Solution Brief

5G Core

Drive Up Density, Throughput and Power Efficiency for 5G Core Workloads

Intel® Xeon® 6 processors with E-cores drive improvements of up to 4.2x higher performance and 2.7x higher performance per watt for 5G Core workloads,[1] enabling mobile network operators to achieve more capacity, higher throughput and energy efficiency across load line.

The drive to more effectively monetize 5G services continues to dominate the competitive landscape for communication service providers (CoSPs). That challenge is made more complex by massive ongoing traffic increases; globally, average monthly mobile data usage per smartphone is expected to reach 56 GB by 2029, rising from 21 GB at the end of 2023.[2] Providers must support that growth in traffic without a corresponding rise in power consumption, which creates pressure to do more with less.

Looking ahead, CoSPs must achieve higher 5G Core throughput and density per rack, not only to reduce equipment capital expense (CapEx) but also to support growth with existing facilities. Likewise, operating expense (OpEx) is driven by power and cooling costs, which makes achieving higher performance per watt an important strategic consideration; improved power efficiency also helps CoSPs work within the constraints of existing rack-level power infrastructure.

The rise of 5G has seen a dramatic acceleration in the adoption of general-purpose, standards-based hardware to replace legacy fixed-function equipment. Highly capable servers replace higher-cost legacy solutions with immediate CapEx savings, as well as ongoing lower energy usage. This transition has also enabled the workload virtualization and consolidation using distributed network architectures that underlie 5G market efficiencies and make it possible for CoSPs to cost-effectively manage traffic growth.

Intel® Xeon® 6 processors break new ground in performance, density and power savings with up to 144 Efficient-cores (E-cores) per socket, or up to 288 cores in a two-socket server. Those high core counts — coupled with high per-core performance — deliver up to 4.2x higher performance,[1] enabling CoSPs to support more simultaneously attached users (SAUs) with the same infrastructure footprint. The efficiency advantages of the E-core architecture

5G UPF on Intel® Xeon® 6 processors

UP TO **4.2x** higher 5G UPF performance[1]

UP TO **2.7x** higher performance/watt (socket power)[1]

with Intel® Xeon® 6780E processor
vs 2nd Gen Intel® Xeon® Gold 6252N processor

compound that savings with up to 2.7x performance per watt,[1] helping reduce total cost of ownership (TCO) for the 5G infrastructure. Additional power savings based on enhanced platform telemetry and Intel® Power Manager offer further opportunities to achieve cost efficiencies.

CPU innovation that powers 5G Core evolution

Intel Xeon 6 processors provide CoSPs with unprecedented parallelism to deploy 5G Core workloads at scale, together with headroom for other virtual functions (VFs) on converged platforms. The greater degree of potential resource sharing enabled by the platform's high core counts is effective at raising system utilization in distributed 5G environments. Core density allows dedicated compute resources to be assigned among large numbers of individual VFs for high throughput, helping enable the ongoing CoSP transition to a cloud-native architecture. Xeon 6 CPUs deliver advanced resources across the balanced platform:

- **Up to 144 Efficient-cores (E-cores) per socket**, in one- or two-socket configurations, are augmented with built-in accelerators[3] that enhance targeted workloads for high throughput at scale.
- **Eight DDR5 memory channels per CPU**, operating at up to 6400 MT/s, provide up to 15% higher bandwidth versus the previous generation to keep the massive execution resources supplied with data.
- **Up to 88 lanes of PCIe 5.0 per socket and Compute Express Link (CXL)** 2.0 provide robust I/O to support workload acceleration and data growth for next-generation 5G Core architectures.

The E-cores that the processor is based on are engineered to enable high VF density per rack, within the platform's 205-330 watt power envelope. They are engineered for small physical size and low power consumption per core, for scale-out performance. They are well suited to the highly threaded usages inherent in CoSP environments as they strive for greater throughput and efficiency in pursuit of business improvements. In addition, long-life availability[4] means that CoSPs can derive more value from these enhancements for years, until their next upgrade.

Ecosystem-driven innovation

Collaboration between Intel and ecosystem partners is a cornerstone of enablement for the telecom industry, including for 5G Core deployments. Deep collaboration with CoSPs as well as the providers of the software, equipment and services they depend on helps create a seamless environment that increases the viability and cost-effectiveness of next-generation network environments.

These partnerships help enable mobile networks with the full range of platform capabilities in Intel hardware, including ongoing innovation alongside the Intel processor roadmap going forward. Major original equipment manufacturers (OEMs) and ISVs have added Intel Xeon 6 processors with E-cores to their roadmaps. Their enabled servers and optimized software are aligned to the processor release, for integration into networks in late 2024 or early 2025.

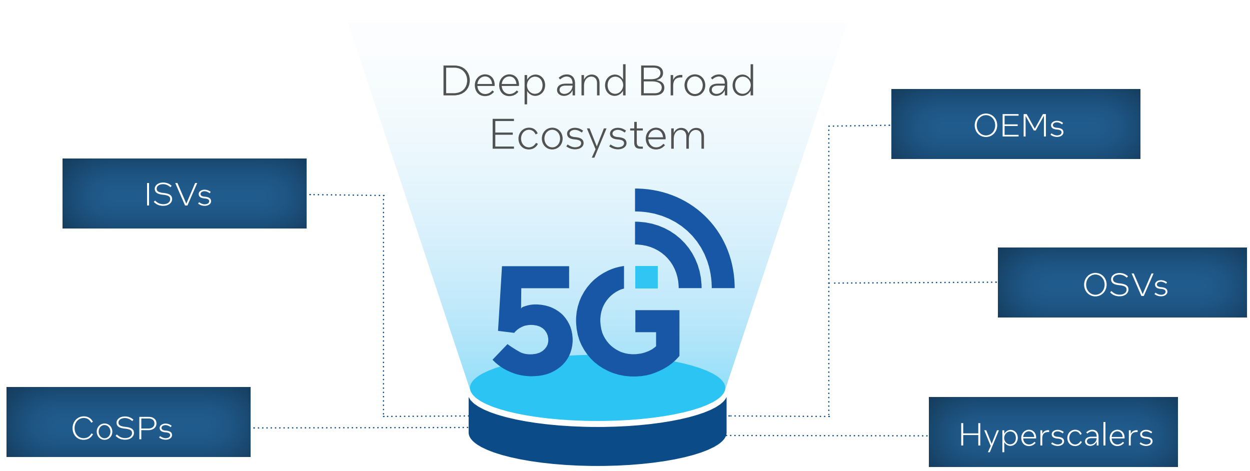
Intel® Network Builders, part of the Intel® Partner Alliance, brings together diverse industry providers to improve the quality and interoperability of solution components. It includes a broad and deep framework of collaboration that encompasses the following:

- **350+ global member companies**, including 35+ member CoSPs, which unifies diverse industry efforts to create synergies and economies of scale for all.
- **100+ proofs of concept, trials and deployments**, to bridge the gap between theoretical technology benefits and the corresponding real business advantages in production.
- **13,000+ developers trained worldwide** to embrace the latest capabilities, best practices and methods, accelerating introduction of the cutting edge.

ERICSSON

"We are planning to adopt the Intel® Xeon® 6 processor with E-cores for use with Ericsson's Cloud Infrastructure and Ericsson's dual-mode 5G Core applications. Our testing resulted in a 3.2x improvement in performance and over 60% reduction in CPU energy consumption compared to the 2nd Gen Intel Xeon Scalable processors, which most of our customers have deployed in their core networks."

– Monica Zethzon, Head of Solution Area Core Networks



Enabling greater throughput, density and scale

CoSPs and other ecosystem members realize the advantages of Intel Xeon 6 processors in part by supporting more SAUs per rack while maintaining existing service levels. Hardware accelerators built into the platform play a central role in the throughput and scalability focus by offloading critical functions from the CPU cores, freeing them for other work.

It is inherently faster and more energy efficient to perform these functions in hardware than with software logic, meaning that in addition to performance advantages, hardware accelerators contribute to better hardware utilization, increased throughput, lower power consumption and lower OpEx. These advantages translate to financial and sustainability benefits for network operators.

Accelerated crypto to reduce the overhead of pervasive encryption

Extensive encryption and decryption operations protect the privacy and integrity of control plane and data plane transmissions in the 5G Core. Because these operations consume significant compute resources, Xeon processors offer hardware acceleration for encryption using built-in Intel® Advanced Vector Extensions 2 (Intel® AVX2), Vectorized Advanced Encryption Standard (V-AES), Intel Multi-Buffer Crypto for IPsec and more for 5G Core workloads and back-office services, such as OSS, BSS and authentication of applications and devices.

Intel® QuickAssist Technology (Intel® QAT) accelerates both encryption and compression. With Intel QAT, there is no requirement to send data over the PCIe bus to communicate with external hardware, resulting in improved throughput and overall responsiveness as well as reduction of power consumption and transfer latency.

Intelligent orchestration among processing cores

Intel Xeon 6 processors are explicitly designed to support the distribution of data plane and signaling workloads including in the 5G Core. The platform optimizes the use of system resources by dynamically tuning processing cores for efficiency. Intel Dynamic Load Balancer (Intel DLB) implements that orchestration with silicon-based load balancing rules and logic built into the processor. This platform feature operates without occupying the processor cores that otherwise would be needed to execute software-based traffic control.

Predictable, innovative, flexible networking with Intel® Ethernet

Performance and scalability enhancements that target 5G Core deployments are enhanced through technologies built into Intel Ethernet network adapters. These include protocol-specific parsing, classification and steering by means of Dynamic Device Personalization (DDP). Intel Ethernet is vital to enabling the shift to open, disaggregated solutions with off-the-shelf components.

Optimizing power efficiency for 5G Core deployments

Alongside performance and scalability considerations, energy efficiency is of increasing concern to CoSPs. In environments where between 20% and 40% of network OpEx may be based on energy consumption,[5] cost considerations can be significant enough to affect competitiveness.

Drive down 5G core energy usage with platform advancements

Pre-determined rack power limits in data centers tend to be limiting factors in raising the density of SAUs per rack, which has direct impact on capacity and operating cost, as well as overall scalability. In addition, network architects are increasingly answerable for reducing energy consumption in support of corporate sustainability targets. These realities make performance per watt a first-order concern for the effective operation of 5G Core workloads.

Despite the small power footprint of the Intel Xeon 6 processor's E-cores, the platform uses the same instruction set architecture as its predecessors. This characteristic enables the 5G Core's performance-per-watt improvement without requiring any changes to application software. Moreover, micro-architectural advances and the Intel 3 process that underlies the Xeon 6 processor give E-cores superior performance across a variety of measures compared to predecessors.

Platform innovations help enable competitive advantage by tailoring power levels on a per-core basis to reduce overall energy consumption while maintaining a steady user experience based on metrics that include throughput, latency and packet drop. Intel lends its platform expertise to the ecosystem in pursuit of greater energy efficiency, through longstanding collaborations that will continue to realize benefits as solutions continue to develop.

Match power usage to traffic load: Intel® Infrastructure Power Manager

Beyond the processor's up-to-2.7x improvement in performance per watt on 5G Core workloads,[1] customers can achieve an additional 30% average power savings using Intel Infrastructure Power Manager (Intel IPM), while maintaining key telco performance metrics.[6] This software solution dynamically controls the power states of individual processor cores at runtime in response to changing traffic flows.

This capability is particularly valuable for 5G user plane traffic, which fluctuates significantly over time. Many CoSPs have traditionally turned off power management to avoid potential performance impacts, but with Intel IPM, that is no longer necessary. User plane functions are generally built using data plane development kit (DPDK) or vector packet processing (VPP) libraries. They typically conduct continuous polling of the network card or software queues, which makes the cores always appear busy to OS-resident power governors, even when there are no packets to process.

Intel IPM provides information on how busy the cores truly are, with millisecond granularity, to dynamically optimize the power state of each core. The solution also enables support for all processor power states, enabling idle cores to be placed in lower power with greater granularity for more aggressive power management, in terms of balancing power savings with recovery time. Intel IPM is being widely adopted by independent software vendors (ISVs), many of which are achieving 30%-40% power savings, in addition to improvements generated by the processor itself.

Testing by SK Telecom demonstrates that Intel IPM can respond without packet loss when traffic spikes in just one second from zero to 18 million packets per second. The solution can be deployed without direct changes to network functions, simply by applying a DPDK or VPP patch and installing Intel IPM on each server. It is built using native microservices, is suitable for all network functions and runs on either bare-metal or VM-based environments.

Conclusion

Intel Xeon 6 processors give CoSPs dramatic CapEx and OpEx advantages for their deployments of 5G Core network functions. As many as 288 E-cores per two-socket server provide performance and density per rack to scale with fast-growing mobile traffic, powered by a global ecosystem of hardware, software and service providers. In addition to being able to extend the future viability of existing facilities, the platform saves on operating costs every day by reducing power and cooling costs, advantages that can be built upon further using Intel IPM in production. With Intel Xeon 6, CoSPs deploy highly parallel, efficient compute that captures new opportunities with a solid focus on the bottom line.

Learn More

www.intel.com/5G

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[1] See [7N1] at intel.com/processorclaims: Intel® Xeon® 6. Results may vary.

[2] Ericsson. "5G to account for 25 percent of mobile data traffic this year." https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/mobile-traffic-forecast.

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

[4] Intel does not commit or guarantee product availability or software support by way of road map guidance. Intel reserves the right to change road maps or discontinue products, software and software support services through standard EOL/PDN processes. Contact your Intel account rep for additional information.

[5] GSMA Intelligence, October 2022. "A blueprint for green networks." https://data.gsmaintelligence.com/research/research/research-2022/a-blueprint-for-green-networks.

[6] Tested by Intel as of January 26, 2023. 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.

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