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# **Mellanox ConnectX®-3 Poll-Mode Driver**

## **Quick Start Guide**

2.7.4

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## Document Revision History

**Table 1: Document Revision History**

Revision	Description
2.7.4	<ul style="list-style-type: none"> <li>Added the following Performance Configuration sections:               <ul style="list-style-type: none"> <li><a href="#">General Settings</a></li> <li><a href="#">KVM Settings</a></li> </ul> </li> <li>Updated the following sections:               <ul style="list-style-type: none"> <li><a href="#">Bare Metal</a></li> <li><a href="#">Hypervisor</a></li> </ul> </li> </ul>
2.6.9	<ul style="list-style-type: none"> <li>Added section <a href="#">Sending and Receiving Jumbo Frames</a></li> <li>Updated the following sections:               <ul style="list-style-type: none"> <li><a href="#">Bare Metal</a></li> <li><a href="#">Hypervisor</a></li> <li><a href="#">Compilation Script</a></li> </ul> </li> <li>Running DPDK Application with Mellanox ConnectX®-3 Poll-Mode Driver</li> </ul>
2.6.8	<ul style="list-style-type: none"> <li>Added the following sections:               <ul style="list-style-type: none"> <li><a href="#">Compilation Script</a></li> <li><a href="#">Configuration Script</a></li> </ul> </li> <li>Updated the following sections:               <ul style="list-style-type: none"> <li><a href="#">Mellanox ConnectX®-3 Poll-Mode Driver (PMD) Overview</a></li> <li><a href="#">Bare Metal</a></li> <li><a href="#">Hypervisor</a></li> <li><a href="#">Running DPDK Application with Mellanox ConnectX®-3 Poll-Mode Driver</a></li> <li><a href="#">Sanity Check</a></li> </ul> </li> <li>Removed the VMware section</li> </ul>
2.5	<ul style="list-style-type: none"> <li>The Quick Start Guide was completely re-structured and re-written</li> </ul>
2.0	<ul style="list-style-type: none"> <li>Updated the following sections:               <ul style="list-style-type: none"> <li>DPDK Poll-Mode Driver Configuration</li> <li><a href="#">Sanity Check</a></li> </ul> </li> </ul>
1.1	<ul style="list-style-type: none"> <li>Updated the following sections:               <ul style="list-style-type: none"> <li>DPDK Poll-Mode Driver (PMD) Overview</li> <li>Internal Compilation</li> <li>External Compilation</li> <li><a href="#">Sanity Check</a></li> </ul> </li> <li>Added the following sections:               <ul style="list-style-type: none"> <li>Automatic Installation</li> <li>mlnx-ofa_kernel-2.0</li> <li>libibverbs-1.1.6mlnx1</li> <li>libmlx4-1.0.4mlnx1</li> <li>DPDK Poll-Mode Driver Configuration</li> </ul> </li> </ul>

Revision	Description
1.0	Initial Release

## Related Documents

The following table lists the documents referenced in this User Manual.

**Table 2: Reference Documents**

Document Name	Description
Mellanox OFED Linux Release Notes	Describes the new features and changes of the latest MLNX_OFED release.
Mellanox OFED Linux User Manual	Provides general information on the installation, configuration, management and maintenance of the software and hardware of VPI (InfiniBand, Ethernet) adapter cards.
Mellanox ConnectX-3 DPDK PMD Release Notes	Describes the new features and changes of the latest DPDK PMD

# 1 Mellanox ConnectX®-3 Poll-Mode Driver (PMD) Overview

librte\_pmd\_mlx4 is the DPDK Poll-Mode Driver (PMD) for Mellanox ConnectX®-3 Ethernet adapters. This driver is based on libibverbs and currently supports:

- Scattering/gathering RX/TX packets
- Multiple RX (with RSS/RCA) and TX queues
- Multiple MAC addresses
- VLAN filtering
- Link state information
- Software counters/statistics
- Start/stop/close operations
- Multiple physical ports host adapter
- Hardware TX and RX checksum offloading
- DPDK 1.7.0 or above from dpdk.org <<http://dpdk.org/>>

## 2 Mellanox ConnectX®-3 Poll-Mode Driver Installation and Configuration

### 2.1 Bare Metal

1. Install MLNX\_OFED-2.4-1.0.0

MLNX\_OFED 2.4-1.0.0 can be downloaded from Mellanox site:

[http://www.mellanox.com/page/products\\_dyn?product\\_family=26&mtag=linux](http://www.mellanox.com/page/products_dyn?product_family=26&mtag=linux)

2. Set all the ports to Ethernet.

```
connectx_port_config
```

And follow the instructions on the screen.

For further instructions on how to run the script, please refer to the MLNX\_OFED User Manual.

3. Download DPDK 1.7.1 or DPDK 1.8.0 from <http://dpdk.org/>
4. Compile DPDK:

```
make install T=x86_64-native-linuxapp-gcc
```

For more advanced DPDK compilation options, please refer to [dpdk.org](http://dpdk.org) documentation:

[http://www.dpdk.org/doc/guides/linux\\_gsg/index.html](http://www.dpdk.org/doc/guides/linux_gsg/index.html)

5. Extract the PMD package `mlx4_pmd_v2.7.4.tar.gz`.
6. Run the compilation script.

```
./compile_mlx4_pmd.sh -s <RTE_SDK> -t <RTE_TARGET>
```

For example:

```
./compile_mlx4_pmd.sh -s /var/soft/dpdk-1.7.1 -t x86_64-native-linuxapp-gcc
```

See section [2.4](#) for all compilation script options.

7. Run the configuration script.

```
./configure_mlx4_pmd.sh -s nosriov
```

See section [2.5](#) for all configuration script options.



**NOTE:** If hugepage reconfiguration is needed after rebooting the machine, you can re-run the configuration script.

Performance can be improved by running the configuration script with the “-o” flag (optimized steering mode).

Example:

```
./configure_mlx4_pmd.sh -s nosriov -o
```





**NOTE:** Please be aware, running this option will prevent the PMD port from receiving packets with the port MAC as DST MAC. To add additional MAC and receive packets with this destination MAC use the `rte_eth_dev_mac_addr_add` DPDK API.



**NOTE:** If promiscuous mode is used, PMD port will receive all packets with all DST MACs except for port's MAC.

- Restart MLNX\_OFED.

```
/etc/init.d/openibd restart
```

- Verify that ConnectX-3 firmware is 2.33.5000. (Use `ibstat` command)

## 2.2 KVM

### 2.2.1 Hypervisor

- Install MLNX\_OFED-2.4-1.0.0.

MLNX\_OFED 2.4-1.0.0 can be downloaded from Mellanox site:

[http://www.mellanox.com/page/products\\_dyn?product\\_family=26&mtag=linux](http://www.mellanox.com/page/products_dyn?product_family=26&mtag=linux)

- Add the following line to `/etc/modprobe.d/mlx4_core.conf`

```
options mlx4_core log_num_mgm_entry_size=-1
```

**Note:** To improve performance you can set `log_num_mgm_entry_size=-7`



**NOTE:** Please be aware, running this option will prevent the PMD port over VF on VM from receiving packets with the port MAC as DST MAC.

When running DPDK on VM, use the DPDK API, `rte_eth_dev_mac_addr_add`, to add additional MAC and receive packets with this destination MAC.

- Restart MLNX\_OFED.

```
/etc/init.d/openibd restart
```

- Verify that ConnectX-3 firmware is v2.33.5000. (Use `ibstat` command)

## 2.3 Virtual Machine

- Download DPDK 1.7 or DPDK 1.8 from <http://dpdk.org/>
- Compile DPDK:

```
make install T=x86_64-native-linuxapp-gcc
```

For more advanced DPDK compilation options please refer to [dpdk.org](http://dpdk.org) documentation:

[http://www.dpdk.org/doc/guides/linux\\_gsg/index.html](http://www.dpdk.org/doc/guides/linux_gsg/index.html)

- Extract the PMD package `mlx4_pmd_v2.7.4.tar.gz`
- Run the compilation script. See section [2.4](#) for all compilation script options.

```
./compile_mlx4_pmd.sh -s <RTE_SDK> -t <RTE_TARGET>
```

For example:

```
./compile_mlx4_pmd.sh -s /var/soft/dpdk-1.7.1 -t x86_64-native-linuxapp-gcc
```

5. Run the configuration script. See section [2.5](#) for all configuration script options.

```
./configure_mlx4_pmd.sh -s kvm
```



**NOTE:** If hugepage reconfiguration is needed after rebooting the machine, you can re-run the configuration script.

## 2.4 Compilation Script

```
./compile_mlx4_pmd.sh -s <RTE_SDK> -t <RTE_TARGET> [ -d (debug) ] [ -m (enable multi-segment send / recv messages ) [ -c (enable HW checksum offloading) ] ]
```

Parameter	Description
-s <RTE_SDK>	This parameter is mandatory, need to specify full path to DPDK compiled sources
-t <RTE_TARGET>	This parameter is mandatory and needs to be specified according to the RTE_TARGET that DPDK was compiled with
-d	Optional parameter which enables PMD debug prints
-m	When compiled with this option, multi-segment send and receive can be used
-c	Enable hardware checksum offloading



**NOTE:** Multi-segment send/recv is not required. Please do not use this flag as it reduces PMD performance.



**NOTE:** Please do not use “-c” flag (hardware checksum offloading) if it is not required as it can reduce PMD performances.

## 2.5 Configuration Script

```
./configure_mlx4_pmd.sh -s kvm/nosriov [-p <PAGE_SIZE>] [-n <HUGE PAGES NUM>] [-o <enable optimized steering mode>]
```

Parameter	Description
-s kvm/nosriov	This parameter is mandatory: For bare metal environment please use “-s nosriov” For KVM’s guest please specify “-s kvm”
-p <PAGE SIZE>	This parameter is optional. If not specified, the default page size is 2K
-n <HUGE PAGES NUM>	This parameter is optional. If not specified, the default number of pages that will be configured is 2048
-o	This parameter is optional. If specified, optimized steering mode will be enabled. When used packet with DST MAC as port’s MAC will not be received With this option DPDK rte_eth_dev_mac_addr_add should be used to add “DPDK” MAC. In case of Bare Metal, promiscuous mode can be used to receive

	packets with DST MAC as any MAC but not port's MAC
--	--

## 2.6 Sending and Receiving Jumbo Frames

- DPDK 1.6:
  - a. Configure the ConnectX-3 MTU.  
Example: `ifconfig eth0 MTU 4160`
  - b. Compile PMD with the “-m” option, if the mbuf size is smaller than the MTU size and you need to use scattered mbuf.
- DPDK 1.7:

Use the `rte_eth_dev_set_mtu` API to set the appropriate MTU.

## 2.7 RX VLAN Filter

1. Make sure that regular steering mode is configured (on Bare Metal and KVM).

```
cat /sys/module/mlx4_core/parameters/log_num_mgm_entry_size  
-1
```

2. Modify the `/etc/modprobe.d/mlnx.conf` file if required.
3. Configure VLAN interface on the port using standard Linux tools.
4. Use `rte_eth_dev_vlan_filter()` DPDK API to add or remove VLAN

## 3 System Performance Configuration

### 3.1 General Settings

- Disable pause frames on all network interfaces managed by mlx4\_en.

```
ethtool -A eth16 rx off tx off
```



**NOTE:** There are systems that increase performance by enabling pause frames.

- Verify that both adapters are located on the same PCI bus (as each CPU socket on a Crown Pass platform manages its own PCI bus) in order to forward packets from one to the other without NUMA performance penalty.

```
lspci -vv | grep Mellanox (To find out PCI slot)

cat /sys/devices/pci0000\:80/0000\:80\:01.0/numa_node

or

lspci -tv
```

On a system with more than one NUMA node, it is recommended to use the CPU near local NUMA node to which the PCIe adapter is connected for better performance. For Virtual Machines (VM), verify that the right CPU and NUMA node are pinned for the VM according to the above.

- Use 1Gb huge pages
- Enable the hyper threading.
- Verify that the CPU is running in performance mode.

```
#!/bin/bash

service cpuspeed stop

NUM_CPUS=32

for (( i=0; i<$NUM_CPUS;))
do
echo performance > /sys/devices/system/cpu/cpu$i/cpufreq/scaling_governor
i=$((i+1))
done
```

- Verify the following BIOS configuration

```
setpci -s <NIC BIOS address> 68.w
5020
```

If the output is different than 5020, set it by:

```
setpci -s <NIC BIOS address> 68.w=5020
```

For example:

```
setpci -s 84:00.0 68.w=5020
```

- Make sure that unnecessary System Management Interrupts (SMIs) are disabled. (For example: SMI that are used for Power Monitoring and for Memory PreFailure

Notification). Please refer to your server provider guides for recommended platform tuning.

- Isolate cores that are used

Use `isolcpus` command for boot configuration

For example, add the following to kernel boot parameters:

```
isolcpus=2,3
```

- Stop irqbalancer

```
service irqbalance stop
```

- Set all possible interrupts to different NUMA:

```
Example: echo '6-9' | sudo tee /proc/irq/*/smp_affinity_list
```

- Set NIC interrupts to same NUMA:

```
Example: set_irq_affinity_cpulist.sh 0-1 ethX
```

- Set other NIC interrupts to different NUMA:

```
Example: set_irq_affinity_cpulist.sh 6-9 ethY
```

- Disable kernel memory compaction:

```
echo never > /sys/kernel/mm/transparent_hugepage/defrag
echo never > /sys/kernel/mm/transparent_hugepage/enabled
echo 0 > /sys/kernel/mm/transparent_hugepage/khugepaged/defrag
sysctl -w vm.swappiness=0
sysctl -w vm.zone_reclaim_mode=0
```

## 3.2 KVM Settings

- Make sure that Hypervisor kernel is 3.16 or newer (For example Ubuntu 14.10 or Fedora 20/21 can be used)
- Configure boot with `"iommu=pt"`
- Use 1G huge pages
- Make sure to allocate VM on huge pages:

Example:

`qemu` is started with the following commands:

```
umount /mnt/huge 2> /dev/null
mount -t hugetlbfs none /mnt/huge &&
echo 8192 > /sys/kernel/mm/hugepages/hugepages-2048kB/nr_hugepages &&

numactl --cpunodebind 1 --membind 1 -- \
qemu-system-x86_64 \
-smp 24 \
-m 4G \
-mem-path /mnt/huge \
-mem-prealloc \
-enable-kvm \
-cpu host \
-serial tcp::999,server,nowait \
-nographic \
-vga none \
- -device pci-assign,host=83:00.1 \
-device pci-assign,host=84:00.1 \
-drive snapshot=on,file=/opt/vm/ubuntu-14.04-template.qcow2 \
```

```
-drive file=/data/data.img
```

Since both adapters are installed on NUMA node 1 PCI slots (CPU socket 1), `*numactl` is used to bind qemu to CPU threads and memory from that node only, which makes a virtual machine without NUMA internally.

All its memory is allocated from huge pages in `/mnt/huge`.

- After loading VM, verify huge pages on your Hypervisor is used by VM:

```
cat
/sys/devices/system/node/node<NUM>/hugepages/hugepages-<PAGE-SIZE>/free_hugepages
```

- Make sure to set CPU pining

For example if you run qemu:

```
(qemu) info cpus
CPU #0: pc=0xffffffff81056306 (halted) thread_id=2719
CPU #1: pc=0xffffffff81056306 (halted) thread_id=2720
CPU #2: pc=0xffffffff81056306 (halted) thread_id=2723
CPU #3: pc=0xffffffff81056306 (halted) thread_id=2724
taskset -p 0x1 2719
taskset -p 0x2 2720
taskset -p 0x4 2723
taskset -p 0x8 2724
```

## 4 Running DPDK Application with Mellanox ConnectX®-3 Poll-Mode Driver

The output of the PMD compilation is a shared object, `librte_pmd_mlx4.so`.

It is created under the

```
mlx4_pmd_v2.7.4/librte_pmd_mlx4/librte_pmd_mlx4.so
```

The `librte_pmd_mlx4.so` should be dynamically loaded during the DPDK application run with the `-d` flag.

For example:

```
app/testpmd -c 0xe000 -n 4 -b 0000:01:00.0 -b 0000:01:00.1 -d
/tmp/mlx4_pmd_v2.7.4/librte_pmd_mlx4/librte_pmd_mlx4.so -- -i --numa
--burst=64 --txd=256 --rxq=256 --mbcache=256 --coremask=0xc000 --rxq=1 --txq=1
--portmask 0xA
```

When running bi-directional traffic, for better performance, use the receive-inline feature that can be enabled by env variable `MLX4_INLINE_RECV_SIZE`

Example: for 64B messages

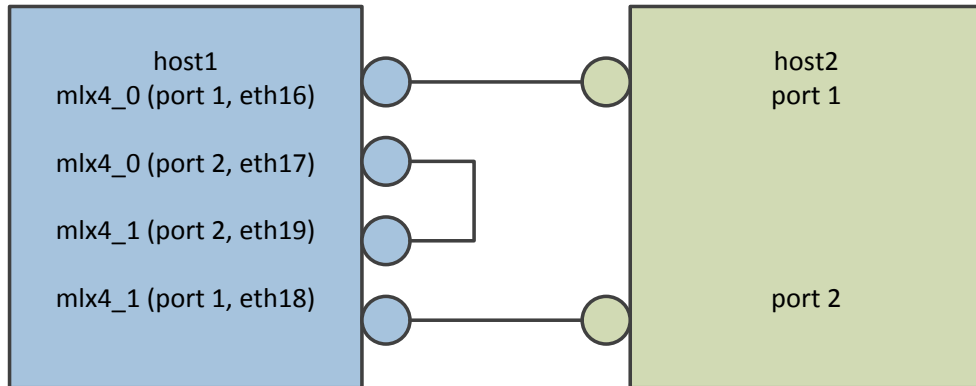
```
MLX4_INLINE_RECV_SIZE=64 app/testpmd -c 0xe000 -n 4 -b 0000:01:00.0 -b
0000:01:00.1 -d /tmp/mlx4_pmd_v2.7.4/librte_pmd_mlx4/librte_pmd_mlx4.so --
-i --numa --burst=64 --txd=256 --rxq=256 --mbcache=256 --coremask=0xc000
--rxq=1 --txq=1 --portmask 0xA
```

## 5 Sanity Check

Provided that all software components have been successfully installed and at least one ConnectX® adapter is present in the host system, run `testpmd` to test PMD.

These examples assume that there is a host with two dual port adapters that:

- First port of each NIC is linked to another similar host
- Second port of each NIC is linked with each other



1. Run `*testpmd*` interactively from the DPDK build tree (for more information about its command-line options, please refer to its documentation: [http://www.dpdk.org/doc/guides/testpmd\\_app\\_ug/index.html](http://www.dpdk.org/doc/guides/testpmd_app_ug/index.html)):

```

root# ~/DPDK/x86_64-native-linuxapp-gcc/app/test-pmd/testpmd -c 0xf000f000
-n 4 -d ./librte_pmd_mlx4.so -- -i
EAL: Detected lcore 0 as core 0 on socket 0
EAL: Detected lcore 1 as core 1 on socket 0
EAL: Detected lcore 2 as core 2 on socket 0
EAL: Detected lcore 3 as core 3 on socket 0
EAL: Detected lcore 4 as core 4 on socket 0
[...]
EAL: Detected lcore 27 as core 3 on socket 1
EAL: Detected lcore 28 as core 4 on socket 1
EAL: Detected lcore 29 as core 5 on socket 1
EAL: Detected lcore 30 as core 6 on socket 1
EAL: Detected lcore 31 as core 7 on socket 1
EAL: Support maximum 64 logical core(s) by configuration.
EAL: Detected 32 lcore(s)
EAL: cannot open VFIO container, error 2 (No such file or directory)
EAL: VFIO support could not be initialized
EAL: Setting up memory...
EAL: Ask a virtual area of 0x6400000 bytes
EAL: Virtual area found at 0x7f15fd600000 (size = 0x6400000)
EAL: Ask a virtual area of 0x200000 bytes
[...]
EAL: PCI device 0000:83:00.0 on NUMA socket 1
EAL: probe driver: 15b3:1007 librte_pmd_mlx4
PMD: librte_pmd_mlx4: PCI information matches, using device "mlx4_0" (VF:
false)
PMD: librte_pmd_mlx4: 2 port(s) detected
PMD: librte_pmd_mlx4: bad state for port 1: "down" (1)
PMD: librte_pmd_mlx4: port 1 MAC address is 00:02:c9:b5:b7:50
PMD: librte_pmd_mlx4: bad state for port 2: "down" (1)
PMD: librte_pmd_mlx4: port 2 MAC address is 00:02:c9:b5:b7:51
EAL: PCI device 0000:84:00.0 on NUMA socket 1
EAL: probe driver: 15b3:1007 librte_pmd_mlx4

```



```

PMD: librte_pmd_mlx4: PCI information matches, using device "mlx4_1" (VF:
false)
PMD: librte_pmd_mlx4: 2 port(s) detected
PMD: librte_pmd_mlx4: bad state for port 1: "down" (1)
PMD: librte_pmd_mlx4: port 1 MAC address is 00:02:c9:b5:ba:b0
PMD: librte_pmd_mlx4: bad state for port 2: "down" (1)
PMD: librte_pmd_mlx4: port 2 MAC address is 00:02:c9:b5:ba:b1
Interactive-mode selected
Configuring Port 0 (socket 0)
PMD: librte_pmd_mlx4: 0x7f35e0: TX queues number update: 0 -> 1
PMD: librte_pmd_mlx4: 0x7f35e0: RX queues number update: 0 -> 1
Port 0: 00:02:C9:B5:B7:50
Configuring Port 1 (socket 0)
PMD: librte_pmd_mlx4: 0x7f3620: TX queues number update: 0 -> 1
PMD: librte_pmd_mlx4: 0x7f3620: RX queues number update: 0 -> 1
Port 1: 00:02:C9:B5:B7:51
Configuring Port 2 (socket 0)
PMD: librte_pmd_mlx4: 0x7f3660: TX queues number update: 0 -> 1
PMD: librte_pmd_mlx4: 0x7f3660: RX queues number update: 0 -> 1
Port 2: 00:02:C9:B5:BA:B0
Configuring Port 3 (socket 0)
PMD: librte_pmd_mlx4: 0x7f36a0: TX queues number update: 0 -> 1
PMD: librte_pmd_mlx4: 0x7f36a0: RX queues number update: 0 -> 1
Port 3: 00:02:C9:B5:BA:B1
Checking link statuses...
Port 0 Link Up - speed 10000 Mbps - full-duplex
Port 1 Link Up - speed 40000 Mbps - full-duplex
Port 2 Link Up - speed 10000 Mbps - full-duplex
Port 3 Link Up - speed 40000 Mbps - full-duplex
Done
testpmd>

```

The following commands are typed from the `*testpmd*` interactive prompt.

#### 1. Check port status:

```

testpmd> show port info all
***** Infos for port 0 *****
MAC address: 00:02:C9:B5:B7:50
Connect to socket: 0
memory allocation on the socket: 0
Link status: up
Link speed: 10000 Mbps
Link duplex: full-duplex
Promiscuous mode: enabled
Allmulticast mode: disabled
Maximum number of MAC addresses: 128
Maximum number of MAC addresses of hash filtering: 0
VLAN offload:
  strip on
  filter on
  qinq(extend) off

***** Infos for port 1 *****
MAC address: 00:02:C9:B5:B7:51
Connect to socket: 0
memory allocation on the socket: 0
Link status: up
Link speed: 40000 Mbps
Link duplex: full-duplex
Promiscuous mode: enabled
Allmulticast mode: disabled
Maximum number of MAC addresses: 128
Maximum number of MAC addresses of hash filtering: 0
VLAN offload:
  strip on
  filter on

```

```

qinq(extend) off

***** Infos for port 2 *****
MAC address: 00:02:C9:B5:BA:B0
Connect to socket: 0
memory allocation on the socket: 0
Link status: up
Link speed: 10000 Mbps
Link duplex: full-duplex
Promiscuous mode: enabled
Allmulticast mode: disabled
Maximum number of MAC addresses: 128
Maximum number of MAC addresses of hash filtering: 0
VLAN offload:
  strip on
  filter on
  qinq(extend) off

***** Infos for port 3 *****
MAC address: 00:02:C9:B5:BA:B1
Connect to socket: 0
memory allocation on the socket: 0
Link status: up
Link speed: 40000 Mbps
Link duplex: full-duplex
Promiscuous mode: enabled
Allmulticast mode: disabled
Maximum number of MAC addresses: 128
Maximum number of MAC addresses of hash filtering: 0
VLAN offload:
  strip on
  filter on
  qinq(extend) off
testpmd>

```

2. Start IO forwarding between ports 1 and 3. The `*tx_first*` argument tells
3. `*testpmd*` to send a single packet burst which will be always forwarded by both ports:

```

testpmd> set fwd io
Set io packet forwarding mode
testpmd> set portlist 1,3
previous number of forwarding ports 4 - changed to number of configured
ports 2
testpmd> start tx_first
io packet forwarding - CRC stripping disabled - packets/burst=32
nb forwarding cores=1 - nb forwarding ports=2
RX queues=1 - RX desc=128 - RX free threshold=0
RX threshold registers: pthresh=8 hthresh=8 wthresh=0
TX queues=1 - TX desc=512 - TX free threshold=0
TX threshold registers: pthresh=32 hthresh=0 wthresh=0
TX RS bit threshold=0 - TXQ flags=0x0
testpmd>

```

4. Display `*testpmd*` port statistics:

```

testpmd> show port stats all

##### NIC statistics for port 0 #####
RX-packets: 0          RX-missed: 0          RX-bytes: 0
RX-badcrc: 0          RX-badlen: 0          RX-errors: 0
RX-nombuf: 0
TX-packets: 0          TX-errors: 0          TX-bytes: 0
#####

##### NIC statistics for port 1 #####
RX-packets: 60800584  RX-missed: 0          RX-bytes: 3891239534
RX-badcrc: 0          RX-badlen: 0          RX-errors: 0
RX-nombuf: 0

```

```

TX-packets: 61146609 TX-errors: 0 TX-bytes: 3913382976
#####

##### NIC statistics for port 2 #####
RX-packets: 0 RX-missed: 0 RX-bytes: 0
RX-badcrc: 0 RX-badlen: 0 RX-errors: 0
RX-nobuf: 0
TX-packets: 0 TX-errors: 0 TX-bytes: 0
#####

##### NIC statistics for port 3 #####
RX-packets: 61146920 RX-missed: 0 RX-bytes: 3913402990
RX-badcrc: 0 RX-badlen: 0 RX-errors: 0
RX-nobuf: 0
TX-packets: 60800953 TX-errors: 0 TX-bytes: 3891262080
#####
testpmd>

```

## 5. Stop forwarding:

```

testpmd> stop
Telling cores to stop...
Waiting for lcores to finish...

----- Forward statistics for port 1 -----
RX-packets: 78238689 RX-dropped: 0 RX-total: 78238689
TX-packets: 78681769 TX-dropped: 0 TX-total: 78681769
-----

----- Forward statistics for port 3 -----
RX-packets: 78681737 RX-dropped: 0 RX-total: 78681737
TX-packets: 78238721 TX-dropped: 0 TX-total: 78238721
-----

+++++++ Accumulated forward statistics for all ports+++++++
RX-packets: 156920426 RX-dropped: 0 RX-total: 156920426
TX-packets: 156920490 TX-dropped: 0 TX-total: 156920490
+++++++

Done.
testpmd>

```

## 6. Exit testpmd.

```

testpmd> quit
Stopping port 0...done
Stopping port 1...done
Stopping port 2...done
Stopping port 3...done
bye...
root#

```