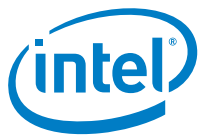


DPDK Intel NIC Performance Report

Release 19.05

Test Date: May 21th 2019

Author: Intel DPDK Validation team



Revision History

Date	Revision	Comment
May 21th, 2019	1.0	Initial document for release



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Audience and Purpose

The primary audience for this test report are architects and engineers implementing the Data Plane Development Kit (DPDK). This report provides information on packet processing performance testing for the specified DPDK release on Intel® architecture. The initial report may be viewed as the baseline for future releases and provides system configuration and test cases based on DPDK examples.

The purpose of reporting these tests is not to imply a single “correct” approach, but rather to provide a baseline of well-tested configurations and procedures with reproducible results. This will help guide architects and engineers who are evaluating and implementing DPDK solutions on Intel® architecture and can assist in achieving optimal system performance.

Test setup:

The device under test (DUT) consists of a system with an Intel® architecture motherboard populated with the following;

- A single or dual processor and PCH chip, except for System on Chip (SoC) cases
- DRAM memory size and frequency (normally single DIMM per channel)
- Specific Intel Network Interface Cards (NICs)
- BIOS settings noting those that updated from the basic settings
- DPDK build configuration settings, and commands used for tests

Connected to the DUT is an IXIA*, a hardware test and simulation platform to generate packet traffic to the DUT ports and determine the throughput at the tester side. The IXIA is used to implement RFC2544 on the DUT.

Benchmarking a DPDK system requires knowledge of networking technologies including knowledge of network protocols and hands-on experience with relevant open-source software, such as Linux*, and the DPDK. Engineers also need benchmarking and debugging skills, as well as a good understanding of the device-under-test (DUT) across compute and networking domains.

DPDK L3fwd Test Case: Documentation may be found at http://www.dpdk.org/doc/guides/sample_app_ug/l3_forward.html.

The application demonstrates the use of the hash and LPM libraries in the DPDK to implement packet forwarding. The lookup method is either hash-based or LPM-based and is selected at compile time. In this test case, the selected lookup method is the default LPM-based without modification, an LPM object is used to emulate the forwarding stage for IPv4 packets. The LPM object is used as the routing table to identify the next hop for each input packet at runtime.

The LPM lookup key is represented by the Destination IP Address field read from the input packet. The ID of the output interface for the input packet is the next hop returned by the LPM lookup. The set of LPM rules used by the application is statically configured and loaded into the LPM object at initialization time.

* Other names and brands may be claimed as the property of others.

In the sample application, hash-based forwarding supports IPv4 and IPv6. LPM-based forwarding supports IPv4 only.

DPDK Testpmd Test Case: Documentation may be found at http://www.dpdk.org/doc/guides/testpmd_app Ug/index.html.

The testpmd application can be used to test the DPDK in a packet forwarding mode and also to access NIC hardware features. Note in the Testpmd example if the `-i` argument is used, the first core is used for the command language interface (CLI).

Below is an example setup topology for the performance test. Generally, NIC ports in DUT connect to the traffic generator ports directly. And we will send bi-directional traffic from traffic generators and calculate the aggregated throughputs at the traffic generator side for the overall throughput. Please note the NIC port connections to traffic generator would vary from case to case.

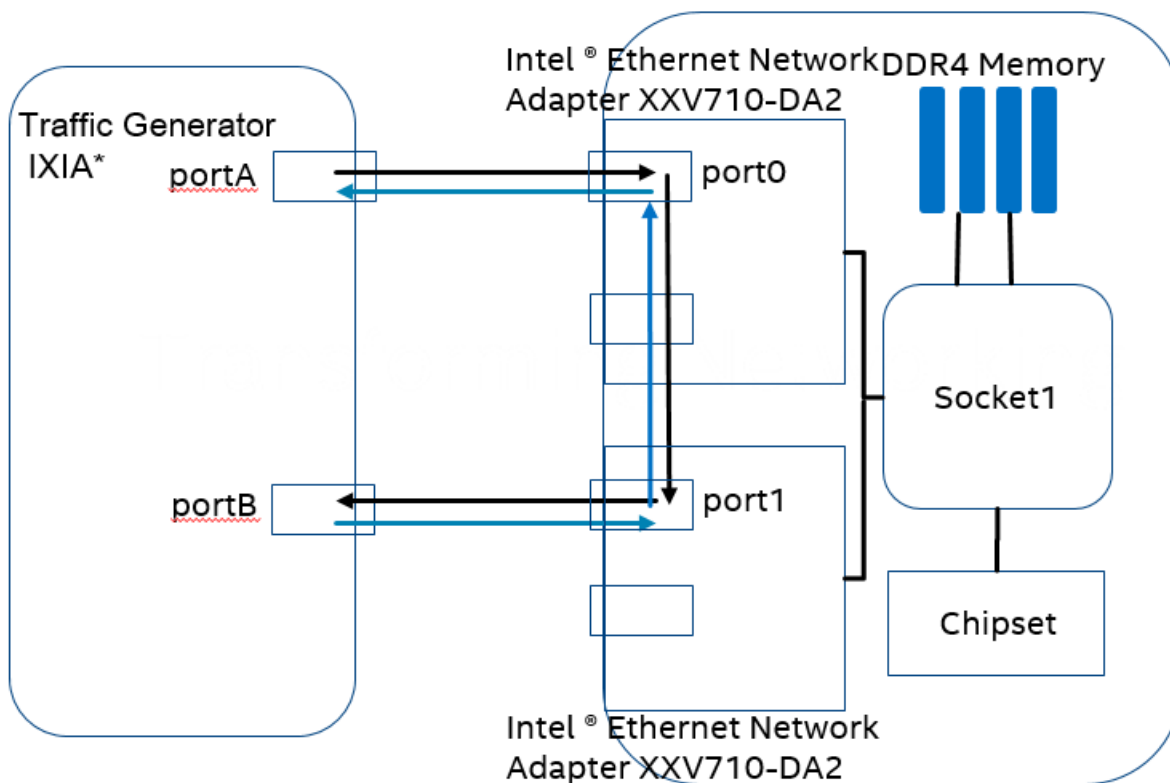


Figure1. DPDK NIC performance test setup(1 port per NIC)

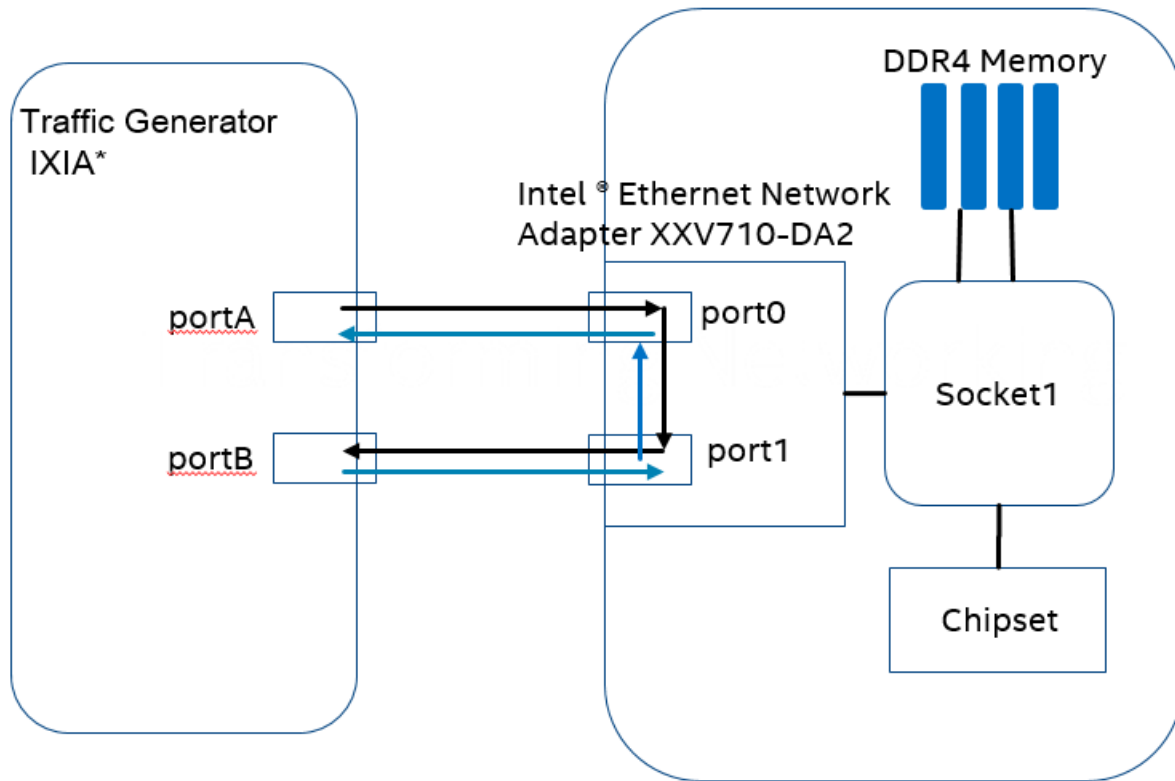


Figure2. DPDK NIC performance test setup(2 port on 1NIC)

RFC2544 Zero packet loss test case: Used to determine the DUT throughput as defined in RFC1242(<https://www.ietf.org/rfc/rfc1242.txt>). Note RFC6201 <https://www.ietf.org/rfc/rfc6201.txt> has updated RFC2544 and RFC1242. Please check the link for more details. In this report, RFC2544 test uses DPDK l3fwd as test application.

Procedure: Send a specific number of frames at a specific rate through the DUT and then count the frames that are transmitted by the DUT. If the count of offered frames is not equal to the count of received frames, the rate of the offered stream is reduced and the test is rerun. The throughput is the fastest rate at which the count of test frames transmitted by the DUT is equal to the number of test frames sent to it by the test equipment.

Test settings: IxNetwork* 8.40 is used here for the test execution. The duration for each round is 60 seconds, and the acceptable packet loss rate is 0. The traffic is 256 flows per port.

Single core test case: Used to check the maximum IO throughput for a single core. The case requires at least 4x 10GbE ports for the ixgbe DPDK Poll Mode Driver (PMD) and 2x 40GbE ports for the i40e DPDK PMD. In this case, we don't calculate the packet loss rate but record the average throughput within 60 seconds.

More details about the DPDK setup and BIOS information can be found at http://dpdk.org/doc/guides/linux_gsg/nic_perf_intel_platform.html



Intel® Xeon® Platinum 8180 (38.5M Cache, 2.50 GHz)

Hardware & Software Ingredients

Item	Description
Server Platform	Intel® Server Board S2600WFT Intel® Server Board S2600WFT Family
CPU	Intel® Xeon® Processor Platinum 8180 (38.5 M Cache, 2.50 GHz) https://ark.intel.com/products/120498/Intel-Xeon-Platinum-8180M-Processor-38_5M-Cache-2_50-GHz Number of cores 56, Number of threads 112.
Memory	Total 98304 MBs over 12 channels @ 2666 MHz
PCIe	3 x PCIe Gen3 x8 slots
NICs	Intel® Ethernet Converged Network Adapter X710-DA4 (4x10G) 2 x Intel® Ethernet Converged Network Adapter XL710-QDA2 (2X40G)
Operating System	Ubuntu 18.04 LTS
BIOS	SE5C620.86B.00.01.0013.030920180427
Microcode	0x2000043
Linux kernel version	4.15.0-20-generic
GCC version	gcc version 7.3.0 (Ubuntu 7.3.0-16ubuntu3)
DPDK version	19.05

Boot and BIOS settings

Item	Description
Boot settings	default_hugepagesz=1G hugepagesz=1G hugepages=16 intel_iommu=on iommu=pt isolcpus=1-21,28-48 nohz_full=1-21,28-48 rcu_nocbs=1-21,28-48 Note: nohz_full and rcu_nocbs is to disable Linux* kernel interrupts, and it's important for zero-packet loss test. Generally, 1G huge pages are used for performance test.
BIOS	CPU Power and Performance Policy <Performance> CPU C-state Disabled CPU P-state Disabled Enhanced Intel® Speedstep® Tech Disabled Turbo Boost Disabled Intel VT For directed I/O (VT-d) Enable Intel Virtualization Technology (VT-x) Enable
DPDK Settings	Build L3fwd: (in l3fwd/main.c) #define RTE_TEST_RX_DESC_DEFAULT 2048 #define RTE_TEST_TX_DESC_DEFAULT 2048

Test Case 1 –RFC2544 zero packet loss test on Intel® Ethernet Converged Network Adapter X710-DA4

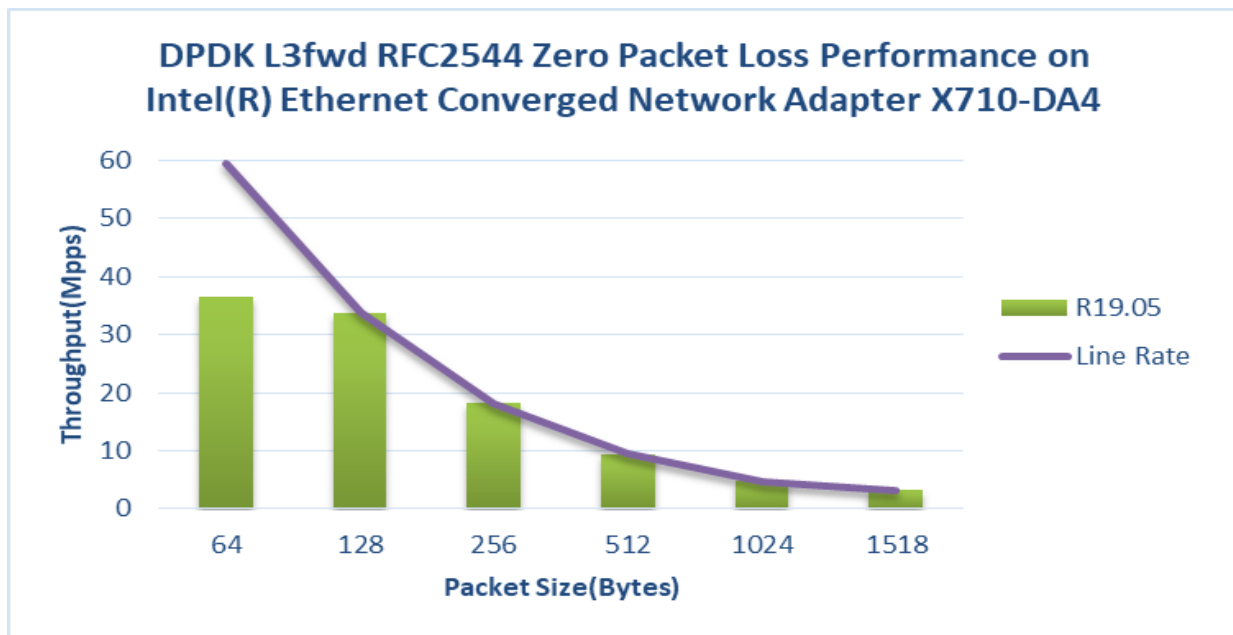
Item	Description
Test Case	RFC2544 zero packet loss test on Intel® Ethernet Converged Network Adapter X710-DA4 (4x10G)
NIC	Intel® Ethernet Converged Network Adapter X710-DA4 (4x10G)
Driver	i40e DPDK PMD(base on vfio-pci)
Device ID	0x1572
Device Driver/ Firmware	Driver version: 2.7.29 firmware-version: 6.80 0x80003c64 1.2007.0
Test configuration	1 NIC card attached to the second processor. 1 port assigned per logical core using 1 queue. Totaling 4 logical cores, 4 queues for 4ports
Command line	<code>./examples/l3fwd/build/l3fwd -c 0x1e0 -n 4 -w 0000:18:00.0 -w 0000:18:00.1 -w 0000:18:00.2 -w 0000:18:00.3 -- -p 0xf --config '(0,0,5),(1,0,6),(2,0,7),(3,0,8)'</code>

Test Result:

Packet Size(Bytes)	Throughput(Mpps)	Line rate%
64	36.50	61.33
128	33.78	100
256	18.11	100

Note: All packet sizes over 128B reach line rate.

Figure3: RFC2544 zero packet loss test on Intel® Ethernet Converged Network Adapter X710-DA4





Test Case 2 – RFC2544 zero packet loss test on 2x Intel® Ethernet Converged Network Adapter XL710-QDA2

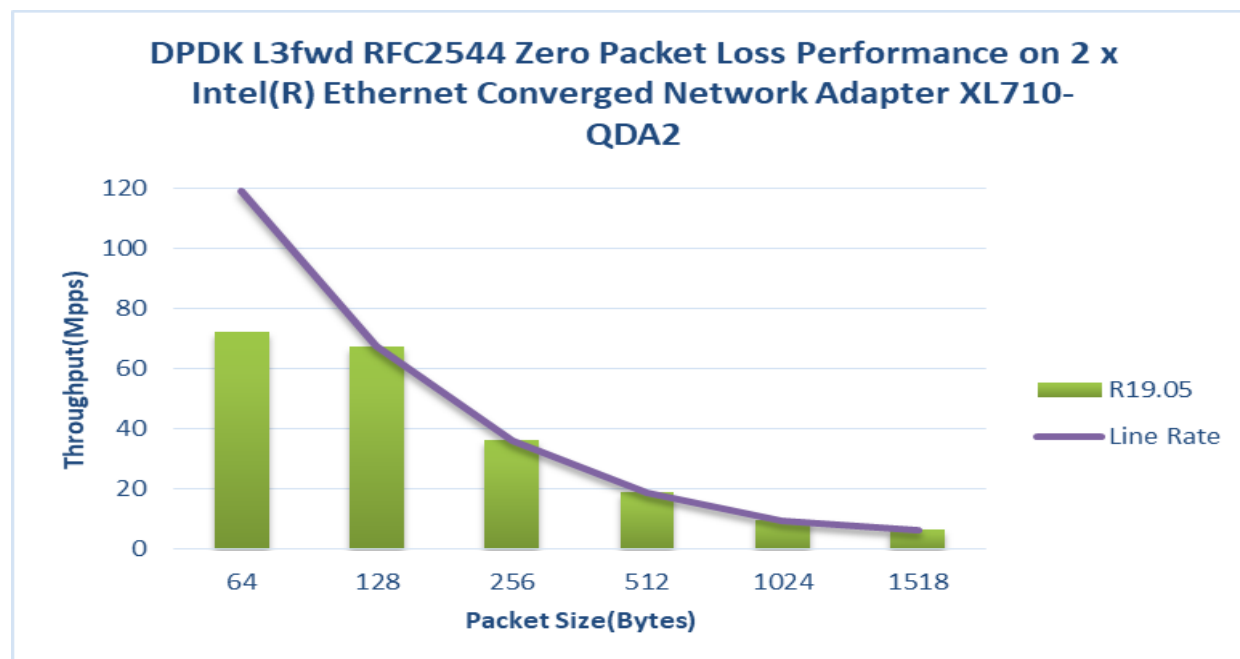
Item	Description
Test Case	RFC2544 zero packet Loss test on 2 x Intel® Ethernet Converged Network Adapter XL710-QDA2 (2X40G)
NIC	2 x Intel® Ethernet Converged Network Adapter XL710-QDA2 (2X40G)
Driver	i40e DPDK PMD(base on vfio-pci)
Device ID	0x1583
Device Driver/Firmware	Driver version: 2.7.29 firmware-version: 6.80 0x80003cfb 1.2007.0
Test configuration	2 NIC cards attached to the second processor only 1 st port used of each NIC. Each port has 2 queues assigned for a total of 4 queues 1 queue assigned per logical core. Totaling 4 logical cores, 4 queues for 2 ports
Command line	<code>./examples/l3fwd/build/l3fwd -c 0x7800000000 -n 4 -w 0000:86:00.0 -w 0000:af:00.0 -- -p 0x3 --config '(0,0,35),(0,1,36),(1,0,37),(1,1,38)'</code>

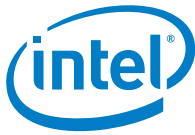
Test Result:

Packet Size (Bytes)	Throughput (Mpps)	Line rate%
64	72.17	60.63
128	67.56	100
256	36.23	100
512	18.80	100

Note: All packet sizes over 128B reach line rate.

Figure4: RFC2544 zero packet Loss test on 2 x Intel® Ethernet Converged Network Adapter XL710-QDA2





Test Case 3 – i40e PMD Single core performance test

Item	Description
Test Case	Single core performance test for i40e DPDK PMD
NIC	2 x Intel® Ethernet Converged Network Adapter XL710-QDA2 (2X40G)
Driver	i40e DPDK PMD(base on vfio-pci)
Device ID	0x1583
Device Firmware	Driver version: 2.7.26 firmware-version: 6.80 0x80003cfb 1.2007.0
Test configuration	Change the config/common_base file and rebuild DPDK. “CONFIG RTE_LIBRTE_I40E_16BYTE_RX_DESC=y” . 2 NIC cards attached to the first processor only 1 st port used of each NIC. Each port has 1 queue assigned. All queues are assigned to the same logical core. The first core defined is for the CLI of the Testpmd example due to the <code>-i</code> argument. I40E Vector PMD and IO forwarding is used for the test. Test duration is 60 seconds.
Command line	<code>./x86_64-native-linuxapp-gcc/app/testpmd -c 0x30000000 -n 4 -w 0000:af:00.0 -w 0000:b1:00.0 -- -i --portmask=0x3 -- txd=2048 --rxq=2048 --txq=2 --rxq=2 Testpmd>start</code>

Test Result:

Packet Size (Bytes)	Throughput (Mpps)	Line Rate%	CPU freq(Ghz)	Cycles per packet= CPU_freq/Throughput
64	47.61	39.99	2.5	52
128	45.57	67.45	2.5	54

Note: All packet sizes over 256B reach line rate, so the single core is not fully stressed when packets are over 256B, then they are not listed here.



Intel® Xeon® Platinum 8180 (38.5M Cache, 2.50 GHz)

Hardware & Software Ingredients

Item	Description
Server Platform	Intel® Server Board S2600WFT Intel® Server Board S2600WFT Family
CPU	Intel® Xeon® Processor Platinum 8180 (38.5 M Cache, 2.50 GHz) https://ark.intel.com/products/120498/Intel-Xeon-Platinum-8180M-Processor-38_5M-Cache-2_50-GHz Number of cores 56, Number of threads 112.
Memory	Total 49152 MBs over 6 channels @ 2133 MHz
PCIe	4x PCIe Gen3 x8 slots
NICs	4x Intel ® Ethernet Converged Network Adapter 82599ES
Operating System	Ubuntu 18.04 LTS
BIOS	SE5C620.86B.00.01.0013.030920180427
Microcode	0x2000043
Linux kernel version	4.15.0-20-generic
GCC version	gcc version 7.3.0 (Ubuntu 7.3.0-16ubuntu3)
DPDK version	19.05

Boot and BIOS settings

Item	Description
Boot settings	default_hugepagesz=1G hugepagesz=1G hugepages=16 intel_iommu=on iommu=pt isolcpus=1-21,28-48 nohz_full=1-21,28-48 rcu_nocbs=1-21,28-48 Note: nohz_full and rcu_nocbs is to disable Linux system interrupts, and it's important for zero-packet loss test. Generally, 1G huge pages are used for performance test.
BIOS	CPU Power and Performance Policy <Performance> CPU C-state Disabled CPU P-state Disabled Enhanced Intel® Speedstep® Tech Disabled Turbo Boost Disabled Intel VT For Directed I/O (VT-d) Enable Intel Virtualization Technology (VT-x) Enable
DPDK Settings	Build L3fwd: (in l3fwd/main.c) #define RTE_TEST_RX_DESC_DEFAULT 2048 #define RTE_TEST_TX_DESC_DEFAULT 2048

Test Case 4 – RFC2544 Zero Packet Loss test on 2x Intel® Ethernet Converged Network Adapter 82599ES

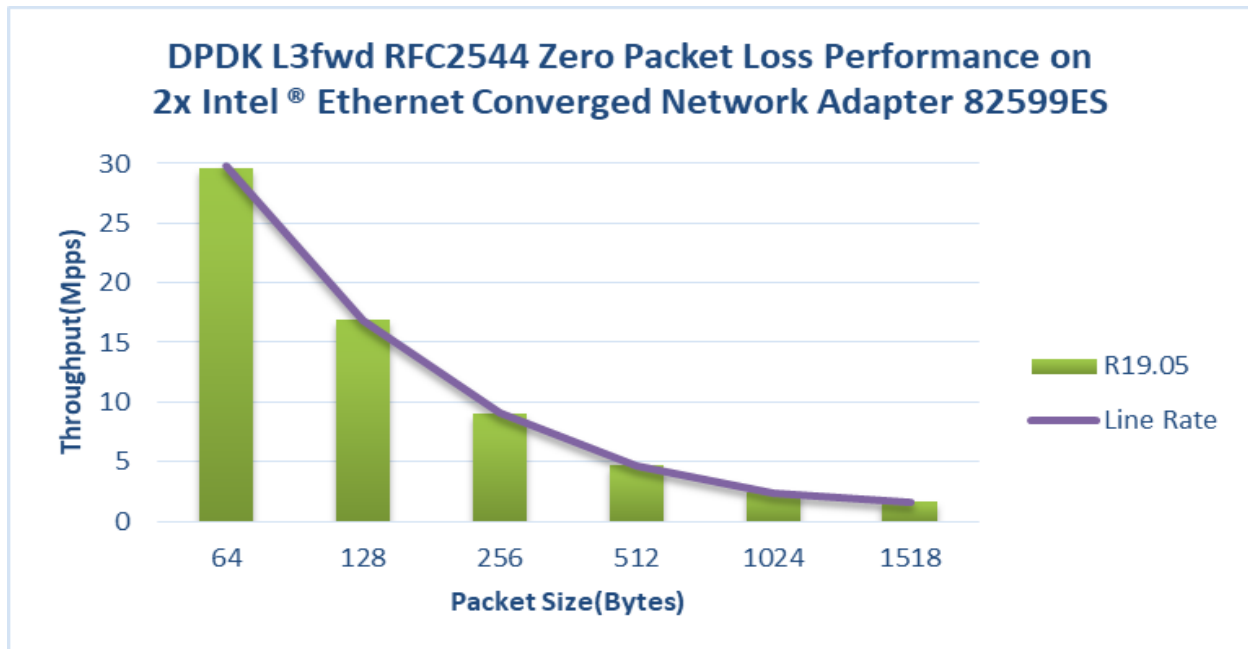
Item	Description
Test Case	RFC2544 Zero Packet Loss test on 2 x Intel® Ethernet Converged Network Adapter 82599ES
NIC	2 x Intel® Ethernet Converged Network Adapter 82599ES
Driver	ixgbe DPDK PMD(base on vfio-pci)
Device ID	0x10fb
Device Firmware	0x61bf0001
Test configuration	2 NIC cards attached to the second processor, using one port per NIC. 1 port assigned per logical core using 1 queue. Totally 2 logical cores, 2 queues for 2ports.
Command line	<code>./examples/l3fwd/build/l3fwd -c 0x1800000000 -n 4 -w 0000:af:00.0 -w 0000:b1:00.0 -- -p 0x3 --config '(0,0,35),(1,0,36)'</code>

Test Result:

Packet Size (Bytes)	Throughput (Mpps)	Line Rate%
64	29.55	99.30
128	16.89	100
256	9.06	100
512	4.70	100
1024	2.39	100

Note: All packet sizes over 128B reach line rate.

Figure5: RFC2544 Zero Packet Loss on 2 x Intel® Ethernet Converged Network Adapter 82599ES





Test Case 5 – ixgbe PMD Single core performance

Item	Description
Test Case	Single core performance for ixgbe PMD
NIC	4 x Intel ® Ethernet Converged Network Adapter 82599ES,
Driver	Ixgbe(base on vfio-pci)
Device ID	0x10fb
Device Firmware	0x61bf0001
Test configuration	4 NIC cards attached to the second processor only 1 st port used of each NIC. Each port has 1 queue assigned. All queues are assigned to the same logical core. The first core defined is for the CLI of the Testpmd example due to the -i argument. Ixgbe Vector PMD and IO forwarding is used for the test. Test duration is 60 seconds.
Command line	<pre>./x86_64-native-linuxapp-gcc/app/testpmd -c 0x1800000000 -n 4 -w 0000:81:00.0 -w 0000:86:00.0 -w 0000:af:00.0 -w 0000:b1:00.0 -- -i --portmask=0xf --txd=128 --rxq=128 -- txq=1 --rxq=1 Testpmd>start</pre>

Test Result:

Packet Size (Bytes)	Throughput (Mpps)	Line Rate%	CPU freq(Ghz)	Cycles per packet= CPU_freq/Throughput
64	52.38	88.01	2.5	47

Note: All packet sizes over 128B reach line rate, so the single core is not fully stressed when packets are over 128B, then they are not listed here.



Intel® Xeon® Platinum 8180 (38.5M Cache, 2.50 GHz)

Hardware & Software Ingredients

Item	Description
Server Platform	Intel® Server Board S2600WFT Intel® Server Board S2600WFT Family
CPU	Intel® Xeon® Processor Platinum 8180 (38.5 M Cache, 2.50 GHz) https://ark.intel.com/products/120498/Intel-Xeon-Platinum-8180M-Processor-38_5M-Cache-2_50-GHz Number of cores 56, Number of threads 112.
Memory	Total 49152 MBs over 6 channels @ 2133 MHz
PCIe	2x PCIe Gen3 x8 slots
NICs	2x Intel® Ethernet Network Adapter XXV710-DA2
Operating System	Ubuntu 18.04 LTS
BIOS	SE5C620.86B.00.01.0009.101920170742
Microcode	0x2000043
Linux kernel version	4.15.0-20-generic
GCC version	gcc version 7.3.0 (Ubuntu 7.3.0-16ubuntu3)
DPDK version	19.05

Boot and BIOS settings

Item	Description
Boot settings	<pre>default_hugepagesz=1G hugepagesz=1G hugepages=16 intel_iommu=on iommu=pt isolcpus=1-21,28-48 nohz_full=1-21,28-48 rcu_nocbs=1-21,28-48</pre> <p>Note: nohz_full and rcu_nocbs is to disable Linux system interrupts, and it's important for zero-packet loss test. Generally, 1G huge pages are used for performance test.</p>
BIOS	CPU Power and Performance Policy <Performance> CPU C-state Disabled CPU P-state Disabled Enhanced Intel® Speedstep® Tech Disabled Turbo Boost Disabled Intel VT Fordirected I/O(VT-d) Enable Intel Virtualization Technology (VT-x) Enable
DPDK Settings	Build L3fwd: (in l3fwd/main.c), change below lines. <pre>#define RTE_TEST_RX_DESC_DEFAULT 2048 #define RTE_TEST_TX_DESC_DEFAULT 2048</pre>



Test Case 6 – RFC2544 zero packet loss test on 2x Intel® Ethernet Network Adapter XXV710-DA2

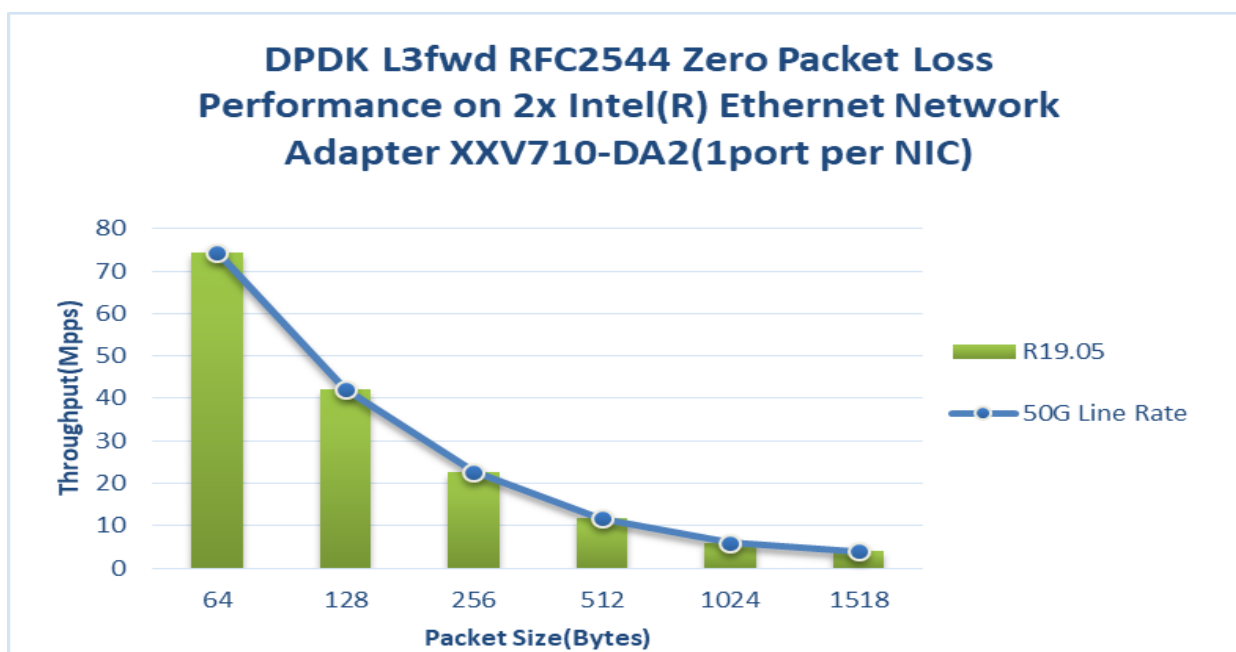
Item	Description
Test Case	RFC2544 zero packet Loss test for Intel® Ethernet Network Adapter XXV710-DA2
NIC	2x Intel® Ethernet Network Adapter XXV710-DA2
Driver	i40e DPDK PMD(base on vfio-pci)
Device ID	0x158b
Device Driver/Firmware	Driver version: 2.7.29 firmware-version: 6.01 0x80003221 1.1691.0
Test configuration- 2core 2queue per port(2c2t2q per port)	2 NIC cards attached to the first processor only 1st port used of each NIC. Each port has 2 queues assigned for a total of 4 queues 1 queue assigned per logical core. Totaling 4 logical cores, 4 queues for 2 ports
Command line— 2c2t2q per port	<code>./examples/l3fwd/build/l3fwd -l 5-8 -n 4 -w 18:00.0 -w 1a:00.0 -- -p 0x3 --config '(0,0,5),(0,1,6),(1,0,7),(1,1,8)'</code>

Test Result:

Packet Size (Bytes)	Throughput with 2c2t2q per port(Mpps)	Line rate%
64	74.4	100
128	42.22	100
256	22.64	100

Note: All packet sizes over 64B reach line rate.

Figure6: RFC2544 zero packet Loss test for 2x Intel® Ethernet Network Adapter XXV710-DA2



Test Case 7 – RFC2544 zero packet loss test on 1x Intel® Ethernet Network Adapter XXV710-DA2

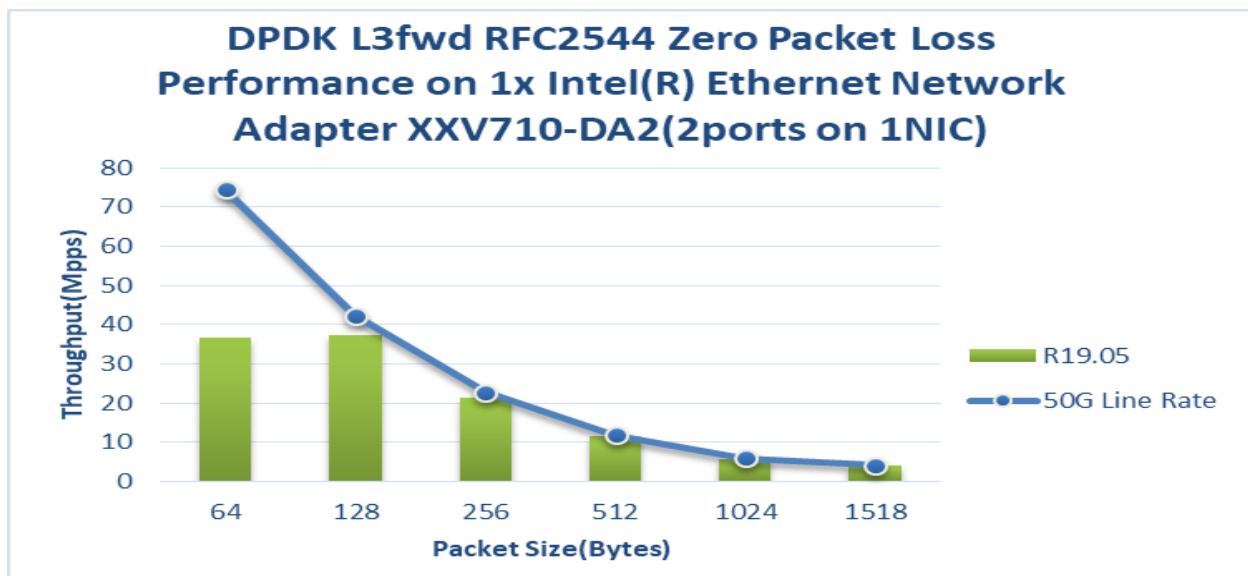
Item	Description
Test Case	RFC2544 zero packet Loss test for Intel® Ethernet Network Adapter XXV710-DA2
NIC	1x Intel® Ethernet Network Adapter XXV710-DA2
Driver	i40e DPDK PMD(base on vfio-pci)
Device ID	0x158b
Device Driver/Firmware	Driver version: 2.7.29 firmware-version: 6.01 0x8000321c 1.1691.0
Test configuration	Change the config/common_base file and rebuild DPDK. “CONFIG_RTE_LIBRTE_I40E_16BYTE_RX_DESC=y”. 1 NIC cards attached to the first processor and 2 ports of the NIC are used. Each port has 1 queues assigned for a total of 2 queues 1 queue assigned per logical core. Totaling 2 logical cores, 2 queues for 2 ports
Command line	<code>./examples/l3fwd/build/l3fwd -c 0xc -n 4 -w 18:00.0 -w 18:00.1 --p 0x3 --config '(0,0,2),(1,0,3)'</code>

Test Result:

Packet Size (Bytes)	Throughput (Mpps)	Line rate%
64	36.74	49.38%
128	37.18	88.05%
256	21.21	93.67%
512	11.42	97.19%
1024	5.82	97.19%
1518	3.92	96.48%

Note: Due to hardware limitation, the throughput at large packets can only reach 95%-97% line rate.

Figure7: RFC2544 zero packet Loss test for 1x Intel® Ethernet Network Adapter XXV710-DA2





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Intel® AES-NI requires a computer system with an AES-NI enabled processor, as well as non-Intel software to execute the instructions in the correct sequence. AES-NI is available on select Intel® processors. For availability, consult your reseller or system manufacturer. **For more information, see <http://software.intel.com/en-us/articles/intel-advanced-encryption-standard-instructions-aes-ni/>**

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