WHITE PAPER

6WIND* and Intel®: Delivering High-Performance Software-Based IP and IPsec Routing

Introduction

Communications service providers, cloud service providers, and enterprises are in the midst of a significant network architecture transformation as they increase the amount of IP routing and security they use, while at the same time reducing their costs. To do that, they are increasingly adopting software-based routing.

While the economic advantage of this approach is substantial – Intel® architecture servers replace dedicated hardware and can drive down the cost per gigabit by up to 80% [1] – many first-generation software routers didn't offer the performance needed for today's network applications. In fact, the performance from Linux*-based routers wasn't enough to fill a 10 Gbps network connection.[2]

That's why 6WIND* developed the Speed Series* for Intel platforms – a 200 Gbps IP router, the industry's first 100 Gbps IPsec software solution, and a software platform for wire speed virtual infrastructure acceleration. The Speed Series is based on 6WINDGate*, a high-performance packet processing software solution. 6WIND also leverages the power of Intel® Xeon® servers and collaborated with Intel on technologies such as the Data Plane Development Kit (DPDK) that are instrumental to achieving these performance levels.

More IP Networks Drives Need for More Routing and Security

From advanced wireless networks to the Internet of Things, the demand for IP routing and network security is growing at a very fast pace.

For example, in the market for service provider routers, 2014 was a record year for the industry with aggregate revenues hitting $10 billion according the research by Dell'Oro Group. [3] The firm also predicts that this growth will continue at least through 2015 when it projects that industry sales of routers will hit $11.5 billion.[4]

This prevalence of IP data traffic also foretells a greater need for routing of IPsec encrypted data packets in order to protect these data flows from security threats. Many new IP applications, such as LTE base stations, cable networks, cloud

[1] 6Wind internal study, available on request under NDA
[2] 6WIND Turbo Router + 6WIND Virtual Accelerator vs. Linux Routing + Open vSwitch. https://www.youtube.com/watch?v=icvVqvvrVeA
The test platform for these results was a server using a 2.8GHz Quad Intel Xeon E7-4890 v2 with 128 Gigabytes of RAM and equipped with 10 dual-port 10GbE Intel network controllers.
[3] Demand for Service Provider Routers Grows to Almost $10 B in 2014, According to Dell'Oro Group
See more at: http://www.delloro.com/news/demand-service-provider-routers-grows-almost-10-b-2014-according-delloro-group#sthash.M8v9gwMm.dpuf
[4] Service Provider Router Market to Exceed $11.5 Billion in 2019, According to Dell'Oro Group Forecast
See more at: http://www.delloro.com/news/service-provider-router-market-exceed-11-5-billion-2019-according-delloro-group-forecast#sthash.DailElGk.dpuf

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computing, and others, have not had the need for security, thus they are not used to the cost and extra hardware needed to provide high-performance IPsec encryption.

Several types of organizations can benefit from high-performance software routing:

Communications Service Providers: For service providers, more services means more revenues. Service providers can tap into high-performance software routers for faster time to market for new services as well as a faster provisioning time, increasing their service agility dramatically.

Cloud Providers: With high-performance IP routers, these providers can leverage their data center expertise to offer increased services and products, including enabling high performance software defined networking (SDN), network functions virtualization (NFV), and virtualization implementations to automate and simplify operations and quickly enable new services.

Enterprise: Private companies can also benefit from software routing with high packet throughput performance to enable the cost-effective deployment of new physical or virtual networks in their building or throughout their campuses.

Clearly, performance has been a stumbling block for the adoption of first-generation virtual routers. Early Linux* software routers offered great support of routing protocols, but didn't have the packet per second throughput to make even their reduced price attractive to customers. This performance was also blocking the movement of IPsec routers into the software world because the added processing needed for packet encryption and decryption made performance even slower.

In a recent test conducted by 6WIND, a Linux-based software router needed a 24-core Intel® x86 server to deliver a throughput of 7 Gbps.[2] This is acceptable performance for 1 Gbps network applications, but cannot scale to support the 10 Gbps and 40 Gbps networks that are growing in popularity.

6WIND has been able to take on this challenge, however, by working to develop both the routing functionality and the server processing acceleration capability needed to match the performance required by communications service providers, cloud providers, and enterprises on Intel architecture servers.

The Foundation: 6WINDGate*

6WIND specializes in high-performance, software-based networking products based on its core 6WINDGate packet processing software.

6WINDGate software is a comprehensive set of optimized layer 2 through 4 networking protocols for Intel-based general-purpose compute platforms that is deployed in carrier and cloud networks worldwide. The software can run on bare metal servers in addition to running in a virtualized environment, having been tested as fully compatible with standard hypervisors.

The 6WINDGate fast path is a packet-processing engine running on dedicated cores. 6WIND's fast path architecture leverages DPDK open source software on Intel x86 platforms for performance, and runs in user space – isolated from the Linux operating system and network stack – which maximizes data plane performance. The fast path supports major networking protocols (IP forwarding, VLAN, IPsec, filtering and NAT, TCP/UDP Termination, Open vSwitch acceleration, and more).

6WINDGate is a stand-alone solution that has been integrated into routers and networking products by many major OEMs. For example, one

OEM leverages the software as the data plane component of a virtual firewall and intrusion prevention system.

6WIND Speed Series*

6WIND has leveraged the 6WINDGate software as the foundation for its Speed Series, which includes 6WIND Turbo Router* and 6WIND Turbo IPsec* software appliances, which provide the following features:

- Linear performance scalability with the number of cores deployed
- Full-featured data plane networking with fast path protocols
- Operates on both bare metal servers and in virtualized environments
- Highly scalable control plane
- CLI, XML, or Linux-based management (iproute2, iptables)
- High performance input/output (I/O) leveraging DPDK with multi-vendor network interface card (NIC) support
- Virtio vNIC support to eliminate standard virtual switch bottlenecks when combined with 6WIND Virtual Accelerator*

Also in the Speed Series is the 6WIND Virtual Accelerator, which provides packet-processing acceleration for virtual network infrastructures with the following features:

- High performance I/O leveraging DPDK, with multi-vendor NIC support
- High performance virtual switching (Open vSwitch and Linux bridge) and networking (overlays, filtering/NAT, IP forwarding)
- Supports existing workloads through standard Virtio drivers
- Transparent to management and orchestration tools such as OpenStack*

6WIND Turbo Router*

The 6WIND Turbo Router is a software-based IP router that delivers up to 200 Gbps performance when running on an Intel Xeon-based server.[5] Turbo Router delivers layer 3 routing with stateful firewall capabilities and is also suitable for service providers, cloud and content providers, and enterprises.

One advantage of the Turbo Router (and Turbo IPsec) design is that performance can scale with the number of cores that are available for the application. In an internal test, 6WIND found that when Turbo Router was run on a 40-core, 2.8GHz Quad Intel Xeon E7-4890 v2 server with 20 10G Ethernet ports, performance scales from 50 Mpps at five cores to 150 Mpps at 15 cores all the way to 200Mpps at 20 cores. The average performance is 9.6 Mpps per core, which is independent of packet size. The test capped out at 200 Gbps, leaving 45% of the performance of the system still available for other applications.[5]

6WIND Turbo IPsec*

6WIND Turbo IPsec is a high-performance software-based IPsec gateway that delivers on two critical performance elements with throughput of more than 100 Gbps and up to 200,000 IPsec tunnels on a 2.8 GHz Quad Intel Xeon processor E7-4800 v2 series system even without external crypto technology. In addition to IPsec encryption and decryption, 6WIND Turbo IPsec delivers layer 3 routing and stateful firewall services.

Thanks to this performance and the use of Intel-based hardware, 6WIND Turbo IPsec provides communications service providers with much better price/performance ratios than dedicated hardware IPsec gateways, making the transition to software-based networking much more cost effective. In its own tests against leading competitive hardware-based solutions, 6WIND Turbo IPsec can save 80% of the cost per gigabit of IPsec throughput.[6]

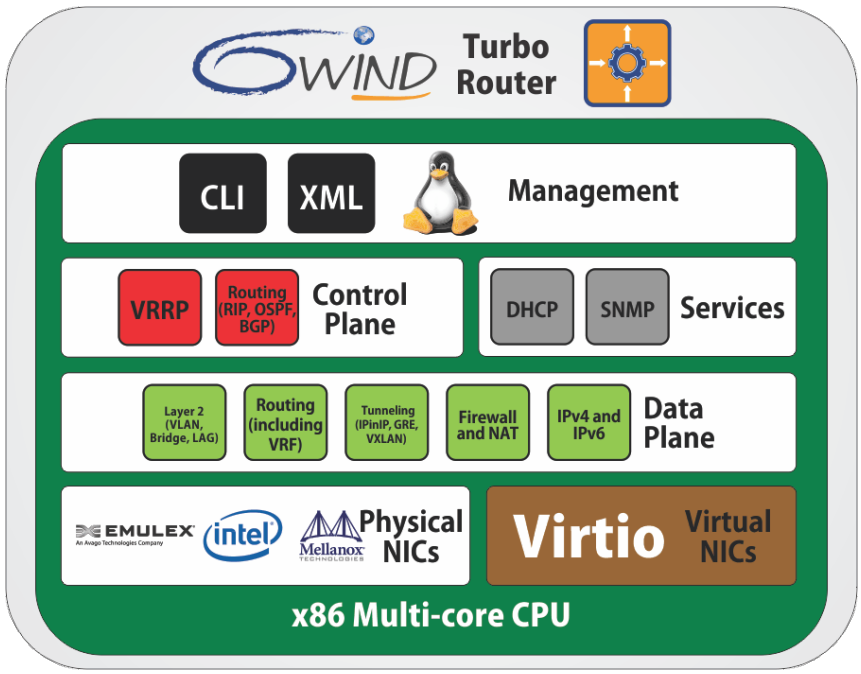

Figure 1: 6WIND Turbo Router

[5] 6WIND Turbo Router Product Webpage http://www.6wind.com/products/6wind-turbo-router/
The test platform for these results was a server using a 2.8GHz Quad Intel Xeon E7-4890 v2 with 128 Gigabytes of RAM and equipped with 10 dual-port 10GbE Intel network controllers.
[6] 6WIND Turbo IPsec Product Webpage http://www.6wind.com/products/6wind-turbo-ipsec/
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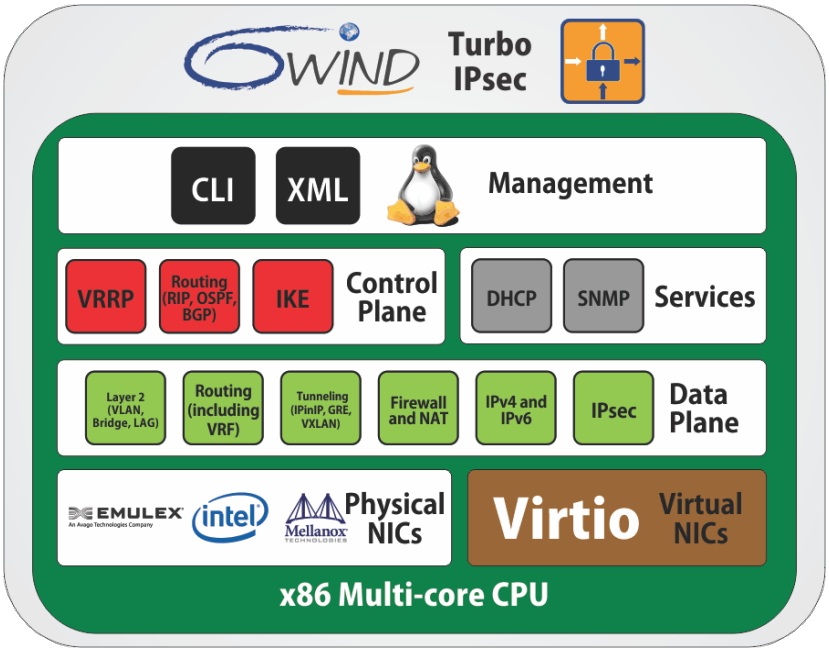

Figure 2: 6WIND Turbo IPsec

The Turbo IPsec application supports all of the protocols necessary for use in all communication service provider, cloud provider, and enterprise network applications. But the beneficial cost-performance ratio of the solution makes it ideal for new applications such as small cell backhauling, WiFi hot spot aggregation, and enterprise virtual customer premise equipment (vCPE).

6WIND Virtual Accelerator*

When transitioning to NFV, there are major bottlenecks in the architecture that prevent virtual network functions (VNFs) such as Turbo Appliances to run at the level of performance they were designed for. Most of the CPU cores are used for networking in the hypervisor instead of being available to actual VNFs.

6WIND Virtual Accelerator is a scalable software networking platform for virtualized infrastructures. It provides virtual switching and networking acceleration to make efficient use of hypervisor CPU cores, so that the virtual switch does not limit VM performance anymore. 6WIND Virtual Accelerator supports existing workloads thanks to its Virtio drivers.

In addition to standard virtual switching, 6WIND Virtual Accelerator supports a complete set of networking protocols to provide a comprehensive virtual networking infrastructure, including but not limited to: VLAN, VXLAN, virtual routing (netns), and filtering and NAT.

6WIND Virtual Accelerator is transparent to management and orchestration technologies. It has been tested with many OpenStack scenarios, including L2, L3, distributed virtual routing, and security groups.

6WIND Virtual Accelerator and Turbo Appliances provide the best combination for high performance NFV deployments.

Real World Performance Results

To demonstrate the impact that the 6WIND solution can have in carrier networks, the company commissioned SDxCentral (via its test partner NitronLabs, LLC) [7] to conduct performance tests on 6WIND Turbo Router, 6WIND Turbo IPsec, and 6WIND Virtual Accelerator.

The purpose of the validation tests was to establish a baseline of the 6WIND software running on a typical Intel x86 COTS server platform, and to validate its L3 forwarding performance, routing control-plane scalability, and IPsec performance and control-plane scalability in a setting relevant to data centers within enterprises, cloud service providers, and communications service providers.

In the tests, 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 and then were subsequently deployed as virtual machines on top of 6WIND Virtual Accelerator running on a hypervisor.

A summary of the testing results shows that 6WIND Turbo Applications were able to achieve dramatic performance improvements compared to standard open-source on Linux solutions as follows:

- Bare Metal L3 Forwarding: 6WIND Turbo Router achieved 115 Gbps of the typical Internet traffic passing the network (knows as Internet mix or IMIX) throughput with near zero frame loss rates.
- Bare Metal IPSec: 6WIND Turbo IPsec demonstrated the ability to handle up to 12,000 tunnel setups

[7] 6WIND Speed Series Performance Validation https://www.sdxcentral.com/download-6wind-speed-series-performance-validation-report/ (A free account with SDxCentral is required.)

per second and maintain 240,000 concurrent tunnels.

- Virtualized Environment: 6WIND Virtual Accelerator combined with 6WIND Turbo Appliances were able to outperform standard open-source equivalents by 10 to 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.

Collaborating for Performance

How does 6WIND get such high data throughput from general-purpose servers? The company has partnered with Intel to leverage some key Intel technologies and DPDK to deliver high performance. In addition, the company has also partnered with Intel to develop a number of value-added enhancements to these technologies.

One key technology that is extensively leveraged in 6WIND products is DPDK, a set of software libraries and drivers for high-performance data plane functionality in an Intel architecture server. DPDK was initially developed by Intel, but is now an open source technology (more information on DPDK can be found at www.dpdk.org.)

With DPDK, 6WIND can execute its routing and IPsec encryption in user space, directly accessing the processor without using the Linux kernel. 6WINDGate leverages the DPDK libraries to handle the I/O and receiving packets in the application.

This direct CPU access facilitates a zero-copy data transfer from network to CPU without any of the typical overhead and latency that comes with the standard Linux networking stack. 6WIND uses DPDK to bind its fast path operations to a specific core, which improves performance dramatically.

6WIND has developed a number of value-added enhancements to the DPDK library that provide increased system functionality and performance compared to the baseline software. These value-added enhancements include:

- High-performance software crypto support, implemented via the Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI) 1 in the Intel Xeon processor E5600 series and E5-2600 series.
- Device monitoring and statistics functions, such as Linux Ethtool MTU support, full RX/TX queue statistics, and CRC error statistics, which enable improved system-level profiling, analysis, and debug.
- Support for additional NICs, such as the Intel® 82571EB Gigabit Ethernet Controller, beyond those supported in the baseline DPDK library.

6WIND also provides a range of optional add-on extensions to the DPDK designed to improve the cost/performance of both physical and virtual networking appliances while enabling the use of the DPDK in software-defined networks.

These DPDK enhancements and optional add-ons are maintained by 6WIND as private branch, regularly synchronized with Intel's ongoing releases of the baseline library.

They are delivered to customers either as a stand-alone library or, for applications that also require high-performance packet processing software, are integrated within the 6WINDGate software solution.

IPsec Use Case: Security in an LTE Network

With its high performance and low overall cost, Turbo IPsec can be used in a wide variety of applications. The use case of LTE backhaul is an interesting case because it is a native IP-based wireless network, which means that a communication service provider must provide IP backhaul to each site.

IPsec is becoming more important in wireless networks as service providers shift to LTE. To meet the bandwidth needs of users, these service providers are moving away from dedicated leased-line (T1/E1) backhaul networks to commercial IP-based networks, which provide more bandwidth for user traffic.

But at the same time, it makes this data much more vulnerable to hackers and other security threats.

In Figure 3, data from small cells (home or pico eNodeBs) and macro base stations are transmitted via IP networks over the Internet or through a dedicated IP network to the evolved packet core for switching.

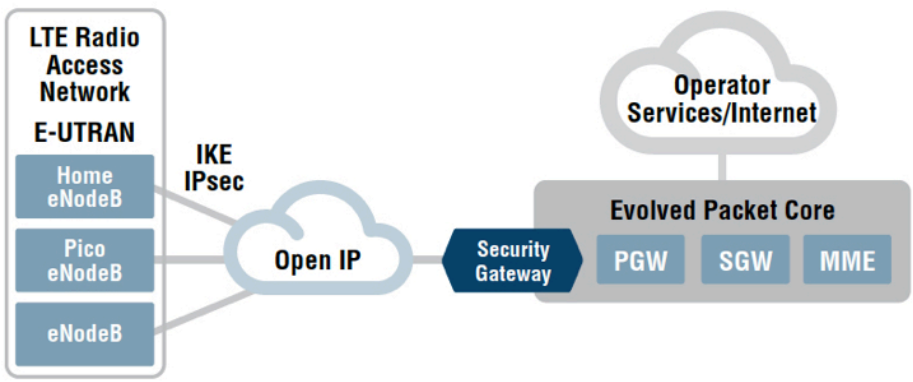

Figure 3

Located at each eNodeB and at the security gateway, Turbo IPsec is able to cipher the traffic for more than 58,000 users.[8] It can also manage a very large number of eNodeBs and home eNodeBs (HeNBs) as only a few IPsec tunnels or IKE sessions have to be established in each remote base station.

With a blade server that contains 10 Intel Xeon blades that are dedicated to the data path and the remaining two blades each running redundant, high-availability control planes, this solution can achieve 80,000 IPsec tunnels or 80,000 IKE sessions. The fast path performance clocks in at 700 Gbps. This solution can service quite a large LTE network (estimated at 580,000 users on tens of thousands of base stations).[8]

Turbo IPsec is an ideal solution for this use case because of its performance and scalability and because it can run in a virtualized server already in use at a base station location.

Summary

While routing has been around since the early days of Ethernet, it is undergoing a paradigm shift from hardware to software that is bringing down cost without sacrificing performance. New applications for routing are emerging as the use of IP grows – as the LTE base station use case demonstrates.

6WIND has pioneered this market with its 6WINDGate and Speed Series software and its collaboration with Intel to drive up the performance of software-based IP and IPsec routers to meet these emerging and growing needs. For more information on the 6WIND Speed Series family of software products, visit the company's website at www.6wind.com.

Disclaimers

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[8] Optimized Data Plane Processing Solutions using the Intel® DPDK https://embedded.communities.intel.com/docs/DOC-7407
The referenced analysis of the system-level performance that is achievable with this solution used a reference platform comprising a platform based on dual Intel Xeon processor E5-2600 series running at 2.7 GHz.