Solution Brief

Power Management
5G Core

Dynamically Tune Intel® CPUs to Maximize Network Energy Efficiency

Intel® Infrastructure Power Manager for 5G Core running on 4th Gen Intel® Xeon® Scalable processors can enable CoSPs to reduce energy costs and carbon emissions by delivering an average power savings of 30% while maintaining key telco performance metrics.[1]

The massive growth in 5G data traffic continues, with a projected increase in global monthly average usage per smartphone from 19 GB in 2023 to 46 GB by the end of 2028.[2] At the same time, communication service providers (CoSPs) face pressure to reduce expenses and fulfill commitments to achieve Net Zero targets. These circumstances make increased energy efficiency a strategic goal for CoSPs.

Intel has long invested in technologies and practices that deliver breakthrough performance while leading the industry in energy efficiency and environmental stewardship, with some examples shown in Figure 1. This multifaceted effort ranges from developing sustainable manufacturing and operating practices to hardware and software innovations that continue to improve performance and performance per watt.

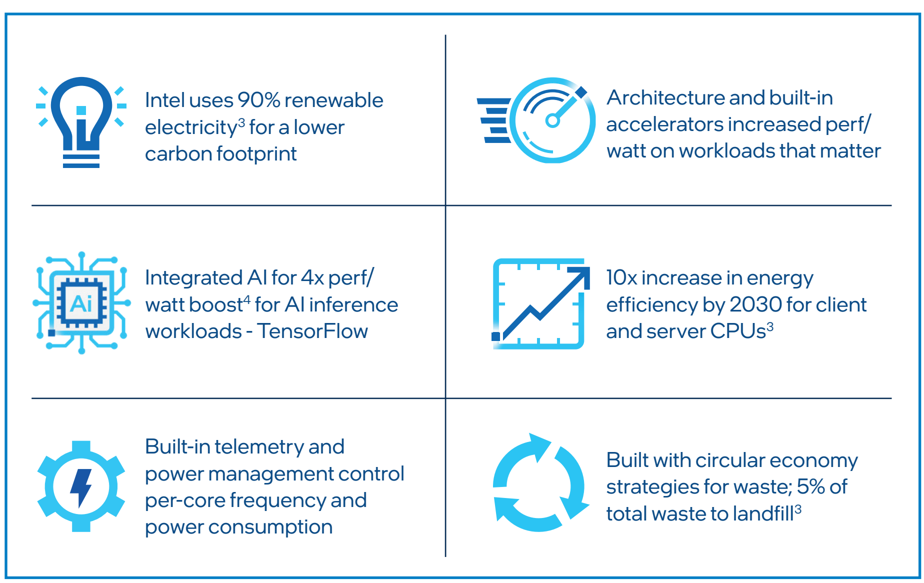

Figure 1. Intel® Xeon® processors: Innovation for performance and sustainability.

Collaboration by Intel and SK Telecom extends this priority with the development of the Intel® Infrastructure Power Manager for 5G Core. This cloud-native software solution continually recalibrates the power states of individual processor cores based on changing workload requirements.

Breakthrough Performance and Power Savings

The performance and energy efficiency of Intel platforms make them foundational to CoSP deployments of 5G networks, including the 5G core. 4th Gen Intel® Xeon® Scalable processors deliver the industry's first 1 Tbps of performance on the 5G UPF workload with a dual-socket server.[5] Intel Infrastructure Power Manager for 5G Core software delivers an average power savings of 30% while maintaining key telco performance metrics.[1] In addition, the software delivers 93% performance-per-watt improvement versus the previous generation platform for 5G core infrastructure without the new software.[1]

4th Gen Intel Xeon Scalable processors include an array of built-in acceleration that makes the processors more energy efficient. These network-optimized processors support more data per clock cycle and deliver 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 responsiveness of power-management software by enabling cores to recover full power more quickly. That 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.

> With dynamic power management, CoSPs can aggressively cut power usage without compromising performance.

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. Intel Xeon Scalable processors incorporate Intel Platform Telemetry Insights for comprehensive platform data to guide these mechanisms. Dedicated hardware registers track metrics such as cache usage, core operating frequencies, memory bandwidth and I/O access.

Telemetry data includes power (CPU, system, memory), thermal (CPU, airflow inlet and outlet, DIMM) and performance (CPU, memory, cache). Harnessing this data, power-management software can improve energy efficiency by dynamically scaling hardware resources to match workload requirements. Highly optimized power management software is even more effective when tuned to hardware with differentiated features, such as fast frequency change, highly granular C-state and P-state controls and platform telemetry. Many CoSPs have traditionally disabled power-saving platform features, which have widely been regarded as having a negative effect on performance. Now, CoSPs can be more aggressive in power management because the new software reduces energy consumption without compromising key performance indicators (KPIs), such as throughput, latency and packet drop.

Software Orchestration of Core Power States Across the Network

Intel Infrastructure Power Manager for 5G Core is a cloud-native software solution that dynamically controls per-core power state at runtime, in response to UPF traffic flows. It is built to be deployed as a Kubernetes pod on each worker node, as shown in Figure 2. This software accelerates time to market for ISVs and CoSPs by simplifying programmatic access to hardware capabilities such as telemetry, granular power control states and low-latency frequency change.

Built natively using microservices, the solution supports dynamic scalability across distributed infrastructure, with a common architecture possible for all network functions in the 5G system, from RAN to core. 5G user plane traffic fluctuates significantly over time, with somewhat predictable patterns of activity over the course of the day. At a more granular level, traffic volume also varies substantially among individual user plane flows, as illustrated in Figure 3. Those individual fluctuations are the basis of the opportunity to realize energy savings by using Intel Infrastructure Power Manager to optimize the granularity and responsiveness of power policy at the per-core level.

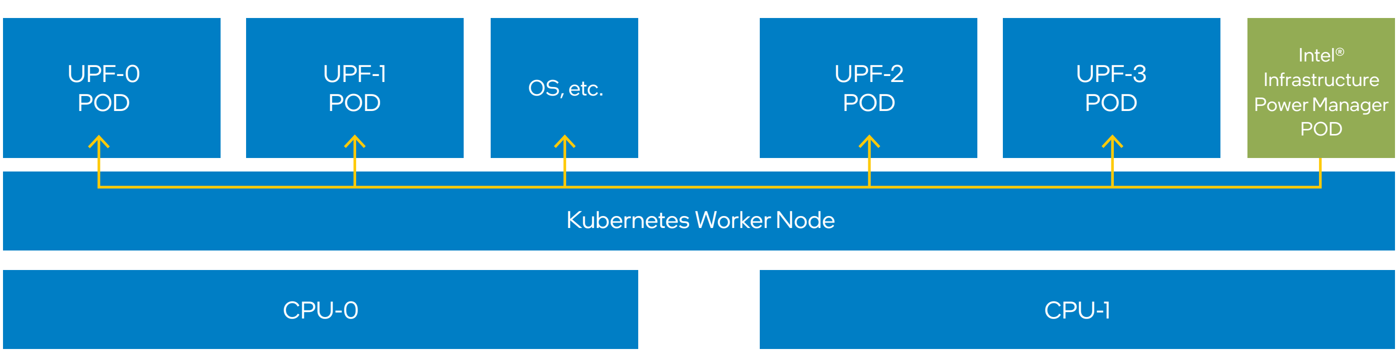

Figure 2. Deployment of Intel® Infrastructure Power Manager for 5G Core as a Kubernetes pod.

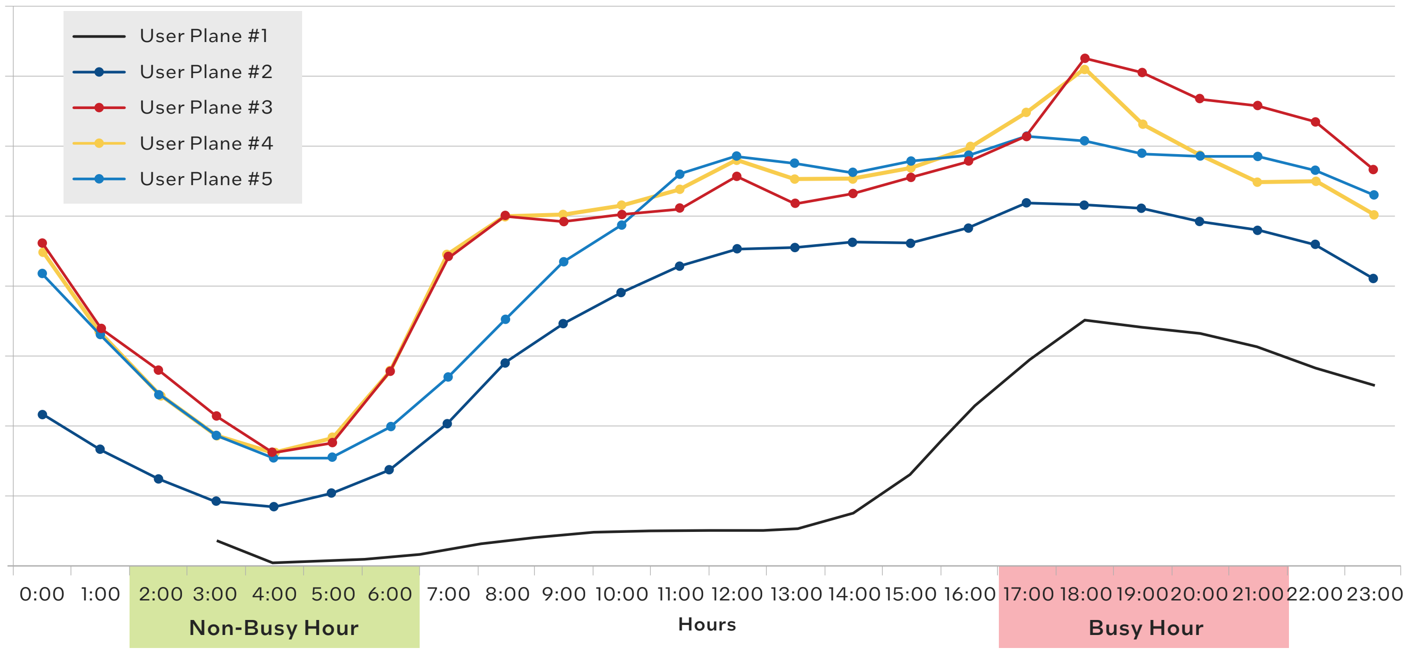

Figure 3. Variations in throughput demand across 5G core workloads and over time.

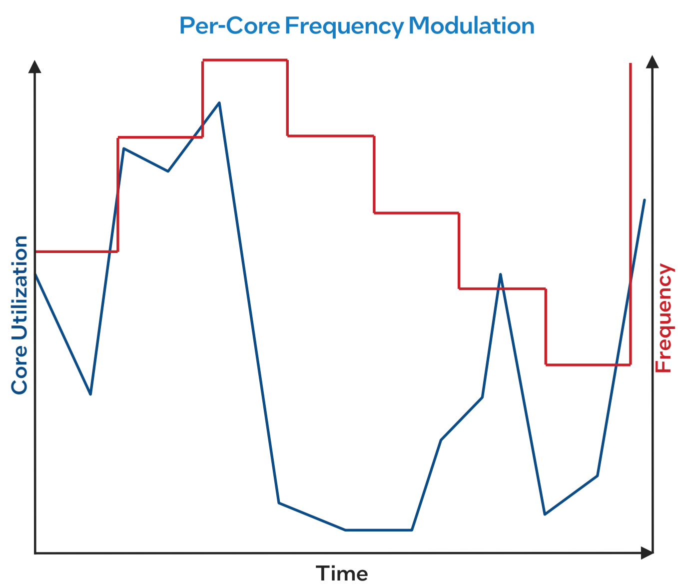

Figure 4. Autonomous user-plane power management.

Packet rate is strongly correlated with how the core is utilized to process that packet flow. Intel Infrastructure Power Manager for 5G Core tracks UPF worker core utilization at millisecond granularity, a level of detail enabling significant power reduction without impacting performance KPIs. Per-core frequency can therefore be modulated in accordance with core utilization as a proxy for packet flow, as illustrated in Figure 4. The solution continually re-computes the target P-states of processor cores to set higher or lower core frequencies as needed, with a configurable bias toward slow reduction and fast increase.

Implementation does not require software changes to the UPF, other than patch integration for the data plane development kit (DPDK), which is available from DPDK 20.11 onward.

Intel Infrastructure Power Manager for 5G Core is part of an extensible framework that will be updated with additional power management capabilities including support for control plane functions. The reference software is available immediately for 5G Core Network Function ISV evaluation, integration and validation.

Conclusion

Run-time power savings is one of the biggest opportunities for CoSPs to lower significant, operating expense (OpEx) energy costs. Intel Infrastructure Power Manager for 5G Core is a breakthrough for CoSPs because it dynamically matches run-time server power consumption with data traffic. The technology makes a vital contribution to strategic efforts to reduce costs and to assist CoSPs in meeting environmental and sustainability goals.

For more information or to obtain the Intel Infrastructure Power Manager software, please contact your Intel sales representative.

Solution provided by:

intel.

[1] Tested by Intel as of 01/26/23. One node, 2x Intel® Xeon® Gold 6438N CPU, 32 cores, Intel® Hyper-Threading Technology enabled; Intel® Turbo Boost Technology disabled; total memory 512 GB (16x 32 GB DDR5 4800 MT/s [4000 MT/s]); BIOS EGSDCRB1.SYS.0090.D03.2210040200; microcode 0x2b0000c0; 2x Intel E810-2CQDA2 (CVL, Chapman Beach, Total – 4x100G ports); 1x 223.6G INTEL SSDSC2KB240G8; 1x 745.2G INTEL SSDSC2BA800G3, Ubuntu 22.04 LTS, 5.15.0-27-generic; GCC 7.5.0; DPDK 22.11.

[2] Ericsson, "Mobile Data Traffic Outlook." https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/mobile-traffic-forecast.

[3] Intel, 2022. "Corporate Responsibility Report." http://csrreportbuilder.intel.com/pdfbuilder/pdfs/CSR-2021-22-Full-Report.pdf.

[4] Results may vary. See https://www.servethehome.com/stop-leaving-performance-aws-ec2-m6i-intel-instances/ for configuration details.

[5] Tested by Intel as of 01/27/23. One node, 2x Intel® Xeon® Platinum 8470N CPU, 52 cores per socket (104 total), Intel® Hyper-Threading Technology enabled; Intel® Turbo Boost Technology disabled; total memory 1024 GB (16x 64 GB DDR5 4800 MT/s [4800 MT/s]); BIOS EGSDCRB1.SYS.0093.D22.2211170057; microcode 0x2b000130; 6x Intel E810-2CQDA2 (CVL, Chapman Beach, Total – 6x 100G ports); 1x Intel E810-CQDA2 (CVL, Tacoma Rapids, Total – 2x100G ports); 1x 447.1G INTEL SSDSCKKB8; 1x 931.5G CT1000MX500SSD1; Ubuntu 22.04 LTS, 5.15.0-53-generic; UPF(GCC 9.4.0/Clang9.0.0,DPDK 22.07,VPP 20.09).

Availability of accelerators varies depending on SKU. Visit the Intel Product Specifications page for additional product details.

Performance varies by use, configuration and other factors. Learn more at https://www.intel.com/PerformanceIndex.

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See configuration disclosure for configuration details. No product or component can be absolutely secure.

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