DPDK
DATA PLANE DEVELOPMENT KIT

DPDK Cookbook

Featuring:

Solution Oriented Mini Sections

User Friendly Screen shots

Links to Videos and Online Contents

Overview

The DPDK Cookbook modules teach you everything you need to know to be productive with DPDK. Here's an overview of the topics covered:

I highly recommended that you devour the Architecture Overview section of Programmer's Guide at dpdk.org. This excellent document, authored by architects and designers, goes into both the how and why of DPDK design.

Acknowledgements

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Build Your Own DPDK Traffic Generator – DPDK-In-A-Box

Introduction

The purpose of this cookbook module is to guide you through the steps required to build a Data Plane Development Kit (DPDK) based traffic generator.

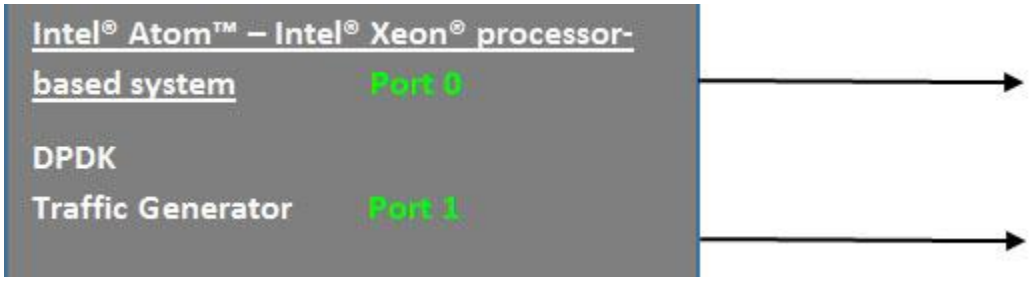
We built a DPDK-in-a-Box using the MinnowBoard Turbot, which is a low cost, portable platform based on the Intel® Atom™ processor E3826. For the OS, we installed Ubuntu* 16.04 client with DPDK. The instructions in this document are tested on our DPDK-in-a-Box, as well as on an Intel® Core i7-5960X Haswell-E desktop. You can use any Intel® Architecture (IA) platform to build your own device.

For the traffic generator, we will use the TRex* realistic traffic generator. The TRex package is self-contained and can be easily installed.

Any Intel processor-based platform will work—desktop, server, laptop or embedded system.

The DPDK Traffic Generator

Block Diagram



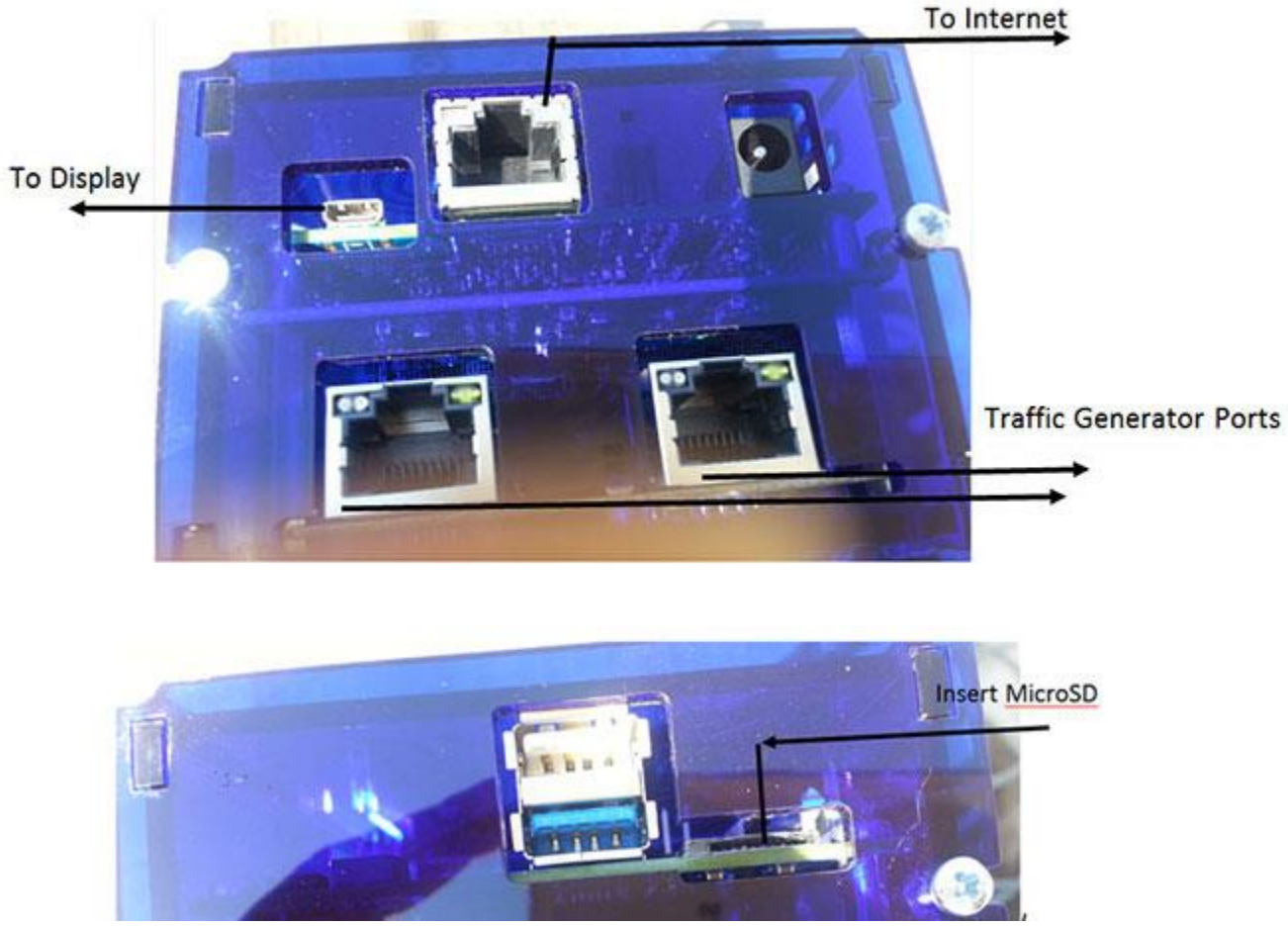
Software

- Ubuntu 16.04 Client OS with DPDK installed
- TRex* realistic traffic generator

Hardware

Our DPDK-in-a-Box uses a MinnowBoard Turbot single board computer:

- Out of the three Ethernet ports, the two at the bottom are for the traffic generator (dual gigabit Intel® Ethernet Controller I350). Connect a loopback cable between them.
- Connect the third Ethernet port to the Internet (to download the TRex package).
- Connect the keyboard and mouse to the USB ports.
- Connect a display to the HDMI Interface.



The MinnowBoard Turbot

The MinnowBoard includes a microSD card and an SD adapter.

- Insert the microSD card into the microSD Slot. The SD adapter should be ignored and not used.
- Power on the DPDK-in-a-Box system. Ubuntu will be up and running right away.

Choose the username `test` and assign the password `tester` (or use the username and password specified by the Quick Start Guide that comes with the platform).

- Log on as root by inputting the command, and verify that you are in the /home/test directory with the following two commands:

```
# sudo su
# ls
```

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# ls
Desktop  Documents  Downloads  dpdk  examples.desktop  Music  Pictures  Public  Templates  Videos
```

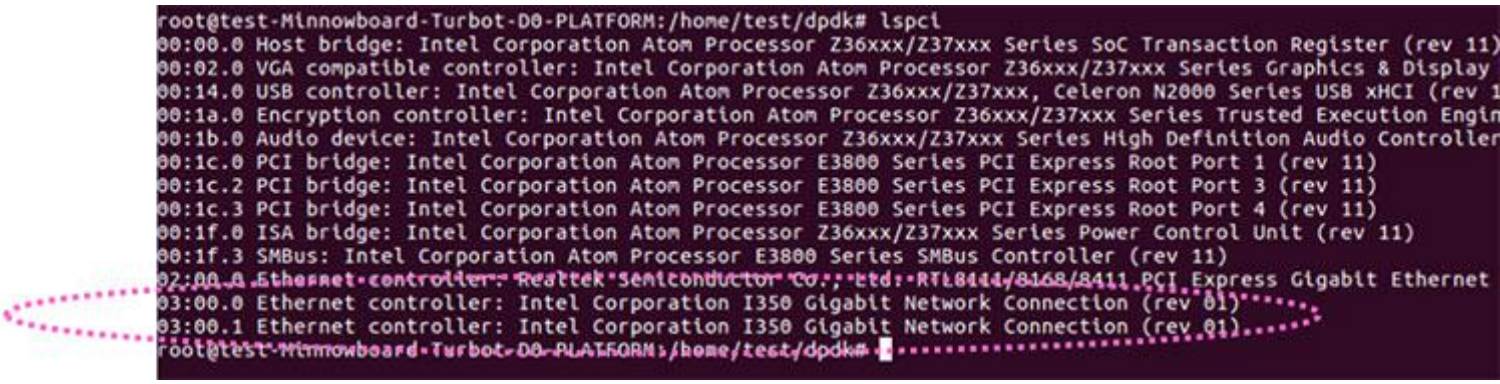
Note NIC Information

The configuration file for the traffic generator needs the PCI bus-related information and the MAC address. Note this information first using Linux commands, because once the DPDK or packet generator is run, these ports are unavailable to Linux.

1. For PCI bus-related NIC information, type the following command:

```
# lspci
```

You will see the following output. Note down that for port 0 the information is 03:00.0 and for port 1 the information is 03:00.1.



2. Find the MAC address with this command:

   ```
   # ifconfig
   ```

   You will see the following output. Note down that for port 0 the MAC address is 00:30:18:CB:F2:70 and for port 2 the MAC address is 00:30:18:CB:F2:71.

   Note that the first port in the screenshot below, enp2s0, is the port connected to the Internet. No need to make a note of this.

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# ifconfig
enp2s0    Link encap:Ethernet  HWaddr 00:08:a2:09:f2:1d
          inet addr:192.168.0.11  Bcast:192.168.0.255  Mask:255.255.255.0
          inet6 addr: fe80::56cd:7409:7867:9572/64 Scope:Link
          inet6 addr: 2601:647:4902:79c0:6a14:5825:3e6c:de09/64 Scope:Global
          inet6 addr: 2601:647:4902:79c0:ac82:14bd:f4da:e627/64 Scope:Global
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:82453 errors:0 dropped:0 overruns:0 frame:0
          TX packets:56424 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:60196138 (60.1 MB)  TX bytes:17006340 (17.0 MB)

enp3s0f0  Link encap:Ethernet  HWaddr 00:30:18:cb:f2:70
          inet6 addr: fe80::ef12:bbfd:4cff:5034/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:103 errors:0 dropped:0 overruns:0 frame:0
          TX packets:135 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:20949 (20.9 KB)  TX bytes:22055 (22.0 KB)
          Memory:90500000-9057ffff

enp3s0f1  Link encap:Ethernet  HWaddr 00:30:18:cb:f2:71
          inet6 addr: fe80::2ad4:3549:f1fa:72f0/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:85 errors:0 dropped:0 overruns:0 frame:0
          TX packets:146 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:16637 (16.6 KB)  TX bytes:24515 (24.5 KB)
          Memory:90600000-9067ffff

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:10234 errors:0 dropped:0 overruns:0 frame:0
          TX packets:10234 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:1072552 (1.0 MB)  TX bytes:1072552 (1.0 MB)
```

Item	Port 0	Port 1
PCI Bus-related NIC info (from lspci)	**03:00.0**	**03:00.1**
MAC address	**00:30:18:CB:F2:70**	**00:30:18:CB:F2:71**

Fill the following table with the information you gathered from your specific platform:

Item	Port 0	Port 1
PCI Bus-related NIC info (from lspci)		
MAC address		

What if you don't see both of the ports in response to the `ifconfig` command?

One possible reason is that you might have run the DPDK based application previously, in which case the application might have claimed those ports, making them unavailable to the kernel. In that case, refer to the appendix on how to unbind the ports from DPDK so that the kernel can claim them and you can find the MAC address with the `ifconfig` command.

In the following sections, we will assume that you successfully found the ports and have noted down the MAC addresses.

Install and Configure the TRex* Traffic Generator

Install the traffic generator

Input the following commands:

```
# pwd
# mkdir trex
# cd trex
# wget -no-cache http://trex-tgn.cisco.com/trex/release/latest
```

You should see that the install is complete, and saved in `/home/test/trex/latest`:

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# pwd
/home/test
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# mkdir trex
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# cd trex
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex# wget --no-cache http://trex-tgn.cisco.com/trex/release/latest
--2016-08-26 01:47:22--  http://trex-tgn.cisco.com/trex/release/latest
Resolving trex-tgn.cisco.com (trex-tgn.cisco.com)... 173.39.246.118
Connecting to trex-tgn.cisco.com (trex-tgn.cisco.com)|173.39.246.118|:80... connected.
HTTP request sent, awaiting response... 301 Moved Permanently
Location: https://trex-tgn.cisco.com/trex/release/latest [following]
--2016-08-26 01:47:22--  https://trex-tgn.cisco.com/trex/release/latest
Connecting to trex-tgn.cisco.com (trex-tgn.cisco.com)|173.39.246.118|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 146045560 (139M) [application/x-tar]
Saving to: 'latest'

latest                                              100%[=================================================================

2016-08-26 01:48:00 (3.76 MB/s) - 'latest' saved [146045560/146045560]

root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex#
```

The next step is to untar the package:

```
# tar -xzvf latest
```

Below you see that version 2.08 is the latest version at the time of this screen capture:

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex# tar -xzvf latest
v2.08/
v2.08/_t-rex-64-debug
v2.08/t-rex-64-debug
v2.08/_t-rex-64
v2.08/t-rex-64
v2.08/_t-rex-64-debug-o
v2.08/t-rex-64-debug-o
v2.08/_t-rex-64-o
```

```
# ls -al
```

You will see the directory with the version installed. In this exercise, the directory is v2.08, as shown below in response to the `ls -al` command. Change directory to the version installed on your system; for example, `cd <dir name with version installed>`:

```
# cd v2.08
```

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex# ls -al
total 142640
drwxr-xr-x  3 root  root        4096 Aug 26 01:48 .
drwxr-xr-x 18 test  test        4096 Aug 26 01:44 ..
-rw-r--r--  1 root  root   146045560 Aug 24 14:35 latest
drwxr-xr-x 11 33066 floppy      4096 Aug 24 14:35 v2.08
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex# cd v2.08
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex/v2.08#
```

```
# ls -al
```

You will see the file `t-rex-64`, which is the traffic generator executable:

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex/v2.08# ls -al
total 176364
drwxr-xr-x 11 33066 floppy     4096 Aug 24 14:35 .
drwxr-xr-x  3 root  root       4096 Aug 26 01:48 ..
drwxr-xr-x  6 33066 floppy     4096 Aug 24 14:34 automation
drwxr-xr-x  2 33066 floppy     4096 Aug 24 14:34 avl
-rwxr-xr-x  1 33066 floppy 27200827 Aug 24 14:34 bp-sim-64
-rwxr-xr-x  1 33066 floppy 16798769 Aug 24 14:34 bp-sim-64-debug
drwxr-xr-x  2 33066 floppy     4096 Aug 24 14:34 cap2
drwxr-xr-x  2 33066 floppy     4096 Aug 24 14:34 cfg
-rwxr-xr-x  1 33066 floppy     5501 Aug 24 14:34 daemon_server
-rwxr-xr-x  1 33066 floppy     2207 Aug 24 14:34 doc_process.py
-rwxr-xr-x  1 33066 floppy    26985 Aug 24 14:34 dpdk_nic_bind.py
-rwxr-xr-x  1 33066 floppy    33325 Aug 24 14:34 dpdk_setup_ports.py
drwxr-xr-x  2 33066 floppy    16384 Aug 24 14:34 exp
drwxr-xr-x 22 33066 floppy     4096 Aug 24 14:34 external_libs
-rwxr-xr-x  1 33066 floppy     2291 Aug 24 14:34 find_python.sh
drwxr-xr-x 15 33066 floppy     4096 Aug 24 14:34 ko
-rw-r--r--  1 33066 floppy  3150071 Aug 24 14:34 libzmq.so.3
-rwxr-xr-x  1 33066 floppy    11148 Aug 24 14:34 master_daemon.py
drwxr-xr-x  3 33066 floppy     4096 Aug 24 14:34 python-lib
-rwxr-xr-x  1 33066 floppy      802 Aug 24 14:34 run_functional_tests
-rwxr-xr-x  1 33066 floppy      832 Aug 24 14:34 run_regression
drwxr-xr-x  6 33066 floppy     4096 Aug 24 14:34 stl
-rwxr-xr-x  1 33066 floppy      403 Aug 24 14:34 stl-sim
-rwxr-xr-x  1 33066 floppy 34390661 Aug 24 14:34 _t-rex-64
-rwxr-xr-x  1 33066 floppy      902 Aug 24 14:34 t-rex-64
-rwxr-xr-x  1 33066 floppy 28843174 Aug 24 14:34 _t-rex-64-debug
-rwxr-xr-x  1 33066 floppy      902 Aug 24 14:34 t-rex-64-debug
-rwxr-xr-x  1 33066 floppy 28812951 Aug 24 14:34 _t-rex-64-debug-o
-rwxr-xr-x  1 33066 floppy      902 Aug 24 14:34 t-rex-64-debug-o
-rwxr-xr-x  1 33066 floppy 35101658 Aug 24 14:34 _t-rex-64-o
-rwxr-xr-x  1 33066 floppy      902 Aug 24 14:34 t-rex-64-o
-rwxr-xr-x  1 33066 floppy     2086 Aug 24 14:34 trex-cfg
-rw-r--r--  1 33066 floppy  6077140 Aug 24 14:35 trex_client_v2.08.tar.gz
-rwxr-xr-x  1 33066 floppy      444 Aug 24 14:34 trex-console
-rwxr-xr-x  1 33066 floppy     5501 Aug 24 14:34 trex_daemon_server
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex/v2.08#
```

Configure the traffic generator

The good news is that the TRex package comes with a sample config file `cfg/simple_cfg.yaml`. Copy that to `/etc/trex_cfg.yaml` and edit the file by issuing the following commands, making sure that you're in your `/home/test/trex/<your version>` directory:

```
# pwd
# cp cfg/simple_cfg.yaml /etc/trex_cfg.yaml
# gedit /etc/trex_cfg.yaml
```

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex/v2.08# cp cfg/simple_cfg.yaml /etc/trex_cfg.yaml
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex/v2.08# gedit /etc/trex_cfg.yaml
```

Edit the file as shown below with the applicable NIC information you gathered in previous steps:

```
Open    trex_cfg.yaml  /etc                                                    Save
- port_limit      : 2         # this option can limit the number of port of the platform
  version         : 2
  interfaces    : ["03:00.0","03:00.1"] #the interfaces using ./dpdk_setup_ports.py -s
  port_info       :  # set eh mac addr
          - dest_mac        :   [0x00,0x30,0x18,0xcb,0xf2,0x71]    # router mac addr should be taken from router
            src_mac         :   [0x00,0x30,0x18,0xcb,0xf2,0x70]  # source mac-addr - taken from ifconfig
          - dest_mac        :   [0x00,0x30,0x18,0xcb,0xf2,0x70]  # router mac addr  taken from router
            src_mac         :   [0x00,0x30,0x18,0xcb,0xf2,0x71]  #source mac-addr  taken from ifconfig
```

```
YAML ▾   Tab Width: 8 ▾   Ln 1, Col 1 ▾   INS
```

Below is the line-by-line description of the configuration information:

- `Port_limit` should be 2 (since DPDK-in-a-Box has two ports)
- Version should be `2`
- Interfaces should be the PCI bus ports you gathered using `lspci`. In this exercise they are `["03:00.0", "03:00.1"]`
- `Port_information` contains a `dest_mac`, `src_mac` pair, which will be in the packet header of the traffic generated. The first pair is for port 0. Since port 0 is connected to port 1, the first `dest_mac` is the MAC address of port 1. The second pair is for port 1. Since port 1 is connected to port 0, the second `dest_mac` is the MAC address of port 0.

  Please note that when you connect an appliance to which traffic must be injected, the `dest_mac` addresses will be that of the appliance.

Note Platform lcore Count

This section is for informational purposes only.

`# cat /proc/cpuinfo` will give you the lcore information as shown in the Exercises section.

Why is this information useful?

The command line below that runs the traffic generator uses the –c option to specify the number of lcores to be used for the traffic generator. You want to know how many lcores exist in the platform. Hence, issuing `cat /proc/cpuinfo` and eyeballing the number of lcores that are available in the system will be helpful.

Run the Traffic Generator

```
# sudo ./t-rex-64 -f cap2/dns.yaml -c 1 -d 100
```

What are the parameters –f, -c, and –d?

`-f` for YAML traffic configuration file
`-c` for number of cores. Monitor the CPU% of TRex – it should be ~50%. Use cores accordingly
`-d` for duration of the test (sec). Default: 0

Summary

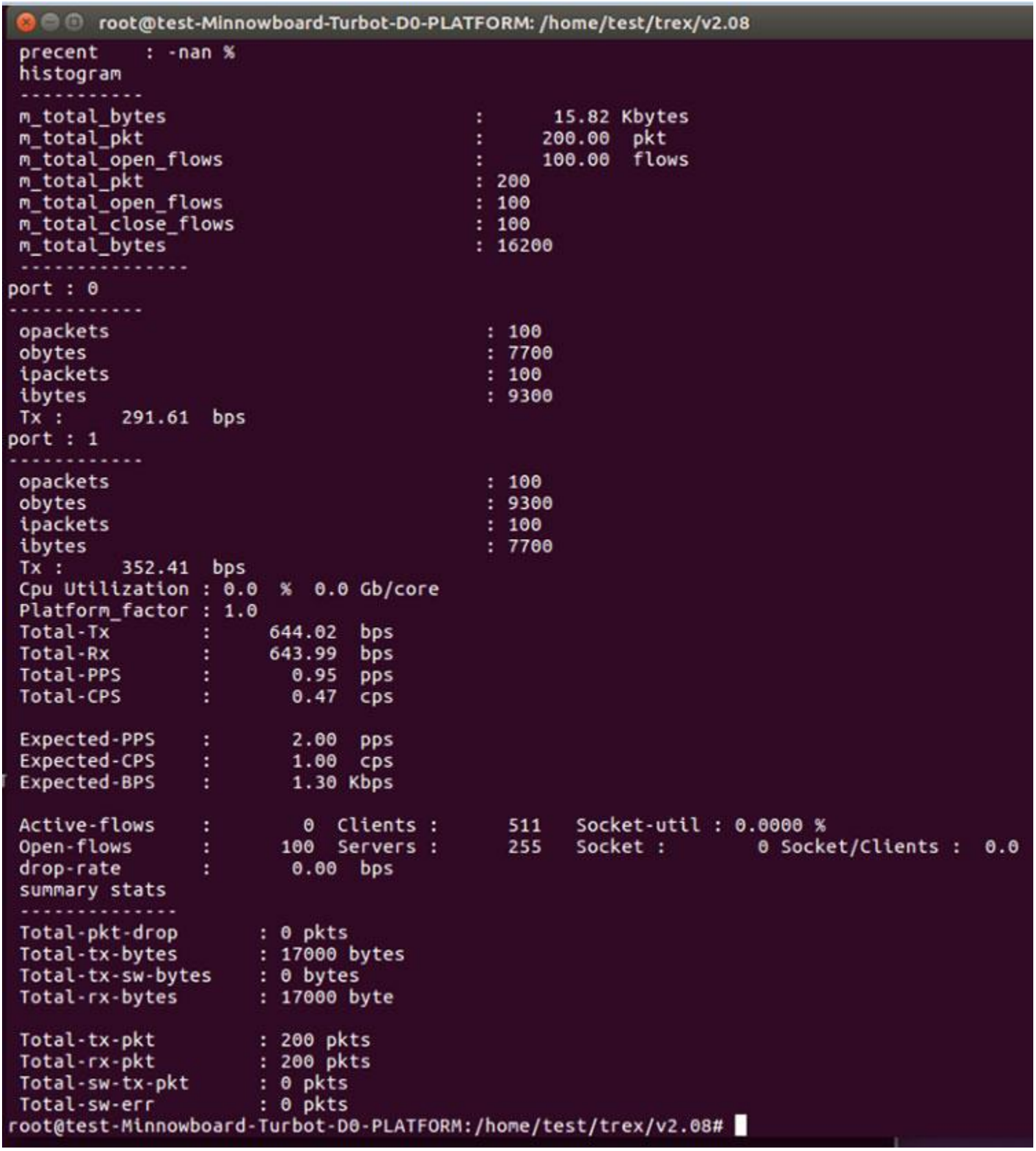
Below are three output screens: 1) During the traffic run, 2) Linux top command output, and 3) Final output after the completion of the run.

```
root@test-Minnowboard-Turbot-D0-PLATFORM: /home/test/trex/v2.08


-Per port stats table
      ports |               0 |               1
 -----------------------------------------------------------------------------------------
   opackets |              15 |              15
     obytes |            1155 |            1395
   ipackets |              15 |              15
     ibytes |            1395 |            1155
    ierrors |               0 |               0
    oerrors |               0 |               0
      Tx Bw |     584.18  bps |     705.57  bps

-Global stats enabled
 Cpu Utilization : 0.0  %  0.0 Gb/core
 Platform_factor : 1.0
 Total-Tx        :       1.29 Kbps
 Total-Rx        :       1.29 Kbps
 Total-PPS       :       1.90  pps
 Total-CPS       :       0.97  cps

 Expected-PPS    :       2.00  pps
 Expected-CPS    :       1.00  cps
 Expected-BPS    :       1.30 Kbps

 Active-flows    :        0  Clients :      511   Socket-util : 0.0000 %
 Open-flows      :       15  Servers :      255   Socket :       15 Socket/Clients :  0.0
 drop-rate       :       0.00  bps
 current time    : 27.0 sec
 test duration   : 73.0 sec
```

Screen output showing traffic during run (15 packets so far Tx & Rx)

```
top - 06:21:00 up  2:05,  1 user,  load average: 1.33, 0.39, 0.18
Threads: 418 total,   2 running, 416 sleeping,   0 stopped,   0 zombie
%Cpu(s): 53.0 us,  2.0 sy,  0.0 ni, 42.0 id,  3.0 wa,  0.0 hi,  0.0 si,  0.0 st
KiB Mem :  1939152 total,   296884 free,  1122584 used,   519684 buff/cache
KiB Swap:  1986556 total,  1639292 free,   347264 used.   454792 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S %CPU %MEM     TIME+ COMMAND
16986 root      20   0  893584   9400   5852 R 99.3  0.5   0:45.47 lcore-slave+
 1956 test      20   0  662648  20424  11936 S  2.6  1.1   0:32.98 gnome-termi+
 1441 test      20   0 1491584  89496  23572 S  1.6  4.6   4:06.93 compiz
16983 root      20   0  893584   9400   5852 S  1.6  0.5   0:05.17 _t-rex-64-o
  775 root      20   0  379904  32892  23824 S  1.3  1.7   1:20.63 Xorg
16114 root      20   0   49268   3468   2444 R  1.0  0.2   1:07.05 top
  589 root      20   0  173360   2100   1888 S  0.3  0.1   0:00.07 thermald
16925 root      20   0       0      0      0 S  0.3  0.0   0:00.13 kworker/u8:3
    1 root      20   0  185372   3520   2192 S  0.0  0.2   0:04.57 systemd
    2 root      20   0       0      0      0 S  0.0  0.0   0:00.00 kthreadd
    3 root      20   0       0      0      0 S  0.0  0.0   0:00.43 ksoftirqd/0
    5 root       0 -20       0      0      0 S  0.0  0.0   0:00.00 kworker/0:0H
    7 root      20   0       0      0      0 S  0.0  0.0   0:07.56 rcu_sched
    8 root      20   0       0      0      0 S  0.0  0.0   0:00.00 rcu_bh
```

Output of top –H command during the run



Screen output after completing the run (100 packets Tx & Rx)

Next Steps

Congratulations! With the above hands-on exercise, you have successfully built your own Intel DPDK based traffic generator.

As a next step, you can connect back-to-back two DPDK-in-a-Box platforms, and use one as a traffic generator and the other as a DPDK application development and test vehicle.

Exercises

1. How would you configure the traffic generator for different packet lengths?
2. To run the traffic generator forever, what should be the value of –d?
3. How would you measure latency (assuming you have more cores)?
4. Reason out the root cause and find the solution by looking up the error, “Note that the uio or vfio kernel modules to be used should be loaded into the kernel before running the dodk-devbind.py script” in Chapter 3 of the DPDK.org document Getting Started Guide for Linux.
5. In the following screenshot, determine the hyperthreading state—enabled vs. disabled? (Hint: this is the Intel Atom processor platform.)

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex/v2.08# cat /proc/cpuinfo
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 55
model name      : Intel(R) Atom(TM) CPU  E3826  @ 1.46GHz
stepping        : 9
cpu MHz         : 536.688
cache size      : 512 KB
physical id     : 0
siblings        : 2
core id         : 0
cpu cores       : 2
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 11
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pa
opl xtopology nonstop_tsc aperfmperf pni pclmulqdq dtes64 monitor ds_cpl vmx est t
xpriority ept vpid tsc_adjust smep erms dtherm arat
bugs            :
bogomips        : 2930.40
clflush size    : 64
cache_alignment : 64
address sizes   : 36 bits physical, 48 bits virtual
power management:

processor       : 1
vendor_id       : GenuineIntel
cpu family      : 6
model           : 55
model name      : Intel(R) Atom(TM) CPU  E3826  @ 1.46GHz
stepping        : 9
cpu MHz         : 1394.531
cache size      : 512 KB
physical id     : 0
siblings        : 2
core id         : 2
cpu cores       : 2
apicid          : 4
initial apicid  : 4
fpu             : yes
fpu_exception   : yes
cpuid level     : 11
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pa
opl xtopology nonstop_tsc aperfmperf pni pclmulqdq dtes64 monitor ds_cpl vmx est t
xpriority ept vpid tsc_adjust smep erms dtherm arat
bugs            :
bogomips        : 2930.40
clflush size    : 64
cache_alignment : 64
address sizes   : 36 bits physical, 48 bits virtual
power management:

root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/trex/v2.08#
```

Appendix: Unbinding from DPDK & Binding to Kernel

This section is not needed if `ifconfig` is able to find the ports you want to use for traffic generation. In that case, you can skip this section.

What is the reason `ifconfig` cannot find the two ports? If you are only interested in the solution, skip this troubleshooting section and go to the Solution section.

Root Cause

`ifconfig` is not showing the two ports below. Why?

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk/tools# ifconfig
enp2s0    Link encap:Ethernet  HWaddr 00:08:a2:09:f2:1d
          inet addr:192.168.0.6  Bcast:192.168.0.255  Mask:255.255.255.0
          inet6 addr: 2601:647:4902:79c0:b98c:9a9e:55f6:8314/64 Scope:Global
          inet6 addr: 2601:647:4902:79c0:8712:fcc2:af9:a689/64 Scope:Global
          inet6 addr: fe80::3603:79d2:fe9e:8468/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:60216 errors:0 dropped:0 overruns:0 frame:0
          TX packets:53600 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:33276201 (33.2 MB)  TX bytes:10484345 (10.4 MB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:15976 errors:0 dropped:0 overruns:0 frame:0
          TX packets:15976 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:1594031 (1.5 MB)  TX bytes:1594031 (1.5 MB)

root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk/tools#
```

The reason that `ifconfig` is unable to find the two ports is possibly because the DPDK application was previously run and was aborted without releasing the ports, or it might be that a DPDK script runs automatically after boot and claims the ports. Regardless of the reason, the solution below will enable `ifconfig` to show both ports.

Solution

1. Run `./setup.sh` in the directory `/home/test/dpdk/tools`
2. Display current Ethernet device settings
3. Unbind the first port from IGB UIO (assuming it is bound to IGB UIO)
4. Bind the port to IGB (the kernel driver)
5. Repeat steps 3-5 to unbind the second port from IGB UIO and bind to IGB.

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk/tools# ls
cpu_layout.py  dpdk_nic_bind.py  pmdinfo.py  setup.sh
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk/tools# ./setup.sh
```

1. Select “Display current Ethernet device settings” (option 23 in this case).

```
[23] Display current Ethernet device settings
[24] Bind Ethernet device to IGB UIO module
[25] Bind Ethernet device to VFIO module
[26] Setup VFIO permissions

------------------------------------------------------------
 Step 3: Run test application for linuxapp environment
------------------------------------------------------------
[27] Run test application ($RTE_TARGET/app/test)
[28] Run testpmd application in interactive mode ($RTE_TARGET/app/testpmd)

------------------------------------------------------------
 Step 4: Other tools
------------------------------------------------------------
[29] List hugepage info from /proc/meminfo

------------------------------------------------------------
 Step 5: Uninstall and system cleanup
------------------------------------------------------------
[30] Unbind NICs from IGB UIO or VFIO driver
[31] Remove IGB UIO module
[32] Remove VFIO module
[33] Remove KNI module
[34] Remove hugepage mappings

[35] Exit Script

Option: 23
```

Status showing two ports claimed by the DPDK driver.

```
Option: 23


Network devices using DPDK-compatible driver
============================================
0000:03:00.0 'I350 Gigabit Network Connection' drv=igb_uio unused=igb,vf
0000:03:00.1 'I350 Gigabit Network Connection' drv=igb_uio unused=igb,vf

Network devices using kernel driver
===================================
0000:02:00.0 'RTL8111/8168/8411 PCI Express Gigabit Ethernet Controller'
o_pci_generic *Active*

Other network devices
=====================
```

Unbind the first NIC from DPDK (specifically IGB UIO).

```
------------------------------------------
 Step 5: Uninstall and system cleanup
------------------------------------------
[30] Unbind NICs from IGB UIO or VFIO driver
[31] Remove IGB UIO module
[32] Remove VFIO module
[33] Remove KNI module
[34] Remove hugepage mappings
```

1. Select option 30 and then enter the PCI address of device to unbind:

```
Option: 30


Network devices using DPDK-compatible driver
============================================
0000:03:00.0 'I350 Gigabit Network Connection' drv=igb
0000:03:00.1 'I350 Gigabit Network Connection' drv=igb

Network devices using kernel driver
===================================
0000:02:00.0 'RTL8111/8168/8411 PCI Express Gigabit Et
o_pci_generic *Active*

Other network devices
=====================
<none>

Enter PCI address of device to unbind: 0000:03:00.0
```

2. Bind the kernel driver igb to the device:

```
Enter name of kernel driver to bind the device to: igb
```

3. If the inputs entered are correct, script acknowledges OK.

```
OK

Press enter to continue ...
```

4. Verify by displaying current Ethernet device settings.

```
Option: 23


Network devices using DPDK-compatible driver
============================================
0000:03:00.1 'I350 Gigabit Network Connection' drv=igb_uio unused=igb,vfio-pci,uio

Network devices using kernel driver
===================================
0000:02:00.0 'RTL8111/8168/8411 PCI Express Gigabit Ethernet Controller' if=enp2s0
o_pci_generic *Active*
0000:03:00.0 'I350 Gigabit Network Connection' if=enp3s0f0 drv=igb unused=igb_uio,

Other network devices
=====================
<none>
```

Success!

Above you will see the first port `0000:30:00.0` bound to the kernel.

Now on to the second port `0000:30:00.1`

Success!

Below you will see both ports bound back to kernel.

```
Option: 23


Network devices using DPDK-compatible driver
============================================
<none>

Network devices using kernel driver
===================================
0000:02:00.0 'RTL8111/8168/8411 PCI Express Gigabit Ethernet Controller' if=enp2s0
o_pci_generic *Active*
0000:03:00.0 'I350 Gigabit Network Connection' if=enp3s0f0 drv=igb unused=igb_uio,
0000:03:00.1 'I350 Gigabit Network Connection' if=enp3s0f1 drv=igb unused=igb_uio,

Other network devices
=====================
<none>
```

Now that both ports are bound back to kernel, `ifconfig` will give the needed info for those ports.

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk# ifconfig
enp2s0    Link encap:Ethernet  HWaddr 00:08:a2:09:f2:1d
          inet addr:192.168.0.6  Bcast:192.168.0.255  Mask:255.255.255.0
          inet6 addr: 2601:647:4902:79c0:249:ce31:c570:85a/64 Scope:Global
          inet6 addr: fe80::a572:b28f:7fd6:5336/64 Scope:Link
          inet6 addr: 2601:647:4902:79c0:6cc6:fc3c:5f31:d114/64 Scope:Global
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:21515 errors:0 dropped:0 overruns:0 frame:0
          TX packets:18422 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:6537879 (6.5 MB)  TX bytes:5099447 (5.0 MB)

enp3s0f0  Link encap:Ethernet  HWaddr 00:30:18:cb:f2:70
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:21 errors:0 dropped:0 overruns:0 frame:0
          TX packets:115 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:5995 (5.9 KB)  TX bytes:21997 (21.9 KB)
          Memory:90500000-9057ffff

enp3s0f1  Link encap:Ethernet  HWaddr 00:30:18:cb:f2:71
          inet6 addr: fe80::f596:8de9:9963:4008/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:2 errors:0 dropped:0 overruns:0 frame:0
          TX packets:54 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:486 (486.0 B)  TX bytes:10474 (10.4 KB)
          Memory:90600000-9067ffff

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:6303 errors:0 dropped:0 overruns:0 frame:0
          TX packets:6303 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:582195 (582.1 KB)  TX bytes:582195 (582.1 KB)
```

DPDK Transmit & Receive Loopback - DPDK-In-A-Box

Introduction

In the previous module, Build Your Own Traffic Generator – DPDK-In-A-Box, you learned how to build a DPDK traffic generator. Once you've done this, the next step is to connect two platforms back to back, and use one as the DPDK traffic generator and the other as a DPDK application development and test vehicle. But what if you have just one system? Read on to learn how to generate traffic and run your DPDK application on the same machine.

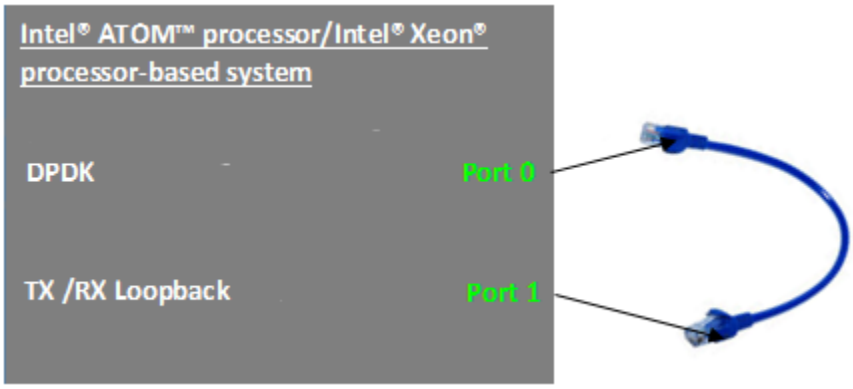
Traffic and the DPDK Application on a Single System

The purpose of this article is to show how to configure a single system to run the DPDK application and provide auto-generated traffic. To provide the traffic, we will showcase **testpmd**, which many DPDK developers and customers consider to be the stethoscope of a DPDK developer.

For your system, you can use any Intel® platform. The instructions in this article have been tested with an Intel® Xeon® processor-based desktop, server, and laptop using either the DPDK traffic generator you built from scratch, or a commercially available DPDK in-a-Box. This is a low-cost, portable platform based on an Intel® Atom™ processor E3826. At the time this article was published, you could purchase a DPDK-in-a-Box from Netgate.

If you are new to DPDK, spend some time reading the DPDK Programmer's Guide at dpdk.org. Authored by architects and

Stethoscope of DPDK Developer – Testpmd



Auto-generating traffic with tx_first Parameter

Challenge

Data plane applications need a traffic generator. The DPDK provides both RX and TX functionality and DPDK applications build poll mode drivers with the RX and TX libraries. With the DPDK poll mode driver, the RX functionality of the driver polls ingress traffic, and after the applicable processing the TX functionality of the poll driver transmits the processed data to the egress interface.

Because the start of the data path involves polling for packets received, data plane applications need a traffic generator. But here we have only one platform. How do you configure the application for this traffic?

Solution

This is where the testpmd tx_first parameter comes in handy. When testpmd is started with the tx_first parameter, the TX function gets executed first—hence the name tx_first—and with an external cable connecting RX and TX, those packets are now available for the RX function to poll. Thus you have achieved running traffic through testpmd without an external traffic generator.

The following screenshots show how to start testpmd and run tx_first with a loopback cable in place.

Starting testpmd

`./x86_64-native-linuxapp-gcc/app/testpmd -- -i` starts testpmd. –i stands for interactive. Please refer to the Testpmd Application User Guide at dpdk.org and to the article Testing DPDK Performance and Features with TestPMD on Intel® Developer Zone for more information about how to build and run testpmd.

While you can use the above command in your specific platform, it is available as a script named run.sh in DPDK-in-a-Box.

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk# cat run.sh
./x86_64-native-linuxapp-gcc/app/testpmd -- -i
```

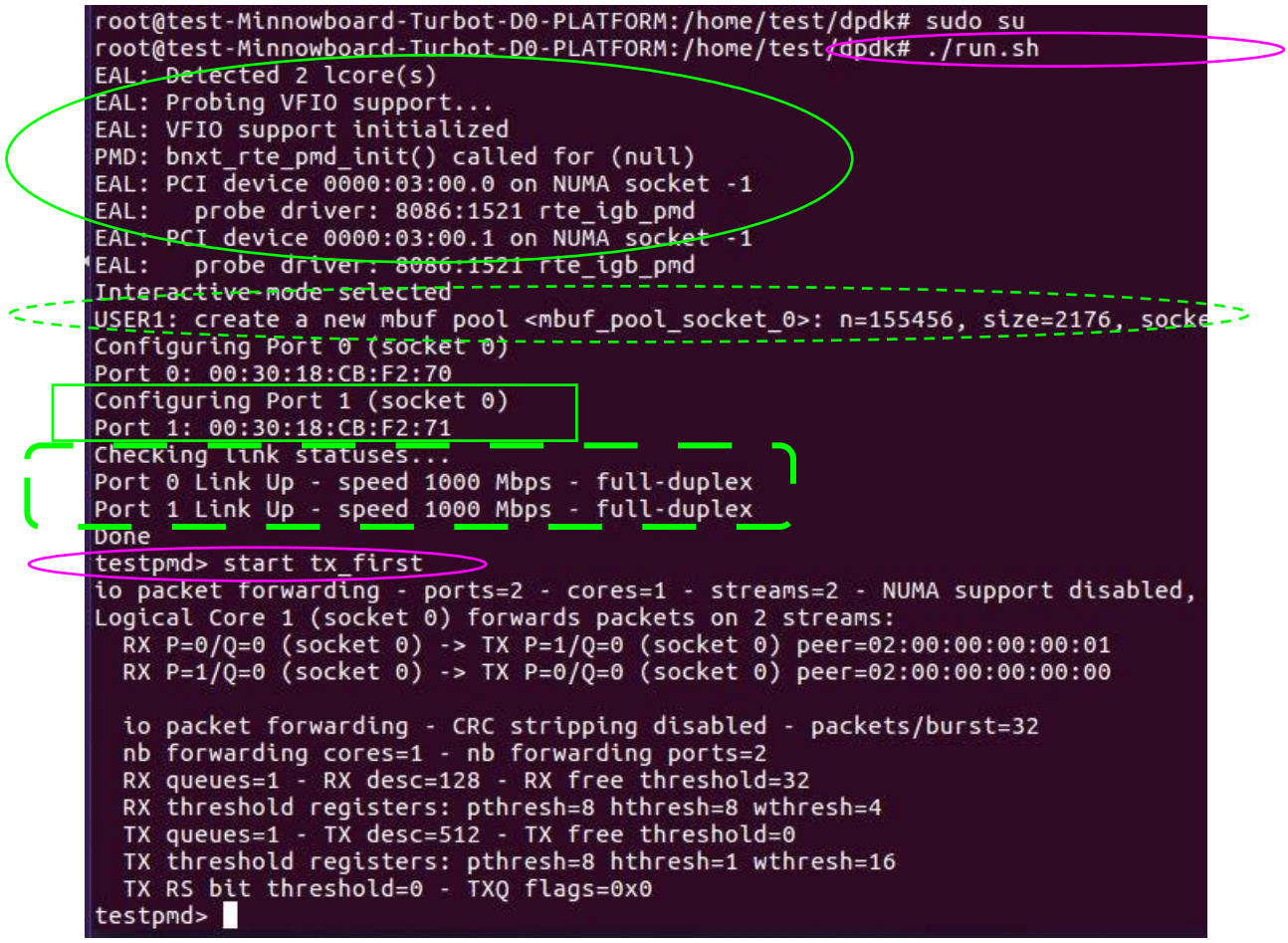
```
root@test-Minnowboard-Turbot-D0-PLATFORM: /home/test/dpdk
test@test-Minnowboard-Turbot-D0-PLATFORM:~$ sudo su
[sudo] password for test:
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# pwd
/home/test
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# ls
Desktop    Downloads  examples.desktop  Pictures  Templates
Documents  dpdk       Music             Public    Videos
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# cd dpdk/
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk# ls
app          doc          lib           Makefile  run.sh
build        drivers      LICENSE.GPL   mk        scripts
buildtools   examples     LICENSE.LGPL  pkg       tools
config       GNUmakefile  MAINTAINERS   README    x86_64-native-linuxapp-gcc
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk# ./run.sh
```

./run.sh starts testpmd, as shown below, yielding the testpmd prompt. Look at the flowchart. What does the initial portion of testpmd do? And what does the runtime portion of testpmd do? Our next step is to initialize testpmd.

Initialization

Initialization consists of 3 steps as shown below.

1. EAL (Environment Abstraction Layer) – Find the number of cores and probe PCI devices
2. Initialize memory zones and memory pools
3. Configure the ports for data path operation



Operation

After initialization, data path operations start and continue in a loop. The poll mode driver section of the DPDK Programmer's Guide is a must-read chapter. It will help you understand and appreciate how you can get the juice out of your system and achieve the desired throughput.

Optimization Knobs You Should Understand

You may want to read through the documentation to fully understand the optimization knobs like those shown in the last paragraph of the output from the **start tx_first** command.

For example, you can note that the RX descriptor counts are 128 whereas the TX desc descriptors are shown as 512. Why are they not equal? And why is the TX descriptor four times that of RX descriptor? Also, analyze the values indicated for the RX threshold registers: pthresh = 8, hthresh = 8, and wthresh = 4; whereas for the TX registers: pthresh = 8, hthresh = 1, and wthresh = 16.

Reading the data sheet, and more importantly the optimization whitepapers of the Intel® 82599 NIC, at least the Receive and Transmit sections, will help you to understand and make the best use of your knobs. Download information here.

Running testpmd Using tx_first Option

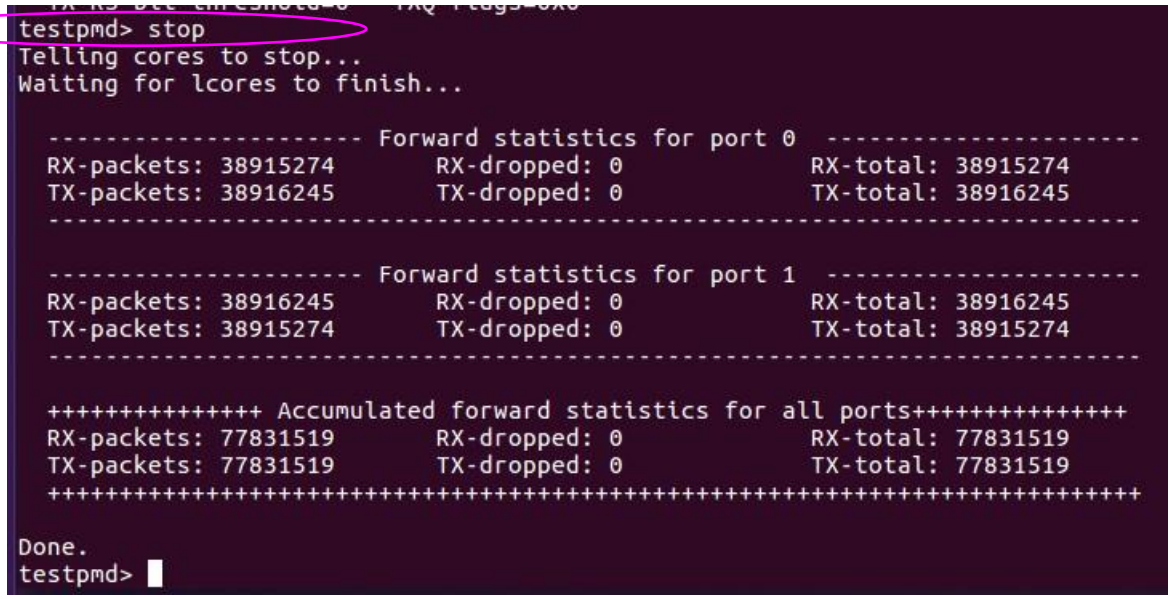
testpmd> `start tx_first`

As shown above, at the **testpmd>** prompt, enter `start tx_first` to auto-generate the traffic. Packets are transmitted when the **testpmd>** command returns. Please note that packets continue to be generated until they are stopped.

In this case, let it run for 10 to 20 seconds, and then stop the run.

testpmd> `stop`

Below you can see the RX and TX total packets per port as well as accumulated totals for both ports.



Learn More About testpmd

Use `-h` or `--help` to find the available command-line options and thus the available functionality of testpmd.

It is highly recommended that you learn hands-on the functionalities of interest to you and note them in the Exercise section. Once you are done, quit by using the quit command.

`quit`, as shown below, does the following:

- Stops the ports
- Closes the ports

You can browse the source code of the entire DPDK tree at http://www.dpdk.org/browse/dpdk/tree/.

Quiz

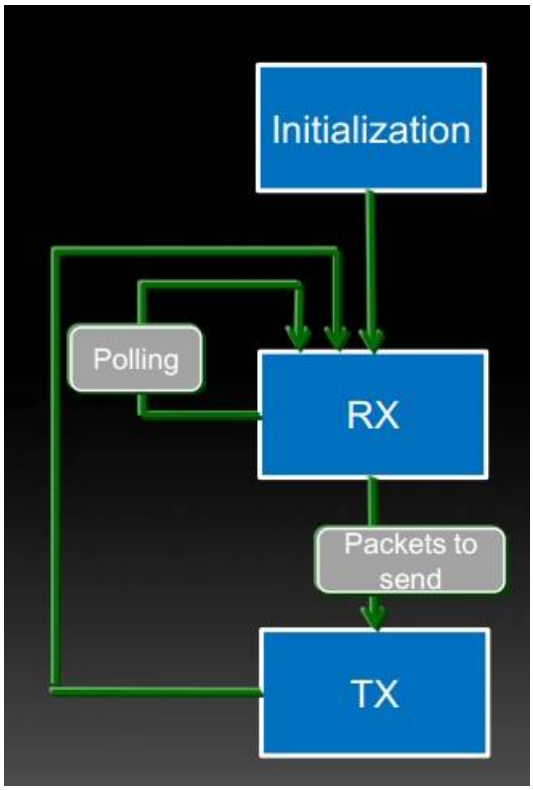
Why is `ifconfig` not showing the NIC ports now (that is, after quitting)?

```
testpmd> quit

Shutting down port 0...
Stopping ports...
Done
Closing ports...
Done

Shutting down port 1...
Stopping ports...
Done
Closing ports...
Done

Bye...
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk# ifconfig
enp2s0    Link encap:Ethernet  HWaddr 00:08:a2:09:f2:1d
          inet addr:192.168.0.6  Bcast:192.168.0.255  Mask:255.255.255.0
          inet6 addr: 2601:647:4902:79c0:249:ce31:c570:85a/64 Scope:Global
          inet6 addr: fe80::a572:b28f:7fd6:5336/64 Scope:Link
          inet6 addr: 2601:647:4902:79c0:6cc6:fc3c:5f31:d114/64 Scope:Global
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:19837 errors:0 dropped:0 overruns:0 frame:0
          TX packets:16896 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:6173309 (6.1 MB)  TX bytes:4888456 (4.8 MB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:5671 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5671 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:523125 (523.1 KB)  TX bytes:523125 (523.1 KB)

root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk#
```

Where are the other ports?

Starting testpmd Without `tx_first`

Below, you can see the flowchart **without tx_first.** RX starts polling first, so in this case you need a traffic generator.



Flowchart for the case of without *tx_first*

We saw that **with tx_first**, TX gets executed first. This emits packets first and before polling, thus auto-generating the traffic. This allowed us to run **testpmd** with traffic in a single platform.

Now, draw the flowchart for **with tx_first**.

Frequently Used Tools and Scripts

Testpmd is the key *stethoscope* for the DPDK developer. In addition, there are other important tools available. Below are some frequently used tools and scripts to study.

./tools/setup.h	Menu driven setup script	In tools subdirectory
./tools/dpdk_nic_bind.py	For binding NIC to driver	In tools subdirectory
./tools/cpu_layout.py	For lcore number & layout	In tools subdirectory
./tools/pmdinfo.py	For pmd info	In tools subdirectory
DPDK Test Suite (DTS)	http://dpdk.org/doc/dts/gsg	Getting Started Guide - DTS

More Scripts in Scripts Subdirectory

Fill in the documentation / description for each script:

Auto-config-h.sh	
Check-git-log.sh	
Check-maintainers.sh	
Checkpatches.sh	
Cocci.sh	
Depdirs-rule.sh	
Gen-build-mk.sh	
Gen-config-h.sh	
Load-devel-config.sh	
Relpath.sh	
Test-build.sh	
Test-null.sh	
Validate-abi.sh	

NIC Key Documentation

The list of supported NICs grows with each new release of DPDK. Please refer to http://dpdk.org/doc/nics for the latest list.

Linux* AF_PACKET socket	Af_packet
Pcap file or kernel driver	Pcap
Ring Memory	ring
Paravirtualization	
Virtio-net*	Virtio-net (QEMU)

Xenvirt*	Xenvirt (Xen)
VMware* ESXi	Vmxnet3 usermap or vmxnet3+uio
Memory NIC	Memnic
Vendors	
Intel® e1000	Intel e1000 (82540, 82545, 82546)
Intel® e1000e	Intel e1000e (82571..82574, 82583, ICH8..ICH10, PCH..PCH2, I217, I218)
Intel® ixb	Intel ixgb (82575..82576, 82580, I210, I211, I350, I354, DH89xx)
Intel® ixgbe	Intel ixgbe (82598..82599, X540, X550)
Intel® I40e	Intel i40e (X710, XL710, X722)
Intel® fm 10k	Intel fm 10K (FM10420)
Amazon ENA*	Ena (Elastic Network Adapter)
Broadcom* bnxt	Bnxt (NetXtreme-C, NetXtreme-E)
Cavium*	Thunderx (CN88XX)
Chelsio*	Cxgbe (Terminator 5)
Cesnet*	Szedata2 (COMBO-80G, COMBO-100G)
CISCO*	Enic (UCS Virtual Interface card)
Emulex*	Oce (OneConnect OCe14000 family)
Mellanox*	Mlx4 (connectX-3, ConnectX-3 Pro), mlx5 (ConnectX-4, ConnectX-4 Lx)
Netronome*	Nfp (NFP-6xxx)
QLogic*	Bnx2x (578xx), qede (FastLinQ QL4xxxx)
Linux* AF_PACKET socket	Af_packet

Key Documentation: Programmers Guide, Sample Applications, Getting Started, and Others

DPDK Quick Start Guide	Simple forwarding test with pcap PMD, which works with any NIC	http://dpdk.org/doc/quick-start
DPDK API Documentation	All libraries and APIs	http://dpdk.org/doc/api/
DPDK Programmers Guide	***The guide you must read first***	http://fast.dpdk.org/doc/pdf-guides/
DPDK Sample Applications Users Guide	More than 40 sample applications – find closest match to your application	
DPDK Testpmd application usage Guide	The key DPDK tool with port, NIC set, and show commands	
DPDK Release Notes	Latest features, issues addressed in past, issues to be addressed in future	
DPDK Linux Getting Started Guide	Build, install and Getting Started	
DPDK How To Guide	1) Live Migration of VM with SR-IOV VF	

	2) Live Migration of VM with Virtio on host running vhost_user 3) Flow Bifurcation How-to Guide	
DPDK Crypto Device Guide	1) Crypto Device Supported Functionality Matrices 2) AESN-NI Multi Buffer Crypto Poll Mode Driver 3) AES-NI GCM Crypto Poll Mode Driver 4) KASUMI Crypto Poll Mode Driver 5) Null Crypto Poll Mode Driver 6) SNOW 3G Crypto Poll Mode Driver 7) Quick Assist Crypto Poll Mode Driver	
Frequently Asked Questions	FAQ	
NIC Drivers Guide	Polled mode driver for all the NICs – Virtual as well as physical NICs from various vendors listed in the table above	
DPDK Free BSD Getting Started Guide	DPDK FreeBSD Linux GSG	
DPDK Xen Guide	DPDK Xen guide for latest release	
Do you want to contribute code and/or documentation to DPDK community?	DPDK contributing guide	

Frequently Used Commands / Scripts

cat /proc/meminfo	Memory – for huge page	See below for screenshots showing usage
./setup.sh	Build, bind, set huge page and other functions script	
./dpdk_nic_bind.py	NIC binding to kernel / DPDK driver	
./cpu_layout.py	Lcore layout for affinity optimization	

Finding Memory Information with Linux Command

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test# cat /proc/meminfo
MemTotal:        1939152 kB
MemFree:          155892 kB
MemAvailable:     209044 kB
Buffers:           12068 kB
Cached:           309116 kB
SwapCached:        14196 kB
Active:           518824 kB
Inactive:         465260 kB
Active(anon):     407424 kB
Inactive(anon):   404812 kB
Active(file):     111400 kB
Inactive(file):    60448 kB
Unevictable:          32 kB
Mlocked:              32 kB
SwapTotal:       1986556 kB
SwapFree:        1557500 kB
Dirty:                 0 kB
Writeback:             0 kB
AnonPages:        655444 kB
Mapped:           147228 kB
Shmem:            149336 kB
Slab:              53084 kB
SReclaimable:      25100 kB
SUnreclaim:        27984 kB
KernelStack:        7392 kB
PageTables:        30136 kB
NFS_Unstable:          0 kB
Bounce:                0 kB
WritebackTmp:          0 kB
CommitLimit:     2615140 kB
Committed_AS:    4444120 kB
VmallocTotal:   34359738367 kB
VmallocUsed:           0 kB
VmallocChunk:          0 kB
HardwareCorrupted:     0 kB
AnonHugePages:    215040 kB
CmaTotal:              0 kB
CmaFree:               0 kB
HugePages_Total:     333
HugePages_Free:        0
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       2048 kB
DirectMap4k:       95824 kB
DirectMap2M:     1892352 kB
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test#
```

Finding Huge Page Information with ./setup.sh

./setup.sh in directory **/home/test/dpdk/tools** has an option to list huge page information from **/proc/meminfo** (option 29 in this version of DPDK).

```
------------------------------------------------------------
 Step 4: Other tools
------------------------------------------------------------
[29] List hugepage info from /proc/meminfo

------------------------------------------------------------
 Step 5: Uninstall and system cleanup
------------------------------------------------------------
[30] Unbind NICs from IGB UIO or VFIO driver
[31] Remove IGB UIO module
[32] Remove VFIO module
[33] Remove KNI module
[34] Remove hugepage mappings

[35] Exit Script

Option: 29

AnonHugePages:    198656 kB
HugePages_Total:     256
HugePages_Free:        0
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       2048 kB

Press enter to continue ...
```

Binding/ Unbinding NIC with ./dpdk_nic_bind.py

```
Examples:
---------

To display current device status:
        dpdk_nic_bind.py --status

To bind eth1 from the current driver and move to use igb_uio
        dpdk_nic_bind.py --bind=igb_uio eth1

To unbind 0000:01:00.0 from using any driver
        dpdk_nic_bind.py -u 0000:01:00.0

To bind 0000:02:00.0 and 0000:02:00.1 to the ixgbe kernel driver
        dpdk_nic_bind.py -b ixgbe 02:00.0 02:00.1
```

Finding CPU layout – with ./cpu_layout.py

CPU info can also be found with DPDK Script **./cpu_layout.py** in /home/test/dpdk/tools

```
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk/tools# ls
cpu_layout.py  dpdk_nic_bind.py  pmdinfo.py  setup.sh
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk/tools# ./cpu_layout.py
============================================================
Core and Socket Information (as reported by '/proc/cpuinfo')
============================================================

cores =  [0, 2]
sockets =  [0]

       Socket 0
       --------
Core 0 [0]
Core 2 [1]
root@test-Minnowboard-Turbot-D0-PLATFORM:/home/test/dpdk/tools#
```

Exercises

1. ***tx_first*** auto generates traffic. How are the parameters of the traffic programmed in this case?
2. You saw the flowchart for the case of **without *tx_first***. Draw the flowchart for the case ***with tx_first***.
3. Note each command-line option and functionality you tried with **testpmd**, and list what you learned about each one, with any suggestions you may have.
4. What is the difference between detaching a port and closing a port? Where will you use detaching a port? Where will you use closing a port?
5. What is the difference between **dpdk_nic_bind** and **dpdk-devbind.py**? Explain.
6. On the mailing list of dpdk.org and/or on the Internet, analyze the root cause and find the solution for the error, “Note that the uio or vfio kernel modules to be used, should be loaded into the kernel before running the dpdk-devbind.py script.”

Build Your Own DPDK Packet Framework with DPDK-In-A-Box

Introduction

The title of this module might as well be “Build Your Own “Software Defined” DPDK Application”. DPDK Packet Framework is a modular building block approach, defined by configuration file, to build complex DPDK applications. For an overview of the value of the DPDK Packet Framework, watch the short video Deep Dive into the Architecture of a Pipeline Stage before you get started with this module.

Here you will build a DPDK packet Framework with just 2 cores – one doing master core functionality and one doing DPDK application functionality.

For hardware, you can use any Intel® Architecture (IA) platform– Intel® Xeon® brand desktop, server or laptop. We will use DPDK -in-a-Box here. This is a low cost portable platform based on Intel® Atom™ Processor E3826.

To build your own DPDK-in-a-Box, please see the first module in this cookbook, Build Your Own DPDK Traffic Generator – DPDK-In-A-Box.

Setting Correct MAC Addresses for DPDK Traffic Generator

If you remember when we built a DPDK Traffic Generator, the configuration file of the DPDK traffic generator was set with its own port’s MAC Addresses since we looped the ports within themselves.

Since here we are connecting them to external DPDK packet Generator, we will set the MAC addresses in the DPDK traffic generator to match the external system that will run the DPDK packet framework.

It is left as an exercise for the developers to find out the MAC address and set the traffic generator configuration file with them.

Updating configuration file for DPDK Packet Framework

The DPDK packet framework configuration files provide a “software defined” modular way to implement complex DPDK applications. If your system has multiple lcores available for packet processing, you can implement both run time completion as well as pipelined applications. Here since we have only 1 core for packet processing with DPDK-in-a-box, we will showcase run to completion implementation.

Building and installing DPDK Packet Framework

We’ll now go through the steps for building and installing DPDK packet Framework, as described in the DPDK sample application user’s guide.

Running the traffic through DPDK Packet Framework

Connect the systems together. Provide the command line option of the traffic generator continuously (this was part of the exercise in the traffic generator building cookbook section). This runs the traffic through DPDK packet Framework.

Run Your Application that is Software Defined by Packet Framework

- Run your application that is Software Defined by Packet Framework.
- Use Profilers to find out where CPU is spending most of the cycles and if it is in line with your expectation.
- Write up your observations and share with the community in dpdk.org

Summary

Application developers will benefit understanding DPDK assumptions on roles / responsibilities of applications. They need to comprehend the scope of DPDK's roles / responsibilities to begin with. This will help them to rightly architect from the get-go obeying DPDK's assumptions in terms of thread safety, lockless API call usage, multiprocessor synchronization and control plane & data plane synchronization.

Exercise

1. Draw your software defined application block diagram

DPDK Data Plane – Multicores and Control Plane Synchronization

Introduction

Many developers and customers are under the impression that DPDK documentation and sample applications only provide Data Plane Applications. In real life scenario, one has to integrate multiple planes – Data Plane, Control and management plane. The purpose of this cookbook is to benefit the users in giving pointers for these needs.

For hardware, you can use any Intel® Architecture (IA) platform– Intel® Xeon® brand desktop, server or laptop. We will use DPDK -in-a-Box here. This is a low cost portable platform based on Intel® Atom™ Processor E3826.

To build your own DPDK-in-a-Box, please see the first module in this cookbook, Build Your Own DPDK Traffic Generator – DPDK-In-A-Box.

Simple Scenarios - Data Plane & Control Plane Interactions

Every product / appliance will have its own share of Data Plane functionality and Control Plane functionality. Here we will illustrate with two simple scenarios – during run time 1) Needing to change the configuration of the NIC port and 2) Needing to change the port itself.

Scenario 1: Change of Hardware

Now multiple cores in servers, as much as 72 lcores (lcore stands for logical core). working with multiple NIC ports, all in parallel doing packet processing, how to in runtime doing these control plane operations in synchronous with Data Plane? What are the things to understand and play by the rules of the game that DPDK assumes and dictates?

What synchronizations needs exist to pull out a transceiver and insert it again – during runtime?

Likewise to pull out a transceiver, say 10 Gig and insert a completely different one, say 1 Gig?

If change of hardware device needs releasing previous instance of the device that was removed and creating new instance, what to do with threads that are still accessing the data structures of original instance?

Releasing the resources needs co-ordination with the users of those resources – which are user space applications. Users can be single core or multiple cores. So, if the resource that is getting released can be used by multiple cores, then we need to have request – acknowledge handshake from ALL the cores, not just one core, indicating they are done with the resource usage and now it can be released safely.

Scenario 2: No Change of Hardware but Change of Parameter

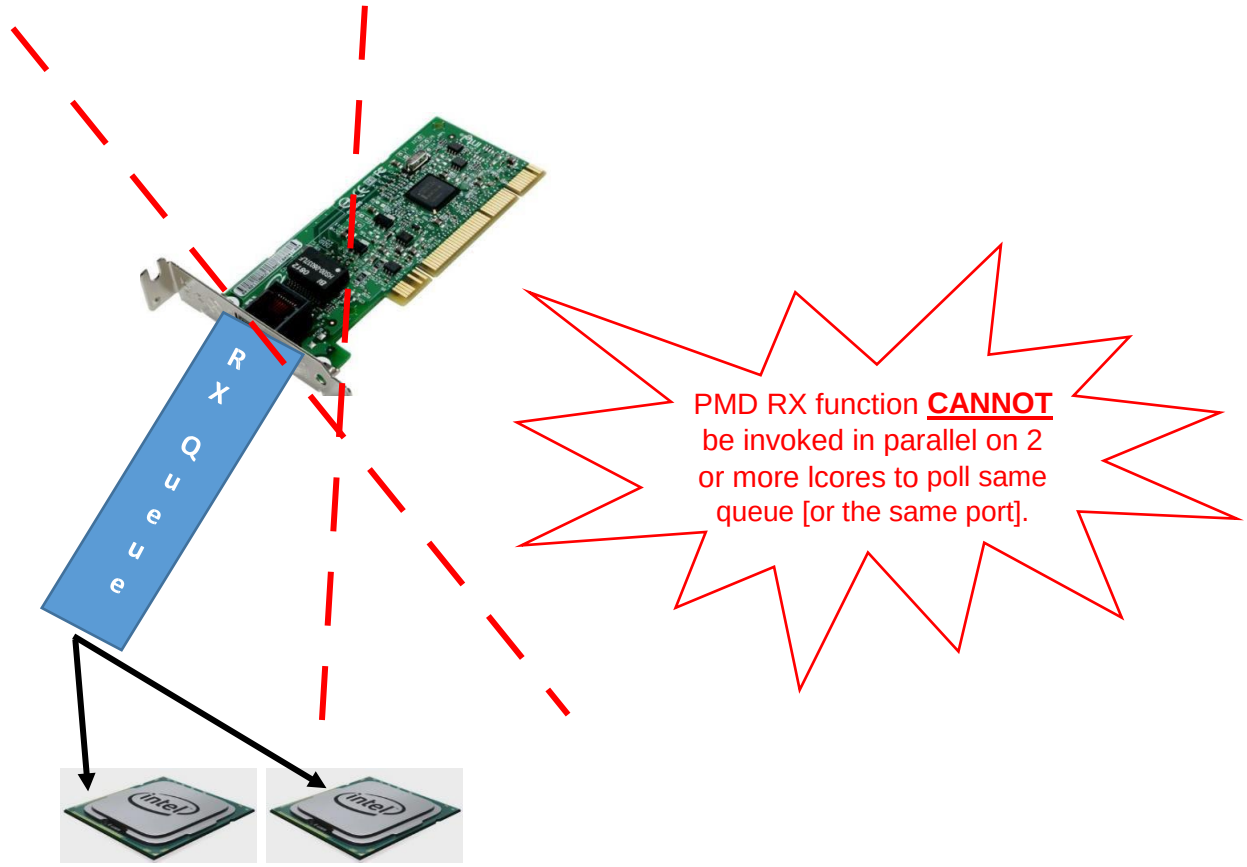
Assume you are not changing any hardware during runtime. But, during runtime, you want to change some global parameter – say MTU. This may be “light weight” initialization compared to the previous case of “heavy weight” initialization. So, when you use APIs that do “light weight initialization” what are the parameter that are persistent across and which parameters you can’t assume remaining same? These are very useful information to know so you can correctly during runtime change parameters.

Please note that this is only part of the story. The other part is synchronizing with the data plane applications that are running – as “the waiting part for resource usage done” so that APIs to reconfigure can be called. We will look at that and refer to pointers available in DPDK documentation and source code.

Before we get into these details, let us step back and look at big picture as what are the core assumptions DPDK makes in terms of concurrency and what are the boundaries and responsibilities between the application and DPDK.

Can Multiple Cores Poll One RX Queue Simultaneously?

By design, the receive function of a PMD **CANNOT** be invoked in parallel on multiple, i.e., two or more logical cores to poll the same RX queue [of the same port]. What is the benefit of this assumption? The benefit is all the functions of the Ethernet Device API exported by a PMD are lockfree functions. This is possible because it assumes not to be invoked in parallel on different logical cores to work on the same target object.



In the case of single RX queue per port, only one core can do RX processing per port.

When you have multiple RX queues per port, each queue of the same port can at the maximum polled by one lcore. Thus if you have 4 RX queues per port, you can have 4 cores per port simultaneously polling the port with the configuration of 1 core per queue.

Can you have 8 cores per port with 4 RX queues per port? No, since that puts more than 1 core per RX queue.

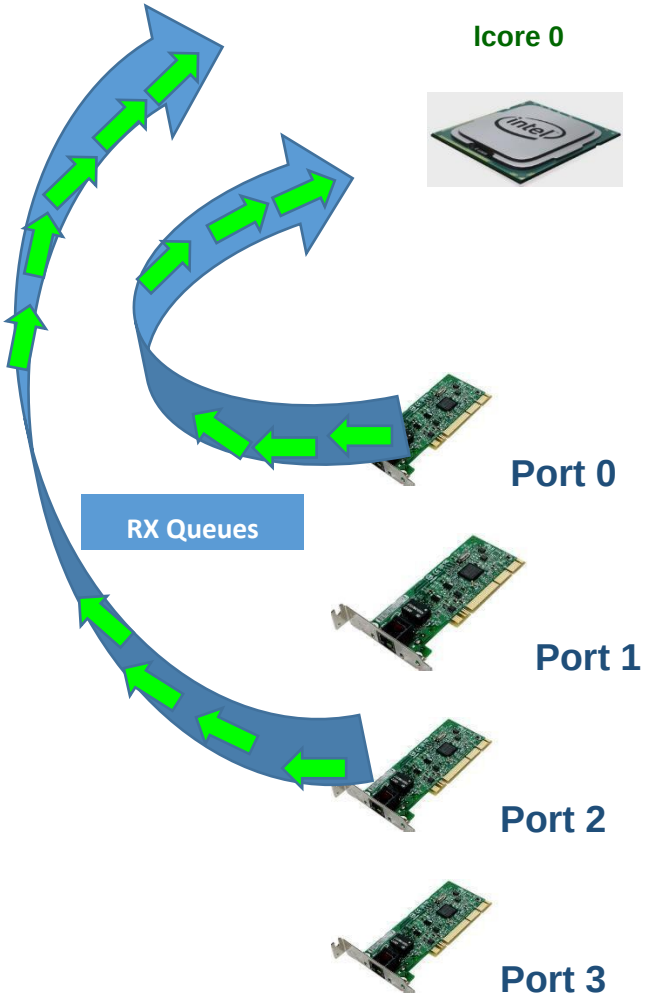
Can you have 4 cores per port with 8 RX queues per port? We can only answer this question by knowing full configuration details. Even though you have more RX queues than cores, if you have configured 2 cores for any single RX queue, that is not allowed. The key is not having more than one core per any RX queues irrespective of more queues in total available compared to number of cores.

Can One lcore poll multiple RX Queues?

Yes. One lcore can poll multiple RX Queues. What is the maximum number of RX Queues that one lcore can poll? That depends on performance requirements and how much headroom should be available for applications after servicing that many queues. Packet size and packets arrival rate also constrain the cycle budget available on the core.

Note that with the port numbering in the system, one lcore can poll multiple RX Queues that need not be necessarily consecutive. This is clear from the figure below. Lcore 0 polls RX Queue 0 and Rx Queue 2. It does not poll RX Queue 1 and RX Queue 3.

One lcore polling multiple RX Queues



Who is responsible for mutual exclusion so that multiple cores don't work on same Receive Queue?

One line answer is – You – the application developer. Since application developer should take care of this, all the functions of the Ethernet Device API exported by a PMD are lock-free functions which assume to not be invoked in parallel on different logical cores to work on the same target object.

For instance, the receive function of a PMD cannot be invoked in parallel on two logical cores to poll the same RX queue [of the same port].

Of course, this function can be invoked in parallel by different logical cores on different RX queues.

Thus please note and be aware that it is the responsibility of the upper level application to enforce this rule.

If you proceed without architecting with these scope in mind and let multiple cores step on each other in accessing the device, you will get segmentation errors and crashes for sure – since DPDK goes with lockless accesses for high performance and assumes you, as a higher level application developer, ensures that multiple cores do not work on same receive Queue.

What if your design needs multiple cores to share queues?

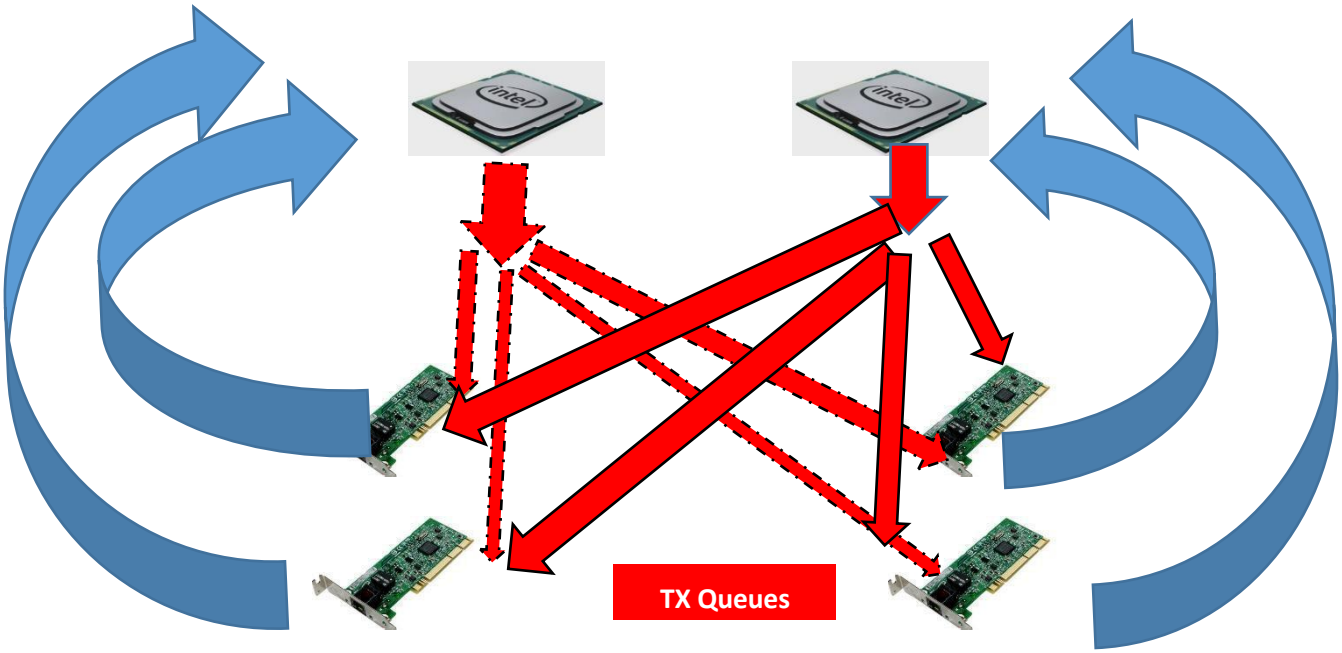
If needed, parallel accesses by multiple logical cores to shared queues shall be explicitly protected by dedicated inline lock-aware functions built on top of their corresponding lock-free functions of the PMD API.

TX Port: Why should each core be able to transmit on each and every Transmit Port?

Question: While we saw in RX Queue, a lcore can only poll a subset of RX ports, what about TX ports? Can a lcore only get connected to the subset of TX ports in the system? Or should each and every lcore has to get connected to all TX ports in the system?

Reasoning & Answer: A forwarding operation running on a lcore may result in a packet destined to *any* TX port in the system. Because of this, each lcore should be able to transmit to each and every TX port in the system.

Key Difference between RX & TX: This is different from the RX side where a subset of RX ports can be handled by a lcore and other RX ports can be handled by other lcores.



While Data Plane can be parallel, Control Plane is Sequential

Control plane operations like “device configuration” and “queues (RX & TX) setup” and “device start” depend on certain sequence to be followed. Hence they are sequential.

If I can do parallel processing of TX / RX, what about configuration and Setting up a Device? – Is there any particular Sequence required?

To set up the device, the following is the sequence required.

```
rte_eth_dev_configure()
rte_eth_tx_queue_setup()
rte_eth_rx_queue_setup()
rte_eth_dev_start()
```

After that, the network application can invoke, in any order, the functions *exported by the Ethernet API to get the MAC address of a given device, to * get the speed and the status of a device physical link, to receive/transmit, [burst of] packets, and so on.

Summary

Application developers will benefit understanding DPDK assumptions on roles / responsibilities of applications. They need to comprehend the scope of DPDK’s roles / responsibilities to begin with. This will help them to rightly architect from the get-go obeying DPDK’s assumptions in terms of thread safety, lockless API call usage, multiprocessor synchronization and control plane & data plane synchronization.

Next Steps

Architect couple of your own usage models of data plane co-existing with control plane/management plane. Look for similar approaches that are used by 1) Testpmd and other 2) “how to DPDK usage guide”. Test them out

Exercises

1. Can you have 8 cores per port with 4 RX queues per port?
2. Can you have 4 cores per port with 8 RX queues per port?
3. What are the implications of multiple cores transmitting on one Transmit Port - in terms of control plane and data plane synchronization?
4. Control plane operations – should it be done in Interrupt context itself or as a deferred procedure?”

DPDK Performance Optimization Guidelines White Paper

Abstract

This paper illustrates best-known methods and performance optimizations used in the Data Plane Development Kit (DPDK). DPDK application developers will benefit by implementing these optimization guidelines in their applications. A problem well stated is a problem half-solved, thus the paper starts with profiling methodology to help identify the bottleneck in an application. Once the type of bottleneck is identified, this paper will help developers determine the optimization mechanism that DPDK uses to overcome such bottleneck. Specifically, the paper refers to the respective sample example application and code snippet that implements corresponding performance optimization technique. The paper concludes with a checklist flowchart that DPDK developers and users can use to ensure they follow the guidelines given here.

For cookbook-style instructions on how to do hands-on performance profiling of your DPDK code with VTune, refer to the module Profiling DPDK Code with Intel® VTune™ Amplifier.

The Strategy and Methodology

A chain is really only as strong as its weakest link. So the strategy is to use profiling tools to identify the hotspot in the system. Once the hotspot is identified, the corresponding optimization technique is looked up for the sample application and code snippet as how it is already solved and implemented in the DPDK. Developers at this stage will implement those specific optimization techniques in their application. They can run respective micro-benchmarks and unit tests on applications provided with the DPDK.

Once the particular hotspot has been addressed, the application is again profiled to find the current hotspot in the system. The above methodology is repeated to the point of satisfaction in terms of achieving desired performance.

The performance optimization involves a gamut of considerations shown in the checklist below:

1. Optimize the BIOS settings.
2. Efficiently partition NUMA resources with improved locality in mind.
3. Optimize the Linux* configuration.
4. To validate the above setup, run *L3-fwd*—as is with default settings—and compare with published performance numbers.
5. Run micro-benchmarks to pick and choose optimum high-performance components (for example,**bulk enqueue/bulk dequeue** as opposed to single enqueue/single dequeue).
6. Pick a sample application that is similar to the target appliance, using the already fine-tuned optimum default settings ***(for example, more TX buffer resources than Rx***).
7. Adapt and update the sample application (**for example, # of queues).** Compile with the correct level of optimization flags.
8. Profile the chosen sample application in order to have a known good comparison base.
9. Run with optimized command-line options, keeping improved locality and concurrency in mind.
10. How to best match application and algorithm to underlying architecture? Run profiling to find memory bound? I/O bound? CPU bound?
11. Apply the corresponding solution: Software prefetch for memory, block mode for I/O, to hyperthread or not to hyperthread for CPU bound.
12. Rerun profiling – Front-end pipeline stall? Back-end pipeline stall?
13. Apply corresponding solution. Write efficient code—branch prediction, Loop unroll, compiler optimization, and so
14. Still don't have desired performance? (back to #9)
15. Record best-known methods and share in dpdk.org.

Recommended Pre-reading

It is recommended that you read, at a minimum, the DPDK Programmer's Guide, and refer to the DPDK Sample Application User Guide before proceeding.

Please refer to other DPDK documents as needed.

BIOS Settings

DPDK L3fwd performance numbers are achieved with the following BIOS settings. To get repeatable performance, use the following settings:

NUMA	ENABLED
Enhanced Intel® SpeedStep® technology	DISABLED
Processor C3	DISABLED
Processor C6	DISABLED
Hyper-Threading	ENABLED
Intel® Virtualization Technology for Directed I/O	DISABLED
MLC Streamer	ENABLED
MLC Spatial Prefetcher	ENABLED
DCU Data Prefetcher	ENABLED
DCU Instruction Prefetcher	ENABLED
CPU Power and Performance Policy	Performance
Memory Power Optimization	Performance Optimized
Memory RAS and Performance Configuration -> NUMA Optimized	ENABLED

Memory RAS and Performance Configuration -> NUMA Optimized

Please note that if the DPDK power management feature is to be used, Enhanced Intel® SpeedStep® technology must be enabled. In addition, C3 and C6 should be enabled. However, to start with, it is recommended that you use the BIOS settings as shown in the table and run basic L3fwd to ensure that the BIOS, platform, and Linux* settings are optimal for performance.

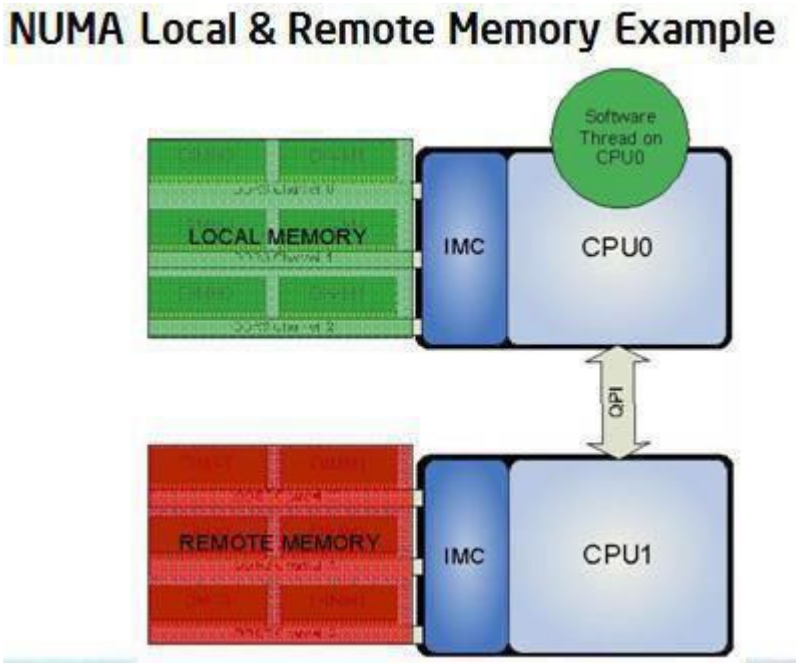
Refer to Intel Document # 557159 titled Intel® Xeon® processor E7-8800/4800 v3 Product Family (code-name Haswell-ex) Performance Tuning Guide for detailed understanding of BIOS setting and performance implications.

Platform Optimizations

Platform optimizations include (1) configuring memory and (2) I/O (NIC Cards) to take advantage of affinity to achieve lower latency.

Platform Optimizations – NUMA & Memory Controller

Below is an example of a multi (dual) socket system. For the threads that runs on CPU0, all the memory accesses going to memory local to socket 0 results in lower latency. Any accesses that cross Intel® QuickPath Interconnect (QPI) to access remote memory (that is, memory local to socket 1) incurs additional latency and should be avoided.

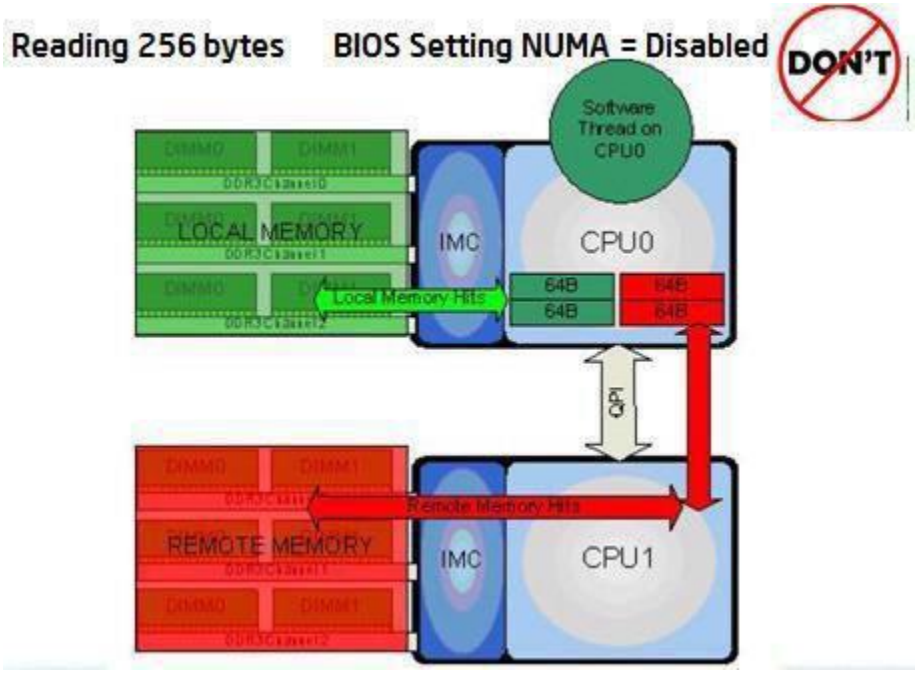


Problem:

What happens when in BIOS NUMA is set to DISABLED? When NUMA is disabled in the BIOS, the memory controller interleaves the accesses across the sockets.

For example, as shown below, CPU0 is reading 256 bytes (4 cache lines). With BIOS NUMA Setting in the DISABLED state, since memory controller interleaves the access across the sockets, out of 256 bytes, 128 bytes are read from local memory and 128 bytes are read from remote memory.

The remote memory accesses end up crossing the QPI link. The impact of this is increased access time for the accesses to the remote memory and the resulting lower performance.

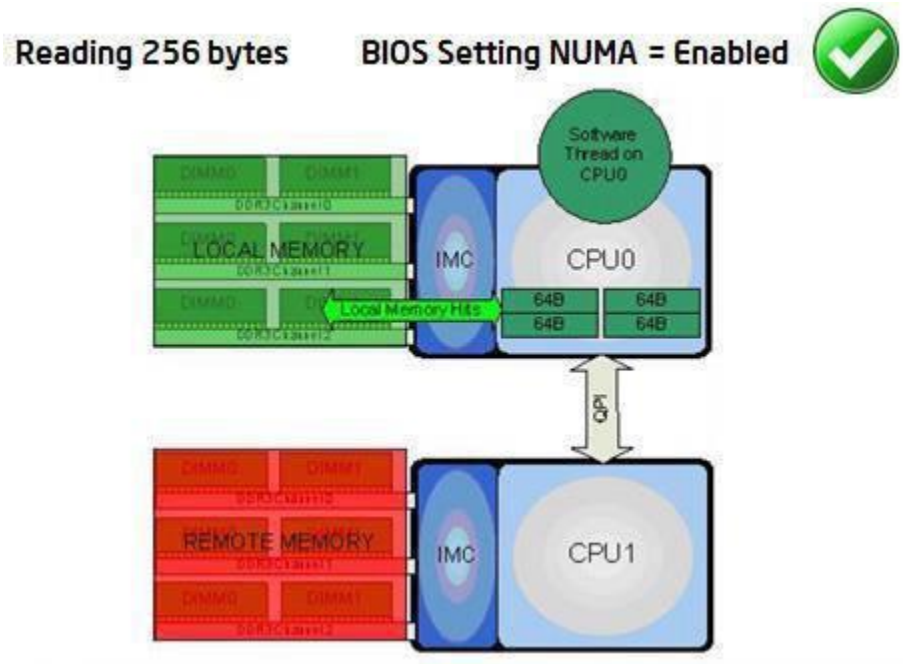


Solution:

As shown below, with BIOS setting NUMA = Enabled, all the accesses go to the same socket (local) memory and there is no crossing of QPI. This results in improved performance because of lower latency of memory accesses.

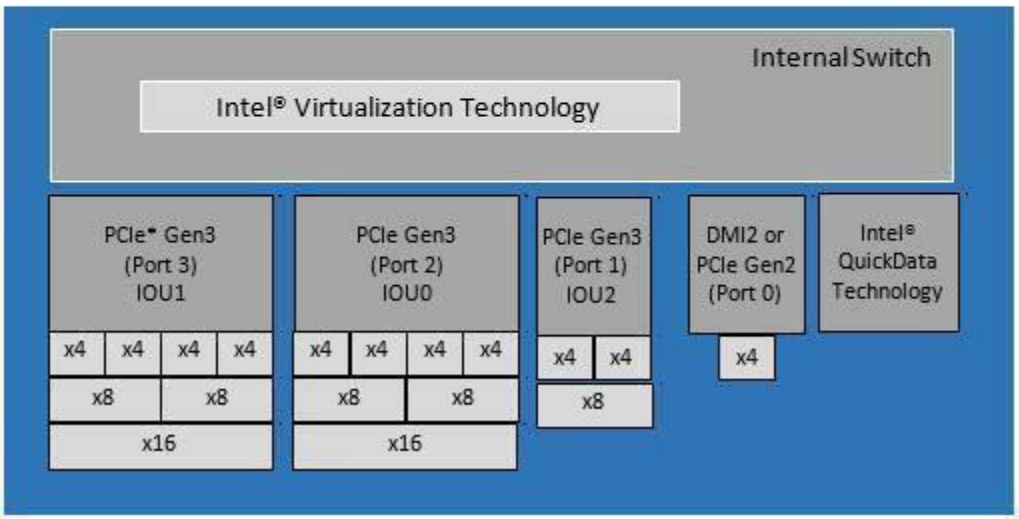
Key Take Away:

Be sure to set NUMA = Enabled in BIOS.



Platform Optimizations – PCIe Layout and IOU Affinity*

	Socket 0			Socket 1			
IOU	IOU-1	IOU-0	IOU-0	IOU-1	IOU-1	IOU-0	IOU-0
Gen3	X8 / x16	x8	x8	x8	x8	x8	x8
Slot	Slot1	Slot2	Slot3	Slot4	Slot5	Slot6	Slot7
Device	SFDA4	X520-SR2	SFDA4	X520-SR2	SFDA4	X520-SR2	SFDA4
	4x10GbE	2x10GbE	4x10GbE	2x10GbE	4x10GbE	2x10GbE	4x10GbE



Linux Optimizations

Reducing Context Switches with isolcpus

To reduce the possibility of context switch, it is desirable to give a hint to the kernel to refrain from scheduling other *user space tasks* on to the cores used by DPDK application threads. ***isolcpus*** Linux kernel parameter serves this purpose. For

example, if DPDK applications are to run on logical cores 1, 2, and 3, the following should be added to the kernel parameter list:

```
isolcpus=1,2,3
```

Note: Even with the *isolcpus* hint, the scheduler may still schedule kernel threads on the isolated cores. Please note that ***isolcpus*** requires a reboot.

Adapt and Update the Sample Application

Now that the relevant sample application has been identified as a starting point to build the end product, the following are the next set of questions to be answered.

Configuration Questions

How to configure the application for best performance?

For example:

- How many queues can be configured per port?
- Can Tx resources be allocated as same size as Rx resources?
- What are the optimum settings for threshold values?

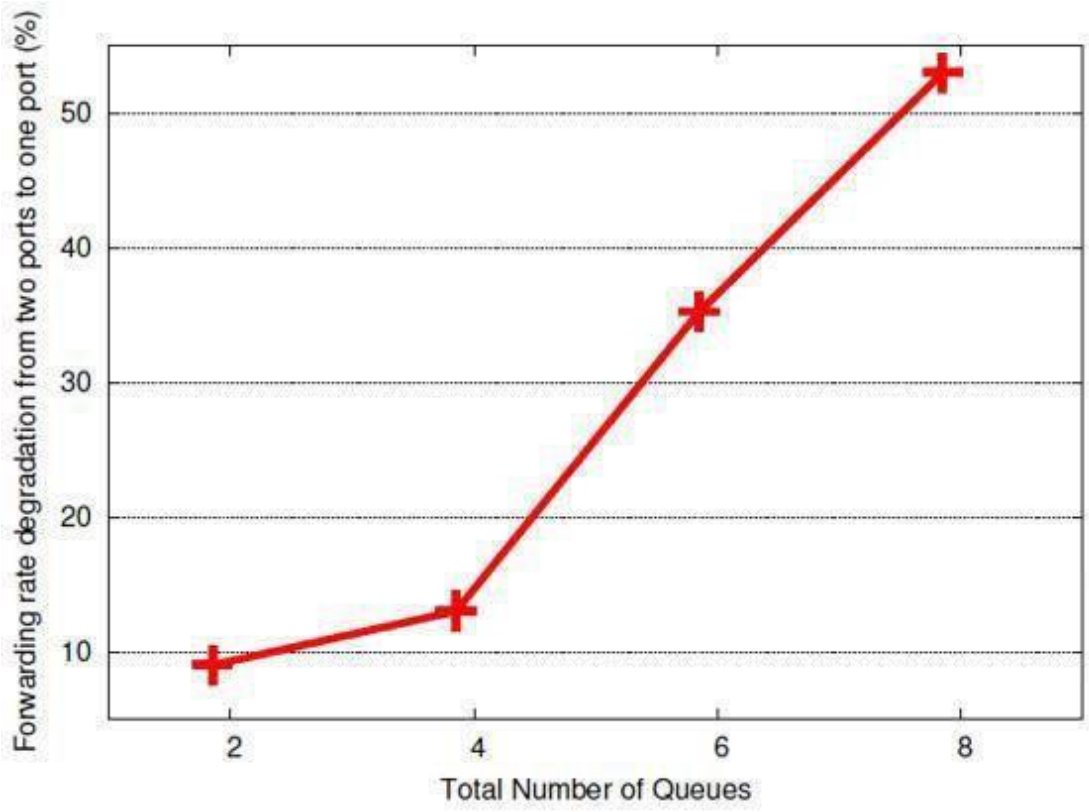
Recommendation: The good news is that the sample application comes with not only optimized code flow but also optimized parameters settings as default values. The recommendation is to use a similar ratio between resources for Tx and Rx. The following are the references and recommendations for Intel® Ethernet Controller 10 Gigabit 82599. For other NIC controllers, please refer to the corresponding data sheets.

How many queues can be configured per port?

Please refer to the white paper Evaluating the Suitability of Server Network Cards for Software Routers for detailed test setup and configuration on this topic.

The following graph (from the above white paper) indicates **not** to use more than 2 to 4 queues per port since the performance degrades with a higher number of queues.

For the best case scenario, the recommendation is to use 1 queue per port. In case more are needed, 2 queues per port can be considered, but not more than that.

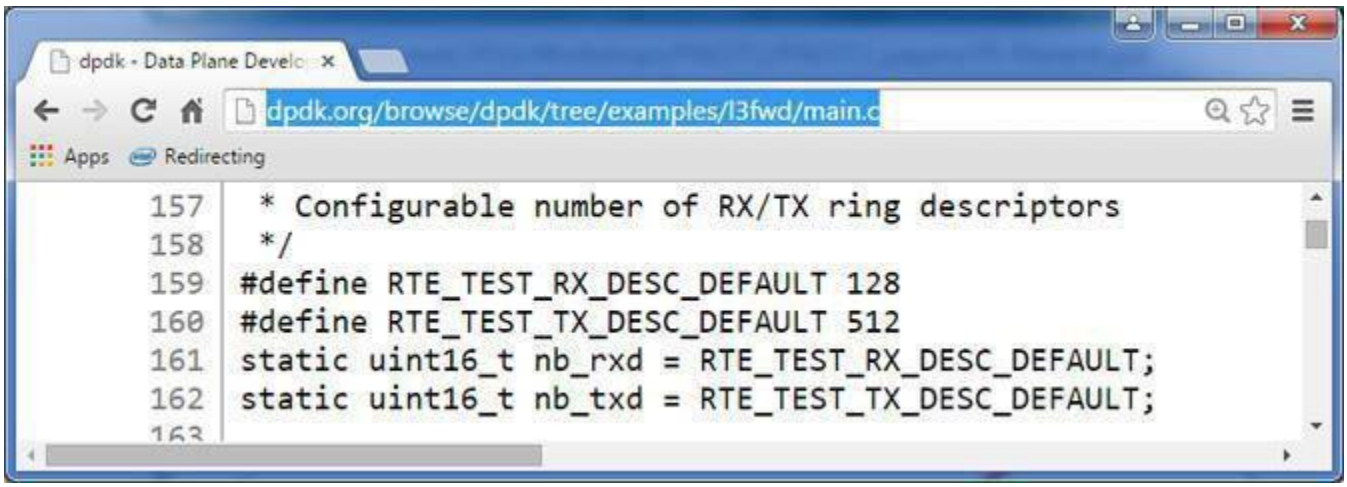


Ratio of the forwarding rate varying the number of hardware queues per port.

Can Tx resources be allocated as same size as Rx resources?

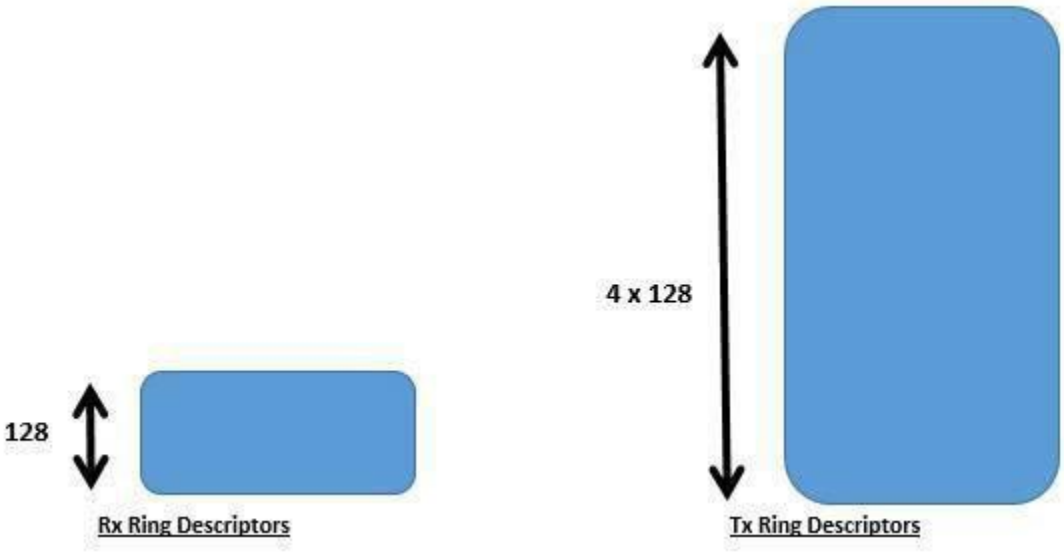
Please use as per the default values that are used in the application. For example for 82599 10 Gig NIC, the default values are not equal. Whereas for XL710, both RX and TX descriptors are of equal size.

82599 10 Gig NIC: It is a natural tendency to allocate equal-sized resources for Tx and Rx. However, please note that http://dpdk.org/browse/dpdk/tree/examples/l3fwd/main.c shows that optimum default size for number of Tx ring descriptors is 512 as opposed to Rx ring descriptors being 128. Thus the number of Tx ring descriptors is 4 times that of the Rx ring descriptors.

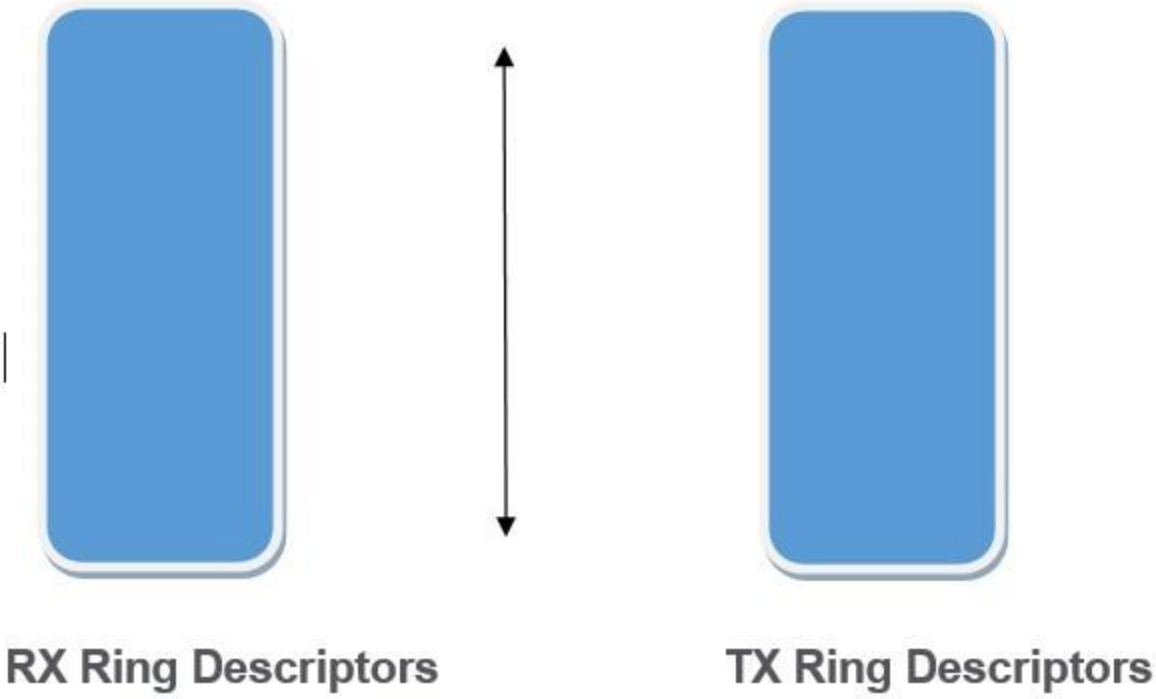


The recommendation is to choose Tx ring descriptors 4 times that of the Rx ring descriptors and not to have them both equal size. The reasoning for this is left as an exercise for the readers to find out.

For 82599 10 Gig NIC

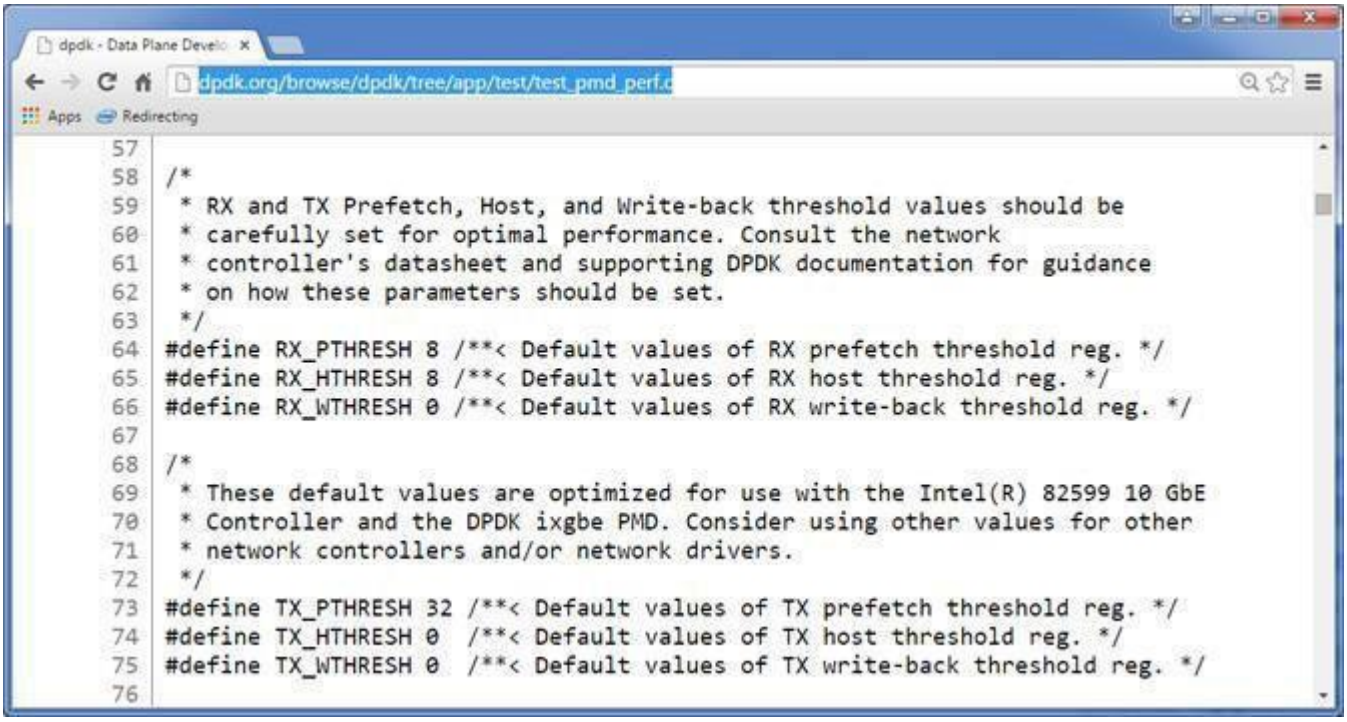


However, for XL710 NIC [Equal Size RX and TX Descriptors]



What are the optimum settings for threshold values?

For instance, http://dpdk.org/browse/dpdk/tree/test/test/test_pmd_perf.c has the following optimized default parameters for the Intel Ethernet Controller 10 Gigabit 82599.



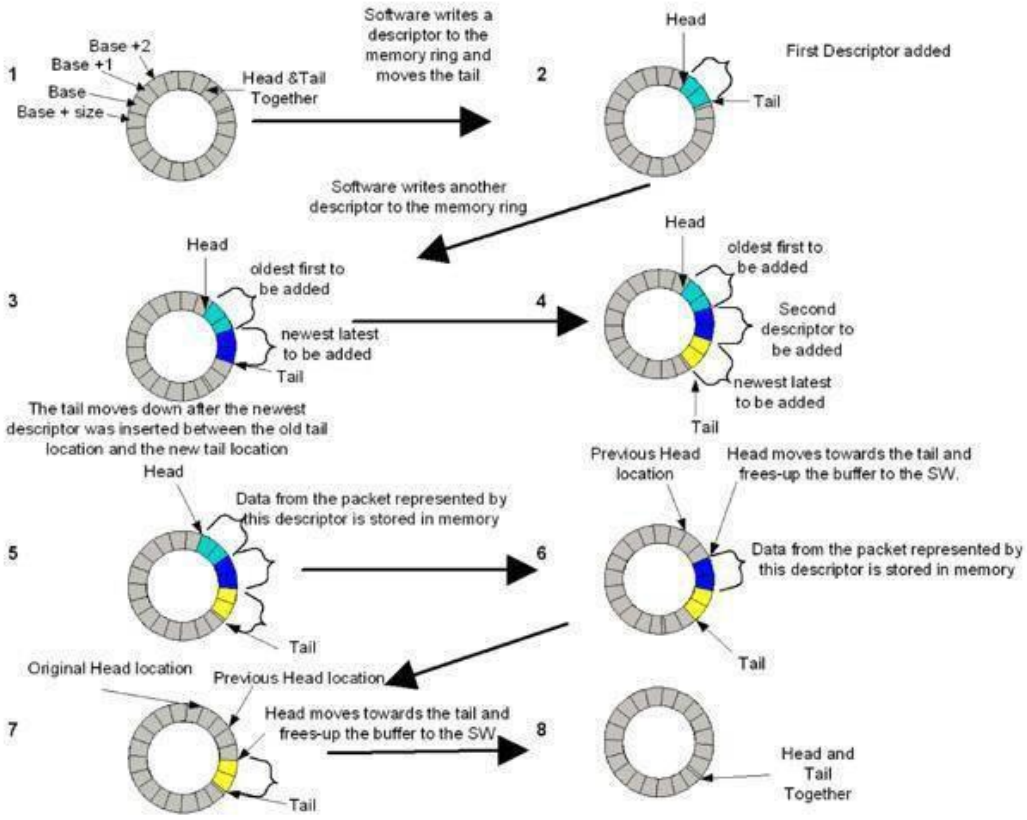
Please refer to [Intel Ethernet Controller 10 Gigabit 82599 data sheet] for detailed explanations.

Rx_Free_Thresh - A Quick Summary and Key Takeaway: The key takeaway is amortization of the cost of PCIe operation (in updating the hardware register) is done by processing batches of packets (before updating the hardware register).

Rx_Free_Thresh - In Detail: As shown below, communication of packets received by the hardware is done using a circular buffer of packet descriptors. There can be up to 64K-8 descriptors in the circular buffer. Hardware maintains a shadow copy that includes those descriptors completed but not yet stored in memory.

The “Receive Descriptor Head register (RDH)” indicates the in-progress descriptor.

The “Receive Descriptor Tail register (RDT)” identifies the location beyond the last descriptor that the hardware can process. This is the location where software writes the first new descriptor.



During runtime, the software processes the descriptors and upon completion of descriptors, increments the Receive Descriptor Tail registers. However, updating the RDT after each packet has been processed by the software has a cost, as it increases PCIe operations.

Rx_free_thresh represents the maximum number of free descriptors that the DPDK software will hold before sending them back to the hardware. Hence, by processing batches of packets before updating the RDT, we can reduce this PCIe cost of this operation.

Fine-tune with the parameters in the rte_eth_rx_queue_setup ( ) function for your configuration

```
1 ret =
  rte_eth_rx_queue_setup(portid,
  0, rmnb_rxd,
2 socketid, &rx_conf, 3
  mbufpool[socketid]);
```

Compile with the correct optimization flags

Apply the corresponding solution: Software prefetch for memory, block mode for I/O, to hyperthread or not to hyperthread for CPU bound applications.

Software prefetch for memory helps to hide memory latency and thus improves memory bound tasks in data plane applications.

PREFETCHW: ***Prefetch data into cache in anticipation of write:*** PREFETCHW, a new instruction from Haswell onward, helps optimizing to hide memory latency and improves network stack. PREFETCHW prefetches data into cache in anticipation of a write.

PREFETCHWT1: *Prefetch hint T1 (temporal L1 cache) with intent to write*: PREFETCHWT1, a new instruction from Haswell onward, fetches the data to a location in the cache hierarchy specified (T1 => temporal data with respect to first level cache) by an intent to write a hint (so that data is brought into 'Exclusive' state via a request for ownership) and a locality hint.

T1 (temporal data with respect to first-evel cache) – prefetches data into the second level cache.

For more information about these instructions refer to the Intel® 64 and IA-32 Architectures Developer's Manual.

Running with optimized command-line options

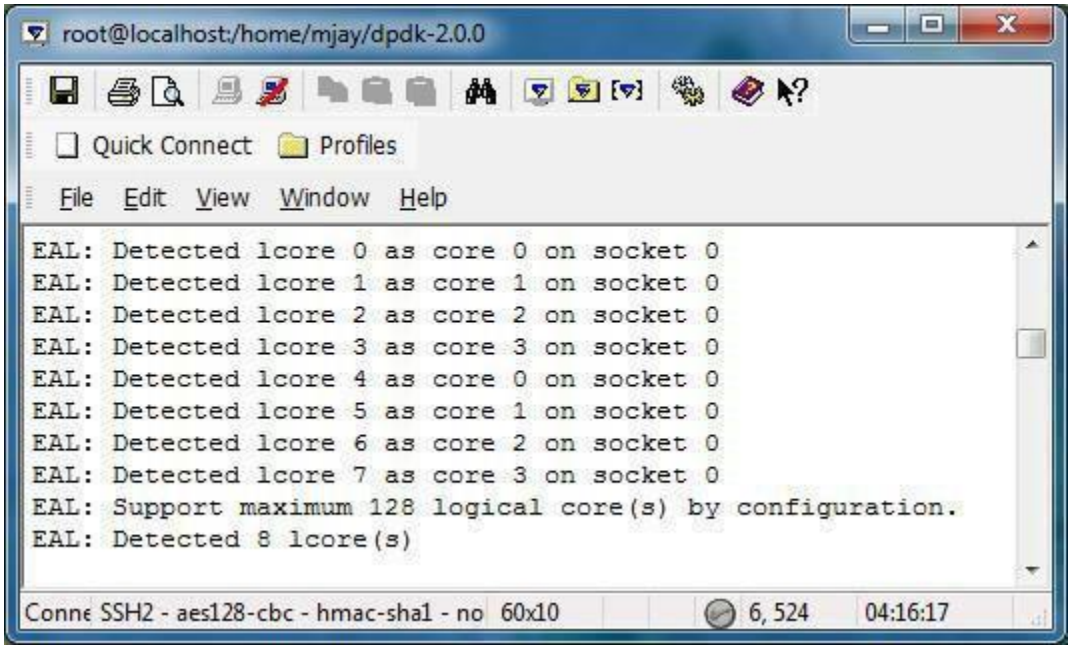
Optimize the application using command line options to improve affinity, locality, and concurrency.

coremask parameter and (wrong) assumption of neighboring cores:

The *coremask* parameter is used with the DPDK application to specify the cores on which to run the application. For higher performance, reducing inter-processor communication cost is a key. The *coremask*should be selected such that the communicating cores are physical neighbors.

Problem: One may (mistakenly), assume core 0 and core 1 are neighboring cores and may choose the coremask accordingly in the DPDK command-line parameter. Please note that these logical core numbers, and their mapping to specific cores on specific NUMA sockets, can vary from platform to platform. While in one platform core 0 and core 1 may be neighbors, in another platform, core 0 and core 1 may end up being across another socket.

For instance, in a single-socket machine (screenshot shown below), lcore 0 and lcore 4 are siblings of the same physical core (core 0). So the communication cost between lcore 0 and lcore 4 will be less than the communication cost between lcore 0 and lcore 1.



Solution: Because of this, it is recommended that the core layout for each platform be considered when choosing the *coremask* to use in each case.

Tools – dpdk/tools/cpu_layout.py

Use ./cpu_layout.py in tools directory to find out the socket ID, the physical core ID, and the logical core ID (processor ID). From this information, correctly fill in the *coremask* parameter with locality of processors in mind.

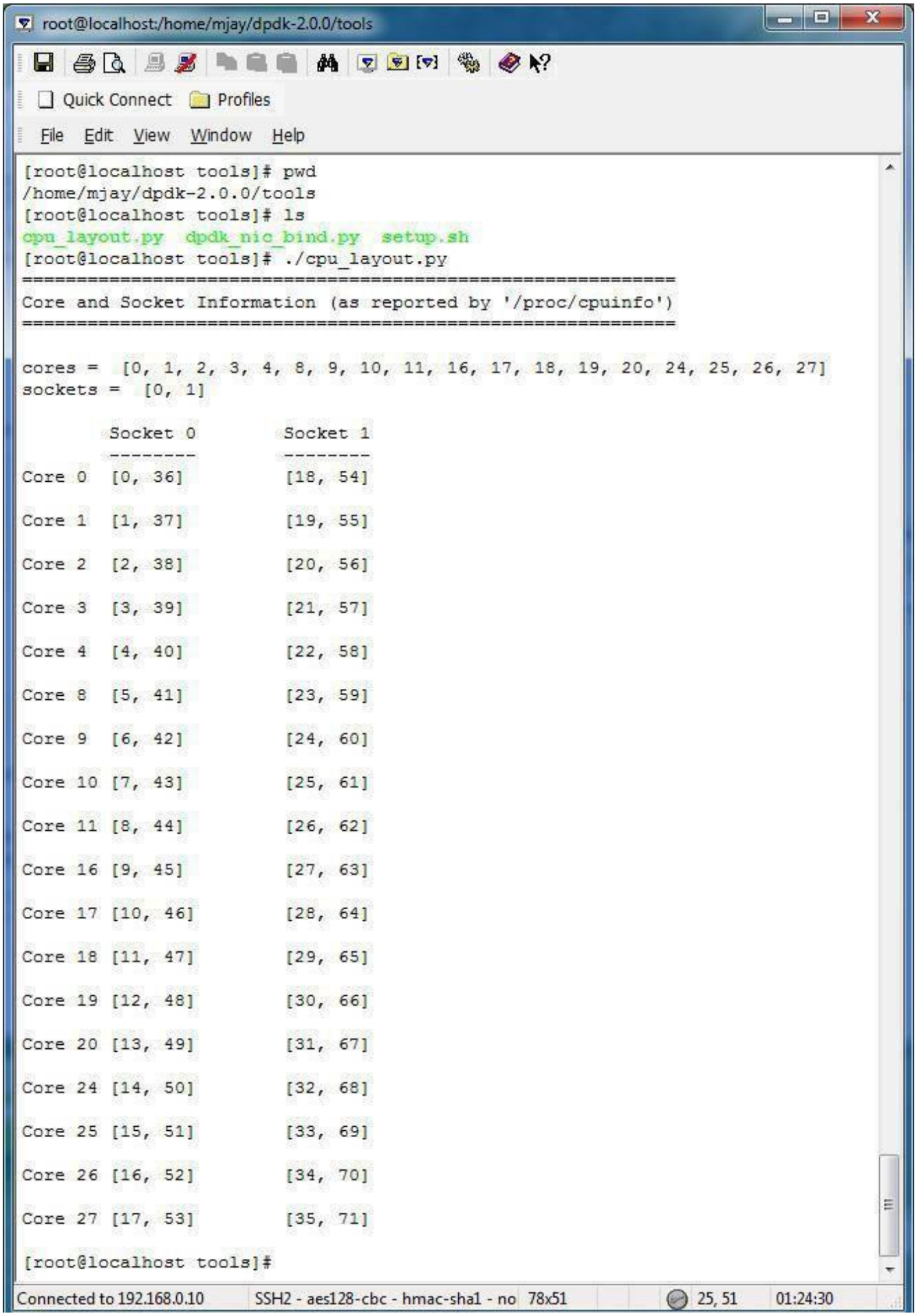
Below is the cpu_layout of a dual socket machine.

The list of physical cores is [0, 1, 2, 3, 4, 8, 9, 10, 11, 16, 17, 18, 19, 20, 24, 25, 26, 27]

Please note that physical core numbers 5, 6, 7, 12, 13, 14, 15, 21, 22, 23 are not in the list. This indicates that one ***cannot*** assume that the physical core numbers are sequential.

How to find out which lcores are hyperthreads from the cpu_layout?

In the picture below, Lcore 1 and lcore 37 are hyperthreads in socket 0. Assigning intercommunicating tasks to lcore 1 and lcore 37 will have lower cost and higher performance compared to assigning tasks to lcore 1 with any other core (other than lcore 37).



Save core 0 for Linux use and do not use core 0 for the DPDK

Refer below for the initialization of the DPDK application. Core 0 is being used by the master core.

```
EAL: Master core 0 is ready (tid=c9f8c880)
EAL: Core 4 is ready (tid=b4dfb700)
EAL: Core 3 is ready (tid=b55fc700)
EAL: Core 2 is ready (tid=b5dfd700)
EAL: Core 1 is ready (tid=b65fe700)
```

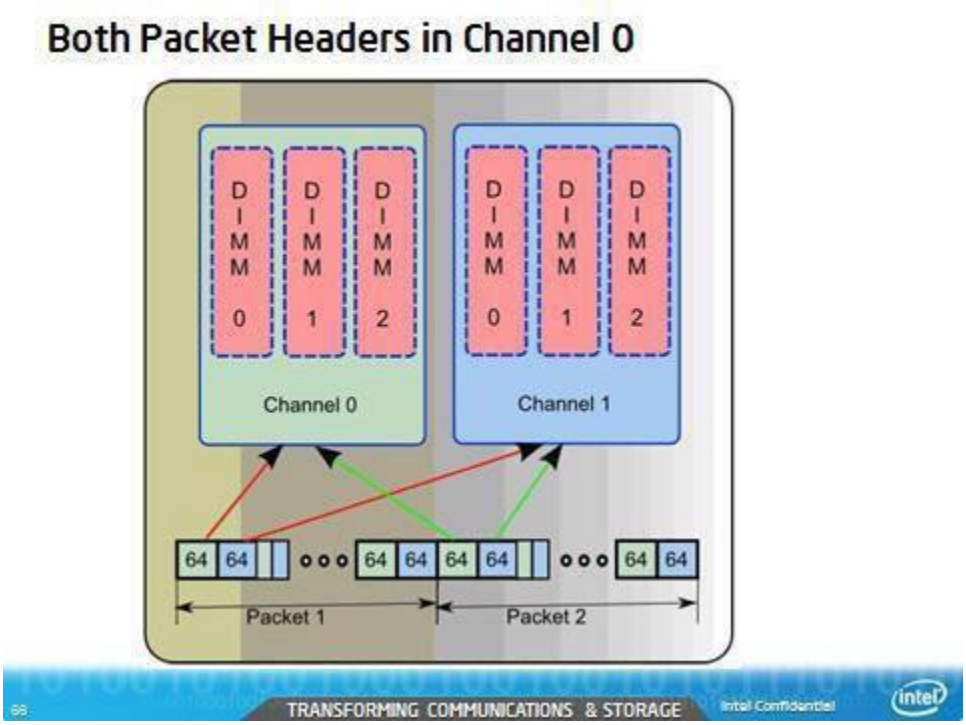
Do not use core 0 for the DPDK applications because it is used by Linux as the master core. For example, using *l3fwd –c 0x1 …* should be avoided since that would be using the core 0 (which is serving the functionality of master core) for l3fwd DPDK application as well.

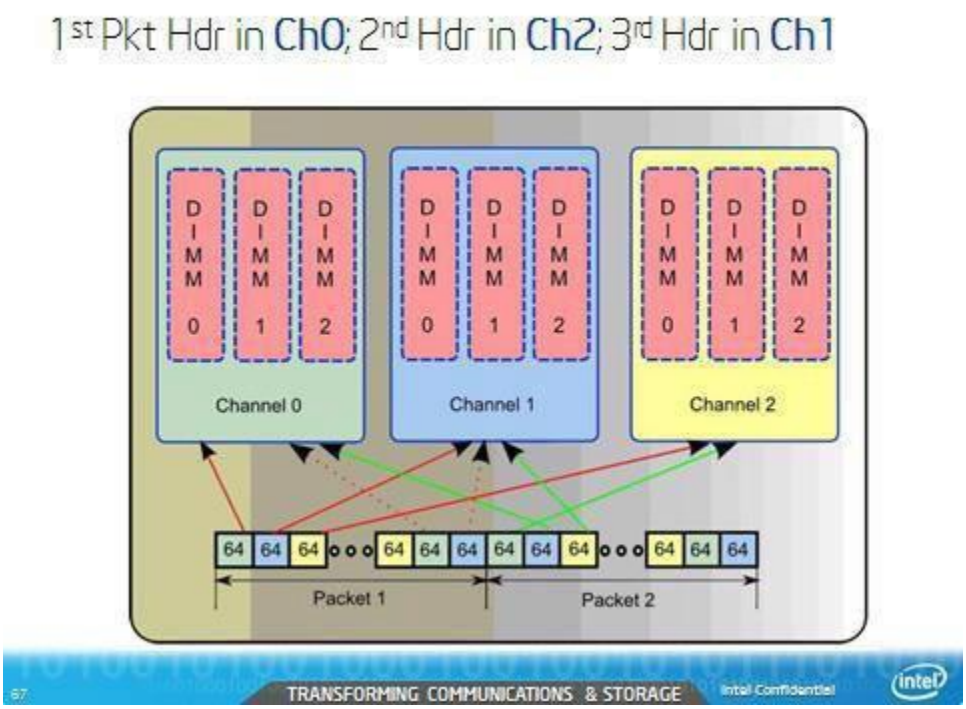
Instead, the command *l3fwd –c 0x2 ….* can be used so that l3fwd application uses core 1.

In realistic use cases like Open vSwitch* with DPDK, a control plane thread pins to the master core, and is responsible for responding to control plane commands from the user or the SDN controller. So, the DPDK application should not use the master core (core 0), and the core bit mask in the DPDK command line should not set bit 0 for the coremask.

Correct use of the Channel Parameter

Be sure to make correct use of the channel parameter. For example, use CHANNEL PARAMETER N = 3 for a 3 channel memory system.





DPDK Micro-benchmarks and auto-tests

The following table tabulates DPDK micro-benchmarks and auto-tests that are available as part of DPDK applications and examples. Developers use these micro-benchmarks to do focused performance measurements for evaluating performance.

The auto-tests are used for functionality verification.

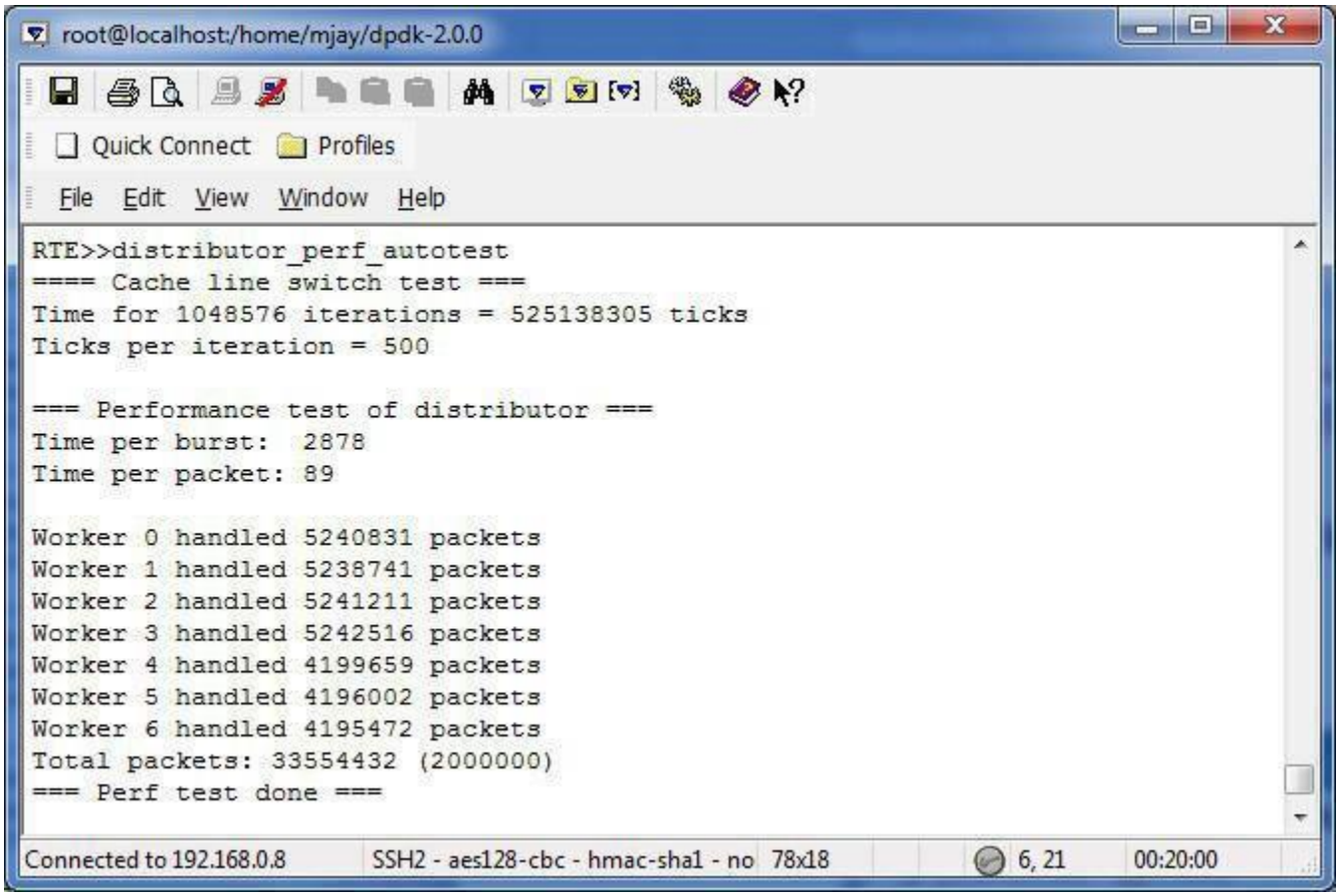
The following are a few sample capabilities of distributor micro-benchmarks for performance evaluation.

How can I measure the time taken for a round-trip of a cache line between two cores and back again?
Time_cache_line_switch( ) function

in http://dpdk.org/browse/dpdk/tree/app/test/test_distributor_perf.comcan be used to time the number of cycles to round-trip a cache line between two cores and back again.

How can I measure the processing time per packet?

Perf_test( ) function in http://dpdk.org/browse/dpdk/tree/app/test/test_distributor_perf.com sends in 32 packets at a time to the distributor and verifies at the end that worker thread got all of them and finally how long the processing per packet took.



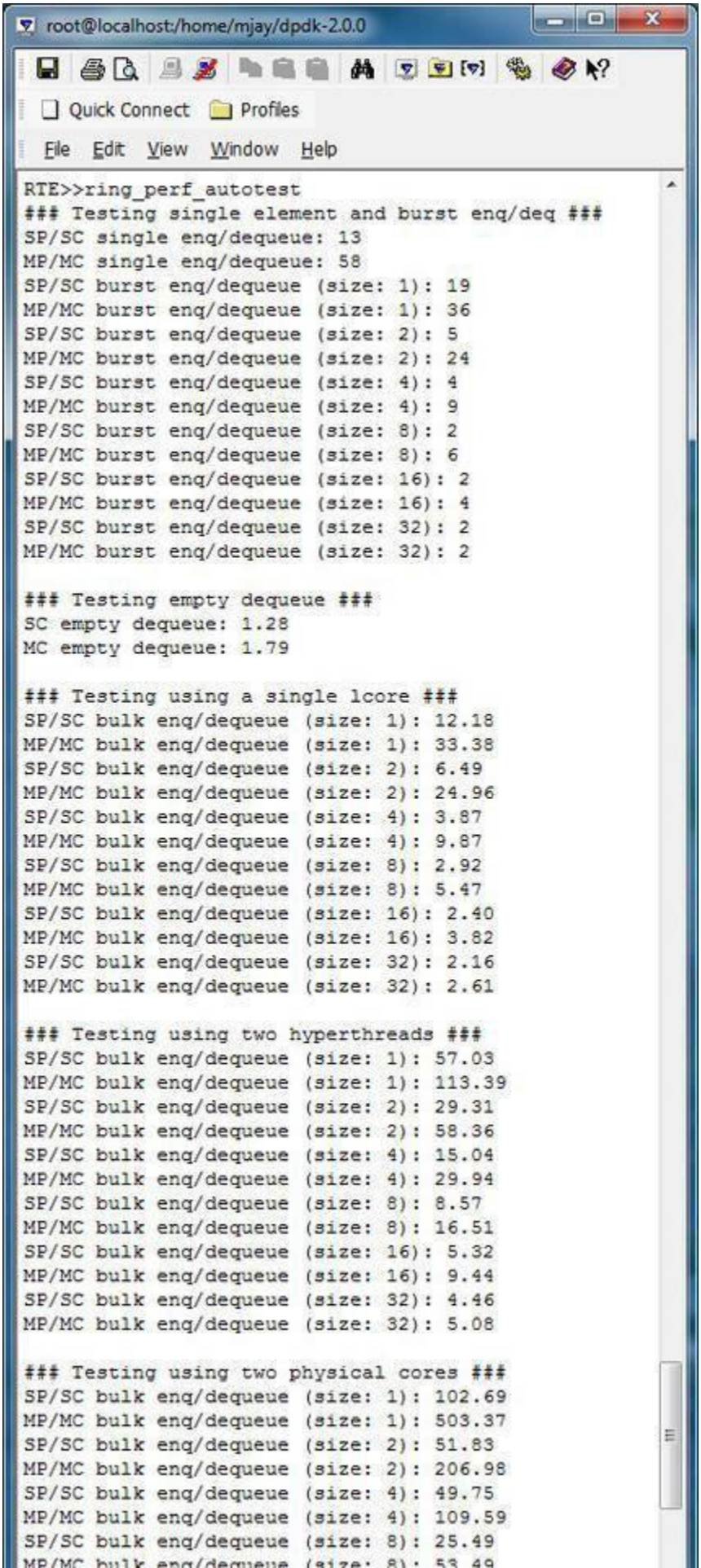
How can I find the performance difference between single producer/single consumer (sp/sc) and multi- producer/multi-consumer (mp/mc)?

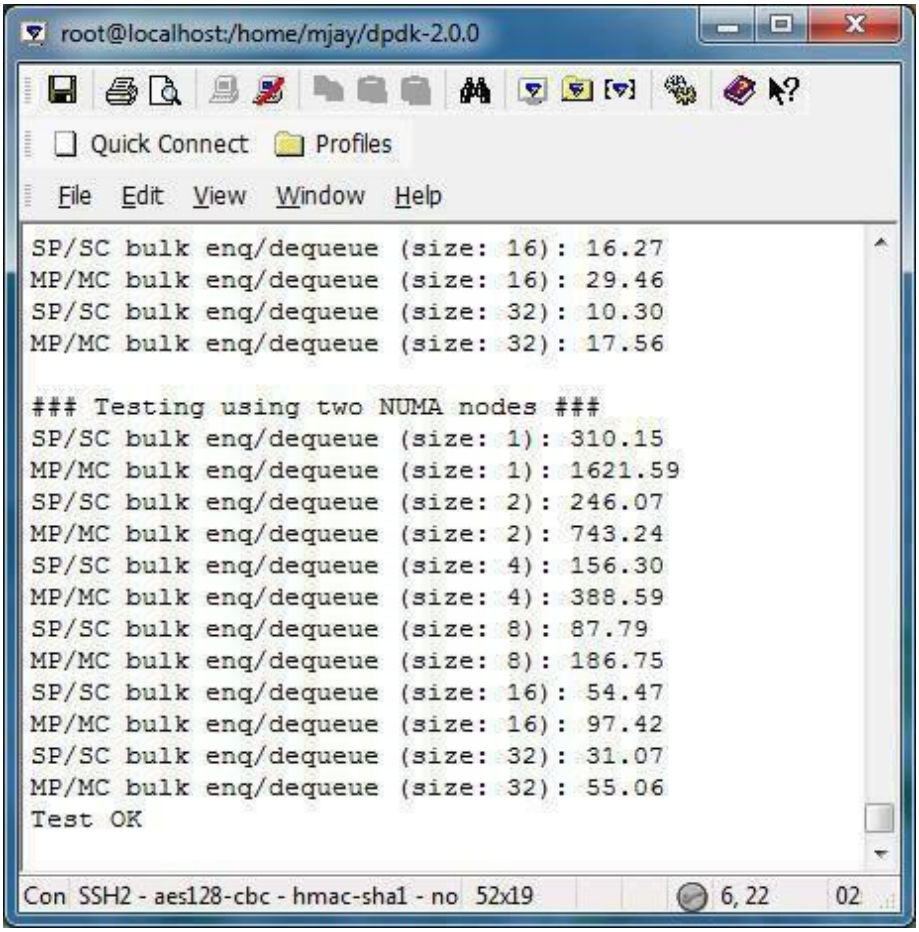
Running ring_perf_auto_test in /app/test gives the number of CPU cycles, in the following screenshot output, to study the performance difference between single producer/single consumer and multi-producer/multi-consumer. It also shows the differences for different bulk sizes.

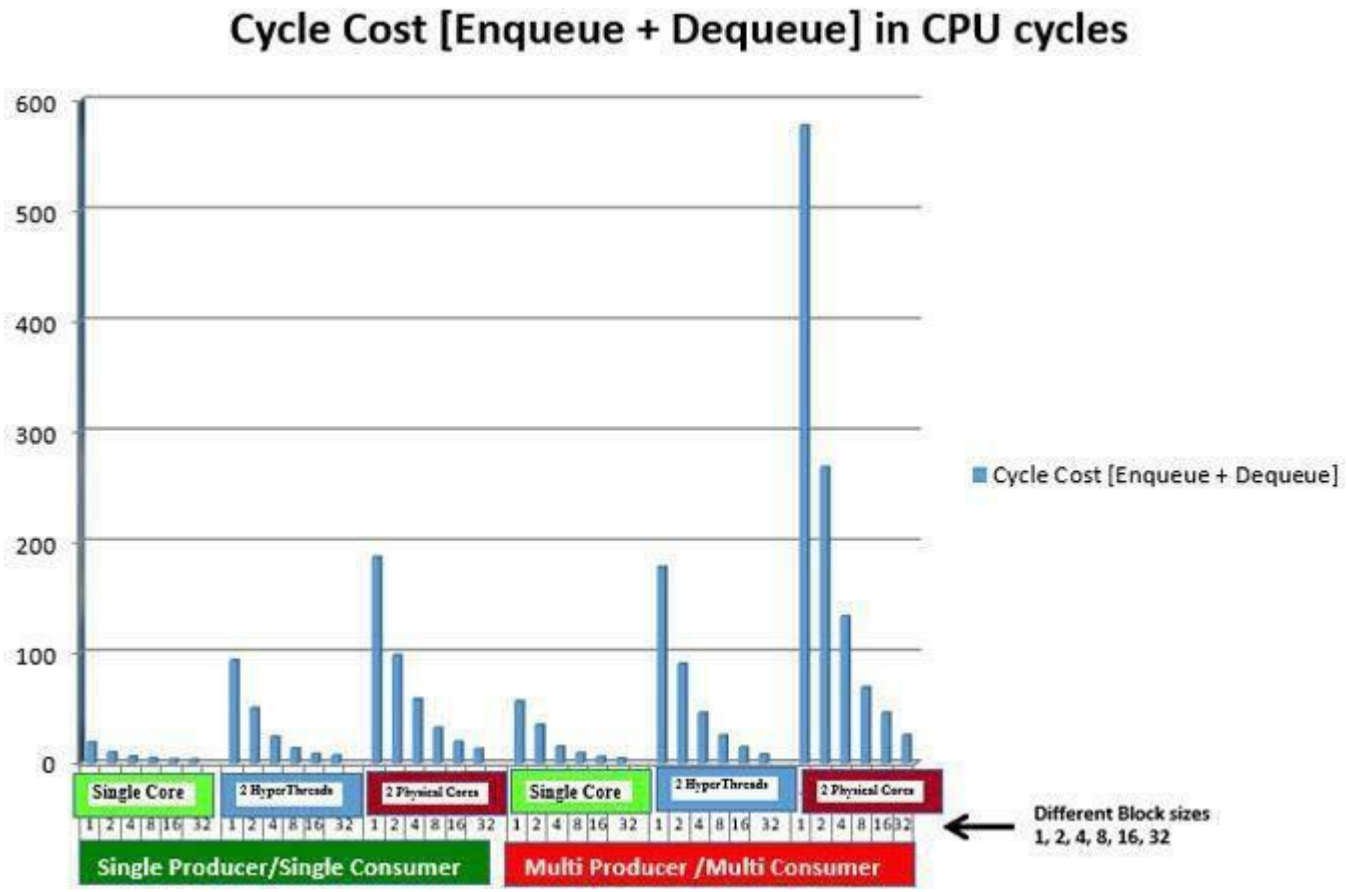
The key takeaway: Using sp/sc with higher bulk sizes gives higher performance.

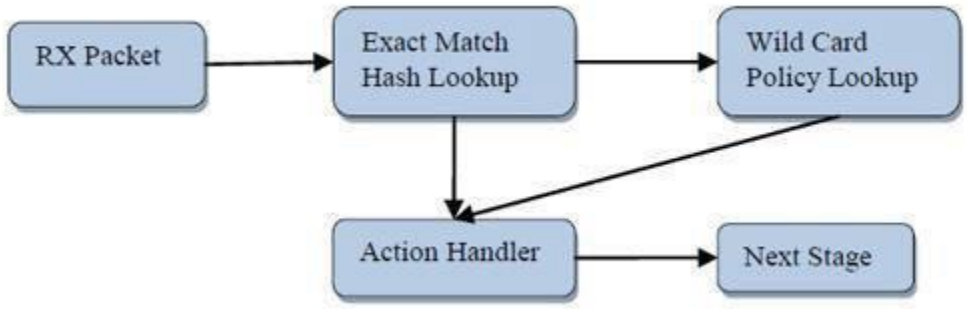
Please note that even though the default ring_perf_autotest runs through the performance test with block sizes of 8 and 32,one can update the source code to include other desired sizes (modify the array bulk_sizes[] to include bulk sizes of interest). For instance, find below the output with the block sizes 1, 2, 4, 8, 16, and 32.

2-Socket System – Huge Page Size = 2 Meg


root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
RTE>>ring_perf_autotest
Testing single element and burst enq/deq
SP/SC single enq/dequeue: 13
MP/MC single enq/dequeue: 58
SP/SC burst enq/dequeue (size: 1): 19
MP/MC burst enq/dequeue (size: 1): 36
SP/SC burst enq/dequeue (size: 2): 5
MP/MC burst enq/dequeue (size: 2): 24
SP/SC burst enq/dequeue (size: 4): 4
MP/MC burst enq/dequeue (size: 4): 9
SP/SC burst enq/dequeue (size: 8): 2
MP/MC burst enq/dequeue (size: 8): 6
SP/SC burst enq/dequeue (size: 16): 2
MP/MC burst enq/dequeue (size: 16): 4
SP/SC burst enq/dequeue (size: 32): 2
MP/MC burst enq/dequeue (size: 32): 2
Testing empty dequeue
SC empty dequeue: 1.28
MC empty dequeue: 1.79
Testing using a single lcore
SP/SC bulk enq/dequeue (size: 1): 12.18
MP/MC bulk enq/dequeue (size: 1): 33.38
SP/SC bulk enq/dequeue (size: 2): 6.49
MP/MC bulk enq/dequeue (size: 2): 24.96
SP/SC bulk enq/dequeue (size: 4): 3.87
MP/MC bulk enq/dequeue (size: 4): 9.87
SP/SC bulk enq/dequeue (size: 8): 2.92
MP/MC bulk enq/dequeue (size: 8): 5.47
SP/SC bulk enq/dequeue (size: 16): 2.40
MP/MC bulk enq/dequeue (size: 16): 3.82
SP/SC bulk enq/dequeue (size: 32): 2.16
MP/MC bulk enq/dequeue (size: 32): 2.61
Testing using two hyperthreads
SP/SC bulk enq/dequeue (size: 1): 57.03
MP/MC bulk enq/dequeue (size: 1): 113.39
SP/SC bulk enq/dequeue (size: 2): 29.31
MP/MC bulk enq/dequeue (size: 2): 58.36
SP/SC bulk enq/dequeue (size: 4): 15.04
MP/MC bulk enq/dequeue (size: 4): 29.94
SP/SC bulk enq/dequeue (size: 8): 8.57
MP/MC bulk enq/dequeue (size: 8): 16.51
SP/SC bulk enq/dequeue (size: 16): 5.32
MP/MC bulk enq/dequeue (size: 16): 9.44
SP/SC bulk enq/dequeue (size: 32): 4.46
MP/MC bulk enq/dequeue (size: 32): 5.08
Testing using two physical cores
SP/SC bulk enq/dequeue (size: 1): 102.69
MP/MC bulk enq/dequeue (size: 1): 503.37
SP/SC bulk enq/dequeue (size: 2): 51.83
MP/MC bulk enq/dequeue (size: 2): 206.98
SP/SC bulk enq/dequeue (size: 4): 49.75
MP/MC bulk enq/dequeue (size: 4): 109.59
SP/SC bulk enq/dequeue (size: 8): 25.49


root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
SP/SC bulk enq/dequeue (size: 16): 16.27
MP/MC bulk enq/dequeue (size: 16): 29.46
SP/SC bulk enq/dequeue (size: 32): 10.30
MP/MC bulk enq/dequeue (size: 32): 17.56
Testing using two NUMA nodes
SP/SC bulk enq/dequeue (size: 1): 310.15
MP/MC bulk enq/dequeue (size: 1): 1621.59
SP/SC bulk enq/dequeue (size: 2): 246.07
MP/MC bulk enq/dequeue (size: 2): 743.24
SP/SC bulk enq/dequeue (size: 4): 156.30
MP/MC bulk enq/dequeue (size: 4): 388.59
SP/SC bulk enq/dequeue (size: 8): 87.79
MP/MC bulk enq/dequeue (size: 8): 186.75
SP/SC bulk enq/dequeue (size: 16): 54.47
MP/MC bulk enq/dequeue (size: 16): 97.42
SP/SC bulk enq/dequeue (size: 32): 31.07
MP/MC bulk enq/dequeue (size: 32): 55.06
Test OK
Con SSH2 - aes128-cbc - hmac-sha1 - no 52x19
6, 22
02





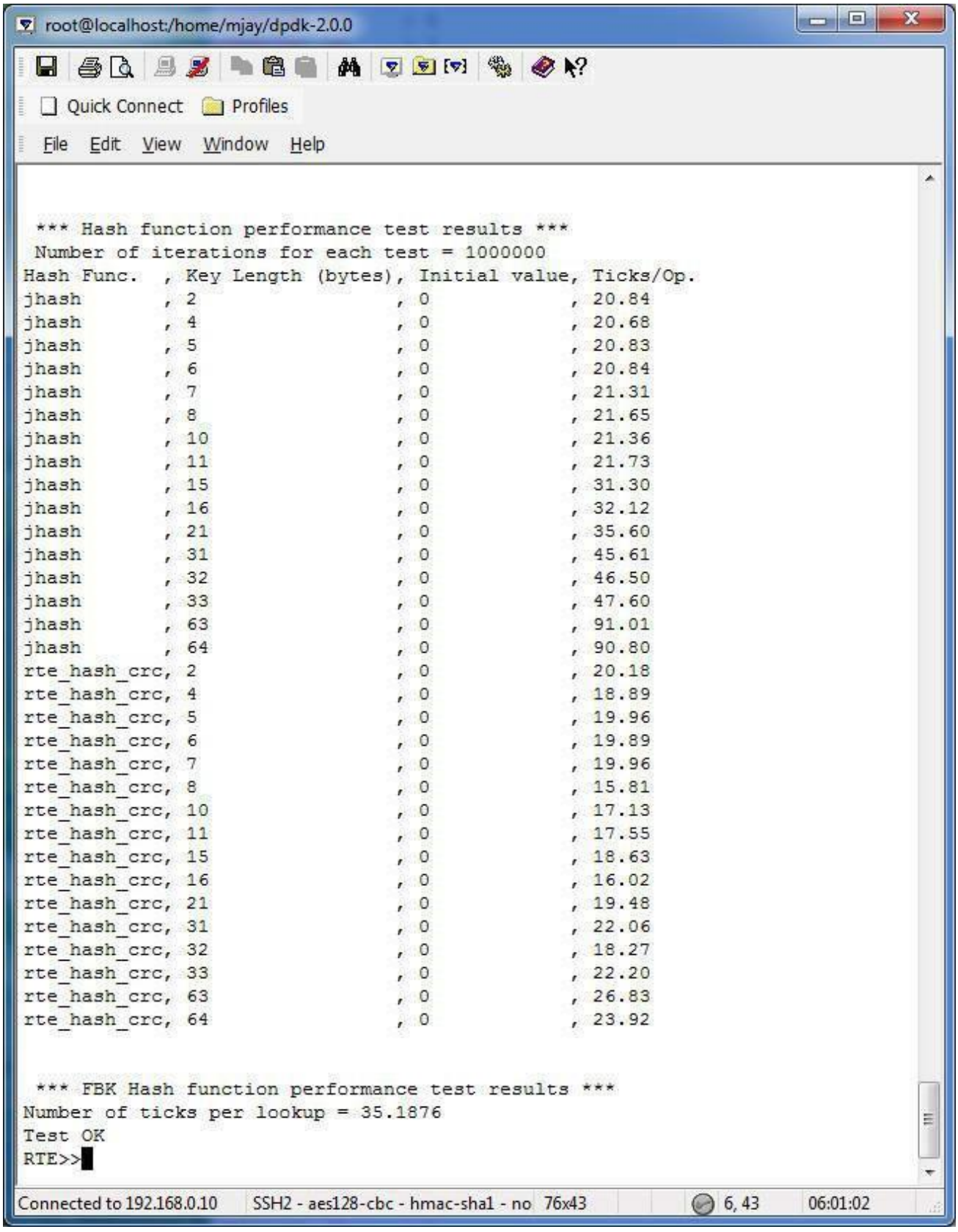
hash_perf_autotest runs through 1,000,000 iterations for each test varying the following parameters and reports Ticks/Op for each combination:

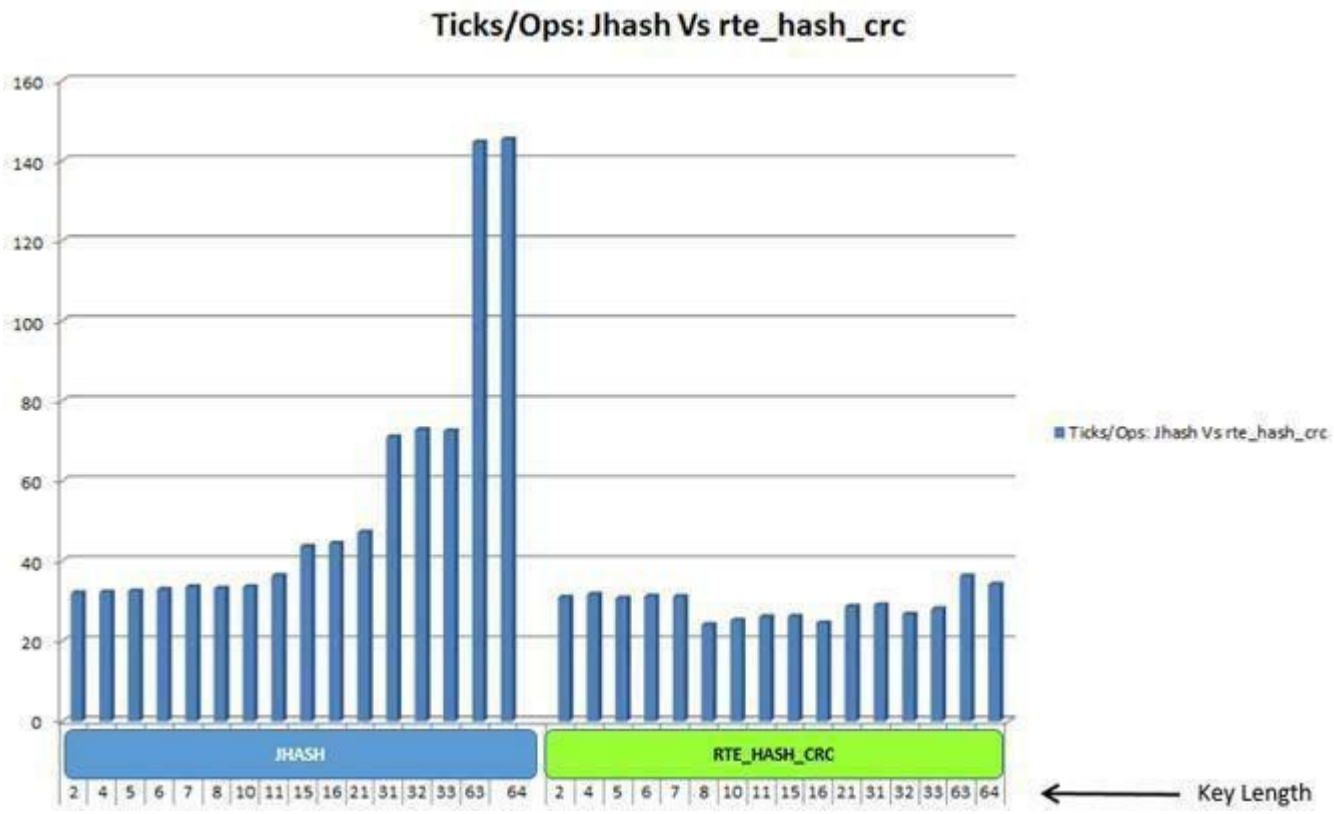
Hash Function	Operation	Key Size (bytes)	Entries	Entries per Bucket
a) Jhash, b) Rte_hash_CRC	a) Add On Empty, b) Add Update, c) Lookup	a) 16, b) 32, c) 48,	a) 1024, b) 1048576	a) 1, b) 2, c) 4,

	d) 64		d) 8, e) 16

The Appendix has the detailed test output and the commands that you can use to evaluate performance with your platform.

The summary of the result is tabulated and charted below:


root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
*** Hash function performance test results ***
Number of iterations for each test = 1000000
Hash Func. , Key Length (bytes), Initial value, Ticks/Op.
jhash , 2 , 0 , 20.84
jhash , 4 , 0 , 20.68
jhash , 5 , 0 , 20.83
jhash , 6 , 0 , 20.84
jhash , 7 , 0 , 21.31
jhash , 8 , 0 , 21.65
jhash , 10 , 0 , 21.36
jhash , 11 , 0 , 21.73
jhash , 15 , 0 , 31.30
jhash , 16 , 0 , 32.12
jhash , 21 , 0 , 35.60
jhash , 31 , 0 , 45.61
jhash , 32 , 0 , 46.50
jhash , 33 , 0 , 47.60
jhash , 63 , 0 , 91.01
jhash , 64 , 0 , 90.80
rte_hash_crc, 2 , 0 , 20.18
rte_hash_crc, 4 , 0 , 18.89
rte_hash_crc, 5 , 0 , 19.96
rte_hash_crc, 6 , 0 , 19.89
rte_hash_crc, 7 , 0 , 19.96
rte_hash_crc, 8 , 0 , 15.81
rte_hash_crc, 10 , 0 , 17.13
rte_hash_crc, 11 , 0 , 17.55
rte_hash_crc, 15 , 0 , 18.63
rte_hash_crc, 16 , 0 , 16.02
rte_hash_crc, 21 , 0 , 19.48
rte_hash_crc, 31 , 0 , 22.06
rte_hash_crc, 32 , 0 , 18.27
rte_hash_crc, 33 , 0 , 22.20
rte_hash_crc, 63 , 0 , 26.83
rte_hash_crc, 64 , 0 , 23.92
*** FBK Hash function performance test results ***
Number of ticks per lookup = 35.1876
Test OK
RTE>>
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no
76x43
6, 43
06:01:02



DPDK Micro-benchmarks and Auto-tests

Sl No.	Focus Area to Improve	Use These Micro-Benchmarks and Auto-Tests
1	Ring For Inter-Core Communication	Performance comparison of bulk enqueue/bulk dequeue versus single enqueue/single dequeue on a single core To measure and compare performance between hyperthreads, cores, and sockets doing bulk enqueue/bulk dequeue on pairs of cores Performance of dequeue from an empty ring http://dpdk.org/browse/dpdk/tree/test/test/test_ring_perf.c Single producer, single consumer – 1 Object, 2 Objects, MAX_BULK Objects – enqueue/dequeue Multi-producer, multi-consumer – 1 Object, 2 Objects, MAX BULK Objects – enqueue/dequeue http://dpdk.org/browse/dpdk/tree/test/test/test_ring.c Tx Burst

Sl No.	Focus Area to Improve	Use These Micro-Benchmarks and Auto-Tests
		Rx Burst http://dpdk.org/browse/dpdk/tree/test/test/test_pmd_ring.c
2	Memcopy	Cache to cache Cache to memory Memory to memory Memory to cache http://dpdk.org/browse/dpdk/tree/test/test/test_memcpy_perf.c
3	Mempool	**“n_get_bulk” “n_put_bulk”** **1 core, 2 cores, max cores with cache objects** **1 core, 2 cores, max cores without cache objects** http://dpdk.org/browse/dpdk/tree/test/test/test_mempool.c
4	Hash	
5		Rte_jhash, rte_hash_crc; Add Lookup Update http://dpdk.org/browse/dpdk/tree/test/test/test_hash_perf.c
6	ACL Lookup	http://dpdk.org/browse/dpdk/tree/test/test/test_acl.c
7	LPM	**Rule with depth > 24** 1) Add, 2) Lookup, 3)Delete
8		http://dpdk.org/browse/dpdk/tree/test/test/test_lpm.c
9		http://dpdk.org/browse/dpdk/tree/test/test/test_lpm6.c
10		
11	**Large Rout**	**Tables:** http://dpdk. org/browse/dpdk/tree/test/test/test_lpm6_data.h

12	Packet Distribution	http://dpdk.org/browse/dpdk/tree/test/test/test_distributor_perf.c

Sl No.	Focus Area to Improve	Use These Micro-Benchmarks and Auto-Tests
13	NIC I/O Benchmark	Measure Tx Only Measure Rx Only, Measure Tx & Rx Benchmarks Network I/O Pipe - NIC h/w + PMD http://dpdk.org/browse/dpdk/tree/test/test/test_pmd_perf.c
10	NIC I/O + Increased CPU processing	Increased CPU processing – NIC h/w + PMD + hash/lpm Examples/l3fwd
11	Atomic Operations/ Lock-rd/wr	http://dpdk.org/browse/dpdk/tree/test/test/test_atomic.c http://dpdk.org/browse/dpdk/tree/test/test/test_rwlock.c
1	SpinLock 2	Takes global lock, display something, then releases the global lock Takes per-lcore lock, display something, then releases the per-core lock http://dpdk.org/browse/dpdk/tree/test/test/test_spinlock.c
13	Software Prefetch	http://dpdk.org/browse/dpdk/tree/test/test/test_prefetch.c Its usage http://dpdk.org/browse/dpdk/tree/lib/librte_table/rte_table_hash_ext.com
14	Packet Distribution	http://dpdk.org/browse/dpdk/tree/app/test/test_distributor_perf.com
15	Reorder and Seq. Window	http://dpdk.org/browse/dpdk/tree/app/test/test_reorder.com
1	Software	

6	Load Balancer	
17	ip_pipeline	Using the packet framework to build a pipelinehttp://dpdk.org/browse/dpdk/tree/app/test/test_table.com

Sl No.	Focus Area to Improve	Use These Micro-Benchmarks and Auto-Tests
		ACL Using Packet Framework http://dpdk.org/browse/dpdk/tree/app/test/test_table_acl.com
18	Reentrancy	http://dpdk.org/browse/dpdk/tree/app/test/test_func_reentrancy.com
19	mbuf	http://dpdk.org/browse/dpdk/tree/app/test/test_mbuf.com
20	memzone	http://dpdk.org/browse/dpdk/tree/app/test/test_memzone.com
21	Ivshmem	http://dpdk.org/browse/dpdk/tree/app/test/test_ivshmem.com
22	Virtual PMD	http://dpdk.org/browse/dpdk/tree/app/test/virtual_pmd.com
23	QoS	http://dpdk.org/browse/dpdk/tree/app/test/test_meter.comhttp://dpdk.org/browse/dpdk/tree/app/test/test_red.com http://dpdk.org/browse/dpdk/tree/app/test/test_sched.com
24	Link Bonding	http://dpdk.org/browse/dpdk/tree/app/test/test_link_bonding.com
2	Kni	Transmit

5		Receive to / from kernel space Kernel Requests http://dpdk.org/browse/dpdk/tree/app/test/test_kni.com
26	Malloc	http://dpdk.org/browse/dpdk/tree/app/test/test_malloc.com
27	Debug	http://dpdk.org/browse/dpdk/tree/app/test/test_debug.com

Sl No.	Focus Area to Improve	Use These Micro-Benchmarks and Auto-Tests
28	Timer	http://dpdk.org/browse/dpdk/tree/app/test/test_cycles.com
29	Alarm	http://dpdk.org/browse/dpdk/tree/app/test/test_alarm.com

Compiler Optimizations

Reference: Pyster - Compiler Design and construction – “Adding optimizations to a compiler is a lot like eating chicken soup when you have a cold. Having a bowl full never hurts, but who knows if it really helps. If the optimizations are structured modularly so that the addition of one does not increase compiler complexity, the temptation to fold in another is hard to resist. How well the techniques work together or against each other is hard to determine."

Performance Optimization and Weakly Ordered Considerations

Background: Linux Kernel synchronization primitives contain needed memory barriers as shown below (both uniprocessor and multiprocessor versions)

Smp_mb ( )	Memory barrier
Smp_rmb ( )	Read memory barrier
Smp_wmb ( )	Write memory barrier
Smp_read_barrier_depends (	Forces subsequent operations that depend on prior operations

)	to be ordered
Mmiowb ( )	Ordering on MMIO writes that are guarded by global spinlocks

Code that uses standard synchronization primitives (spinlocks, semaphores, read copy update) should not need explicit memory barriers, since any required barriers are already present in these primitives.

Challenge: If you are writing code bypassing these standard synchronization primitives for optimization purposes, then consider your requirement in using the proper barrier.

Consideration: x86 provides "process ordering" memory model in which writes from a given CPU are seen in order by all CPUs, and weak consistency, which permits arbitrary reordering, limited only by explicit memory-barrier instructions.

The *smp_mp ( ), smp_rmb ( ), smp_wmb ( )* primitives also force the compiler to avoid any optimizations that would have the effect of reordering memory optimizations across the barriers.

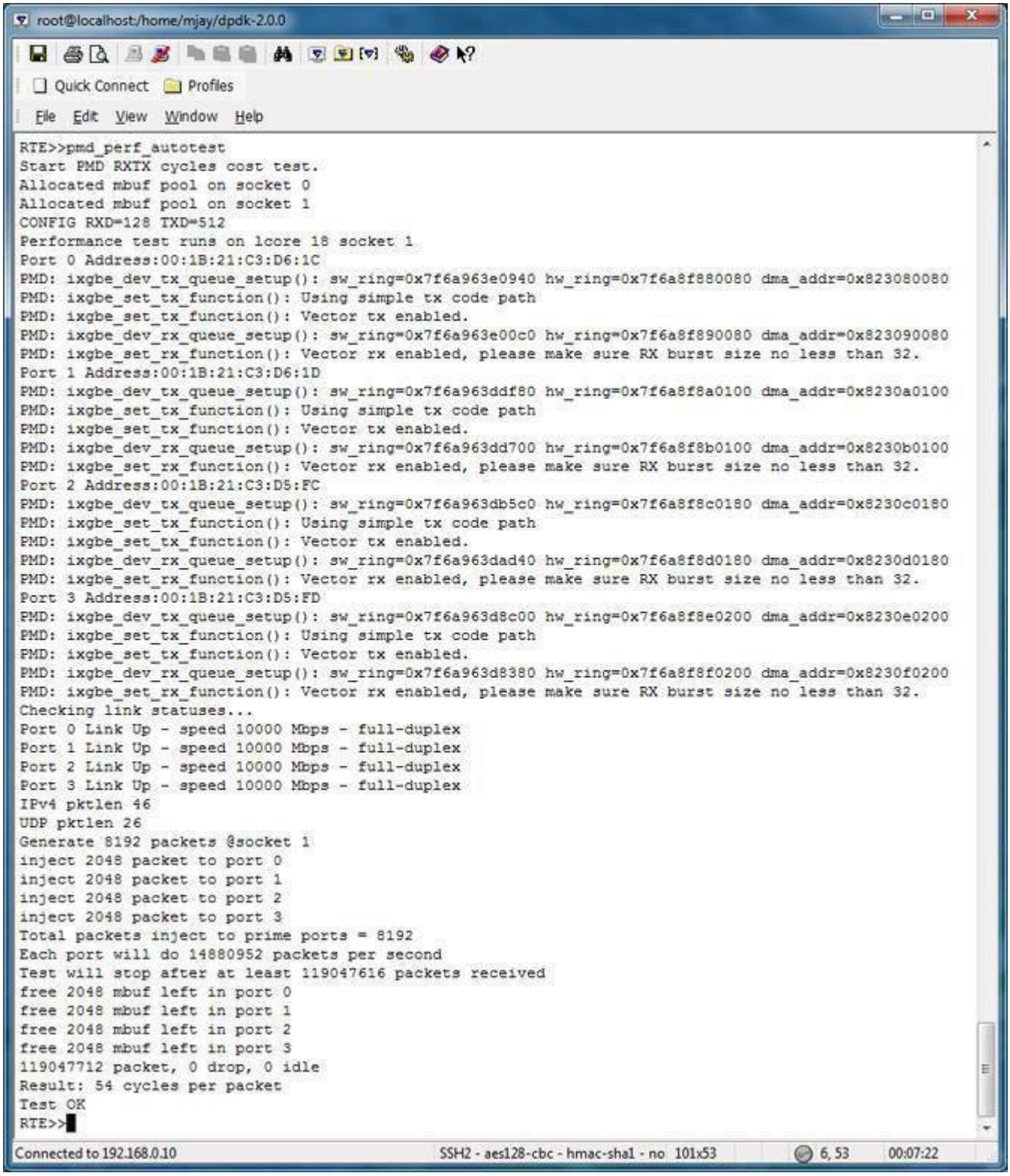
Some SSE instructions are weakly ordered (clflush and non-temporal move instructions. CPUs that have SSE can use mfence for smp mb(), lfence for smp rmb(), and sfence for smp wmb().

Appendix

Pmd_perf_autotest

To evaluate the performance in your platform, run /app/test/pmd_perf_autotest

The key takeaway: The cost for RX+TX cycles per packet in test Polled Mode Driver is 54 cycles
With 4 ports and –n = 4 memory channels



What if you need to find the cycles taken for only rx? Or only tx?

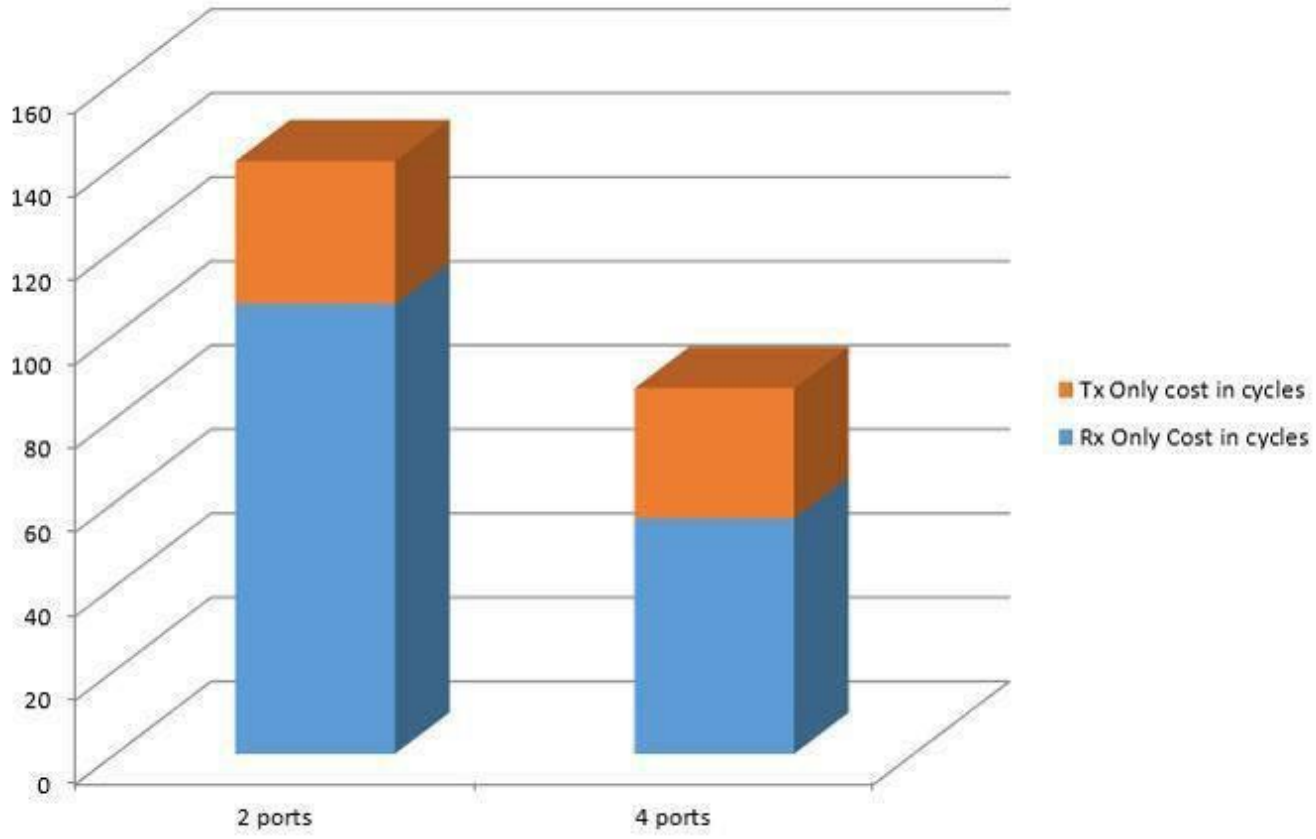
To find rx-only time, use the command *set_rxtx_anchor rxonly* before issuing the command pmd_perf_autotest.

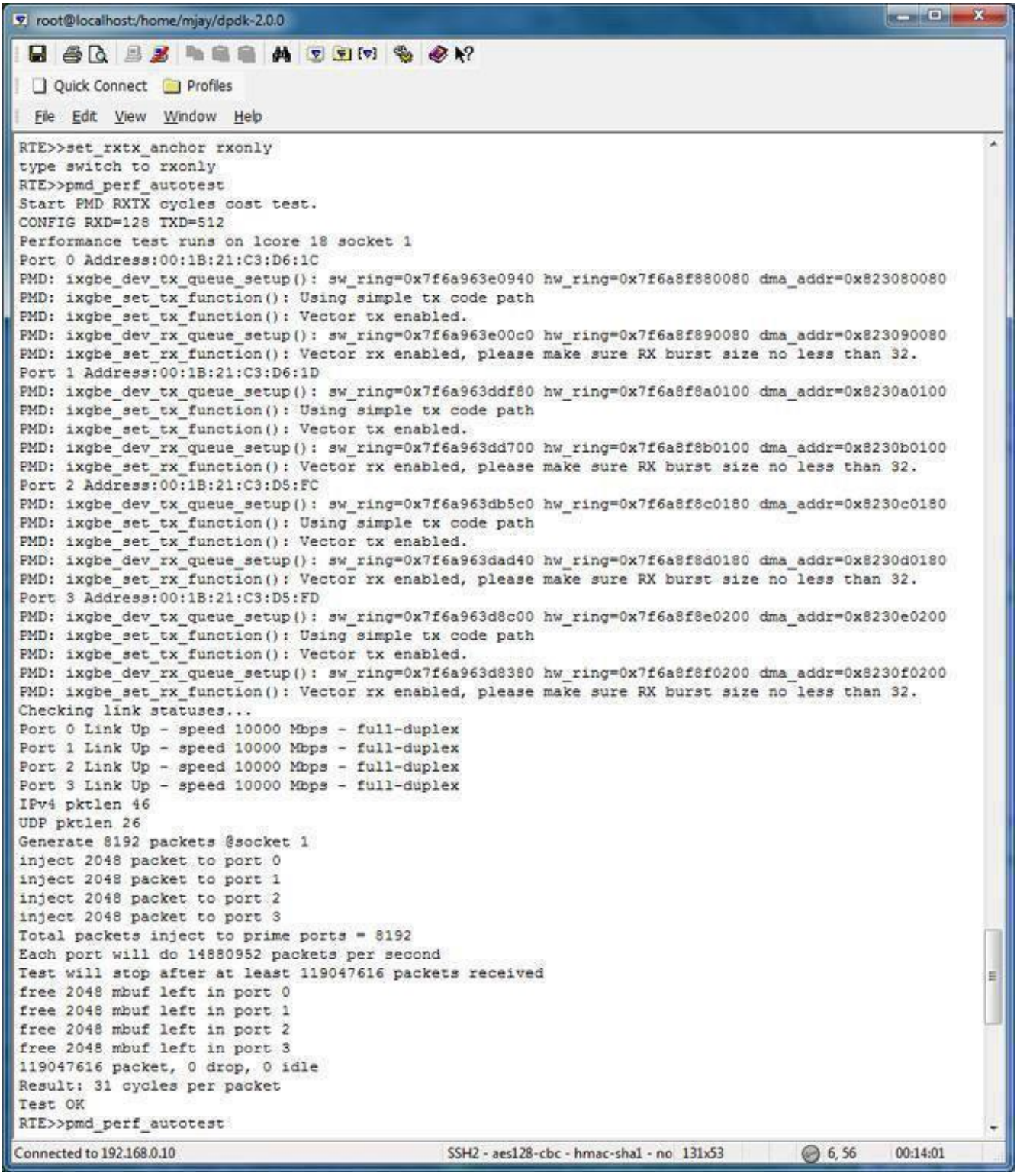
Similarly to find tx-only time, use the command *set_rxtx_anchor txonly* before issuing the command pmd_perf_autotest.

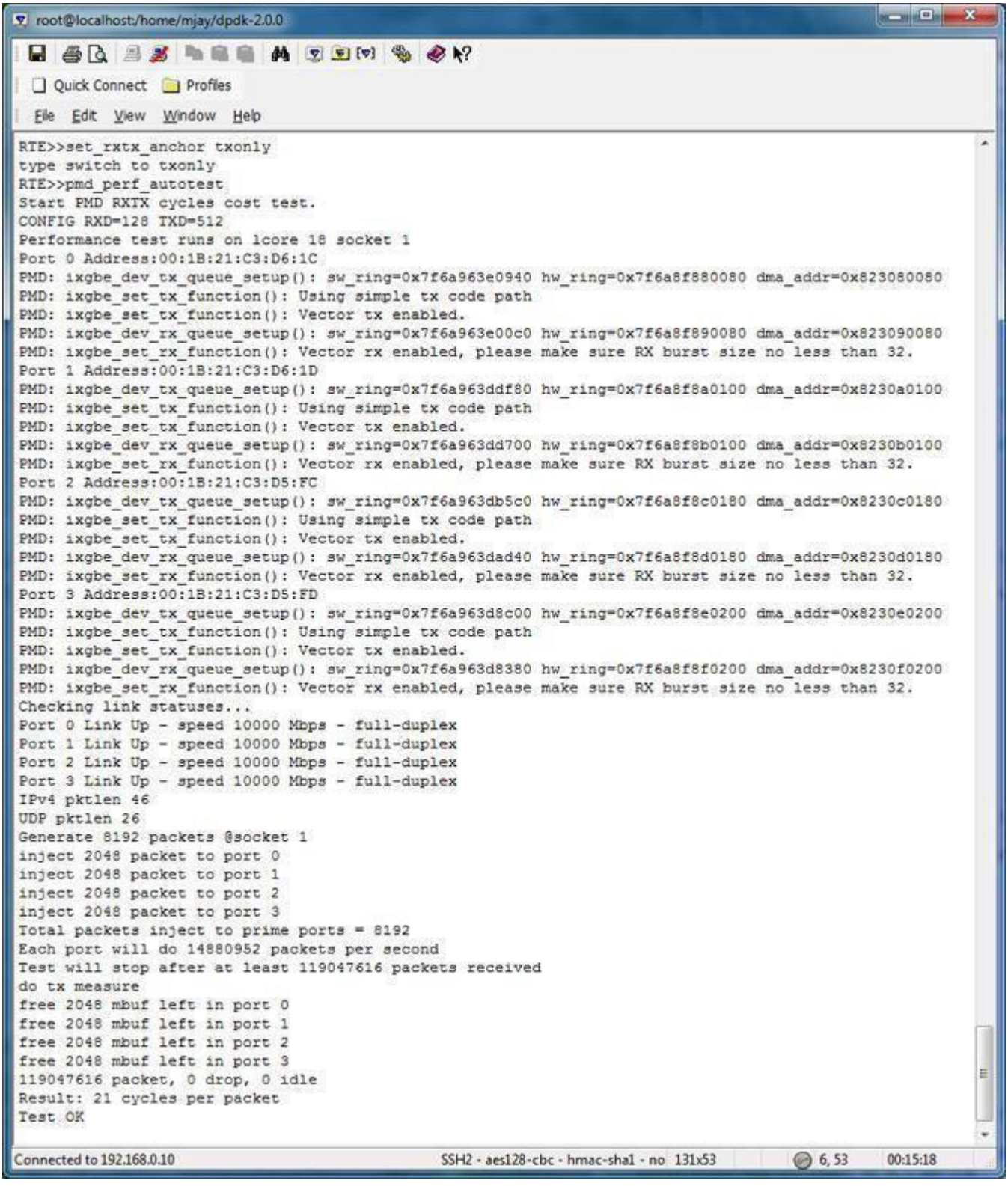
Packet Size = 64B **# of channels** n= 4

# of cycles per packet	TX+RX Cost	TX only Cost	Rx only Cost
With 4 ports	54 cycles	21 cycles	31 cycles

Below is the screen output for the *rxonly* and *txonly* respectively.

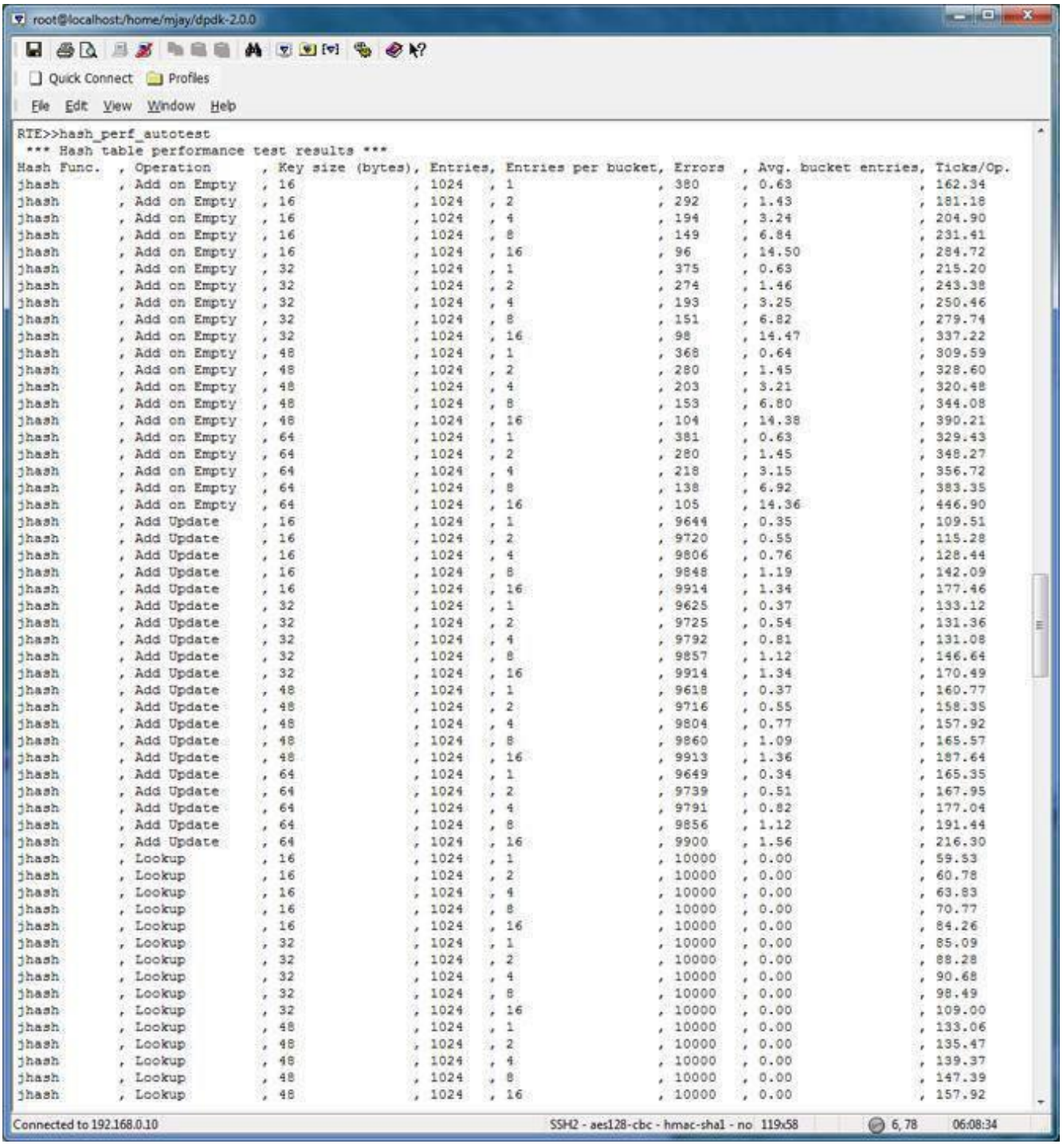


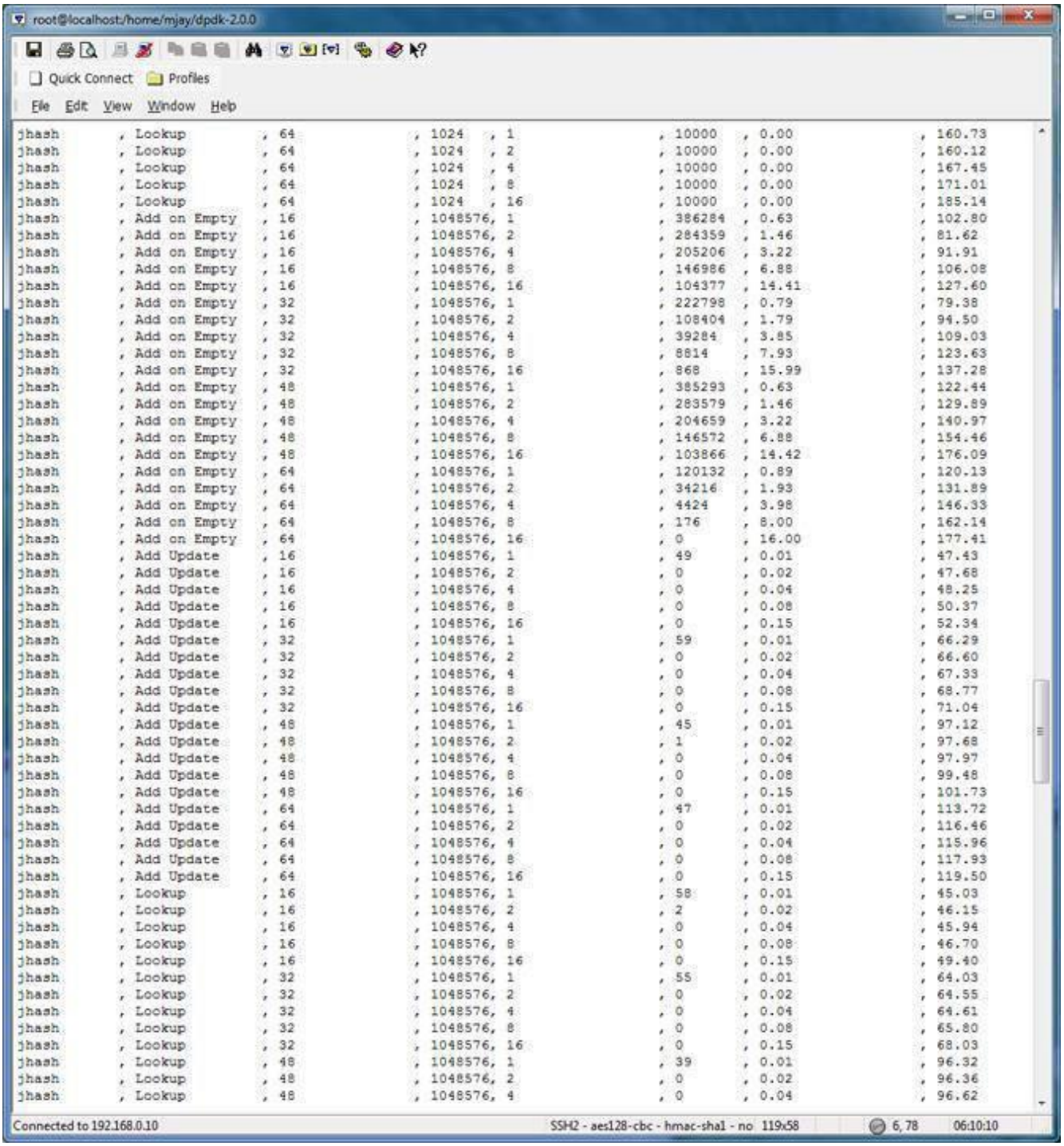

root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
RTE>>set_rxtx_anchor rxonly
type switch to rxonly
RTE>>pmd_perf_autotest
Start PMD RXTX cycles cost test.
CONFIG RXD=128 TXD=512
Performance test runs on lcore 18 socket 1
Port 0 Address:00:1B:21:C3:D6:1C
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963e0940 hw_ring=0x7f6a8f880080 dma_addr=0x823080080
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963e00c0 hw_ring=0x7f6a8f890080 dma_addr=0x823090080
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Port 1 Address:00:1B:21:C3:D6:1D
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963ddf80 hw_ring=0x7f6a8f8a0100 dma_addr=0x8230a0100
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963dd700 hw_ring=0x7f6a8f8b0100 dma_addr=0x8230b0100
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Port 2 Address:00:1B:21:C3:D5:FC
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963db5c0 hw_ring=0x7f6a8f8c0180 dma_addr=0x8230c0180
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963dad40 hw_ring=0x7f6a8f8d0180 dma_addr=0x8230d0180
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Port 3 Address:00:1B:21:C3:D5:FD
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963d8c00 hw_ring=0x7f6a8f8e0200 dma_addr=0x8230e0200
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963d8380 hw_ring=0x7f6a8f8f0200 dma_addr=0x8230f0200
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Checking link statuses...
Port 0 Link Up - speed 10000 Mbps - full-duplex
Port 1 Link Up - speed 10000 Mbps - full-duplex
Port 2 Link Up - speed 10000 Mbps - full-duplex
Port 3 Link Up - speed 10000 Mbps - full-duplex
IPv4 pktlen 46
UDP pktlen 26
Generate 8192 packets @socket 1
inject 2048 packet to port 0
inject 2048 packet to port 1
inject 2048 packet to port 2
inject 2048 packet to port 3
Total packets inject to prime ports = 8192
Each port will do 14880952 packets per second
Test will stop after at least 119047616 packets received
free 2048 mbuf left in port 0
free 2048 mbuf left in port 1
free 2048 mbuf left in port 2
free 2048 mbuf left in port 3
119047616 packet, 0 drop, 0 idle
Result: 31 cycles per packet
Test OK
RTE>>pmd_perf_autotest
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no 131x53
6, 56
00:14:01

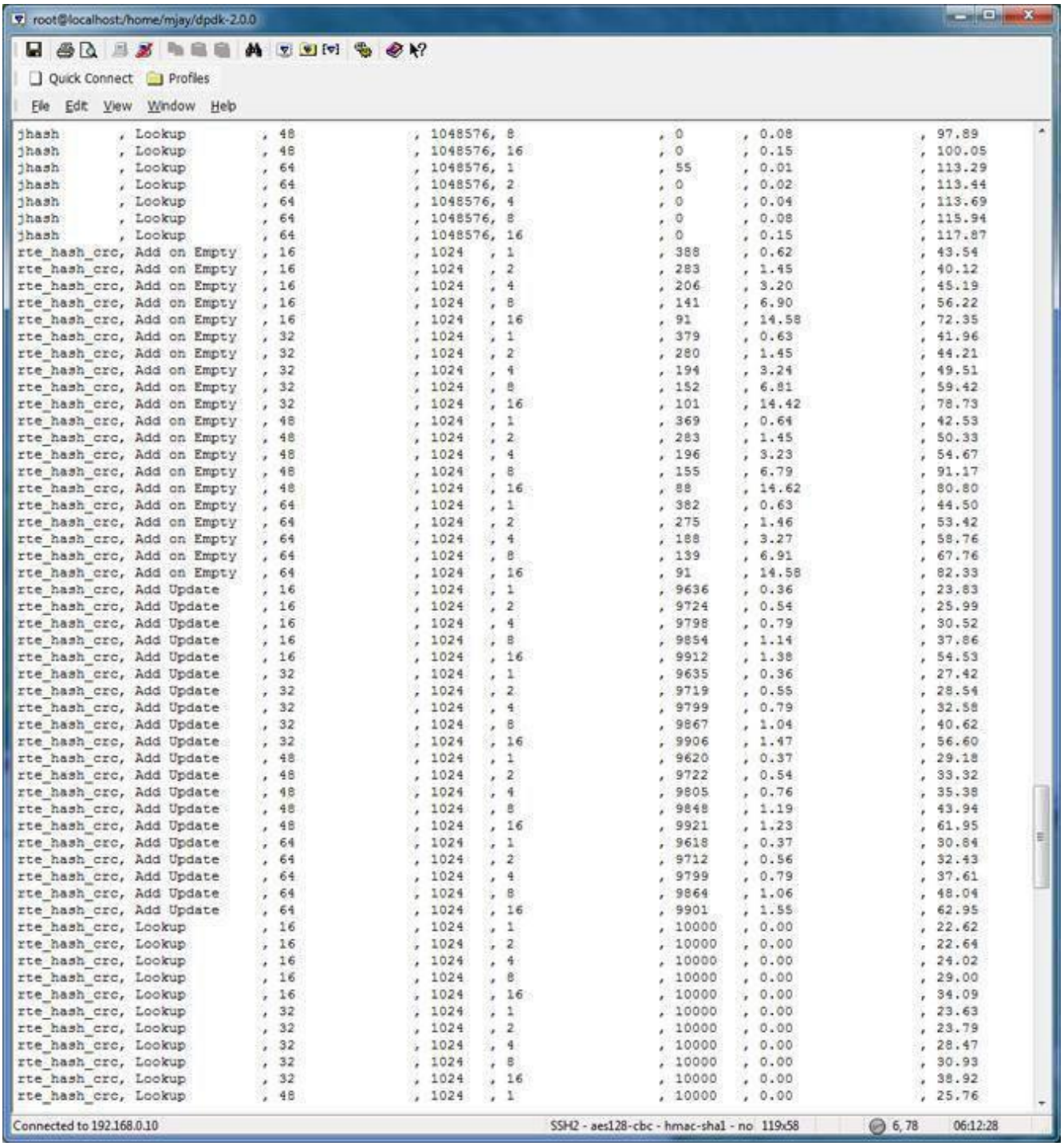

root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
RTE>>set_rxtx_anchor txonly
type switch to txonly
RTE>>pmd_perf_autotest
Start PMD RXTX cycles cost test.
CONFIG RXD=128 TXD=512
Performance test runs on lcore 18 socket 1
Port 0 Address:00:1B:21:C3:D6:1C
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963e0940 hw_ring=0x7f6a8f880080 dma_addr=0x823080080
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963e00c0 hw_ring=0x7f6a8f890080 dma_addr=0x823090080
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Port 1 Address:00:1B:21:C3:D6:1D
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963ddf80 hw_ring=0x7f6a8f8a0100 dma_addr=0x8230a0100
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963dd700 hw_ring=0x7f6a8f8b0100 dma_addr=0x8230b0100
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Port 2 Address:00:1B:21:C3:D5:FC
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963db5c0 hw_ring=0x7f6a8f8c0180 dma_addr=0x8230c0180
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963dad40 hw_ring=0x7f6a8f8d0180 dma_addr=0x8230d0180
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Port 3 Address:00:1B:21:C3:D5:FD
PMD: ixgbe_dev_tx_queue_setup(): sw_ring=0x7f6a963d8c00 hw_ring=0x7f6a8f8e0200 dma_addr=0x8230e0200
PMD: ixgbe_set_tx_function(): Using simple tx code path
PMD: ixgbe_set_tx_function(): Vector tx enabled.
PMD: ixgbe_dev_rx_queue_setup(): sw_ring=0x7f6a963d8380 hw_ring=0x7f6a8f8f0200 dma_addr=0x8230f0200
PMD: ixgbe_set_rx_function(): Vector rx enabled, please make sure RX burst size no less than 32.
Checking link statuses...
Port 0 Link Up - speed 10000 Mbps - full-duplex
Port 1 Link Up - speed 10000 Mbps - full-duplex
Port 2 Link Up - speed 10000 Mbps - full-duplex
Port 3 Link Up - speed 10000 Mbps - full-duplex
IPv4 pktlen 46
UDP pktlen 26
Generate 8192 packets @socket 1
inject 2048 packet to port 0
inject 2048 packet to port 1
inject 2048 packet to port 2
inject 2048 packet to port 3
Total packets inject to prime ports = 8192
Each port will do 14880952 packets per second
Test will stop after at least 119047616 packets received
do tx measure
free 2048 mbuf left in port 0
free 2048 mbuf left in port 1
free 2048 mbuf left in port 2
free 2048 mbuf left in port 3
119047616 packet, 0 drop, 0 idle
Result: 21 cycles per packet
Test OK
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no 131x53
6, 53
00:15:18

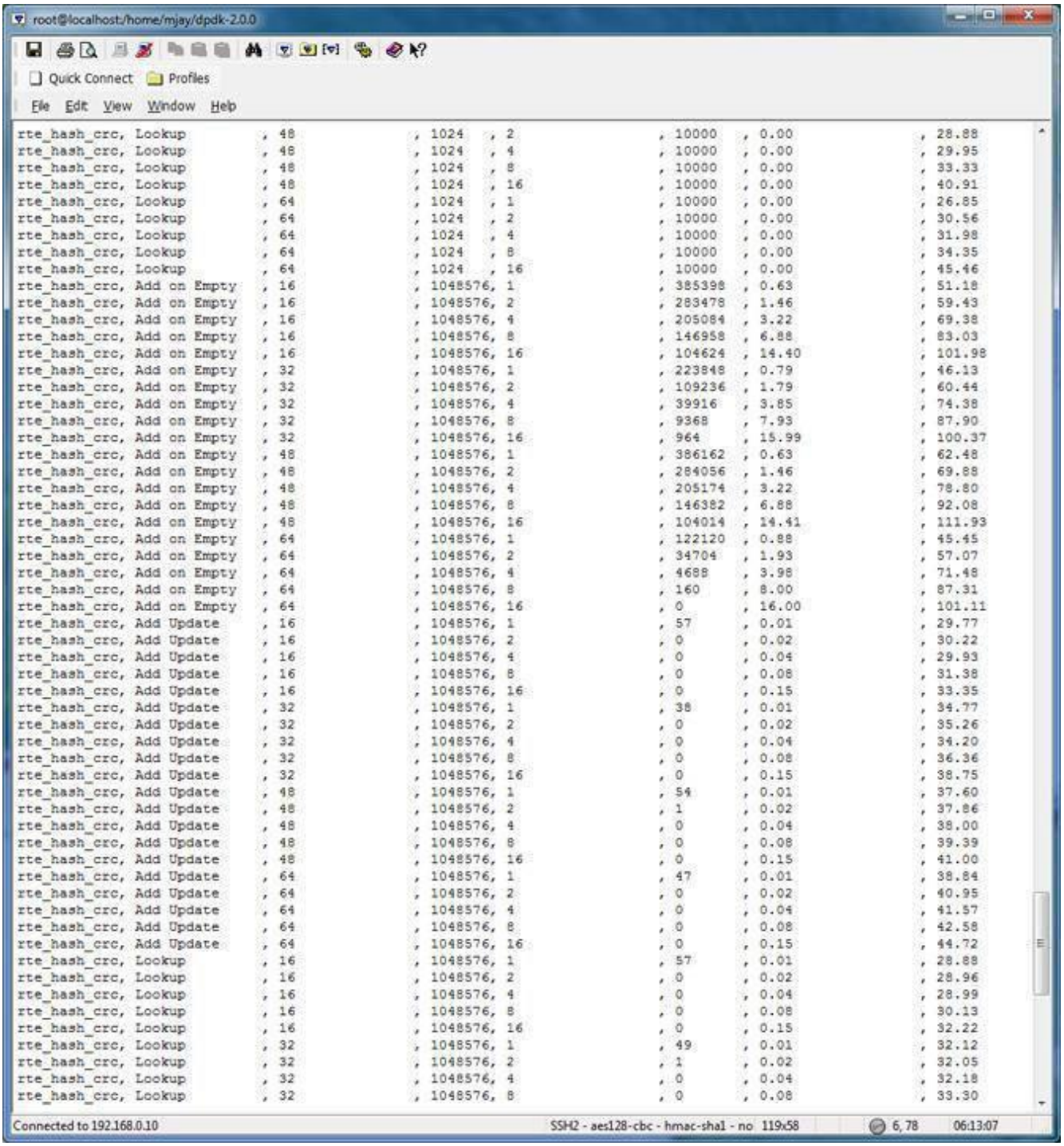
Hash Table Performance Test Results

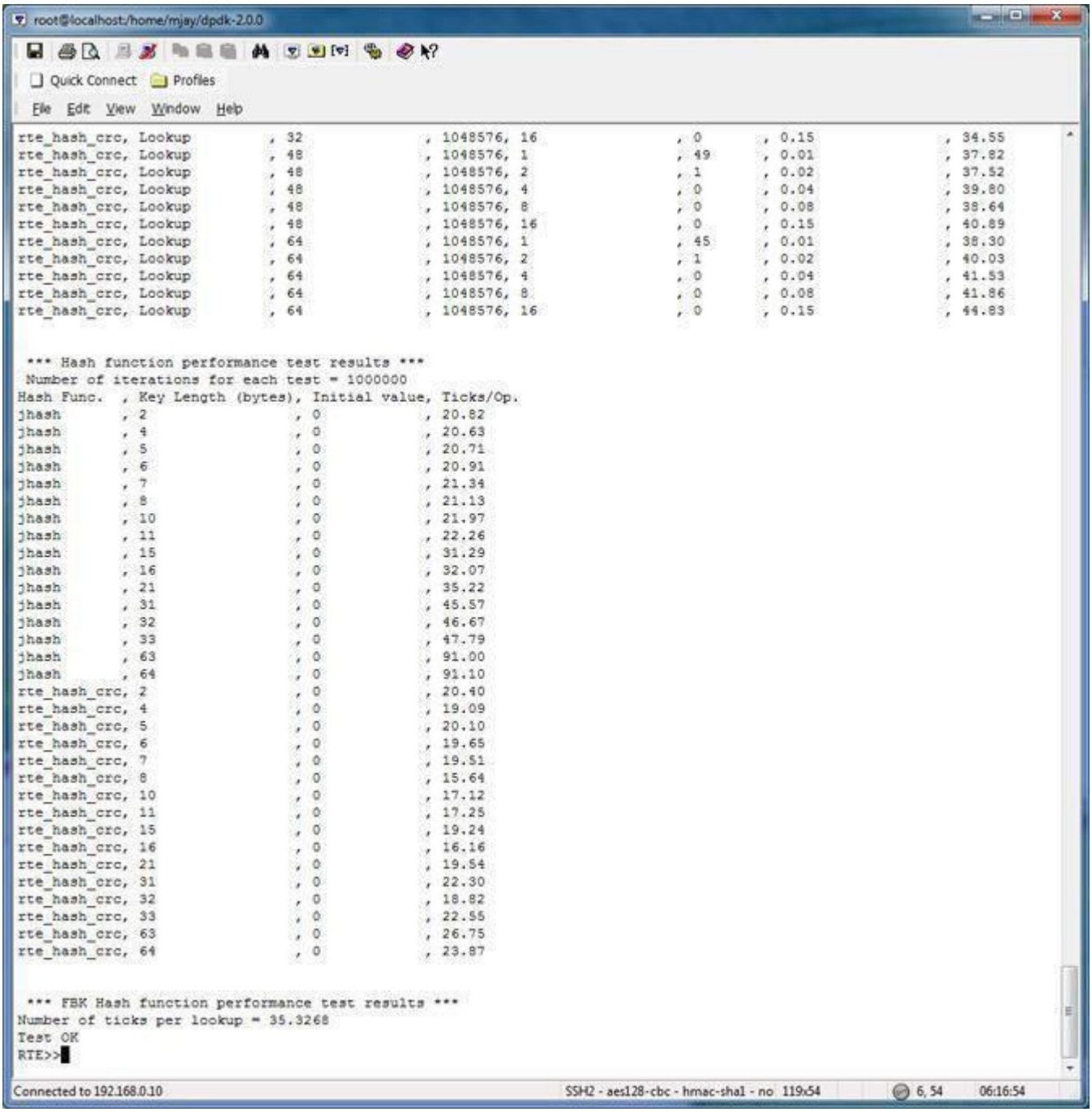
To evaluate the performance in your platform, run /app/test/hash_perf_autotest




root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
jhash , Lookup , 64 , 1024 , 1 , 10000 , 0.00 , 160.73
jhash , Lookup , 64 , 1024 , 2 , 10000 , 0.00 , 160.12
jhash , Lookup , 64 , 1024 , 4 , 10000 , 0.00 , 167.45
jhash , Lookup , 64 , 1024 , 8 , 10000 , 0.00 , 171.01
jhash , Lookup , 64 , 1024 , 16 , 10000 , 0.00 , 185.14
jhash , Add on Empty , 16 , 1048576, 1 , 386284 , 0.63 , 102.80
jhash , Add on Empty , 16 , 1048576, 2 , 284359 , 1.46 , 81.62
jhash , Add on Empty , 16 , 1048576, 4 , 205206 , 3.22 , 91.91
jhash , Add on Empty , 16 , 1048576, 8 , 146986 , 6.88 , 106.08
jhash , Add on Empty , 16 , 1048576, 16 , 104377 , 14.41 , 127.60
jhash , Add on Empty , 32 , 1048576, 1 , 222798 , 0.79 , 79.38
jhash , Add on Empty , 32 , 1048576, 2 , 108404 , 1.79 , 94.50
jhash , Add on Empty , 32 , 1048576, 4 , 39284 , 3.85 , 109.03
jhash , Add on Empty , 32 , 1048576, 8 , 8814 , 7.93 , 123.63
jhash , Add on Empty , 32 , 1048576, 16 , 868 , 15.99 , 137.28
jhash , Add on Empty , 48 , 1048576, 1 , 385293 , 0.63 , 122.44
jhash , Add on Empty , 48 , 1048576, 2 , 283579 , 1.46 , 129.89
jhash , Add on Empty , 48 , 1048576, 4 , 204659 , 3.22 , 140.97
jhash , Add on Empty , 48 , 1048576, 8 , 146572 , 6.88 , 154.46
jhash , Add on Empty , 48 , 1048576, 16 , 103866 , 14.42 , 176.09
jhash , Add on Empty , 64 , 1048576, 1 , 120132 , 0.89 , 120.13
jhash , Add on Empty , 64 , 1048576, 2 , 34216 , 1.93 , 131.89
jhash , Add on Empty , 64 , 1048576, 4 , 4424 , 3.98 , 146.33
jhash , Add on Empty , 64 , 1048576, 8 , 176 , 8.00 , 162.14
jhash , Add on Empty , 64 , 1048576, 16 , 0 , 16.00 , 177.41
jhash , Add Update , 16 , 1048576, 1 , 49 , 0.01 , 47.43
jhash , Add Update , 16 , 1048576, 2 , 0 , 0.02 , 47.68
jhash , Add Update , 16 , 1048576, 4 , 0 , 0.04 , 48.25
jhash , Add Update , 16 , 1048576, 8 , 0 , 0.08 , 50.37
jhash , Add Update , 16 , 1048576, 16 , 0 , 0.15 , 52.34
jhash , Add Update , 32 , 1048576, 1 , 59 , 0.01 , 66.29
jhash , Add Update , 32 , 1048576, 2 , 0 , 0.02 , 66.60
jhash , Add Update , 32 , 1048576, 4 , 0 , 0.04 , 67.33
jhash , Add Update , 32 , 1048576, 8 , 0 , 0.08 , 68.77
jhash , Add Update , 32 , 1048576, 16 , 0 , 0.15 , 71.04
jhash , Add Update , 48 , 1048576, 1 , 45 , 0.01 , 97.12
jhash , Add Update , 48 , 1048576, 2 , 1 , 0.02 , 97.68
jhash , Add Update , 48 , 1048576, 4 , 0 , 0.04 , 97.97
jhash , Add Update , 48 , 1048576, 8 , 0 , 0.08 , 99.48
jhash , Add Update , 48 , 1048576, 16 , 0 , 0.15 , 101.73
jhash , Add Update , 64 , 1048576, 1 , 47 , 0.01 , 113.72
jhash , Add Update , 64 , 1048576, 2 , 0 , 0.02 , 116.46
jhash , Add Update , 64 , 1048576, 4 , 0 , 0.04 , 115.96
jhash , Add Update , 64 , 1048576, 8 , 0 , 0.08 , 117.93
jhash , Add Update , 64 , 1048576, 16 , 0 , 0.15 , 119.50
jhash , Lookup , 16 , 1048576, 1 , 58 , 0.01 , 45.03
jhash , Lookup , 16 , 1048576, 2 , 2 , 0.02 , 46.15
jhash , Lookup , 16 , 1048576, 4 , 0 , 0.04 , 45.94
jhash , Lookup , 16 , 1048576, 8 , 0 , 0.08 , 46.70
jhash , Lookup , 16 , 1048576, 16 , 0 , 0.15 , 49.40
jhash , Lookup , 32 , 1048576, 1 , 55 , 0.01 , 64.03
jhash , Lookup , 32 , 1048576, 2 , 0 , 0.02 , 64.55
jhash , Lookup , 32 , 1048576, 4 , 0 , 0.04 , 64.61
jhash , Lookup , 32 , 1048576, 8 , 0 , 0.08 , 65.80
jhash , Lookup , 32 , 1048576, 16 , 0 , 0.15 , 68.03
jhash , Lookup , 48 , 1048576, 1 , 39 , 0.01 , 96.32
jhash , Lookup , 48 , 1048576, 2 , 0 , 0.02 , 96.36
jhash , Lookup , 48 , 1048576, 4 , 0 , 0.04 , 96.62
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no 119x58
6, 78
06:10:10

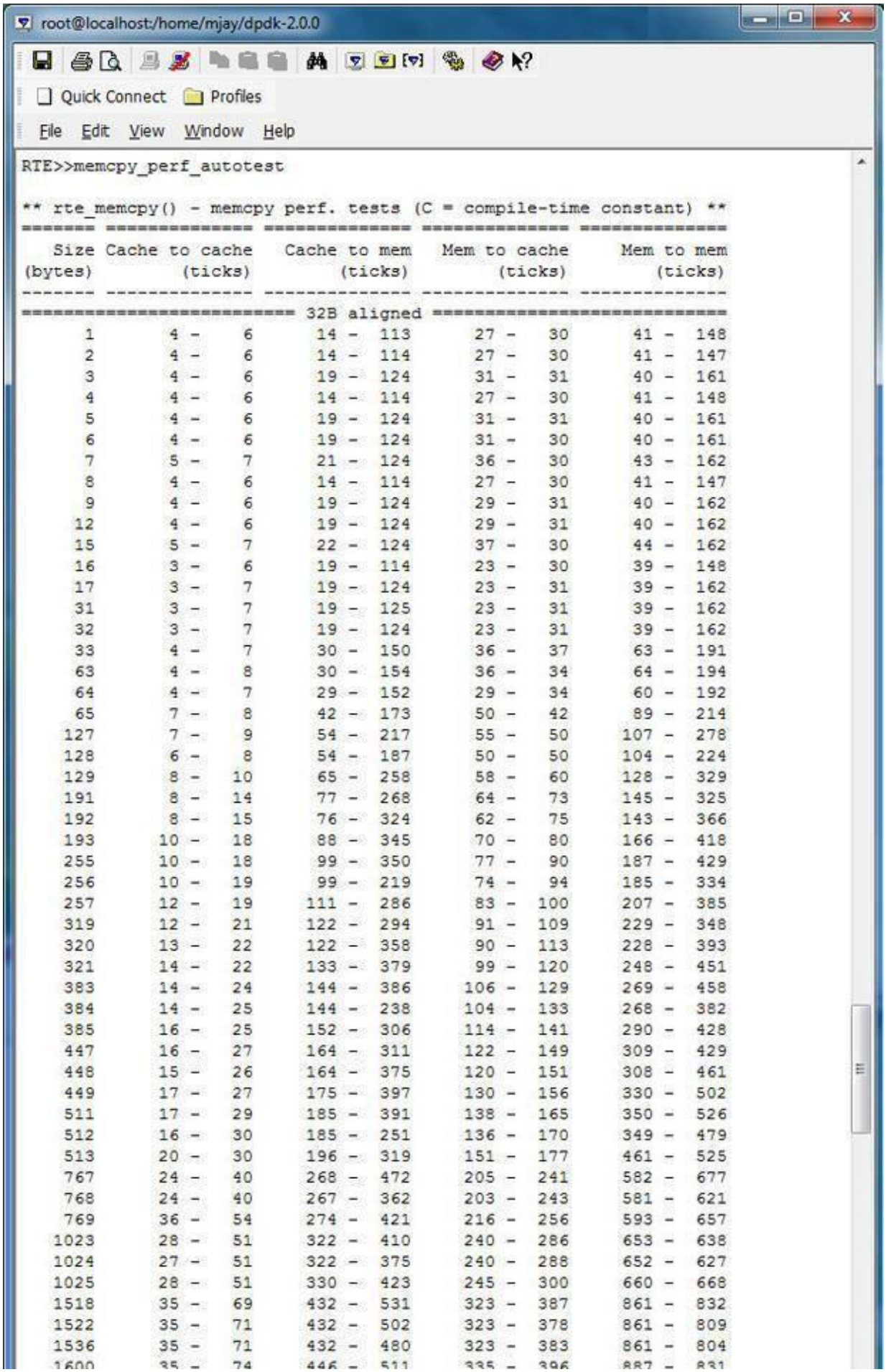

root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
jhash , Lookup , 48 , 1048576, 8 , 0 , 0.08 , 97.89
jhash , Lookup , 48 , 1048576, 16 , 0 , 0.15 , 100.05
jhash , Lookup , 64 , 1048576, 1 , 55 , 0.01 , 113.29
jhash , Lookup , 64 , 1048576, 2 , 0 , 0.02 , 113.44
jhash , Lookup , 64 , 1048576, 4 , 0 , 0.04 , 113.69
jhash , Lookup , 64 , 1048576, 8 , 0 , 0.08 , 115.94
jhash , Lookup , 64 , 1048576, 16 , 0 , 0.15 , 117.87
rte_hash_crc, Add on Empty , 16 , 1024 , 1 , 388 , 0.62 , 43.54
rte_hash_crc, Add on Empty , 16 , 1024 , 2 , 283 , 1.45 , 40.12
rte_hash_crc, Add on Empty , 16 , 1024 , 4 , 206 , 3.20 , 45.19
rte_hash_crc, Add on Empty , 16 , 1024 , 8 , 141 , 6.90 , 56.22
rte_hash_crc, Add on Empty , 16 , 1024 , 16 , 91 , 14.58 , 72.35
rte_hash_crc, Add on Empty , 32 , 1024 , 1 , 379 , 0.63 , 41.96
rte_hash_crc, Add on Empty , 32 , 1024 , 2 , 280 , 1.45 , 44.21
rte_hash_crc, Add on Empty , 32 , 1024 , 4 , 194 , 3.24 , 49.51
rte_hash_crc, Add on Empty , 32 , 1024 , 8 , 152 , 6.81 , 59.42
rte_hash_crc, Add on Empty , 32 , 1024 , 16 , 101 , 14.42 , 78.73
rte_hash_crc, Add on Empty , 48 , 1024 , 1 , 369 , 0.64 , 42.53
rte_hash_crc, Add on Empty , 48 , 1024 , 2 , 283 , 1.45 , 50.33
rte_hash_crc, Add on Empty , 48 , 1024 , 4 , 196 , 3.23 , 54.67
rte_hash_crc, Add on Empty , 48 , 1024 , 8 , 155 , 6.79 , 91.17
rte_hash_crc, Add on Empty , 48 , 1024 , 16 , 88 , 14.62 , 80.80
rte_hash_crc, Add on Empty , 64 , 1024 , 1 , 382 , 0.63 , 44.50
rte_hash_crc, Add on Empty , 64 , 1024 , 2 , 275 , 1.46 , 53.42
rte_hash_crc, Add on Empty , 64 , 1024 , 4 , 188 , 3.27 , 58.76
rte_hash_crc, Add on Empty , 64 , 1024 , 8 , 139 , 6.91 , 67.76
rte_hash_crc, Add on Empty , 64 , 1024 , 16 , 91 , 14.58 , 82.33
rte_hash_crc, Add Update , 16 , 1024 , 1 , 9636 , 0.36 , 23.83
rte_hash_crc, Add Update , 16 , 1024 , 2 , 9724 , 0.54 , 25.99
rte_hash_crc, Add Update , 16 , 1024 , 4 , 9798 , 0.79 , 30.52
rte_hash_crc, Add Update , 16 , 1024 , 8 , 9854 , 1.14 , 37.86
rte_hash_crc, Add Update , 16 , 1024 , 16 , 9912 , 1.38 , 54.53
rte_hash_crc, Add Update , 32 , 1024 , 1 , 9635 , 0.36 , 27.42
rte_hash_crc, Add Update , 32 , 1024 , 2 , 9719 , 0.55 , 28.54
rte_hash_crc, Add Update , 32 , 1024 , 4 , 9799 , 0.79 , 32.58
rte_hash_crc, Add Update , 32 , 1024 , 8 , 9867 , 1.04 , 40.62
rte_hash_crc, Add Update , 32 , 1024 , 16 , 9906 , 1.47 , 56.60
rte_hash_crc, Add Update , 48 , 1024 , 1 , 9620 , 0.37 , 29.18
rte_hash_crc, Add Update , 48 , 1024 , 2 , 9722 , 0.54 , 33.32
rte_hash_crc, Add Update , 48 , 1024 , 4 , 9805 , 0.76 , 35.38
rte_hash_crc, Add Update , 48 , 1024 , 8 , 9848 , 1.19 , 43.94
rte_hash_crc, Add Update , 48 , 1024 , 16 , 9921 , 1.23 , 61.95
rte_hash_crc, Add Update , 64 , 1024 , 1 , 9618 , 0.37 , 30.84
rte_hash_crc, Add Update , 64 , 1024 , 2 , 9712 , 0.56 , 32.43
rte_hash_crc, Add Update , 64 , 1024 , 4 , 9799 , 0.79 , 37.61
rte_hash_crc, Add Update , 64 , 1024 , 8 , 9864 , 1.06 , 48.04
rte_hash_crc, Add Update , 64 , 1024 , 16 , 9901 , 1.55 , 62.95
rte_hash_crc, Lookup , 16 , 1024 , 1 , 10000 , 0.00 , 22.62
rte_hash_crc, Lookup , 16 , 1024 , 2 , 10000 , 0.00 , 22.64
rte_hash_crc, Lookup , 16 , 1024 , 4 , 10000 , 0.00 , 24.02
rte_hash_crc, Lookup , 16 , 1024 , 8 , 10000 , 0.00 , 29.00
rte_hash_crc, Lookup , 16 , 1024 , 16 , 10000 , 0.00 , 34.09
rte_hash_crc, Lookup , 32 , 1024 , 1 , 10000 , 0.00 , 23.63
rte_hash_crc, Lookup , 32 , 1024 , 2 , 10000 , 0.00 , 23.79
rte_hash_crc, Lookup , 32 , 1024 , 4 , 10000 , 0.00 , 28.47
rte_hash_crc, Lookup , 32 , 1024 , 8 , 10000 , 0.00 , 30.93
rte_hash_crc, Lookup , 32 , 1024 , 16 , 10000 , 0.00 , 38.92
rte_hash_crc, Lookup , 48 , 1024 , 1 , 10000 , 0.00 , 25.76
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no 119x58
6, 78
06:12:28


root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
rte_hash_crc, Lookup , 48 , 1024 , 2 , 10000 , 0.00 , 28.88
rte_hash_crc, Lookup , 48 , 1024 , 4 , 10000 , 0.00 , 29.95
rte_hash_crc, Lookup , 48 , 1024 , 8 , 10000 , 0.00 , 33.33
rte_hash_crc, Lookup , 48 , 1024 , 16 , 10000 , 0.00 , 40.91
rte_hash_crc, Lookup , 64 , 1024 , 1 , 10000 , 0.00 , 26.85
rte_hash_crc, Lookup , 64 , 1024 , 2 , 10000 , 0.00 , 30.56
rte_hash_crc, Lookup , 64 , 1024 , 4 , 10000 , 0.00 , 31.98
rte_hash_crc, Lookup , 64 , 1024 , 8 , 10000 , 0.00 , 34.35
rte_hash_crc, Lookup , 64 , 1024 , 16 , 10000 , 0.00 , 45.46
rte_hash_crc, Add on Empty , 16 , 1048576, 1 , 385398 , 0.63 , 51.18
rte_hash_crc, Add on Empty , 16 , 1048576, 2 , 283478 , 1.46 , 59.43
rte_hash_crc, Add on Empty , 16 , 1048576, 4 , 205084 , 3.22 , 69.38
rte_hash_crc, Add on Empty , 16 , 1048576, 8 , 146958 , 6.88 , 83.03
rte_hash_crc, Add on Empty , 16 , 1048576, 16 , 104624 , 14.40 , 101.98
rte_hash_crc, Add on Empty , 32 , 1048576, 1 , 223848 , 0.79 , 46.13
rte_hash_crc, Add on Empty , 32 , 1048576, 2 , 109236 , 1.79 , 60.44
rte_hash_crc, Add on Empty , 32 , 1048576, 4 , 39916 , 3.85 , 74.38
rte_hash_crc, Add on Empty , 32 , 1048576, 8 , 9368 , 7.93 , 87.90
rte_hash_crc, Add on Empty , 32 , 1048576, 16 , 964 , 15.99 , 100.37
rte_hash_crc, Add on Empty , 48 , 1048576, 1 , 386162 , 0.63 , 62.48
rte_hash_crc, Add on Empty , 48 , 1048576, 2 , 284056 , 1.46 , 69.88
rte_hash_crc, Add on Empty , 48 , 1048576, 4 , 205174 , 3.22 , 78.80
rte_hash_crc, Add on Empty , 48 , 1048576, 8 , 146382 , 6.88 , 92.08
rte_hash_crc, Add on Empty , 48 , 1048576, 16 , 104014 , 14.41 , 111.93
rte_hash_crc, Add on Empty , 64 , 1048576, 1 , 122120 , 0.88 , 45.45
rte_hash_crc, Add on Empty , 64 , 1048576, 2 , 34704 , 1.93 , 57.07
rte_hash_crc, Add on Empty , 64 , 1048576, 4 , 4688 , 3.98 , 71.48
rte_hash_crc, Add on Empty , 64 , 1048576, 8 , 160 , 8.00 , 87.31
rte_hash_crc, Add on Empty , 64 , 1048576, 16 , 0 , 16.00 , 101.11
rte_hash_crc, Add Update , 16 , 1048576, 1 , 57 , 0.01 , 29.77
rte_hash_crc, Add Update , 16 , 1048576, 2 , 0 , 0.02 , 30.22
rte_hash_crc, Add Update , 16 , 1048576, 4 , 0 , 0.04 , 29.93
rte_hash_crc, Add Update , 16 , 1048576, 8 , 0 , 0.08 , 31.38
rte_hash_crc, Add Update , 16 , 1048576, 16 , 0 , 0.15 , 33.35
rte_hash_crc, Add Update , 32 , 1048576, 1 , 38 , 0.01 , 34.77
rte_hash_crc, Add Update , 32 , 1048576, 2 , 0 , 0.02 , 35.26
rte_hash_crc, Add Update , 32 , 1048576, 4 , 0 , 0.04 , 34.20
rte_hash_crc, Add Update , 32 , 1048576, 8 , 0 , 0.08 , 36.36
rte_hash_crc, Add Update , 32 , 1048576, 16 , 0 , 0.15 , 38.75
rte_hash_crc, Add Update , 48 , 1048576, 1 , 54 , 0.01 , 37.60
rte_hash_crc, Add Update , 48 , 1048576, 2 , 1 , 0.02 , 37.86
rte_hash_crc, Add Update , 48 , 1048576, 4 , 0 , 0.04 , 38.00
rte_hash_crc, Add Update , 48 , 1048576, 8 , 0 , 0.08 , 39.39
rte_hash_crc, Add Update , 48 , 1048576, 16 , 0 , 0.15 , 41.00
rte_hash_crc, Add Update , 64 , 1048576, 1 , 47 , 0.01 , 38.84
rte_hash_crc, Add Update , 64 , 1048576, 2 , 0 , 0.02 , 40.95
rte_hash_crc, Add Update , 64 , 1048576, 4 , 0 , 0.04 , 41.57
rte_hash_crc, Add Update , 64 , 1048576, 8 , 0 , 0.08 , 42.58
rte_hash_crc, Add Update , 64 , 1048576, 16 , 0 , 0.15 , 44.72
rte_hash_crc, Lookup , 16 , 1048576, 1 , 57 , 0.01 , 28.88
rte_hash_crc, Lookup , 16 , 1048576, 2 , 0 , 0.02 , 28.96
rte_hash_crc, Lookup , 16 , 1048576, 4 , 0 , 0.04 , 28.99
rte_hash_crc, Lookup , 16 , 1048576, 8 , 0 , 0.08 , 30.13
rte_hash_crc, Lookup , 16 , 1048576, 16 , 0 , 0.15 , 32.22
rte_hash_crc, Lookup , 32 , 1048576, 1 , 49 , 0.01 , 32.12
rte_hash_crc, Lookup , 32 , 1048576, 2 , 1 , 0.02 , 32.05
rte_hash_crc, Lookup , 32 , 1048576, 4 , 0 , 0.04 , 32.18
rte_hash_crc, Lookup , 32 , 1048576, 8 , 0 , 0.08 , 33.30
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no
119x58
6, 78
06:13:07

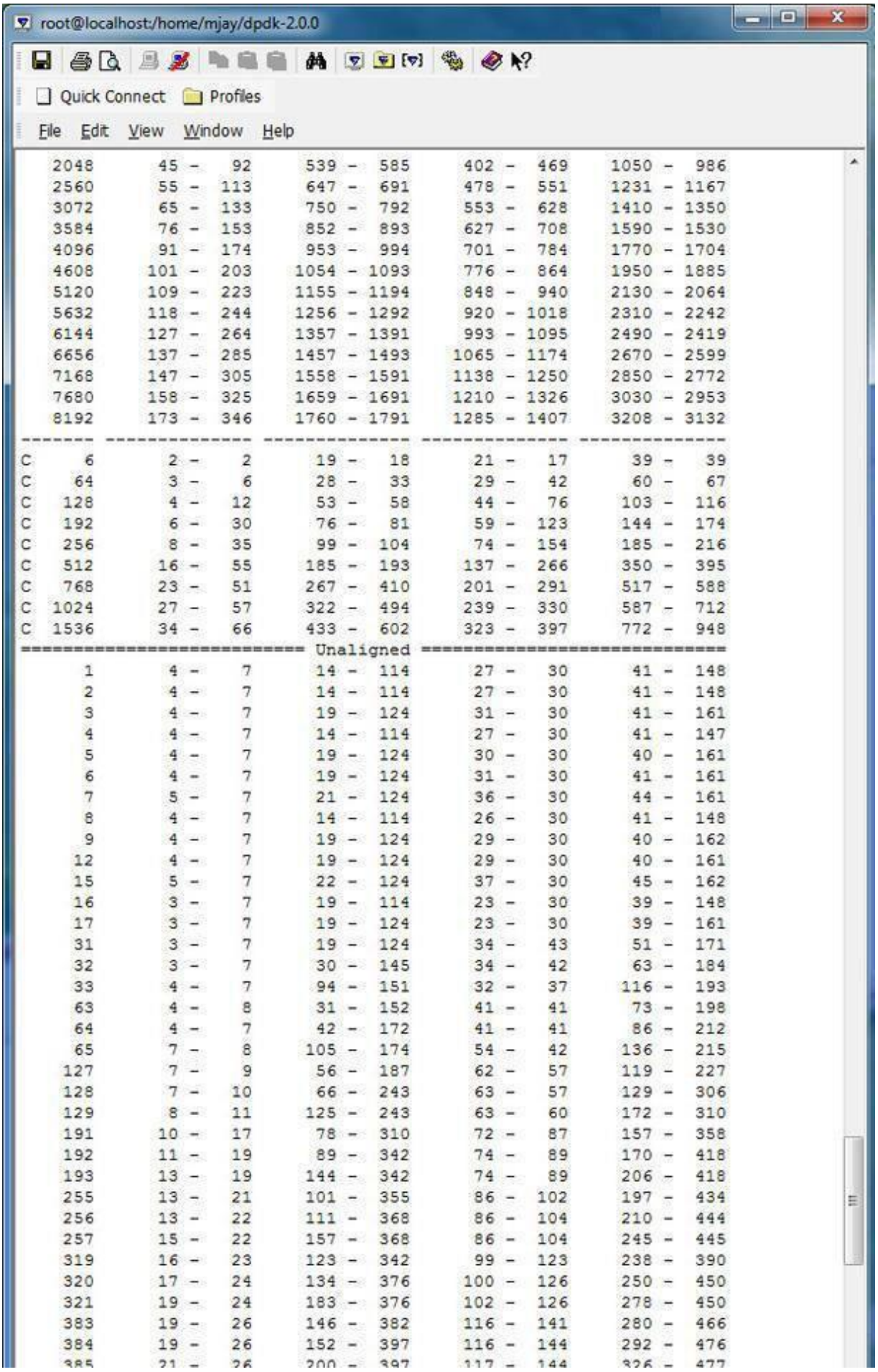


Memcpy_perf_autotest Test Results

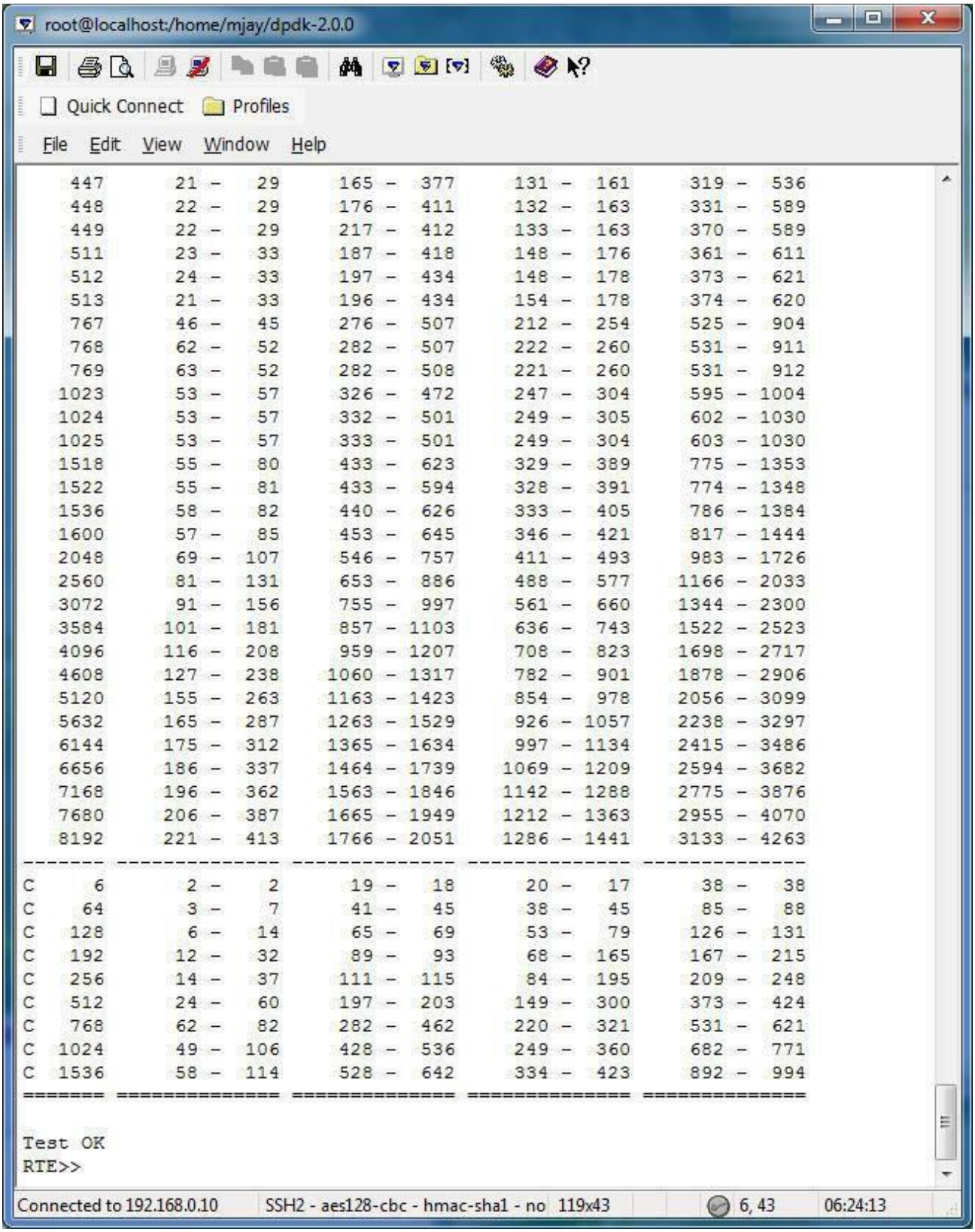
To evaluate the performance in your platform, run /app/test/memcpy_perf_autotest, for both 32 bytes aligned and unaligned.




```
RTE>>memcpy_perf_autotest

** rte_memcpy() - memcpy perf. tests (C = compile-time constant) **
======= ============== ============== ============== ==============
   Size Cache to cache    Cache to mem   Mem to cache     Mem to mem
(bytes)        (ticks)         (ticks)        (ticks)         (ticks)
------- -------------- -------------- -------------- --------------
=========================== 32B aligned ===============================
      1       4 -    6       14 -  113       27 -   30       41 -  148
      2       4 -    6       14 -  114       27 -   30       41 -  147
      3       4 -    6       19 -  124       31 -   31       40 -  161
      4       4 -    6       14 -  114       27 -   30       41 -  148
      5       4 -    6       19 -  124       31 -   31       40 -  161
      6       4 -    6       19 -  124       31 -   30       40 -  161
      7       5 -    7       21 -  124       36 -   30       43 -  162
      8       4 -    6       14 -  114       27 -   30       41 -  147
      9       4 -    6       19 -  124       29 -   31       40 -  162
     12       4 -    6       19 -  124       29 -   31       40 -  162
     15       5 -    7       22 -  124       37 -   30       44 -  162
     16       3 -    6       19 -  114       23 -   30       39 -  148
     17       3 -    7       19 -  124       23 -   31       39 -  162
     31       3 -    7       19 -  125       23 -   31       39 -  162
     32       3 -    7       19 -  124       23 -   31       39 -  162
     33       4 -    7       30 -  150       36 -   37       63 -  191
     63       4 -    8       30 -  154       36 -   34       64 -  194
     64       4 -    7       29 -  152       29 -   34       60 -  192
     65       7 -    8       42 -  173       50 -   42       89 -  214
    127       7 -    9       54 -  217       55 -   50      107 -  278
    128       6 -    8       54 -  187       50 -   50      104 -  224
    129       8 -   10       65 -  258       58 -   60      128 -  329
    191       8 -   14       77 -  268       64 -   73      145 -  325
    192       8 -   15       76 -  324       62 -   75      143 -  366
    193      10 -   18       88 -  345       70 -   80      166 -  418
    255      10 -   18       99 -  350       77 -   90      187 -  429
    256      10 -   19       99 -  219       74 -   94      185 -  334
    257      12 -   19      111 -  286       83 -  100      207 -  385
    319      12 -   21      122 -  294       91 -  109      229 -  348
    320      13 -   22      122 -  358       90 -  113      228 -  393
    321      14 -   22      133 -  379       99 -  120      248 -  451
    383      14 -   24      144 -  386      106 -  129      269 -  458
    384      14 -   25      144 -  238      104 -  133      268 -  382
    385      16 -   25      152 -  306      114 -  141      290 -  428
    447      16 -   27      164 -  311      122 -  149      309 -  429
    448      15 -   26      164 -  375      120 -  151      308 -  461
    449      17 -   27      175 -  397      130 -  156      330 -  502
    511      17 -   29      185 -  391      138 -  165      350 -  526
    512      16 -   30      185 -  251      136 -  170      349 -  479
    513      20 -   30      196 -  319      151 -  177      461 -  525
    767      24 -   40      268 -  472      205 -  241      582 -  677
    768      24 -   40      267 -  362      203 -  243      581 -  621
    769      36 -   54      274 -  421      216 -  256      593 -  657
   1023      28 -   51      322 -  410      240 -  286      653 -  638
   1024      27 -   51      322 -  375      240 -  288      652 -  627
   1025      28 -   51      330 -  423      245 -  300      660 -  668
   1518      35 -   69      432 -  531      323 -  387      861 -  832
   1522      35 -   71      432 -  502      323 -  378      861 -  809
   1536      35 -   71      432 -  480      323 -  383      861 -  804
   1600      35 -   74      446 -  511      335 -  396      887 -  831
```



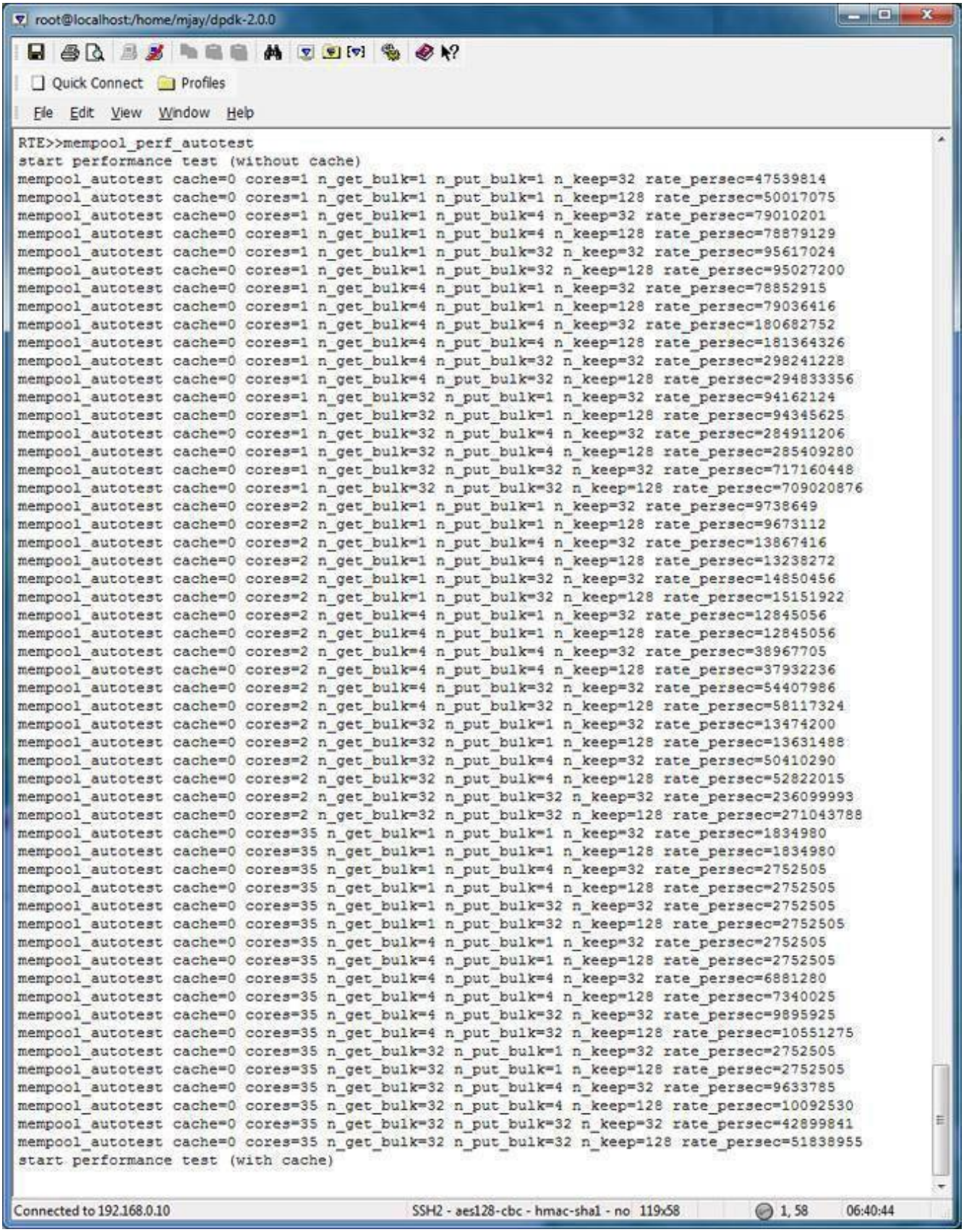
2048	45 - 92	539 - 585	402 - 469	1050 - 986
2560	55 - 113	647 - 691	478 - 551	1231 - 1167
3072	65 - 133	750 - 792	553 - 628	1410 - 1350
3584	76 - 153	852 - 893	627 - 708	1590 - 1530
4096	91 - 174	953 - 994	701 - 784	1770 - 1704
4608	101 - 203	1054 - 1093	776 - 864	1950 - 1885
5120	109 - 223	1155 - 1194	848 - 940	2130 - 2064
5632	118 - 244	1256 - 1292	920 - 1018	2310 - 2242
6144	127 - 264	1357 - 1391	993 - 1095	2490 - 2419
6656	137 - 285	1457 - 1493	1065 - 1174	2670 - 2599
7168	147 - 305	1558 - 1591	1138 - 1250	2850 - 2772
7680	158 - 325	1659 - 1691	1210 - 1326	3030 - 2953
8192	173 - 346	1760 - 1791	1285 - 1407	3208 - 3132
C 6	2 - 2	19 - 18	21 - 17	39 - 39
C 64	3 - 6	28 - 33	29 - 42	60 - 67
C 128	4 - 12	53 - 58	44 - 76	103 - 116
C 192	6 - 30	76 - 81	59 - 123	144 - 174
C 256	8 - 35	99 - 104	74 - 154	185 - 216
C 512	16 - 55	185 - 193	137 - 266	350 - 395
C 768	23 - 51	267 - 410	201 - 291	517 - 588
C 1024	27 - 57	322 - 494	239 - 330	587 - 712
C 1536	34 - 66	433 - 602	323 - 397	772 - 948
Unaligned				
1	4 - 7	14 - 114	27 - 30	41 - 148
2	4 - 7	14 - 114	27 - 30	41 - 148
3	4 - 7	19 - 124	31 - 30	41 - 161
4	4 - 7	14 - 114	27 - 30	41 - 147
5	4 - 7	19 - 124	30 - 30	40 - 161
6	4 - 7	19 - 124	31 - 30	41 - 161
7	5 - 7	21 - 124	36 - 30	44 - 161
8	4 - 7	14 - 114	26 - 30	41 - 148
9	4 - 7	19 - 124	29 - 30	40 - 162
12	4 - 7	19 - 124	29 - 30	40 - 161
15	5 - 7	22 - 124	37 - 30	45 - 162
16	3 - 7	19 - 114	23 - 30	39 - 148
17	3 - 7	19 - 124	23 - 30	39 - 161
31	3 - 7	19 - 124	34 - 43	51 - 171
32	3 - 7	30 - 145	34 - 42	63 - 184
33	4 - 7	94 - 151	32 - 37	116 - 193
63	4 - 8	31 - 152	41 - 41	73 - 198
64	4 - 7	42 - 172	41 - 41	86 - 212
65	7 - 8	105 - 174	54 - 42	136 - 215
127	7 - 9	56 - 187	62 - 57	119 - 227
128	7 - 10	66 - 243	63 - 57	129 - 306
129	8 - 11	125 - 243	63 - 60	172 - 310
191	10 - 17	78 - 310	72 - 87	157 - 358
192	11 - 19	89 - 342	74 - 89	170 - 418
193	13 - 19	144 - 342	74 - 89	206 - 418
255	13 - 21	101 - 355	86 - 102	197 - 434
256	13 - 22	111 - 368	86 - 104	210 - 444
257	15 - 22	157 - 368	86 - 104	245 - 445
319	16 - 23	123 - 342	99 - 123	238 - 390
320	17 - 24	134 - 376	100 - 126	250 - 450
321	19 - 24	183 - 376	102 - 126	278 - 450
383	19 - 26	146 - 382	116 - 141	280 - 466
384	19 - 26	152 - 397	116 - 144	292 - 476
385	21 - 26	200 - 397	117 - 144	326 - 477

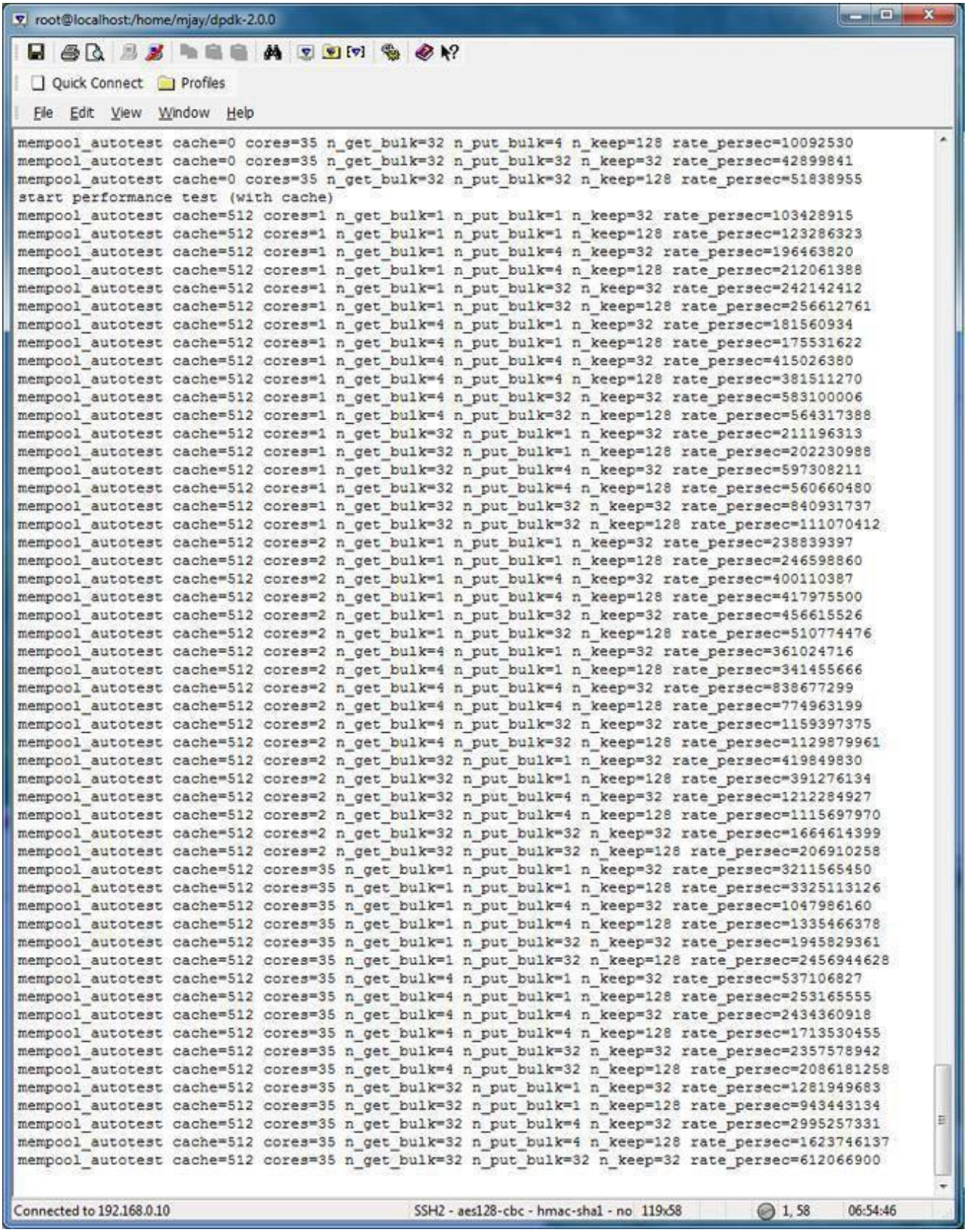

root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
447 21 - 29 165 - 377 131 - 161 319 - 536
448 22 - 29 176 - 411 132 - 163 331 - 589
449 22 - 29 217 - 412 133 - 163 370 - 589
511 23 - 33 187 - 418 148 - 176 361 - 611
512 24 - 33 197 - 434 148 - 178 373 - 621
513 21 - 33 196 - 434 154 - 178 374 - 620
767 46 - 45 276 - 507 212 - 254 525 - 904
768 62 - 52 282 - 507 222 - 260 531 - 911
769 63 - 52 282 - 508 221 - 260 531 - 912
1023 53 - 57 326 - 472 247 - 304 595 - 1004
1024 53 - 57 332 - 501 249 - 305 602 - 1030
1025 53 - 57 333 - 501 249 - 304 603 - 1030
1518 55 - 80 433 - 623 329 - 389 775 - 1353
1522 55 - 81 433 - 594 328 - 391 774 - 1348
1536 58 - 82 440 - 626 333 - 405 786 - 1384
1600 57 - 85 453 - 645 346 - 421 817 - 1444
2048 69 - 107 546 - 757 411 - 493 983 - 1726
2560 81 - 131 653 - 886 488 - 577 1166 - 2033
3072 91 - 156 755 - 997 561 - 660 1344 - 2300
3584 101 - 181 857 - 1103 636 - 743 1522 - 2523
4096 116 - 208 959 - 1207 708 - 823 1698 - 2717
4608 127 - 238 1060 - 1317 782 - 901 1878 - 2906
5120 155 - 263 1163 - 1423 854 - 978 2056 - 3099
5632 165 - 287 1263 - 1529 926 - 1057 2238 - 3297
6144 175 - 312 1365 - 1634 997 - 1134 2415 - 3486
6656 186 - 337 1464 - 1739 1069 - 1209 2594 - 3682
7168 196 - 362 1563 - 1846 1142 - 1288 2775 - 3876
7680 206 - 387 1665 - 1949 1212 - 1363 2955 - 4070
8192 221 - 413 1766 - 2051 1286 - 1441 3133 - 4263
C 6 2 - 2 19 - 18 20 - 17 38 - 38
C 64 3 - 7 41 - 45 38 - 45 85 - 88
C 128 6 - 14 65 - 69 53 - 79 126 - 131
C 192 12 - 32 89 - 93 68 - 165 167 - 215
C 256 14 - 37 111 - 115 84 - 195 209 - 248
C 512 24 - 60 197 - 203 149 - 300 373 - 424
C 768 62 - 82 282 - 462 220 - 321 531 - 621
C 1024 49 - 106 428 - 536 249 - 360 682 - 771
C 1536 58 - 114 528 - 642 334 - 423 892 - 994
Test OK
RTE>>
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no
119x43
6, 43
06:24:13

Mempool_perf_autotest Test Results

Core Configuration	Cache Object	Bulk Get Size	Bulk Put Size	# of Kept Objects
a) 1 Core b) 2 Cores c) Max. Cores	a) with cache object b) without cacheobject	a) 1 b) 4 c) 32	a) 1 b) 4 c) 32	a) 32 b) 128

To evaluate the performance in your platform, run /app/test/mempool_perf_autotest.

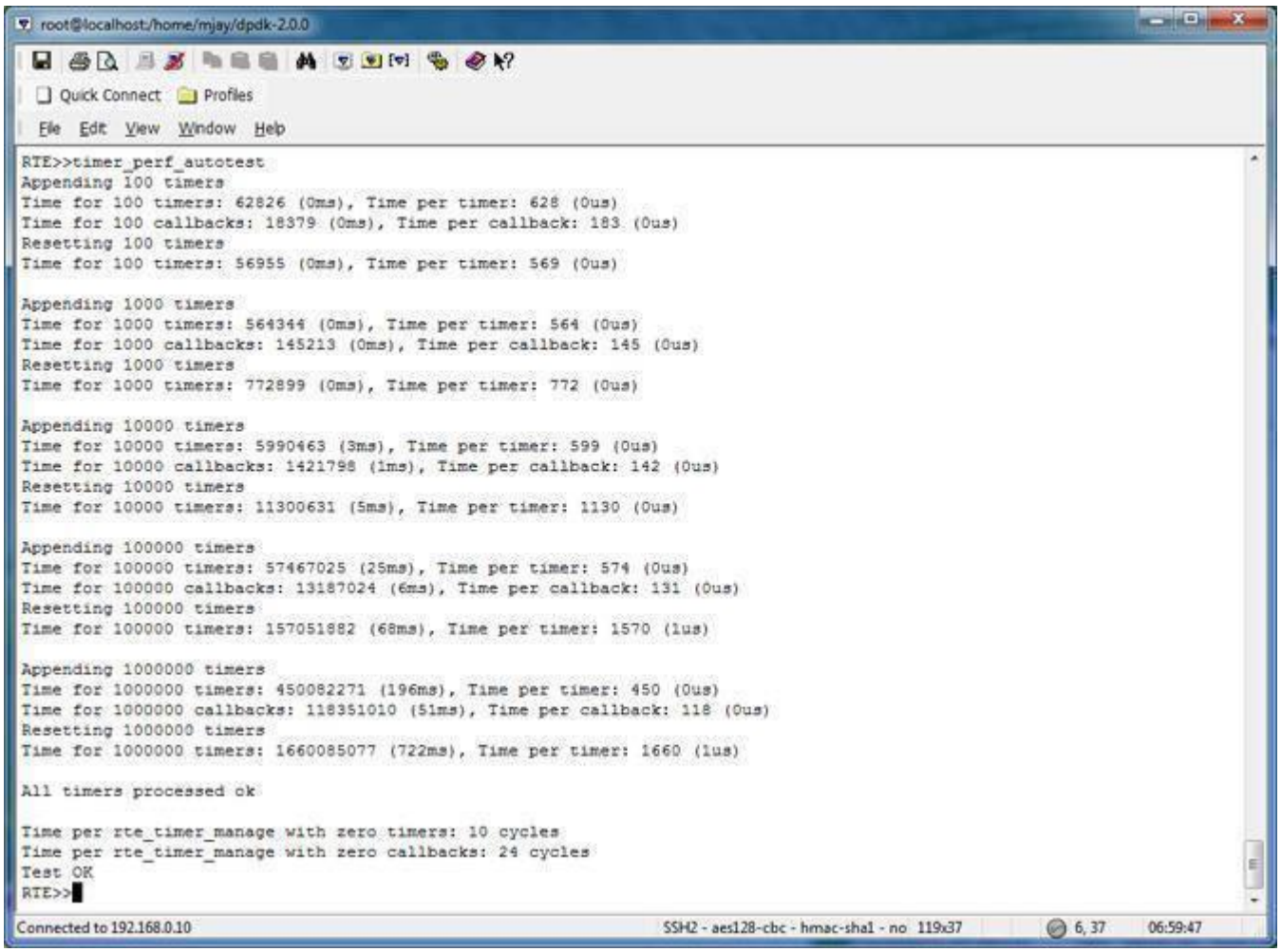

root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
RTE>>mempool_perf_autotest
start performance test (without cache)
mempool_autotest cache=0 cores=1 n_get_bulk=1 n_put_bulk=1 n_keep=32 rate_persec=47539814
mempool_autotest cache=0 cores=1 n_get_bulk=1 n_put_bulk=1 n_keep=128 rate_persec=50017075
mempool_autotest cache=0 cores=1 n_get_bulk=1 n_put_bulk=4 n_keep=32 rate_persec=79010201
mempool_autotest cache=0 cores=1 n_get_bulk=1 n_put_bulk=4 n_keep=128 rate_persec=78879129
mempool_autotest cache=0 cores=1 n_get_bulk=1 n_put_bulk=32 n_keep=32 rate_persec=95617024
mempool_autotest cache=0 cores=1 n_get_bulk=1 n_put_bulk=32 n_keep=128 rate_persec=95027200
mempool_autotest cache=0 cores=1 n_get_bulk=4 n_put_bulk=1 n_keep=32 rate_persec=78852915
mempool_autotest cache=0 cores=1 n_get_bulk=4 n_put_bulk=1 n_keep=128 rate_persec=79036416
mempool_autotest cache=0 cores=1 n_get_bulk=4 n_put_bulk=4 n_keep=32 rate_persec=180682752
mempool_autotest cache=0 cores=1 n_get_bulk=4 n_put_bulk=4 n_keep=128 rate_persec=181364326
mempool_autotest cache=0 cores=1 n_get_bulk=4 n_put_bulk=32 n_keep=32 rate_persec=298241228
mempool_autotest cache=0 cores=1 n_get_bulk=4 n_put_bulk=32 n_keep=128 rate_persec=294833356
mempool_autotest cache=0 cores=1 n_get_bulk=32 n_put_bulk=1 n_keep=32 rate_persec=94162124
mempool_autotest cache=0 cores=1 n_get_bulk=32 n_put_bulk=1 n_keep=128 rate_persec=94345625
mempool_autotest cache=0 cores=1 n_get_bulk=32 n_put_bulk=4 n_keep=32 rate_persec=284911206
mempool_autotest cache=0 cores=1 n_get_bulk=32 n_put_bulk=4 n_keep=128 rate_persec=285409280
mempool_autotest cache=0 cores=1 n_get_bulk=32 n_put_bulk=32 n_keep=32 rate_persec=717160448
mempool_autotest cache=0 cores=1 n_get_bulk=32 n_put_bulk=32 n_keep=128 rate_persec=709020876
mempool_autotest cache=0 cores=2 n_get_bulk=1 n_put_bulk=1 n_keep=32 rate_persec=9738649
mempool_autotest cache=0 cores=2 n_get_bulk=1 n_put_bulk=1 n_keep=128 rate_persec=9673112
mempool_autotest cache=0 cores=2 n_get_bulk=1 n_put_bulk=4 n_keep=32 rate_persec=13867416
mempool_autotest cache=0 cores=2 n_get_bulk=1 n_put_bulk=4 n_keep=128 rate_persec=13238272
mempool_autotest cache=0 cores=2 n_get_bulk=1 n_put_bulk=32 n_keep=32 rate_persec=14850456
mempool_autotest cache=0 cores=2 n_get_bulk=1 n_put_bulk=32 n_keep=128 rate_persec=15151922
mempool_autotest cache=0 cores=2 n_get_bulk=4 n_put_bulk=1 n_keep=32 rate_persec=12845056
mempool_autotest cache=0 cores=2 n_get_bulk=4 n_put_bulk=1 n_keep=128 rate_persec=12845056
mempool_autotest cache=0 cores=2 n_get_bulk=4 n_put_bulk=4 n_keep=32 rate_persec=38967705
mempool_autotest cache=0 cores=2 n_get_bulk=4 n_put_bulk=4 n_keep=128 rate_persec=37932236
mempool_autotest cache=0 cores=2 n_get_bulk=4 n_put_bulk=32 n_keep=32 rate_persec=54407986
mempool_autotest cache=0 cores=2 n_get_bulk=4 n_put_bulk=32 n_keep=128 rate_persec=58117324
mempool_autotest cache=0 cores=2 n_get_bulk=32 n_put_bulk=1 n_keep=32 rate_persec=13474200
mempool_autotest cache=0 cores=2 n_get_bulk=32 n_put_bulk=1 n_keep=128 rate_persec=13631488
mempool_autotest cache=0 cores=2 n_get_bulk=32 n_put_bulk=4 n_keep=32 rate_persec=50410290
mempool_autotest cache=0 cores=2 n_get_bulk=32 n_put_bulk=4 n_keep=128 rate_persec=52822015
mempool_autotest cache=0 cores=2 n_get_bulk=32 n_put_bulk=32 n_keep=32 rate_persec=236099993
mempool_autotest cache=0 cores=2 n_get_bulk=32 n_put_bulk=32 n_keep=128 rate_persec=271043788
mempool_autotest cache=0 cores=35 n_get_bulk=1 n_put_bulk=1 n_keep=32 rate_persec=1834980
mempool_autotest cache=0 cores=35 n_get_bulk=1 n_put_bulk=1 n_keep=128 rate_persec=1834980
mempool_autotest cache=0 cores=35 n_get_bulk=1 n_put_bulk=4 n_keep=32 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=1 n_put_bulk=4 n_keep=128 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=1 n_put_bulk=32 n_keep=32 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=1 n_put_bulk=32 n_keep=128 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=4 n_put_bulk=1 n_keep=32 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=4 n_put_bulk=1 n_keep=128 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=4 n_put_bulk=4 n_keep=32 rate_persec=6881280
mempool_autotest cache=0 cores=35 n_get_bulk=4 n_put_bulk=4 n_keep=128 rate_persec=7340025
mempool_autotest cache=0 cores=35 n_get_bulk=4 n_put_bulk=32 n_keep=32 rate_persec=9895925
mempool_autotest cache=0 cores=35 n_get_bulk=4 n_put_bulk=32 n_keep=128 rate_persec=10551275
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=1 n_keep=32 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=1 n_keep=128 rate_persec=2752505
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=4 n_keep=32 rate_persec=9633785
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=4 n_keep=128 rate_persec=10092530
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=32 n_keep=32 rate_persec=42899841
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=32 n_keep=128 rate_persec=51838955
start performance test (with cache)
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no 119x58
1, 58
06:40:44


root@localhost:/home/mjay/dpdk-2.0.0
Quick Connect
Profiles
File Edit View Window Help
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=4 n_keep=128 rate_persec=10092530
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=32 n_keep=32 rate_persec=42899841
mempool_autotest cache=0 cores=35 n_get_bulk=32 n_put_bulk=32 n_keep=128 rate_persec=51838955
start performance test (with cache)
mempool_autotest cache=512 cores=1 n_get_bulk=1 n_put_bulk=1 n_keep=32 rate_persec=103428915
mempool_autotest cache=512 cores=1 n_get_bulk=1 n_put_bulk=1 n_keep=128 rate_persec=123286323
mempool_autotest cache=512 cores=1 n_get_bulk=1 n_put_bulk=4 n_keep=32 rate_persec=196463820
mempool_autotest cache=512 cores=1 n_get_bulk=1 n_put_bulk=4 n_keep=128 rate_persec=212061388
mempool_autotest cache=512 cores=1 n_get_bulk=1 n_put_bulk=32 n_keep=32 rate_persec=242142412
mempool_autotest cache=512 cores=1 n_get_bulk=1 n_put_bulk=32 n_keep=128 rate_persec=256612761
mempool_autotest cache=512 cores=1 n_get_bulk=4 n_put_bulk=1 n_keep=32 rate_persec=181560934
mempool_autotest cache=512 cores=1 n_get_bulk=4 n_put_bulk=1 n_keep=128 rate_persec=175531622
mempool_autotest cache=512 cores=1 n_get_bulk=4 n_put_bulk=4 n_keep=32 rate_persec=415026380
mempool_autotest cache=512 cores=1 n_get_bulk=4 n_put_bulk=4 n_keep=128 rate_persec=381511270
mempool_autotest cache=512 cores=1 n_get_bulk=4 n_put_bulk=32 n_keep=32 rate_persec=583100006
mempool_autotest cache=512 cores=1 n_get_bulk=4 n_put_bulk=32 n_keep=128 rate_persec=564317388
mempool_autotest cache=512 cores=1 n_get_bulk=32 n_put_bulk=1 n_keep=32 rate_persec=211196313
mempool_autotest cache=512 cores=1 n_get_bulk=32 n_put_bulk=1 n_keep=128 rate_persec=202230988
mempool_autotest cache=512 cores=1 n_get_bulk=32 n_put_bulk=4 n_keep=32 rate_persec=597308211
mempool_autotest cache=512 cores=1 n_get_bulk=32 n_put_bulk=4 n_keep=128 rate_persec=560660480
mempool_autotest cache=512 cores=1 n_get_bulk=32 n_put_bulk=32 n_keep=32 rate_persec=840931737
mempool_autotest cache=512 cores=1 n_get_bulk=32 n_put_bulk=32 n_keep=128 rate_persec=111070412
mempool_autotest cache=512 cores=2 n_get_bulk=1 n_put_bulk=1 n_keep=32 rate_persec=238839397
mempool_autotest cache=512 cores=2 n_get_bulk=1 n_put_bulk=1 n_keep=128 rate_persec=246598860
mempool_autotest cache=512 cores=2 n_get_bulk=1 n_put_bulk=4 n_keep=32 rate_persec=400110387
mempool_autotest cache=512 cores=2 n_get_bulk=1 n_put_bulk=4 n_keep=128 rate_persec=417975500
mempool_autotest cache=512 cores=2 n_get_bulk=1 n_put_bulk=32 n_keep=32 rate_persec=456615526
mempool_autotest cache=512 cores=2 n_get_bulk=1 n_put_bulk=32 n_keep=128 rate_persec=510774476
mempool_autotest cache=512 cores=2 n_get_bulk=4 n_put_bulk=1 n_keep=32 rate_persec=361024716
mempool_autotest cache=512 cores=2 n_get_bulk=4 n_put_bulk=1 n_keep=128 rate_persec=341455666
mempool_autotest cache=512 cores=2 n_get_bulk=4 n_put_bulk=4 n_keep=32 rate_persec=838677299
mempool_autotest cache=512 cores=2 n_get_bulk=4 n_put_bulk=4 n_keep=128 rate_persec=774963199
mempool_autotest cache=512 cores=2 n_get_bulk=4 n_put_bulk=32 n_keep=32 rate_persec=1159397375
mempool_autotest cache=512 cores=2 n_get_bulk=4 n_put_bulk=32 n_keep=128 rate_persec=1129879961
mempool_autotest cache=512 cores=2 n_get_bulk=32 n_put_bulk=1 n_keep=32 rate_persec=419849830
mempool_autotest cache=512 cores=2 n_get_bulk=32 n_put_bulk=1 n_keep=128 rate_persec=391276134
mempool_autotest cache=512 cores=2 n_get_bulk=32 n_put_bulk=4 n_keep=32 rate_persec=1212284927
mempool_autotest cache=512 cores=2 n_get_bulk=32 n_put_bulk=4 n_keep=128 rate_persec=1115697970
mempool_autotest cache=512 cores=2 n_get_bulk=32 n_put_bulk=32 n_keep=32 rate_persec=1664614399
mempool_autotest cache=512 cores=2 n_get_bulk=32 n_put_bulk=32 n_keep=128 rate_persec=206910258
mempool_autotest cache=512 cores=35 n_get_bulk=1 n_put_bulk=1 n_keep=32 rate_persec=3211565450
mempool_autotest cache=512 cores=35 n_get_bulk=1 n_put_bulk=1 n_keep=128 rate_persec=3325113126
mempool_autotest cache=512 cores=35 n_get_bulk=1 n_put_bulk=4 n_keep=32 rate_persec=1047986160
mempool_autotest cache=512 cores=35 n_get_bulk=1 n_put_bulk=4 n_keep=128 rate_persec=1335466378
mempool_autotest cache=512 cores=35 n_get_bulk=1 n_put_bulk=32 n_keep=32 rate_persec=1945829361
mempool_autotest cache=512 cores=35 n_get_bulk=1 n_put_bulk=32 n_keep=128 rate_persec=2456944628
mempool_autotest cache=512 cores=35 n_get_bulk=4 n_put_bulk=1 n_keep=32 rate_persec=537106827
mempool_autotest cache=512 cores=35 n_get_bulk=4 n_put_bulk=1 n_keep=128 rate_persec=253165555
mempool_autotest cache=512 cores=35 n_get_bulk=4 n_put_bulk=4 n_keep=32 rate_persec=2434360918
mempool_autotest cache=512 cores=35 n_get_bulk=4 n_put_bulk=4 n_keep=128 rate_persec=1713530455
mempool_autotest cache=512 cores=35 n_get_bulk=4 n_put_bulk=32 n_keep=32 rate_persec=2357578942
mempool_autotest cache=512 cores=35 n_get_bulk=4 n_put_bulk=32 n_keep=128 rate_persec=2086181258
mempool_autotest cache=512 cores=35 n_get_bulk=32 n_put_bulk=1 n_keep=32 rate_persec=1281949683
mempool_autotest cache=512 cores=35 n_get_bulk=32 n_put_bulk=1 n_keep=128 rate_persec=943443134
mempool_autotest cache=512 cores=35 n_get_bulk=32 n_put_bulk=4 n_keep=32 rate_persec=2995257331
mempool_autotest cache=512 cores=35 n_get_bulk=32 n_put_bulk=4 n_keep=128 rate_persec=1623746137
mempool_autotest cache=512 cores=35 n_get_bulk=32 n_put_bulk=32 n_keep=32 rate_persec=612066900
Connected to 192.168.0.10
SSH2 - aes128-cbc - hmac-sha1 - no 119x58
1, 58
06:54:46

Timer_perf_autotest Test Results

# of Timers Configuration	Operations Timed
a) 0 Timer b) 100 Timers c) 1000 Timers d) 10,000 Timers e) 100,000 Timers f) 1,000,000 Timers	- Appending - Callback - Resetting

To evaluate the performance in your platform, run /app/test/timer_perf_autotest



References

For cookbook-style instructions on how to do hands-on performance profiling of your DPDK code with VTune, refer to the companion article Profiling DPDK Code with Intel® VTune™ Amplifier.

Code Optimization Handout 20 - CS 143 Summer 2008 by Maggie Johnson

Document #5571159 Intel® Xeon® processor E7-8800/4800 v3 Performance Tuning Guide

Intel® Optimizing Non-Sequential Data Processing Applications – Brian Forde and John Browne

Measuring Cache and Memory Latency and CPU to Memory Bandwidth - For use with Intel® Architecture– Joshua Ruggiero

Compile with Performance Settings, Use PGO, Evaluate IPP / SSE 4.2 Strings

Use PCM to determine L3 Cache Misses, Core transitions and Keep data in L3 Cache

Tuning Applications Using a Top-down Microarchitecture Analysis Method

Intel® Processor Trace architecture details can be found in the Intel® 64 and IA-32 Architectures Software Developer Manuals

Evaluating the Suitability of Server Network Cards for Software Routers

Low Latency Performance Tuning Guide For Red Hat Enterprise Linux 6 Jeremy Eder, Senior Software Engineer

Red Hat Enterprise Linux 6 Performance Tuning Guide

Network Function Virtualization: Virtualized BRAS with Linux* and Intel® Architecture

A Path to Line-Rate-Capable NFV Deployments with Intel® Architecture and the OpenStack® Juno Release

Memory Ordering in Modern Microprocessors – Paul E McKenney Draft of 2007/09/19 15:15

What is RCU, Fundamentally?

Concurrency and Locking

Additional Reading - Topic Links

Network Functions Virtualization (NFV)

Software Defined Networking (SDN)

Server

Linux

E5 Xeon Architecture

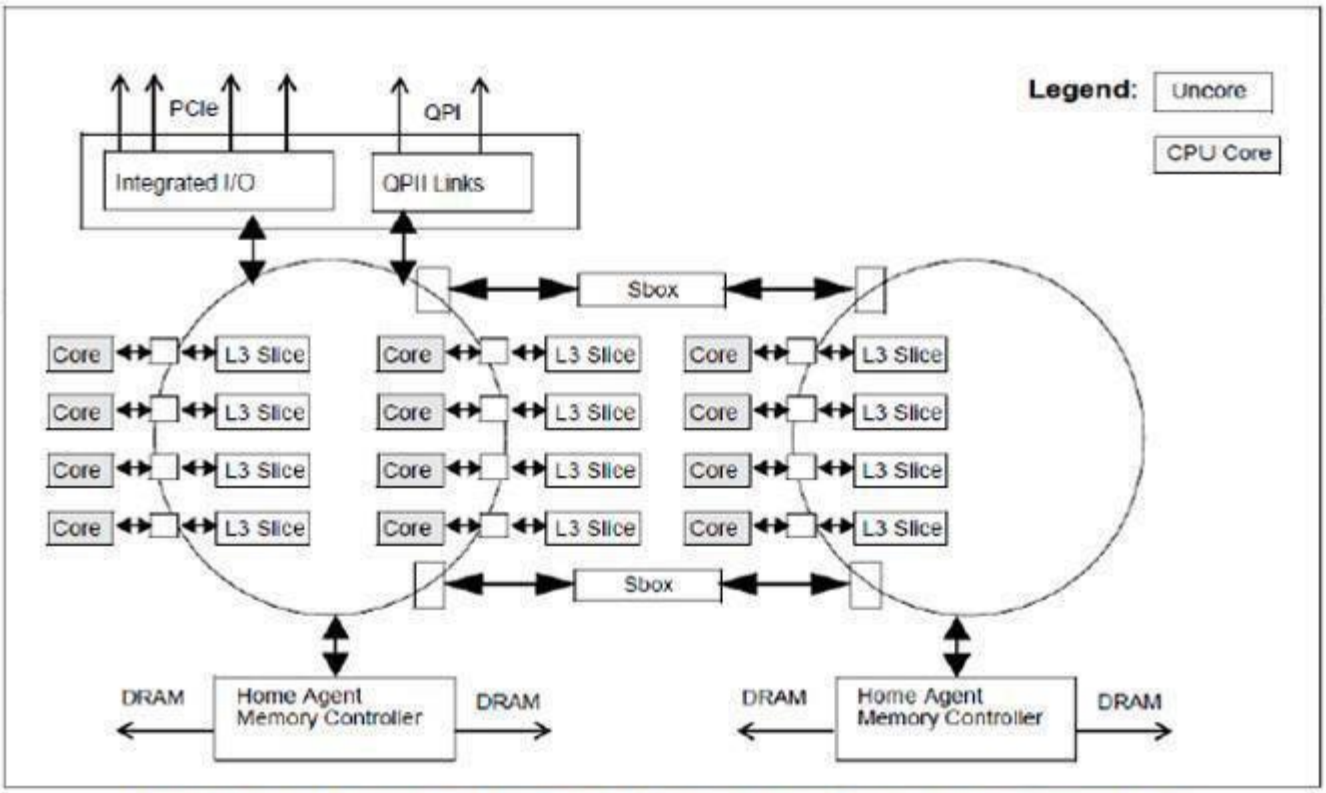


Figure 2-3. An Example of the Haswell-E Microarchitecture Supporting 12 Processor Cores

Profiling DPDK Code with Intel® VTune™ Amplifier

Introduction

Performance is a key factor in designing and shipping best of class products. Optimizing performance requires visibility into system behavior. In this module, we'll learn how to use Intel® VTune™ Amplifier to profile Data Plane Development Kit (DPDK) code.

The reader will find this paper to be a comprehensive reference and cook book style guidelines to install and use these tools **Intel® VTune™ Amplifier, MLC, PCM,** and run and profile couple of **DPDK micro benchmarks** (often referred as the best kept secret) as an example of getting deep visibility into system, cores communication and core pipeline and usage. To find overview of these tools, please go to section titled installing Intel(R) VTune.

Extensive screenshots are provided to enable readers to compare their output with the screenshots. The commands are given, in addition, so that the readers can copy and paste the commands wherever possible.

Outline

This module walks you through the following steps to get started using Intel VTune amplifier with a DPDK application.

- Install Linux*
- Install Data Plane Development Kit (DPDK)
- Install the tools
    - Source editor
    - Intel® VTune™ Amplifier
- Install & Profile the application of your choice
    - Distributor Application
    - Ring Tests Application
- Conclusion and Next Steps

Install Linux

Install from the Linux DVD with iso image:
http://old-releases.ubuntu.com/releases/15.04/ubuntu-15.04-desktop-amd64.iso

Prior to Install

```
dpdk@dpdk:~/dpdk-16.04$ uname -a
Linux dpdk 3.19.0-59-generic #66-Ubuntu SMP Thu May 12 22:35:27 UTC 2016 x86_64 x86_64
NU/Linux
```

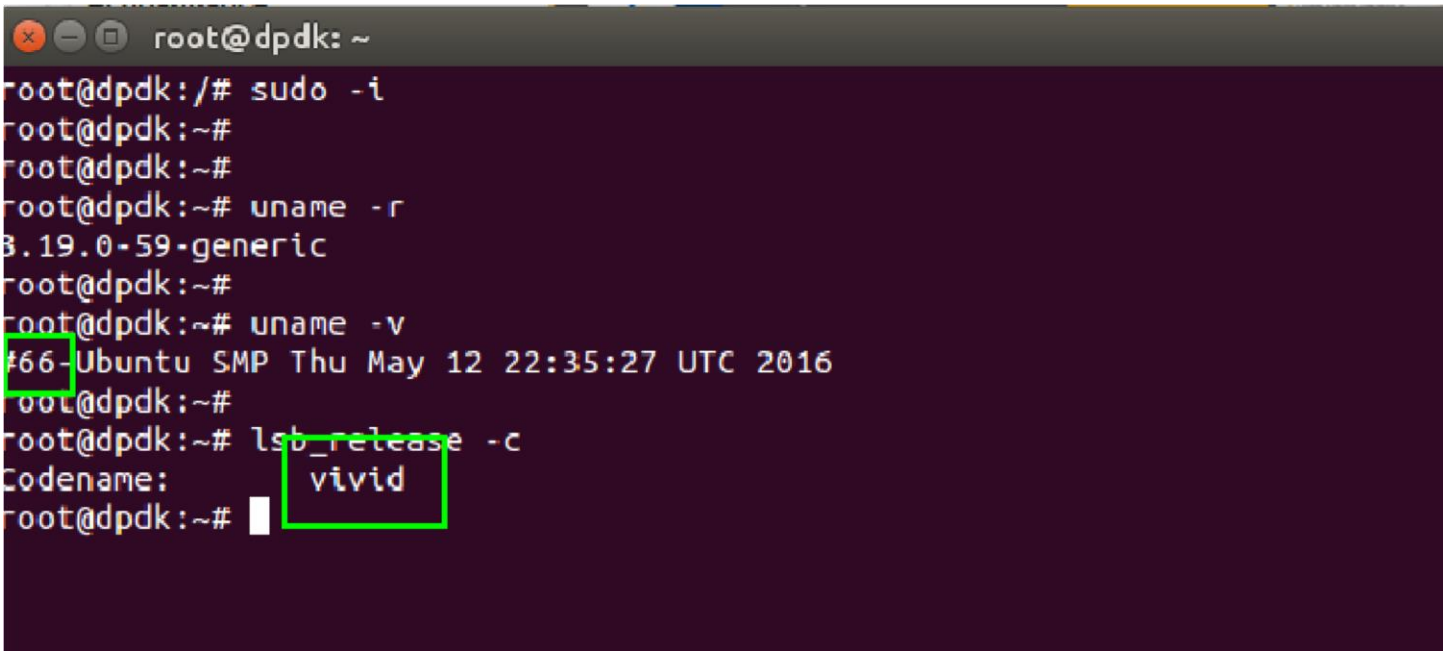
If you have a laptop installed with Windows* 8, go to safe mode (SHIFT+RESTART). Once in safe mode, choose boot option # 1 to boot from the external USB DVD drive.

Restart and install.

NOTE: In this paper, for example, we have installed Ubuntu* 15.04. Please refer for system details in Appendix 3.

After Install:

1. Verify whether the kernel version installed is the correct version as per the DPDK release notes.



`$uname –a`

The above output verifies the Kernel release as 3.19.0-59-generic, the version number as #66, and the distro as Ubuntu 64 bit.

`$uname –v`

Gives the version # – version #66 as shown below.

`$lsb_release –c`

Gives the code name – the code name is vivid as shown below.

2. Verify Internet connectivity. In some cases the network-manager service has to be restarted for the Ethernet service to be operational. `$ sudo service network-manager restart`

Install DPDK

Get the latest DPDK release as shown below and in the screenshot.

`$ sudo wget www.dpdk.org/browse/dpdk/snapshot/dpdk-16.04.tar.xz`

```
dpdk@dpdk:~$ sudo wget www.dpdk.org/browse/dpdk/snapshot/dpdk-16.04.tar.xz
```

The response for the above command is as shown below.

```
dpdk@dpdk:~$ sudo wget www.dpdk.org/browse/dpdk/snapshot/dpdk-16.04.tar.xz
--2016-06-02 19:05:07--  http://www.dpdk.org/browse/dpdk/snapshot/dpdk-16.04.tar.xz
Resolving www.dpdk.org (www.dpdk.org)... 92.243.14.124
Connecting to www.dpdk.org (www.dpdk.org)|92.243.14.124|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: unspecified [application/x-xz]
Saving to: 'dpdk-16.04.tar.xz'

dpdk-16.04.tar.xz           [                <=>             ]  10.42M   213KB/s   in 36s

2016-06-02 19:05:44 (295 KB/s) - 'dpdk-16.04.tar.xz' saved [10925676]

dpdk@dpdk:~$
```

You will find the DPDK tar file downloaded as shown below.

```
$ ls
```

```
dpdk@dpdk:~$ ls
Desktop    Downloads          examples.desktop  Pictures  Templates
Documents  dpdk-16.04.tar.xz  Music             Public    Videos
```

Extract the tar ball.

```
$ tar xf dpdk-16.04.tar.xz
```

You will find that the directory dpdk-16.04 was created.

```
$ ls
```

```
dpdk@dpdk:~$ tar xf dpdk-16.04.tar.xz
dpdk@dpdk:~$
dpdk@dpdk:~$ ls
Desktop    Downloads    dpdk-16.04.tar.xz  Music     Public     Videos
Documents  dpdk-16.04   examples.desktop   Pictures  Templates
```

Change to the DPDK directory to list the files.

```
$ cd dpdk-16.04
$ ls –al
```

```
dpdk@dpdk:~$ cd dpdk-16.04/
dpdk@dpdk:~/dpdk-16.04$
dpdk@dpdk:~/dpdk-16.04$ ls -al
total 128
drwxrwxr-x 12 dpdk dpdk  4096 Apr 11 14:56 .
drwxr-xr-x 18 dpdk dpdk  4096 Jun  2 21:36 ..
drwxrwxr-x  8 dpdk dpdk  4096 Apr 11 14:56 app
drwxrwxr-x  2 dpdk dpdk  4096 Apr 11 14:56 config
drwxrwxr-x  5 dpdk dpdk  4096 Apr 11 14:56 doc
drwxrwxr-x  4 dpdk dpdk  4096 Apr 11 14:56 drivers
drwxrwxr-x 44 dpdk dpdk  4096 Apr 11 14:56 examples
-rw-rw-r--  1 dpdk dpdk     0 Apr 11 14:56 .gitignore
-rw-rw-r--  1 dpdk dpdk  1826 Apr 11 14:56 GNUmakefile
drwxrwxr-x 30 dpdk dpdk  4096 Apr 11 14:56 lib
-rw-rw-r--  1 dpdk dpdk 17987 Apr 11 14:56 LICENSE.GPL
-rw-rw-r--  1 dpdk dpdk 26530 Apr 11 14:56 LICENSE.LGPL
-rw-rw-r--  1 dpdk dpdk 16797 Apr 11 14:56 MAINTAINERS
-rw-rw-r--  1 dpdk dpdk  1708 Apr 11 14:56 Makefile
drwxrwxr-x  8 dpdk dpdk  4096 Apr 11 14:56 mk
drwxrwxr-x  2 dpdk dpdk  4096 Apr 11 14:56 pkg
-rw-rw-r--  1 dpdk dpdk   499 Apr 11 14:56 README
drwxrwxr-x  3 dpdk dpdk  4096 Apr 11 14:56 scripts
drwxrwxr-x  2 dpdk dpdk  4096 Apr 11 14:56 tools
dpdk@dpdk:~/dpdk-16.04$
```

Install the Tools

Install the source editor of your choice. Here, CSCOPE is chosen.

1. First check to see whether the correct repository is enabled.

   Check that the universe repository is enabled by inspecting `/etc/apt/sources.list`

   ```
   $ sudo gedit /etc/apt/sources.list
   ```

   As highlighted below, you may see “restricted” [both highlighted and the line below] and not having “universe”

   ```
   # See http://help.ubuntu.com/community/UpgradeNotes for how to upgrade to
   # newer versions of the distribution.
   deb http://us.archive.ubuntu.com/ubuntu/ vivid main restricted
   deb-src http://us.archive.ubuntu.com/ubuntu/ vivid main restricted
   ```

   In that case, edit the file by replacing “restricted” with “universe” [both highlighted and the line below], as shown below.

   ```
   # See http://help.ubuntu.com/community/UpgradeNotes for how to upgrade to
   # newer versions of the distribution.
   deb http://us.archive.ubuntu.com/ubuntu/ vivid main universe
   deb-src http://us.archive.ubuntu.com/ubuntu/ vivid main universe
   ```

Now save the file.

2. Update the system.

```
$ sudo apt-get update
```

```
dpdk@dpdk:~/dpdk-16.04$ sudo apt-get update
```

The system is updated as shown below.

```
dpdk@dpdk:~/dpdk-16.04$ sudo apt-get update
Hit http://us.archive.ubuntu.com vivid InRelease
Hit http://us.archive.ubuntu.com vivid-updates InRelease
Hit http://us.archive.ubuntu.com vivid-backports InRelease
Hit http://security.ubuntu.com vivid-security InRelease
Hit http://us.archive.ubuntu.com vivid/main Sources
Hit http://security.ubuntu.com vivid-security/main Sources
Hit http://us.archive.ubuntu.com vivid/multiverse Sources
Hit http://us.archive.ubuntu.com vivid/main amd64 Packages
```

Install CSCOPE.

```
$ sudo apt-get install cscope
```

```
dpdk@dpdk:~/dpdk-16.04$ sudo apt-get install cscope
Reading package lists... Done
Building dependency tree
Reading state information... Done
Suggested packages:
  cscope-el
The following NEW packages will be installed:
  cscope
0 upgraded, 1 newly installed, 0 to remove and 313 not upgraded.
Need to get 149 kB of archives.
After this operation, 762 kB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu/ vivid/universe cscope amd64 15.8a-2 [149 kB]
Fetched 149 kB in 0s (344 kB/s)
Selecting previously unselected package cscope.
(Reading database ... 202629 files and directories currently installed.)
Preparing to unpack .../cscope_15.8a-2_amd64.deb ...
```

As shown above, CSCOPE 15.8a-2 is installed.

Install Kernel Debug Symbols

1. The first step is to add the repository containing debugging symbols. For that, first create a new file ddebs.list (if it does not exist already). `$ cat /dev/null > /etc/apt/sources.list.d/ddebs.list`

```
dpdk@dpdk:~$ sudo su
[sudo] password for dpdk:
root@dpdk:/home/dpdk#
root@dpdk:/home/dpdk# cat /dev/null > /etc/apt/sources.list.d/ddebs.list
root@dpdk:/home/dpdk#
```

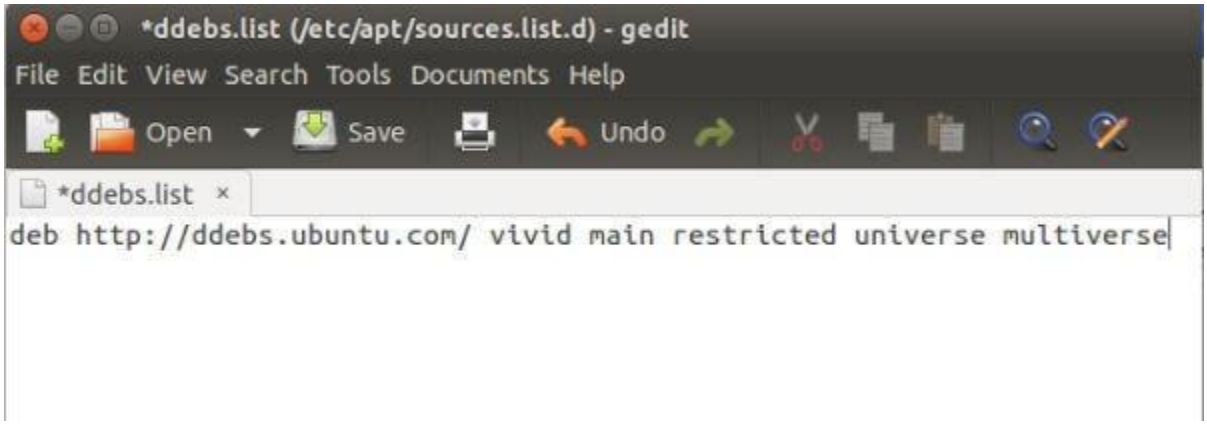
2. Next edit the file.

```
$ gedit /etc/apt/sources.list.d/ddebs.list
```

```
root@dpdk:/home/dpdk# gedit /etc/apt/sources.list.d/ddebs.list
```

3. Add the following line to /etc/apt/sources.list.d/ddebs.list as shown below and save it.

```
deb http://ddebs.ubuntu.com/ vivid main restricted universe
multiverse
```



4. Update the system to load the package list from the new repository.

```
$ sudo apt-get update
```

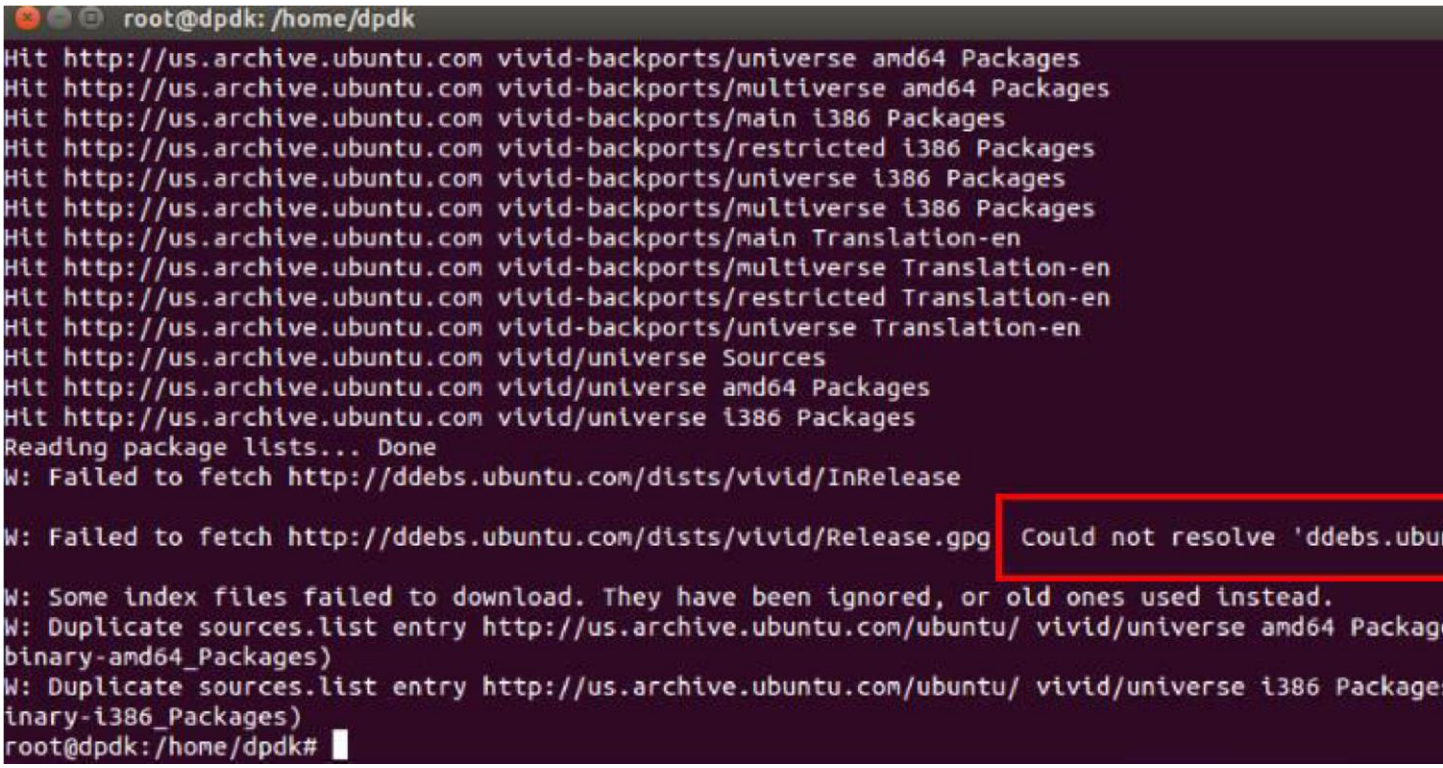
```
dpdk@dpdk:~/dpdk-16.04$ sudo apt-get update
```

In this case, the system gave the following error.

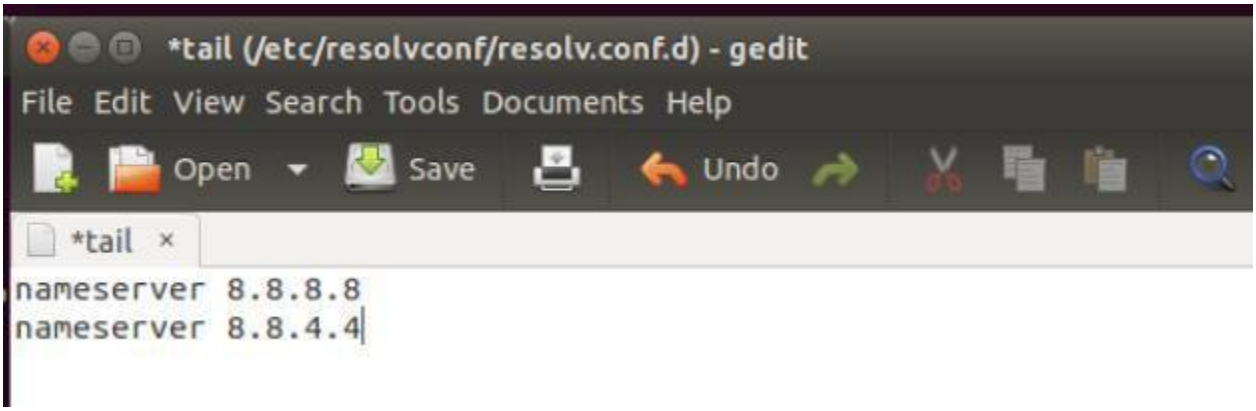
If you don't see the resolution error in your system, skip the instructions here that are colored in red and proceed to the next section.

5. To resolve name servers:

```
$ sudo gedit /etc/resolvconf/resolv.conf.d/tail
```



6. Add these two name servers (below).
7. Save the file.



8. Restart the service.

   ```
   $ sudo /etc/init.d/resolveconf restart
   ```

9. If the `sudo apt-get update` is done now without resetting the system, it still gives the resolve error.

   It is recommended to shut down and restart the system.

   After the shutdown and restart, restart the service.

   ```
   $ sudo /etc/init.d/resolvconf restart
   ```

10. Update the system.

```
$ sudo apt-get update
```

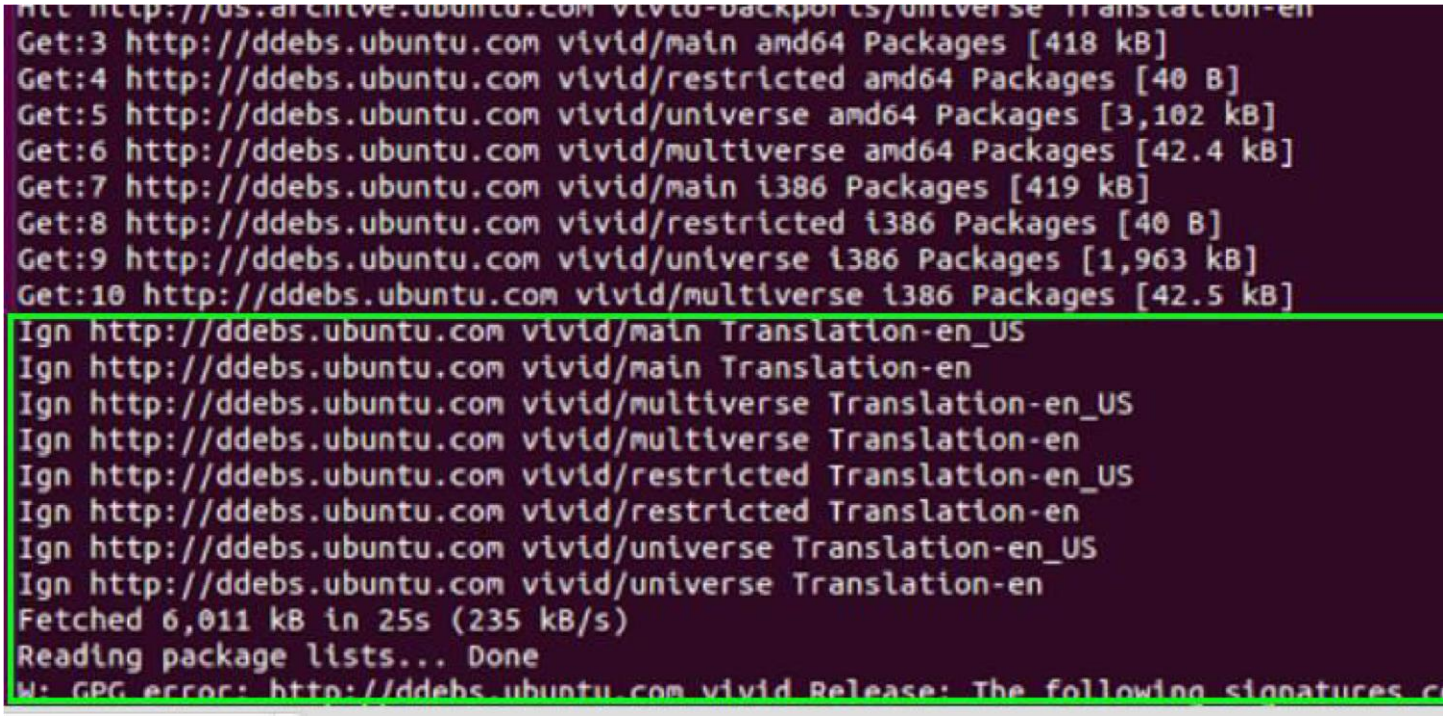
With the above steps, access to http://ddebs.ubuntu.com has been resolved.

However there is a new error “GPG error” as shown at the bottom of the screenshot above.

11. Add the GPG key.

```
$ sudo apt-key adv –keyserver pool.sks-keyservers.net –recv-keys
C8CAB6595FDFF622
```

With the repository added, the next step is to install the symbol package by running the following command:




```
apt-get install linux-image-<release>-dbgsym=<release>.<version>
```

With the release as 3.19.0-59-generic and the version as 66 this is:

```
dpdk@dpdk:~$ sudo su
[sudo] password for dpdk:
root@dpdk:/home/dpdk# sudo apt-key adv --keyserver pool.sks-keyservers.net --recv-keys C
Executing: gpg --ignore-time-conflict --no-options --no-default-keyring --homedir /tmp/t
usted.gpg --keyserver pool.sks-keyservers.net --recv-keys C8CAB6595FDFF622
gpg: requesting key 5FDFF622 from hkp server pool.sks-keyservers.net
gpg: key 5FDFF622: public key "Ubuntu Debug Symbol Archive Automatic Signing Key (2016)
gpg: Total number processed: 1
gpg:               imported: 1  (RSA: 1)
```

$ apt-get install linux-image-3.19.0-59-generic-dbgsym=3.19.0-59.66

Please note that the above resulted in an error because it could not locate the package **linuximage-3.19.0-59-generic-dbgsym**. If you want to set breakpoints by function names and viewing local variables, this error must be resolved.

Install the Linux Source Package

```
$ sudo apt-get install linux-source-3.19.0=3.19.0-59.66
```

```
root@dpdk:/home/dpdk# sudo apt-get install linux-image-3.19.0-59-generic-dbgsym=3.19.0-59.6
Reading package lists... Done
Building dependency tree
Reading state information... Done
E: Unable to locate package linux-image-3.19.0-59-generic-dbgsym
E: Couldn't find any package by regex 'linux-image-3.19.0-59-generic-dbgsym'
root@dpdk:/home/dpdk#
```

With the package now installed, go to /usr/src/linux-source-3.19.0 and unpack the source tarball.

```
$ cd /usr/src/linux-source-3.19.0
```

```
root@dpdk:/home/dpdk# sudo apt-get install linux-source-3.19.0=3.19.0-59.66
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  linux-headers-3.19.0-15 linux-headers-3.19.0-15-generic linux-image-3.19.0-15
Use 'apt-get autoremove' to remove them.
Suggested packages:
  libncurses-dev ncurses-dev kernel-package libqt3-dev
The following NEW packages will be installed:
  linux-source-3.19.0
0 upgraded, 1 newly installed, 0 to remove and 11 not upgraded.
Need to get 103 MB of archives.
After this operation, 119 MB of additional disk space will be used.
Get:1 http://us.archive.ubuntu.com/ubuntu/ vivid-updates/main linux-source-3.19
Fetched 103 MB in 5s (19.2 MB/s)
Selecting previously unselected package linux-source-3.19.0.
(Reading database ... 262860 files and directories currently installed.)
Preparing to unpack .../linux-source-3.19.0_3.19.0-59.66_all.deb ...
Unpacking linux-source-3.19.0 (3.19.0-59.66) ...
Setting up linux-source-3.19.0 (3.19.0-59.66) ...
root@dpdk:/home/dpdk#
```

$ tar xjf linux-source-3.19.0.tar.bz2

Set Up Intel® VTune Amplifier

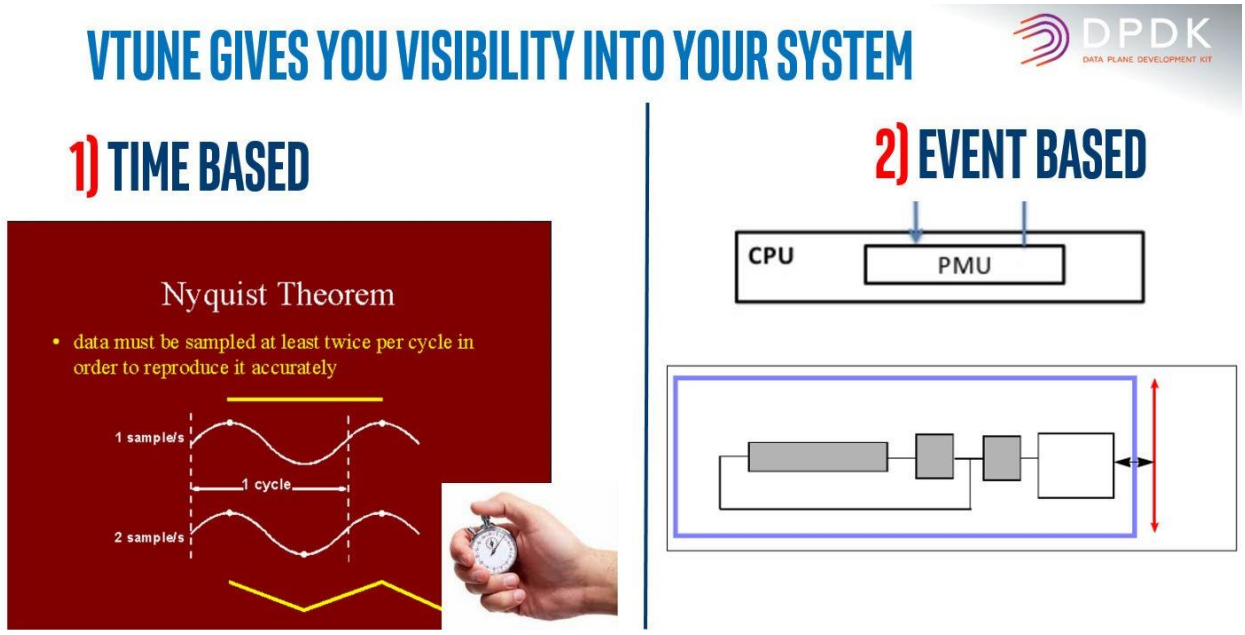
Click https://software.intel.com/en-us/intel-vtune-amplifier-xe to get to the Intel VTune Amplifier download page. We will cover first 2018 s/w version (for readers who are getting 2018 version) and next we will cover 2016 version (for readers who already have 2016 version.

```
root@dpdk:/home/dpdk# cd /usr/src/linux-source-3.19.0
root@dpdk:/usr/src/linux-source-3.19.0# ls
debian  debian.master  linux-source-3.19.0.tar.bz2
root@dpdk:/usr/src/linux-source-3.19.0# tar xjf linux-source-3.19.0.tar.bz2
root@dpdk:/usr/src/linux-source-3.19.0#
```

This section could have been titled Performance Tools – since in addition to Intel® VTune, it also covers Intel® Memory Latency Checker as well as Intel® Processor counter.

Why we have to cover the above three performance tools in a DPDK Cookbook?

Because DPDK is all about performance. To find where the problem is, we need to identify it and measure it.



Remember the arrival rate and service rate that we studied in performance optimization class? Now let us dig into detail.

Getting Started Videos for Intel VTune Amplifier

- Creating an Intel® VTune™ Amplifier Project | Intel® Software

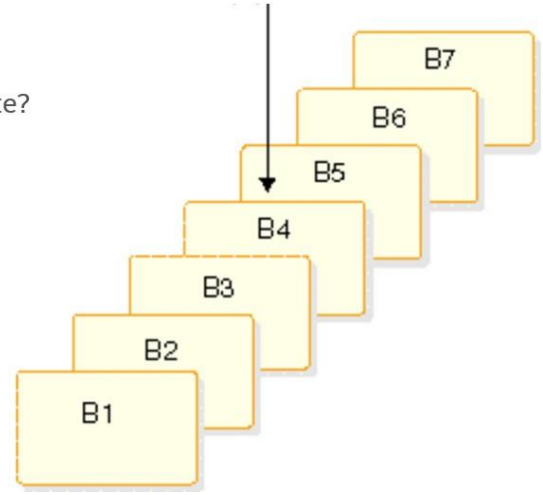
How Do I Spot Hot Spot? https://software.intel.com/en-us/videos/intel-vtune-amplifierhotspots-analysis

YOUR FAST PATH CODE – PROFILING FOR BUDGET

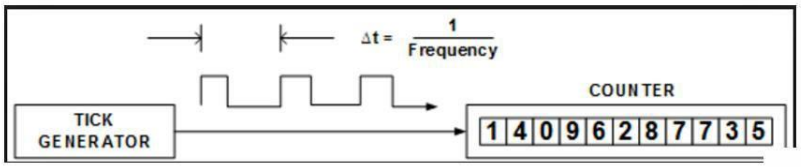
DPDK
DATA PLANE DEVELOPMENT KIT

Measuring the Budget taken in your Fast Path code

- You know your code.
- You identified your fast path.
- How to find out the maximum attainable packet rate?



TIME YOUR FAST PATH - RDTSC



Quiz: Even with low throughput, if response time is high…the area to focus is?

Intel® Memory Latency Checker

Read Intel® Memory Latency Checker v3.4 for more information.

Where is that Black Hole?

- I Did Measure The Time Taken In My Code.
- I Am Getting Lower Packet Rate
- Where is that black hole?

What if… cycles are stolen?

Scheduler takes CPU away for some time? What to do?

Use ISOLCPU in grub to isolate CPU(s) from scheduler.

What if, likewise, interrupt, Page Walks, etc., take away from the task?

That is why polling and hugepages are useful for performance.

Intel® Memory Latency Checker v3.4

Thinking that memory latency may be the bottleneck?

Want to know the platform memory performance? Get the output of mlc utility.

How to install Memory Latency Checker?

Installation of Intel® MLC – supports both Linux & Windows Linux:

- Copy the mlc library to any directory on your system
- Intel® MLC dynamically links to GNU C library (glibc/pthread) and this library must be present on the system.
- Root privileges are required to run this tool as the tool modifies the H/W prefetch control MSR to enable/disable prefetchers for latency and b/w measurements. Refer readme documentation on running without root privileges.
- MSR driver (not part of the install package) should be loaded. This can typically be done with 'modprobe msr' command if it is not already included.

How does Intel® Memory Latency Checker work?

One of the main features of Intel® MLC is measuring how latency changes as b/w demand increases. To facilitate this, it creates several threads where the number of threads matches the number of logical

CPUs minus 1. These threads are used to generate the load (henceforth, these threads will be referred to as load-generator threads). The primary purpose of the load-generation threads is to generate as many memory references as possible. While the system is loaded like this, the remaining one CPU, that is not used for load generation) runs a thread that is used to measure latency. This thread is

known as latency thread and it issues dependent reads. Basically, this traverses an array of pointers where each pointer is pointing to the next one, thereby creating dependency in reads. The average time taken for the reads provides latency. Depending on the load generated by the load generating threads, the latency will vary. For more details read the readme file that comes with the package please.

Memory Latency Checker Command Line Arguments:

Command line arguments

Launching Intel® MLC without any parameters measures several things as stated earlier. However, with command line arguments, each of the following specific actions can be performed in sequence:

mlc --latency_matrix

prints a matrix of local and cross-socket memory latencies

mlc --bandwidth_matrix

prints a matrix of local and cross-socket memory b/w

mlc --peak_injection_bandwidth

prints peak memory b/w (core generates requests at fastest possible rate) for various read-write ratios with all local accesses

mlc --max_bandwidth

prints maximum memory b/w (by automatically varying load injection rates) for various read-write ratios with all local accesses

mlc --idle_latency

prints the idle memory latency of the platform

mlc --loaded_latency

prints the loaded memory latency of the platform

mlc --c2c_latency

prints the cache-to-cache transfer latencies of the platform

mlc -e

do not modify prefetcher settings

There are more options for each of the commands above. Those are documented in the readme file in more detail and can be downloaded

How does a sample output of Memory Latency Check look?

```
Measuring Loaded Latencies for the system
Using all the threads from each core if Hyper-threading is enabled
```

```
Intel(R) Memory Latency Checker - v3.3
Measuring idle latencies (in ns)...
        Memory node
Socket       0       1
     0    81.5    81.5
     1   140.2   140.2

Measuring Peak Memory Bandwidths for the system
Bandwidths are in MB/sec (1 MB/sec = 1,000,000 Bytes/sec)
Using all the threads from each core if Hyper-threading is enabled
Using traffic with the following read-write ratios
ALL Reads        :      93190.9
3:1 Reads-Writes :      78829.3
2:1 Reads-Writes :      74731.7
1:1 Reads-Writes :      54653.2
Stream-triad like:      68780.8

Measuring Memory Bandwidths between nodes within system
Bandwidths are in MB/sec (1 MB/sec = 1,000,000 Bytes/sec)
Using all the threads from each core if Hyper-threading is enabled
Using Read-only traffic type
        Memory node
 Socket      0       1
     0  94281.2 92246.0
     1  34475.4 34470.0
```

```
Using Read-only traffic type
Inject  Latency Bandwidth
Delay   (ns)    MB/sec
==========================
 00000  292.12    90718.1
 00002  289.80    91195.9
 00008  288.13    91219.6
 00015  284.77    91281.0
 00050  272.97    91269.4
 00100  240.02    91137.1
 00200  146.29    82683.2
 00300  119.82    69158.2
 00400  105.74    55501.1
 00500   98.42    45506.9
 00700   93.26    33390.3
 01000   90.15    23946.1
 01300   87.74    18745.1
 01700   85.99    14606.2
 02500   84.24    10250.6
 03500   82.74     7592.0
 05000   81.89     5566.5
 09000   81.54     3447.9
 20000   81.54     1987.6
```

```
Measuring cache-to-cache transfer latency (in ns)...
Local Socket L2->L2 HIT  latency        53.0
Local Socket L2->L2 HITM latency        53.1
Remote Socket L2->L2 HITM latency (data address homed in writer socket)
                Reader Socket
Writer Socket        0       1
            0        -   114.5
            1    184.8       -
Remote Socket L2->L2 HITM latency (data address homed in reader socket)
                Reader Socket
Writer Socket        0       1
            0        -   114.5
            1    184.0       -
```

Intel® Processor Counter Monitor

Intel® Performance Counter Monitor - A better way to measure CPU utilization

PCM

Please find the github for Intel Processor Counter Monitor at **https://github.com/opcm/pcm**

This is a self-help section. Readers are encouraged to access the github and use the following pointers to use this tool for yourselves.

Where to download PCM?

https://github.com/opcm/pcm

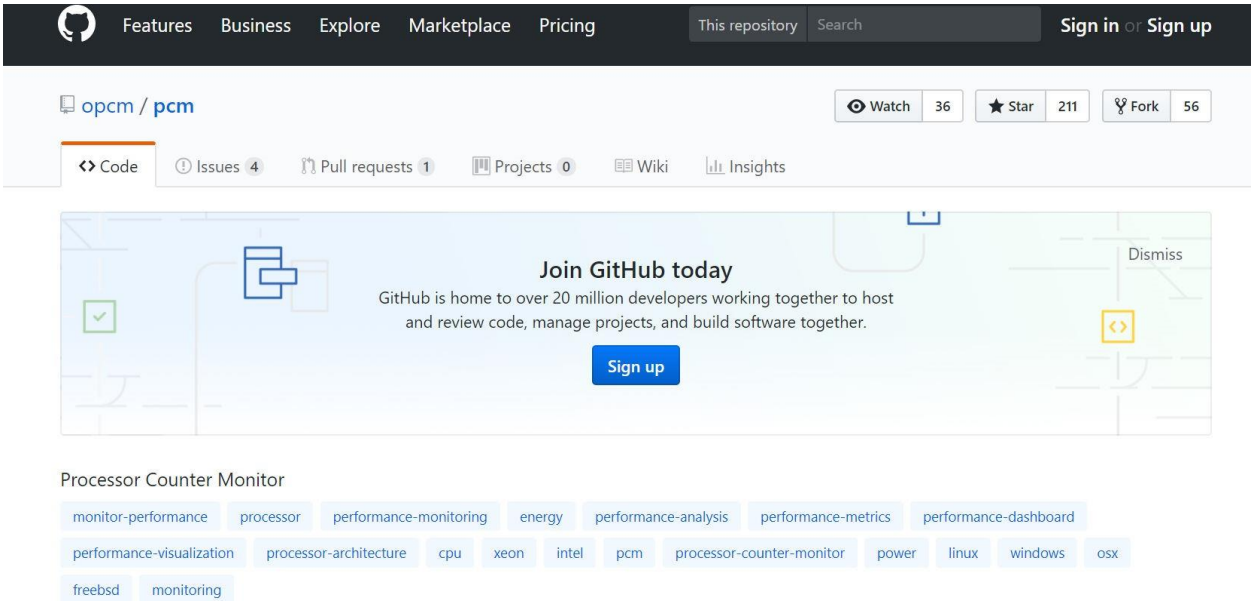
How to download?

Click Clone or Download and Press Download ZIP. It will download zip file named pcm-master.zip.

What to run?

Depends on your workload.

1. If it is CPU intensive, run PCM-x
2. If it is memory intensive, run PCM-memory
3. If it is i/o intensive, run PCM-iio



1) run Your application on host/guest, as your desired setup .

2) While it is running, run the above 3 pcm tools in the host

Where is a good article on PCM?

- https://software.intel.com/en-us/articles/intel-performancecounter-monitor

How to build and run?

Linux: Just type `make`. You will get all the 3 utilities pcm.x, pcm.memory and pcm.iio built in the main PCM directory.

How to make pcm?

How to make the pcm?

```
lease just type make in the main PCM directory and see what binaries have been
build: ls *.x

pcm.x - command line PCM utility
pcm-sensor.x - PCM plugin for use with KSysGuard
pcm-power.x - command line utility for reading energy and power related
metrics on Intel(r) microarchitecture codename Sandy/Ivy-Bridge EP/EN/E/EX
pcm-memory.x - command line utility for reading memory channel related metrics
on Intel(r) microarchitecture codename Sandy/Ivy-Bridge EP/EN/E/EX
pcm-msr.x - utility to read-write model specific registers

if compiled with Linux perf (-DPCM_USE_PERF option in Makefile) then
additionally CAP_SYS_ADMIN privileges needed for users executing the utilities
```

Do I have a Readme file for Intel®PCM?

```
--------------------------------------------------------------------------------
--
PCM Tools
--------------------------------------------------------------------------------
--

PCM provides a number of command-line utilities for real-time monitoring:

- pcm : basic processor monitoring utility (instructions per cycle, core
frequency (including Intel(r) Turbo Boost Technology), memory and Intel(r)
Quick Path Interconnect bandwidth, local and remote memory bandwidth, cache
misses, core and CPU package sleep C-state residency, core and CPU package
thermal headroom, cache utilization, CPU and memory energy consumption)
- pcm-memory : monitor memory bandwidth (per-channel and per-DRAM DIMM rank)
- pcm-pcie : monitor PCIe bandwidth per-socket
- pcm-iio : monitor PCIe bandwidth per PCIe device
- pcm-numa : monitor local and remote memory accesses
- pcm-power : monitor sleep and energy states of processor, Intel(r) Quick
Path Interconnect, DRAM memory, reasons of CPU frequency throttling and other
energy-related metrics
- pcm-tsx: monitor performance metrics for Intel(r) Transactional
Synchronization Extensions
- pcm-core and pmu-query: query and monitor arbitrary processor core events

Graphical front ends:
- pcm-sensor :  front-end for KDE KSysGuard
- pcm-service :  front-end for Windows perfmon

There is also a utility for reading/writing Intel model specific registers
(pcm-msr) supported on Linux, Windows, Mac OS X and FreeBDS.

And finally a daemon that stores core, memory and QPI counters in shared
memory that can be be accessed by non-root users.

--------------------------------------------------------------------------------
```

How does PCM output look like?

```
EXEC  : instructions per nominal CPU cycle
IPC   : instructions per CPU cycle
FREQ  : relation to nominal CPU frequency='unhalted clock ticks'/'invariant timer
AFREQ : relation to nominal CPU frequency while in active state (not in power-savi
L3MISS: L3 cache misses
L2MISS: L2 cache misses (including other core's L2 cache *hits*)
L3HIT : L3 cache hit ratio (0.00-1.00)
L2HIT : L2 cache hit ratio (0.00-1.00)
L3MPI : number of L3 cache misses per instruction
L2MPI : number of L2 cache misses per instruction
READ  : bytes read from main memory controller (in GBytes)
WRITE : bytes written to main memory controller (in GBytes)
L3OCC : L3 occupancy (in KBytes)
TEMP  : Temperature reading in 1 degree Celsius relative to the TjMax temperature
energy: Energy in Joules
```

Core	(SKT)	EXEC	IPC	FREQ	AFREQ	L3MISS	L2MISS	L3HIT	L2HIT	L3MPI	L2MPI	L3OCC	TEMP
0	0	0.00	0.82	0.00	1.00	35 K	113 K	0.64	0.47	0.00	0.01	144	57
1	0	0.00	1.91	0.00	1.00	968	2796	0.45	0.38	0.00	0.00	144	56
2	0	1.15	1.16	0.99	1.00	600 K	7301 K	0.81	0.65	0.00	0.00	1224	54
3	0	1.16	1.16	1.00	1.00	577 K	7264 K	0.81	0.65	0.00	0.00	1656	52
4	0	0.01	0.99	0.01	1.00	20 K	46 K	0.47	0.68	0.00	0.00	144	55
5	0	1.13	1.14	0.99	1.00	597 K	7344 K	0.81	0.64	0.00	0.00	1224	54
6	0	1.14	1.15	0.99	1.00	600 K	7469 K	0.81	0.64	0.00	0.00	1368	52
7	0	1.16	1.16	0.99	1.00	576 K	7207 K	0.81	0.65	0.00	0.00	1296	51
8	0	1.16	1.17	0.99	1.00	573 K	6983 K	0.81	0.66	0.00	0.00	1440	51
9	0	1.15	1.15	0.99	1.00	587 K	6959 K	0.81	0.66	0.00	0.00	1296	54
10	0	1.11	1.11	1.00	1.00	824 K	5965 K	0.72	0.65	0.00	0.00	2016	53
11	0	1.17	1.17	1.00	1.00	571 K	6930 K	0.81	0.66	0.00	0.00	2016	52
12	0	1.15	1.15	1.00	1.00	578 K	7274 K	0.81	0.65	0.00	0.00	1224	51
13	0	1.15	1.16	0.99	1.00	587 K	6922 K	0.81	0.67	0.00	0.00	1944	52
14	0	0.00	0.65	0.01	1.00	11 K	36 K	0.55	0.65	0.00	0.00	216	56
15	0	1.17	1.18	1.00	1.00	571 K	7060 K	0.82	0.65	0.00	0.00	1224	52

35	1	0.00	0.37	0.00	1.00	697	3008	0.73	0.38	0.00	0.01	2880	65
SKT	0	0.77	1.15	0.67	1.00	7415 K	85 M	0.80	0.65	0.00	0.00	19224	51
SKT	1	0.00	0.53	0.00	1.00	7050	38 K	0.74	0.45	0.00	0.00	8280	63
TOTAL	*	0.38	1.15	0.33	1.00	7422 K	85 M	0.80	0.65	0.00	0.00	N/A	N/A

Instructions retired: 37 G ; Active cycles: 32 G ; Time (TSC): 2694 Mticks ; C0 (active,non-halted) core residency: 33.28 %

C1 core residency: 66.72 %; C6 core residency: 0.00 %;
C2 package residency: 0.00 %; C6 package residency: 0.00 %;

PHYSICAL CORE IPC : 1.15 => corresponds to 28.84 % utilization for cores in active state
Instructions per nominal CPU cycle: 0.38 => corresponds to 9.60 % core utilization over time interval
SMI count: 0

Intel(r) UPI data traffic estimation in bytes (data traffic coming to CPU/socket through UPI links):

		UPI0	UPI1	UPI2	UPI0	UPI1	UPI2
SKT	0	646 K	738 K	0	0%	0%	0%
SKT	1	660 K	586 K	0	0%	0%	0%

Total UPI incoming data traffic: 2632 K UPI data traffic/Memory controller traffic: 0.00

Intel(r) UPI traffic estimation in bytes (data and non-data traffic outgoing from CPU/socket through UPI links):

		UPI0	UPI1	UPI2	UPI0	UPI1	UPI2
SKT	0	305 M	303 M	0	1%	1%	0%
SKT	1	304 M	304 M	0	1%	1%	0%

Total UPI outgoing data and non-data traffic: 1218 M

MEM (GB)->		READ	WRITE	CPU energy	DIMM energy
SKT	0	3.68	2.54	109.80	28.02
SKT	1	0.00	0.00	67.91	0.00
	*	3.68	2.54	177.70	28.02

In case I want to optimize at CPU Instruction Level – can I find out instruction's Latency & Throughput?

Yes. You can find that in https://software.intel.com/sites/default/files/managed/ad/dc/Intel-XeonScalable-Processor-throughput-latency.pdf

How Do I get started? Do you have getting started videos?

https://software.intel.com/en-us/videos/creating-an-intel-vtune-amplifierproject

Is there community I can plug into for VTune?

Yes. You Plug into the Forum https://software.intel.com/en-us/forums/intel-vtune-amplifier-xe

Getting Started:

2018 Version followed by 2016 version:

Below you will see first 2018 getting started followed by 2016

https://software.intel.com/en-us/get-started-with-vtune-2018-beta

Getting Started with Intel® VTune™ Amplifier

2018 (Beta)

Actions

Last updated on April 11, 2017

Learn about how to start analyzing system performance and the key features of Intel VTune Amplifier.

Intel® VTune™ Amplifier can be installed on Windows*, macOS*, and Linux* platforms and used for analysis of local and remote target systems. Use this tool to analyze the algorithm choices, find serial and parallel code bottlenecks, understand where and how your application can benefit from available hardware resources, and speed up the execution.

VTune Amplifier is available as a standalone product as well as part of the following suites:

- Intel® Parallel Studio XE 2018 Cluster Edition and Professional Edition
- Intel® Media Server Studio 2018 Professional Edition

Visit the VTune Amplifier training page for videos, webinars, and more to help you get started.

NOTE

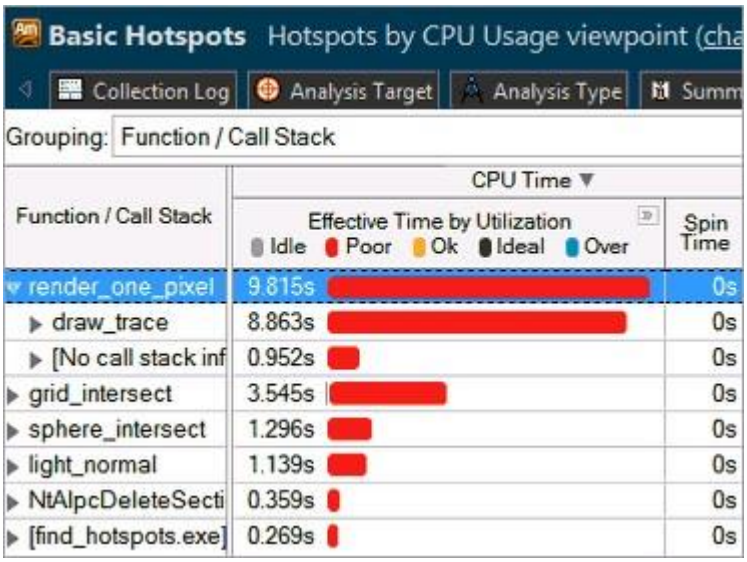
Starting with Intel VTune Amplifier 2018 version, product help, tutorials, and Release Notes are available **online only** from the Intel Software Documentation Library in the Intel Developer Zone (IDZ). You can also download an offline version of the product help either from IDZ or from the Intel® Software Products Registration Center > **Product List** > **Intel® Parallel Studio XE Documentation Beta**.

Select Your Host System to Get Started

Click the button for your host system to learn more about system-specific features for Windows*, Linux*, or macOS*.

Key Features

ALGORITHM ANALYSIS



- Run **Basic Hotspots** analysis type to understand application flow and identify sections of code that get a lot of execution time (hotspots).

  See tutorials for Linux host - C++ sample | Linux host - Fortran sample | Windows host - C++ sample | Windows host - Fortran sample

- Use the algorithm **Advanced Hotspots** analysis to extend Basic Hotspots analysis by collecting call stacks and analyze CPI (Cycles Per Instructions) metric. **NEW**: You can also use this analysis type to profile native or Java* applications running in a Docker* container on a Linux system. See the tutorial for Linux host - embedded Linux target system

- **NEW**: Use **Memory Consumption** analysis for your native Linux* or Python* targets to explore RAM usage over time and identify memory objects allocated and released during the analysis run.

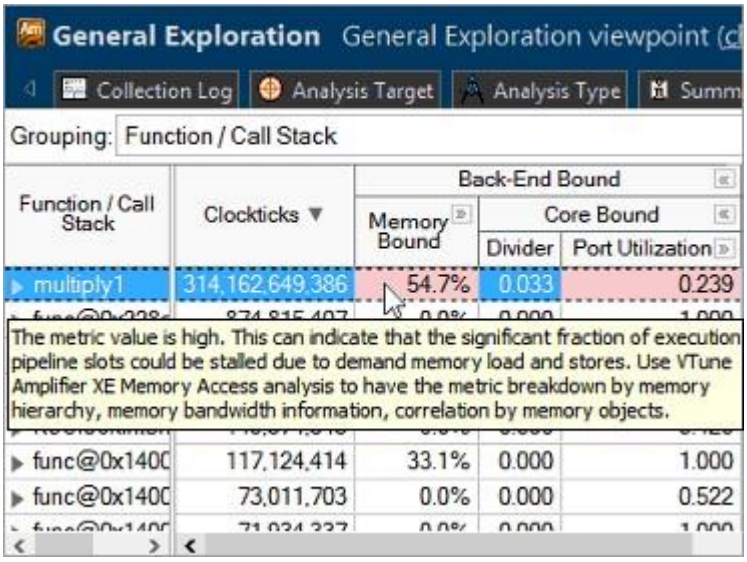
- Run **Concurrency** analysis to estimate parallelization in your code and understand how effectively your application uses available cores.

  See tutorials for Linux host - Fortran sample | Windows host - Fortran sample.

- Run **Locks and Waits** analysis to identify synchronization objects preventing effective utilization of processor resources.

  See tutorials for Linux host - C++ sample code | Windows host - C++ sample code.

MICROARCHITECTURE ANALYSIS



- Run **General Exploration** analysis to triage hardware issues in your application. This type collects a complete list of events for analyzing a typical client application.

  See tutorials for Linux host - C++ sample code | Windows host - C++ sample code.

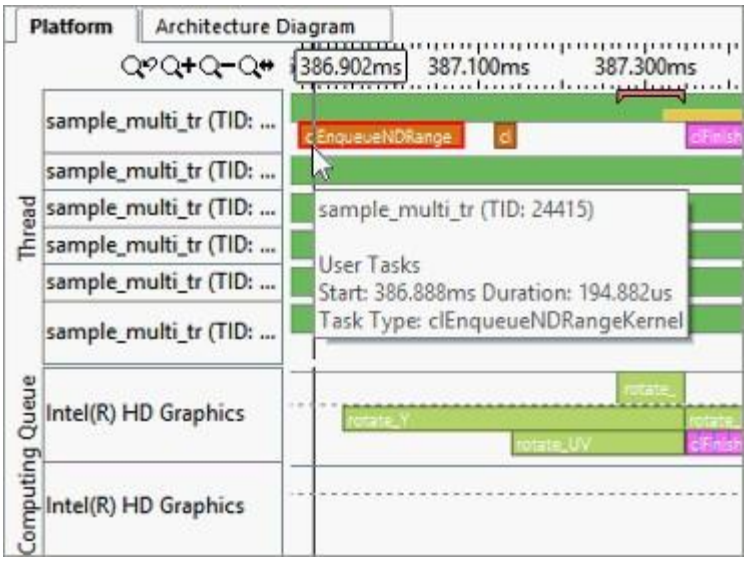
- Use **Memory Access** analysis to identify memory-related issues, like NUMA problems and bandwidthlimited accesses, and attribute performance events to memory objects (data structures), which is provided due to instrumentation of memory allocations/de-allocations and getting static/global variables from symbol information.

  See the tutorial for Linux Host - C sample code.

- For systems with Intel® Software Guard Extensions (Intel SGX) feature enabled, run **SGX Hotspots** analysis to identify performance-critical program units inside security enclaves. This analysis type uses the INST_RETIRED.PREC_DIST hardware event that emulates precise clockticks which is mandatory for the analysis on the systems with the Intel SGX enabled.

- For the Intel processors supporting Intel® Transactional Synchronization Extensions (Intel TSX), run the **TSX Exploration** and **TSX Hotspots** analysis types to measure transactional success and analyze causes of transactional aborts.

Platform Analysis

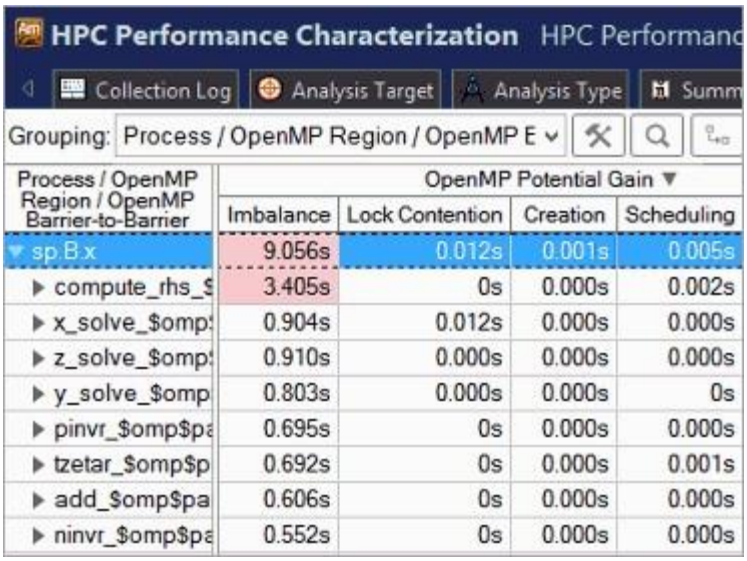


- Run **System Overview** analysis to review general behavior of a target Linux* or Android* system and correlate power and performance metrics with the interrupt request (IRQ).
- Run **CPU/GPU Concurrency** analysis to identify code regions where your application is CPU or GPU bound.
- Use **GPU Hotspots** analysis to identify GPU tasks with high GPU utilization and estimate the effectiveness of this utilization.
- For GPU-bound applications running on Intel HD Graphics, collect GPU hardware events to estimate how effectively the Processor Graphics are used.
- Collect data on Ftrace* events on Android and Linux targets and Atrace* events on Android targets.
- Analyze hot Intel® Media SDK programs and OpenCL™ kernels running on a GPU. For OpenCL application analysis, use the Architecture Diagram to explore GPU hardware metrics per GPU architecture blocks.
- Run **Disk Input and Output** analysis to monitor utilization of the disk subsystem, CPU and processor buses. This

- analysis type provides a consistent view of the storage sub-system combined with hardware events and an easy-to-use method to match user-level source code with I/O packets executed by the hardware.

  See the tutorial for Linux Host - C++ sample code.

Compute-Intensive Applications Analysis

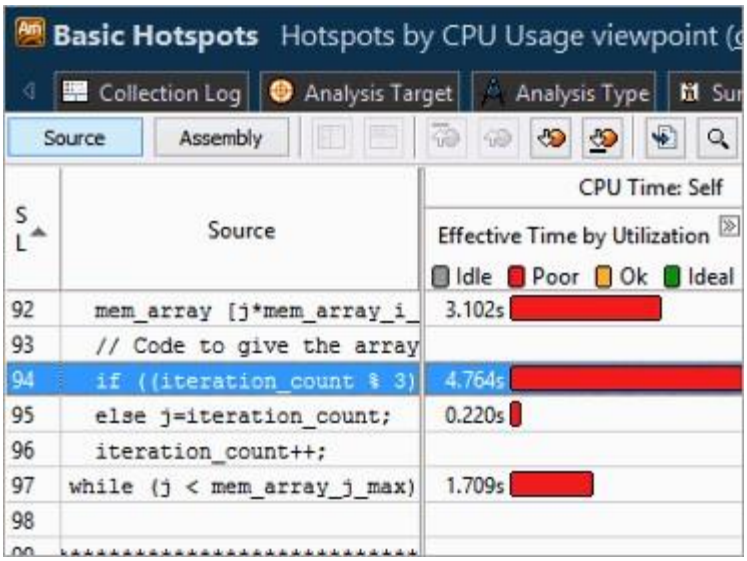


Process / OpenMP Region / OpenMP Barrier-to-Barrier	OpenMP Potential Gain ▼			
	Imbalance	Lock Contention	Creation	Scheduling
sp.B.x	9.056s	0.012s	0.001s	0.005s
compute_rhs_$	3.405s	0s	0.000s	0.002s
x_solve_omp	0.904s	0.012s	0.000s	0.000s
z_solve_omp	0.910s	0.000s	0.000s	0.000s
y_solve_$omp	0.803s	0.000s	0.000s	0s
pinvr_omppa	0.695s	0s	0.000s	0.000s
tzetar_ompp	0.692s	0s	0.000s	0.001s
add_omppa	0.606s	0s	0.000s	0.000s
ninvr_omppa	0.552s	0s	0.000s	0.000s

- Run **HPC Performance Characterization** analysis to identify how effectively your high-performance computing application uses CPU, memory, and floating-point operation hardware resources. This analysis type provides additional scalability metrics for applications that use OpenMP or Intel MPI runtime libraries.
- Run an Algorithm analysis type with the **Analyze OpenMP regions** option enabled to collect OpenMP or MPI data for applications using OpenMP or MPI runtime libraries. Note that **HPC Performance Characterization** analysis has the option enabled by default.
- For OpenMP applications, analyze the collected performance data to identify inefficiencies in parallelization. Review the Potential Gain metric values per OpenMP region to understand the maximum time that could be saved if the OpenMP region is optimized to have no load imbalance assuming no runtime overhead.
- For hybrid OpenMP and MPI applications, explore OpenMP efficiency metrics by MPI processes laying on the critical path.

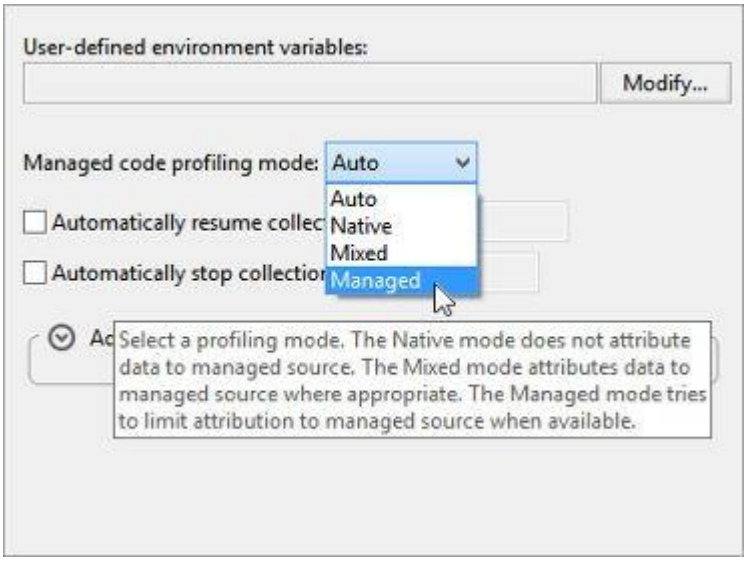
  See the tutorial for Linux Host - OpenMP and MPI hybrid sample code.

Source Analysis



- Double click a hotspot function to drill down to the source code and analyze performance per source line or assembler instruction. By default, the hottest line is highlighted.
- For help on an assembly instruction, right-click the instruction in the Assembly pane and select **Instruction Reference** from the context menu.

Managed Code Analysis

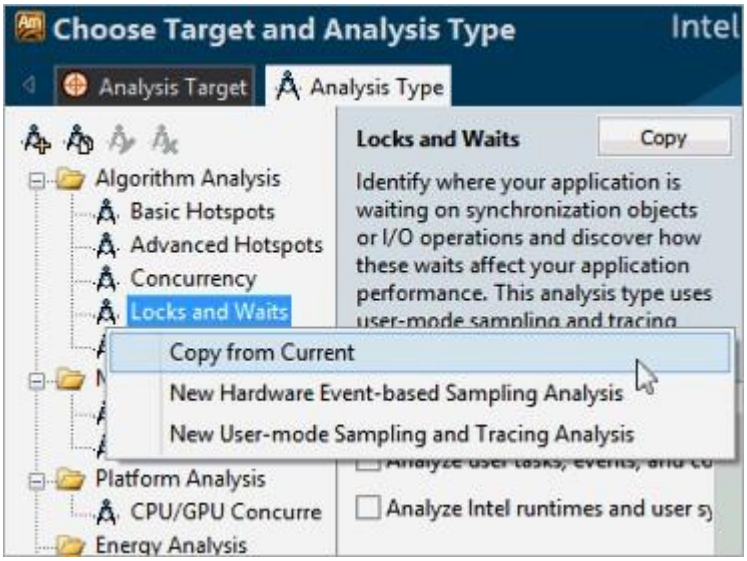


Configure target options for managed code analysis in the native, managed, or mixed mode:

- **Windows host only:** Event-based sampling (EBS) analysis for Windows Store C/C++, C# and JavaScript applications running in the **Attach** or **System-wide**mode;

- EBS or user-mode sampling and tracing analysis for Java* applications running in the **Launch Application**or **Attach** mode;
- **Basic Hotspots** and **Locks and Waits** analysis for Python* applications running in the **Launch Application** and **Attach to Process** modes.

Custom Analysis



- Select **Custom Analysis** branch in the analysis tree to create your own analysis configurations using any of the available VTune Amplifier data collectors.
- Run your own custom collector from the VTune Amplifier to get the aggregated performance data, from your custom collection and VTune Amplifier analysis, in the same result.
- Import performance data collected by your own or third-party collector into the VTune Amplifier result collected in parallel with your external collection. Use the **Import from CSV** button to integrate the external data to the result.
- Collect data from a remote virtual machine by configuring KVM guest OS profiling, which makes use of the Linux Perf KVM feature. Select **Analyze KVM guest OS**from the **Advanced** options.

For the detailed list of product features, see Intel VTune Amplifier Help.

Remote Collection Modes

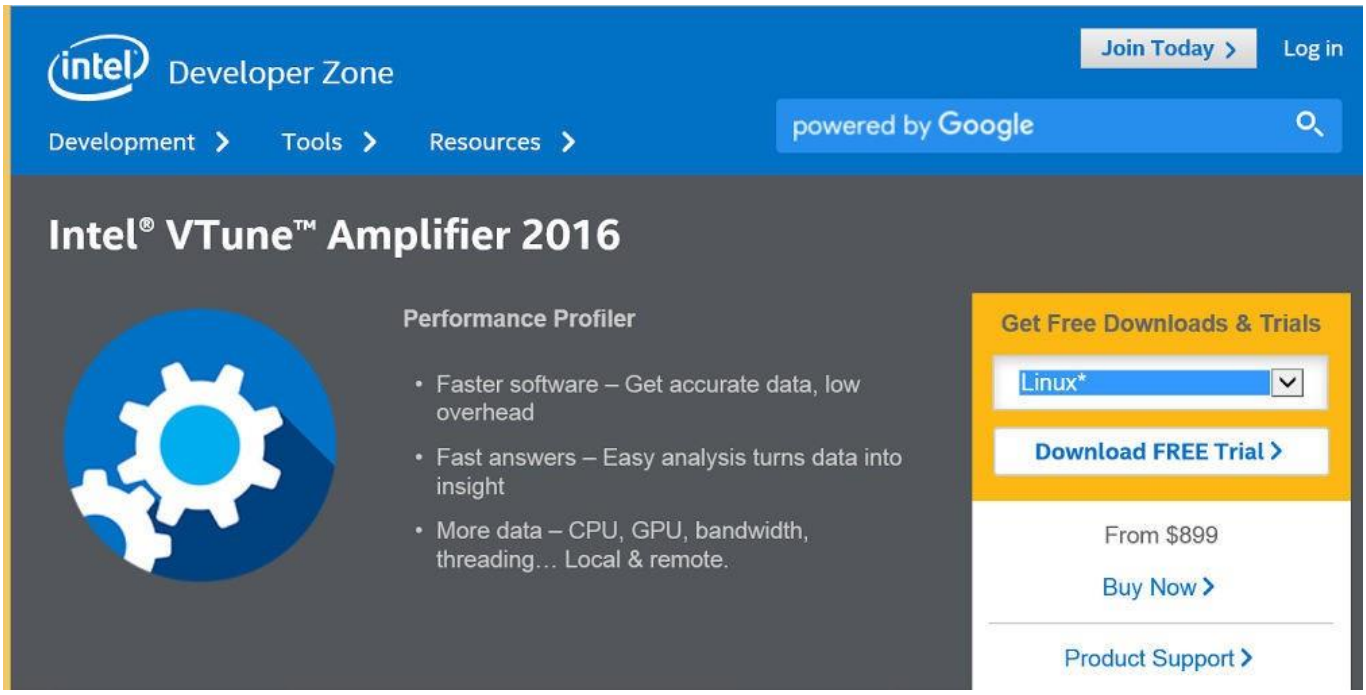
You can collect data on your Linux, Windows, or Android system using any of the following modes:

- (Linux and Android targets) Remote analysis via SSH/ADB communication with VTune Amplifier graphical and command line interface (amplxe-cl) installed on the host and VTune Amplifier target package installed on the remote target system. Recommended for resource-constrained embedded platforms (with insufficient disk space, memory, or CPU power).

See the tutorial for Linux host - Android target | Windows host - Android target | Linux host - embedded Linux target system

- (Android targets) Disconnected analysis via SSH/ADB communication with VTune Amplifier installed on the host and the VTune Amplifier target package installed on the remote Android system. The analysis is initiated from the host system, but data collection does not begin until the device is unplugged from the host system. The results are finalized after the device is reconnected to the host system.
- (Linux and Windows targets) Native performance analysis with the VTune Amplifier graphical or command line interface installed on the target system. Analysis is started directly on the target system.
- (Linux and Windows targets) Native hardware event-based sampling analysis with the VTune Amplifier's Sampling Enabling Product (SEP) installed on the target embedded system.

Legal Information



The product comes with multiple options (examples: for Windows, for Linux*, with only C /C++, or with Fortran and C/C++. Select the option you want as shown below.

INTEL® PARALLEL STUDIO XE *Technical Computing, Enterprise and HPC Development*		**SELECT**
Intel® Parallel Studio XE Professional Edition for Fortran and C++ Linux* *(Includes Intel® C and C++ Compiler, Intel® Fortran Compiler, Intel® MKL, Intel® TBB, Intel® IPP, adds Intel® VTune™ Amplifier XE, Intel® Inspector XE, Intel® Advisor XE)*	More Info>	☐
Intel® Parallel Studio XE Professional Edition for C++ Linux* *(Includes Intel® C and C++ Compiler, Intel® MKL, Intel® TBB, Intel® IPP, adds Intel® VTune™ Amplifier XE, Intel® Inspector XE, Intel® Advisor XE)*	More Info>	☑

After you submit your selection, you will get a separate e-mail with 1) serial number, 2) license file attached and 3) download location as shown in the screenshot below.

Released Intel® Software Development Products for Internal Use

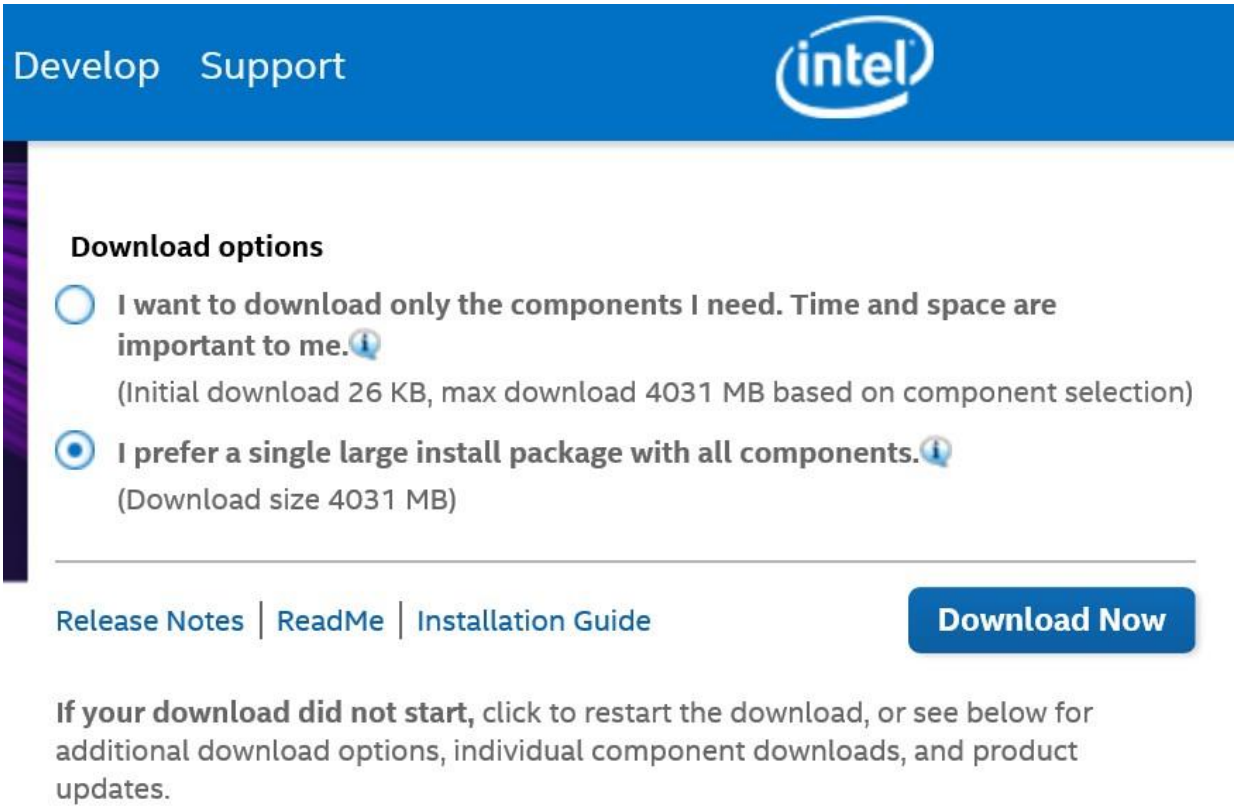
You will receive a separate email with the serial number, license file and download location, if applicable, for each product listed below. The serial numbers have been registered to your Intel email address. If you did not have an account at the Intel® Software Development Products Registration Center or Intel® Premier Support, an account was created for you.

These license are only to be used for internal or personal (home) use.

SERIAL NUMBER	**REGISTERED PRODUCTS**	
[redacted]	Intel® Parallel Studio XE Professional Edition for C++ Linux* *(Includes Intel® C and C++ Compiler, Intel® MKL, Intel® TBB, Intel® IPP, adds Intel® VTune™ Amplifier XE, Intel® Inspector XE, Intel® Advisor XE)*	Download >

After clicking Download, you will be presented with two options as shown in the screenshot below, with the default option selected for single install package with all components.

Note that in addition to the getting started guide for Intel VTune Amplifier, there are three other useful documents as shown in the screenshot below: the release notes, ReadMe, and the installation guide.



Access the Intel VTune Amplifier Getting Started Guide at https://software.intel.com/en-us/node/544004

For hardware event-based sampling, verify the sampling driver is installed properly as shown in

https://software.intel.com/en-us/sep_driver

The Intel VTune Installation Guide is at https://software.intel.com/en-us/Intel-VTune-Amplifier-XEInstall-Guide-Linux

Later when you untar the Intel VTune Amplifier package, you will find the installation guide's PDF file that comes with the package. It is recommended that you use that file.

You can access Intel VTune Amplifier ReadMe at https://software.intel.com/en-us/articles/intelparallel-studio-xe-2016-update-3-readme Access Intel VTune Amplifier release notes at https://software.intel.com/en-us/articles/intel-vtune-amplifier-xe-release-notes

At this point you have six different important items.

- Image – parallel_studio_xe_2016_update3.tgz

- Serial number
- License file
- Release notes
- ReadMe file
- Installation guide

Registering your product with the serial number

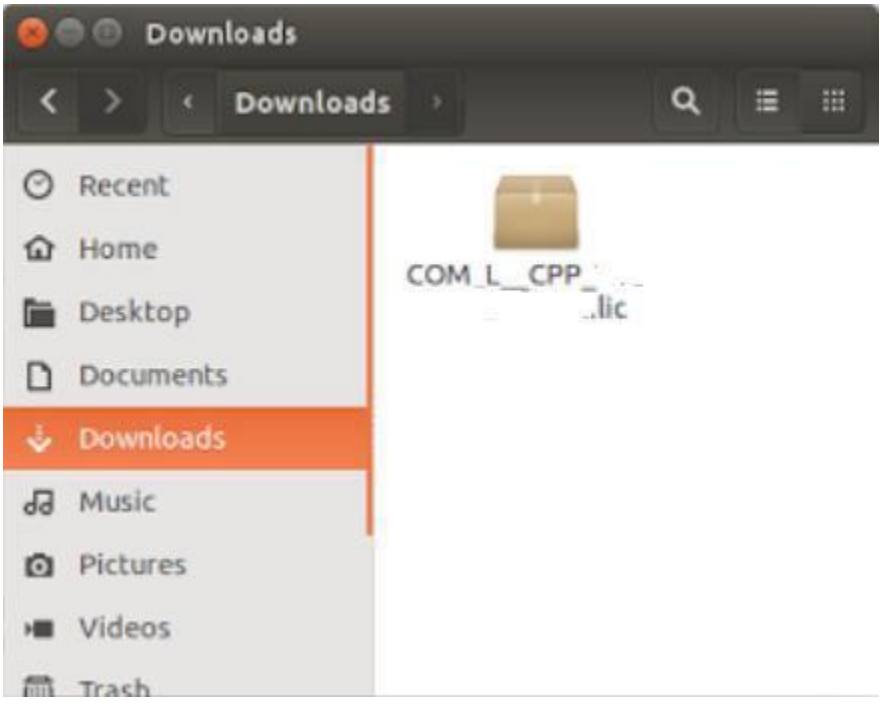
Register your product at https://registrationcenter.intel.com/en/ so that when you install (using serial number method, if you choose) successful authentication is possible.

Since VTune supports Ubuntu 15.10 from update 2 and later, and since we're using Intel VTune Amplifier update 3 Ubuntu 15.04, our Ubuntu version is verified as being supported with the Intel VTune Amplifier version we are using, as per the release notes.

Please take time to read the release notes, ReadMe file, and installation guide. Taking notes and highlighting the steps you need to do will make following the steps easier.

Note the serial number you got through e-mail.

Download the License File, .lic (shown in the download folder below)



Untar the Intel VTune Amplifier Package

```
$ tar -zxvf parallel_studio_xe_2016_update3.tgz
```

```
root@dpdk:/home/dpdk# pwd
/home/dpdk
root@dpdk:/home/dpdk# tar -zxvf parallel_studio_xe_2016_update3.tgz
```

You will see the following output as an example. Specifically, a new directory has been created named parallel_studio_xe_2016_update3

```
parallel_studio_xe_2016_update3/rpm/intel-mkl-ps-common-jp-210-11.3.3-210.noarch
.rpm
parallel_studio_xe_2016_update3/rpm/intel-ifort-l-ps-devel-210-16.0.3-210.i486.r
pm
parallel_studio_xe_2016_update3/license_ja.htm
parallel_studio_xe_2016_update3/silent.cfg
parallel_studio_xe_2016_update3/cd_eject.sh
parallel_studio_xe_2016_update3/ipsxe_support_fcompxe.txt
parallel_studio_xe_2016_update3/Install_Guide.pdf
root@dpdk:/home/dpdk# ls
Desktop                    parallel_studio_xe_2016_update3
Documents                  parallel_studio_xe_2016_update3 (copy).tgz
Downloads                  parallel_studio_xe_2016_update3.tgz
dpdk-16.04                 Pictures
```

Some of the files are noteworthy.

```
$ cd parallel_studio_xe_2016_update3
$ ls
```

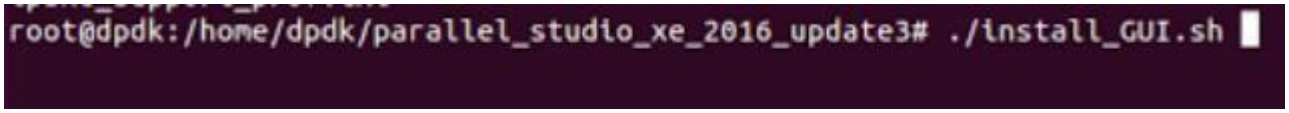
```
root@dpdk:/home/dpdk# cd parallel_studio_xe_2016_update3
root@dpdk:/home/dpdk/parallel_studio_xe_2016_update3# ls
cd_eject.sh                    license.htm
Install_Guide_JA.pdf           license_ja.htm
Install_Guide.pdf              license_ja.txt
install_GUI.sh                 license.txt
install.sh                     m_ita_p_9.1.2.024.dmg
ipsxe_support_ccompxe.txt      pset
ipsxe_support_cluster.txt      PUBLIC_KEY.PUB
ipsxe_support_compxe.txt       rpm
ipsxe_support_fcompxe.txt      silent.cfg
ipsxe_support_prof_c.txt       sshconnectivity.exp
ipsxe_support_prof_fortran.txt w_ita_p_9.1.2.024.exe
ipsxe_support_prof.txt
root@dpdk:/home/dpdk/parallel_studio_xe_2016_update3#
```

Note that Install_Guide.pdf resides in the directory shown above. Since this directory comes with the package, following this installation guide is more suitable for these installation steps. **install_GUI.sh** and **install.sh** are the install files for GUI and the command line, respectively. **silent.cfg** is the configuration file used in non-interactive (that is, silent) mode for installation.

VTune Installation Steps

In this example, we will use interactive installation and **install_GUI.sh.**

```
$ ./install_GUI.sh
```



The resulting successive screens with queries are shown in Appendix 1.

Verify and compare notes with your screen outputs to those shown in Appendix 1.

Following are the steps after successful complete installation.

Verifying whether the driver is installed

By default, using interrupt sampling mode should work indicating the driver is installed correctly. If interrupt sampling mode is not working properly, verify whether the driver is installed correctly. The verification steps are listed in Appendix 2.

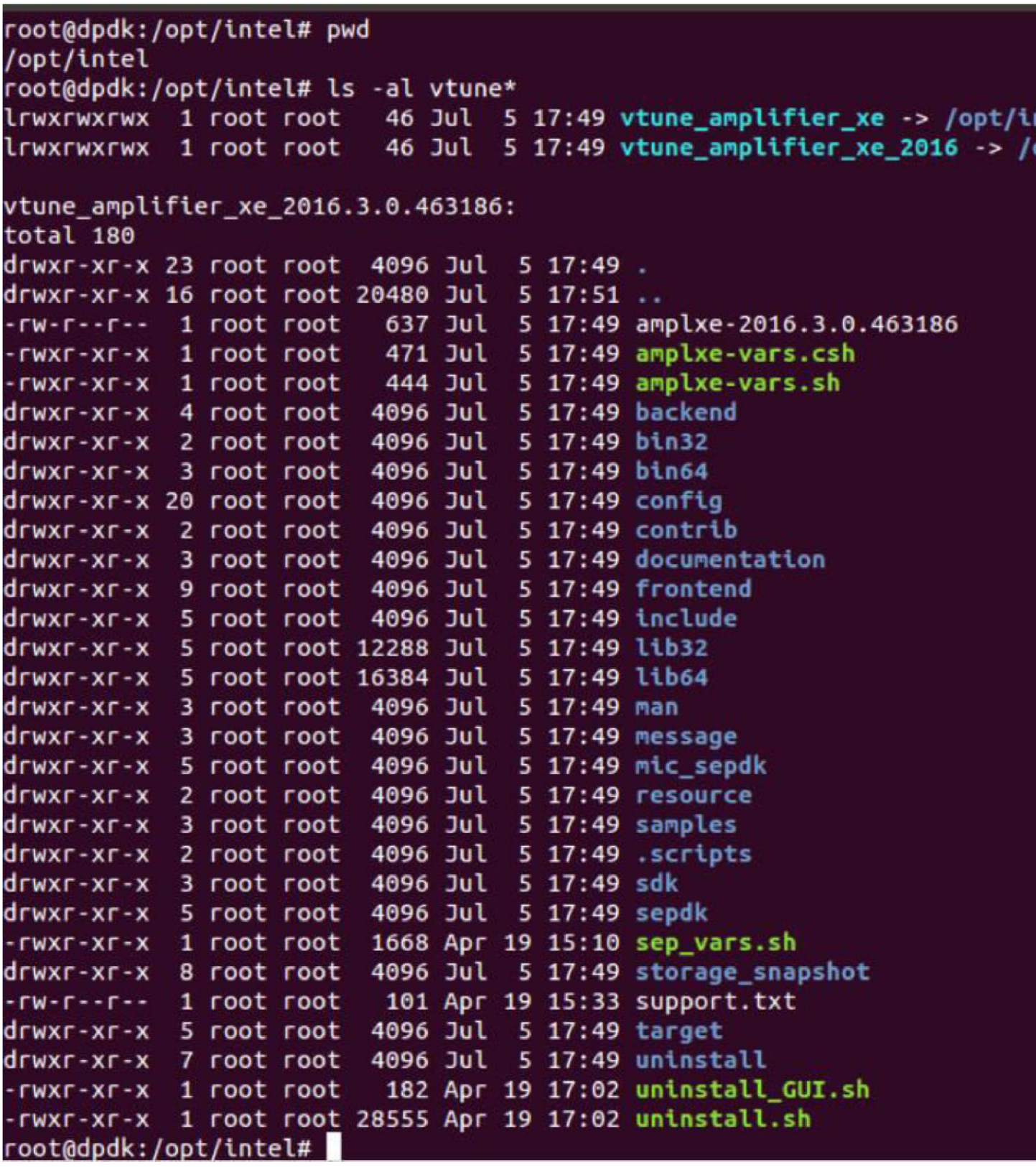
Following are the steps after successful verification.

Before Starting Intel VTune Amplifier

Before starting Intel VTune Amplifier, let's take a quick look at the directory structure and the key files.

amplxe-vars.sh and ***amplxe-vars.csh*** shown below are for setting environment variables.

Please note the softlinks **vtune_amplifier_xe_2016** and **vtune_amplifier_xe** are listed below.



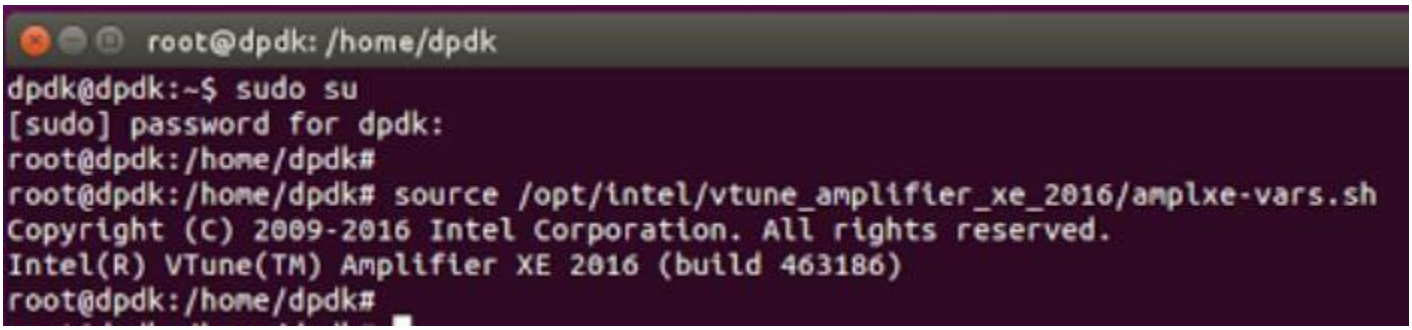
Starting Intel VTune Amplifier

Note that <*install_dir*> is */opt/intel/vtune_amplifier_xe_2016*

- Set up the environment variables. source

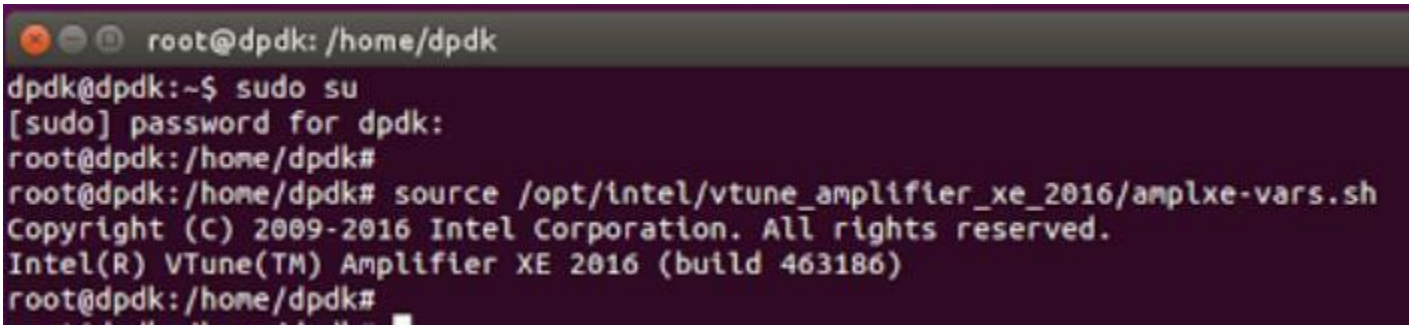
  <install_dir>/amplxe-vars.sh translates to $ *source*

  /opt/inte/vtune_amplifier_xe_2016/amplxe-vars.sh

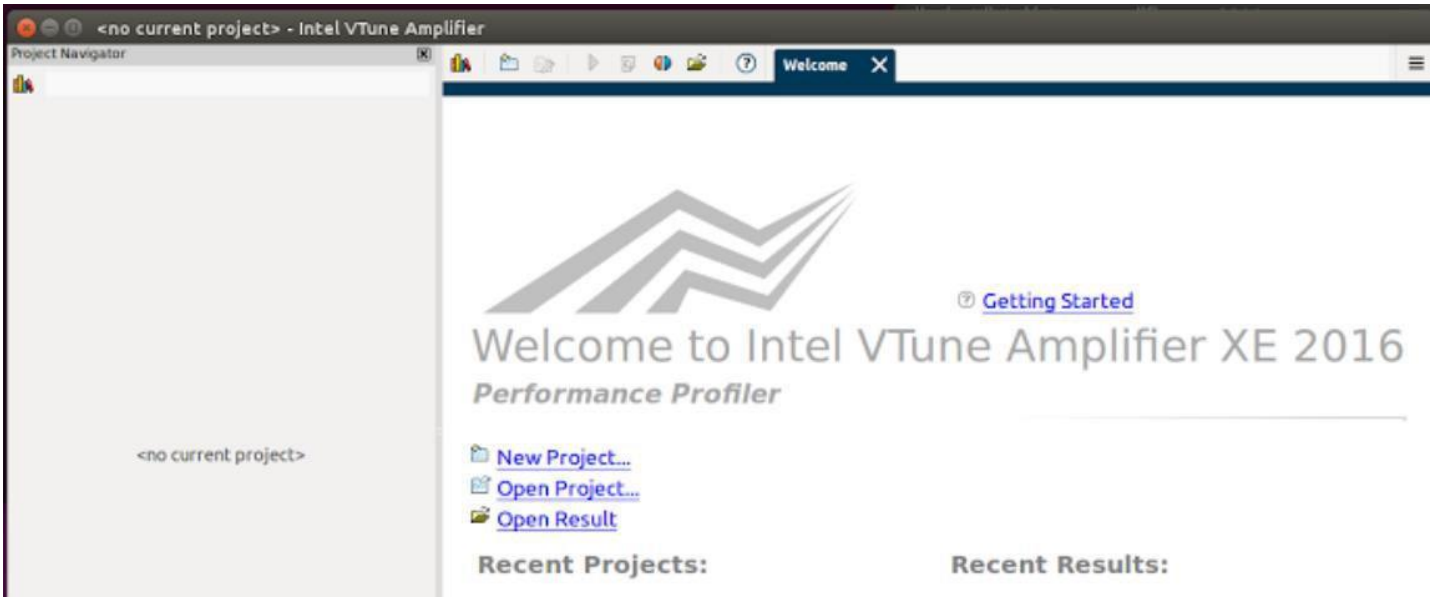


- Launch Intel VTune Amplifier in graphic mode.

  $ *amplxe-gui*



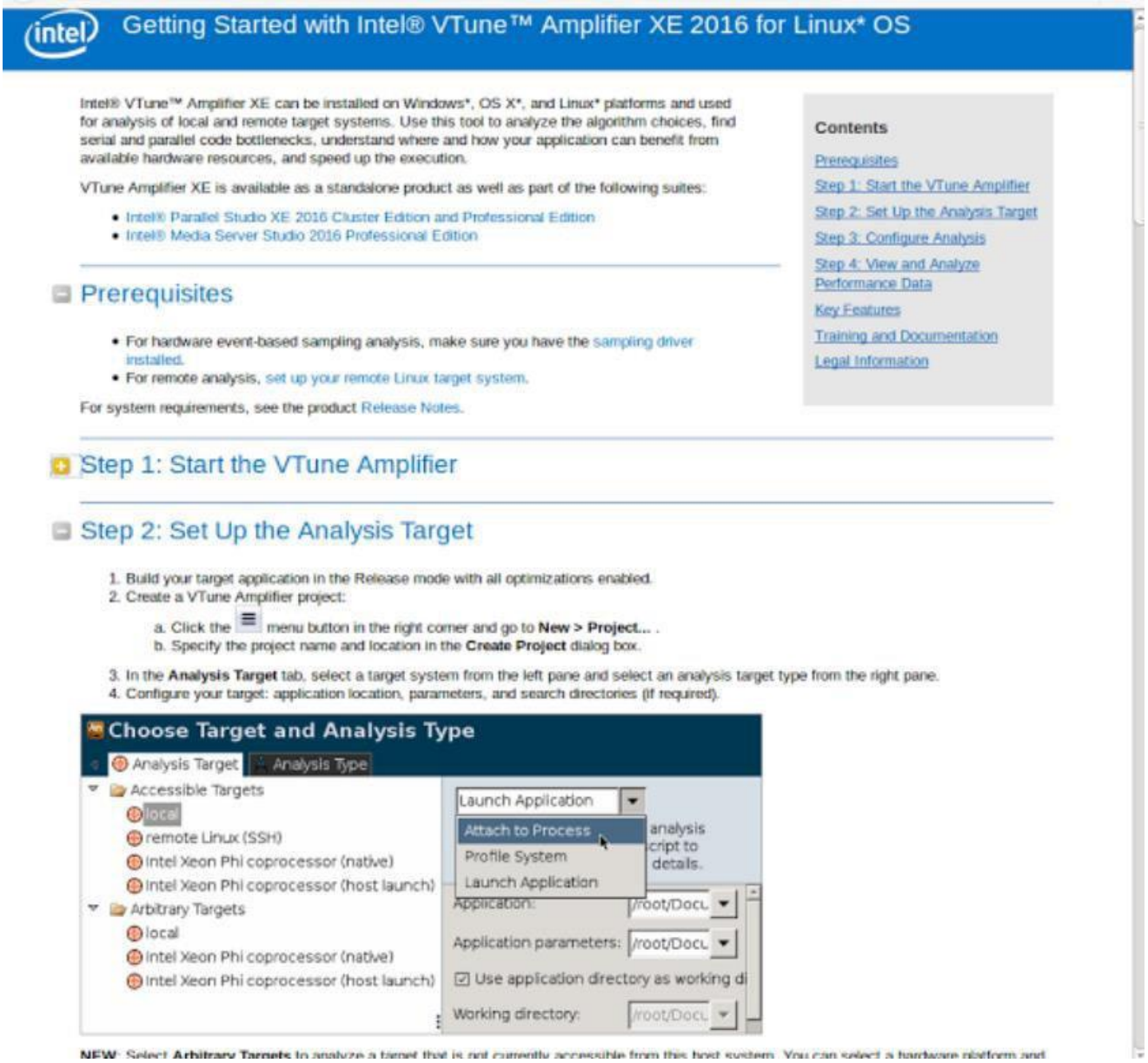
  You will see Intel VTune Amplifier launching as shown below.



Click Getting Started in the welcome banner to open the Getting Started instructions specific to the Intel VTune Amplifier installed.

Now you can start building your project as per the steps shown in the Getting Started notes.

In this paper, we will profile couple of DPDK performance functions to illustrate VTune profiling of DPDK code.

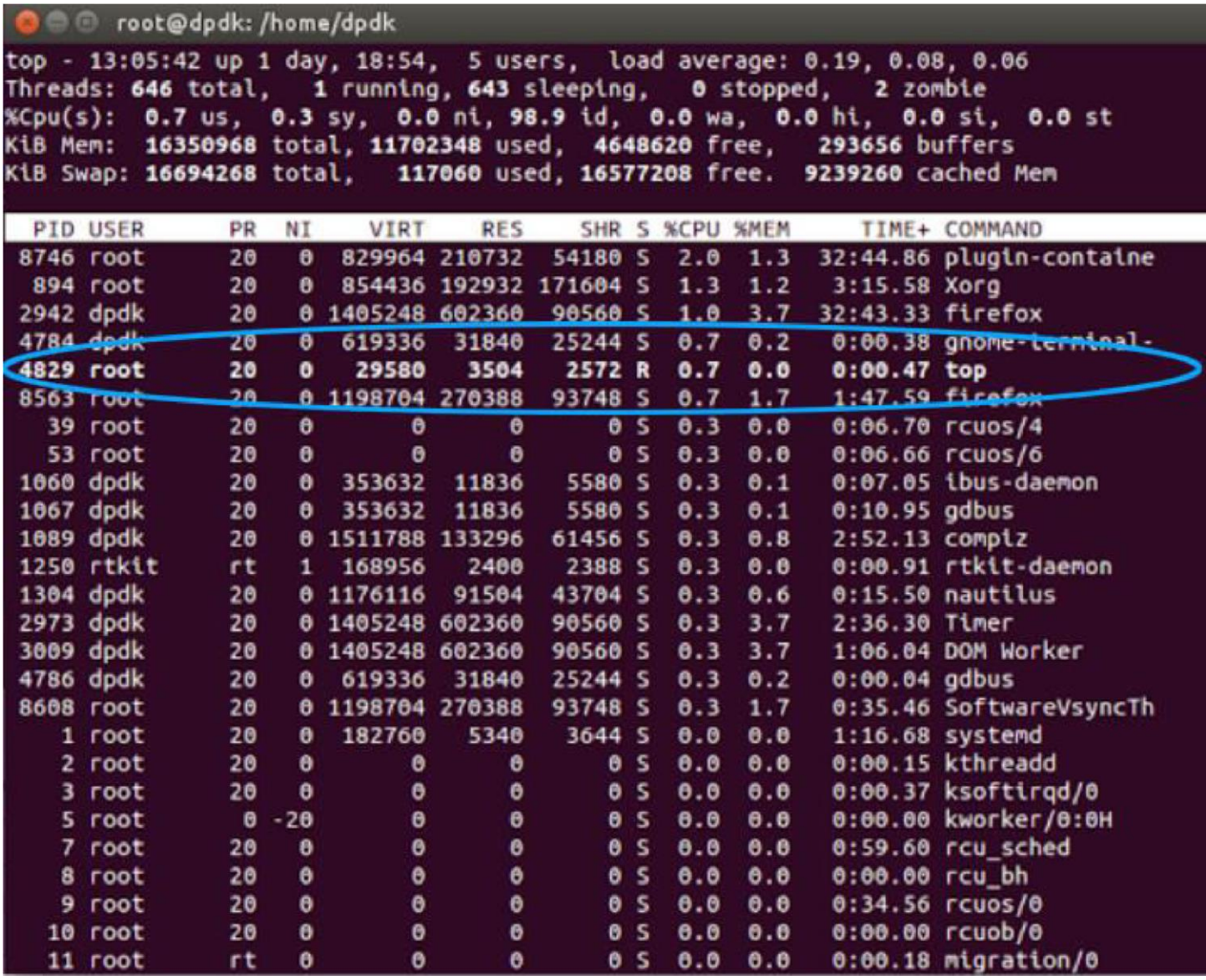


Stepping Back & Seeing the Big Picture

It behooves to step back and see the big picture first – as what other components exist in the system. If there is some unrelated component consuming resources and if we only focus on measuring our specific application, then we may be coming to wrong conclusion because of partial information.

So, here, even before running DPDK application, we are just running *top –H* and see where CPU is spending its cycles even without our specific application running.

Below you will see VTune showing *top –H* running as well as web browser running. Now the user can understand that *top* is something user just ran whereas web browser is something he does not want to take CPU cycles while running the application of interest. Similarly the user may find some unwanted daemons. So, the user stops the unwanted applications, daemons and any other components.

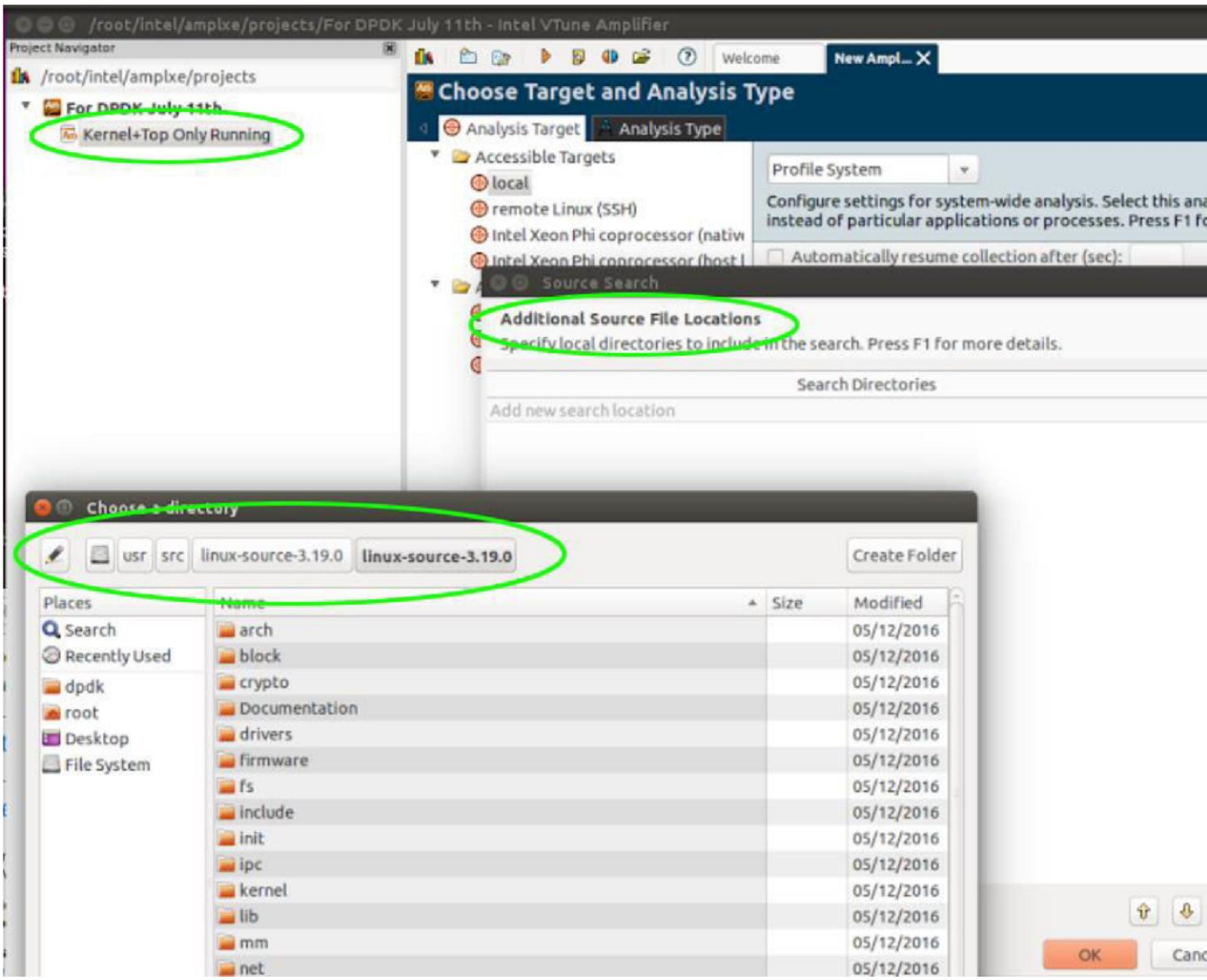


Pointing to the Source Directory

The following screenshot shows in VTune how to point to the source directory of the s/w components of interest. You can add multiple directories.

Profiling DPDK code with VTune

1. Reserving Huge Page Creating /mnt/huge and mounting as hgetlbfs:



$ *cd /home/dpdk/dpdk-16.04*

$ *sudo su*

$ *echo 128 > /sys/kernel/mm/hugepages/hugepages-2048kB/nr_hugepages*

Please note that 128 is chosen here with memory constrain in the laptop chosen. In case you are using server/desktop 1024 can be chosen.

```
root@dpdk:/home/dpdk/dpdk-16.04# sudo su
```

```
# echo 128 > /sys/kernel/mm/hugepages/hugepages-2048kB/nr_hugepages
```

2. Creating /mnt/huge and mounting as hgetlbfs:

$ *sudo bash*

$ *mkdir –p –v /mnt/huge* [-v for verbose, as you can see below response from the system]

$ *mount –t hugetlbfs nodev /mnt/huge*

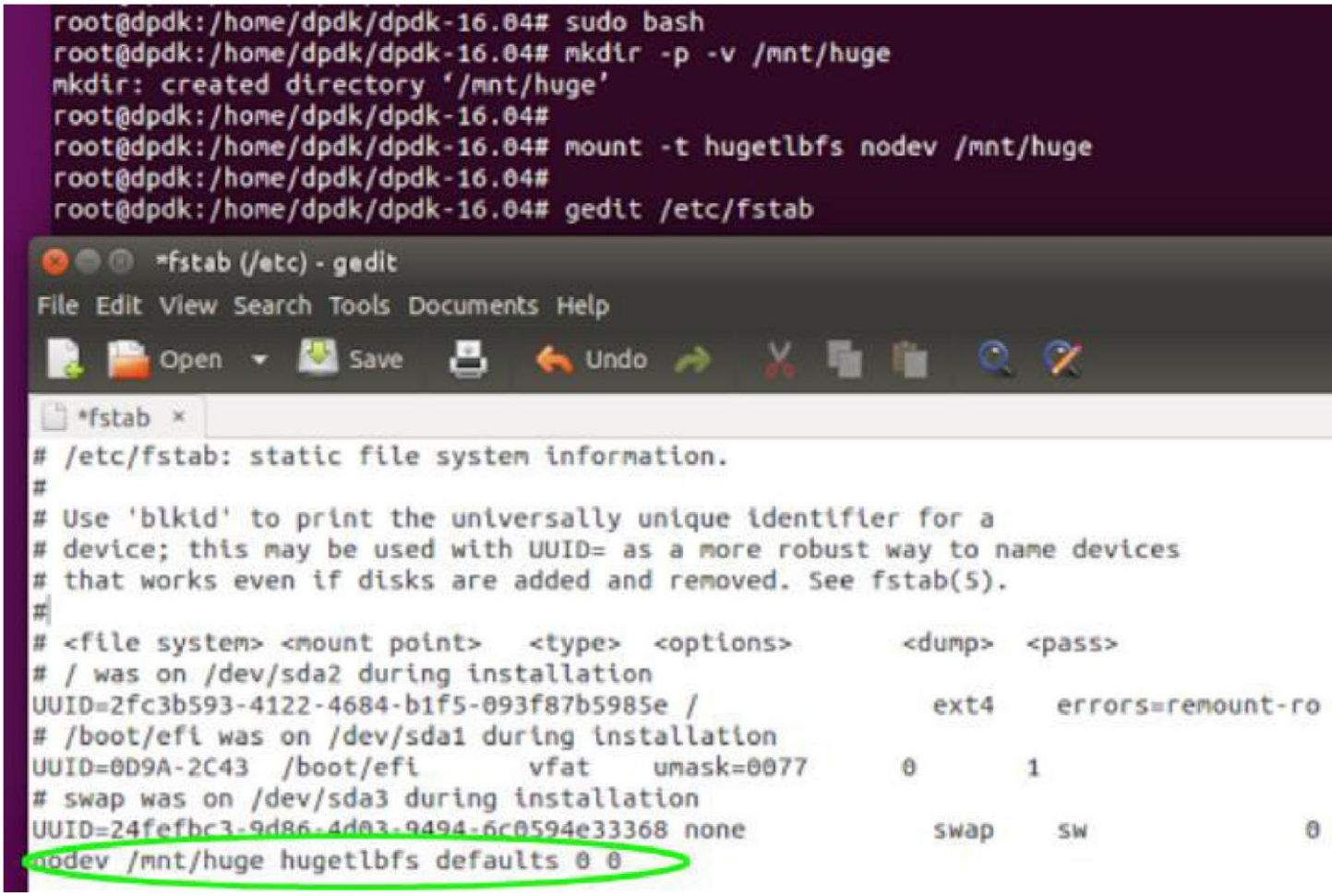
Making the mount point permanent across reboots, by adding the following line to the */etc/fstab* file:

nodev /mnt/huge hugetlbfs defaults 0 0

3. Building DPDK Test Application & DPDK Library:

$ *export RTE_SDK=/home/dpdk/dpdk-16.04*

$ *export RTE_TARGET=x86_64-native-linuxapp-gcc*



$ *export EXTRA_CFLAGS='-g'* [For DPDK symbols] $ *make*

install T=x86_64-native-linuxapp-gcc DESTDIR=install

The output of build will complete successfully as shown below.

```
root@dpdk:/home/dpdk/dpdk-16.04#
root@dpdk:/home/dpdk/dpdk-16.04# export RTE_SDK=/home/dpdk/dpdk
root@dpdk:/home/dpdk/dpdk-16.04# export RTE_TARGET=x86_64-nativ
root@dpdk:/home/dpdk/dpdk-16.04#
root@dpdk:/home/dpdk/dpdk-16.04# export EXTRA_CFLAGS='-g'
root@dpdk:/home/dpdk/dpdk-16.04#
root@dpdk:/home/dpdk/dpdk-16.04# make install T=x86_64-native-l

== Build app/proc_info
  CC main.o
  LD dpdk_proc_info
  INSTALL-APP dpdk_proc_info
  INSTALL-MAP dpdk_proc_info.map
Build complete [x86_64-native-linuxapp-gcc]
================== Installing install/
Installation in install/ complete
root@dpdk:/home/dpdk/dpdk-16.04#
```

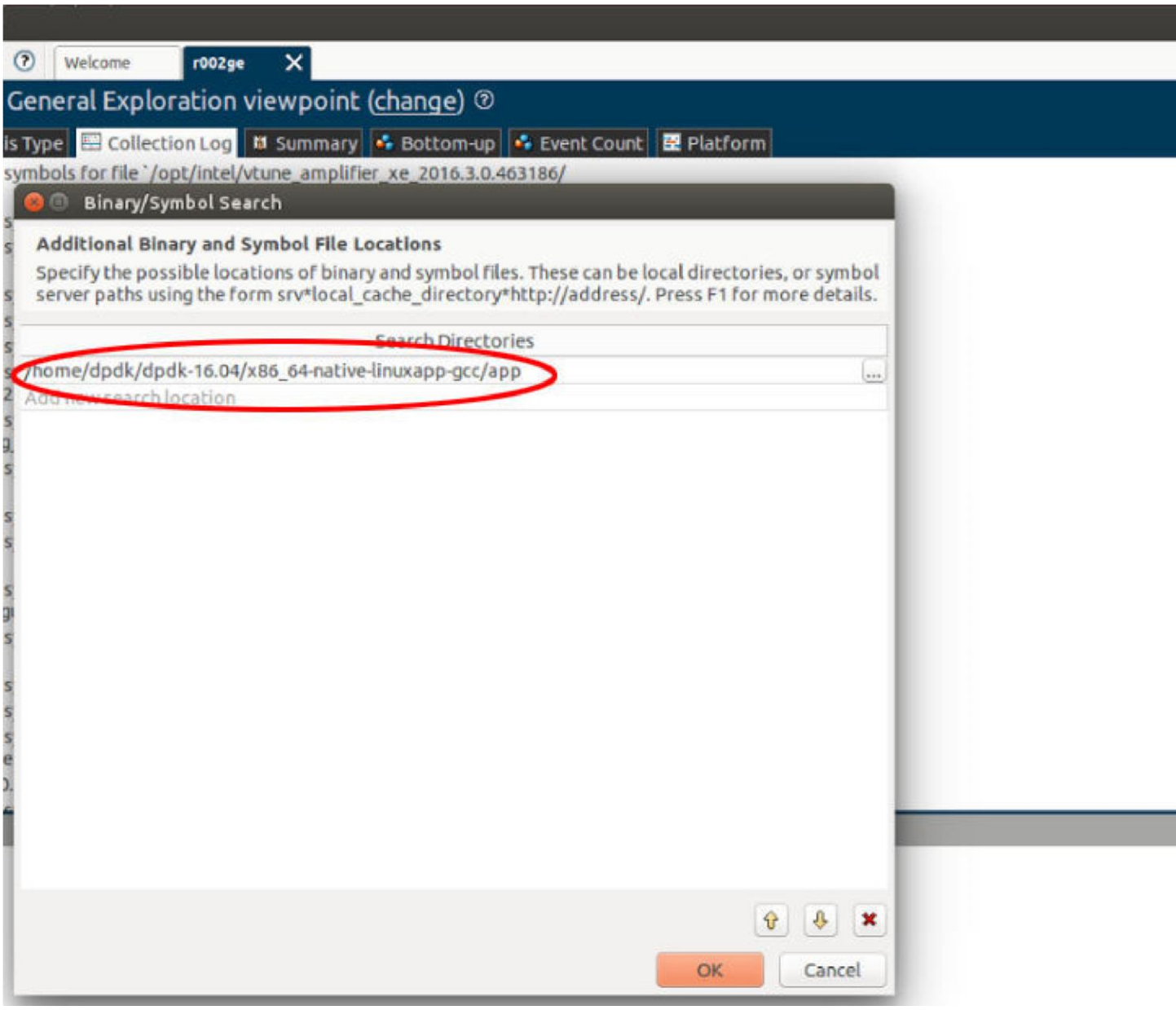
4. Enable Userspace IO for DPDK by Loading uio Modules:

$ *sudo modprobe uio*

$ *sudo insmod x86_64-native-linuxapp-gcc/kmod/igb_uio.ko*

5. Add path to Symbols (DPDK Test Application) in VTune:

```
root@dpdk:/home/dpdk/dpdk-16.04# sudo modprobe uio
root@dpdk:/home/dpdk/dpdk-16.04#
root@dpdk:/home/dpdk/dpdk-16.04# sudo insmod x86_64-native-linuxapp-gcc/kmod/igb_uio.ko
root@dpdk:/home/dpdk/dpdk-16.04#
root@dpdk:/home/dpdk/dpdk-16.04#
```

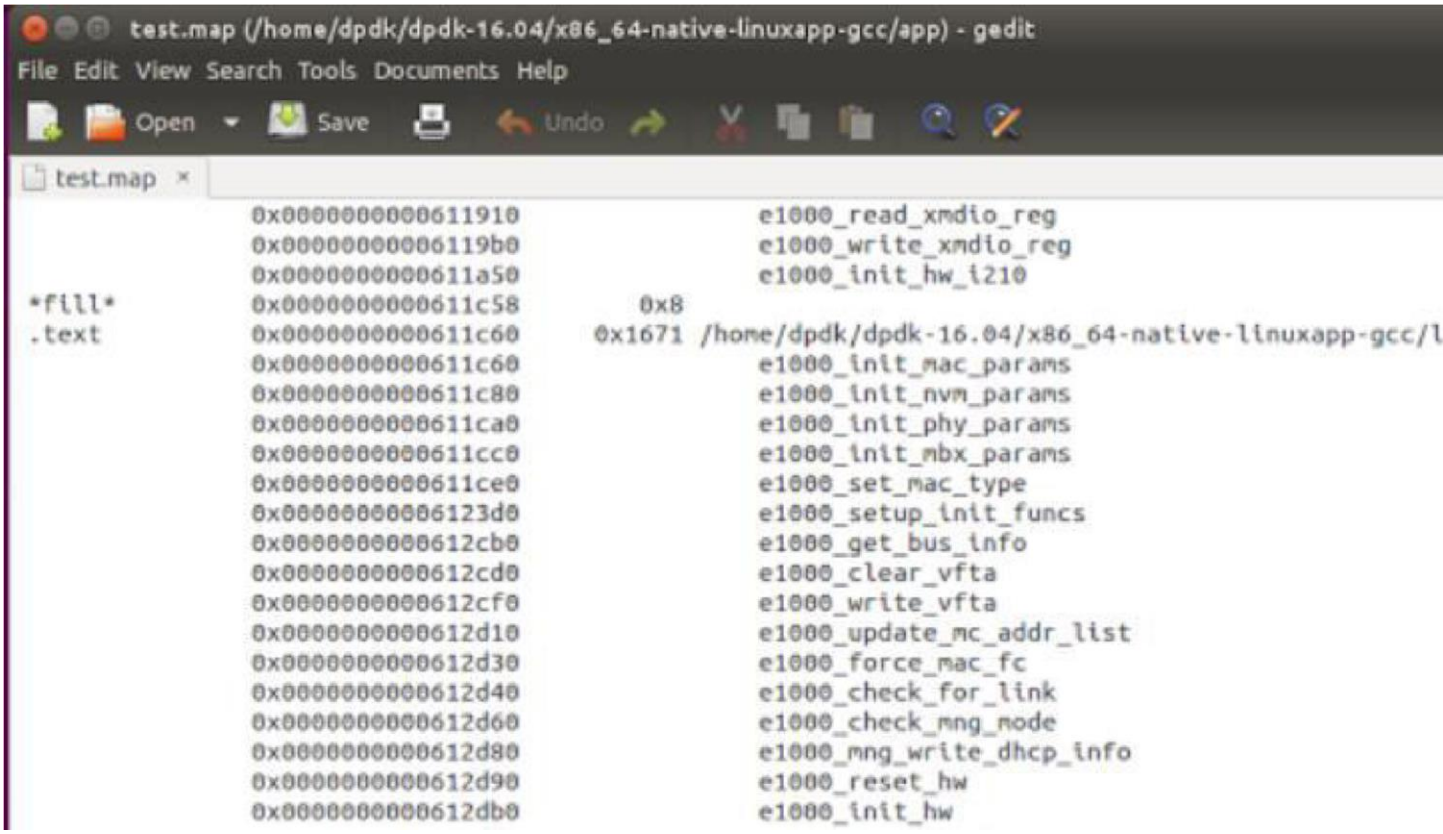


You can verify the symbols in the above directory in .map file

Profiling DPDK Code with VTune Amplifier

$ *cd /home/dpdk/dpdk-16.04/x86_64-native-linuxapp-gcc/app*

$ *sudo su*



$ *./test*

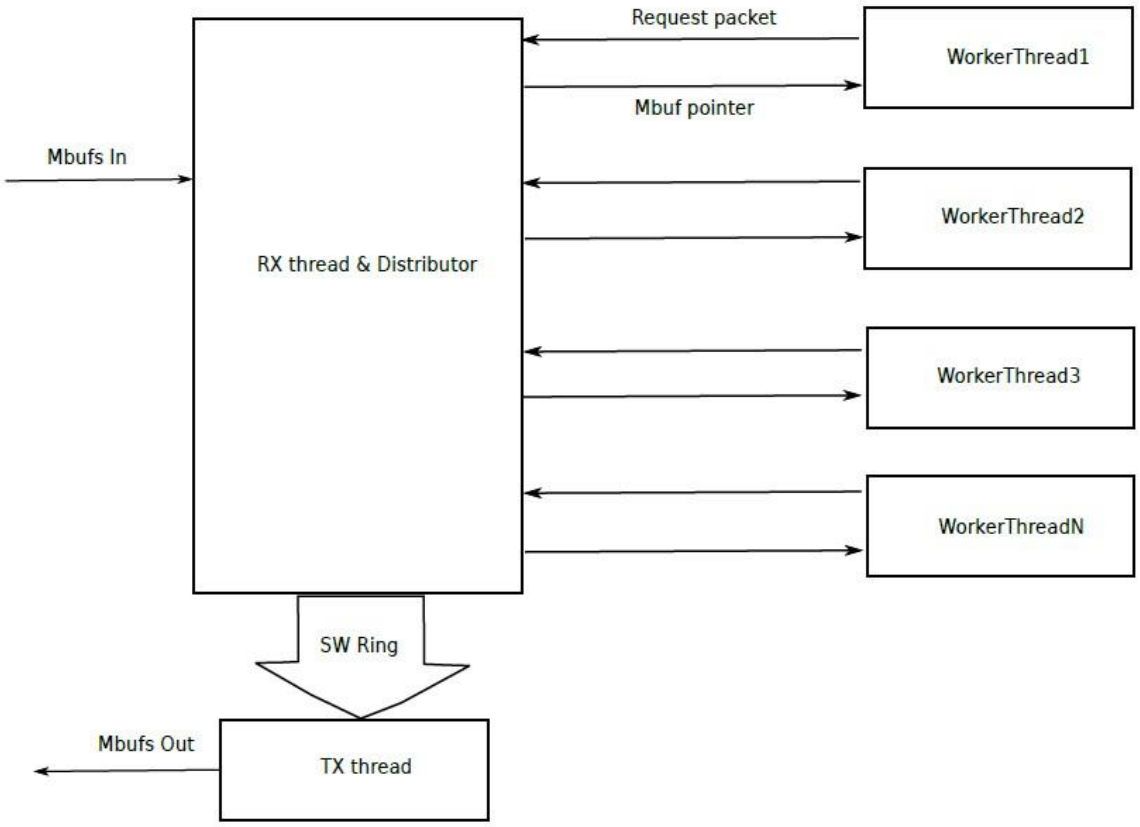
The test will issue prompt RTE>> as shown below.

$? will give the list of tests and help.

Next we will run a handful of microbenchmarks.

Profiling Distributor Perf Autotest

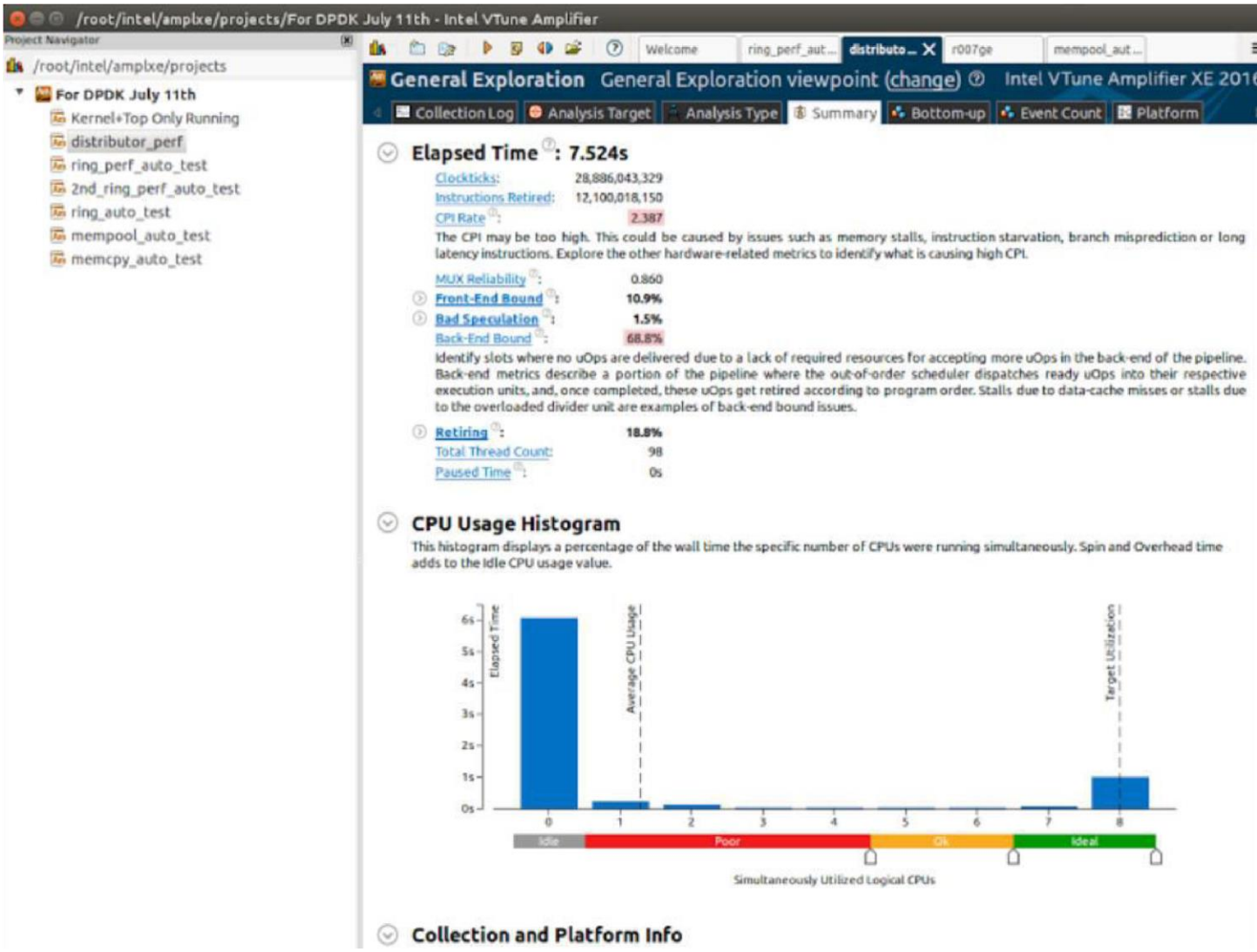
RTE>> *distributor_perf_autotest*



Distributor Sample Application Layout

```
RTE>>
RTE>>distributor_perf_autotest
==== Cache line switch test ===
Time for 1048576 iterations = 233243764 ticks
Ticks per iteration = 222

=== Performance test of distributor ===
Time per burst:  2028
Time per packet: 63

Worker 0 handled 5211363 packets
Worker 1 handled 5208936 packets
Worker 2 handled 5214205 packets
Worker 3 handled 5218201 packets
Worker 4 handled 4254659 packets
Worker 5 handled 4233312 packets
Worker 6 handled 4213756 packets
Total packets: 33554432 (2000000)
=== Perf test done ===
```

The summary highlights CPI rate indicating it is beyond the normal range. It also highlights “Back End Bound” indicating memory bound application nature.

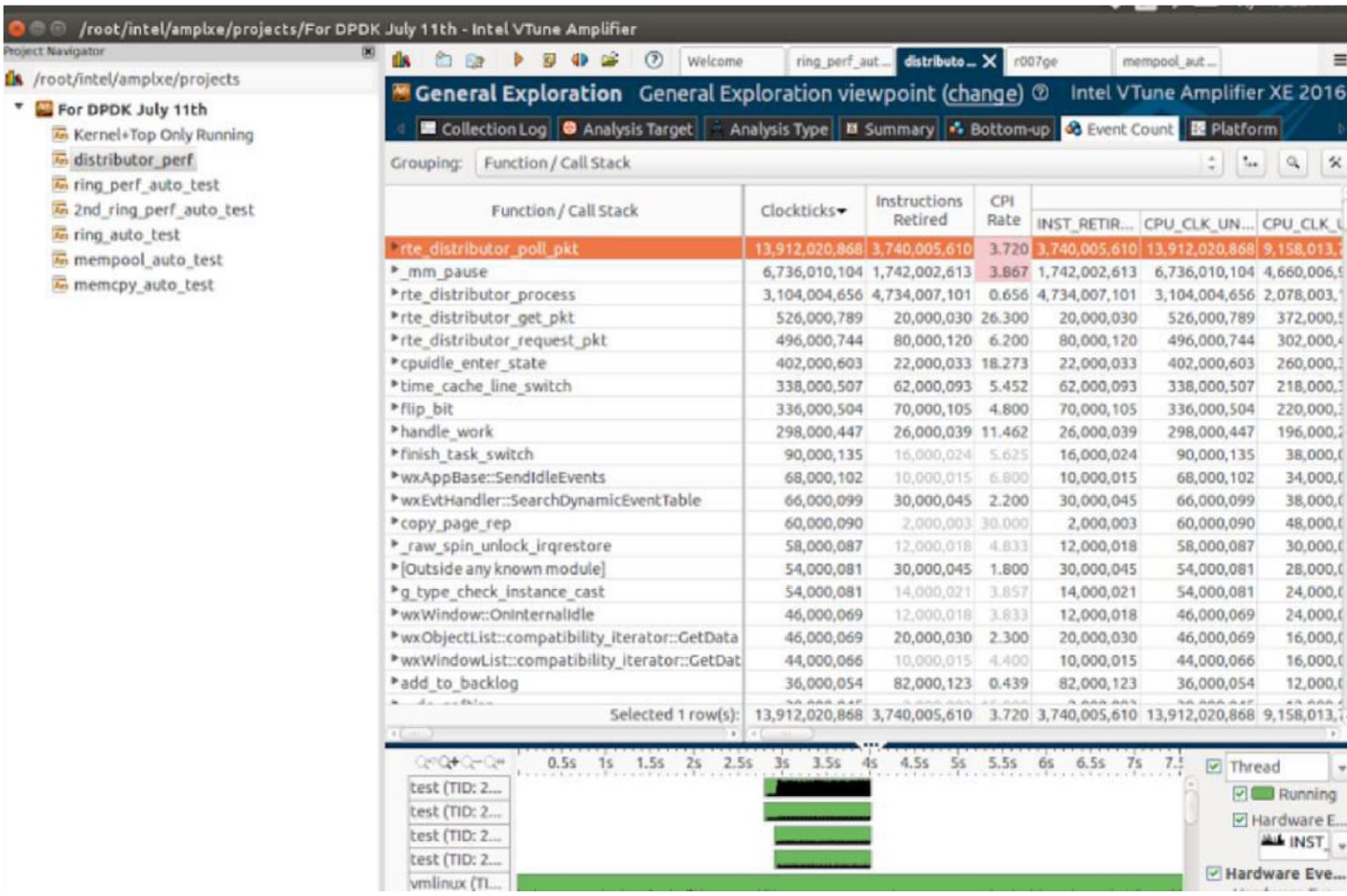


The details are shown below:

The Function/Call Stack indicates ***rte_distributor_poll_pkt*** *consumes CPI rate of 3.720 and* ***_mm_pause*** consuming CPI rate of 3.867.

You can observe rte_distributor_get_pkt runs with CPI rate of 26.30. However it is not highlighted since it does not run as many clock ticks as other functions.

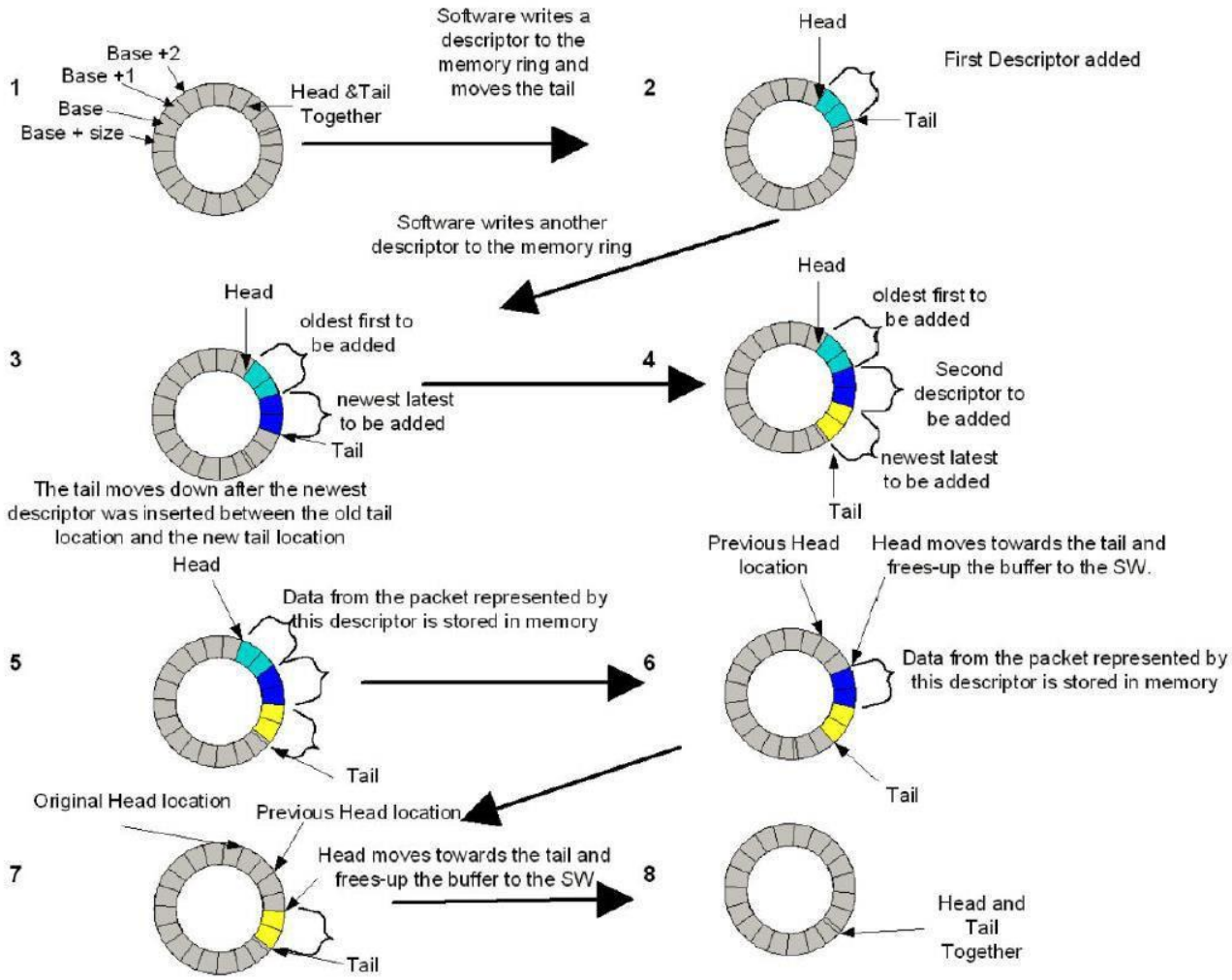
You will see other functions listed here along with the CPI each one takes – ***rte_distributor_process***, ***rte_distributor_request_pkt, time_cache_line_switch*** for instance.



Profiling Rings

The Communication between cores for interprocessor communication as well as communication between cores and NIC happens through rings and descriptors.

While NIC hardware does optimizations in terms of RS bit and DD bit (Descriptor Done bit) in bunching the data size, DPDK in addition enhances bunching with amortizing by offering API for bulk communication through rings.

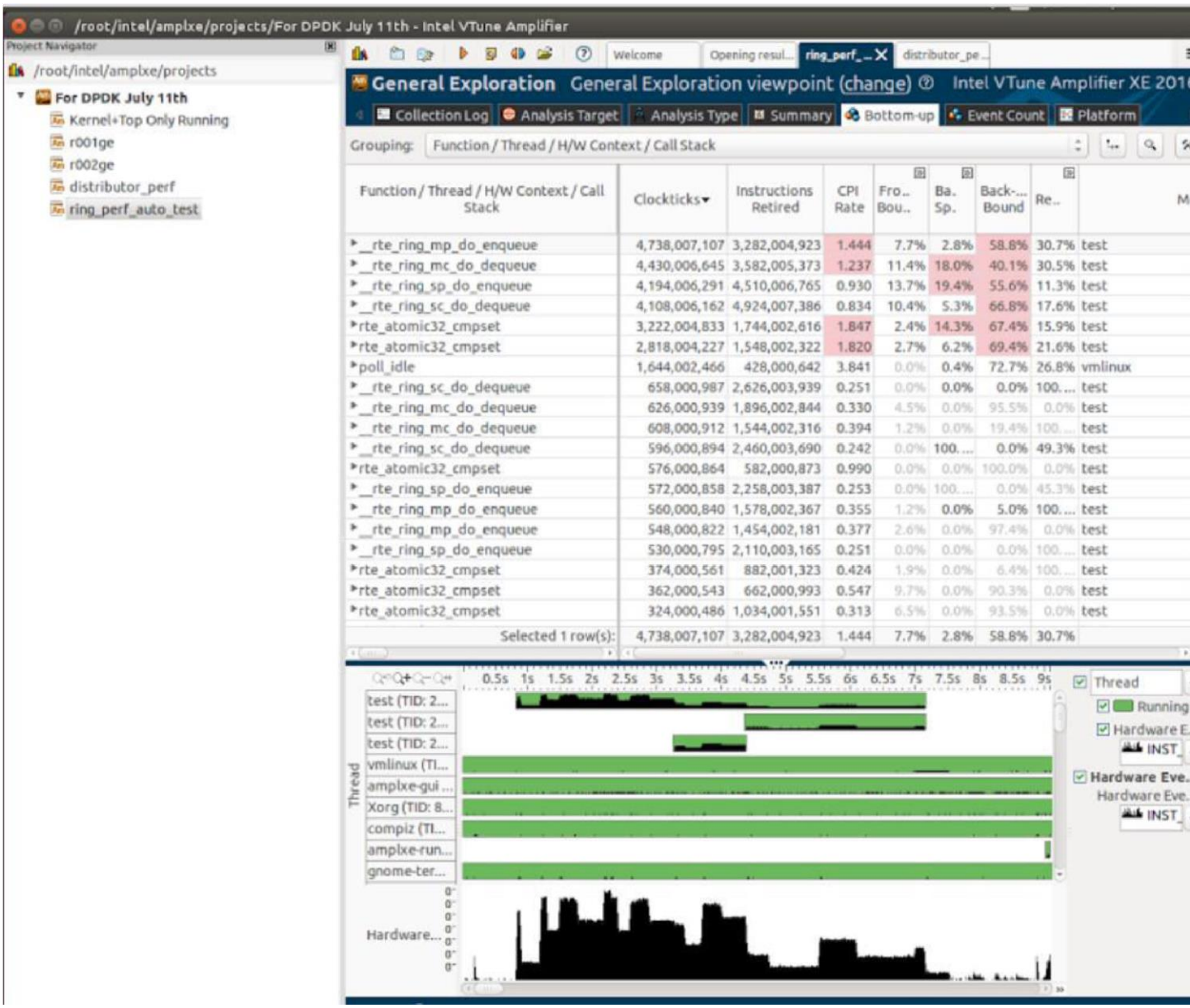


The rings tests show Single producer single consumer (SP/SC) with bulk sizes both in enqueue / dequeue gives best performance compared to Multiple producers multiple consumers (MP/MC). Below are the steps.

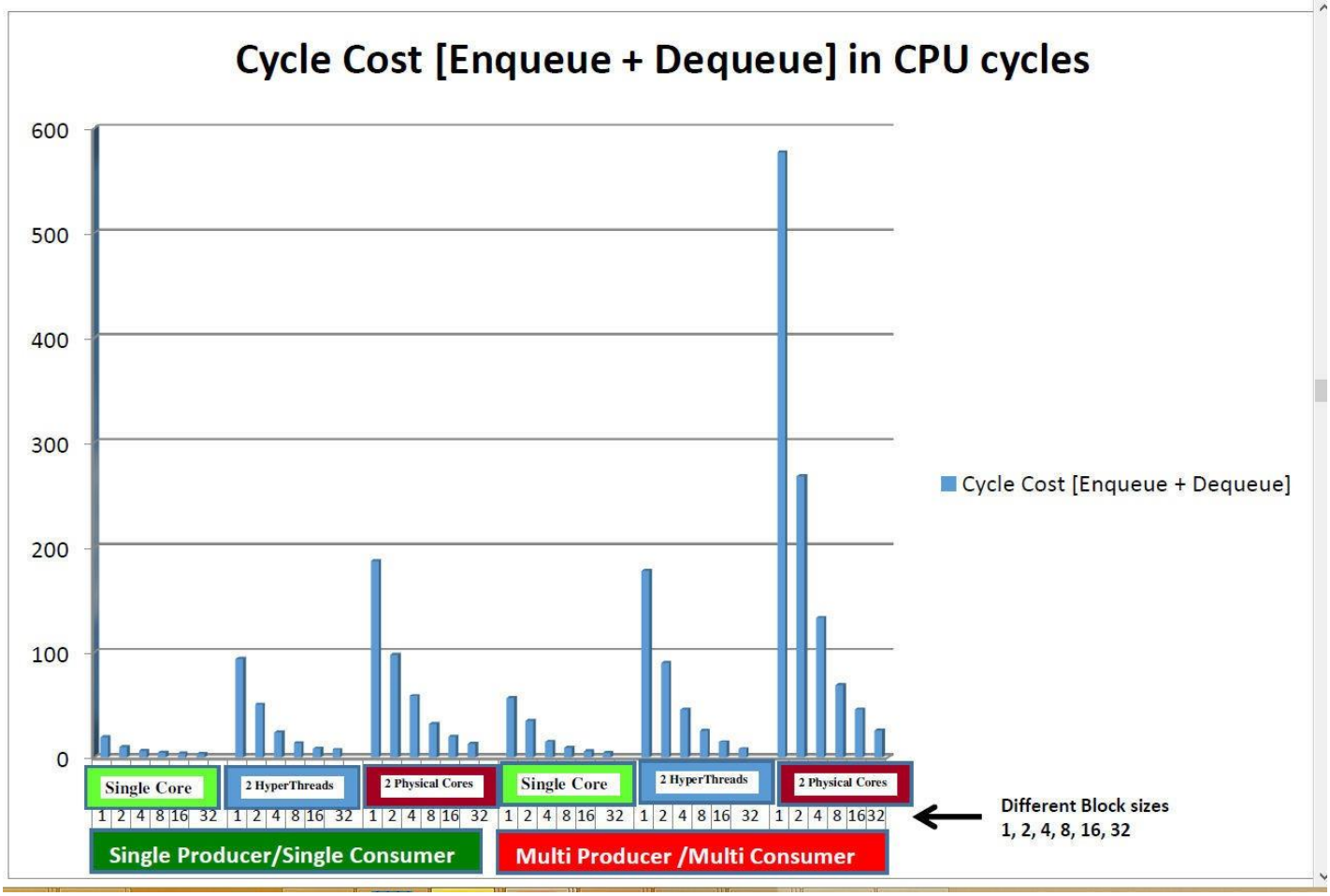
Profiling ring_perf_autotest

```
RTE>>ring_perf_autotest
### Testing single element and burst enq/deq ###
SP/SC single enq/dequeue: 6
MP/MC single enq/dequeue: 37
SP/SC burst enq/dequeue (size: 8): 2
MP/MC burst enq/dequeue (size: 8): 5
SP/SC burst enq/dequeue (size: 32): 2
MP/MC burst enq/dequeue (size: 32): 3

### Testing empty dequeue ###
SC empty dequeue: 1.34
MC empty dequeue: 1.90

### Testing using a single lcore ###
SP/SC bulk enq/dequeue (size: 8): 3.08
MP/MC bulk enq/dequeue (size: 8): 5.82
SP/SC bulk enq/dequeue (size: 32): 2.13
MP/MC bulk enq/dequeue (size: 32): 3.00

### Testing using two hyperthreads ###
SP/SC bulk enq/dequeue (size: 8): 9.18
MP/MC bulk enq/dequeue (size: 8): 15.96
SP/SC bulk enq/dequeue (size: 32): 4.52
MP/MC bulk enq/dequeue (size: 32): 5.68

### Testing using two physical cores ###
SP/SC bulk enq/dequeue (size: 8): 20.62
MP/MC bulk enq/dequeue (size: 8): 46.49
SP/SC bulk enq/dequeue (size: 32): 8.52
MP/MC bulk enq/dequeue (size: 32): 15.80
Test OK
```

Below the rings tests show in detail that the code is backend bound and you can see the call stack showing the Single producer single consumer (SP/SC) with bulk sizes as well Multiple producers multiple consumers (MP/MC).



To appreciate relative performance of SP/SC with single data size and bulk size and comparing with MP/MC with single data size and bulk size following graph can be referred. Please note the impact of core placement – a) siblings, b) within the same socket, c) across multi sockets.



Conclusion & Next Steps

Practice profiling on additional sample DPDK applications. With the experience you gather, extend the profiling and optimization to your own applications that you are building on top of DPDK.

Get plugged into the DPDK community to learn on the latest from developers and architects and keep your products highly optimized. Register at http://www.dpdk.org/ml/listinfo/dev

Reference

Enabling Internet connectivity: http://askubuntu.com/questions/641591/internet-connection-not-working-in-ubuntu-15-04

Getting Kernel Symbols/Sources on Ubuntu Linux:

http://sysprogs.com/VisualKernel/tutorials/setup/ubuntu/

How to debug libraries in Ubuntu: http://stackoverflow.com/questions/14344654/how-to-use-debug-libraries-on-ubuntu

How to install a package that contains Ubuntu debug symbols:

http://askubuntu.com/questions/197016/how-to-install-a-package-that-contains-ubuntu-kerneldebug-symbols Debug symbol packages:

https://wiki.ubuntu.com/Debug%20Symbol%20Packages

Ask Ubuntu for challenges in Apt-get update failure to fetch:

http://askubuntu.com/questions/135932/apt-get-update-failure-to-fetch-cant-connect-to-any-sources

DNS Name Server IP Address:

http://www.cyberciti.biz/faq/ubuntu-linux-configure-dns-nameserver-ip-address/

How to fix Public Key is not available issue:

https://chrisjean.com/fix-apt-get-update-the-following-signatures-couldnt-be-verified-because-thepublic-key-is-not-available/

Ubuntu Key server: http://keyserver.ubuntu.com:11371/

Installing CSCOPE:

http://installion.co.uk/ubuntu/vivid/init/c/cscope/install/index.html http://freecode.com/projects/cscope

Performance optimization:

http://www.agner.org/optimize/instruction_tables.pdf Intel

VTune Amplifier data collection:

https://software.intel.com/en-us/articles/data-collection

Using Intel VTune Amplifier with a virtual machine:

https://software.intel.com/en-us/node/638180

Challenges in installing VTune? Refer these links below:

https://software.intel.com/en-us/forums/intel-vtune-amplifier-xe/topic/340649

http://software.intel.com/en-us/articles/vtune-amplifier-xe-2013-u3-works-on-customized-embeddedlinux-system http://softwareproducts.intel.com/ilc/

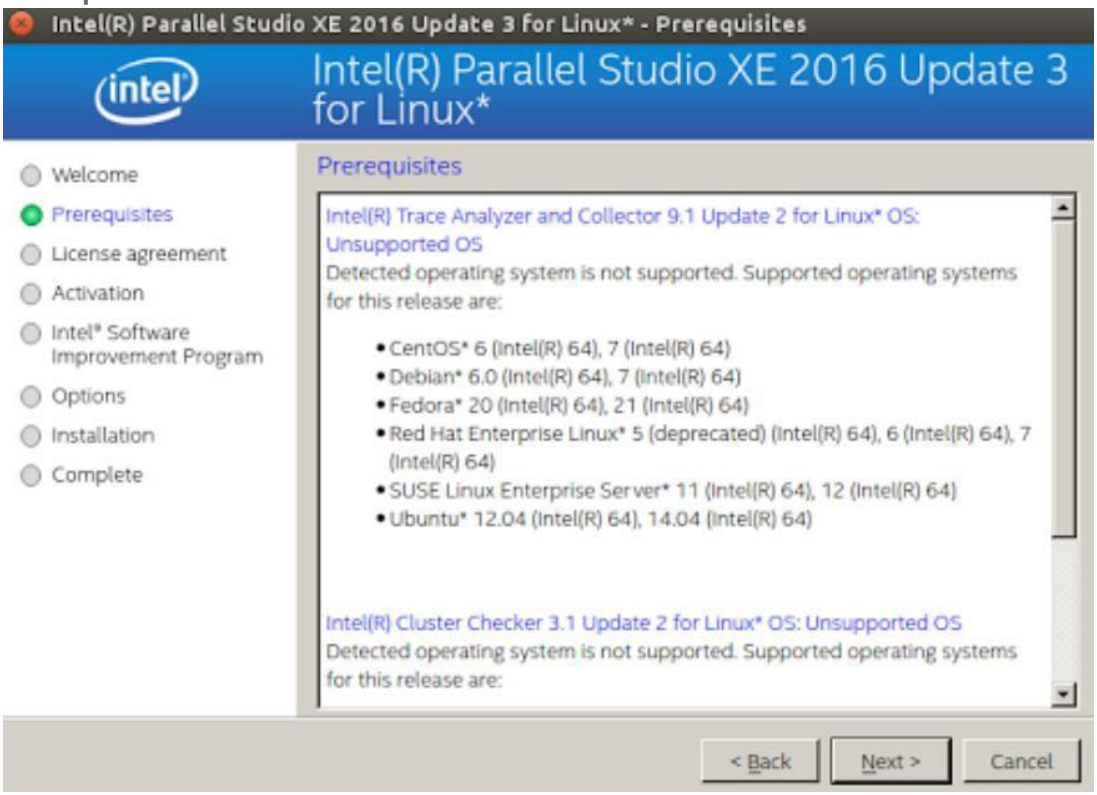
Appendix 1: Intel VTune Amplifier Install Steps

For the input ./install_GUI.sh following are the screen outputs. 1.

Welcome Screen

2.

Prerequisites



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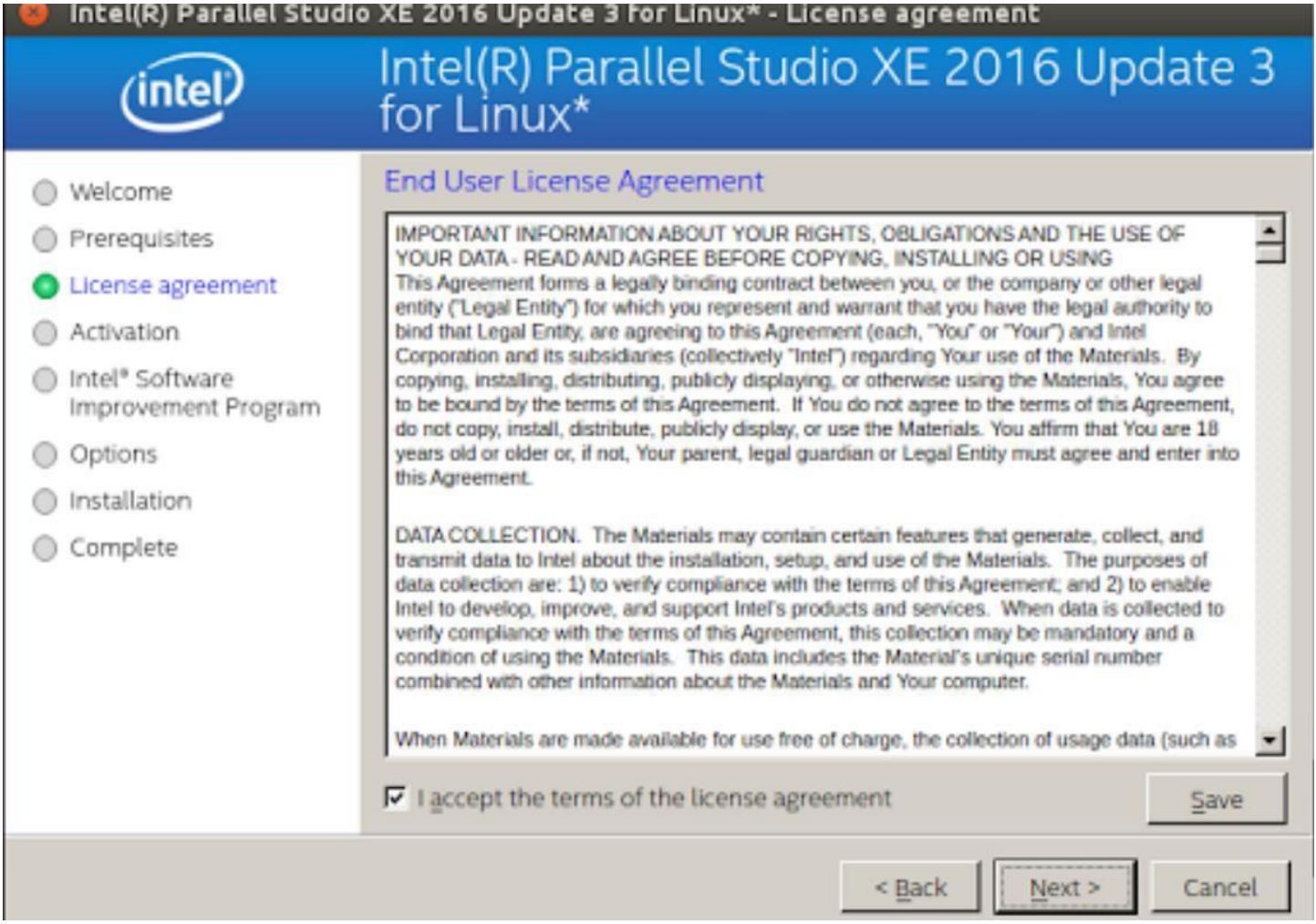
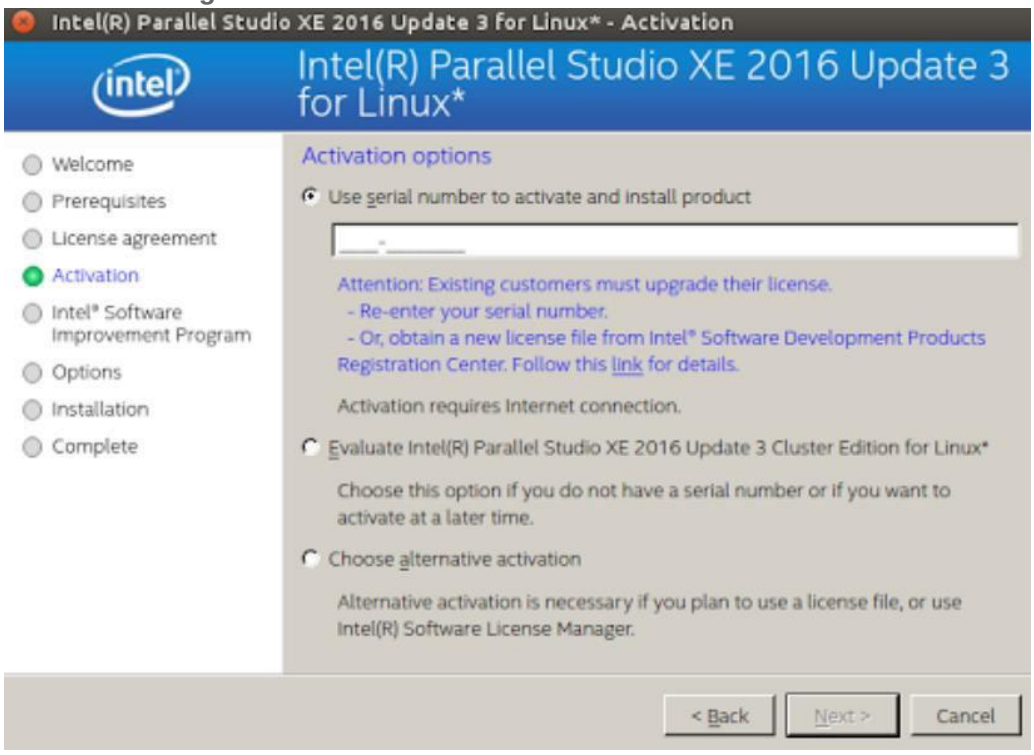


End User License Agreement

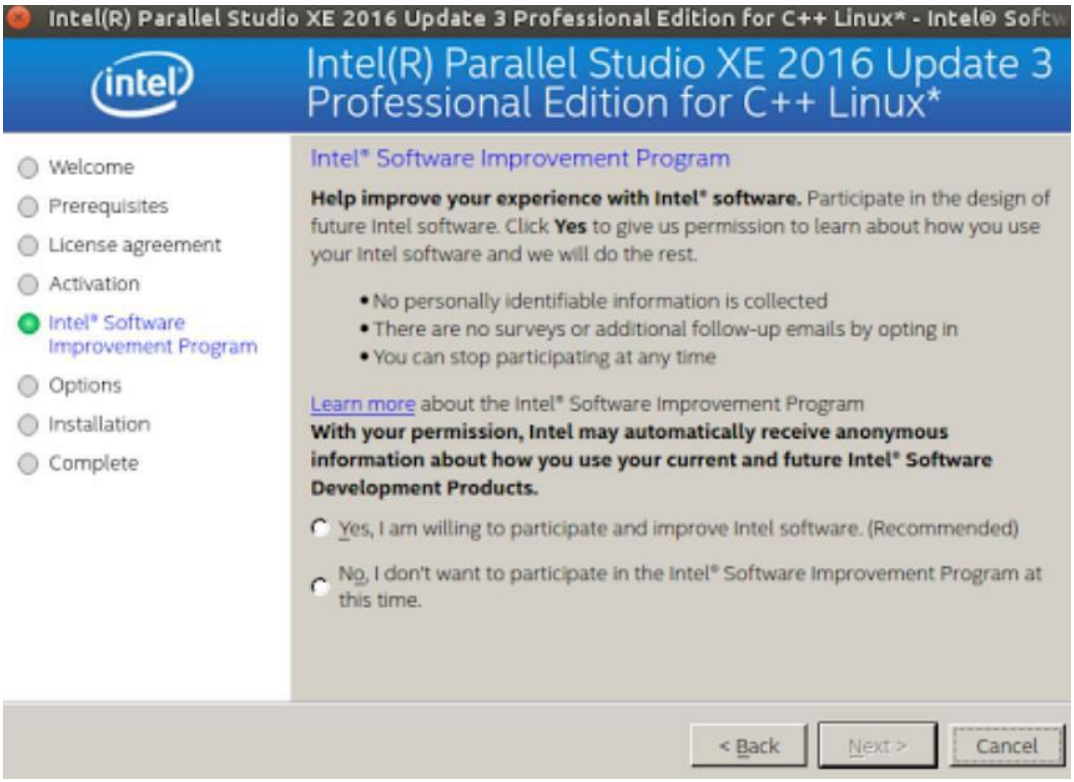
4.

Activation Using Serial Number

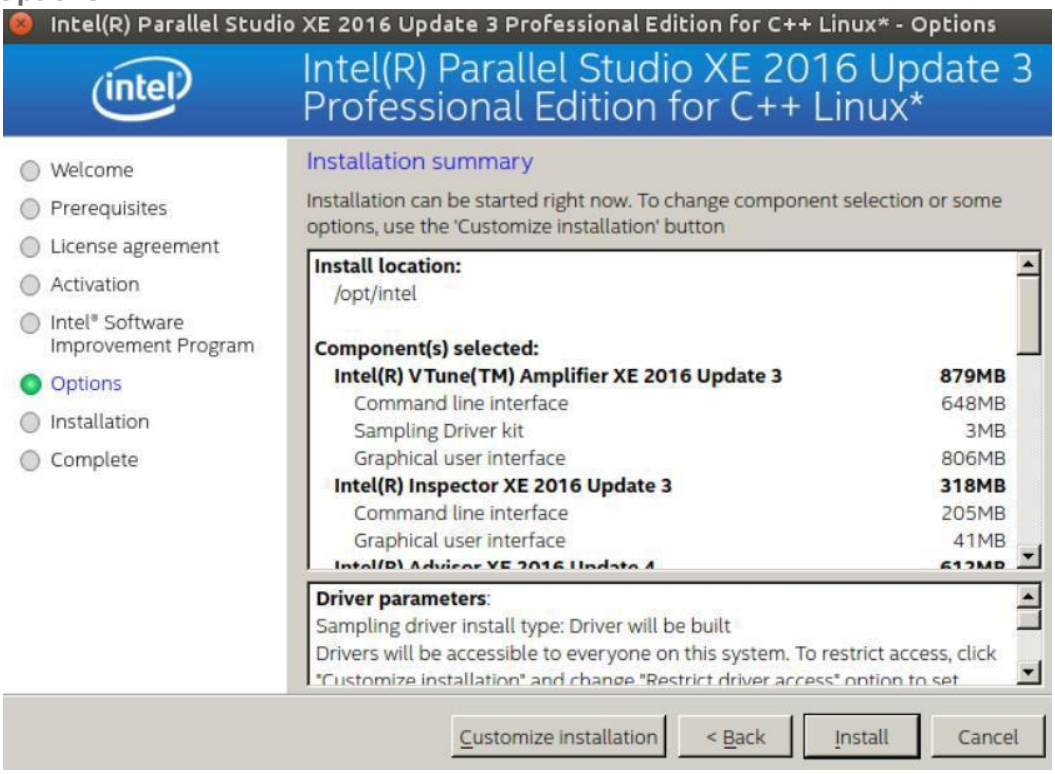


5. **Intel® Software Improvement Program**

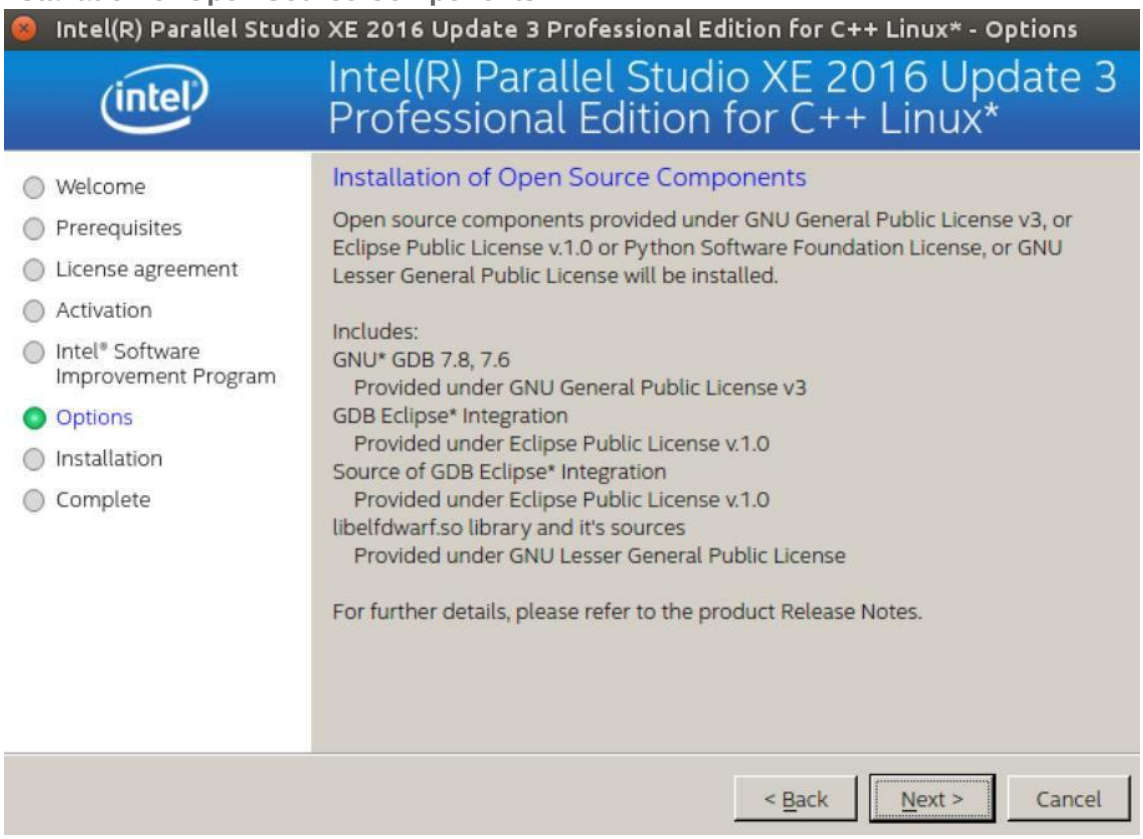
5.


Intel(R) Parallel Studio XE 2016 Update 3 Professional Edition for C++ Linux* - Intel® Softw
intel
Intel(R) Parallel Studio XE 2016 Update 3 Professional Edition for C++ Linux*
Welcome
Prerequisites
License agreement
Activation
Intel® Software Improvement Program
Options
Installation
Complete
Intel® Software Improvement Program
Help improve your experience with Intel® software. Participate in the design of future Intel software. Click Yes to give us permission to learn about how you use your Intel software and we will do the rest.
• No personally identifiable information is collected
• There are no surveys or additional follow-up emails by opting in
• You can stop participating at any time
Learn more about the Intel® Software Improvement Program
With your permission, Intel may automatically receive anonymous information about how you use your current and future Intel® Software Development Products.
Yes, I am willing to participate and improve Intel software. (Recommended)
No, I don't want to participate in the Intel® Software Improvement Program at this time.
< Back
Next >
Cancel

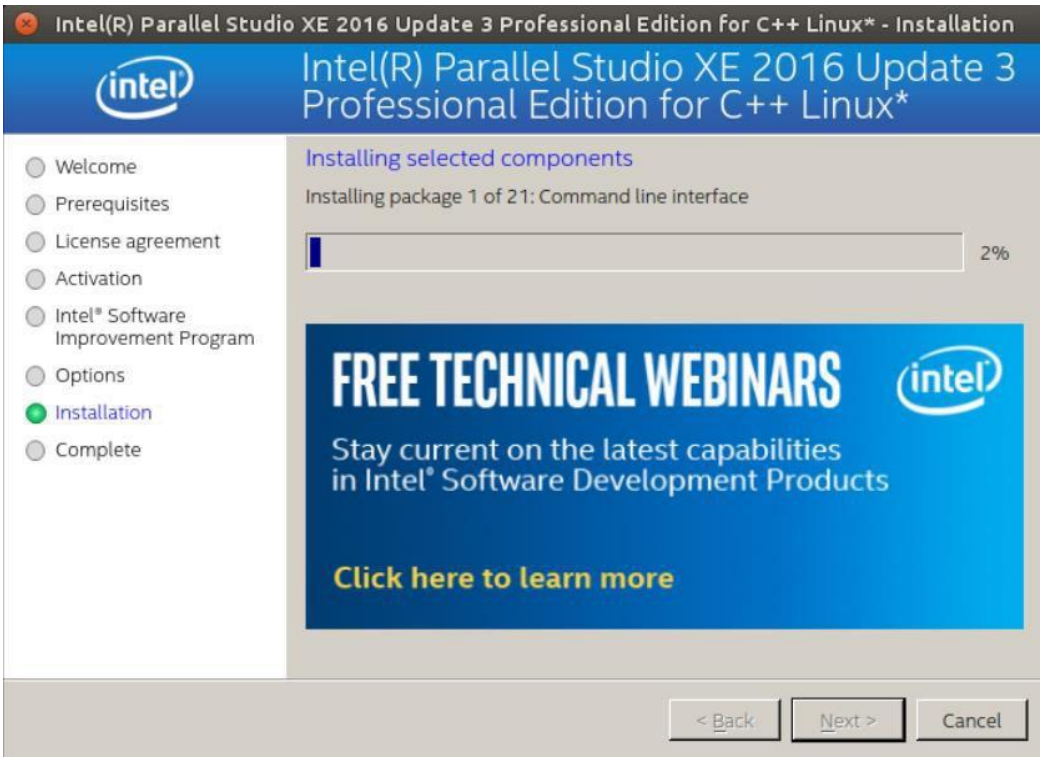
6. **Options**



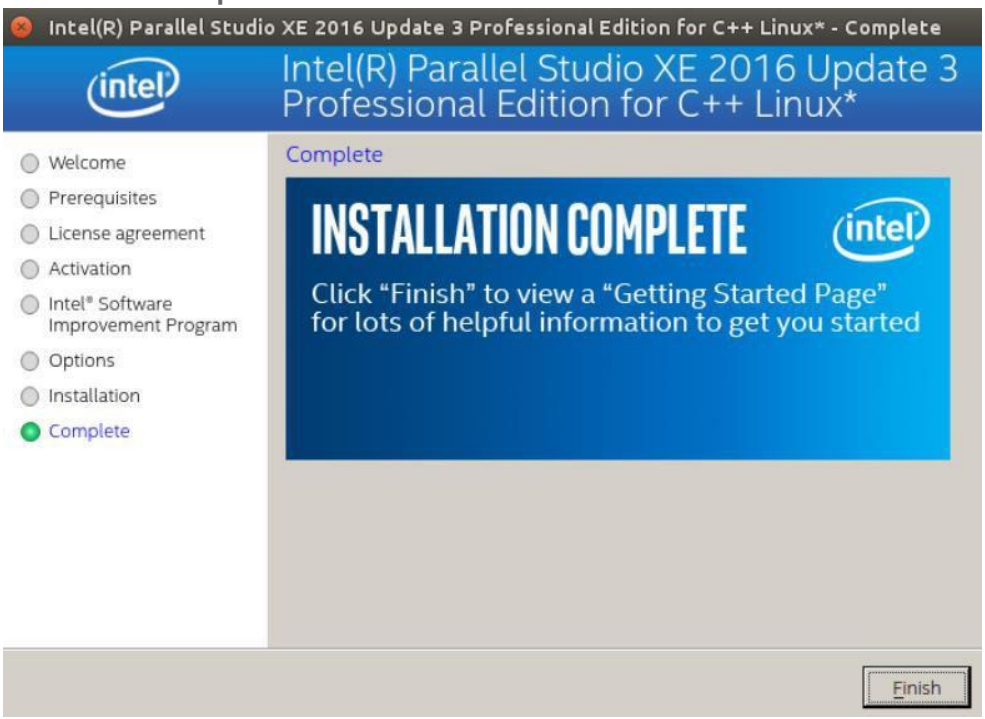
7. **Installation of Open Source Components**



8. **Installation starts with all the above-selected items**



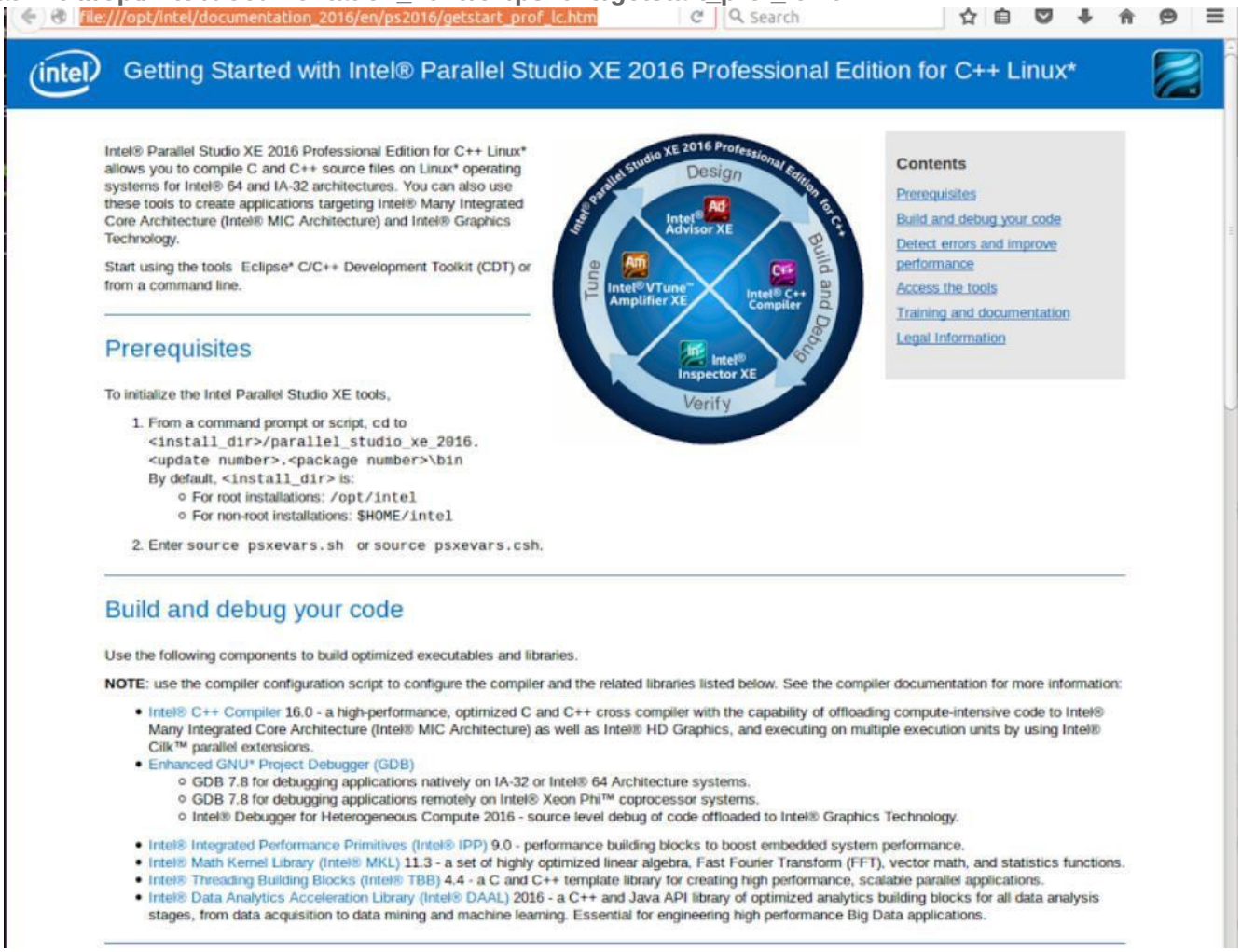
9. **Installation complete**



The following three steps and associated screenshots are recommended for gaining additional insight in using Intel® VTune™ Amplifier.

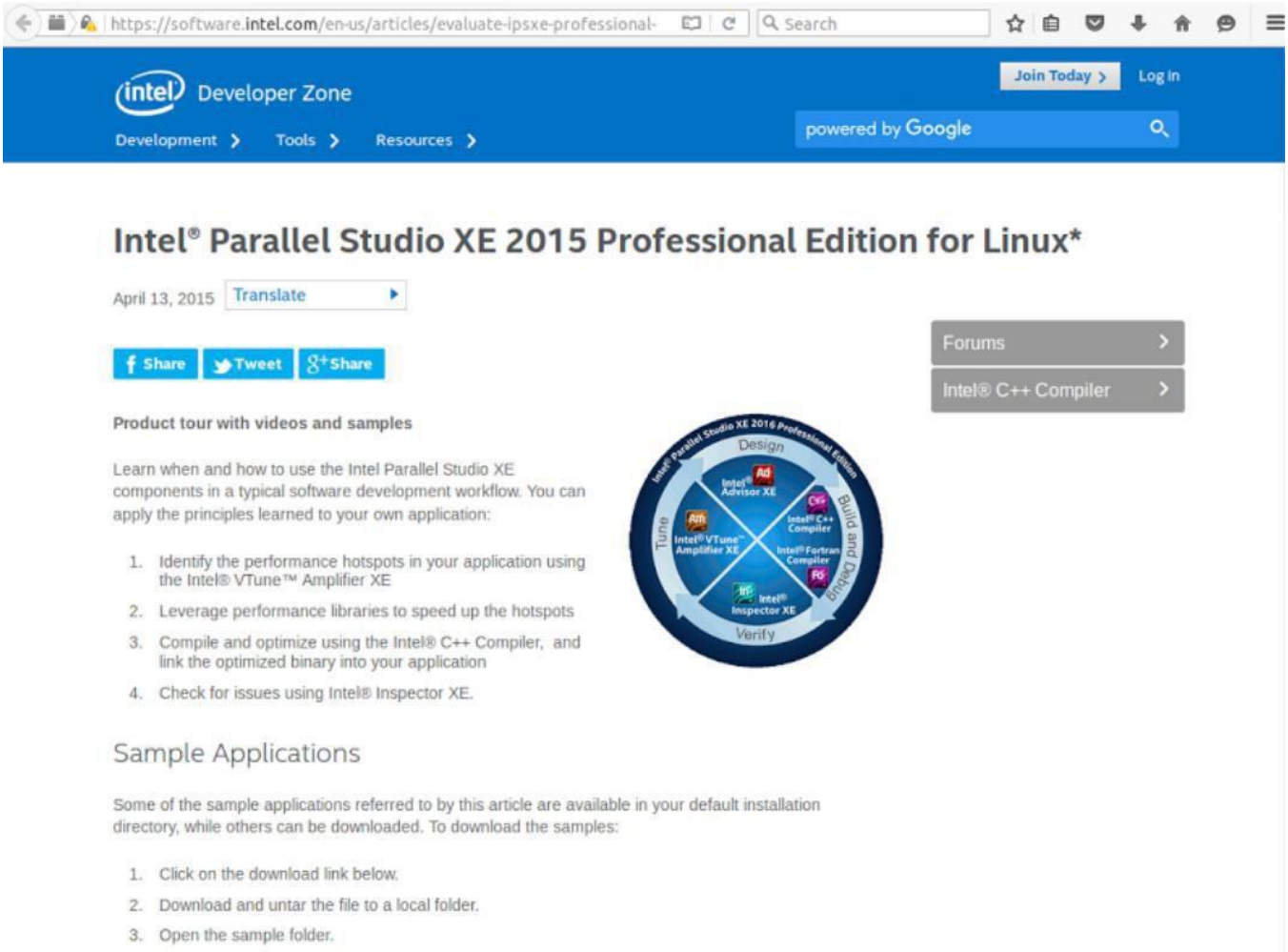
1.

Click Finish to view the file on the local machine
at file:///opt/intel/documentation_2016/en/ps2016/getstart_prof_lc.htm



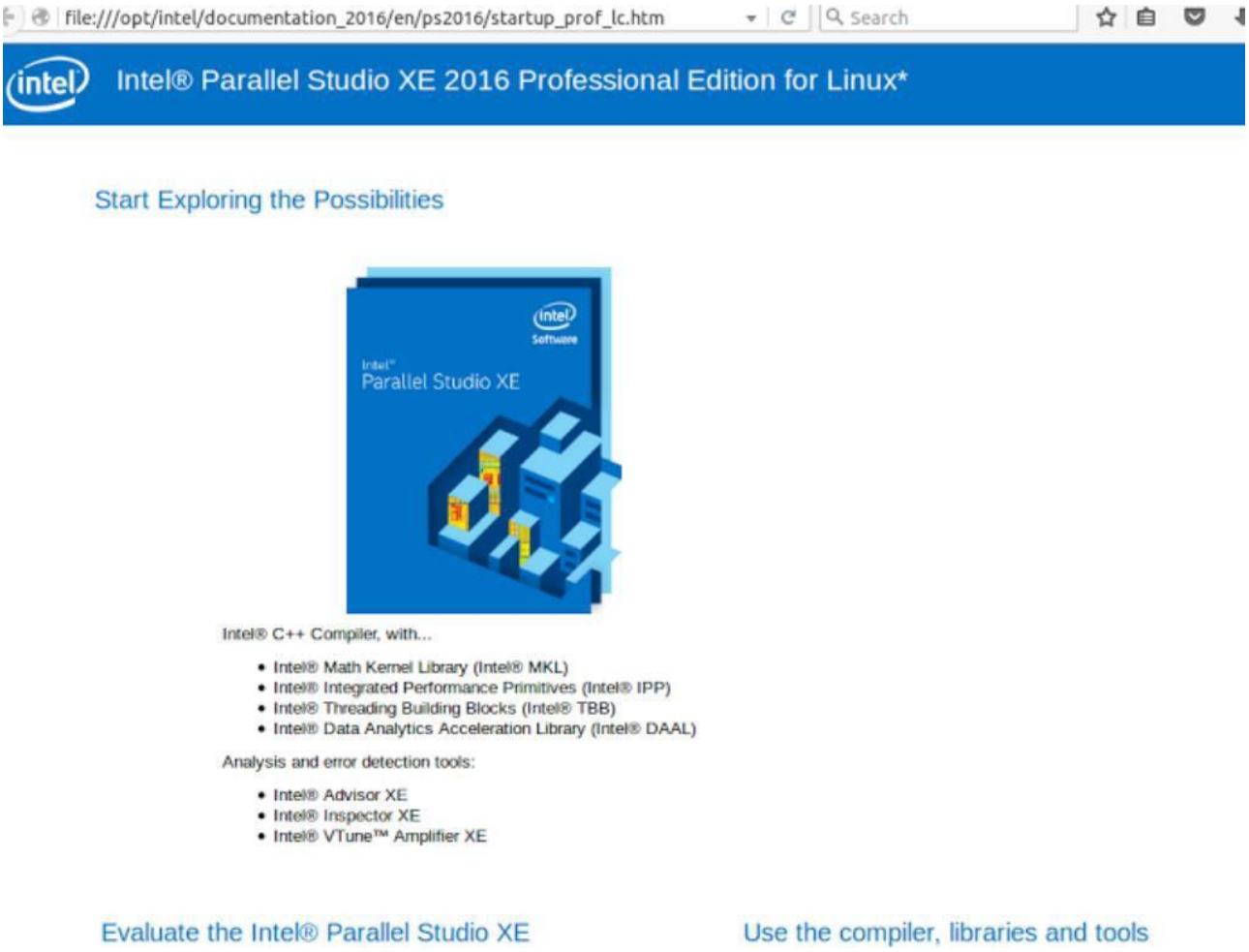
To see a product tour with videos and sample apps
https://software.intel.com/en-us/articles/evaluate-ipsxe-professional-linux

2.



To evaluate Intel® Parallel Studio XE access, view the local file on the local machine at file:///opt/intel/documentation_2016/en/ps2016/startup_prof_lc.htm

3.



Appendix 2

Please run the steps in the installation guide to verify the driver's proper installation.

Appendix 3

System Details


Details
All Settings
Details
Overview
Default Applications
Removable Media
Legal Notice
ubuntu 15.04
Device name
dpdk
Memory
15.6 GiB
Processor
Intel® Core™ i7-4750HQ CPU @ 2.00GHz × 8
Graphics
Intel® Haswell Mobile
OS type
64-bit
Disk
219.3 GB

References

- MinnowBoard Wiki Home at minnowboard.org – learn more about the MinnowBoard Turbot single board computer.
- Profiling DPDK Code with Intel® VTune™ Amplifier - Use Intel® VTune™ Amplifier to profile DPDK micro benchmarks with your application. This comprehensive reference provides guidelines and instructions.
- Intel® VTune™ and Performance Optimizations - This session recording from the July 11, 2016DPDK/NFV DevLab covers performance optimization best practices, including analysis of NUMA affinity, microarchitecture optimizations with VTune, and tips to help you identify hotspots in your own application.
- DPDK Performance Optimization Guidelines White Paper **-** Learn best-known methods to optimize your DPDK application's performance. Includes profiling methodology to help identify bottlenecks, then shows how to optimize BIOS settings, partition NUMA resources, optimize your Linux* configuration for DPDK, and more.

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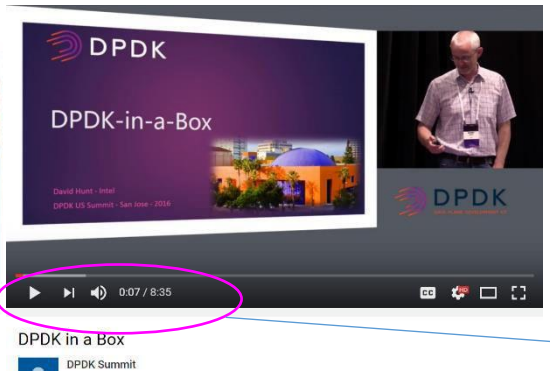
DPDK 101: Introduction to Data Plane Development Kit	https://www.brighttalk.com/webcast/12229/171171
Data Plane Development Kit – Sample Applications and New Features Deep Dive	https://www.brighttalk.com/webcast/12229/173281
DPDK 2.2 New Features	https://www.brighttalk.com/webcast/12229/186455
DPDK 16.04 New Features	https://www.brighttalk.com/webcast/12229/198051?utm_campaign=webcasts-search-resultsfeed&utm_content=dpdk&utm_source=brighttalk-portal&utm_medium=web&utm_term=
DPDK 16.07 New Features	https://www.brighttalk.com/webcast/12229/214089?utm_campaign=webcasts-search-resultsfeed&utm_content=dpdk&utm_source=brighttalk-portal&utm_medium=web&utm_term=
Accelerate Your Cloud & Enterprise with Data Plane Development Kit (DPDK)	https://www.brighttalk.com/webcast/12229/163039
Enabling the Storage Transformation with SPDK	https://www.brighttalk.com/webcast/10773/178503?utm_campaign=webcasts-search-resultsfeed&utm_content=dpdk&utm_source=brighttalk-portal&utm_medium=web&utm_term=

Open vSwitch with DPDK in OVS 2.4.0	https://www.brighttalk.com/webcast/12229/194949?utm_campaign=knowledgefeed&utm_content=&utm_source=brighttalk-portal&utm_medium=web&utm_term=
Intel Software Defined Infrastructure: Tips, Tricks and Tools for Network Design and Optimization	https://www.youtube.com/watch?v=TXPLK2uBy3I

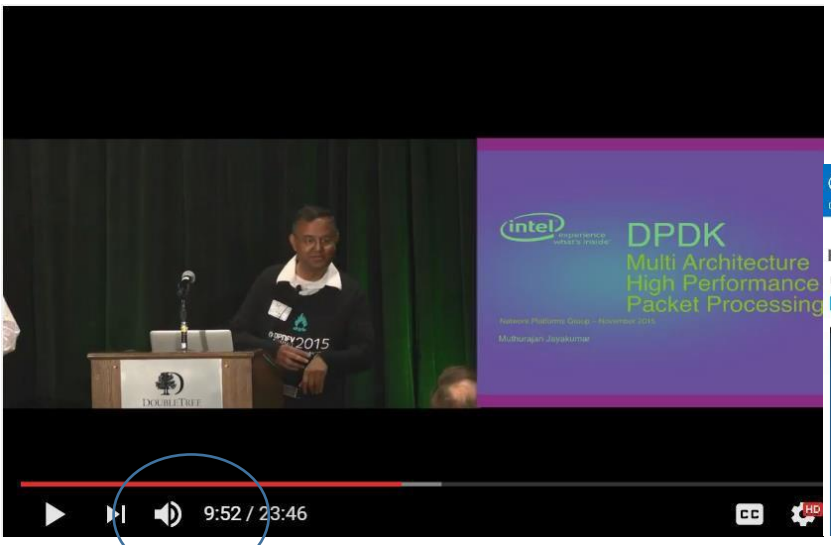
2 Minutes Video

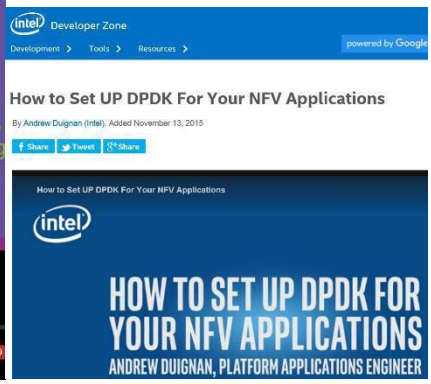
DPDK Summit Channel

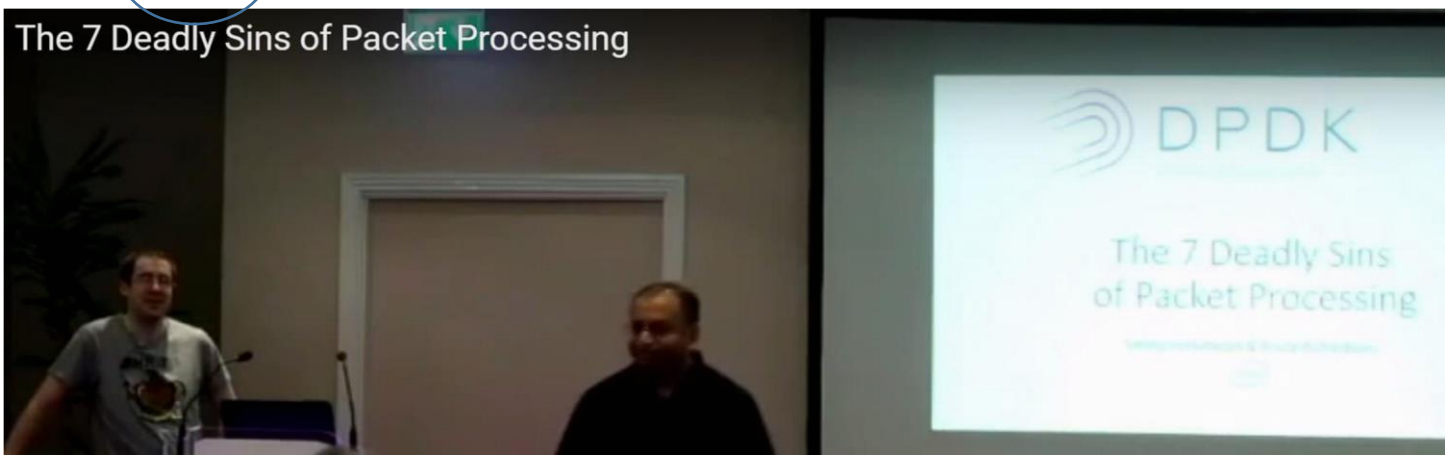


8 Minutes Video

10 Minutes M Jay DPDK **10 Minutes Roger OVS** **IDZ Andrew Video**





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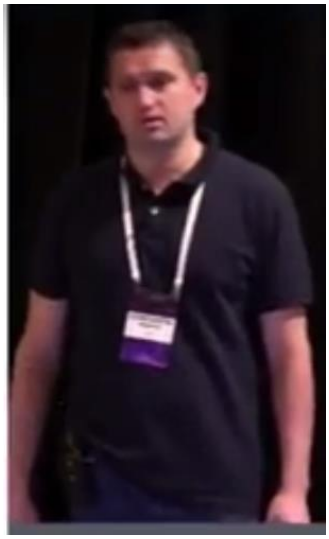
Transport Layer Development Kit (TLDK)



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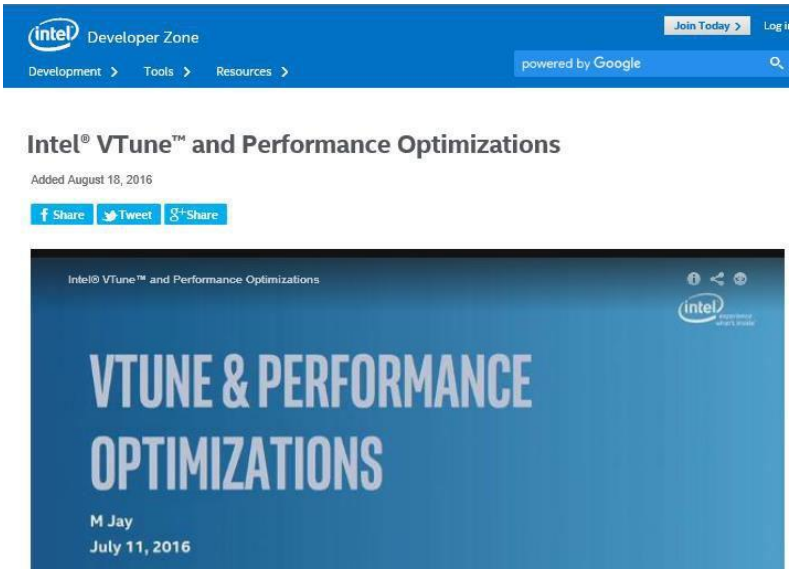
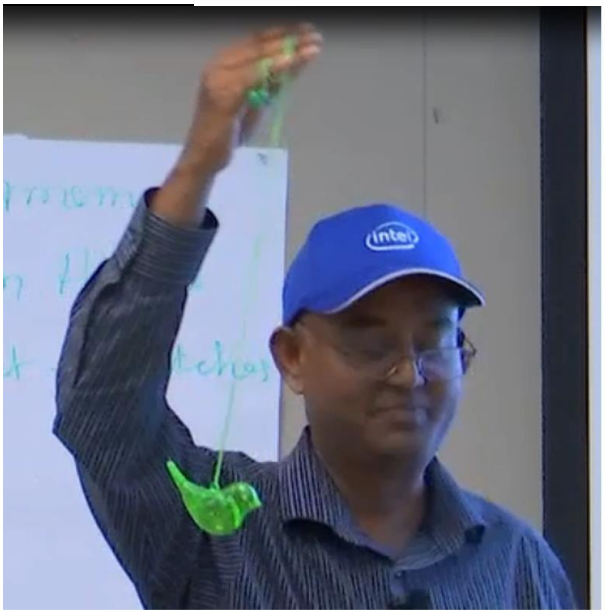


Hackathon



https://software.intel.com/en-us/videos/intel-vtune-and-performance-optimizations

Acknowledgements

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Jijang Liu	Bill Carlson	Wenzhuo Lu	Yuan Kuok Nee
Vadim Sukhomlinov	Ed Whitney	Jasvinder Singh	Gerald Rogers
Mark D Gray	Peter Mangan	Andrey Chilikin	Patrick Liu
Dana Nehama	Tony Dempsey	Srikanth Shah	Eric D Heaton
Ed Pullin	Anju Mercian	Debra H Graham	Priya V Autee
Yu Y Liu	Young Liu	Each & Everyone in Architecture & Design Engineering	Each & Everyone in Marketing & Validation & Field Support

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