FPGA setup for TOE100G-IP on Silicom NIC

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1   Overview

This document describes how to setup Silicom fb2CGhh@KU15P NIC that is plugged-in to the host system and how to prepare the test environment for running TOE100G-IP with DMA feature demo on the Silicom NIC. PacketMover FPGA Acceleration platform by Silicom is used as a based design of this demo. TOE100G-IP by Design Gateway is implemented in the user logic area of this platform. With our TOE100G-IP integration on the platform, it allows the standard NIC feature and also the high-speed TCP/IP on 100Gb connection through our IP.
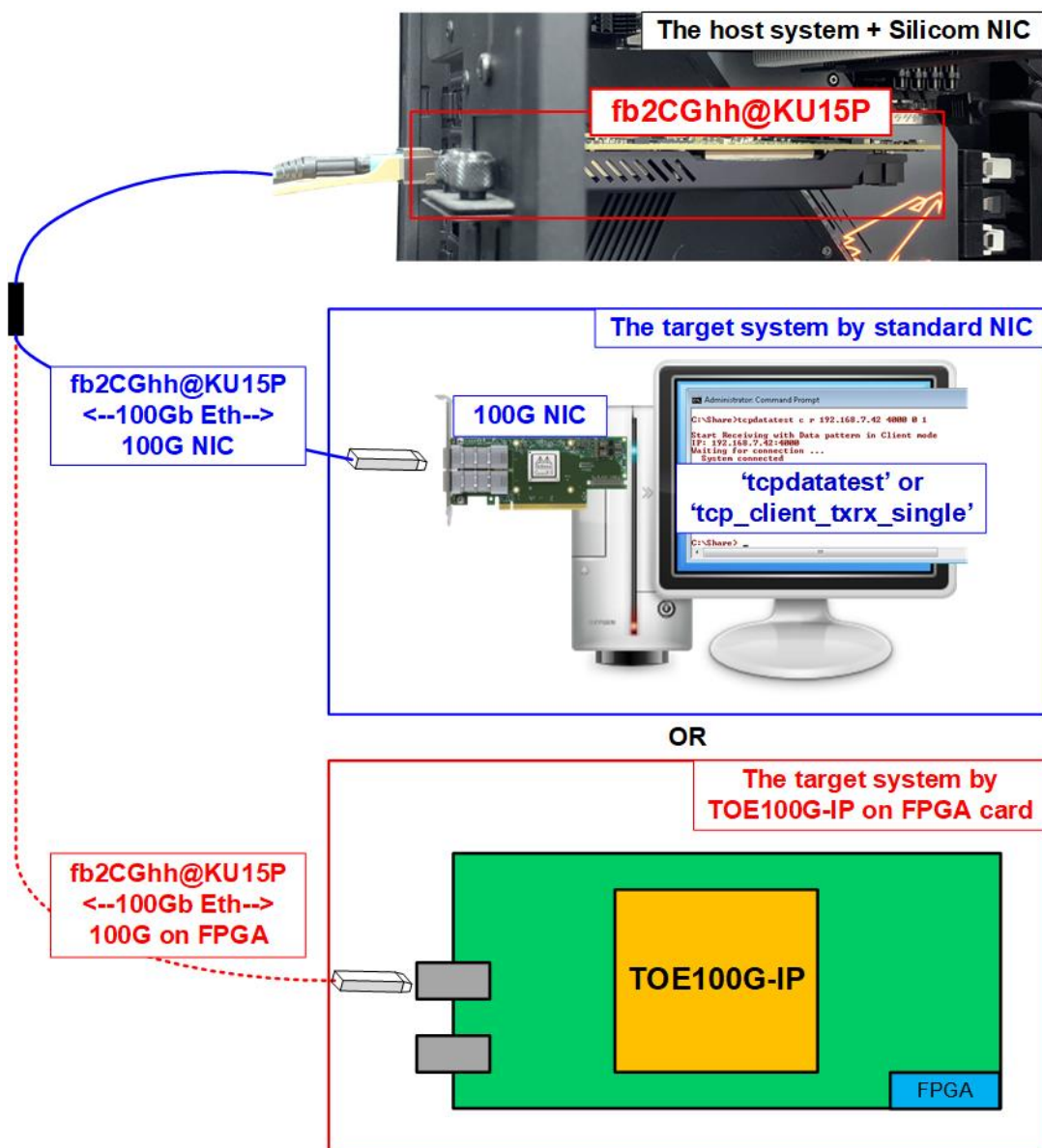

Figure 1-1 Two test environments for running the demo

Figure 1-1 shows the test environment to transfer the data on 100G Ethernet of this demo system. The first side of 100G Ethernet is the host system with Silicom NIC that includes TOE100G-IP. While another side of 100G Ethernet is the target system which may be Test PC with standard NIC or TOE100G-IP on the FPGA platform. When the target system uses the standard NIC, the test performance is not good and less than peak bandwidth of 100G Ethernet connection. While using TOE100G-IP on FPGA card to be the target system, the test performance can show the peak performance of 100G Ethernet connection.

For the first test environment, the example software applications to run on the target system that uses standard NIC are also provided by Design Gateway on both Windows OS and Ubuntu OS, i.e., "tcpdatatest" for half-duplex test and "tcp_client_txrx_single" for full-duplex test. For the second test environment, there are many reference designs of TOE100G-IP that are run on many FPGA cards provided on our website. Please see more details from following links.

TOE100G-IP Standard demo on Xilinx standalone board
https://dgway.com/products/IP/TOE100G-IP/dg_toe100gip_cpu_refdesign_xilinx.pdf

TOE100G-IP Multi-session demo on Xilinx board
https://dgway.com/products/IP/TOE100G-IP/dg_toe100gip_cpu_4ss_refdesign_xilinx.pdf

In the document, topic 2 shows the procedure to setup the system with Silicom NIC plugged in and to run the demo on the card. Topic 3 shows the hardware setup on the target system by using the 100G standard NIC. Finally, topic 4 shows the hardware setup on the target system by using TOE100G-IP demo on FPGA card. More details of each topic are described as follows.

2   Silicom NIC with TOE100G-IP setup

Before getting started, please prepare the release stuff of "Silicom PacketMover platform" version 1.4.0. More details about the platform can be checked from Silicom website by the following link. https://www.silicom.dk/product-details/packetmover-fpga-acceleration/

Follow the instruction that is described in "readme.txt" in the Silicom release stuff to build the driver, install the driver, and verify the standard NIC function of the Silicom card.

Note: After finishing Silicom card system preparation, please confirm that the logical name of two Ethernet connections on Silicom NIC are "feth0" and "feth1", as described in topic "Driver Load and Verification" in "readme.txt". The demo software uses this logical name for running the test.

Design Gateway provides an archive file which is needed for running the demo. Extract the file and move "download" folder to directory path, "*/1_4_0/sw/PacketMover_SW_1_4_0/*". In "download" directory, it consists of two files – "multcp_dma_silicom_exe" (test application of TOE100G-IP demo on Silicom NIC) and "tivoli_wolfsburg_2x100g_dgTOEIP.bit" (FPGA configuration file for downloading to Silicom NIC).

The system with Silicom NIC consists of two hardwares, as shown in Figure 2-1.
- Silicom card: fb2CGhh@KU15P card
- Host system by PC that installs Ubuntu 20.04 LTS Server OS (Kernel version: 5.4.0)
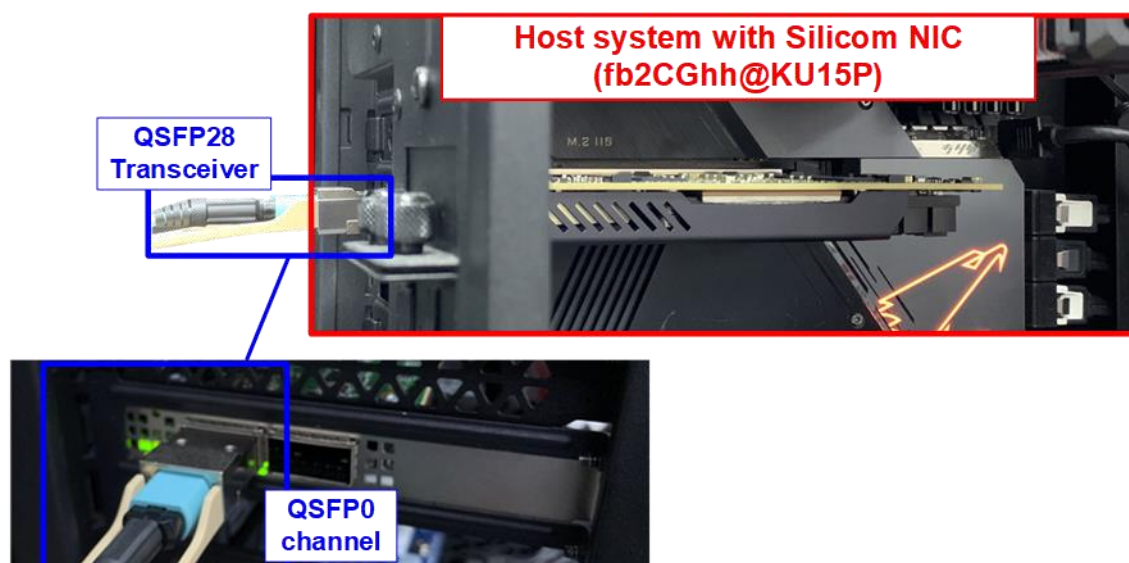

Figure 2-1 Silicom fb2CGhh@KU15P installation to the host

The steps to download configuration file to Silicom NIC are described as follows.
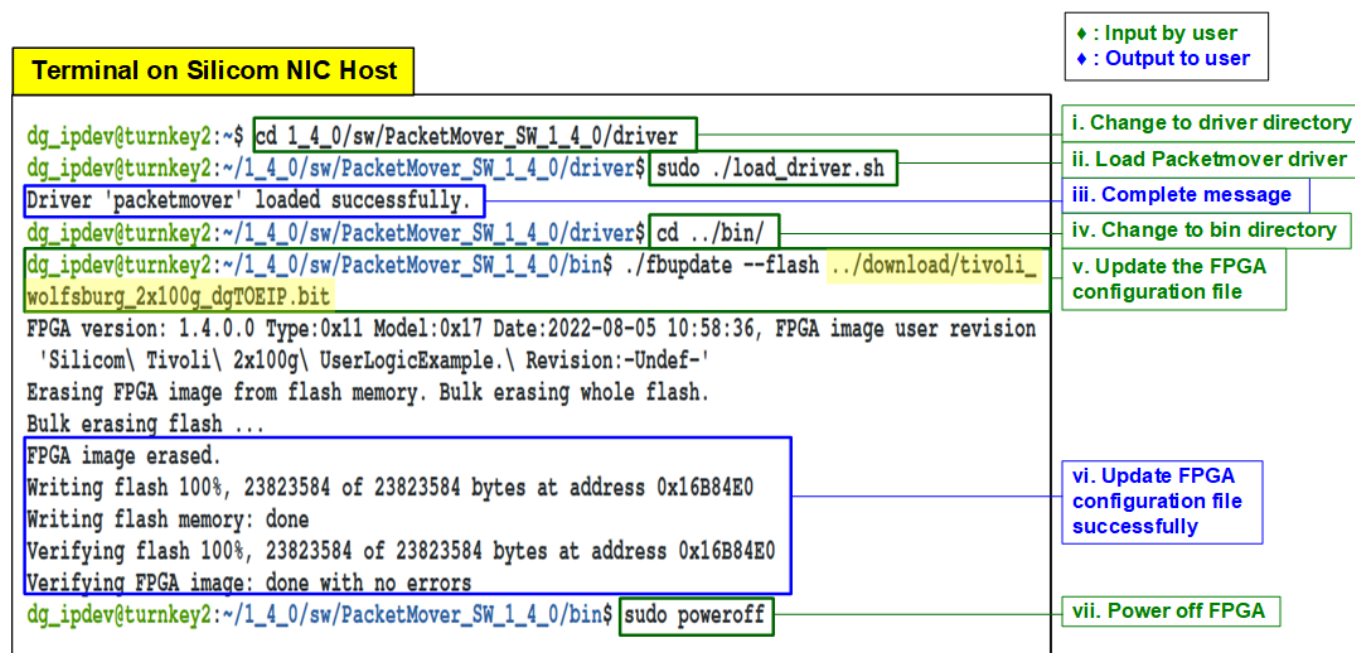

Figure 2-2 Program the bit file to FPGA

1) Plug-in fb2CGhh@KU15P card to the host system and power on. After that, program configuration file of the demo to the Silicom card by using following step. This step is run once and can be skipped for the next run time.

    i.   Change current directory to Silicom driver directory. The example extracts the stuff to home directory. Therefore, use following command to change directory.
            >> cd 1_4_0/sw/PacketMover_SW_1_4_0/driver

    ii.   Load Silicom PacketMover driver by using the Silicom script file.
            >> sudo ./load_driver.sh

    iii.   After loading the driver successfully, the complete message is displayed.

    iv.   Change the driver directory to the bin directory by the following command.
            >> cd ../bin

    v.   Use "fbupdate" tool to update FPGA configuration file that is stored in "1_4_0/sw/PacketMover_SW_1_4_0/download/" directory.
            >> ./fbupdate --flash ../download/tivoli_wolfsburg_2x100g_dgTOEIP.bit

    vi.   Wait until the configuration fie is updated successfully. Confirm that there is no error message displayed.

    vii.   Power off the system by using the following command.
            >> sudo poweroff

After finishing this step, the configuration file is updated. Therefore, the updated configuration file will be loaded to FPGA when the system is powered-on next time.

2) Insert QSFP28 Transceiver of 100G Ethernet cable to QSFP0 connector on fb2CGhh card.
   Note: QSFP#0 is the Ethernet channel that supports standard NIC feature and two high-speed TCP sessions by TOE100G-IP. While QSFP#1 is the Ethernet channel that supports only standard NIC feature.
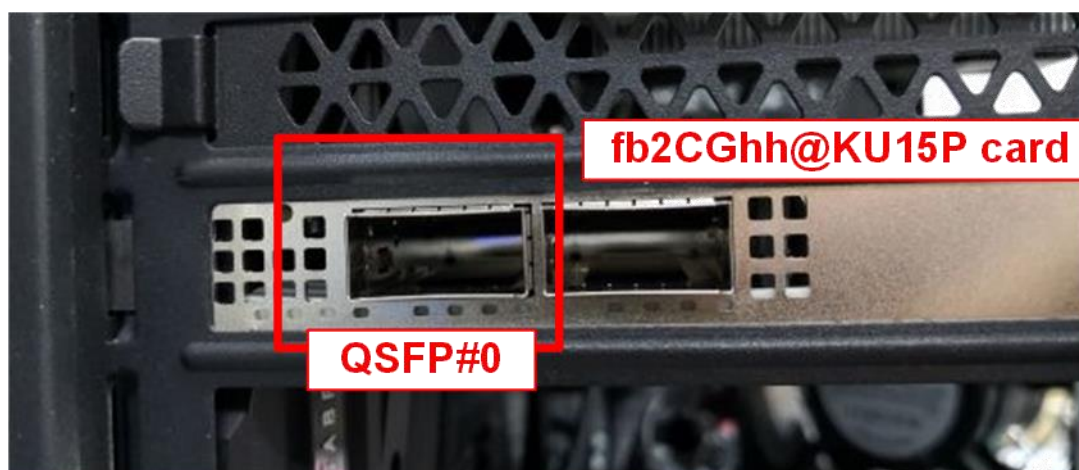

Figure 2-3 100G Ethernet connection on Silicom fb2CGhh card

3) Insert another side of 100G Ethernet cable to the target system. After that, Ethernet hardware connection is ready for use.
4) Power on the host system and then prepare the environment of Silicom NIC with TOE100G-IP by following step.

   i. Change current directory to Silicom driver directory by using the following command.
      >> cd 1_4_0/sw/PacketMover_SW_1_4_0/driver
   ii. Load Silicom PacketMover driver using the Silicom script file.
      >> sudo ./load_driver.sh
   iii. After loading the driver successfully, the completed message is displayed.
   iv. Display all network interfaces including Silicom NIC interfaces by using the following command.
      >> ifconfig -a
   v. Check the Silicom network interfaces status. Two interfaces - "feth0" and "feth1" are found and the status is disabled.
   vi. Set the IP address to Silicom network interface#0 ("feth0") and enable it by using the following command (IP address = "192.168.100.42" and a network mask = "255.255.255.0").
      >> sudo ifconfig 192.168.100.42/24
   vii. After that, use "ifconfig" to check the network interfaces.
      >> ifconfig
   viii. Verify that Silicom network interface#0 status ("feth0") is "UP" and "RUNNING". Also, its IP address must be matched with the set value in step vi.
   ix. Allow ARP table to be updated by Silicom network interface#0 ("feth0") by using the following command.
      >> sudo sysctl -w net.ipv4.conf.feth0.arp_accept=1
   x. Verify that the enable flag is updated to 1.
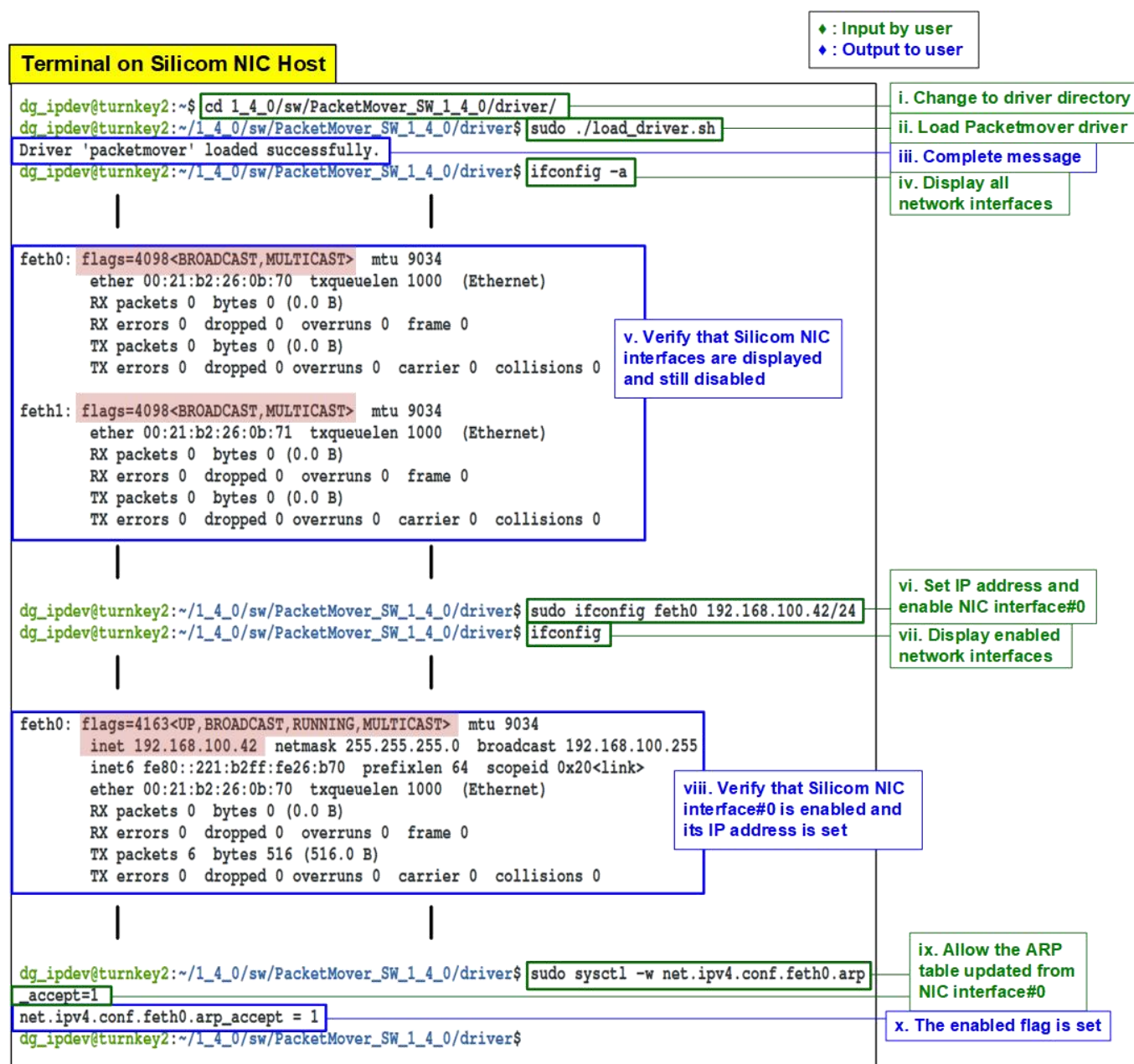
Terminal on Silicom NIC Host

♦ : Input by user
♦ : Output to user

```
dg_ipdev@turnkey2:~$ cd 1_4_0/sw/PacketMover_SW_1_4_0/driver/
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/driver$ sudo ./load_driver.sh
Driver 'packetmover' loaded successfully.
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/driver$ ifconfig -a
```

i. Change to driver directory
ii. Load Packetmover driver
iii. Complete message
iv. Display all network interfaces

```
feth0: flags=4098<BROADCAST,MULTICAST>  mtu 9034
        ether 00:21:b2:26:0b:70  txqueuelen 1000  (Ethernet)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

feth1: flags=4098<BROADCAST,MULTICAST>  mtu 9034
        ether 00:21:b2:26:0b:71  txqueuelen 1000  (Ethernet)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

v. Verify that Silicom NIC interfaces are displayed and still disabled

```
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/driver$ sudo ifconfig feth0 192.168.100.42/24
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/driver$ ifconfig
```

vi. Set IP address and enable NIC interface#0
vii. Display enabled network interfaces

```
feth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 9034
        inet 192.168.100.42  netmask 255.255.255.0  broadcast 192.168.100.255
        inet6 fe80::221:b2ff:fe26:b70  prefixlen 64  scopeid 0x20<link>
        ether 00:21:b2:26:0b:70  txqueuelen 1000  (Ethernet)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 6  bytes 516 (516.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

viii. Verify that Silicom NIC interface#0 is enabled and its IP address is set

```
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/driver$ sudo sysctl -w net.ipv4.conf.feth0.arp
_accept=1
net.ipv4.conf.feth0.arp_accept = 1
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/driver$
```

ix. Allow the ARP table updated from NIC interface#0
x. The enabled flag is set

Figure 2-4 Prepare Silicom NIC with TOE100G-IP environment

5) Run the demo application "multcp_dma_silicom_exe" on the Silicom NIC Host, as shown in Figure 2-5.

   i. Change the current directory from the driver directory to download directory that stores the demo application.
>> cd ../download/

   ii. Run the demo application as a root by using following command.
>> sudo ./multcp_dma_silicom_exe

   iii. The welcome message and the default parameters of the demo application is displayed after the application is run.

Note: "multcp_dma_silicom_exe" is pre-built application that is stored in the "download" directory, provided by Design Gateway.
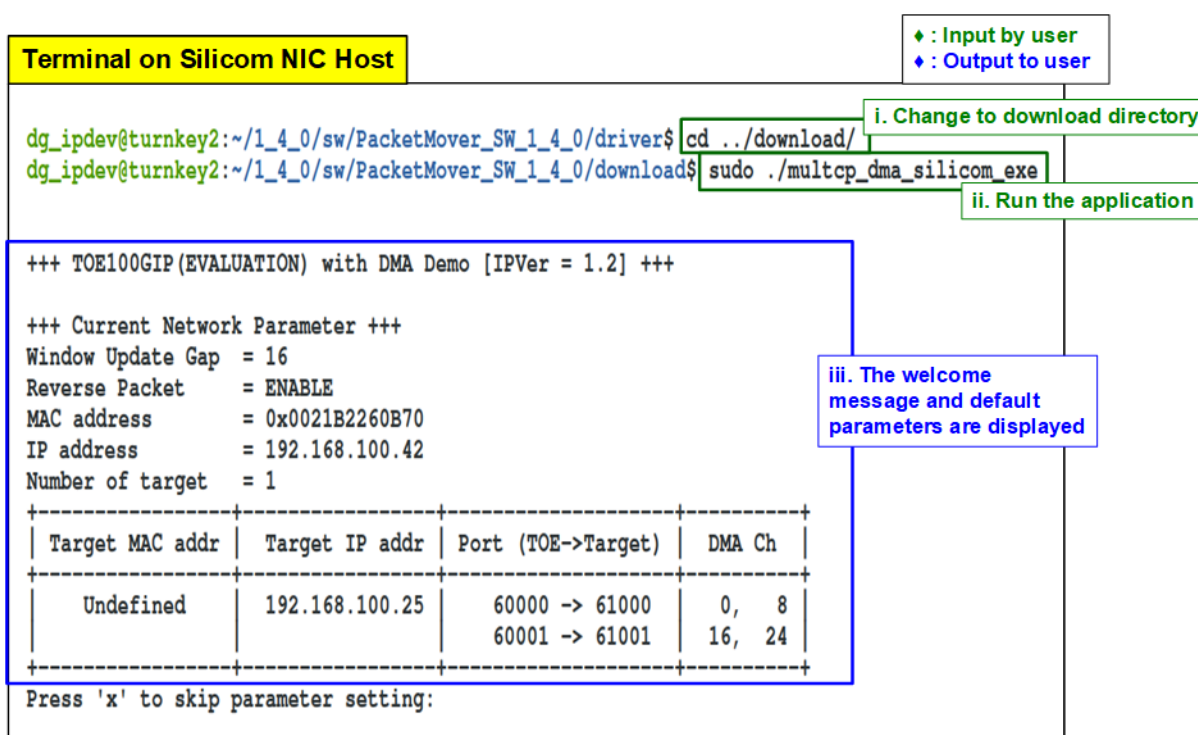
```
Terminal on Silicom NIC Host                    ♦ : Input by user
                                                ♦ : Output to user

                                                    i. Change to download directory
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/driver$ cd ../download/
dg_ipdev@turnkey2:~/1_4_0/sw/PacketMover_SW_1_4_0/download$ sudo ./multcp_dma_silicom_exe
                                                    ii. Run the application

+++ TOE100GIP(EVALUATION) with DMA Demo [IPVer = 1.2] +++

+++ Current Network Parameter +++
Window Update Gap  = 16
Reverse Packet     = ENABLE             iii. The welcome
MAC address        = 0x0021B2260B70     message and default
IP address         = 192.168.100.42     parameters are displayed
Number of target   = 1
+------------------+------------------+----------------------+-----------+
| Target MAC addr  | Target IP addr   | Port (TOE->Target)   | DMA Ch    |
+------------------+------------------+----------------------+-----------+
|    Undefined     | 192.168.100.25   |    60000 -> 61000    |  0,    8  |
|                  |                  |    60001 -> 61001    | 16,   24  |
+------------------+------------------+----------------------+-----------+
Press 'x' to skip parameter setting:
```

Figure 2-5 Run the demo application on Silicom NIC Host

6) Wait until the target system completes to prepare the 100G Ethernet connection. After that, enter 'x' to skip parameter setting for using default parameters to begin TOE100G-IP initialization, as shown in Figure 2-6. If the other keys are entered, the menu for changing parameter is displayed, similar to "Reset TCPIP parameters" menu which is described in the demo instruction document.

```
Terminal on Silicom NIC Host        ♦ : Input by user
                                    ♦ : Output to user

Press 'x' to skip parameter setting: x
IP initialization complete              Initialize by using
                                        default parameters

--- TOE100G-IP menu ---
[0] : Display TCPIP parameters          Main menu
[1] : Reset TCPIP parameters
[2] : Half duplex Test (TOEIP - Target)
[3] : Full duplex Test (TOEIP <-> Target)
>>>
```
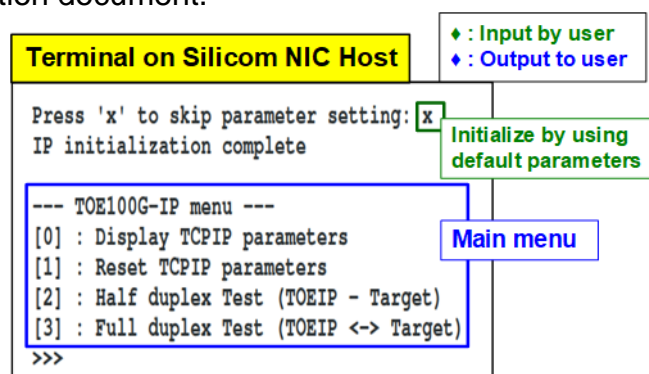
Figure 2-6 Initialization complete

7) To exit the demo application, enter "CTRL+C" while there is no test run. After that, "Exiting the application!" is displayed and the application is terminated, as shown in Figure 2-7.

Note: If "CTRL+C" is entered while the test operation is running, user must re-program the FPGA by using Silicom script file "reload_fw.sh" in driver directory.
>> ./reload_fw.sh

Figure 2-7 Close the software application

3 Test environment setup when the target uses 100G standard NIC

Please prepare the following environment.

- PC with 100G standard NIC
- 2xQSFP28 transceiver (100GBASE-SR) and MPO to MPO cable. One for connecting the Silicom NIC and another for plugging into 100G standard NIC on Target PC.
- Test application provided by Design Gateway for running on Target PC. "tcpdatatest" and "tcp_client_txrx_single" for half-duplex test and full-duplex test, respectively.
  Note: The provided test applications are proved for running on Windows 10 OS and Ubuntu 20.04 LTS OS.

Example hardware lists for running the demo are shown as follows.
1) 100G Network Adapter: MCX614106A-CCAT
   https://docs.nvidia.com/networking/display/ConnectX6EN
2) 100G Ethernet cable
   QSFP28 Transceiver: AMQ28-SR4-M1
   https://www.sfpcables.com/100gb-s-qsfp28-sr4-optical-transceiver-module-1499
   MPO to MPO cable: OM4-MPO-8MPO-1M
   https://www.sfpcables.com/mpo-to-mpo-multimode-om4-50-125-m-8-core-4381
3) Target system: Turnkey accelerator system (TKAS-D2101) with Ubuntu 20.04 LTS Server OS
   https://dgway.com/AcceleratorCards.html
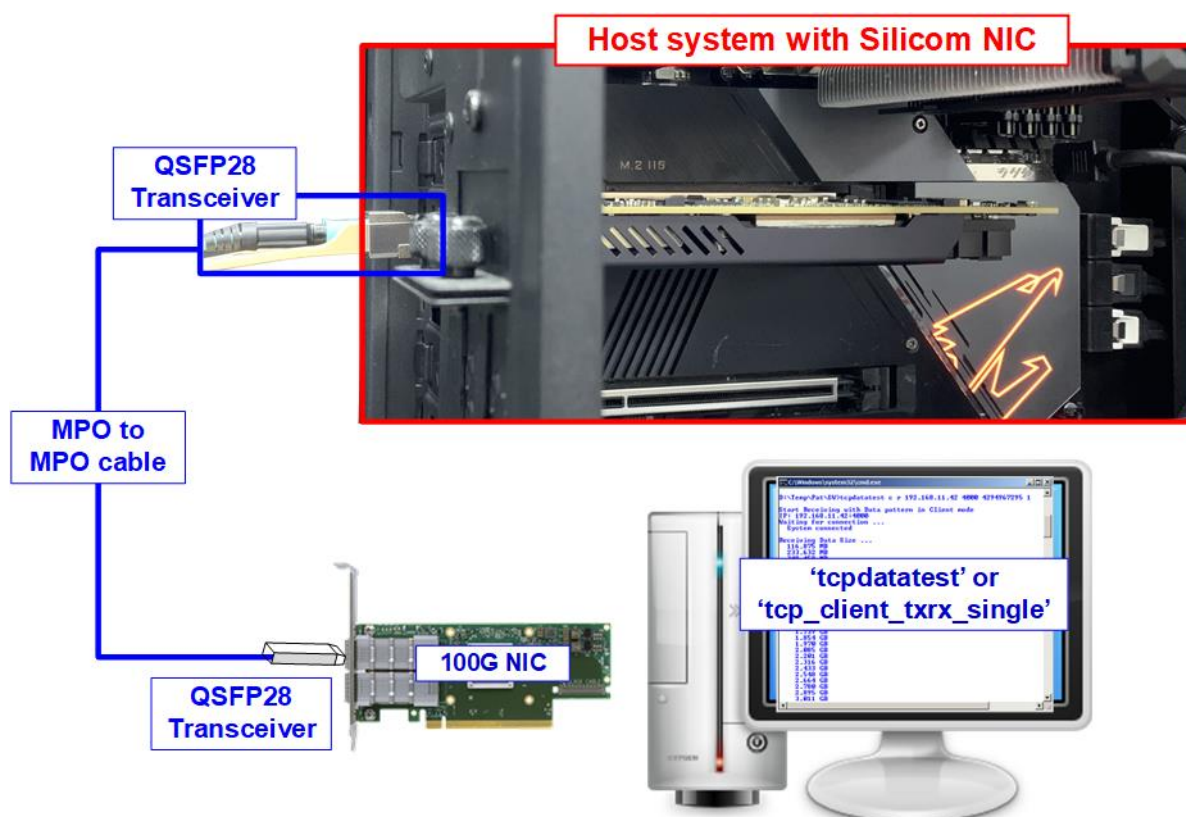
Figure 3-1 Demo setup when the target uses standard NIC

Note: Silicom NIC is configured to enable RS-FEC, so the network device that connects to Silicom NIC on the target system must support RS-FEC.

4 Test environment setup when the target uses TOE100G-IP on FPGA

Please prepare the following environment to set up the target system by TOE100G-IP on FPGA. The step to set up the TOE100G-IP on FPGA board are described in following document. https://dgway.com/products/IP/TOE100G-IP/dg_toeudp100gip_fpgasetup_xilinx.pdf

Example hardware lists for running the demo are shown as follows.
1) FPGA with TOE100G-IP demo: KCU116 board
   https://www.xilinx.com/products/boards-and-kits/ek-u1-kcu116-g.html
2) 100G Ethernet cable: 4xSFP28 to QSFP28 connection
   SFP28 Transceiver: AZS85-S28-M1
   https://www.sfpcables.com/25gb-s-sfp28-sr-transceiver-850nm-up-to-100m-2866
   QSFP28 Transceiver: AMQ28-SR4-M1
   https://www.sfpcables.com/100gb-s-qsfp28-sr4-optical-transceiver-module-1499
   MTP to 8xLC Fiber cable: OM4-MTP-8LC-1M
   https://www.fs.com/products/68047.html
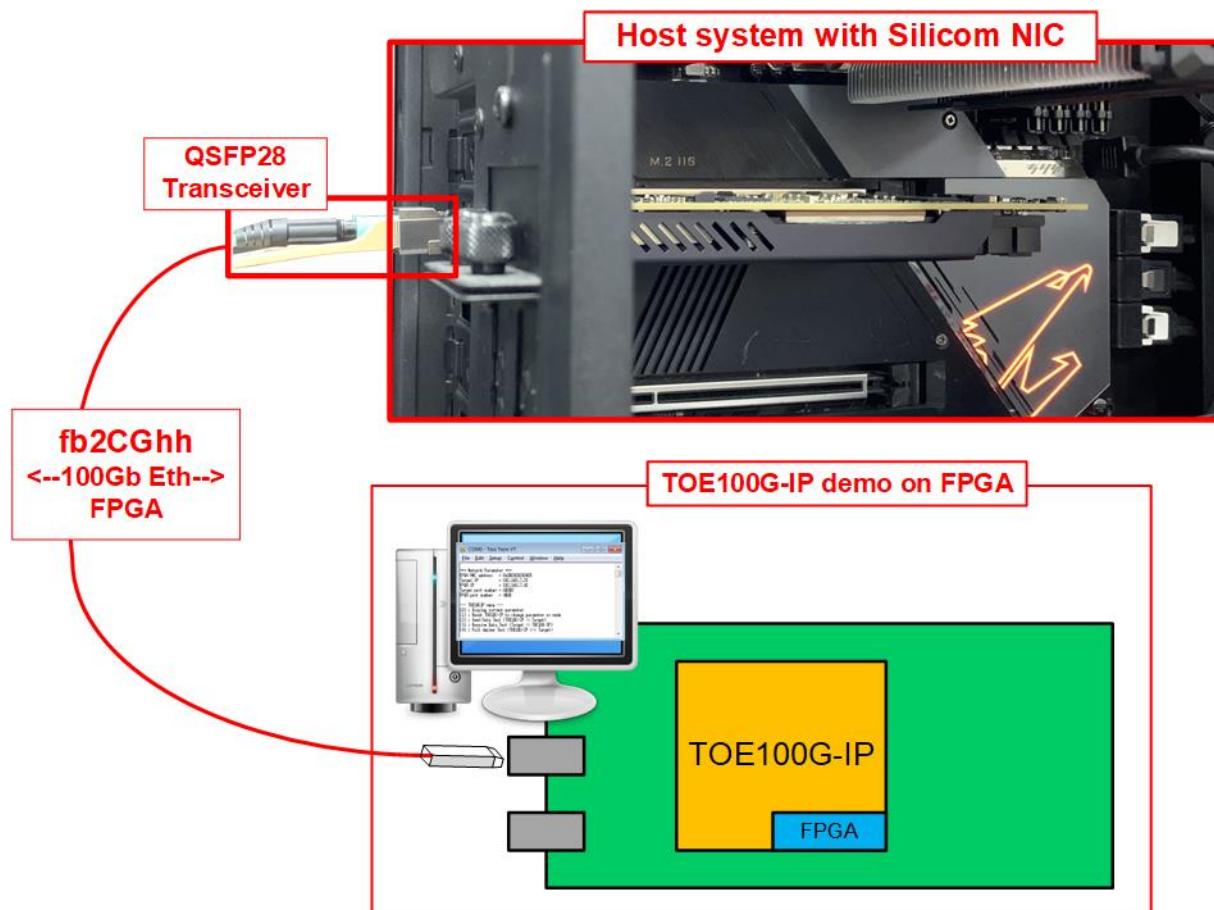
Figure 4-1 Demo setup when the target is TOE100G-IP on FPGA

Note: Silicom NIC is configured to enable RS-FEC, so the network device that connects to Silicom NIC on the target system must support RS-FEC.

The step to setup test environment when the target system uses FPGA board with TOE100G-IP demo are described in more details as follows.

1) Prepare Silicom NIC environment following step 1) – 5) of topic 2 (Silicom NIC with TOE100G-IP setup).
2) Prepare target TOE100G-IP demo system following step 1) – 8) of topic 2 (Test environment setup when using FPGA and PC) in the FPGA setup document.
https://dgway.com/products/IP/TOE100G-IP/dg_toeudp100gip_fpgasetup_xilinx.pdf
3) Start the initialization process. The example to initialize the target system by using TOE100G-IP demo system in Server mode is described as follows.
   i. Default parameters of the Silicom NIC Host are displayed after running the application.
   ii. Set '1' on Terminal of the Target TOE100G-IP demo system for running Server mode.
   iii. Default parameters of the Server are displayed, as shown in Figure 4-2.

Figure 4-2 Input mode for system initialization

4) Input 'x' to use default parameters or other keys to change parameters. The parameters of Server mode must be set before the other side starts initializing. Please run the following step to complete the initialization process, as shown in Figure 4-3.

   i.   Set parameters on Server terminal (Target TOE100G-IP demo system).

   ii. Set parameters on Client terminal (Silicom NIC with TOE100G-IP) to start IP initialization by transferring ARP packet.

   iii. After finishing initialization process, "IP initialization complete" and main menu are displayed on Silicom NIC Host.

   iv. Check Server console that "IP initialization complete" and main menu are displayed. If not, open the new Terminal on Silicom NIC Host and then use "arping" command to send ARP request from the Silicom NIC Host by following command.

   >> sudo arping -c 1 <target IP address>

   After that, the MAC address of the target (TOE100G-IP on Server) is displayed on the new Terminal. Also, the "IP initialization complete" and main menu are displayed on the Server console.

   Note: TOE100G-IP initialization in Server mode waits for ARP request from the Client. The application on Silicom does not send ARP request if ARP table has this IP address information. Therefore, ARP sending manually is required in this condition.
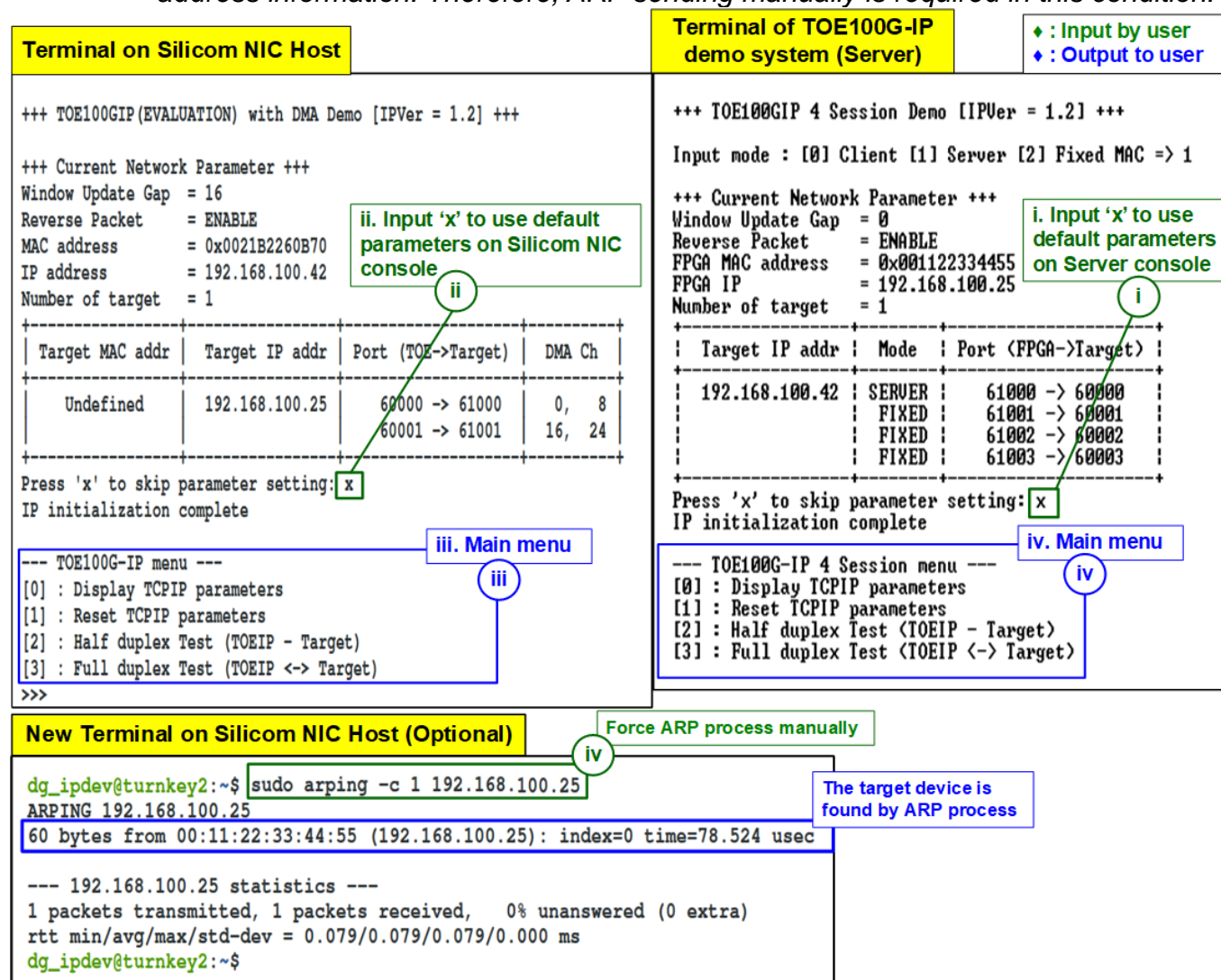

Figure 4-3 Main menu of TOE100G-IP demo

5 Revision History

Revision	Date	Description
1.0	16-Dec-22	Initial version release