Solution Brief

Communications Service Providers

6WIND VSR Reduces Network Power Use with Intel Power Management

This solution brief highlights tests showing how 6WIND Virtual Service Router (VSR), enhanced by Intel power management, can reduce power consumption during low loads, improving the power efficiency of service provider networks

In today's environmentally conscious world, service providers face increasing pressure to reduce their carbon footprint and energy consumption. This need is driven by growing regulatory requirements, corporate sustainability goals, and consumer demand for greener services.

Reducing energy consumption not only helps mitigate the impact on climate change but also leads to significant cost savings and operational efficiencies. Concurrently, the rapid expansion of digital services and the demand for seamless connectivity necessitate high-performance virtual network solutions. These solutions must deliver robust performance and scalability while minimizing power usage.

By adopting energy-efficient technologies and practices, service providers can achieve a dual objective: minimizing environmental impact and meeting the high-performance demands of modern network infrastructures. This strategic shift not only benefits the environment but also positions service providers as leaders in sustainability, potentially attracting eco-conscious customers and investors while maintaining competitive service quality.

The 6WIND Virtual Service Router (VSR) product suite offers an innovative software-based networking solution that meets these needs and provides high-performance, scalable, and energy-efficient network solutions.

6WIND is an Intel® Industry Solution Builders' Network Builders Community member. This joint brief outlines the technical aspects and benefits of combining 6WIND VSR with Intel's power management features for higher efficiency and reduced operational costs.

6WIND VSR Overview

6WIND VSR is a product suite of state-of-the-art networking solutions, designed for virtualized environments, that combine unmatched performance, scalability, innovation, and power efficiency.

The product suite supports a comprehensive range of network functions, including routing, firewall, security, CGNAT, BNG, and UPF, making it an adaptable solution for various networking needs.

Engineered to meet the demanding requirements of modern network infrastructures, 6WIND VSR sets new standards in each aspect. With its high-performance, it ensures seamless data handling and minimal latency, guaranteeing optimal network performance even under heavy workloads. Scalability is another hallmark feature of 6WIND VSR, allowing organizations to easily expand their network infrastructure to accommodate growing demands without sacrificing performance or efficiency.

The innovative design of 6WIND VSR incorporates cutting-edge technologies, enabling advanced functionalities and future-proofing network investments. 6WIND VSR prioritizes power efficiency through intelligent resource management and integration with energy-saving technologies, such as Intel's power management, ensuring sustainable and cost-effective operation.

Intel Power Management Technologies

Intel Power Management technologies allow deployments to be tuned for optimal performance per watt at peak and sustained loads, while also enabling significant power savings when the deployment is lightly loaded, reducing overall energy consumption through active power management (see Figure 1).

The 4th Gen Intel® Xeon® Scalable processors include, for instance, an array of built-in accelerators that accelerate compute-centric workloads without the power requirements of an external card.

For example, the network-optimized variant in the processor family supports more data per clock cycle and delivers highly granular control over power states and frequency and therefore power consumption at the per-core level.

The platform introduces two new light sleep power states that improve the potential workload responsiveness of power-management software by enabling cores to recover full power more quickly. This reduced exit latency helps avoid delays in the packet processing execution pipeline that could otherwise manifest as dropped packets or other negative impacts on service quality.

Taking full advantage of CPU power states depends on sophisticated mechanisms that respond to real-world conditions, intelligently adjusting the frequency of individual processor cores to changing traffic loads.

Power Management Technology Description

Performance States (P-states):

A Performance State (P-state) (see Figure 2) is an operating point in an Intel® architecture CPU where a core is operating at a specific frequency and voltage while executing instructions. As the core moves to lower P-states, the frequency and associated voltage drops resulting in reduced power consumption and performance. The Advanced Configuration and Power Interface (ACPI) defines the performance states that are exposed to system software. Software interfaces provided by Enhanced Intel SpeedStep® Technology allow P-states to be controlled per core.

P-states are used to dynamically reduce frequency per core, reducing the power consumption of the server. They can be either managed by hardware through the hardware-controlled performance states (also known as hardware p-state or HWP), allowing much faster and finer adjustments of the frequency and voltage based on each core load, or by software through a user plane application via the Linux kernel system.

Idle power-saving states (C-states):

C-states are power states that a CPU can use to reduce power consumption on a per-core level, or on a CPU package level, by powering down portions of the core, package, or both. Disabling portions of the core allows for large power savings but prevents the core from executing instructions.

C-states can be either managed by hardware, through the CPU power control unit (PCU) responsible for autonomously coordinating core and package C-states, or by software through the OS as defined by the ACPI specification.

For instance, with the 4th Gen Intel Xeon Scalable Processor, a user space application can, through the waitpkg instructions,

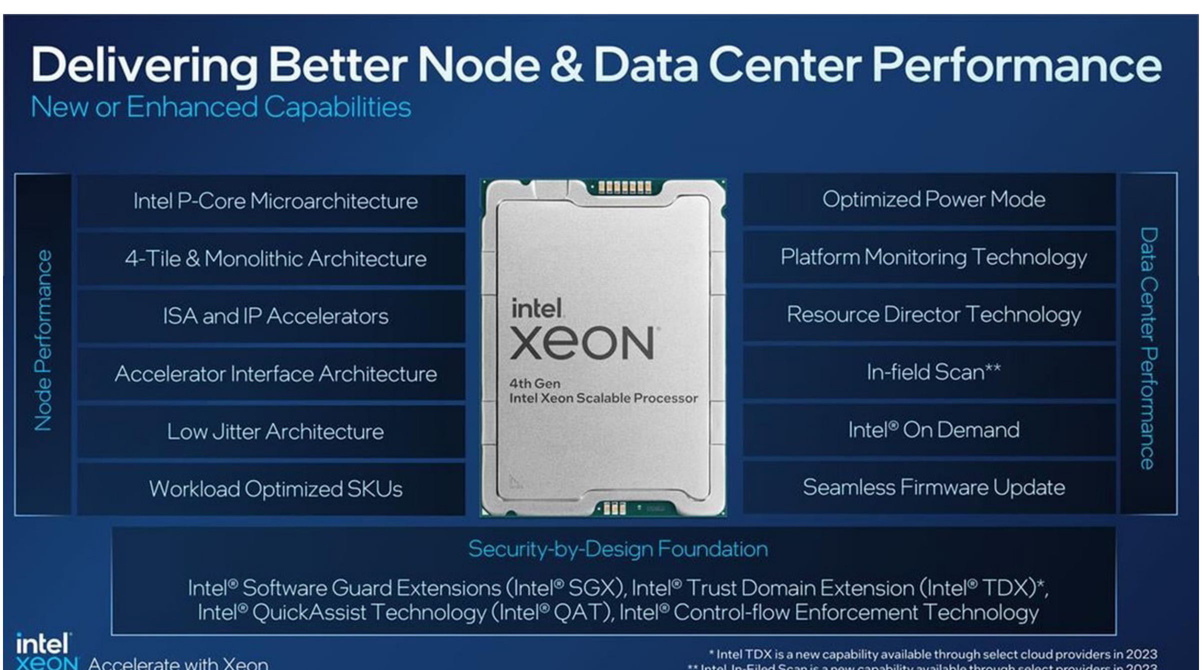

Figure 1. 4th Gen Intel® Xeon® Scalable Processor - delivering better performance.

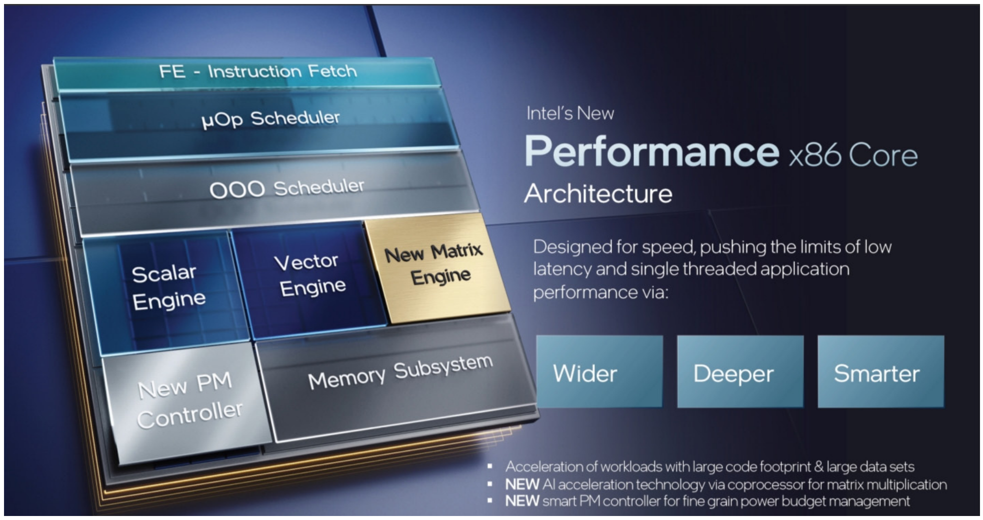

Figure 2. Intel's new performance core design principles.

request a power-optimized state and cause a CPU core to move into a light sleep state without incurring the cost of a system call.

Technical Solution: Integrating 6WIND VSR with Intel Power Management Technologies

Intel's power management technologies, specifically C-states and P-states, play a crucial role in further enhancing 6WIND VSR's power efficiency.

The new software version of 6WIND VSR comes with a set of new features that enable CPU power states' management offering an innovative solution that continuously adapts power consumption to network throughput requirements.

The 6WIND VSR offers an "ECO MODE" that puts the CPU cores allocated for data plane processing in a low power consumption mode when no traffic is processed by the VSR and in an adequate performance mode (frequency adjustment) when traffic is processed. The VSR constantly monitors processed traffic and adjusts, thanks to the Intel power management technologies, the CPU power consumption accordingly without impacting performance and latency.

The following sections describe the setup used to demonstrate the gain resulting from the use of these new VSR power management features.

Use Case Description

To demonstrate the reduction in power consumption derived from the different power management features enabled in the 6WIND VSR, a setup is built with a 6WIND vSecGW instance running virtualized on an Intel® architecture-based host platform with Intel power management technologies enabled.

The 6WIND vSecGW instance used as a device under test (DUT) is a critical network function used in communications service provider (CoSP) networks to secure and encrypt traffic between network domains. Service providers require security gateways to ensure secure and encrypted communication across their networks.

By encrypting packets, the gateway protects these data from being intercepted or tampered with, ensuring confidentiality and integrity. This is crucial for safeguarding sensitive information, maintaining secure connections between different network segments, and providing a reliable and trusted service to customers, especially those who are transmitting data over public or untrusted networks.

Typically, the security gateway is deployed at the edge of the service provider network (see Figure 3) to aggregate IPsec traffic from multiple remote end-point devices.

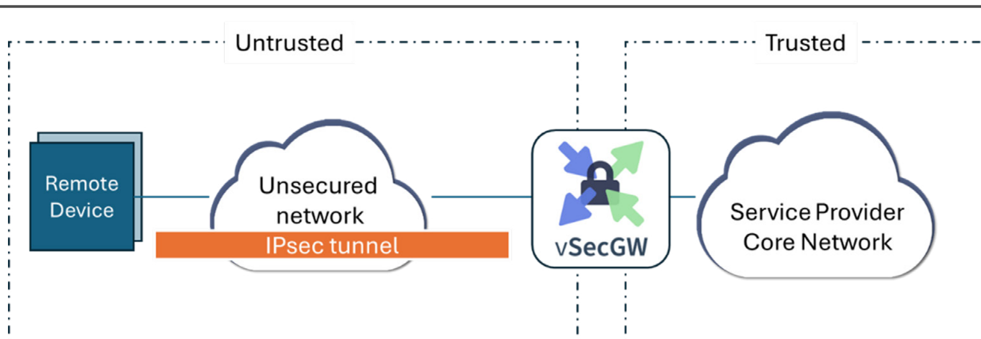

Figure 3. 6WIND vSecGW securing CoSP networks.

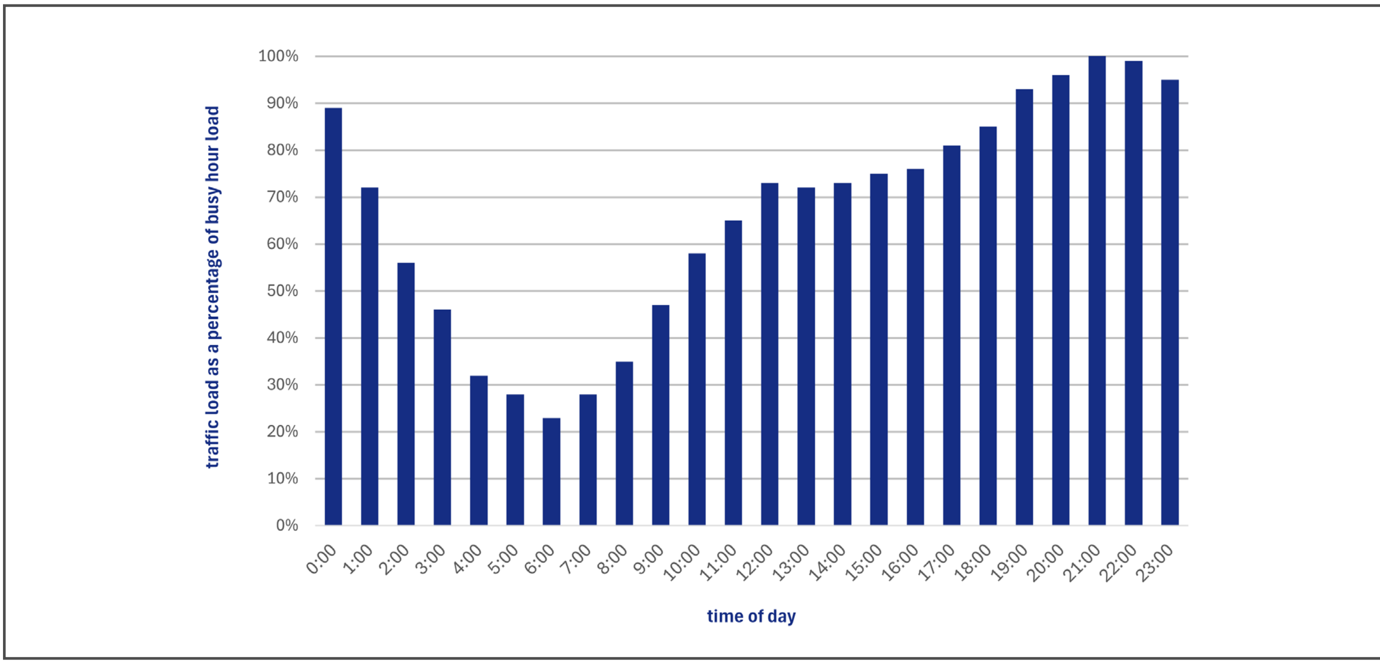

Figure 4. Hourly variation of traffic load as a percentage of busy hour load over a typical day for a mobile network operator in London, UK.

A traffic generator is used to feed the 6WIND vSecGW instance with IPsec traffic in one direction and clear traffic on the other. The setup uses a variable traffic load (0 to 200Gbps) to emulate a typical daily network load variation in a service provider network (see Figure 4).

As the traffic load varies over time, the 6WIND vSecGW (DUT) leverages the embedded new features in combination with the power state capabilities of the Intel processor to adjust its power consumption based on processed traffic.

The 6WIND vSecGW uses techniques to identify when the data plane CPU cores need to be set in low-power mode and when they should be set to the maximum frequency without impacting the delivered service quality.

Test Environment

The test environment (see Figure 5) is defined with a minimal setup including a traffic generator, a COTS server running a 4th Gen Intel Xeon Scalable processor (host platform), and a cloud-based monitoring instance for collecting the different KPIs from the 6WIND vSecGW.

The 6WIND vSecGW runs virtualized on the host platform and uses SR-IOV to map the network interfaces to the underlying physical NICs.

The setup uses one physical 2x100G Intel® Ethernet Network Adapter E810 on the host platform and one on the traffic generator with a bidirectional traffic between both (see Figure 5).

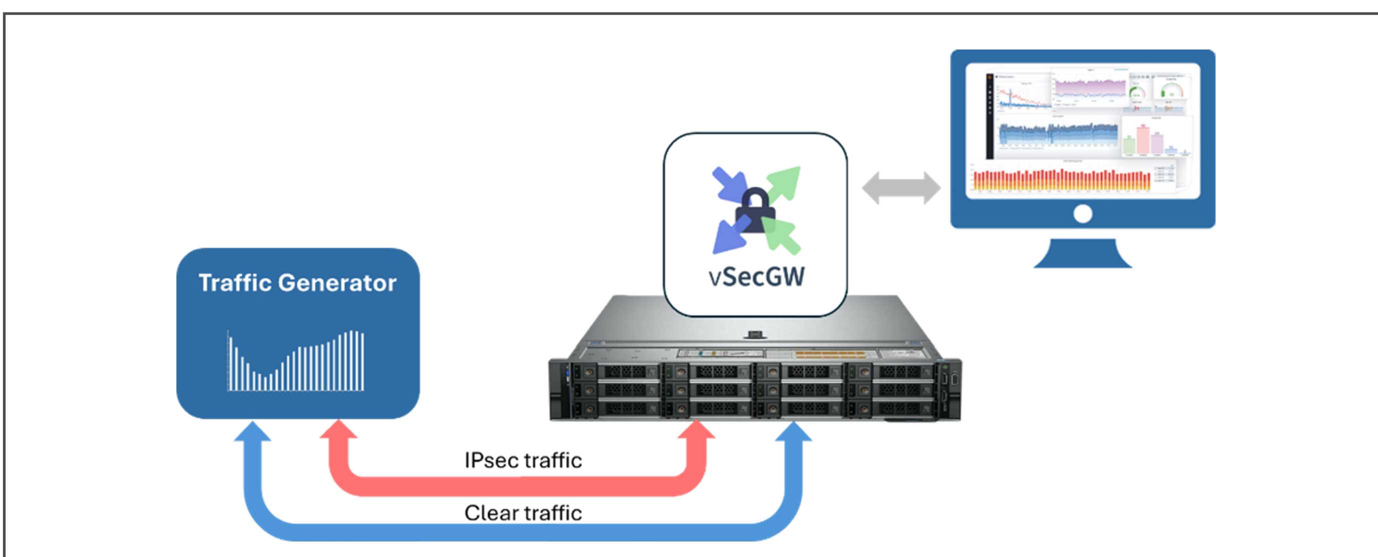

Figure 5. Test environment overview.

	Host Platform	Traffic Generator	DUT
CPU	2 x Intel® Xeon® Gold 6438N Processor 32C/64T@2.0GHz	2 x Intel® Xeon® CPU E5-2697 v2 Processor 24C/48T@2.70GHz	16 vCPU
Memory	64G	64G	8G
HDD	800G	200G	20G
NICs	1 x Intel® Ethernet Network Adapter E810-CQDA2 (2x 100G)	1 x Intel® Ethernet Network Adapter E810-CQDA2 (2x 100G)	1 x Intel® Ethernet Network Adapter E810-CQDA2 (2x 100G – SR-IOV/VF)
Software	Ubuntu 22.04.4 LTS	Ubuntu 22.04.4 LTS	6WIND vSecGW v3.9

Table 1. Specifications for host platform, traffic generator and device under test (DUT).

The traffic generator (see Figure 6) establishes 16 IPsec tunnels with the vSecGW and varies the traffic load from 0 Gbps to almost 128Gbps on each direction (total received/ total sent).

Results and Analysis

The collected results show a perfect correlation between processed traffic load and CPU frequency adjustment (see Figure 7). This correlation is obtained thanks to the VSR power management feature. The VSR continuously adjusts the CPU frequency to the traffic load in order to optimize the CPU power consumption.

In order to avoid latency and packet loss, the VSR adopts a power management algorithm that continuously determines the adequate CPU frequency based on different parameters including traffic profile and queue buffers.

The results also show the gain of power consumption that we can derive from the CPU frequency adjustment applied by the 6WIND VSR on the data plane CPU cores. Figure 7 shows how power consumption varies with CPU frequency.

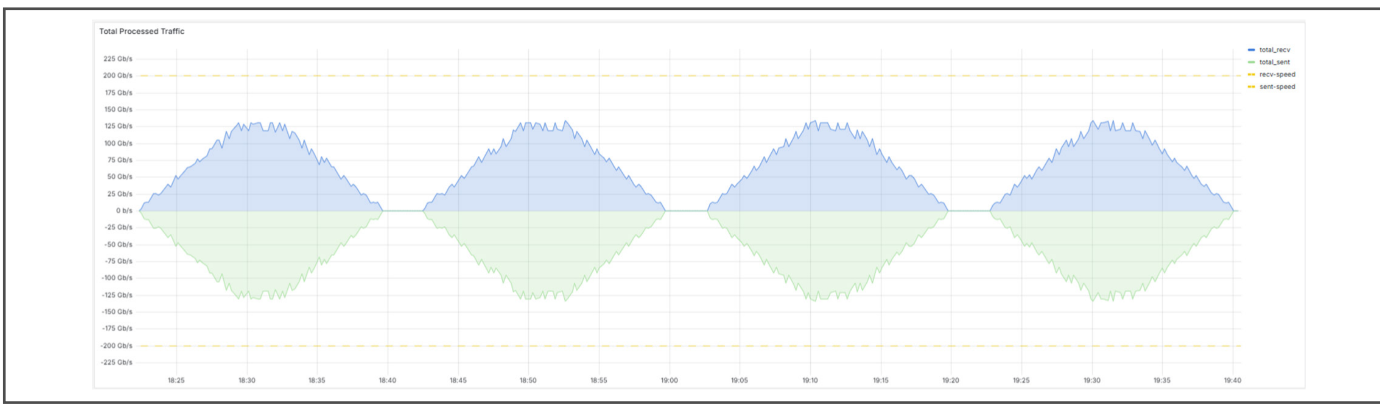

Figure 6. Traffic variation over time.

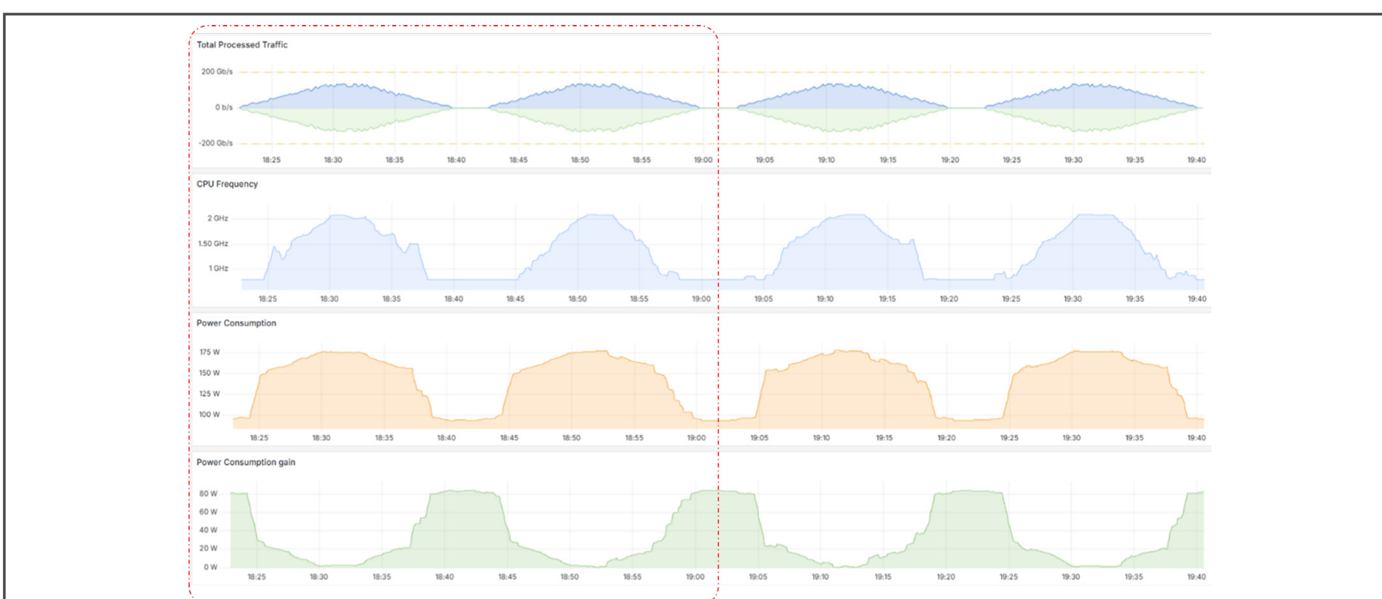

Figure 7. Grafana dashboard.

In the next paragraphs we will go through the details behind the previously highlighted correlation between traffic load, CPU frequency, and power consumption. Different phases define each cycle of traffic load variation. Figure 8 highlights the seven phases of each cycle:

- Phases 1 and 7 highlight the times when the appliance is not processing any traffic. In this case, the CPU cores are maintained at their minimum frequency (800Mhz) for a lower power consumption.
- The phases 2 and 6, are interesting as they represent the phases where the power management efficiency is the most relevant. For instance, for up to almost 50Gbps of processed IPsec traffic, the low CPU frequency is sufficient.
- Phase 3 and 5, are the phases where the system continuously adjusts the CPU frequency to the right level to maintain the minimum watt per Gbps ratio.
- Phase 4, is the phase where the system is at its optimal level. All the consumed power is used to process traffic.

Note: In this test, CPU idling (C-state) was not used. Only CPU frequency scaling (P-state) was used to set the CPU core frequency to its minimum when no traffic is processed. Using the C-state to put the CPUs in sleep or idle state when no traffic is processed, for instance during phases 1 and 7, would further enhance the power saving.

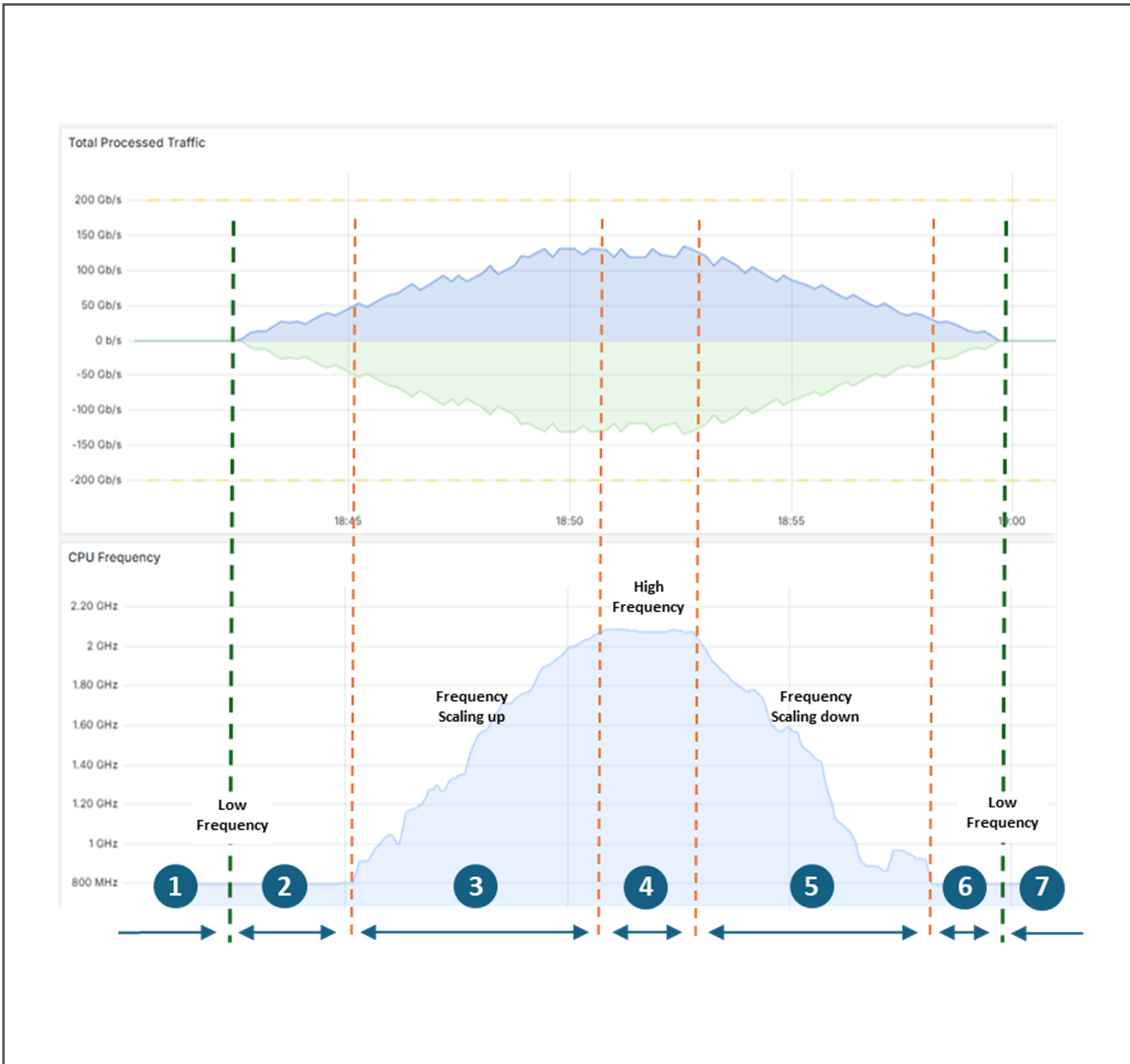

Figure 8. The seven phases of frequency scaling based on traffic load.

In Figure 9, the load variation appears uneven due to the traffic generator, which manages stepped scaling and causes packet bursts between steps. This accounts for the irregularities in the CPU frequency scaling curve.

This uneven variation in the traffic load is interesting, as it simulates what might occur in real-world traffic, where bursts can sporadically appear during a traffic variation cycle.

Note: The test aimed to improve power efficiency while maintaining service quality (ensuring no packet loss). The bursts produced by the traffic generator were instrumental in validating the expected system behavior.

From Frequency Scaling to Power Saving

Figure 9 illustrates how the frequency scaling technique translates into power saving. The different phases described in the previous paragraph can be easily identified in the figure below.

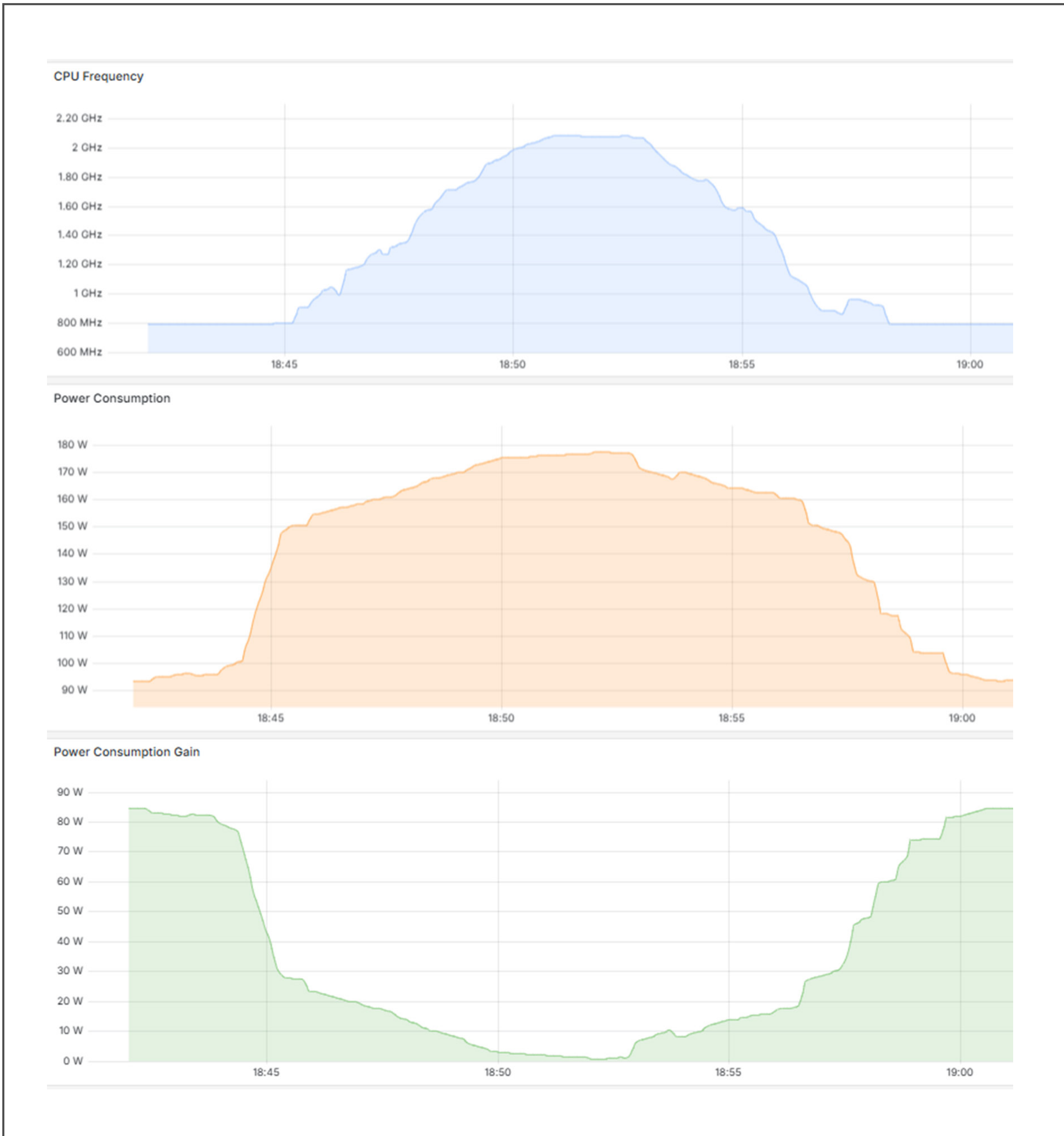

Figure 9. Power consumption gain.

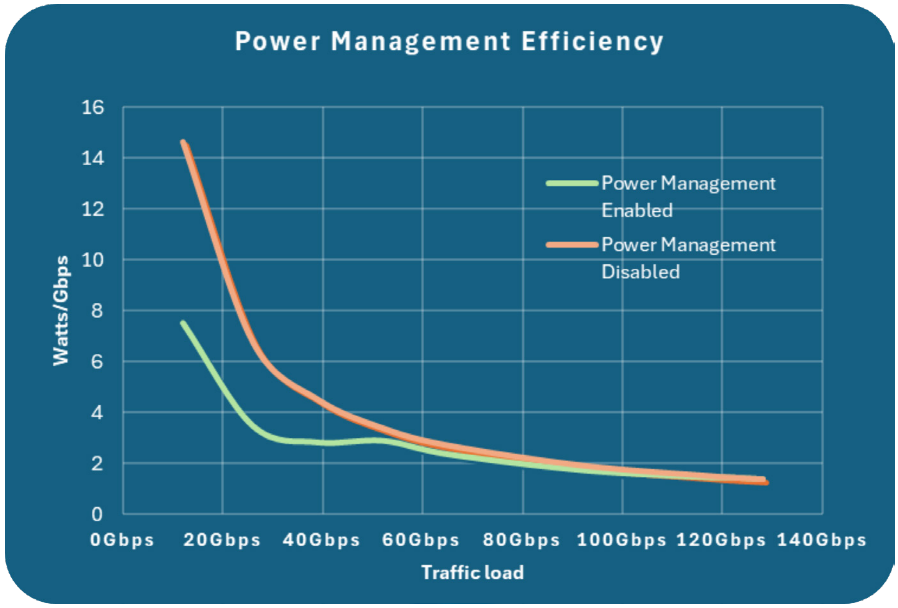

Figure 10. Delivering higher efficiency with power management (lower is more power efficient).

Compared to a system where the CPU power is not driven based on the traffic load, the gain in power consumption is at maximum when the load is low.

In a mobile network, as highlighted in Figure 4, a typical traffic load varies over 24 hours between 20% and 100%. Based on this traffic load profile and on the measured results, the reduction in power consumption over a 24-hour period when the power optimization feature is enabled is estimated to be in the range of 30% to 35%.

It is important to highlight that the frequency scaling granularity (frequency steps) directly impacts the achieved gain. The more the system is able to adjust the frequency the better the gain.

Figure 10 shows how the system behaves with and without power management at different loads. When the system is not loaded at its maximum, the power management feature boosts the system efficiency by drastically reducing the watt per Gbps ratio. At high throughput, when the CPUs are fully loaded, the system achieves the best watt/Gbps ratio.

Based on this last observation, to further enhance overall system efficiency, it is better to keep the CPUs fully loaded by leveraging the CPU idling technique (C-state) and processing the traffic with less CPUs when the load is low.

This approach based on C-state adjustments should be considered as a next step in 6WIND's VSR products and will be addressed in a specific future solution brief.

Solution Benefits for CoSPs

Energy Efficiency

Utilizing Intel's C-states and P-states, 6WIND VSR reduces power consumption, leading to lower energy costs and a smaller environmental footprint.

- **Reduced Energy Costs**: Lower power consumption during idle and low activity periods decreases overall energy expenses.
- **Sustainability**: Improved energy efficiency contributes to environmental sustainability initiatives.

Enhanced Performance

The 6WIND VSR, through the dynamic adjustment of CPU performance, handles varying network loads efficiently, maintaining high performance when needed.

- **High Throughput**: Smooth network operations through efficient handling of high data volumes.
- **Low Latency**: Minimizes delays, enhancing user experience.

Scalability and Flexibility

6WIND VSR's ability to scale and adapt to changing network demands allows service providers to grow their infrastructure seamlessly.

- **Scalable Infrastructure**: Easily accommodates increasing network demands without significant changes to existing infrastructure.
- **Flexible Deployment**: Supports various network functions, providing a versatile solution for diverse network environments.

Operational Expense Savings

By optimizing power usage and maintaining high performance, 6WIND VSR helps service providers reduce operational costs and improve return on investment (ROI).

- **Operational Savings**: Lower energy consumption translates to reduced operational expenses.
- **Improved ROI**: Enhanced efficiency and performance contribute to better overall financial performance.

Conclusion

6WIND VSR delivers exceptional technical value through its high-performance, scalable, and versatile software-based networking capabilities. Designed for virtualized environments, 6WIND VSR offers superior throughput and low latency, ensuring efficient data handling and minimal delays.

The 6WIND VSR is engineered for scalability, easily accommodating growing network demands, and facilitating seamless integration into existing infrastructures.

The integration of 6WIND VSR with Intel's power management technologies, particularly C-states and P-states, provides a powerful solution for service providers seeking to enhance network efficiency, reduce operational costs, without compromising performance. This technical solution enables service providers to optimize their network operations, achieve sustainability goals, and improve their overall competitiveness in the market.

Learn More

6WIND Virtual Service Router

4th Gen Intel® Xeon® Scalable Processor

Overview of Intel power saving technologies

Overview on using user space C-states with a DPDK PMD workload

Overview of Enhanced Intel SpeedStep® Technology

Intel® Industry Solution Builders

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