

**QCT Reference Architecture for
Network Function Virtualization Infrastructure
(NFVI) on Ubuntu* Host OS**



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1. Overview

Intel is dedicated to bringing the data center innovation with Intel® Select Solutions with new released Intel® Xeon® Scalable Processors. In order to have a solution branded as an Intel Select Solution, Intel and leading industry solution providers perform testing and validation, aiming to achieve the goal of accelerating the development of today's data center workloads and applications.

Quanta Cloud Technology (QCT) has engineered an Intel Select Solution for Network Functions Virtualization Infrastructure (NFVI) on Ubuntu, hereafter called the “reference architecture,” based on a reference design developed by Intel. QCT’s solution was verified by Intel to meet the expected performance based on Intel’s reference design. QCT’s reference architecture empowers communication service providers (CoSP) and network operators to build an optimized, agile NFVI with latest Intel technologies.

This reference architecture provides the overview from the ETSI NFV framework, QCT hardware configuration and software configuration along with the installation guide that help CoSPs and network operators deploy their NFVI with less time, effort, and expense. The adoption of Intel® QuickAssist Technology (Intel® QAT) and Data Plane Development Kit (DPDK) are core platform technologies in this reference architecture. The test results will be demonstrated to prove that performance is complying with Intel Select Solution standards. CoSPs and network operators can plan their own NFVI based on this reference architecture when they seek the computing and storage resources with add-in platform acceleration products for carrier class use cases that require high reliability and performance.

2. ETSI NFV Framework

Established in 1988, the European Telecommunications Standards Institute (ETSI) is a non-profit organization whose objective is to produce international telecommunications standards intended to accelerate the development of reliable products and services in Telco industry. As NFV attracts extensive attention, several network operators formed the Industry Specification Group (ISG) in 2013 and release a NFV framework including the requirements of NFV Infrastructure (NFVI), Virtualized Network Functions (VNFs) and NFV Management and Orchestration (NFV MANO).



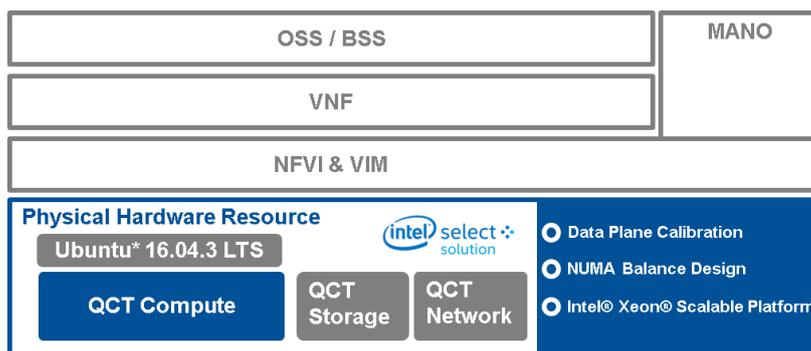


Figure 1: QCT Reference Architecture for NFVI on Ubuntu* Host OS

QCT’s reference architecture focuses on the optimization on the infrastructure layer (see “Figure 1”). The physical resource in NFVI layer is assumed to be open x86 commercial off-the-shelf (COTS) servers as it provides the flexibility compared to traditional proprietary hardware set. As a global datacenter solution provider, QCT chooses its compatible hardware from diverse product lines and tunes the stack with Intel’s deep expertise on data plane calibration to provide the reference architecture.

3. Hardware Configuration

The reference architecture will be based on the following QCT hardware configuration which showcases the best combination of Intel® Xeon® CPU technology with Intel QAT. These technologies are integrated to deliver best-in-class NFVI performance for networking, storage, cryptography and compression.

	Description	QTY
System	QuantaGrid D52BQ-2U	1
CPU	Intel® Xeon® Gold 6152 Processor (30.25M Cache, 2.10 GHz)	2
RAM	384GB (12 * 32GB 2666MHz DDR4 RDIMM)	12
SSD-NVMe	Intel® SSD DC P4500 SERIES 2TB	4
SSD-SATA	Intel® SSD S4600 SERIES 960GB	2
NIC card	Intel® PCIe 25G 2 port-low profile XXV710DA2G1P5	2
QAT	Intel® QuickAssist Adapter 8970	1

Table 1: Hardware Configuration in QCT Reference Architecture

QCT QuantaGrid D52BQ-2U server with two CPU sockets in combination with the Lewisburg PCH (PCH) board design provides a symmetric I/O design. The symmetric design provides balanced I/O partitioning that facilitates discovery and provisioning of networking, storage, and other peripherals, as well as improved performance and management of those peripherals. Also, its ultimate compute and storage density,



flexible and scalable I/O options expansion slot hardware design are good for NFVI solutions since CoSPs and network operators are looking for high computing, low latency, high throughput solution.

QCT QuantaGrid D52BQ-2U server board configuration, shown below, provides the optimized hardware design (see “Figure 2”). This reference architecture is based on the high-performance Intel Xeon Gold 6152 processor. All processors support up to 48 lanes of PCI Express* 3.0 links capable of 8.0 GT/s, and 4 lanes of DMI3/PCI Express* 3.0. It features 2 Integrated Memory Controllers (IMC), each IMC supporting up to 3 channels of DDR4 DIMMs with up to 2 DIMM per channel.

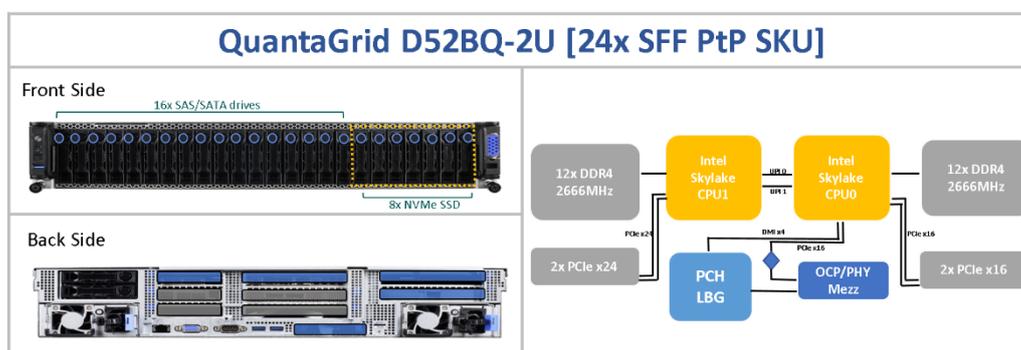


Figure 2: QCT QuantaGrid D52BQ-2U Hardware Design

This features specifies network and storage to leverage Intel CPU technologies to maximize virtual machine density, also the high-performance CPUs, balanced I/O with Intel QAT combined with optimizations through DPDK, allow for the achievement of exceptional throughput and latency performance. Through these technologies, QCT and Intel have improved data and control plane throughput, latency, and jitter performance, and allow virtual network functions (VNFs) to meet their performance requirements.

4. Software Configuration

The reference architecture will be based on the following QCT software configuration. A series of requirements are defined for achieving the expected performance. The BIOS and firmware in QCT QuantaGrid D52BQ-2U server are upgraded to the latest version for hardware management. For version of DPDK, in this reference architecture, 16.11.3 is chosen as it is the Long Term Support (LTS) version recommended by Intel.

Software	Item	Version
Firmware	BIOS	3A08.E1
	BMC	3.46.00
	Ethernet controller	5.51 0x80002bca 1.1568.0
Host	DPDK	16.11.3
	Ubuntu*	16.04.3 (Kernel 4.4.0-97-generic)
	KVM/QEMU	2.5
	Libvirt	1.3.1-1
	OpenSSL	1.1.0e
	QAT engine	0.5.29
	QAT driver	1.7.Upstream.L.1.0.3_42
	I40e driver	2.0.26
	Ixgbe driver	5.2.4

Table 2: Software Configuration in QCT Reference Architecture

5. Installation Guide

This section contains the instructions of BIOS tuning and software installation following the above configuration requirements for building up a basic foundation of NFVI with QCT QuantaGrid D52BQ-2U servers.

5.1 BIOS Tuning

To meet the optimized deterministic performance requirements in the Intel reference design, the following BIOS settings must be set as specified in the table below:

Menu (Advanced)	Path to BIOS Setting	BIOS Setting	Required Setting for Deterministic Performance
Power Configuration	Power & Performance	CPU Power and Performance Policy	Performance
	CPU P State Control	Enhanced Intel SpeedStep Technology	Disabled
	Hardware P States	Hardware P-States	Disabled
	CPU C State Control	Package C-State	C0/C1 State
		C1E	Disabled
		Processor C6	Disabled
Virtualization Configuration	Processor Virtualization Feature	Intel® Virtualization Technology (Intel® VT)	Enabled
	Integrated IO Virtualization Configuration	Intel® VT for Directed I/O	Enabled

Table 3: Required BIOS settings in QCT Reference Architecture



5.2 Software Installation

There are four main jobs need to be done during software installation:

1. Upgrade NIC driver (Ixgbe and I40E)
2. Install DPDK
3. Install Intel QAT engine and Intel QAT driver
4. Compile and install OpenSSL

QCT provides a script to help you to accomplish installation. Create a script file named **setup.sh** with the contents as following:

```
#!/usr/bin/env bash
# Install packages
apt -y install msr-tools libvirt-bin qemu-kvm build-essential
libboost-dev pciutils libudev-dev libssl-dev zlib1g-dev
pkg-config linux-headers-`uname -r` libpcap-dev libpcr3-dev
htop unzip git python dos2unix

# Install OpenSSL
git clone https://github.com/openssl/openssl.git /opt/openssl
cd /opt/openssl && \
    git checkout OpenSSL_1_1_0e && \
    ./config --prefix=/usr/local/ssl && \
    make depend && \
    make && \
    make install

# Install DPDK
mkdir -p /opt/APP/utility/
wget -O- http://fast.dpdk.org/rel/dpdk-16.11.3.tar.xz | tar xvfJ
- -C /opt/APP/utility/
mv /opt/APP/utility/dpdk-stable-16.11.3
/opt/APP/utility/dpdk-16.11.3
cd /opt/APP/utility/dpdk-16.11.3 && \
    rm -rf build/.config && \
    sed -i
's/CONFIG_RTE_LIBRTE_I40E_16BYTE_RX_DESC=n/CONFIG_RTE_LIBRTE_
```



```
I40E_16BYTE_RX_DESC=y' config/common_base
make config T=x86_64-native-linuxapp-gcc && \
sed -ri 's,(PMD_PCAP=).*,\1y,' build/.config && \
make && \
make install && \
depmod -ae && \

# Compile l3fwd
export RTE_SDK=$PWD && \
ln -s $PWD/build x86_64-native-linuxapp-gcc && \
cd examples/l3fwd && \
make

# Install QAT driver
mkdir -p /opt/APP/driver/
wget -O- --no-check-certificate
https://downloadmirror.intel.com/27023/eng/QAT1.7.Upstream.L.
1.0.3_42.tar.gz | tar zxf - -C /opt/APP/driver/
mv /opt/APP/driver/QAT1.7.Upstream.L.1.0.3_42
/opt/APP/driver/QAT
cd /opt/APP/driver/QAT && \
./configure --prefix=/usr/local --enable-qat-uis && \
make && \
make install && \
make samples-install

# Install ixgbe driver
wget -O- --no-check-certificate
https://downloadmirror.intel.com/14687/eng/ixgbe-5.2.4.tar.gz
| tar zxf - -C /opt/APP/driver/
cd /opt/APP/driver/ixgbe-5.2.4/src && \
make && make install

# Install i40e driver
wget -O- --no-check-certificate
https://downloadmirror.intel.com/27044/eng/i40e-2.0.26.tar.gz
| tar zxf - -C /opt/APP/driver/
cd /opt/APP/driver/i40e-2.0.26/src/ && \
```



```
make && make install

# Install QAT engine
git clone -b v0.5.29 https://github.com/01org/QAT_Engine.git
/opt/openssl/QAT_Engine
./configure --prefix=/usr/local \
  --with-qat_dir=/opt/APP/driver/QAT \
  --with-openssl_dir=/opt/openssl \
  --with-openssl_install_dir=/opt/openssl \
  --with-qat_install_dir=/usr/local \
  --enable-upstream_driver --enable-usdm \
  --disable-qat_lenstra_protection
make && make install
```

Edit /etc/profiles, append bash environment arguments as following:

```
export OPENSSL_ENGINES=/usr/local/ssl/lib/engines-1.1
export LD_LIBRARY_PATH="/usr/local/lib64"
```

Then, run this script to install packages and drivers:

```
source /etc/profiles
bash ./setup.sh
```



6. Test Methodology

QCT conducts five validation tests in order to provide a reliable NFVI reference architecture with deterministic performance. The principal objectives of the testing are as following:

- To confirm the hardware and software setup meet the design specifications in QCT Reference Architecture for NFVI Ubuntu* Host OS.
- To present a platform with DPDK and QAT implementation achieving Intel QAT and OpenSSL performance requirements.
- To show packet processing performance improvements possible with DPDK L3 Forwarding.

The test topology (see “figure 3”) is to ensure that the validation test generate results with efficiency, correctness when running testing. CoSPs and network operators could validate the performance of OpenSSL Speed and packet processing under this test setup.

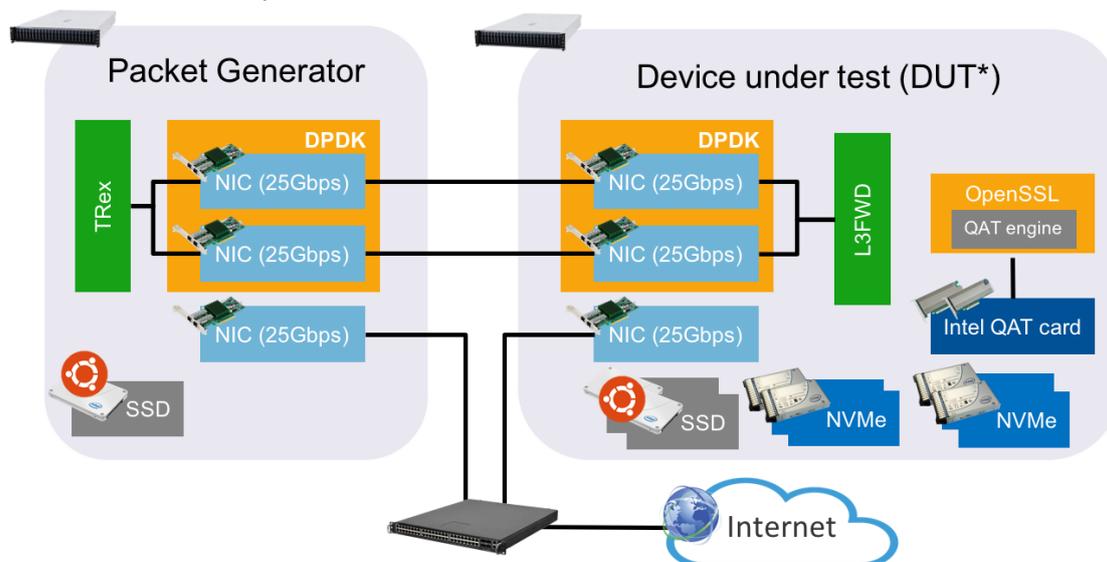


Figure 3: Test Topology in QCT Reference Architecture

In the above figure, there are two QCT QuantaGrid D52BQ-2U servers, one served as packet generator, and the other one as Device under test (DUT^{1*}). Each server have at least three network ports (two NICs and each NIC has two ports), and hookup with back-to-back connection on two ports.

¹ * DUT(QCT QuantaGrid D52BQ-2U) is based on QCT Reference Architecture

7. Test Results and Summary

QCT QuantaGrid D52BQ-2U server has been verified to be part of Intel Select Solution for NFVI on Ubuntu * Host OS. This product is built on top of software stacks which has been hardened and tested by Intel and the underlying NFVI is optimized accelerating the onboarding of VNF's and solution Time to Market (TTM). As a result, value add on top of these hardware and software build up as defined in Intel reference design becomes streamlined with minimal exposure to integration challenges for CoSPs and network operators.

This product has the advantage of offering IO NUMA balance topology and tested for L3FWD RFC2544 and meeting the performance metric requirement with DPDK poll mode driver. Platform BIOS is checked to meet optimal settings recommended by Intel. Additionally, this product is also armed with the capability of Intel QuickAssist Technology offering co-processing for Bulk Cryptography, PKE and Compression offload. This product has been verified to achieve the bulk cryptography, PKE and compression performance metric as following:

- Throughput of 51693 (Mbps) at packet size of 4096 for algorithm Cipher Encrypt AES128-CBC versus 40Gbps requirement
- Operations per second (Ops/sec) of 101411 at modulus size of 2048 for algorithm RSA CRT DECRYPT versus 40k Ops/sec requirement
- Throughput of 54445 (Mbps) for the case Compression DP/STATIC/COMPRESS/STATELESS/8192 versus the 40Gbps requirement

With this Intel® QuickAssist Technology hardware acceleration, QCT QuantaGrid D52BQ-2U server can achieve 100k Sign Operations per second with Openssl* RSA2048 algorithm, about 48Gbps bulk crypto performance of Openssl* aes-128-cbc-hmac-sha1 algorithm.



8. Conclusion

The need to implement a reliable NFVI has never been greater for CoSPs and network operators than it is today, as they face evolving markets and increasing customer expectations. The Intel Select Solution for NFVI developed by QCT, based on Ubuntu* Host OS, opens the door for CoSPs and network operators to build a highly flexible foundation with outstanding network performance on a verified configuration.

This solution features a NFV workload-optimized software stack tuned to take full advantage of the Intel® architecture CPU in QCT hardware platform. The software stack includes firmware, Intel QuickAssist Technology, and leading NFV open source software (DPDK) that has been tested and integrated to ensure interoperability. CoSPs and network operators could leverage the Intel hardware to achieve goals on critical performance and design flexibility referring to this reference architecture.

For more information about the QCT Solutions for NFV, visit <http://qct.io/>. For more information about the Overall Intel Select Solution Program, visit <https://www.intel.com/content/www/us/en/architecture-and-technology/intel-select-solutions-overview.html>





About QCT

QCT (Quanta Cloud Technology) is a global datacenter solution provider extending the power of hyperscale datacenter design in standard and open SKUs to all datacenter customers.

Product lines include servers, storage, network switches, integrated rack systems and cloud solutions, all delivering hyperscale efficiency, scalability, reliability, manageability, serviceability and optimized performance for each workload.

QCT offers a full spectrum of datacenter products and services from engineering, integration and optimization to global supply chain support, all under one roof.

The parent of QCT is Quanta Computer Inc., a Fortune Global 500 technology engineering and manufacturing company.

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