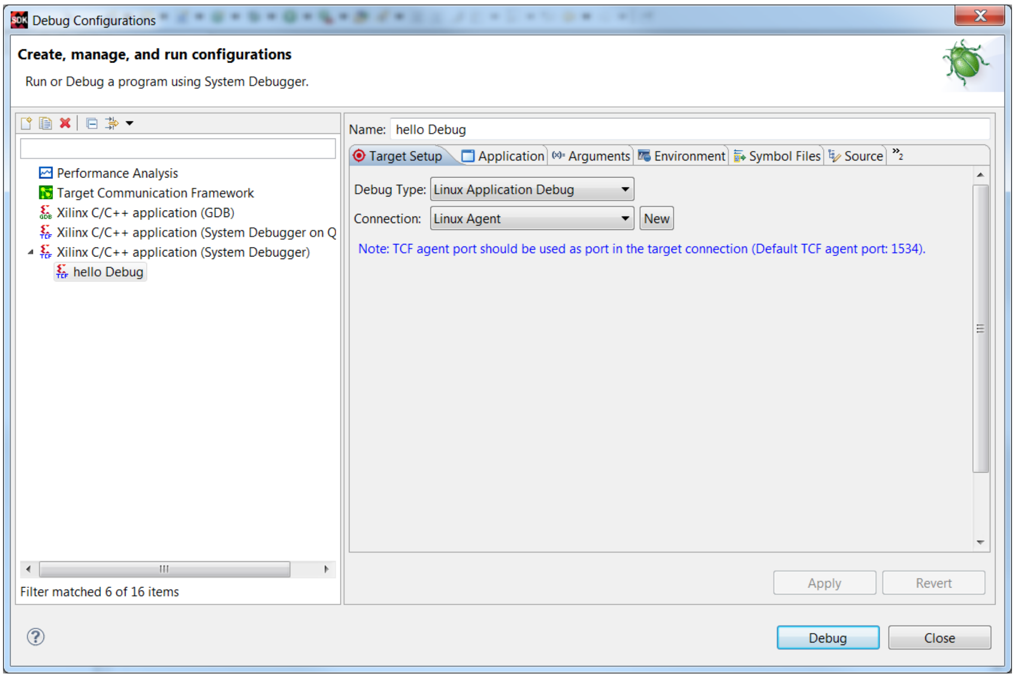
Double click on the Linux Agent. This will pop up the GUI below. Set this as follows:



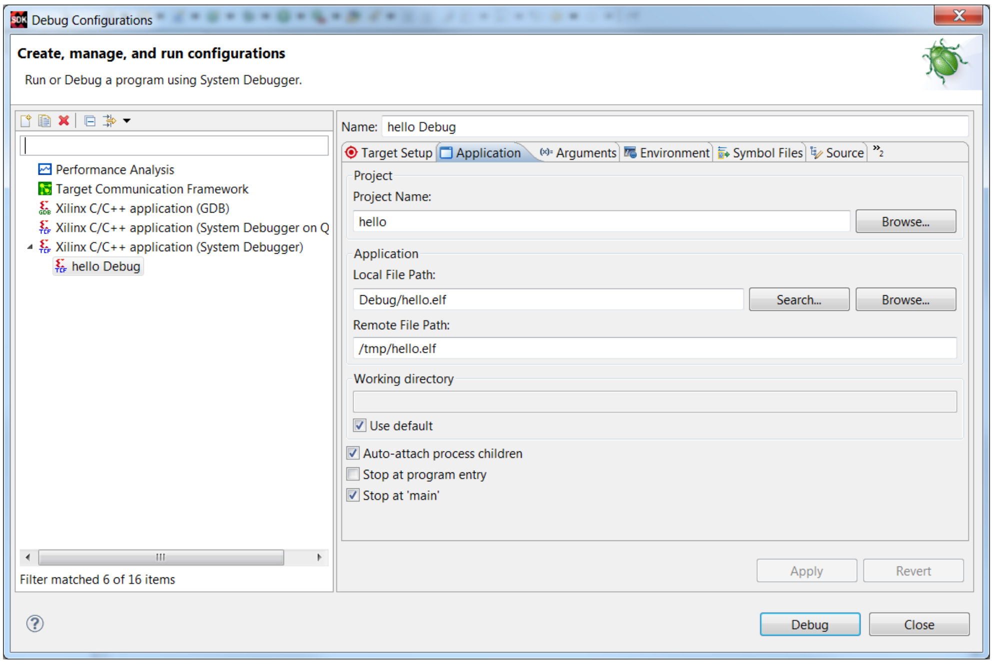
Note: Here, I used the same IP address as the one we specified when setting this up in the Linux.

Also, make sure that the Use Symbol Server option is selected.

Next, right click on the application, and select Debug As -> Debug Configurations. Double Click on the Xilinx C/C++ application (System Debugger). Under the Target Setup tab, For the Debug Type, select Linux Application Debug and the Connection, set this the Linux Agent

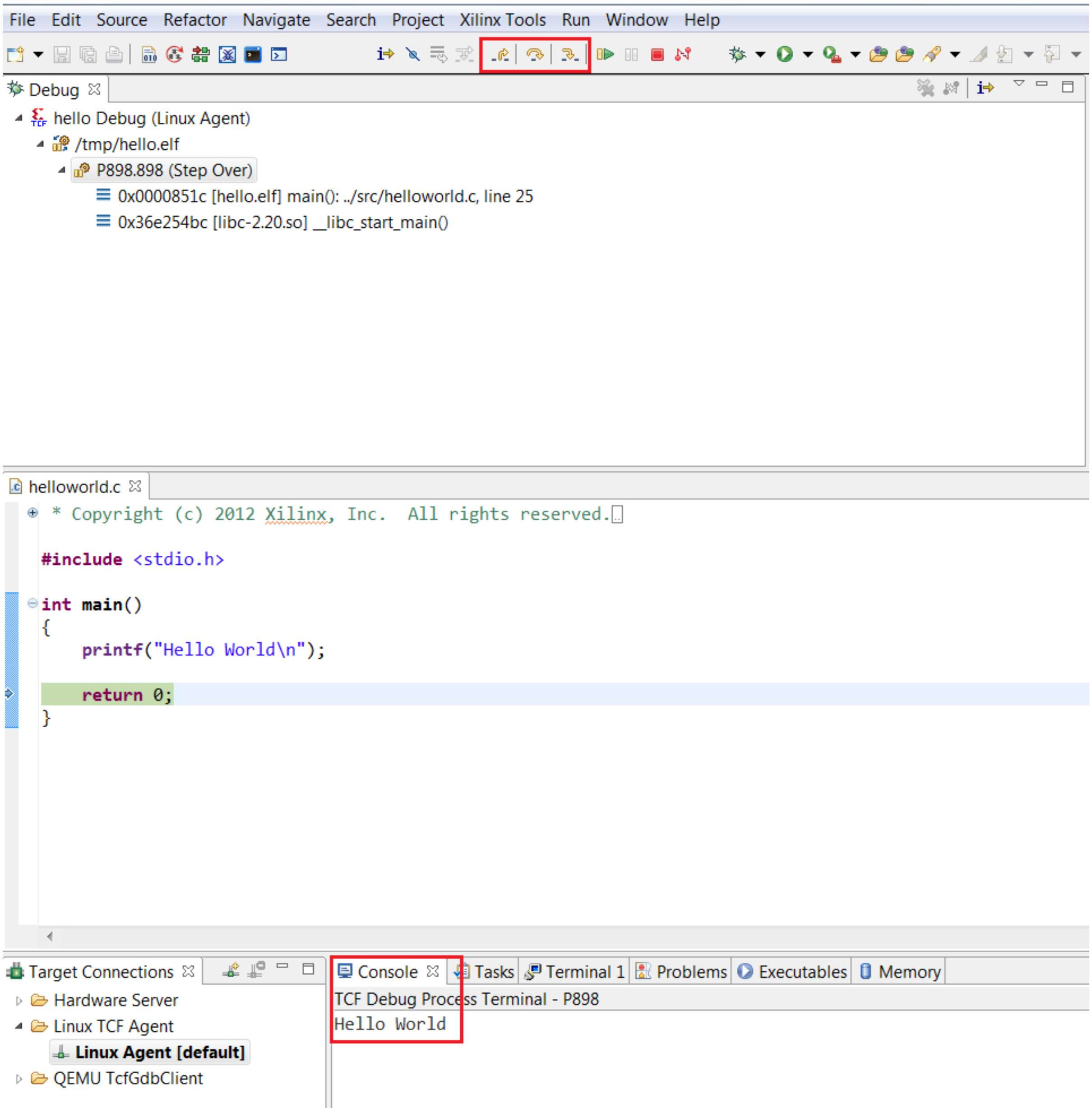


Next, Under the Application tab. Setup as follows:



Select Debug to continue.

This will open the Debug Perspective. Users will be able to step over, into, ect the application code. The STDIO will be shown on the console:



Section 2: QEMU Debug

Using the QEMU to debug A Standalone Zynq Application:

Petalinux comes Pre-packaged with QEMU. We can use this to debug ZC702 standalone application too.

Tip: To get the path to the QEMU use the command below:

- *which qemu-system-aarch64*

/proj/gsd/petalinux/2015.2/tools/linux-i386/petalinux/bin/qemu-system-aarch64 -m 1024 -nographic -M arm-generic-fdt-plnx -dtb $path/images/linux/system.dtb -serial /dev/null -serial mon:stdio -gdb tcp::1137 –S

Note: I want to connect UART1 to the terminal, and ignore UART0. I used the table below for reference:

<arg>	Effects
/dev/null	Disconnect this particular serial.
mon:stdio	Connect this serial to the terminal.
telnet::<port>,server, nowait	Create a localhost telnet server on <port> for the serial connection. It can be accessed by: telnet localhost <port>.
chardev: dev	Connects serial to a backend; for example, to a socket, pipe, or terminal.

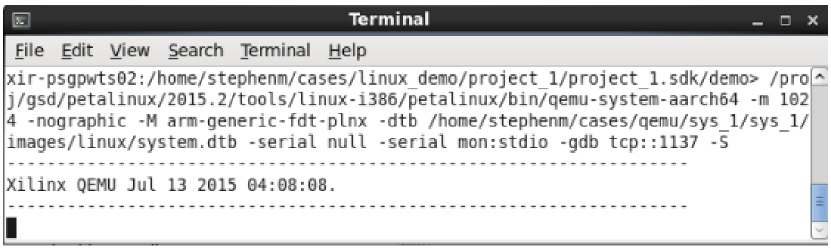
Table 1.0

Here, is a list of the QEMU commands for reference:

Option	Description
-device loader,file=<progam.elf>,cpu=<cpu-id>	Specify the software to run (in ELF format).
-device loader,addr=<cpu-reset-register-addr>,data=<value>,data-len=4	Release CPU from reset.
-boot mode=<boot-mode-id>	Specify the boot mode pins.
-drive file=<image-path>, if=<[sd | mtd | pflash]>, format=raw, index=<index_num>	Specify files for persistent storage media (SD, QSPI or NAND respectively.). <index_num> specifies the respective controller for each media type.
-M arm-generic-fdt -nographic -dtb <hw-dtb>	Standard options. <hw-dtb> is the QEMU machine description.

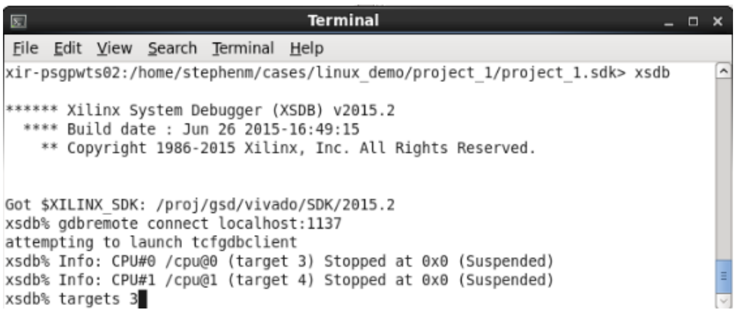
Table 1.1

This will launch a QEMU session as shown below:



Next, open a new terminal and launch XSDB and connect to this session using the command:

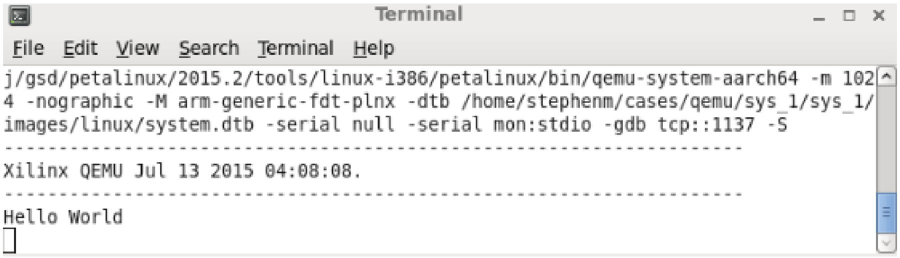
- gbdremote connect localhost:1137



Next connect to the first CPU, using the commands below:

- *targets 3*
- *dow hello_world.elf*
- *con*

You should see the Hello World in the QEMU:



Note: To kill a QEMU use the command below:

Ctrlr + A & x

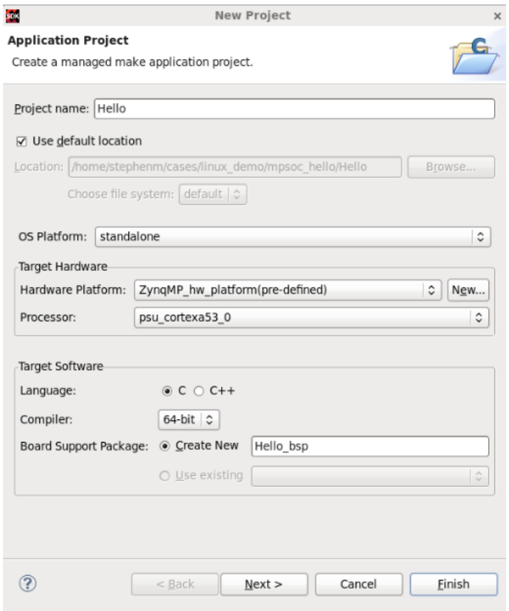
Introducing the MPSoC in QEMU:

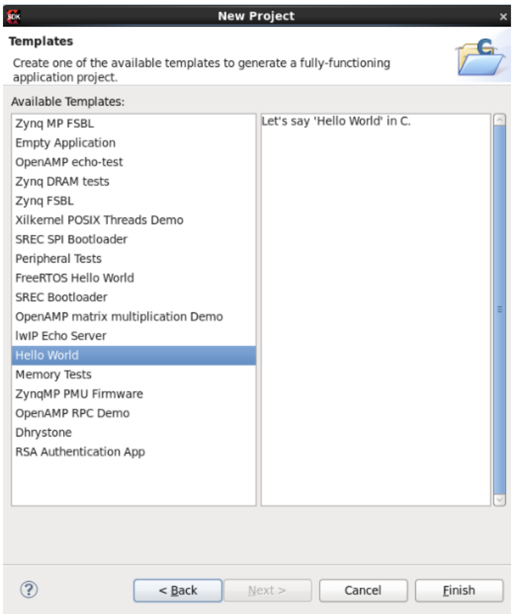
The flow to use MPSoC is pretty similar to Zynq, with added complexity due to the increased processors.

- *petalinux-create -t project -s /proj/petalinux/petalinux-v2015.SW_Beta2_bsps_latest/Xilinx-ZynqMP-QEMU-EAApr2015-v2015.SW_Beta2-final.bsp*
- *source /proj/petalinux/petalinux-v2015.SW_Beta2_daily_latest/petalinux-v2015.SW_Beta2-final/settings.csh*
- *cd Xilinx-ZynqMP-QEMU-EAApr2015*
- *petalinux-build*

Next, launch SDK and create a simple Hello World project targeting the MPSoC.

File -> New -> Application Project. Use the MPSoC pre-defined Hardware platform:





Debugging Hello World A53 App on MPSoC using XSDB CommandLine

We can use the pre-built DTB to debug the Hello world application targeting the first A53 (CPU0). For example, we can run the command below:

/proj/gsd/petalinux/2015.2/tools/linux-i386/petalinux/bin/qemu-system-aarch64 -nographic -M arm-generic-fdt -dtb /home/stephenm/cases/linux_demo/project_1/project_1.sdk/Xilinx-ZynqMP-QEMU-EAApr2015/pre-built/linux/images/xilinx-ronaldo-arm.dtb -device loader,file=/home/stephenm/cases/linux_demo/mpsoc_hello/Hello/Debug/Hello.elf,cpu=0 -device loader,addr=0xfd1a0104,data=0x8000000e,data-len=4 -serial mon:stdio -gdb tcp::1137 –S

I am using the table in UG1169 as reference here to bring the CPU0 out of reset (see *Table 1.1*):

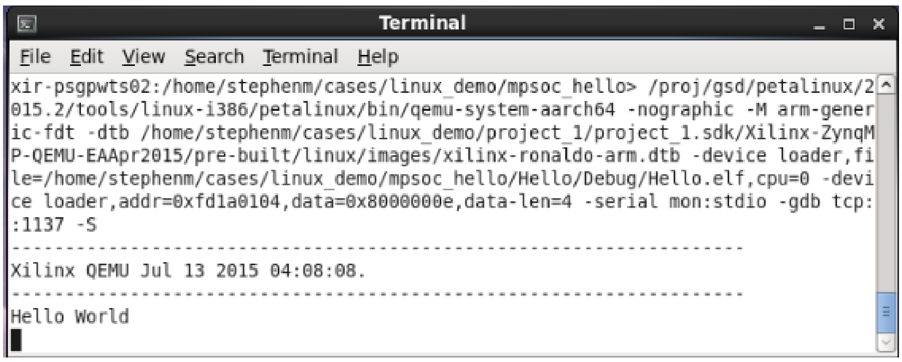
Argument	Command
A53-0	-device loader addr=0xfd1a0104,data=0x8000000e,data-len=4
A53-1	-device loader addr=0xfd1a0104,data=0x8000000d,data-len=4
A53-2	-device loader addr=0xfd1a0104,data=0x8000000b,data-len=4
A53-3	-device loader addr=0xfd1a0104,data=0x80000007,data-len=4
All A53	-device loader addr=0xfd1a0104,data=0x80000000,data-len=4

Table 1.2

Next, open a XSDB in a terminal, and use the commands below:

- *gdbremote connect localhost:1137*
- *targets (this is just to see the whole chain)*
- *targets 3*
- *dow Hello.elf*
- *con*

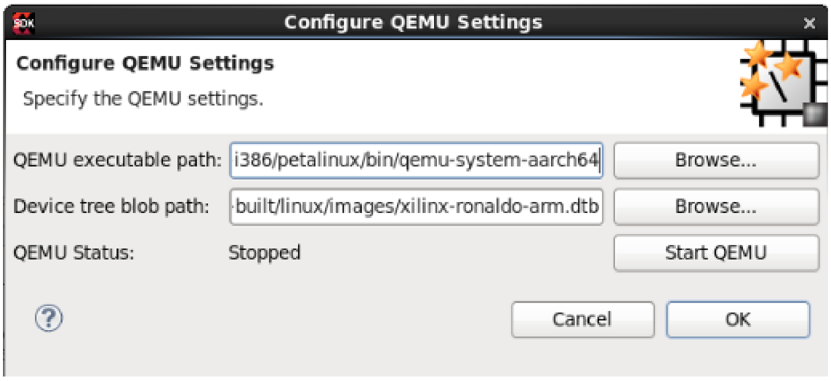
You should see the Hello World on the console:



Debugging Hello World A53 App on MPSoC using SDK GUI

There are two ways to connect to a QEMU session in SDK, users can connect to a QEMU session that is launched from a separate Terminal, or they can connect to a QEMU running from SDK. Here, I will discuss both.

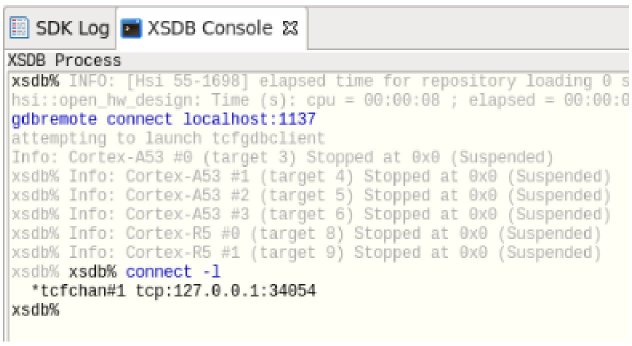
From SDK GUI, users can select Xilinx Tools –> Configure QEMU Settings. In the pop up box place the path to the QEMU executable path (Tip, this can be obtained using the *which qemu-system-aarch64* command), and the Device tree blob path from the pre-built Petalinux Image. Then press Start QEMU to start



You will see the QEMU start on the SDK console. To kill this session, select Stop QEMU in the same QEMU. The QEMU session here has limited configurability, so we shall use the one from the terminal.

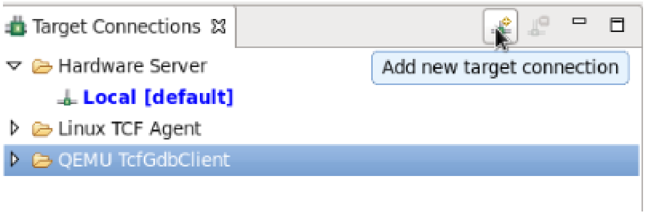
Another flow (and the one used in this demo), is to connect to a QEMU session launched from a console. For example, we can use the same session that we ran from the previous page. We can then connect to this remotely using the XSDB (Xilinx Tools -> XSDB Console) commands below:

- *gdbremote connect localhost:1137*
- *connect –l*
  - *connect –l is to get the connection info.*

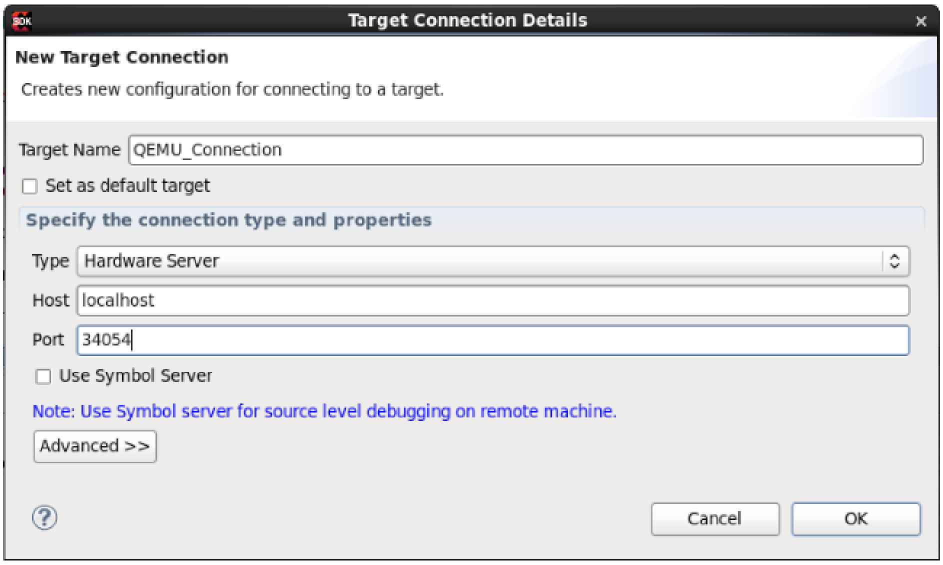


Next, Set up the Target Configuration. In the bottom left in the SDK, dropdown the Hardware Server,

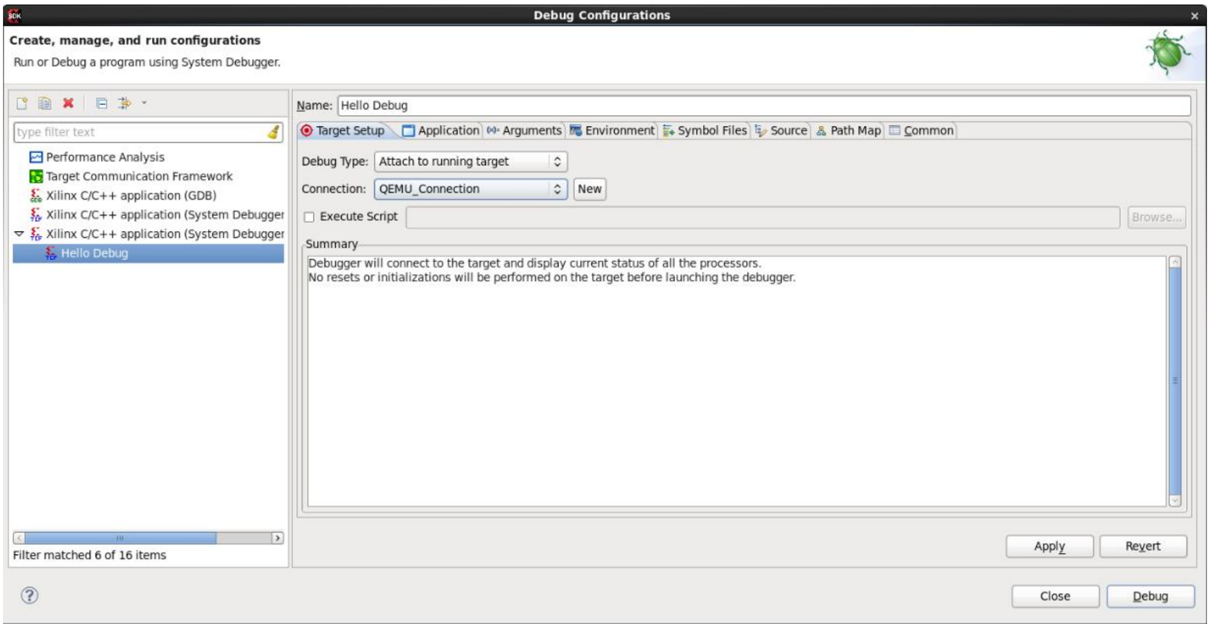
And select Add new target connection:



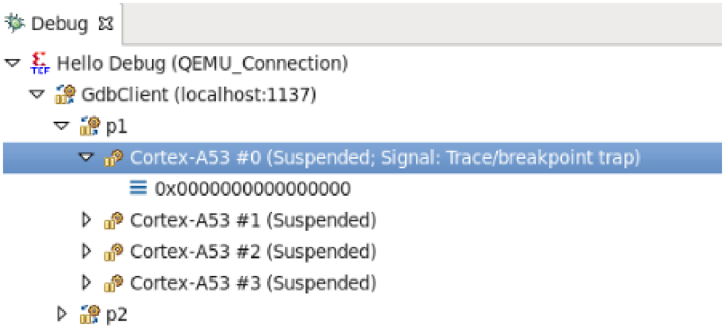
In the GUI, enter the Target Name, Host and the Port. The Host and Port is obtained from the connect –l ran in the XSDB in the previous page. For example, here this is:



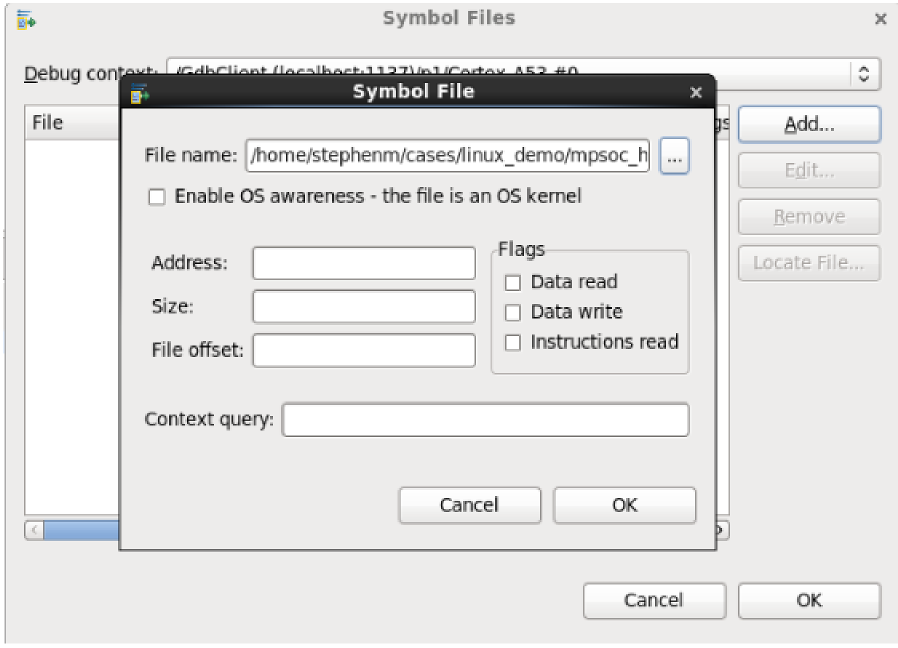
Next, setup the Debug Configurations (Run -> Debug Configurations). Double click on the Xilinx C/C++ application (System Debugger) to create a new Debug Configuration. Under the Target Setup , set the Debug Type as Attach to running target. Set the Connect as the new connection that we set up on the previous page. Apply, and Debug:



Select Yes to open the Debug Perspective. Next, right click on the Cortex-A53 #0:

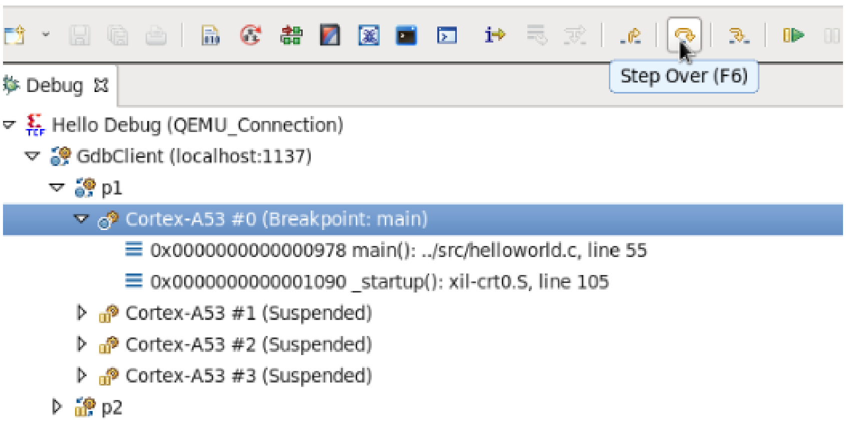


Select, Symbol Files and Select Add and add the ELF file and OK to continue:



Select Resume to jump to the breakpoint at the main (there is a breakpoint by default at main):

User can then, single step, step over ect:



Note: In the QEMU session that we are connecting to has the *-serial mon:stdio* option, so we expect to see the Hello World on the QEMU console:

```
xir-psgpwts02:/home/stephenm/cases/linux_demo/mpsoc_hello> /proj/gsd/petalinux/2
015.2/tools/linux-i386/petalinux/bin/qemu-system-aarch64 -nographic -M arm-gener
ic-fdt -dtb /home/stephenm/cases/linux_demo/project_1/project_1.sdk/Xilinx-ZynqM
P-QEMU-EAApr2015/pre-built/linux/images/xilinx-ronaldo-arm.dtb -device loader,fi
le=/home/stephenm/cases/linux_demo/mpsoc_hello/Hello/Debug/Hello.elf,cpu=0 -devi
ce loader,addr=0xfd1a0104,data=0x8000000e,data-len=4 -serial mon:stdio -gdb tcp:
:1137 -S
-------------------------------------------------------------------
Xilinx QEMU Jul 13 2015 04:08:08.
-------------------------------------------------------------------
Hello World
```

Note: To kill a QEMU use the command below:

Ctrlr + A & x

Debugging Hello World A53 App on MPSoC using GDB

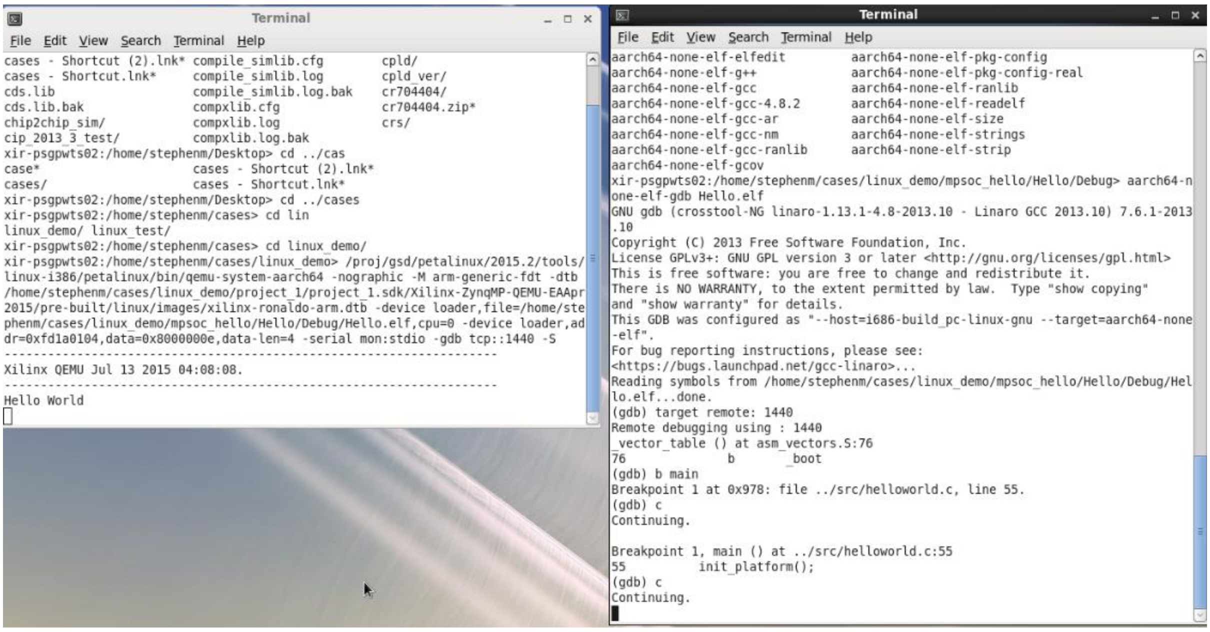
Here, we can use the GDB debugger to debug a Hello World application on the first A53 processor. We can use the same command as above:

/proj/gsd/petalinux/2015.2/tools/linux-i386/petalinux/bin/qemu-system-aarch64 -nographic -M arm-generic-fdt -dtb /home/stephenm/cases/linux_demo/project_1/project_1.sdk/Xilinx-ZynqMP-QEMU-EAApr2015/pre-built/linux/images/xilinx-ronaldo-arm.dtb -device loader,file=/home/stephenm/cases/linux_demo/mpsoc_hello/Hello/Debug/Hello.elf,cpu=0 -device loader,addr=0xfd1a0104,data=0x8000000e,data-len=4 -serial mon:stdio -gdb tcp::1440 –S

Then in a separate terminal, launch the GDB:

- aarch64-none-elf-gdb Hello.elf
    - *For Linux, this is aarch64-linux-gnu-gdb*
- target remote: 1440
- b main (to set a breakpoint at main)
- c to continue

For, example. Here, I ran c (to continue to breakpoint), and then ran c again. Here, I see Hello World on the QEMU console:



Note: To kill a QEMU use the command below:

Ctrlr + A & x

Debugging Hello World R5 App on MPSoC using System Debugger

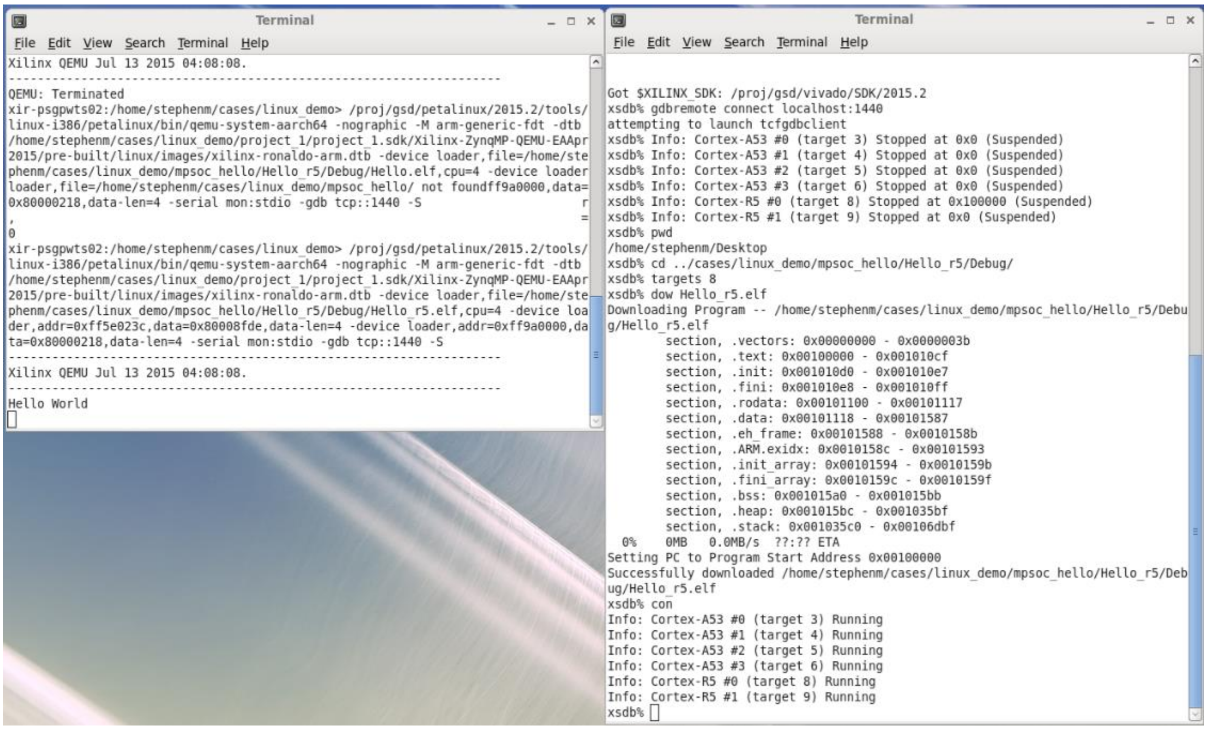
Here, we can debug the first R5 using the System Debugger (XSDB). First, we need to configure the QEMU:

/proj/gsd/petalinux/2015.2/tools/linux-i386/petalinux/bin/qemu-system-aarch64 -nographic -M arm-generic-fdt -dtb /home/stephenm/cases/linux_demo/project_1/project_1.sdk/Xilinx-ZynqMP-QEMU-EAApr2015/pre-built/linux/images/xilinx-ronaldo-arm.dtb -device loader,file=/home/stephenm/cases/linux_demo/mpsoc_hello/Hello_r5/Debug/Hello_r5.elf,cpu=4 -device loader,addr=0xff5e023c,data=0x80008fde,data-len=4 -device loader,addr=0xff9a0000,data=0x80000218,data-len=4 -serial mon:stdio -gdb tcp::1440 -S

Here, I am bring the first R5 (CPU4) out of reset. I am connecting UART0 to the terminal.

I then launch XSDB, and used the commands below:

- *gdbremote connect localhost:1440*
- *targets (this is just to see the whole chain)*
- *targets 8*
- *dow Hello_r5.elf*
- *con*



Note: To kill a QEMU use the command below:

Ctrlr + A & x