Solution Brief

Virtualized Radio Access Networks (vRANs)
Intel® Xeon® 6 SoC

Platform and Performance Advantages to Accelerate vRAN Deployments

With significant enhancements across the platform, including Intel® vRAN Boost, integrated Intel® Ethernet and Intel® Advanced Matrix Extensions (Intel® AMX), the Intel® Xeon® 6 SoC provides a leap forward in capacity and total cost of ownership (TCO), enabling a single server per cell site to support the majority of vRAN deployments.

As network operators increasingly adopt virtualized RAN (vRAN) solutions, their key priorities are to achieve significant TCO reductions, ensure headroom for network capacity growth, and to cost effectively realize the promised benefits of AI. The Intel® Xeon® 6 SoC is designed to fulfill these critical market demands.

This evolution from fixed-function approaches to highly interoperable stacks of open ecosystem solutions provides flexibility to help drive down implementation cost and complexity, with improved future-readiness. Industry analysts estimate that Open RAN will account for more than 25% of the total RAN market by 2028.[1]

MORE THAN **25%** by 2028

Open RAN portion of total RAN market[1]

Disaggregated network architectures enable network operators to mix and match best-of-breed system elements from a broad solutions ecosystem, including the open source software community, to meet each operator's unique requirements. Network operators also have greater freedom of choice and can save significantly on capital expense by powering their networks with commercial off the shelf (COTS) hardware instead of single-purpose equipment.

An engine for RAN innovation

The Intel Xeon 6 SoC improves dramatically upon the architectures of predecessors for vRANs, increasing system capacity and energy efficiency to drive down total TCO. Integrated accelerators and other built-in features enhance the processors' performance and flexibility, with up to 2.4x capacity gain,[2] up to 70% performance per watt improvement[3] and up to 3.2x AI RAN performance per core gain[4] compared to the prior generation.

These processors boast architectural enhancements and more than twice the core count of Intel's previous generation vRAN solution. Their integrated Intel® vRAN Boost acceleration and integrated Intel® Ethernet enhance the platform's performance, security and manageability, while also reducing the solution's component requirements. The combination of optimized architecture and capacity gain will help network operators dramatically reduce their server footprints, enabling most site configurations that typically required two or more servers to run on just a single vRAN server.

This consolidation can significantly reduce capital expense (CapEx) and operating expense (OpEx), compared to previous platforms, which often have required multiple servers and other connected hardware and software components. The processors' increased performance per watt further enhances this benefit with energy savings to reduce ongoing operating expense. The Intel Xeon 6 SoC delivers substantial hardware upgrades for vRAN deployments:

- **Expanded execution resources.** Up to 72 cores built on Intel 3 process technology, with further enhancements to Intel® vRAN Boost that enable higher vRAN capacity compared to predecessor platforms.
- **Enhanced memory subsystem**. Up to eight channels of DDR5 memory at up to 6400 MT/s and ~2.2x larger cache than predecessors, to keep more warm data closely accessible to the processing cores and reduce how often data is required from DRAM.
- **Innovations for high-performance, efficient I/O**. The SoC features Integrated Intel® Ethernet supporting up to 200 Gbps through up to eight individual ports of 25 Gbps Ethernet, as well as up to 32 lanes PCIe 5.0 and up to 16 lanes PCIe 4.0, for 48 lanes total.
- **Extended-temperature version**. Operates in challenging environments with ambient temperatures down to -40°C.

Platform integration for efficiency and performance

SoC designs are built for compactness and integration; a core design premise of the Intel Xeon 6 SoC is to integrate select platform elements into the SoC package. This approach helps simplify the bill of materials to reduce system cost for vRAN servers. It also reduces accesses to external devices such as discrete accelerators and network cards across the PCIe bus, for lower power consumption and lower latency. Executing workloads on an optimized SoC provides superior latency and energy efficiency compared to a disaggregated solution.

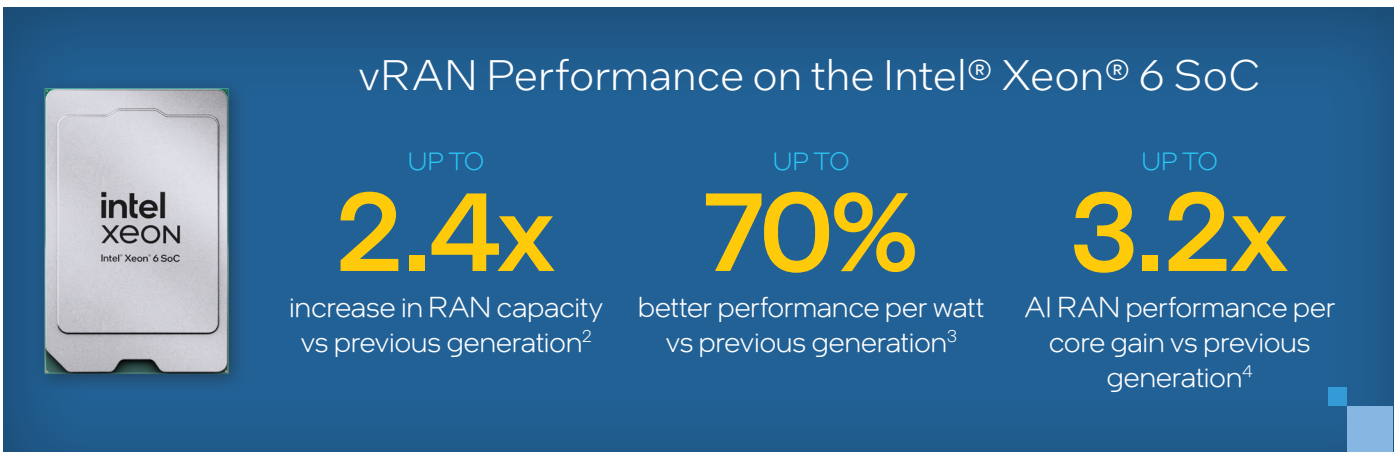
Based on the standard Performance-core (P-core) die used in other current Intel Xeon processors, the Intel Xeon 6 SoC provides seamless software portability with current and previous generations, providing a converged-services advantage. Operators can draw on this capability to run all core, edge and access workloads flexibly on a common platform, driving dramatic resource efficiencies and reducing TCO.

For private network and enterprise use cases, the Intel Xeon 6 SoC provides the compute capacity and flexibility to deploy both the 5G RAN network and 5G Core network. With more than twice the core count of the previous generation, Intel Xeon 6 SoC can additionally support other applications and services for a wide variety of use cases on the same server.

Acceleration on the CPU: Intel vRAN Boost

The Intel Xeon 6 SoC provides outstanding energy-efficient performance across networking use cases, including vRAN deployments. The platform's P-cores are optimized for high throughput and low latency, with built-in acceleration for packet and signal processing, load balancing and AI. Building on that foundation, Intel vRAN Boost integrates vRAN acceleration directly into the SoC. Using the O-RAN Acceleration Abstraction Layer standardized DPDK interface, independent software vendors and software developers can easily optimize their vRAN software stacks for vRAN Boost hardware acceleration. The standardized interface makes it easier to move from one generation of Intel vRAN Boost to the next.

Intel vRAN Boost is sized to ensure ample headroom even in the most intense use-cases and with the highest core count options, allowing future software optimizations to further increase server capacity without worrying about hitting acceleration limits.



Connectivity and synchronization: Integrated Intel Ethernet

Integrated Intel Ethernet provides high network throughput and advanced functionality, eliminating up to two external Ethernet adapters. In addition to robust, compact connectivity, integrated Intel Ethernet also provides accurate and reliable network synchronization to meet the strict timing requirements for commercial radio access networks. This capability helps ensure smooth hand-offs between cells, without packet loss or corruption. Integrated Ethernet optimizes the leader/follower timing architecture, reducing complexity and cost.

Phase accuracy among nodes is accomplished by incorporating precise timing data into each packet in the data stream, using IEEE 1588 precision time protocol (PTP) and Synchronous Ethernet (SyncE). Standards-based synchronization mechanisms are increasingly valuable as the shift continues away from single-vendor solutions, enabling precise interoperation across elements from different providers.

Expanding connectivity, capacity and capability with Intel® Ethernet E830 Network Adapters

In addition to integrated Intel Ethernet in the Intel Xeon 6 SoCs, the E830 Network Adapters offer expanded, high-performance network connectivity for high-traffic, demanding vRAN workload requirements. Achieve high-precision time synchronization within the compute platform and across your network with features such as Precision Time Measurement (PTM), PTP timestamping and integrated SyncE, which offer increased integrated timing performance and reduced cost. The adapter's programmable receive pipeline Dynamic Device Protocol (DDP) feature can be programmed to flexibly offload key network traffic from the CPU, improving performance and reducing latency. With extensive security and manageability features, Intel Ethernet E830 network adapters amplify Intel Xeon 6 processors' performance by accelerating network connectivity securely and effectively for vRAN and other complex applications. Providing up to 8x 25 Gbps Ethernet connectivity each, the Intel E830 Network Adapters complement the Intel Xeon 6 SoC's integrated Ethernet to build out the 16, 24 or more ports of 25Gbps Ethernet needed for future vRAN applications.

Accelerated encryption: Built-in Intel® QuickAssist Technology (Intel® QAT)

Intel® QuickAssist Technology (Intel® QAT) is a hardware accelerator built into the Intel Xeon 6 SoC to increase the performance of encryption and compression operations. In vRAN deployments, Intel QAT can provide up to 200 Gbps IPsec throughput. The latest generation built into the Intel Xeon 6 SoC also provides support to accelerate wireless ciphers such as AES, as well as SNOW 3G and ZUC, which are used in the 5G CU workload. Having both Intel vRAN Boost and Intel QAT accelerators integrated into the CPU provides for both distributed and centralized deployment scenarios with the DU and CU co-located or separated.

Intel QAT enables a growing scope of security functions to be offloaded from the processor cores, freeing up compute resources for increased capacity. Offloading and accelerating those functions helps customers get more value from their vRAN hardware as the rollout of high-bandwidth 5G services continues. In addition, performing encryption and compression in hardware instead of in software is substantially more efficient, further reducing power consumption.

Ecosystem Support Through Intel® Network Builders

The Intel Industry Solution Builders program helps partners innovate and adapt to evolving business, technology and end-user needs, effectively and cost-efficiently. The program provides members with a variety of technical enablement options such as hands-on support from subject matter experts, access to virtual testing and optimization labs, training, tools and other resources.

AI enhancements for next-generation vRANs

Intel® Advanced Matrix Extensions (Intel® AMX) accelerates matrix multiplication for deep learning algorithms. To operate on larger amounts of data at a time, Intel AMX supports 2D register files rather than conventional one-dimensional registers. It also enables more calculations per cycle to be accomplished on larger data sets, thereby increasing throughput.

With the Intel Xeon 6 SoCs, Intel AMX adds support for FP16 data types. The complex FP16 data type improves efficiency in targeted parts of the vRAN L1 pipeline, while the FP16 AI data type offers significant advantages for AI acceleration at reduced power and memory footprint, compared to FP32 and other larger data types. Complex FP16 in Intel AMX also supports accelerated matrix multiplication operations for vRAN workloads such as zero-forcing algorithm, which is ideal for beamforming.

vRAN Inferencing Runs Better on Intel® CPUs

The Intel® Xeon® 6 SoC helps network operators enhance RAN efficiency and profitability with AI-powered intelligent network optimization, predictive maintenance and resource allocation. The Intel® vRAN AI Development Kit continues the drive toward making AI ubiquitous in RANs by streamlining adoption of the platform's advanced AI capabilities. Learn more.

As AI workloads proliferate, this capability can increase system capacity and enable the use of deep learning models to analyze network data, identify patterns and predict trends. Real-time decisions made by these systems can help optimize resource utilization, latency and energy efficiency to improve network throughput, user experience and operating costs. Accelerating these functions on the CPU improves the ability for network operators to continually evolve their vRAN deployments to improve all these key metrics.

Conclusion

The Intel Xeon 6 SoC delivers the performance, system density and energy efficiency network operators need to deploy vRANs successfully and cost-effectively. In addition to enhancements over predecessors across the platform, the SoC features an unprecedented level of component integration. With Intel vRAN Boost, integrated Intel Ethernet, discrete Intel Ethernet network adapters, built in hardware Intel QAT and enhanced Intel AMX, the platform drives up vRAN throughput and performance per watt today and transforms the RAN from a closed system to a flexible, observable, AI-enhanced service.

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[1] Dell'Oro Group, August 8, 2024. "North America Leading the Open RAN Movement, According to Dell'Oro Group." https://www.delloro.com/news/north-america-leading-the-open-ran-movement/.

[2] See [7ND21] at intel.com/processorclaims: Intel® Xeon® 6. Results may vary.

[3] See [7ND22] at intel.com/processorclaims: Intel Xeon 6. Results may vary.

[4] See [7ND34] at intel.com/processorclaims: Intel Xeon 6. Results may vary.

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