

6WIND Speed Series Performance Validation

Routing and Security Performance Benchmark –
Bare Metal and Virtual Machines

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1 EXECUTIVE SUMMARY

6WIND's commercial software solves performance challenges for network vendors in telecom, enterprise and cloud infrastructure markets. The company's packet processing software, accelerated virtual networking infrastructure and software appliances are optimized for cost-effective hardware running Linux with a choice of multicore processors to deliver a wide variety of networking and security protocols and features.

6WIND enables Service Providers, Cloud Service Providers and Enterprises to transparently evolve their networks and seamlessly progress from dedicated hardware to bare metal and virtualized architectures, without sacrificing performance. For Service Providers, NFV (Network Functions Virtualization) promises to enable rapid innovation by liberating networking functions from proprietary hardware platforms. Core to the success of NFV is the level of performance that can be achieved with software equivalents of purpose-built networking appliances. Public and private Cloud Service Providers want to deliver fast innovative services and increase workload density by improving their servers' networking capabilities. Network Equipment Vendors aim at reducing development costs and increasing their margins thanks to a new generation of network appliances based on standard technology.

In this report commissioned by 6WIND and conducted by NitronLabs LLC on behalf of SDxCentral, we investigated the performance of the 6WIND Speed Series product family on x86 COTS server platforms commonly found in public and private cloud environments. IXIA generously provided use of its iSimCity facilities and traffic-generation equipment for routing and IPsec testing.

6WIND Speed Series product family comprises:

- 6WIND Turbo Appliances including 6WIND Turbo Router™ and 6WIND Turbo IPsec™ that provide high performance, ready-to-use software network appliances, to be deployed in bare metal environments or in virtual machines.
- 6WIND Virtual Accelerator™ that provides packet processing acceleration for virtual network infrastructures.

The goals of this validation were to establish a baseline of the 6WIND software running on a typical x86 COTS server platform, and to validate its L3 forwarding performance, routing control-plane scalability, IPsec performance and control-plane scalability in a setting relevant to data centers within Enterprises, Cloud Service Providers, and Service Providers. The performance of the 6WIND software is compared to open-source equivalents to characterize the significant performance gains achieved by using 6WIND solutions.

6WIND Turbo Appliances were first benchmarked in bare metal deployments to demonstrate how they can achieve the highest networking performance on COTS hardware to lower CAPEX versus dedicated, purpose-built network appliances. They were subsequently deployed as virtual machines on top of 6WIND Virtual Accelerator running on a hypervisor to determine if the combination of Virtual Accelerator with the Turbo Appliances could minimize the computing resources dedicated to virtualization and routing, freeing up computing power to operate virtual machines for other NFV VNFs (virtual network functions).

Testing results showed that 6WIND was able to achieve dramatic performance improvements compared to standard open-source on Linux solutions as follows:

Bare Metal Performance

- L3 Forwarding: 6WIND Turbo Router achieved 115 Gbps of IMIX throughput with near zero frame loss rates
- IPsec: 6WIND Turbo IPsec demonstrated the ability to handle tunnel setups as 12K/sec and maintain 240K concurrent tunnels.

Virtualized Performance

- 6WIND Virtual Accelerator combined with 6WIND Turbo Appliances were able to outperform standard open-source equivalents by 10-40 times depending on the metric, proving that 6WIND can enable efficient and high-performing NFV deployments for routing, IPsec termination and other NFV VNFs.

1.1 Bare Metal Results Highlights

In this test we compare Linux Ubuntu performance versus 6WIND Turbo Appliances for L3 forwarding and IPsec. L3 forwarding on Ubuntu is based on Quagga and IPsec on Ubuntu is based on strongSwan. 6WIND L3 forwarding is based on 6WIND Turbo Router and 6WIND IPsec is based on 6WIND Turbo IPsec. Details of the platform are available in Section 3.

BARE METAL HIGHLIGHTS

- 6WIND Turbo Router able to forward 138 Million of packets per second with 64-byte frames, 51 times faster than stock Quagga on Ubuntu Linux
- Turbo Router was able to sustain 115 Gbps of throughput with a dual-stack v4/v6 IMIX workload with less than 0.2% frame loss
- 6WIND Turbo IPsec demonstrated 70 Gbps of throughput which represents 6 times performance improvement over strongSwan
- Turbo IPsec was able to set up over 12,000 tunnels/second (48 times strongSwan on Ubuntu Linux) and maintain over 240,000 concurrent tunnels (8 times that of strongSwan)

1.1.1 Bare Metal Routing Performance

- High-performance L3 forwarding rates showing 8X to 50X speed improvements over Quagga on Linux
 - Aggregate maximum rate of 138 Mpps with 64 byte frames
 - Aggregate 115 Gbps with dual-stack v4/v6 IMIX frame size workload with no frame loss (similar results for IMIX 1, IMIX 2 and IMIX 3)

Select Test-Cases	Performance 6WIND Turbo IPsec vs. Quagga Ubuntu		
	Open-Source Comparison	6WIND	~ Multiplier
IPv4 64-byte frame uniform	2.7 Mpps (98% frame loss)	138 Mpps (*) (22% frame loss)	51x
IMIX2 v4/v6 dual-stack bi-directional	14 Gbps (84% frame loss)	115 Gbps (0.16% frame loss)	8

(*) This is the max capacity of the CEuT (23 Mpps per NIC, 6 NICs => 138Mpps)

Note: 6WIND control-plane performance was similar to Quagga on Linux with 6M BGP routes and 4M OSPF routes supported

1.1.2 Bare Metal IPsec Performance

- High-performance data-plane rates showing 5-6X speed improvements over strongSwan on Linux
 - Aggregate maximum rate of 70 Gbps throughput with 4 port-pairs
- High-performance control-plane performance with 8-48X improvement compared to strongSwan on Linux
- 240K maximum tunnels and a maximum setup rate of 12K tunnels/second

Select Test-Cases	Performance 6WIND Turbo IPsec vs. strongSwan Ubuntu		
	Open-Source Comparison	6WIND	~ Multiplier
Bi-directional UDP 1418-byte payload, 4 port-pairs	12.6 Gbps (82% frame loss)	70 Gbps (*) (0.48% frame loss)	6x
Maximum Concurrent IPsec Tunnels:	30K tunnels (@30 tunnel/sec)	240K tunnels (@500 tunnels/sec)	8x
Maximum IPsec Tunnel Setup Rate:	250 tunnels/sec (up to 10K tunnels)	12K tunnels/sec (up to 40K tunnels)	48x

(*) This is the maximum capacity of the IPsec tester that was used

1.2 Virtual Performance Tests Highlights

In this test we compare virtual deployments running on a KVM hypervisor with Linux Ubuntu host + Linux Ubuntu VM performance versus 6WIND Virtual Accelerator in the host + 6WIND Turbo Router or 6WIND Turbo IPsec in the VM. The L3 forwarding VM on Ubuntu is based on Quagga and the IPsec VM on Ubuntu is based on strongSwan. 6WIND’s L3 forwarding VM is based on 6WIND Turbo Router and 6WIND’s IPsec VM is based on 6WIND Turbo IPsec.

VIRTUAL DEPLOYMENT HIGHLIGHTS

- 6WIND Turbo Router on 6WIND Virtual Accelerator was able to forward 21 million packets per second with 64-byte frames, 10 times faster than stock Quagga on Ubuntu Linux VM on Linux Ubuntu host
- Turbo Router was able to sustain 80 Gbps of throughput with a dual-stack v4/v6 IMIX workload, representing 12 times stock Quagga
- 6WIND Turbo IPsec on 6WIND Virtual Accelerator demonstrated 53 Gbps of throughput which represents 44 times performance improvement over strongSwan on Ubuntu Linux VM on KVM
- Turbo IPsec was able to set up over 12,000 tunnels/second (48 times strongSwan on Ubuntu Linux) and maintain over 240,000 concurrent tunnels (8 times that of strongSwan)

1.2.1 Virtualized Routing Performance

- High-performance L3 forwarding rates showing 10X to 14X speed improvements over Quagga on Linux
- 6WIND Turbo Router can be used efficiently and effectively as an NFV VNF providing high-speed routing in service chains
 - Aggregate maximum rate of 21 Mpps with 64 byte frames
 - Aggregate 86 Gbps of throughput with dual-stack v4/v6 IMIX frame size workload

Select Test-Cases	Performance 6WIND Turbo Router vs. Quagga Ubuntu		
	Open-Source Comparison	6WIND	~ Multiplier
IPv4 64-byte frame uniform	2.14 Mpps (98% frame loss)	21.351 Mpps (76% frame loss)	10x
IPv4 128-byte frame uniform	1.977 Mpps (97.4% frame loss)	25.27 Mpps (0.26% frame loss)	13x
IMIX2 v4/v6 dual-stack bi-directional	6.4 Gbps (94.2% frame loss)	80.02Gbps (7.8% frame loss)	12x

Note: 6WIND control-plane performance is similar to Quagga on Linux with 6M BGP routes and 4M OSPF routes supported

1.2.2 Virtualized IPsec Performance

- Virtualized environment shows high-fidelity application quality of experience (QoE) over IPsec tunnels with high performance crypto data-plane forwarding – demonstrating 44X performance over strongSwan on Ubuntu

Test-Cases	Performance 6WIND Turbo IPsec vs. strongSwan Ubuntu		
	Open-Source Comparison	6WIND	~ Multiplier
Bi-directional UDP 1418-byte payload, 4 port-pairs	1.18 Gbps (98% frame loss)	52.98 Gbps (23% frame loss)	44x

Note: Control-plane performance is similar to Bare Metal IPsec Control-Plane Performance

2 BACKGROUND AND VALIDATION GOALS

The shift from rigid and costly dedicated hardware equipment to virtual and cloud-based architectures on standard servers promise cost savings and flexibility. However, when transitioning from high performance specialized hardware to standard servers, there have been performance trade-offs. With virtualization, the performance trade-offs become even greater.

On standard servers, Linux-based architectures cannot deliver the expected level of performance for several reasons. Standard interrupt-based Linux drivers running on the server platform are not designed to receive and send packets at a very high rate. The Linux networking stack doesn't scale on multi-core architectures.

Virtualization adds additional performance bottlenecks at the hypervisor level. The Linux virtual switch has bottlenecks as it is not designed to scale on a large number of cores and is not able to deliver the expected network bandwidth to VMs. The host/guest communication based standard virtual NIC drivers suffer from the Linux environment bottlenecks and the lack of multi-queue support.

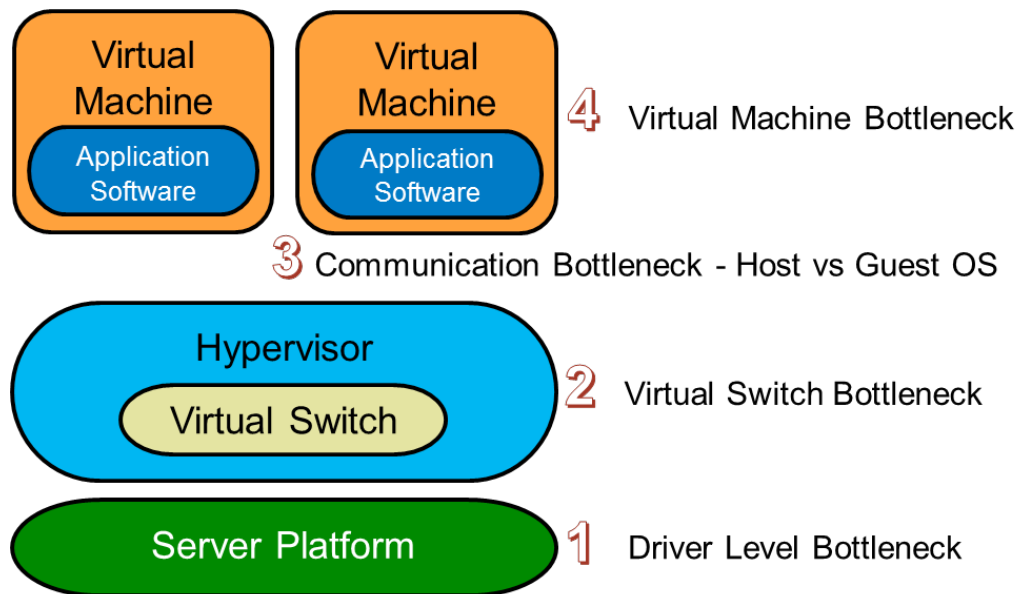


Figure 1. Networking performance bottlenecks in a virtual infrastructure

6WIND Speed Series products are designed around the following concepts:

- A high performance data-plane stack (fast path) specifically designed to scale linearly on multi-core architectures; this data-plane software runs on dedicated cores and resides beside the Linux networking stack.
- The fast path leverages the DPDK (Data Plane Development Kit) for maximum input / output performance.
- No modification in the software environment is required to integrate the fast path with the Linux kernel.
- A seamless integration with Linux control-plane daemons and processes including management (OpenStack, SDN Controller...) that makes the fast path transparent for the applications.

These concepts come from 6WIND's long standing 6WINDGate technology, which has been incorporated by many major Network Equipment Manufacturers (NEMs) in an OEM context into equipment running at many of the world's largest service providers.

6WIND Turbo Appliances are software appliances that provide high networking performance on COTS x86 servers. They can be deployed in both bare metal and virtualized environments. In order to get the best performance in virtualized environments, 6WIND Virtual Accelerator is used in the hypervisor to get rid of the performance bottlenecks described above.

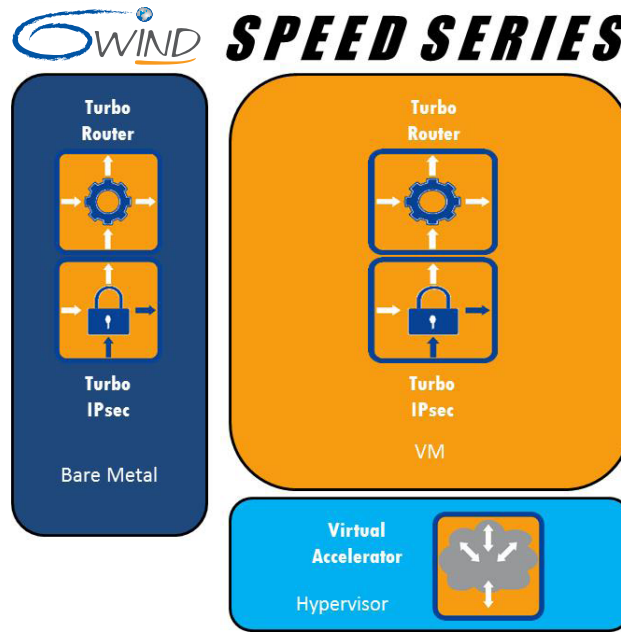


Figure 2. 6WIND Speed Series product portfolio

To allow for a reference comparison to the 6WIND Turbo Appliance products, we benchmarked the performance of vanilla Ubuntu Linux with the same routing and IPsec control-plane daemons installed. A first test campaign is done in a bare metal environment. A varying number of processing cores are assigned to the fast path, in order to demonstrate performance under various deployment scenarios, including an analysis of the least number of cores required to achieve a given level of performance.

In a second step, the Turbo Appliances are instantiated in a VM. 6WIND Virtual Accelerator is added at the hypervisor level to deliver high performance to the VM. The benchmarks done with Turbo Appliances are performed again for the virtualized configuration, with a fixed core distribution between Virtual Accelerator and Turbo Appliances, computed according to the bare metal results.

3 COMPUTE ENVIRONMENT UNDER TEST

3.1.1 System Configuration

The compute environment under test (CEuT) consists of hardware, 6WIND software components and the open-source comparison software listed in Table 6. The term CEuT will be used to denote the entire platform/system under test throughout the document that comprises the physical compute with network interfaces, the 6WIND software and the host OS / virtual libraries for the virtual scenarios.

CEuT Components	Model/Version
COTS Compute Hardware	
CPUs	Dual Intel(R) Xeon(R) CPU E5-2680 v3 @ 2.50GHz
Memory	Eight DDR4 2133 MHz Registered (buffered) 16GB (128GB total)
10G Adaptors	Six Intel X520-DA2 (dual port 10GbE) for total of 12 physical ports
6WIND Software	
6WIND Turbo Router	v1.0
6WIND Turbo IPsec	v1.0
6WIND Virtual Accelerator	v1.1
Open-Source Software	
Ubuntu Server (Host OS)	14.04.2
Quagga Ubuntu	0.99.22.4-3ubuntu1
strongSwan Ubuntu	5.1.2
Open vSwitch	2.0.1/2.1.3

Table 1. Compute Environment under Test (CEuT) specifications with approximate pricing

The validation was performed on a commercial server, which consists of an Intel E5 v3 Xeon platform with dual physical CPUs each having 12 physical cores (24 logical cores), with each logical core rated at 2.5GHz clock speed.

3.1.2 6WIND Configuration

The architecture of the 6WIND software is based on a high-performance fast path data-plane that is able to seamlessly interact and synchronize with standard Linux libraries including control-plane daemons used for routing, IPsec and other network services. This allows users to employ standard Linux tools to setup and monitor network functions.

The 6WIND fast path must be configured to use underlying compute cores that poll each of the physical and/or virtual network interfaces. In all cases, the cores used for polling are configured so that the Intel QPI bus between

the physical cores is not used for packet traversal. The cores are assigned to a specific network interface based on NUMA boundaries.

3.1.3 Network and CPU Block Diagram

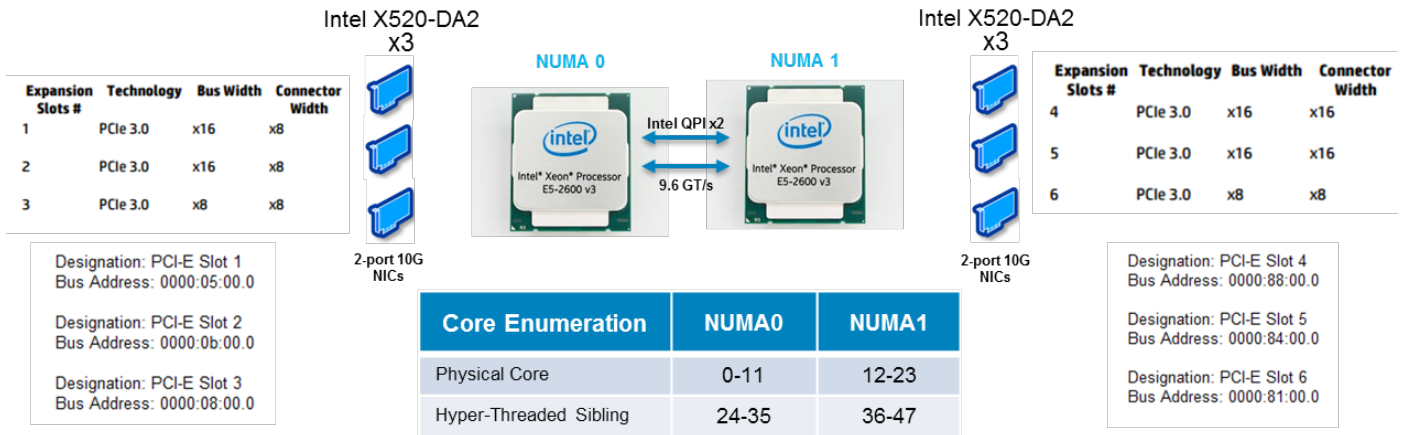


Figure 3. Compute Node CPU/Memory/PCI-E Interface Block Diagram

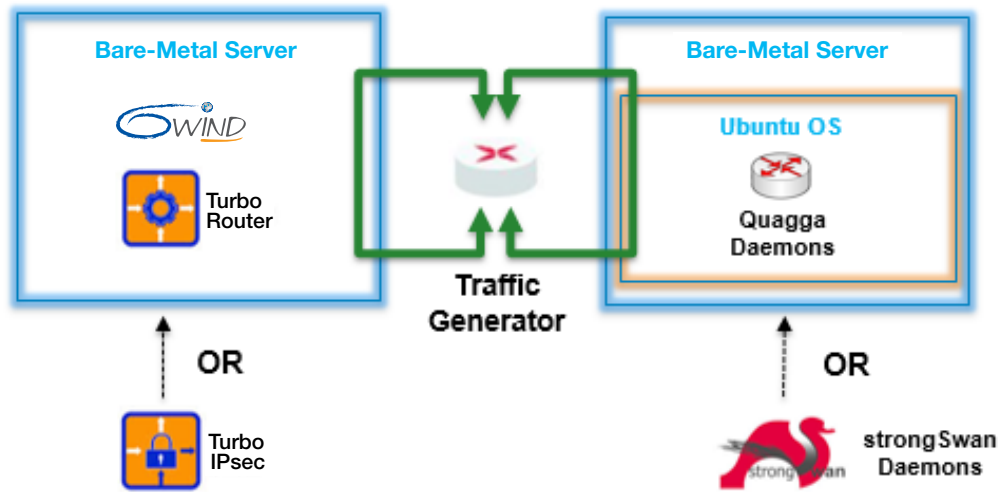
Six Intel dual-port 10G network adaptors (X520-DA2) are installed into available PCI-E slots within the server. Three network interface cards are connected to each of the physical CPUs and have the Linux designations shown in the bottom left and right of Figure X.

A total of 128GB of memory is available on the server with 64GB available to each NUMA node.

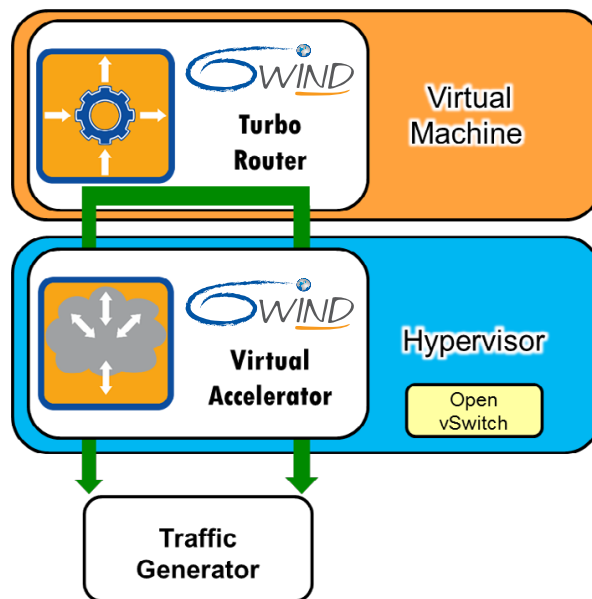
3.1.4 Bare Metal Configuration

The server is setup to boot the 6WIND Turbo Router or Turbo IPsec in bare metal scenarios using appropriate grub entries as well as stock Ubuntu. The standard VM images for the bare metal setting are provided by 6WIND as part of their Turbo Appliance offerings.

For the open-source routing and IPsec images, stock Ubuntu server 14.0.4.2 was installed on the machine and on top of that, the Quagga Ubuntu and strongSwan Ubuntu packages were installed. Optimizations were performed within the Ubuntu host such as disabling the firewall, installing the latest Linux Intel 10G network adaptor drivers and disabling flow control on the 10G network interfaces. Linux taskset was used to try and restrict cores assigned to Quagga or strongSwan daemons within Ubuntu. However, this had little impact on performance.



3.1.5 Virtual Machine Configuration



For the virtual machine setup, we employed a standard Ubuntu 14.04.2 server Linux distribution with associated KVM/QEMU hypervisor packages installed.

6WIND Virtual Accelerator is installed beside the Open vSwitch (OVS) in the hypervisor domain. Both use physical interfaces. The Turbo Appliances are interfaced with the Virtual Accelerator through a virtual interface (virtio). The 6WIND Virtual Accelerator is validated in 6WIND virtual deployment scenarios using OVS as an underlying switching platform. The fast path for the 6WIND Virtual Accelerator on the host OS is started first followed by the fast path for the guest Turbo Appliance virtual machines.

The 6WIND Virtual Accelerator is not enabled when benchmarking the open-source comparison but still employs OVS bridges to link virtual and physical interfaces.

4 TEST HARNESS

An Ixia Xcellon-Flex 10GE load module is used to generate deterministic L2/3 workloads across twelve 10GE ports up to 120 Gbps to assess the L3 forwarding and routing scalability of 6WIND Turbo Router and Virtual Accelerator products. The Ixia IxNetwork client application is used to generate L3 flows with various benchmarking traffic characteristics across the CEuT’s twelve physical 10G interfaces. Routing emulation is employed on test interfaces to generate millions of routes for the routing control-plane scalability validation scenarios.

The IPsec test harness consists of the Ixia PerfectStorm hardware platform for the IPsec client/initiator, private server endpoint emulations and UDP workload generation between them at high data rates. The Ixia IxLoad client application is used to configure IPsec tunnel pools, tunnel setup rates and UDP workloads over the established tunnels to assess the performance of the 6WIND Turbo IPsec appliance.

Test Harness Components	Model	Software Version
Hardware		
Ixia Chassis	XGS12	N/A
- PerfectStorm 10GE Load Modules	PS10GE8NG	N/A
Ixia Chassis	Optixa XM2	N/A
- Xcellon-Flex 10GE Load Modules	FlexAP10G16S	N/A
Software		
L2/3 and Routing Emulation	IxNetwork	7.41.945.9 EA
- Platform Software	IxOS	6.80.1100.9 EA-SP1
IPsec Emulation	IxLoad	6.50.0.380 EA
- Platform Software	IxOS	6.70.1050.7.9 EA

Table 2. Ixia test hardware and software versions used during the 6WIND performance validation

Ixia’s IxVM solution was also employed before official validation phases took place, as depicted in Figure 3. The IxVM solution consists of virtual machines that can be deployed within a supported hypervisor and support emulation consistent with Ixia’s physical hardware test ports. This allowed the CEuT configuration and test emulation to be created and debugged prior to real testing that was recorded with the Ixia hardware platforms.

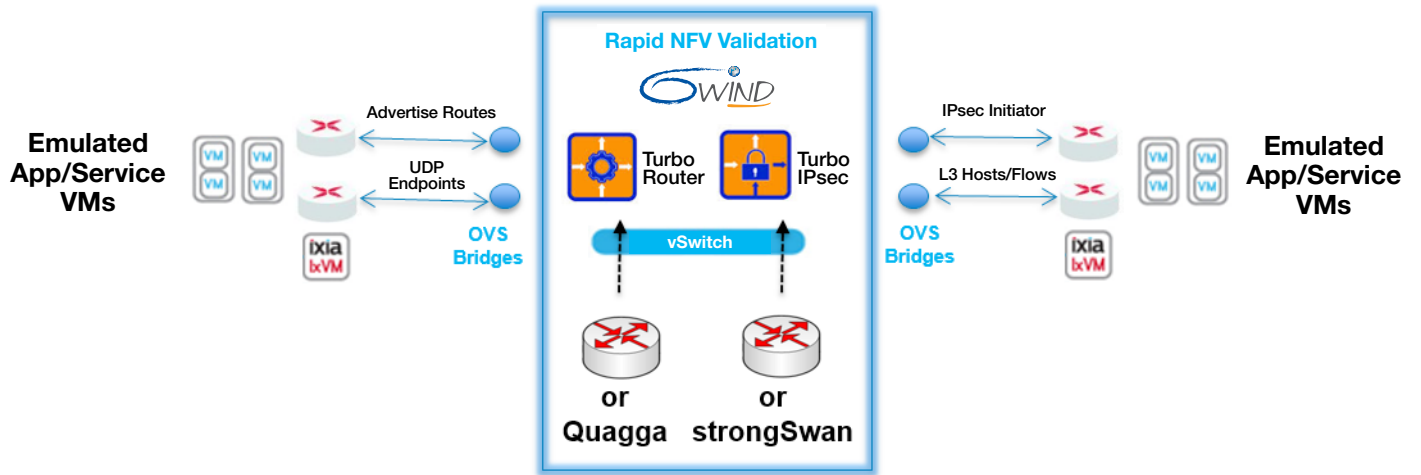


Figure 4. Ixia IxVM solutions for rapid NFV functional validation supporting IPsec/Routing control-plane and L3/UDP data-plane

5 SUMMARY TEST METHODOLOGY & RESULTS

The overall goal of the 6WIND bare metal tests is to measure the performance of the software over a range of different fast path core assignments to demonstrate how high performance can be achieved with the least number of cores and understand tradeoffs between handling uniform small frame sizes (not realistic) and Internet mix distributions (more realistic). The overarching methodology goal of the 6WIND virtual tests is instead to find the maximum performance of the 6WIND software using an optimized core distribution between the 6WIND Virtual Accelerator and the 6WIND Turbo Appliance VMs. A performance tuning stage was undertaken for virtual testing prior to recording measurements to find the optimal core distribution to achieve performance with the least number of cores.

Three major test categories comprise the methodology that is used to validate the performance of the 6WIND software and the open-source comparisons:

Validation Category	Open-Source	6WIND Software
Routing Data-Plane Performance: bare metal	Quagga Ubuntu	6WIND Turbo Router
Routing Data-Plane Performance: virtual	Open vSwitch / Quagga Ubuntu	6WIND Virtual Accelerator / Turbo Router
Routing Control-Plane Performance: bare metal	Quagga Ubuntu	6WIND Turbo Router
IPsec Performance: bare metal	strongSwan Ubuntu	6WIND Turbo IPsec
IPsec Performance: virtual	Open vSwitch / strong-Swan Ubuntu	6WIND Virtual Accelerator / Turbo IPsec

Table 3. 6WIND software validated in each category and open-source comparison

The overall methodology employs a progression through the test categories outlined above. L3 packet forwarding performance is established with the minimum functions (static routes) enabled in the 6WIND Turbo Router. L3 packing forwarding rates are reported in both packets per second (PPS) and gigabits per second (Gbps) to find maximum packet rates with small frame sizes and bit rates with Internet mix (IMIX) distributions. IMIX distributions comprised small frame sizes for both IPv4 (> 50% 64 byte frames) and IPv6 (> 50% 78 byte frames) in majority. The offered load is varied in increments of 25% rather than using 5 or 10% to reduce the number of permutations across deployment scenarios. Reported forwarding rates can actually be higher if more granular forwarding rates or RFC2544 binary searches were employed. Frame loss is reported for each offered load iteration.

The maximum forwarding rates above are then used as maximums for benchmarking the routing control-plane using routing protocols. The routing control-plane performance tests seek to find the maximum number of routes the CEuT can learn and verify by sending traffic over each advertised route at rates lower than the measured maximum forward rates for a given frame size. The data-plane and control-plane tests of the 6WIND Turbo Router are compared to Quagga daemons running on a Ubuntu instance. Quagga IP and routing configurations are shared between 6WIND Turbo Router and Quagga Ubuntu comparisons for consistency.

The IPsec performance category validates the control-plane and forwarding performance of the Turbo IPsec gateway and compares results against strongSwan running on Ubuntu acting as a VPN gateway. IPsec control-plane performance tests measure the maximum tunnel establishment rates and maximum concurrent tunnels the VPN

gateway under test can sustain by varying offered tunnel establishment rates and concurrent tunnels and reporting maximums by ensuring there are no tunnel failures. Tunnel state is validated by sending IPsec data-plane traffic over the tunnels once the tunnel establishment phase completes. IPsec forwarding performance is measured by sending UDP traffic with uniform frame sizes offered at the maximum load the test tool can generate across a fixed number of tunnels and measuring network transmit and receive bit rates in uni and bi-directional traffic patterns. The IPsec forwarding performance in bare-metal deployments were measured across 8 ports rather than 12 because of constraints accessing IPsec load generation hardware platforms during early testing cycles.

The virtual topology used for open-source comparisons consists of an Ubuntu host OS with KVM/Qemu hypervisor and Open vSwitch (OVS) packages installed within the host. A guest VM is installed within the hypervisor that is again Ubuntu with Quagga or strongSwan daemons enabled in a mutually exclusive fashion. OVS bridges are configured in a multi-homed fashion across the guest VM that link virtual ports with physical ports in the host OS. This allows traffic from the load generator to flow through the guest VM across physical test ports end-to-end.

5.1 Bare Metal Tests

5.1.1 Bare Metal L3 Routing Performance

The goal of the L3 forwarding performance test category is to yield the highest possible aggregate IP forwarding rates across the twelve 10G physical ports in the CEuT. The frame-loss test from RFC2544 is used to determine forwarding rates and frame loss across the desired spectrum of traffic emulation and deployment scenarios.

Iteration is employed rerunning the RFC2544 tests across:

- Emulated L3 traffic diversity: L3 flow count, uniform or distribution of frame sizes, traffic patterns, etc.
- Core scaling: increasing core assignment to 6WIND Turbo Appliance and 6WIND Virtual Accelerator fast paths
- CEuT Deployment scenarios: bare metal, virtual

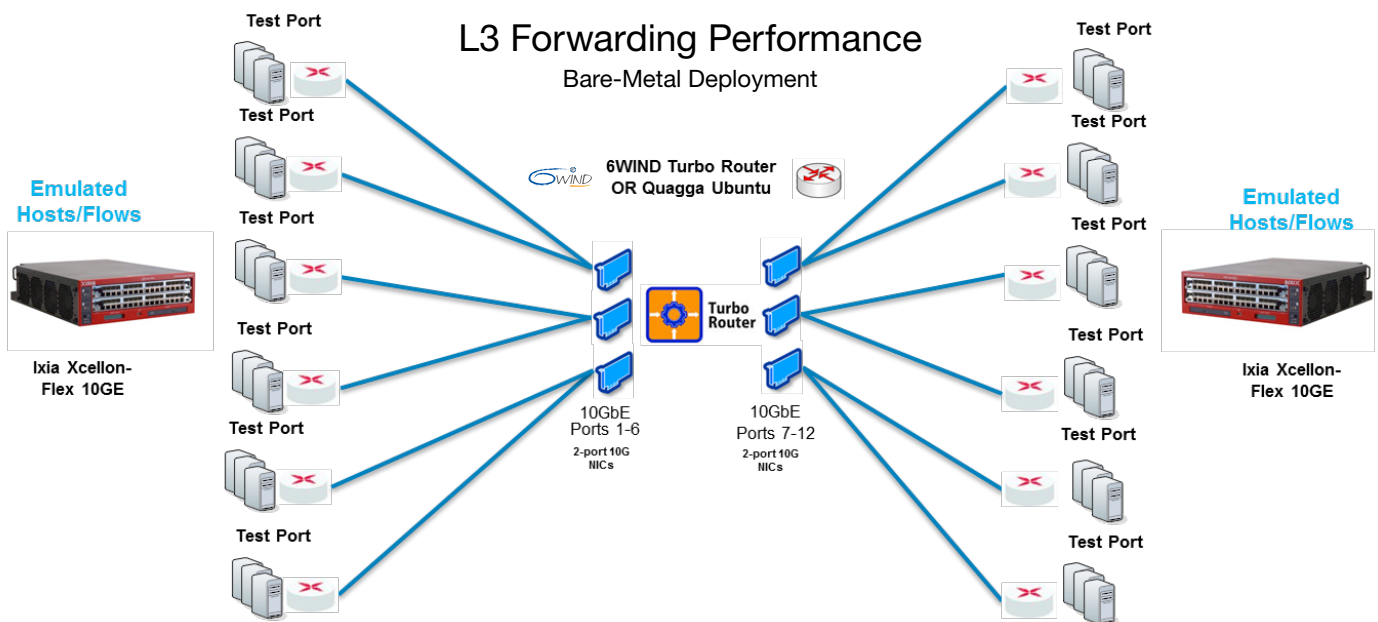


Figure 5. Bare-metal topology used for L3 forwarding test-cases

The emulation uses a varying number of emulated flows on each of twelve network subnets configured within the 6WIND Turbo Router. The 6WIND Turbo Router is configured for dual-stack IPv4 and IPv6 operation. Emulated flows are configured in different IPv4 and IPv6 ratios to evaluate whether the Turbo Router is suitable for carrier IPv4/v6 co-existence deployments enabling carriers in the effort to become fully IPv6 ready. IMIX (distributions of commonly observed Internet frame sizes) test variants are included to validate that performance can be maintained with a more realistic distribution of mixed frames sizes.

5.1.1.1 Bare Metal L3 Routing Data-plane Performance

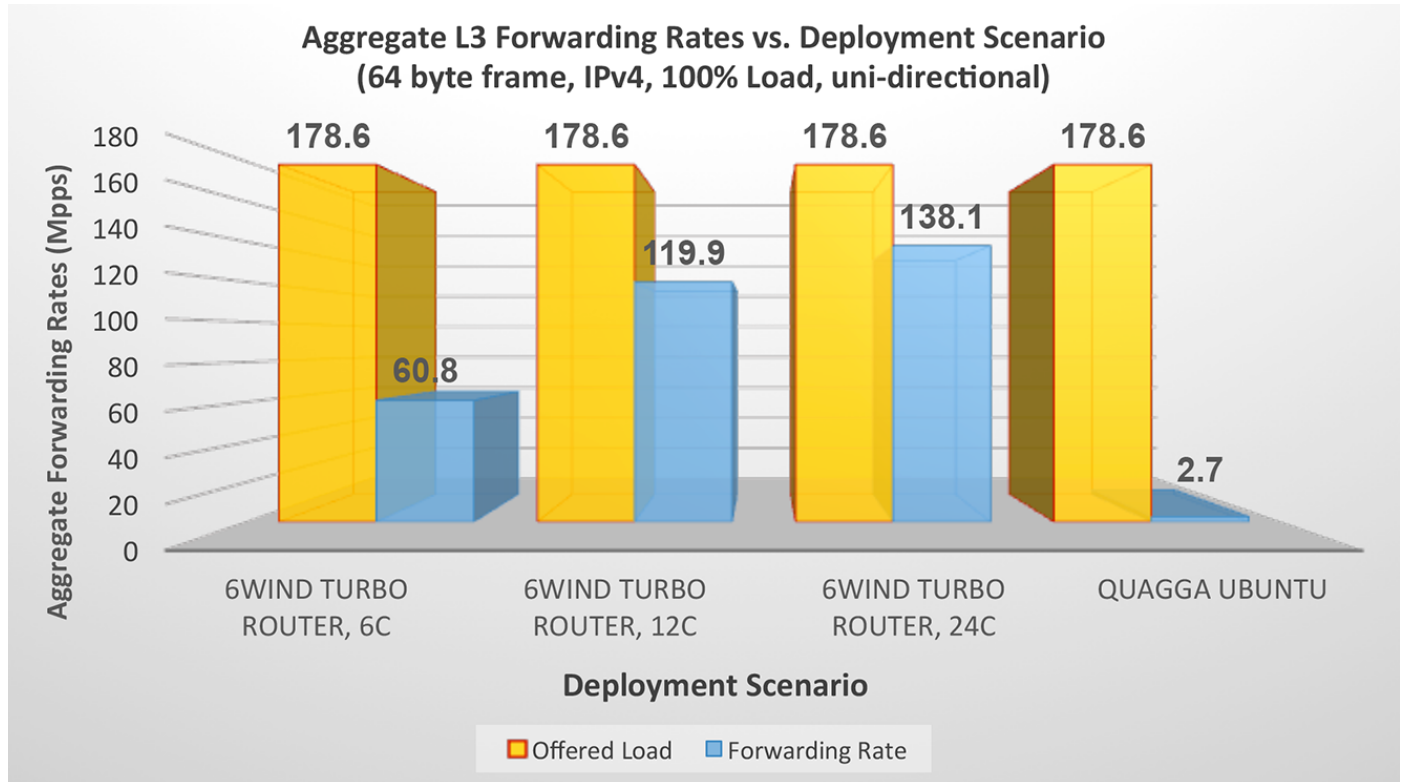


Figure 6. 6WIND Turbo Router (6/12/24 cores assigned to fast path) and Quagga Ubuntu aggregate L3 forwarding performance in bare-metal deployment (L3 emulation: twelve port-pairs, uni-directional, 64 byte uniform frame-size, 100% offered load)

Figure 6 shows the aggregate IPv4 L3 forwarding performance with a uniform 64 byte frame size workload in bare-metal deployment. The 6WIND Turbo Router is able to forward 60.8M packets per second (pps) with 6 cores assigned to the fast path. This scales linearly to almost 120 Mpps when 12 cores are assigned to the fast path whereby each core is able to process 10 Mpps. **The Intel X520-DA2 NICs within the CEuT have a known limitation that prevents more than 23-24 Mpps aggregate from being forwarded.** The 6WIND Turbo Router hits this ceiling when 24 cores are assigned to the fast path (6 NICs * 23M) at approximately 138Mpps.

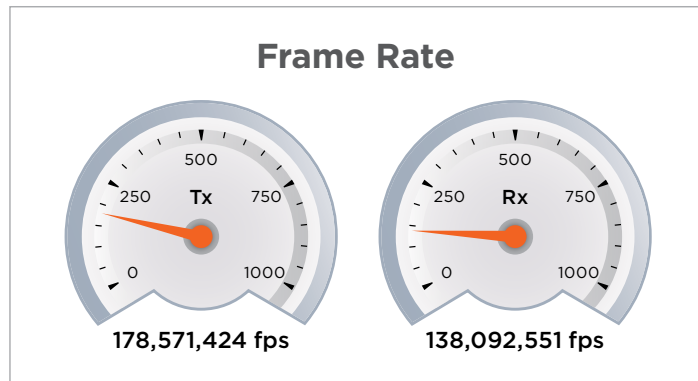


Figure 7. 6WIND Turbo Router (24 cores assigned to fast path) aggregate L3 forwarding performance in bare-metal deployment (L3 emulation: 64 byte uniform frame-size, 100% offered load)

Figure 7 depicts the IPv4 aggregate offered and received frames for the 6WIND Turbo Router using the same workload generated in Figure 5 with 24 cores assigned to the fast path. 178.6 Mpps of traffic is offered across twelve port-pairs generated from Ixia test ports and 138.1 Mpps is the measured receive rate.

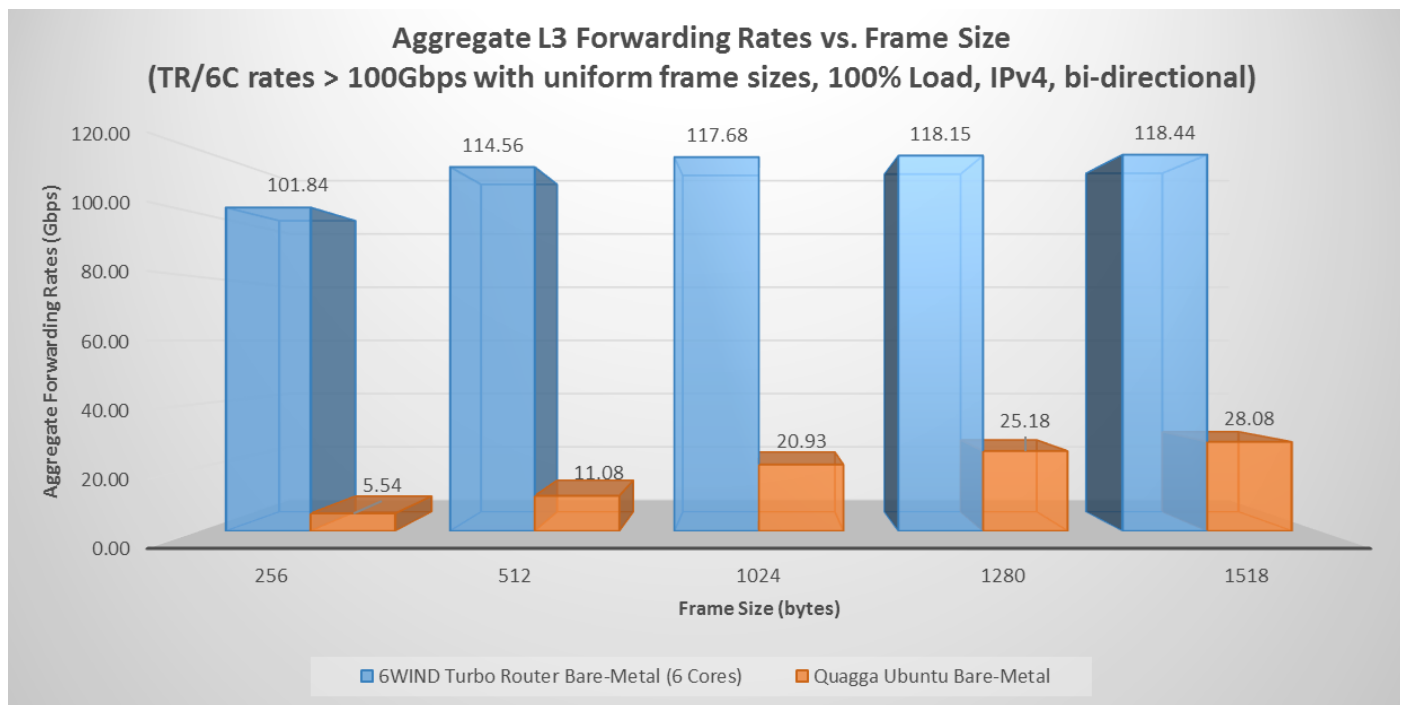


Figure 8. 6WIND Turbo Router (6 cores assigned to fast path) versus Quagga Ubuntu maximum L3 forwarding performance in bare-metal deployment (L3 emulation: twelve port-pairs, bi-directional aggregate L3 forwarding performance, uniform frame-sizes (256-1518 bytes), 100% offered load)

Figure 8 depicts the L3 forwarding performance of the 6WIND Turbo Router with only 6 cores assigned to the fast path. Greater than 100 Gbps is achieved using uniform frame sizes ranging from 256–1518 bytes sizes with maximum bit rates of ~ 118 Gbps for 1024–1518 byte frame sizes. The performance of Quagga Ubuntu is also shown as a series in Figure 8 and the performance of the 6WIND Turbo Router is ~ 5–20 times the performance of Quagga Ubuntu with an increasing multiplier with decreasing frame sizes. The 6WIND Turbo Router is configured to use only 6 of the available 48 logical cores within the system whereas the Quagga Ubuntu bare-metal comparison is not restricted in any fashion.

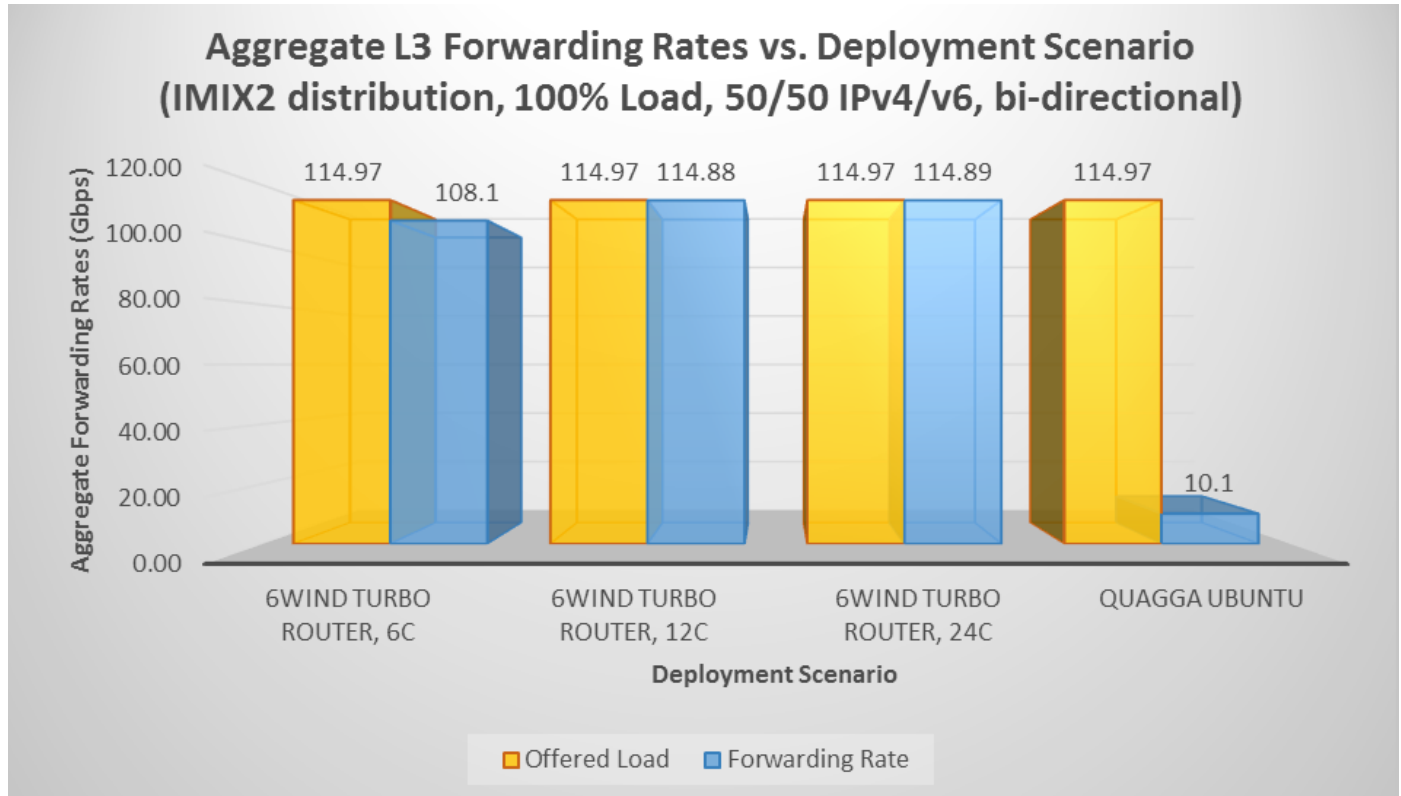


Figure 9. 6WIND Turbo Router (6/12/24 cores assigned to fast path) and Quagga Ubuntu L3 forwarding performance in bare-metal deployment (L3 emulation: twelve port-pairs, bi-directional aggregate, IMIX2 - 50/50 IPv4/v6 ratio, 100% offered load)

The 6WIND Turbo Router forwarding performance is impressive using IPv4, IPv6 and dual-stack IMIX distributions. Figure 9 depicts the L3 forwarding performance of the 6WIND Turbo Router with an IMIX2 (50/50 IPv6/v6) bi-direction with close to 115 Gbps bit forwarding rates. The IMIX workloads generate a maximum of approximately 115 Gbps of offered load due to limitations of inter-packet gaps using non-uniform frame sizes. The 6WIND Turbo Router performs with nearly zero frame loss (0.08%) when forwarding IMIX2 at the ~115Gbps maximum offered load when only 12 cores are assigned to the fast path. The Quagga Ubuntu comparison can only forward 10 Gbps with the equivalent IMIX2 workload which is approximately 11 times less than the 6WIND Turbo Router.

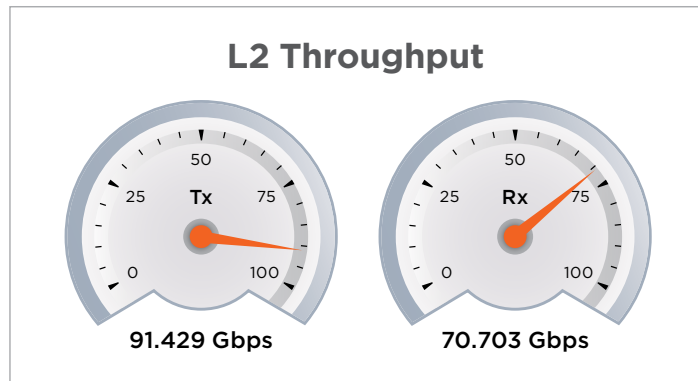


Figure 10. 6WIND Turbo Router (12 cores assigned to fast path) aggregate L3 forwarding performance in bare-metal deployment (L3 Emulation: twelve port-pairs, bi-directional aggregate L3 forwarding performance, IMIX2 - 50/50 IPv4/v6 ratio, 100% offered load)

5.1.1.2 Bare Metal L3 Routing Control-plane Performance

The goal of the routing validation category is to determine the 6WIND Turbo Router control-plane performance using a series of BGP and OSPF route/peering scalability test scenarios. The validation demonstrates the ability for the Turbo Router’s routing information base (RIB) to hold a large number of routes from one or many routing peers/adjacencies and its ability to dynamically add/remove entries from the RIB.

This validation category consists of two test-cases:

- Route/Peer Scalability
- Route Convergence

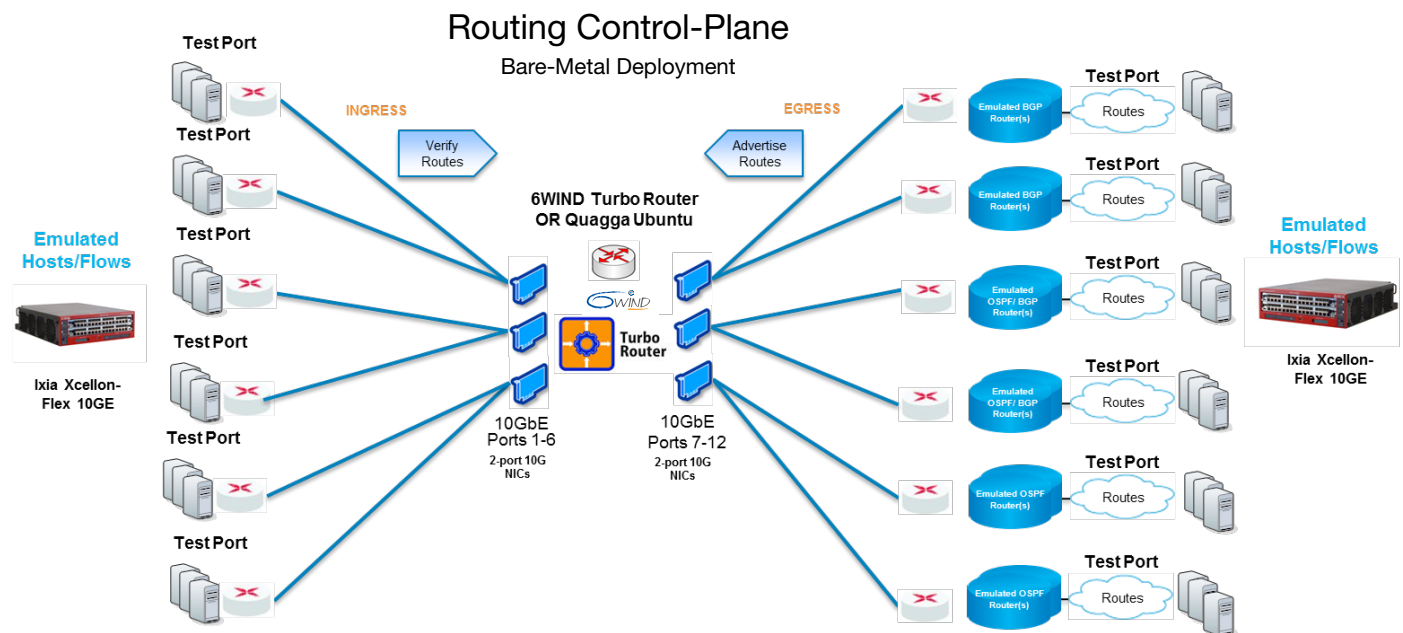


Figure 11. Topology used for routing control-plane performance test-cases

6WIND Speed Series

Distinct peers are configured on each of the egress test ports and establish peering sessions with the 6WIND Turbo Router or Quagga Ubuntu baseline. Different numbers of routes are advertised to the router from the emulated routers on the egress test interfaces. Traffic is sent from ingress ports with destinations matching all of the routes advertised by emulated routers on egress ports. Route learning by the router is validated by transmitting data-plane traffic below maximum forwarding rates found in the L3 forwarding test category for a given frame size and checking that traffic arrives at egress ports with no frame loss. The RFC2544 frame loss test is used for this purpose with ingress port(s) transmitting to all route prefixes advertised from egress port(s). This ensures the learned routes are sustained in the router's routing tables.

The statistics output from the bgpd/ospfd daemons for both the 6WIND Turbo Router and Quagga Ubuntu comparison are also employed to validate that peering/adjacency sessions are established with the router under test and the total number of routes is learned for each iteration.

A maximum of 12 emulated peers/adjacencies that advertise routes is attempted from test interfaces. In these scenarios, each test port is configured with an emulated router advertising routes and also sends traffic to another egress port.

A portion of the iterations performed for the routing scalability validation are shown for the 6WIND Turbo Router and Quagga Ubuntu baseline. The 6WIND Turbo Router can learn up to 6M routes from one emulated BGP peer or from up to four peers. The route capacity of the routers under test diminishes when more BGP peers are emulated from test interfaces.

Routing & L2/3 Emulation				Routes Learned	Frame Loss %	Deployment Scenario
Total Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)			
6M	1	0	512	6M	0	bm, 1c, TR
6M	4	0	512	6M	0	bm, 1c, TR
4M	0	1	512	4M	0	bm, 1c, TR
4M	0	2	512	4M	0	bm, 1c, TR

Table 4. BGP and OSPF Routing Scalability for 6WIND Turbo Router in bare-metal deployment

Routing & L2/3 Emulation				Routes Learned	Frame Loss %	Deployment Scenario
Total Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)			
6M	1	0	512	6M	0	bare-metal
6M	4	0	512	6M	0	bare-metal
4M	0	1	512	4M	0	bare-metal
4M	0	2	512	4M	0	bare-metal

Table 5. BGP and OSPF Routing Scalability for Quagga on Ubuntu in bare-metal deployment

6WIND Speed Series

The maximum route capacity with OSPF emulation for both the 6WIND Turbo Router and Quagga Ubuntu is 4M routes. Advertising beyond 4M routes from one or two OSPF adjacencies resulted in failed route learning or frame loss across some of the advertised routes during the data-plane traffic validation step.

The convergence measurements in the tables below are obtained using a subset of the topology in Figure 11. Three test interfaces are employed consisting of an ingress port and two egress ports. The two egress ports each have an emulated router that advertise the same routes to the router under test but with different weights (BGP) pre-determined for each router or different costs (OSPF) sent directly in the advertised routes. This establishes both a primary and secondary path across the router under test to the egress ports. Data-plane traffic is sent from the ingress port to all the routes advertised from the emulated routers. The routes on the primary path are withdrawn from the emulated router on the primary path and traffic is observed to stop propagating on the primary path and arrive on the secondary path. The routes are re-advertised (TO) from the emulated router on the primary path and the time it takes data-plane traffic to arrive again on the primary path for all advertised routes (T1) is measured as the convergence time.

The BGP and OSPF convergence times between the 6WIND Turbo Router and the Quagga on Ubuntu baseline were similar. Some iterations failed as the number of duplicate routes advertised on primary and secondary paths increased.

Routing & L2/3 Emulation				Convergence Times (sec)	Deployment Scenario
Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)		
1M	2	0	512	1.2	bm, 1c, TR
2M	2	0	512	2.69	bm, 1c, TR
4M	2	0	512	6.1	bm, 1c, TR
6M	2	0	512	9.9	bm, 1c, TR
20K	0	2	512	7.1	bm, 1c, TR
50K	0	2	512	17.1	bm, 1c, TR
100K	0	2	512	35.2	bm, 1c, TR
500K	0	2	512	170.1	bm, 1c, TR
1M	0	2	512	344	bm, 1c, TR
2M	0	2	512	580	bm, 1c, TR

Table 6. BGP and OSPF Routing convergence times for 6WIND Turbo Router in bare-metal deployment

Routing & L2/3 Emulation				Convergence Times (sec)	Deployment Scenario
Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)		
1M	2	0	512	2.2	bm, quagga
2M	2	0	512	4.3	bm, quagga
4M	2	0	512	9.5	bm, quagga
6M	2	0	512	11.3	bm, quagga
20K	0	2	512	7.1	bm, quagga
50K	0	2	512	15.5	bm, quagga
100K	0	2	512	34.7	bm, quagga
500K	0	2	512	176	bm, quagga
1M	0	2	512	357	bm, quagga
2M	0	2	512	672	bm, quagga

Table 7. BGP and OSPF Routing convergence times for Quagga Ubuntu in bare-metal deployment

Both Quagga Ubuntu and the 6WIND Turbo Router Quagga control-plane daemons perform well up to millions of routes from several peers. The 6WIND Turbo Router employs the underlying Quagga daemons for routing allowing for seamless marriage between Linux open-source and the high-performance 6WIND Turbo Router fast path. Linux fans will appreciate the ability to troubleshoot routing issues using standard routing and network monitoring packages.

5.1.2 Bare Metal IPsec Performance

The goal of the IPsec Performance validation category is to benchmark the control-plane scalability of the 6WIND Turbo IPsec appliance and its data forwarding performance once tunnels are established. The tests are also run against strongSwan on Ubuntu to baseline the 6WIND Turbo IPsec appliance against the Linux open-source equivalent.

A tunnel capacity test case is employed to measure the total number of open or concurrent tunnels the VPN gateway under test can maintain with short-lived data transactions occurring over the tunnels. The rate at which the VPN gateway can process tunnels is important to verify, as many deployment scenarios have VPN traffic that exhibits sudden spikes in tunnel rates, such as users logging in all at once in the morning (especially for remote access VPN deployment scenarios). A tunnel setup rate test case is used to measure the maximum rate of tunnels the 6WIND Turbo IPsec appliance can handle per second.

The final test-case benchmarks the overall data-plane performance of the 6WIND Turbo IPsec appliance while it encrypts/decrypts network traffic over the IPsec tunnels and measures the aggregate network forwarding rates for UDP traffic. The validation category consists of three test-cases:

- Concurrent Tunnel Capacity
- Tunnel Setup Rate
- IPsec Forwarding Performance

IPsec Performance Bare-Metal Deployment

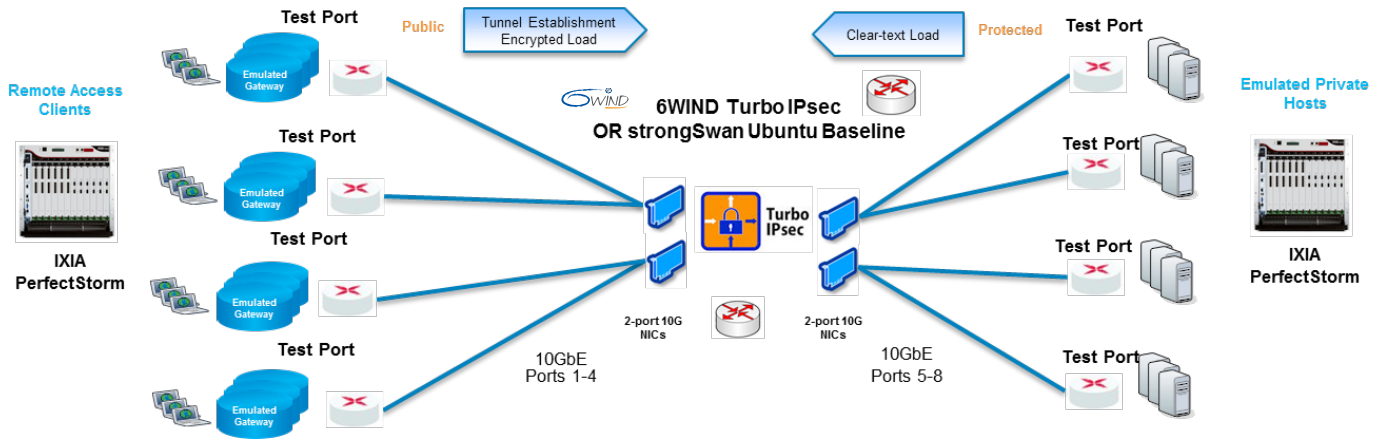


Figure 12. Topology used for all IPsec performance test-cases in bare-metal deployment validation scenarios

The 6WIND Turbo IPsec or strongSwan Ubuntu baseline are configured with four public interfaces that terminate IPsec tunnels from emulated remote access IPsec initiator test ports. The other four ports are configured with emulated host endpoints that are on private networks and terminate traffic from IPsec initiator ports in port pairs. Each of the IPsec initiator ports is configured with an emulated gateway with pools of remote access IPsec clients establishing tunnels with the VPN gateway under test. The IPsec forwarding performance test-case sends UDP in port-pairs uni and bi-directionally between public and private host endpoints.

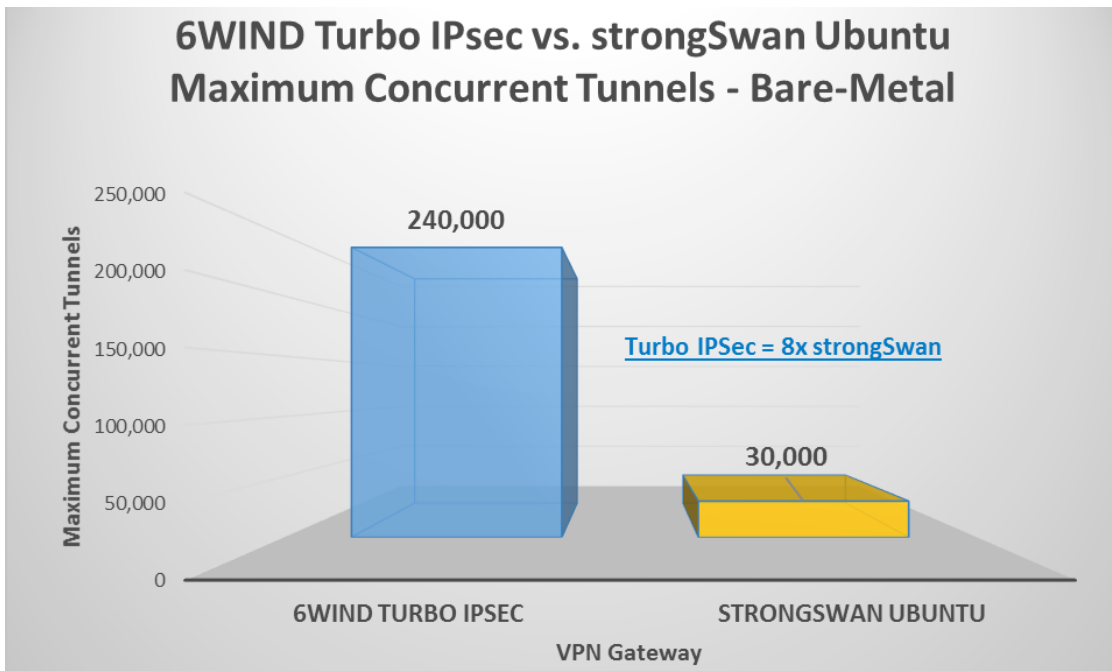


Figure 13. Maximum concurrent tunnels for 6WIND Turbo IPsec, strongSwan Ubuntu in bare-metal deployment

The maximum concurrent tunnels that can be setup with the 6WIND Turbo IPsec appliance in bare-metal deployment is 240K tunnels at 500 tunnels/sec, which compares much more favorably than 30K tunnels with strongSwan Ubuntu at 40 tunnels/sec.

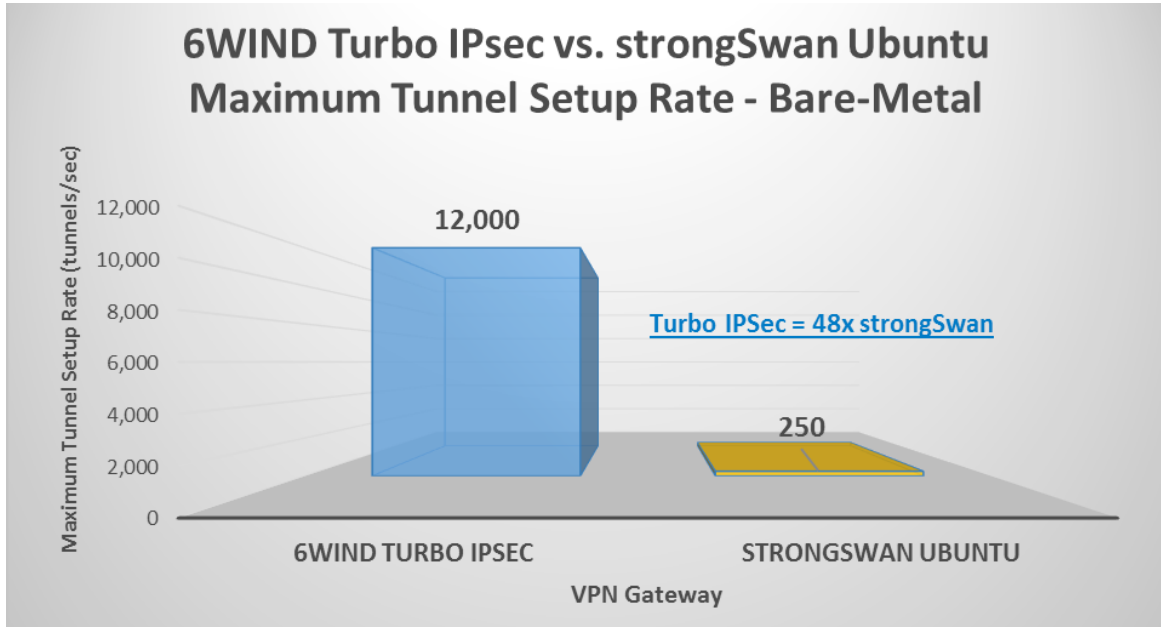


Figure 14. Maximum tunnel setup rate for 6WIND Turbo IPsec, strongSwan Ubuntu in bare metal deployment

As for maximum tunnel setup rate, the 6WIND Turbo IPsec appliance in bare-metal deployment delivered 12K tunnels/sec up to 40K total tunnels versus 250 tunnels/sec with strongSwan Ubuntu with 10K total tunnels. Beyond the 40K tunnels, the tunnel setup rate for the 6WIND was reduced to closer to 2K tunnels/sec.

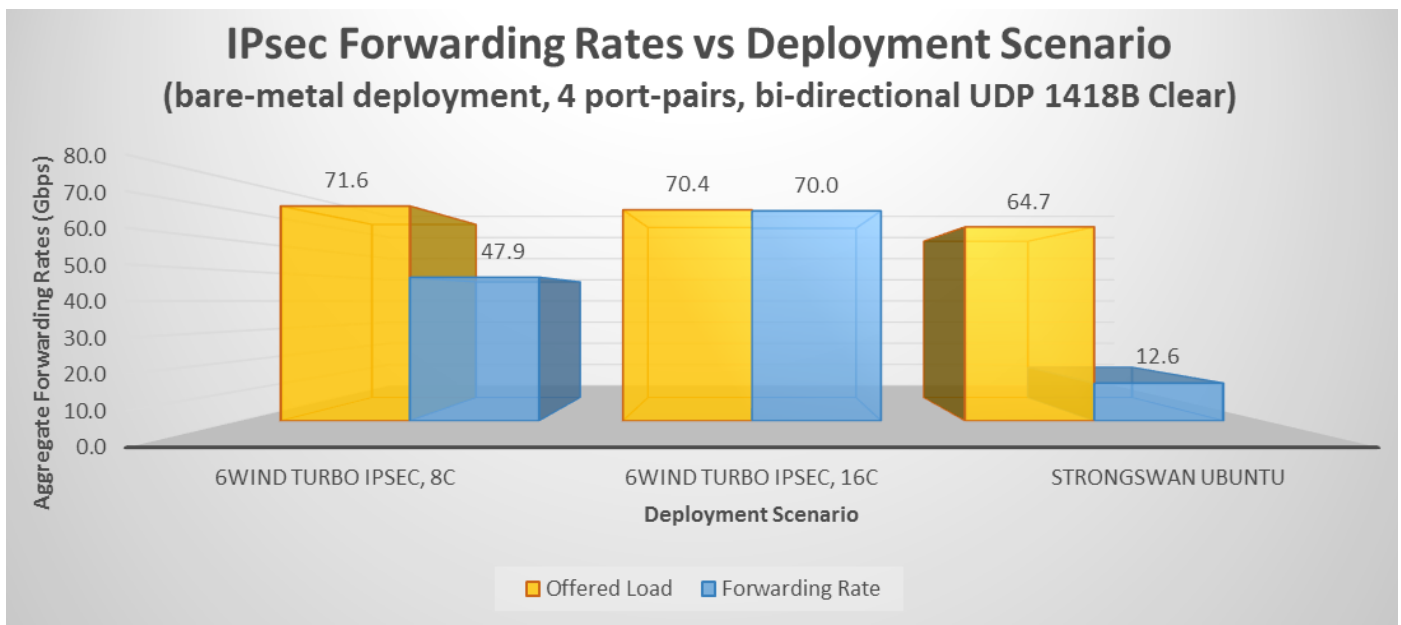


Figure 15. IPsec UDP forwarding rates for 6WIND Turbo IPsec and strongSwan Ubuntu in bare metal deployment across 4 port-pairs using 1418-byte cleartext payload

For forwarding rates, the 6WIND Turbo IPsec appliance was able to achieve 70 Gbps (the maximum traffic generation rate of the testing harness) using 16 cores. This compares favorably to the 12.6 Gbps achieved by strongSwan Ubuntu with all cores made available to it.

5.2 Virtual Environment Performance

In the virtual environment setup, similar tests for routing performance and IPsec performance were repeated. However, this time, we wanted to determine what the ideal mix of cores assigned to 6WIND Virtual Accelerator and to the Turbo appliances would achieve maximal efficiencies on a KVM hypervisor system.

5.2.1 Virtual Routing Performance

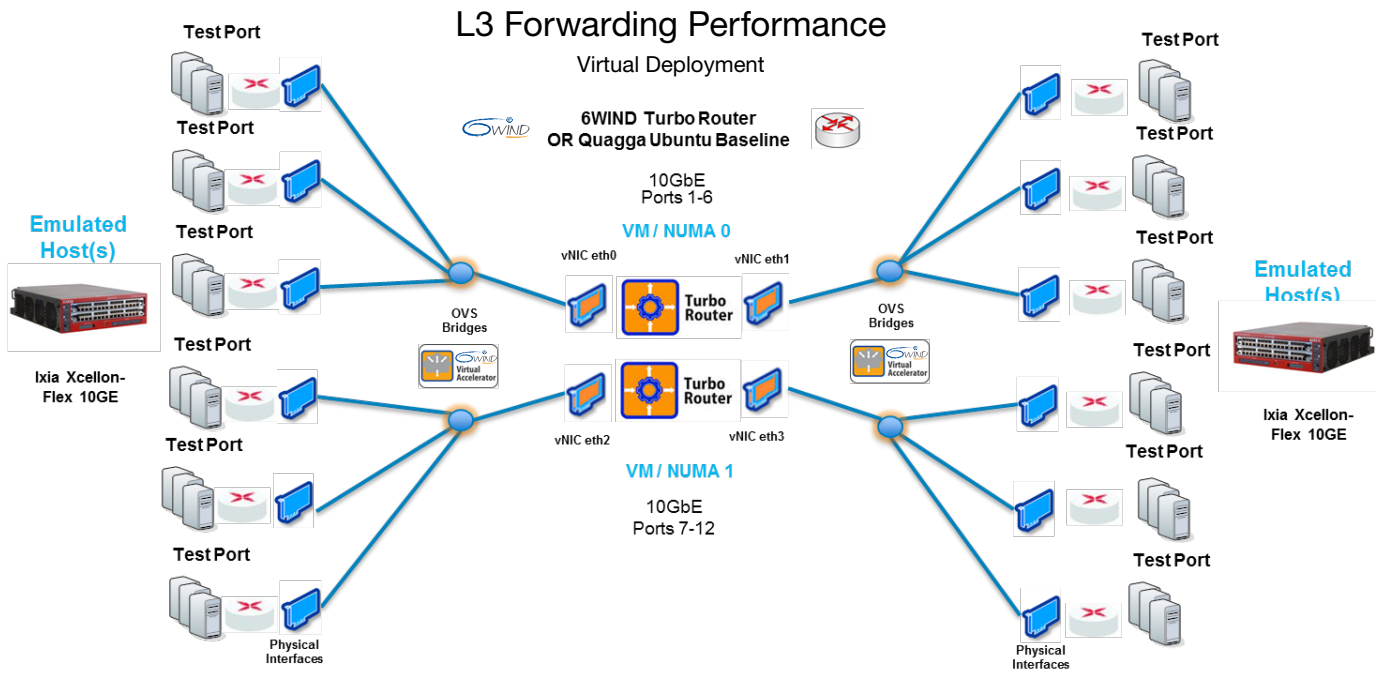


Figure 16. Virtual topology used for L3 forwarding test-cases

The figure above shows the virtual topology that was validated in the L3 forwarding test category and is similar to that of the bare metal scenario. To demonstrate maximum performance, we ensured that port-pairs did not cross NUMA boundaries. To achieve this, we instantiated two 6WIND Turbo Router virtual machines, each running within NUMA boundaries. The Turbo Router VMs were configured with two virtual interfaces each tied to L3 test ports via separate OVS bridges. Three physical network interfaces are also associated to each OVS bridge to allow test traffic to flow through the 6WIND Turbo Router virtual instance under test from physical Ixia 10G test ports. The 6WIND Virtual Accelerator is installed and configured within the host OS to accelerate the switching performance of standard OVS.

For the virtual environment, we focused on primarily forwarding performance and did not rerun the control plane tests—we have every reason to believe that the same number of maximum routes (as on bare metal) can be achieved, as long as the memory capacity is sufficient.

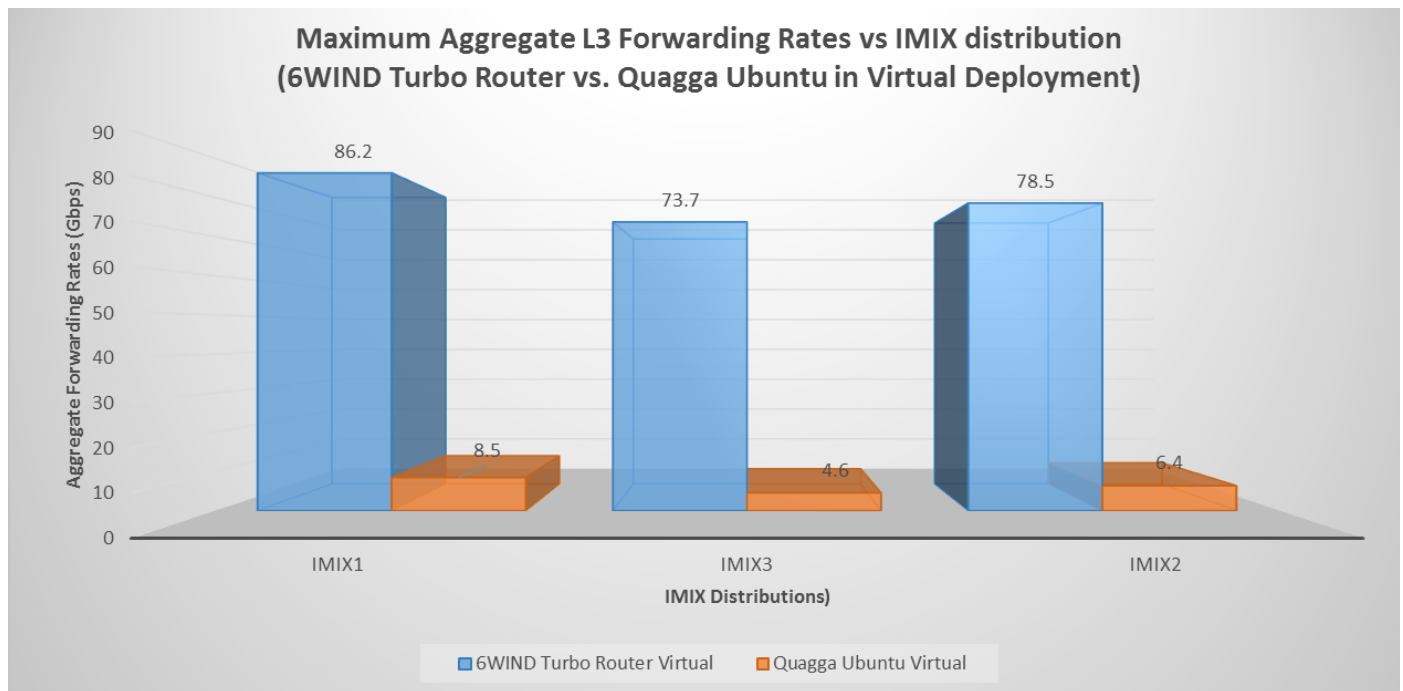


Figure 17. 6WIND Turbo Router versus Quagga Ubuntu maximum L3 forwarding performance in virtual deployment; L3 emulation: IMIX1 (IPv4), IMIX3 (IPv6), IMIX2 (IPv4/v6)

As captured in the above figure, the 6WIND Turbo Router / Virtual Accelerator combination delivers excellent performance in virtual deployments versus Quagga Ubuntu. L3 forwarding performance with all IMIX frame size distributions employed in the validation measure consistently over 10-15x Quagga Ubuntu. The figure above highlights the performance delta with between 73.7-86.2 Gbps L3 forwarding rates with the 6WIND Turbo Router / Virtual Accelerator versus 4.6-8.5 Gbps L3 forwarding rates with Quagga Ubuntu without OVS acceleration.

5.2.2 Virtual IPsec Performance

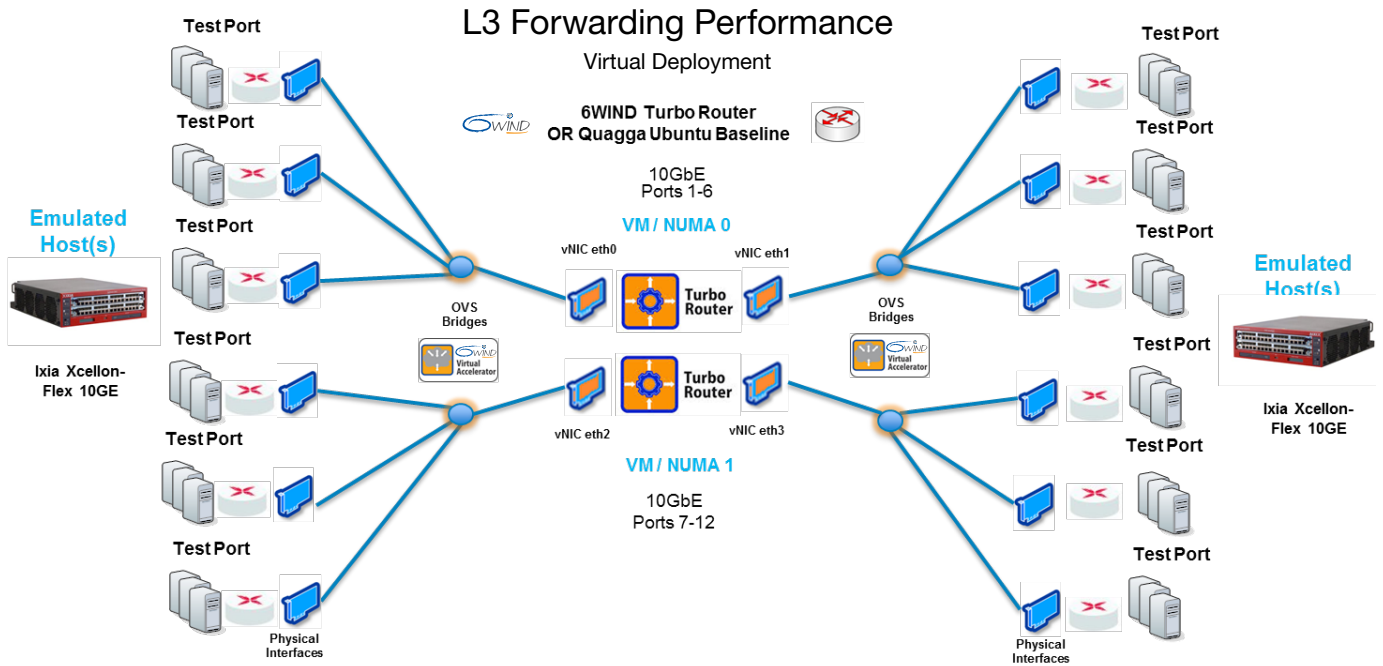


Figure 18. Topology used for all IPsec performance test-cases in virtual deployment validation scenarios

To examine the performance of 6WIND Turbo IPsec compared to strongSwan on Ubuntu in a virtual hypervisor-based environment, we constructed a topology as depicted in Figure 18 that is similar to the topology used for the virtual L3 forwarding validation category.

Based on our testing, we were able to determine that the maximum tunnel setup rate delivered by the 6WIND Turbo IPsec appliance in virtual deployment is 5K tunnels/sec with 40K total tunnels versus 250 tunnels/sec with strongSwan Ubuntu with 10K total tunnels, represent a significant advantage.

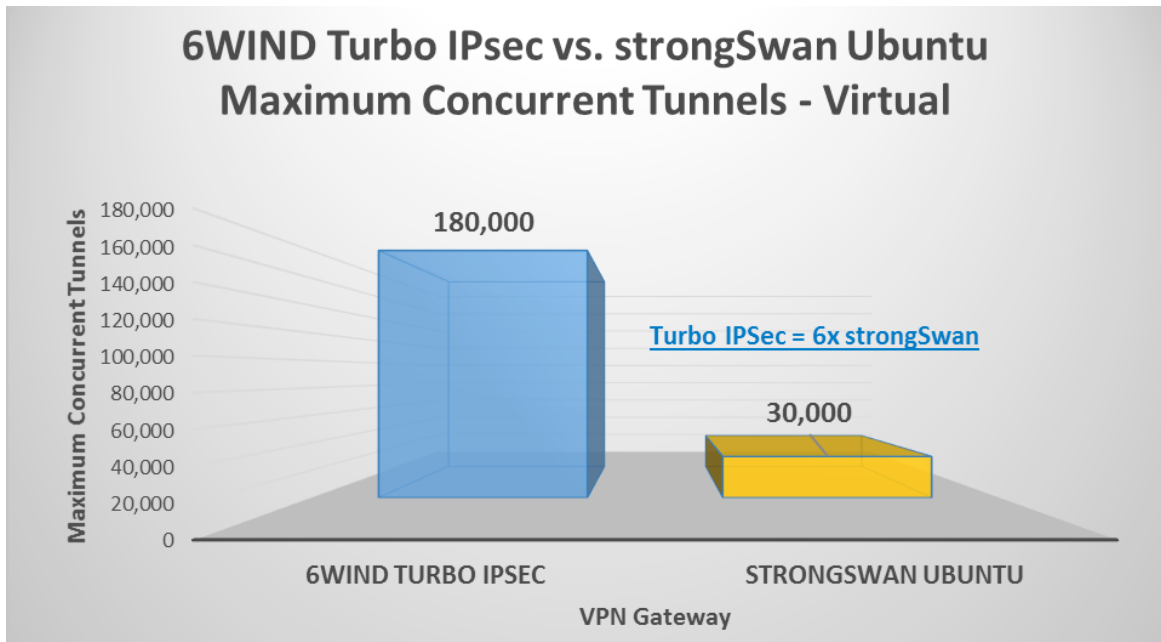


Figure 19. Maximum concurrent tunnels for 6WIND Turbo IPsec, strongSwan Ubuntu in virtual deployment

The maximum concurrent tunnels that can be setup with the 6WIND Turbo IPsec appliance in virtual deployment is 180K tunnels at 400 tunnels/sec, which compares much more favorably than 30K tunnels with strongSwan Ubuntu at 40 tunnels/sec.

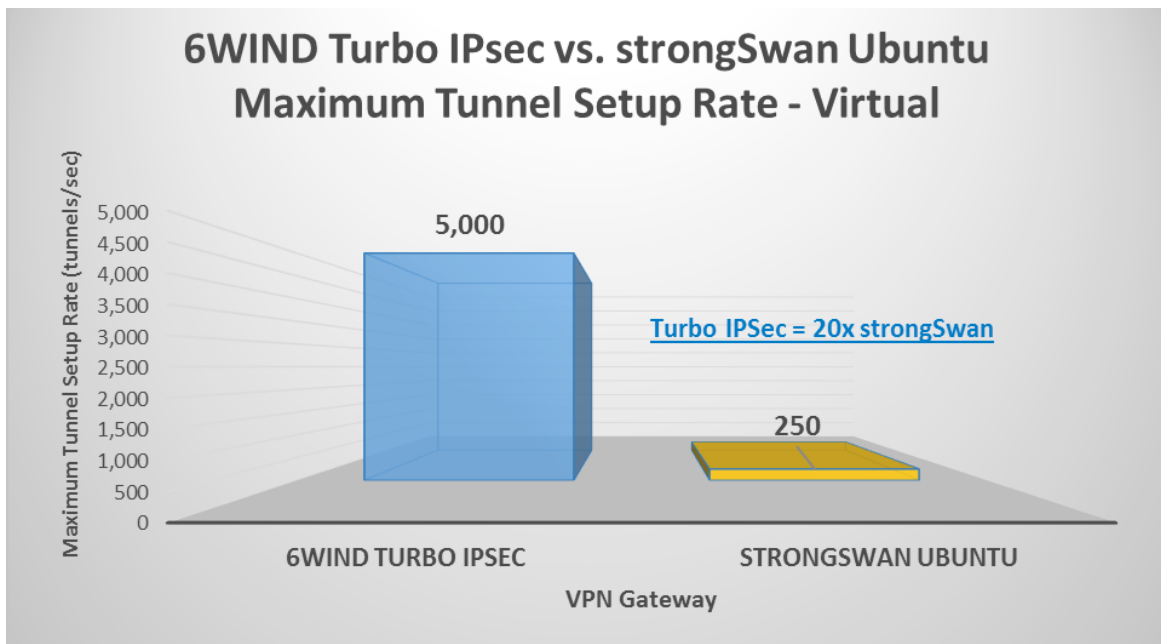


Figure 20. Maximum tunnel setup rate for 6WIND Turbo IPsec, strongSwan Ubuntu in virtual deployment

As for maximum tunnel setup rate, the 6WIND Turbo IPsec appliance in virtual deployment delivered 5K tunnels/sec up to 40K total tunnels versus 250 tunnels/sec with strongSwan Ubuntu with 10K total tunnels. Beyond the 40K tunnels, the tunnel setup rate for the 6WIND was reduced to closer to 1K tunnels/sec.

As for IPsec forwarding rates, we were able to achieve close to 53 Gbps of traffic compared to 1.18 Gbps achieved by strongSwan on Ubuntu, an impressive 45x improvement.

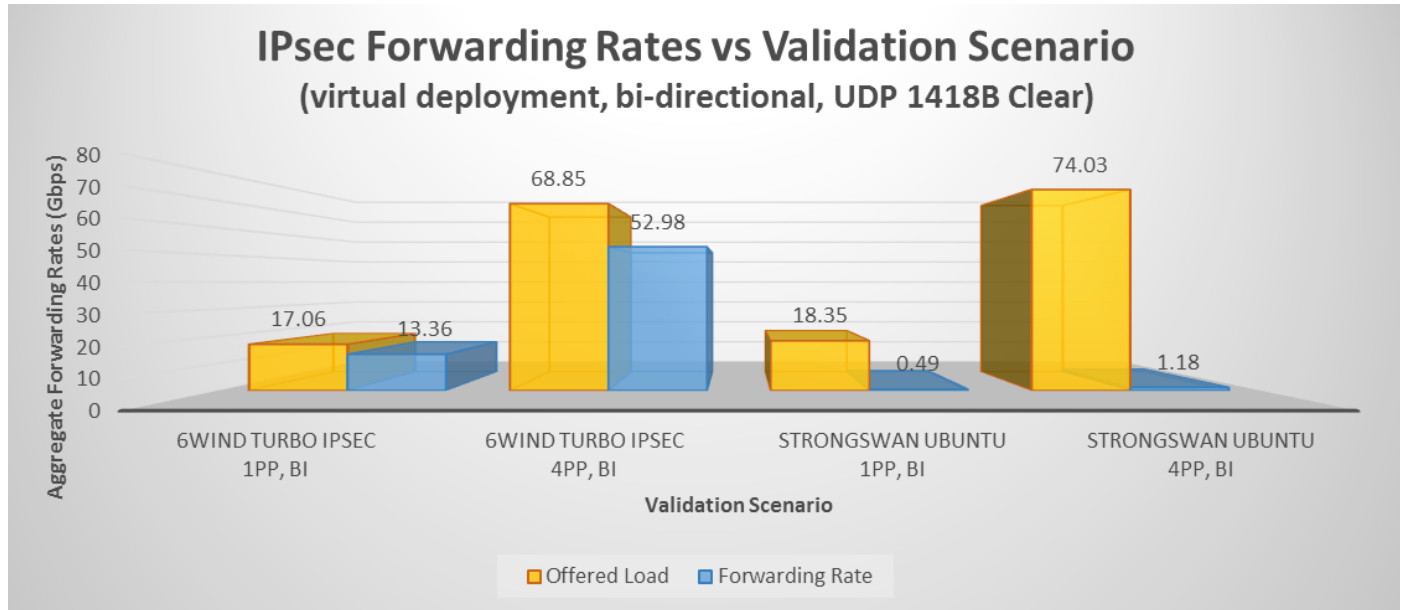


Figure 21. IPsec UDP forwarding rates for 6WIND Turbo IPsec and strongSwan Ubuntu in virtual deployment across 1 port-pair and 4 port-pair validation scenarios using 1418-byte cleartext payload

6 CONCLUSION

6WIND Speed Series with Turbo Appliances and Virtual Accelerator enable networking performance close to specialized hardware, on generic COTS x86 servers for a fraction of the cost.

As 6WIND Turbo Appliances support Linux-based configuration, the same networking configuration was used when comparing with Linux. This is a good advantage for users who already have their own management tools and network administrators accustomed to Linux.

In bare metal deployment, wirespeed L3 forwarding performance is achieved in both pps with small packets sizes and Gbps with IMIX traffic, which is more than 70 times Linux performance in the same conditions. We have measured 70 Gbps of IPsec data-plane processing; 240K concurrent tunnels were setup (8 times Linux) and a tunnel setup rate of 12K tunnels/s was measured (48 times Linux). Turbo IPsec data-plane performance is more than 5 times Linux using 2/3 of the CPU resources, and tunnel setup rate is 48 times better.

In virtual deployment, 6WIND Turbo Router achieves more than 80 Gbps IMIX performance as well, when Linux remains below 10 Gbps and 6WIND Turbo IPsec reaches more than 50 Gbps when Linux is a bit above 1 Gbps. This level of performance can be reached thanks to 6WIND Virtual Accelerator running in the hypervisor to enable performance at the VM level. Without 6WIND Virtual Accelerator, the networking performance of standard Linux hypervisors is just not viable for modern NFV, data center or enterprise private cloud deployments. And as 6WIND Virtual Accelerator supports the Virtio standard, its acceleration can also benefit third-party VMs, in addition to 6WIND Turbo Appliances.

6WIND Speed Series brings an alternative to specialized hardware, and competing software-based solutions, with bare metal and virtual deployment options that deliver a unique price/performance value proposition that is worth consideration for networking and security requirements.

7 APPENDIX – TABLES OF RESULTS

IMIX1	IMIX2	IMIX3
64 - 55%	IMIX1 - 50%	78 - 58%
594 - 25%	IMIX3- 50%	496 - 3%
1518 - 20%		594 - 24%
		1518 - 15%

Table 1. Internet mix frame size distributions used for L3 forwarding test category

7.1 Bare Metal

7.1.1 6WIND Turbo Router L3 Forwarding - IPv4 - Bare-Metal

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
2	12pp - uni	100/0	64	100	119.944	63.33	31.232	12c/bm/TR
2	12pp - uni	100/0	128	100	95.767	98.065	5.51	12c/bm/TR
2	12pp - uni	100/0	256	100	54.213	111.028	0.248	12c/bm/TR
2	12pp - uni	100/0	512	100	28.189	115.464	0.021	12c/bm/TR
2	12pp - uni	100/0	1024	100	14.367	117.697	0.003	12c/bm/TR
2	12pp - uni	100/0	1280	100	11.538	118.15	0.003	12c/bm/TR
2	12pp - uni	100/0	1518	100	9.753	118.436	0.003	12c/bm/TR
2	12pp - uni	100/0	64	100	138.078	70.696	22.676	24c/bm/TR
2	12pp - uni	100/0	128	100	98.833	101.205	2.484	24c/bm/TR
2	12pp - uni	100/0	256	100	54.346	111.3	0.003	24c/bm/TR
2	12pp - uni	100/0	512	100	28.195	115.485	0.003	24c/bm/TR
2	12pp - uni	100/0	1024	100	14.367	117.697	0.002	24c/bm/TR
2	12pp - uni	100/0	1280	100	11.538	118.15	0.002	24c/bm/TR
2	12pp - uni	100/0	1518	100	9.753	118.436	0.002	24c/bm/TR
2	12pp - uni	100/0	64	100	60.821	31.14	65.94	6c/bm/TR
2	12pp - uni	100/0	128	75	60.768	62.227	20.055	6c/bm/TR
2	12pp - uni	100/0	128	100	60.830	62.29	39.981	6c/bm/TR
2	12pp - uni	100/0	256	100	49.850	102.093	8.276	6c/bm/TR
2	12pp - uni	100/0	512	100	28.101	115.102	0.335	6c/bm/TR
2	12pp - uni	100/0	1024	100	14.367	117.697	0.003	6c/bm/TR
2	12pp - uni	100/0	1280	100	11.538	118.15	0.003	6c/bm/TR
2	12pp - uni	100/0	1518	100	9.753	118.436	0.003	6c/bm/TR

Table 2. 6WIND Turbo Router L3 Forwarding - IPv4 - Bare-Metal

L3 Emulation Legend

uni: uni-directional / bi: bi-directional / pp: port-pair

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
TR: 6WIND Turbo Router

7.1.2 6WIND Turbo Router L3 Forwarding - IPv6 - Bare-Metal

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
2	12pp - uni	0/100	78	75	101.728	63.478	11.383	12c/bm/TR
2	12pp - uni	0/100	78	100	101.673	63.444	33.573	12c/bm/TR
2	12pp - uni	0/100	128	100	100.105	102.507	1.229	12c/bm/TR
2	12pp - uni	0/100	256	100	54.315	111.238	0.059	12c/bm/TR
2	12pp - uni	0/100	512	100	28.195	115.485	0.003	12c/bm/TR
2	12pp - uni	0/100	1024	100	14.367	117.697	0.003	12c/bm/TR
2	12pp - uni	0/100	1280	100	11.538	118.15	0.003	12c/bm/TR
2	12pp - uni	0/100	1518	100	9.753	118.436	0.003	12c/bm/TR
2	12pp - uni	0/100	78	75	61.072	38.109	46.799	24c/bm/TR
2	12pp - uni	0/100	78	100	61.114	38.135	60.072	24c/bm/TR
2	12pp - uni	0/100	128	75	61.077	62.543	19.65	24c/bm/TR
2	12pp - uni	0/100	128	100	61.058	62.524	39.755	24c/bm/TR
2	12pp - uni	0/100	256	100	54.315	111.237	0.06	24c/bm/TR
2	12pp - uni	0/100	512	100	28.194	115.485	0.003	24c/bm/TR
2	12pp - uni	0/100	1024	100	14.367	117.697	0.003	24c/bm/TR
2	12pp - uni	0/100	1280	100	11.538	118.15	0.003	24c/bm/TR
2	12pp - uni	0/100	1518	100	9.753	118.436	0.003	24c/bm/TR
2	12pp - uni	0/100	78	75	46.058	28.74	59.878	6c/bm/TR
2	12pp - uni	0/100	78	100	45.986	28.695	69.955	6c/bm/TR
2	12pp - uni	0/100	128	75	45.962	47.065	39.534	6c/bm/TR
2	12pp - uni	0/100	128	100	45.965	47.068	54.647	6c/bm/TR
2	12pp - uni	0/100	256	100	45.873	93.948	15.593	6c/bm/TR
2	12pp - uni	0/100	512	100	26.909	110.22	4.562	6c/bm/TR
2	12pp - uni	0/100	1024	100	14.367	117.697	0.003	6c/bm/TR
2	12pp - uni	0/100	1280	100	11.538	118.15	0.003	6c/bm/TR
2	12pp - uni	0/100	1518	100	9.753	118.436	0.003	6c/bm/TR

Table 3. 6WIND Turbo Router L3 Forwarding - IPv6 - Bare-Metal

L3 Emulation Legend

uni: uni-directional / bi: bi-directional / pp: port-pair

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal

TR: 6WIND Turbo Router

7.1.3 Quagga Ubuntu L3 Forwarding - IPv4/IPv6 - Bare-Metal

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
2	12pp - uni	100/0	64	75	2.721	1.437	97.92	bm/quagga
2	12pp - uni	100/0	128	100	2.745	2.811	97.292	bm/quagga
2	12pp - uni	100/0	256	75	2.792	5.718	93.15	bm/quagga
2	12pp - uni	100/0	512	100	2.705	11.08	90.406	bm/quagga
2	12pp - uni	100/0	1024	50	2.866	23.48	60.101	bm/quagga
2	12pp - uni	100/0	1280	50	2.919	29.894	49.397	bm/quagga
2	12pp - uni	100/0	1518	75	2.892	35.118	60.465	bm/quagga
2	12pp - uni	0/100	78	75	2.548	1.59	97.884	bm/quagga
2	12pp - uni	0/100	128	50	2.551	2.613	94.965	bm/quagga
2	12pp - uni	0/100	256	75	2.559	5.242	93.726	bm/quagga
2	12pp - uni	0/100	512	25	2.600	10.65	63.268	bm/quagga
2	12pp - uni	0/100	1024	50	2.598	21.279	63.841	bm/quagga
2	12pp - uni	0/100	1280	75	2.589	26.514	70.078	bm/quagga
2	12pp - uni	0/100	1518	100	2.597	31.543	73.367	bm/quagga

Table 4. Quagga Ubuntu - IPv4/IPv6 - Bare-Metal

L3 Emulation Legend

uni: uni-directional / bi: bi-directional / pp: port-pair

CEuT Deployment Legend

bm: bare-metal
quagga: Quagga Ubuntu

The table above summarizes the maximum forwarding rates achieved under IPv4 and IPv6 workloads with uniform frame sizes for Quagga Ubuntu. The maximum packet forwarding rate is 2.92 Mpps measured with 1280 byte packet size. The maximum bit forwarding rate for Quagga Ubuntu is 35.12 Gbps with 1518 byte packet size.

The tables below reports the results using workloads with three IMIX distributions. IMIX1 is an IPv4 frame size distribution with 64 byte frame size comprising 55% of the total mix. The IMIX3 is an IPv6 frame size distribution with 78 byte frame size comprising 58% of the total mix. IMIX2 is dual-stack IPv4/v6 mix that is a 50/50 ratio of IMIX1/IMIX3.

7.1.4 6WIND Turbo Router L3 Forwarding - IMIX - Bare-Metal

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
2	12pp - uni	100/0	IMIX1	100	29.193	113.395	1.269	6c/bm/TR
2	12pp - uni	100/0	IMIX1	100	29.522	115.118	0.155	12c/bm/TR
2	12pp - uni	100/0	IMIX1	100	29.552	115.199	0	24c/bm/TR
2	12pp - uni	0/100	IMIX3	100	31.114	106.666	6.58	6c/bm/TR
2	12pp - uni	0/100	IMIX3	100	33.253	114.516	0.158	12c/bm/TR
2	12pp - uni	0/100	IMIX3	100	33.276	114.57	0.027	24c/bm/TR
4	12pp - uni	50/50	IMIX2	100	29.902	108.776	4.883	6c/bm/TR
4	12pp - uni	50/50	IMIX2	100	31.387	114.818	0.157	12c/bm/TR
4	12pp - uni	50/50	IMIX2	100	31.390	114.819	0.148	24c/bm/TR
8	12pp - bi	50/50	IMIX2	100	29.724	108.101	5.449	6c/bm/TR
8	12pp - bi	50/50	IMIX2	100	31.411	114.884	0.081	12c/bm/TR
8	12pp - bi	50/50	IMIX2	100	31.412	114.886	0.078	24c/bm/TR

Table 5. 6WIND Turbo Router L3 Forwarding - IMIX - Bare-Metal

L3 Emulation Legend

uni: uni-directional / bi: bi-directional / pp: port-pair

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
TR: 6WIND Turbo Router

7.1.5 Quagga Ubuntu L3 Forwarding - IMIX - Bare-Metal

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
2	12pp - uni	100/0	IMIX1	75	3.591	14.51	83.808	bm/quagga
2	12pp - uni	0/100	IMIX3	100	2.154	7.702	93.532	bm/quagga
4	12pp - uni	50/50	IMIX2	75	3.821	14.119	83.792	bm/quagga
8	12pp - bi	50/50	IMIX2	100	2.751	10.1	91.309	bm/quagga

Table 6. Quagga Ubuntu L3 Forwarding - IMIX - Bare-Metal

L3 Emulation Legend

uni: uni-directional / bi: bi-directional / pp: port-pair
 IMIX1:IMIX2:IMIX3: frame size distributions - Table 1

CEuT Deployment Legend

bm: bare-metal
 quagga: Quagga Ubuntu

7.1.6 6WIND Turbo Router / Virtual Accelerator L3 Forwarding - IPv4 - Virtual

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
4	3pp -bi	100/0	512	100	14.097	57.742	0.006	VA/1s_TR
4	3pp -bi	100/0	1024	100	7.184	58.849	0.006	VA/1s_TR
4	3pp -bi	100/0	1280	100	5.769	59.075	0.005	VA/1s_TR
4	3pp -bi	100/0	1518	100	4.876	59.218	0.005	VA/1s_TR
4	6pp -bi	100/0	64	50	21.351	10.932	76.088	VA/2s_TR
4	6pp -bi	100/0	128	25	25.273	25.88	0.261	VA/2s_TR
4	6pp -bi	100/0	256	50	23.402	47.926	13.886	VA/2s_TR
4	6pp -bi	100/0	512	50	14.081	57.674	0.127	VA/2s_TR
4	6pp -bi	100/0	512	75	21.093	86.397	0.258	VA/2s_TR
4	6pp -bi	100/0	1024	100	14.357	117.614	0.079	VA/2s_TR
4	6pp -bi	100/0	1280	100	11.532	118.089	0.061	VA/2s_TR
4	6pp -bi	100/0	1518	100	9.747	118.372	0.063	VA/2s_TR

Table 7. 6WIND Turbo Router L3 Forwarding - IPv4 - Virtual

L3 Emulation Legend

uni: bi: bi-directional / pp: port-pair

CEuT Deployment Legend

VA: Virtual Accelerator

1s_TR: 12 cores to VA, 6 cores to TR

2s_TR: 24 cores to VA, 12 cores to 2xTR

7.1.7 6WIND Turbo Router / Virtual Accelerator L3 Forwarding - IPv6 - Virtual

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
4	3pp -bi	0/100	1024	100	6.962	57.029	3.097	VA/1s_TR
4	3pp -bi	0/100	1280	100	5.767	59.054	0.041	VA/1s_TR
4	3pp -bi	0/100	1518	100	4.876	59.211	0.017	VA/1s_TR
4	6pp -bi	0/100	78	25	25.330	15.806	33.805	VA/2s_TR
4	6pp -bi	0/100	128	50	25.198	25.802	50.279	VA/2s_TR
4	6pp -bi	0/100	256	75	22.615	46.315	44.52	VA/2s_TR
4	6pp -bi	0/100	512	100	20.657	84.613	26.738	VA/2s_TR
4	6pp -bi	0/100	1024	100	14.367	117.691	0.013	VA/2s_TR
4	6pp -bi	0/100	1280	100	11.538	118.149	0.008	VA/2s_TR
4	6pp -bi	0/100	1518	100	9.753	118.435	0.008	VA/2s_TR

Table 8. 6WIND Turbo Router L3 Forwarding - IPv6 - Virtual

L3 Emulation Legend

uni: bi: bi-directional / pp: port-pair

CEuT Deployment Legend

VA: Virtual Accelerator

1s_TR: 12 cores to VA, 6 cores to TR

2s_TR: 24 cores to VA, 12 cores to 2xTR b

7.1.8 Quagga Ubuntu L3 Forwarding - IPv4/IPv6 - Virtual

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
2	12pp - uni	100/0	64	75	2.143	1.132	98.362	virt/quagga
2	12pp - uni	100/0	128	75	1.977	2.025	97.4	virt/quagga
2	12pp - uni	100/0	256	75	1.939	3.972	95.241	virt/quagga
2	12pp - uni	100/0	512	100	1.681	6.887	94.572	virt/quagga
2	12pp - uni	100/0	1024	100	1.695	13.886	88.204	virt/quagga
2	12pp - uni	100/0	1280	100	1.618	16.564	85.984	virt/quagga
2	12pp - uni	100/0	1518	25	1.591	19.326	34.741	virt/quagga
2	12pp - uni	0/100	78	100	1.867	1.165	98.781	virt/quagga
2	12pp - uni	0/100	128	100	2.241	2.295	97.993	virt/quagga
2	12pp - uni	0/100	256	100	1.757	3.598	96.768	virt/quagga
2	12pp - uni	0/100	512	100	1.724	7.063	93.899	virt/quagga
2	12pp - uni	0/100	1024	75	1.641	13.442	84.857	virt/quagga
2	12pp - uni	0/100	1280	25	1.512	15.479	47.61	virt/quagga
2	12pp - uni	0/100	1518	100	1.509	18.324	84.53	virt/quagga

Table 9. Quagga Ubuntu L3 Forwarding - IPv4/IPv6 - Virtual

L3 Emulation Legend

uni: bi: bi-directional / pp: port-pair

CEuT Deployment Legend

quagga: Quagga Ubuntu
virt: virtual 16 cores to Quagga

7.1.9 6WIND Turbo Router / Virtual Accelerator L3 Forwarding - IMIX - Virtual

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
4	3pp -bi	100/0	IMIX1	100	14.772	57.586	0.026	VA/1s_TR
8	3pp -bi	50/50	IMIX2	100	15.407	56.057	0.155	VA/1s_TR
4	3pp -bi	0/100	IMIX3	100	15.630	53.169	0	VA/1s_TR
4	6pp -bi	100/0	IMIX1	75	22.116	86.216	0.277	VA/2s_TR
8	6pp -bi	50/50	IMIX2	75	21.738	80.018	7.813	VA/2s_TR
4	6pp -bi	0/100	IMIX3	100	22.030	73.652	33.816	VA/2s_TR
400k	3pp -bi	50/50	IMIX2	100	15.369	55.887	2.181	VA/1s_TR
400k	6pp -bi	50/50	IMIX2	75	21.329	78.494	9.549	VA/2s_TR

Table 10. 6WIND Turbo Router L3 Forwarding - IMIX - Virtual

L3 Emulation Legend

bi: bi-directional / pp: port-pair
IMIX1:IMIX2:IMIX3: frame size distributions - Table 1

CEuT Deployment Legend

VA: Virtual Accelerator
1s_TR: 12 cores to VA, 6 cores to TR
2s_TR: 24 cores to VA, 12 cores to 2xTR

7.1.10 Quagga Ubuntu L3 Forwarding - IMIX - Virtual

L3 Emulation					Aggregate Forwarding Rates (Mpps)	Aggregate Forwarding Rates (Gbps)	Frame Loss (%)	CEuT Deployment
Flows	Traffic Pattern	IPv4/v6 Ratio	Frame Size (bytes)	Offered Load (%)				
2	12pp - uni	100/0	IMIX1	100	2.124	8.508	92.817	virt/quagga
2	12pp - uni	0/100	IMIX3	100	1.150	4.069	97.121	virt/quagga
4	12pp - uni	50/50	IMIX2	100	1.722	6.362	94.197	virt/quagga
8	12pp - bi	50/50	IMIX2	100	1.573	5.75	94.996	virt/quagga

Table 11. Quagga Ubuntu L3 Forwarding - IMIX - Bare-Metal

L3 Emulation Legend

bi: bi-directional / pp: port-pair
IMIX1:IMIX2:IMIX3: frame size distributions - Table 1

CEuT Deployment Legend

quagga: Quagga Ubuntu
virt: virtual 16 cores to Quagga

7.1.11 6WIND Turbo Router – Routing Convergence Times

Routing & L2/3 Emulation				Convergence Times (sec)	CEuT Deployment
Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)		
1M	2	0	512	1.2	bm, 12c, TR
2M	2	0	512	2.69	bm, 12c, TR
4M	2	0	512	6.1	bm, 12c, TR
6M	2	0	512	9.9	bm, 12c, TR
20K	0	2	512	7.1	bm, 12c, TR
50K	0	2	512	17.1	bm, 12c, TR
100K	0	2	512	35.2	bm, 12c, TR
500K	0	2	512	170.1	bm, 12c, TR
1M	0	2	512	344	bm, 12c, TR
2M	0	2	512	580	bm, 12c, TR

Table 12. BGP and OSPF Routing convergence times for 6WIND Turbo Router in bare-metal deployment

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
 TR: 6WIND Turbo Router

7.1.12. Quagga Ubuntu – Routing Convergence Times

Routing & L2/3 Emulation				Convergence Times (sec)	CEuT Deployment
Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)		
1M	2	0	512	2.2	bm, quagga
2M	2	0	512	4.3	bm, quagga
4M	2	0	512	9.5	bm, quagga
6M	2	0	512	11.3	bm, quagga
20K	0	2	512	7.1	bm, quagga
50K	0	2	512	15.5	bm, quagga
100K	0	2	512	34.7	bm, quagga
500K	0	2	512	176	bm, quagga
1M	0	2	512	357	bm, quagga
2M	0	2	512	672	bm, quagga

Table 13. BGP and OSPF Routing convergence times for Quagga Ubuntu in bare-metal deployment

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
quagga: Quagga Ubuntu

7.1.13 Routing Scalability – 6WIND Turbo Router

Routing & L2/3 Emulation				Routes Learned	Frame Loss %	CEuT Deployment
Total Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)			
6M	1	0	512	6M	0	bm, 12c, TR
6M	2	0	512	6M	0	bm, 12c, TR
6M	4	0	512	6M	0	bm, 12c, TR
4M	0	1	512	4M	0	bm, 12c, TR
4M	0	2	512	4M	0	bm, 12c, TR
2M	0	4	512	2M	0	bm, 12c, TR

Table 14. BGP and OSPF Routing Scalability for 6WIND Turbo Router in bare-metal deployment

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
TR: 6WIND Turbo Router

7.1.14 Routing Scalability – Quagga Ubuntu

Routing & L2/3 Emulation				Routes Learned	Frame Loss %	CEuT Deployment
Total Offered Routes	EBGP Peers	OSPF Adjacencies	Frame Size (bytes)			
6M	1	0	512	6M	0	bm, quagga
6M	4	0	512	6M	0	bm, quagga
4M	0	1	512	4M	0	bm, quagga
4M	0	2	512	4M	0	bm, quagga

Table 15. BGP and OSPF Routing Scalability for Quagga Ubuntu in bare-metal deployment

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
quagga: Quagga Ubuntu

7.1.15 6WIND Turbo IPsec Concurrent Tunnel Capacity – Bare-Metal

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	400	200K	400	bm, 8c, TI
aes128-sha1-modp768	500	240K	500	bm, 8c, TI

Table 16. 6WIND Turbo IPsec concurrent tunnel capacity in bare-metal deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
TI: 6WIND Turbo IPsec

7.1.16 strongSwan Ubuntu Concurrent Tunnel Capacity - Bare-Metal

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	40	30K	30	bm, SS
aes128-sha1-modp768	40	40K	fail	bm, SS
aes128-sha1-modp768	40	35K	fail	bm, SS
aes128-sha1-modp768	20	40K	fail	bm, SS

Table 17. strongSwan Ubuntu concurrent tunnel capacity in bare-metal deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

SS: strongSwan Ubuntu
bm: bare-metal

7.1.17 6WIND Turbo IPsec Concurrent Tunnel Capacity - Virtual

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	400	100K	400	virt, 8c, TI
aes128-sha1-modp768	400	120K	400	virt, 8c, TI
aes128-sha1-modp768	400	200K	fail	virt, 8c, TI
aes128-sha1-modp768	400	180K	400	virt, 8c, TI

Table 18. 6WIND Turbo IPsec concurrent tunnel capacity in virtual deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

c: cores assigned to fast path / virt: virtual
TI: 6WIND Turbo IPsec

7.1.18 strongSwan Ubuntu Concurrent Tunnel Capacity - Virtual

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	40	30K	40	virt, SS
aes128-sha1-modp768	40	35K	fail	virt, SS
aes128-sha1-modp768	40	40K	fail	virt, SS
aes128-sha1-modp768	20	40K	fail	virt, SS

Table 19. strongSwan Ubuntu concurrent tunnel capacity in virtual deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

SS: strongSwan Ubuntu
 virt: virtual 16 cores assigned to strongSwan

The maximum concurrent tunnels that can be setup with the 6WIND Turbo IPsec appliance in virtual deployment is 180K tunnels at 400 tunnels/sec versus 30K tunnels with strongSwan Ubuntu at 40 tunnels/sec.

7.1.19 6WIND Turbo IPsec Tunnel Setup Rate - Bare-Metal

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	9K	40K	9K	bm, 8c, TI
aes128-sha1-modp768	10K	40K	10K	bm, 8c, TI
aes128-sha1-modp768	11K	40K	11K	bm, 8c, TI
aes128-sha1-modp768	12K	40K	12K	bm, 8c, TI
aes128-sha1-modp768	13K	40K	fail	bm, 8c, TI

Table 20. Tunnel setup rates for 6WIND Turbo IPsec in bare-metal deployment.

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
TI: 6WIND Turbo IPsec

7.1.20 strongSwan Ubuntu Tunnel Setup Rate - Bare-Metal

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	100	10K	100	bm, SS
aes128-sha1-modp768	150	15K	150	bm, SS
aes128-sha1-modp768	250	10K	250	bm, SS
aes128-sha1-modp768	300	10K	fail	bm, SS

Table 21. Tunnel setup rates for strongSwan Ubuntu in bare-metal deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

SS: strongSwan Ubuntu
bm: bare-metal

7.1.21 6WIND Turbo IPsec Tunnel Setup Rate - Virtual

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	400	100K	400	virt, 8c, TI
aes128-sha1-modp768	4K	40K	4K	virt, 8c, TI
aes128-sha1-modp768	5K	40K	5K	virt, 8c, TI
aes128-sha1-modp768	6K	20K	fail	virt, 8c, TI

Table 22. Tunnel setup rates for 6WIND Turbo IPsec in virtual deployment.

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

c: cores assigned to fast path / virt: virtual
TI: 6WIND Turbo IPsec

7.1.22 strongSwan Ubuntu Tunnel Setup Rate - Virtual

IPsec Emulation			Measured Rate tunnels/s (TPS)	CEuT Deployment
Crypto	Attempted Tunnel Setup Rate (TPS)	Tunnel Capacity		
aes128-sha1-modp768	150	15K	150	virt, SS
aes128-sha1-modp768	200	15K	fail	virt, SS
aes128-sha1-modp768	200	10K	200	virt, SS
aes128-sha1-modp768	250	10K	250	virt, SS
aes128-sha1-modp768	300	10K	fail	virt, SS

Table 23. Tunnel setup rates for strongSwan Ubuntu in virtual deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

SS: strongSwan Ubuntu
virt: virtual 16 cores assigned to strongSwan

7.1.23 6WIND Turbo IPsec Forwarding Performance – Bare-Metal

UDP Emulation			Aggregate Tx Forwarding Rates (Gbps)	Aggregate Rx Forwarding Rates (Gbps)	CEuT Deployment
Traffic Pattern	Crypto	Payload Size (bytes)			
4pp, bi	aes128-sha1-modp768	1024	64.32	43.92	bm, 8c
4pp, bi	aes128-sha1-modp768	1024	60.11	60.27	bm, 16c
4pp, bi	aes128-sha1-modp768	1024	65.92	65.90	bm, 32c
4pp, bi	aes128-sha1-modp768	1418	69.84	69.81	bm, 32c
4pp, bi	aes128-sha1-modp768	1418	70.38	70.04	bm, 16c
4pp, bi	aes128-sha1-modp768	1418	71.63	47.90	bm, 8c

Table 24. IPsec forwarding performance for 6WIND Turbo IPsec in bare-metal deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

c: cores assigned to fast path / bm: bare-metal
 TI: 6WIND Turbo IPsec

7.1.24 6WIND Turbo IPsec / Virtual Accelerator Forwarding Performance - Virtual

UDP Emulation			Aggregate Tx Forwarding Rates (Gbps)	Aggregate Rx Forwarding Rates (Gbps)	CEuT Deployment
Traffic Pattern	Crypto	Payload Size (bytes)			
4pp, bi	aes128-sha1-modp768	1024	64.43	47.15	VA/2s_TI
6pp, bi	aes128-sha1-modp768	1024	98.47	55.01	VA/2s_TI
4pp, bi	aes128-sha1-modp768	1418	68.85	52.98	VA/2s_TI
6pp, bi	aes128-sha1-modp768	1418	103.37	64.02	VA/2s_TI
3pp, bi	aes128-sha1-modp768	1024	49.86	29.03	VA/1s_TI
3pp, bi	aes128-sha1-modp768	1418	51.67	32.92	VA/1s_TI

Table 25. IPsec forwarding performance for 6WIND Turbo IPsec in virtual deployment

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

VA: Virtual Accelerator
 1s_TI: 6 cores to VA, 12 cores to TI
 2s_TI: 12 cores to VA, 24 cores to 2xTI

7.1.25 strongSwan Ubuntu IPsec Forwarding Performance - Bare-Metal / Virtual

UDP Emulation			Aggregate Tx Forwarding Rates (Gbps)	Aggregate Rx Forwarding Rates (Gbps)	CEuT Deployment
Traffic Pattern	Crypto	Payload Size (bytes)			
4pp, bi	aes128-sha1-modp768	1024	64.68	11.14	bm, SS
4pp, bi	aes128-sha1-modp768	1418	74.03	12.6	bm, SS
4pp, bi	aes128-sha1-modp768	1024	70.41	1.47	virt, SS
4pp, bi	aes128-sha1-modp768	1418	74.03	1.18	virt, SS

Table 26. IPsec forwarding performance for strongSwan Ubuntu in bare-metal and virtual deployments

IPsec Emulation Legend

Hash Algorithm: HMAC-SHA1-96 / Encryption Algorithm Phase1/2: AES128-CBC DH Group: DH-1 (MODP-768)

CEuT Deployment Legend

SS: strongSwan Ubuntu
 virt: virtual 16 cores assigned to strongSwan / bm: bare-metal

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