# SOLUTION BRIEF

Intel Corporation

# Modular Single-Socket Reference Design for 4th Generation Intel® Xeon® Scalable Processor

This reference design (based on the 4th Gen Intel® Xeon® processor) is a modular and single socket hardware solution for all markets including Enterprise, Cloud, and Network Edge.

## Introductions

The single-socket modular reference design is a new, innovative platform architecture created to meet the needs of a broad range of network edge, mainstream enterprise, and cloud markets. The flexible, modular platform can be configured for a wide variety of servers for the 4th Generation Intel® Xeon® Scalable processor, and future generations of processors.

The reference design architecture combines new technology and open standards in a modular, flexible design, optimized for the 4th Gen Intel Xeon processor. The single-socket compute module is designed to support XCC, MCC, and EE SKU variants, addressing the wide variety of markets mentioned earlier.

PCIe* cable connections provide flexibility in I/O or storage configurations. The architecture accommodates choices through standards: Open Compute Project (OCP) NICs 3.0, for growing 3rd party board products, and provisioning for a pluggable BMC module for solution flexibility. In addition, the modular architecture will support the next generation Intel® Xeon®. Hence, engineering investment is greatly reduced while ROI increases because an ODM or OEM can offer multiple products over at least two CPU generations based on the same architecture.

The introduction of the single socket reference design offers operational efficiencies through I/O balance, simplified CPU pinning, and simpler workload orchestration. It is an excellent fit for a variety of workloads across different markets in Networking and Communications, Enterprise and Cloud, and Internet of Things (IOT). A small sample of use cases includes:

- Quick storage collection for video analytics
- Lightning-fast analytics in financial trading
- Efficient access to streaming video, and 5G core and optimized edge data processing in telecommunications.

The modular architecture provides TEMs, OEMs, and ODMs a product-ready design to bring any of these solutions to market.

## Technical Details

The modular single-socket reference design is based on a single motherboard for 1U or 2U systems, both standard and short depth, and allows many I/O and storage configurations. Cabled PCIe*, growing in popularity, provides PCIe* flexibility for OEM servers and simplified and less expensive PCIe* Gen5 board routing. The operating system boots from the PCH to maximize CPU lane flexibility. Almost any type of storage is supported including HDD, U.2 and E.x drives. The BMC (Board Management Controller) provides server control, security, and management access. This design uses a modular BMC. This will accommodate DC-SCM v2.0 in future generations in alignment with those platforms.

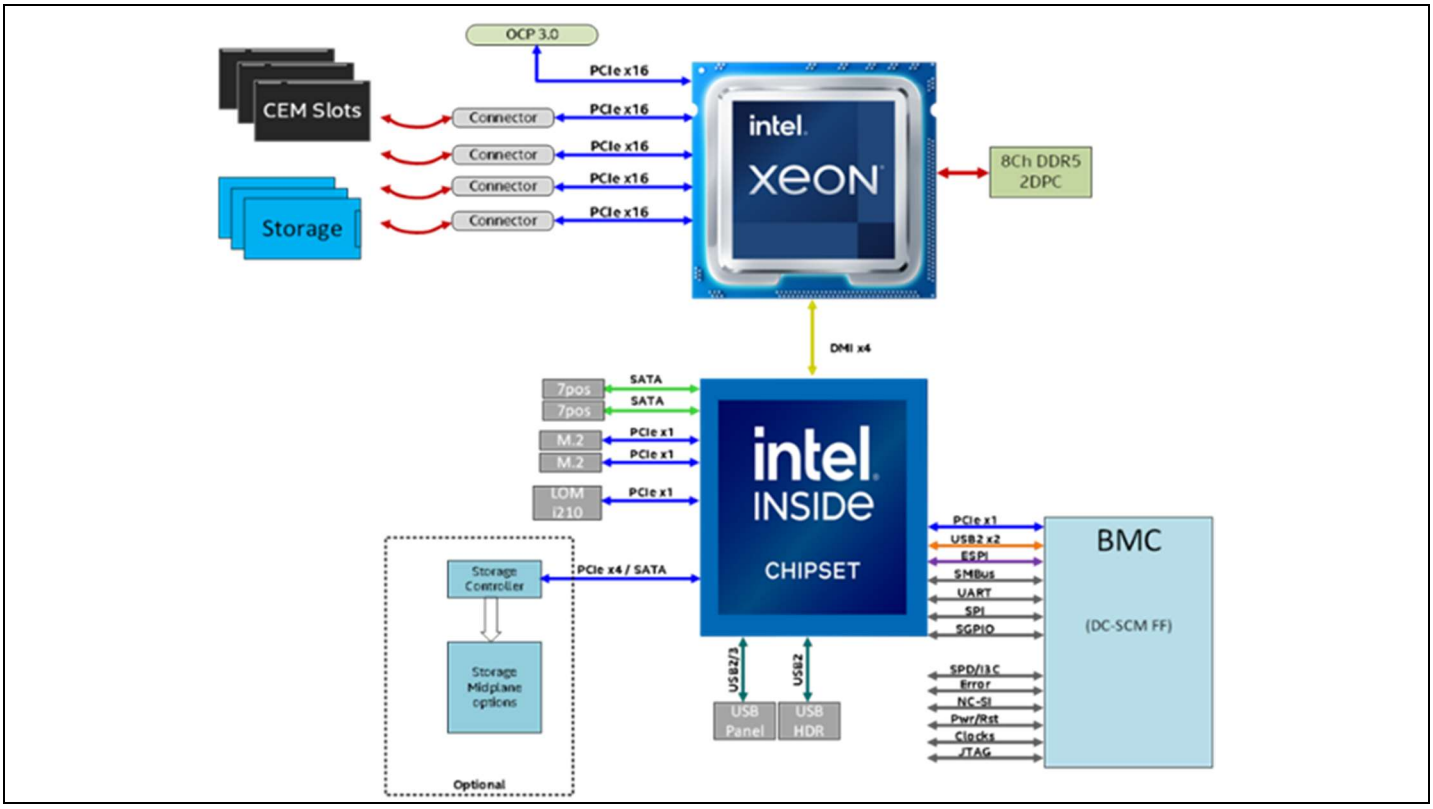


**Figure 1. Modular Single-Socket Architecture**

The motherboard is combined with modular system elements. An ODM or OEM may layout the elements based on component accessibility (i.e. front and/or rear in a rack), desired air flow, or other physical requirements.

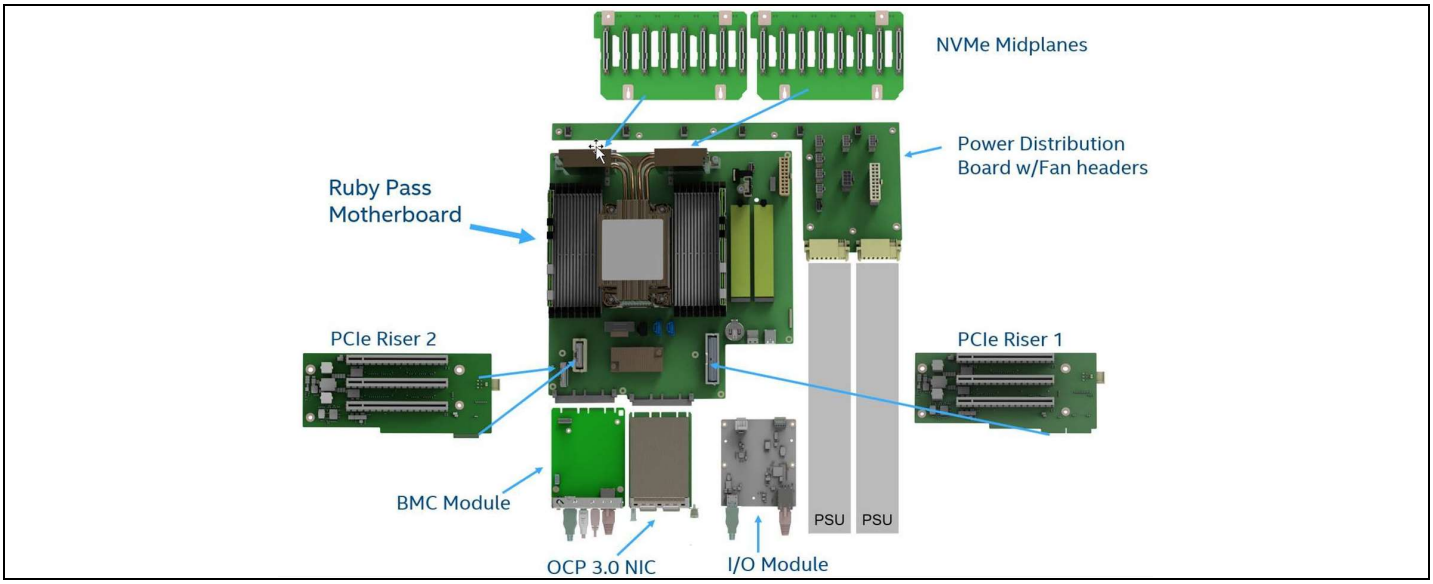


**Figure 2. System Elements**

The following examples are just four potential configurations based on the modular single-socket reference design.

The system in Figure 3 supports 72 I/O lanes with 8 lanes of storage. Note, the 2U super set 3D concept represents all possible accessories in this 2U chassis and includes OCP modules, legacy I/O modules, full length, and ½ length PCIe* modules, etc.

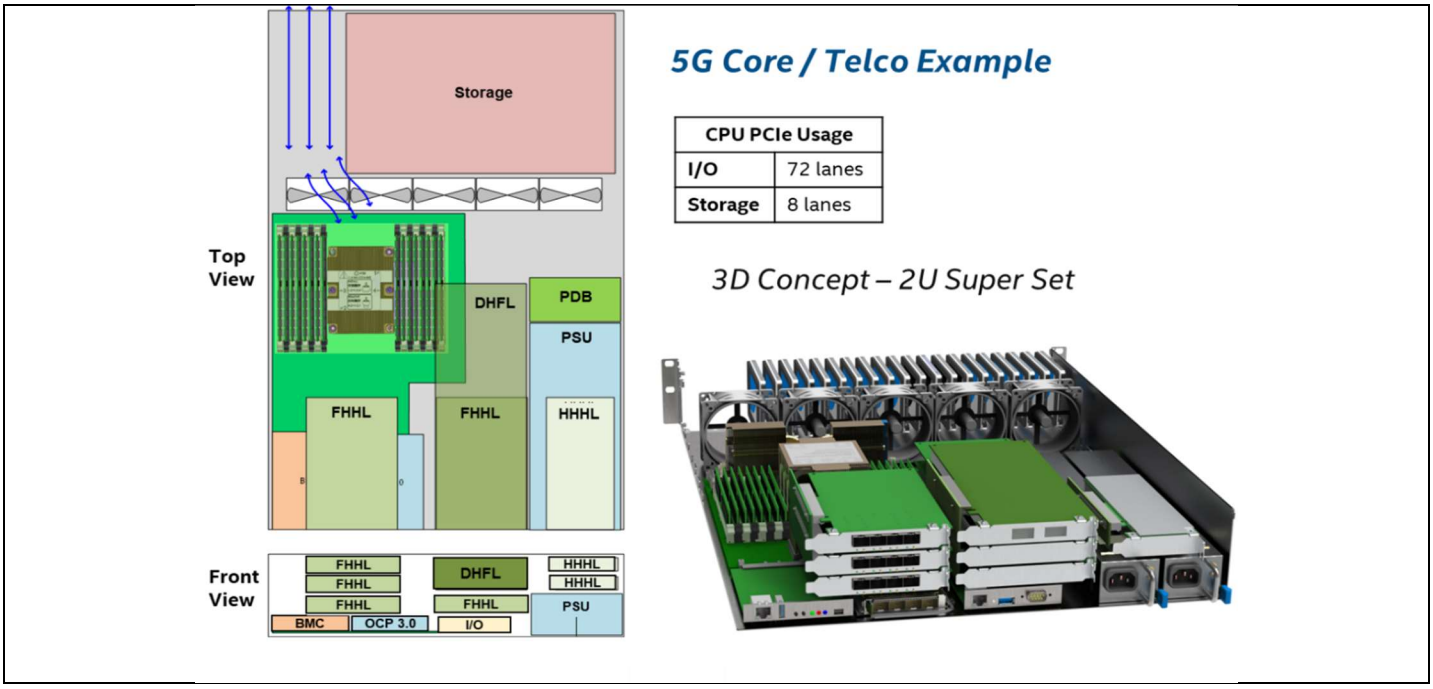


**Figure 3. 2U Standard Depth Configuration**

Figure 4 shows a 1U, standard depth balanced system with 32 PCIe* lanes for I/O. It also has 48 PCIe* lanes for storage, which is useful for a content delivery network server.

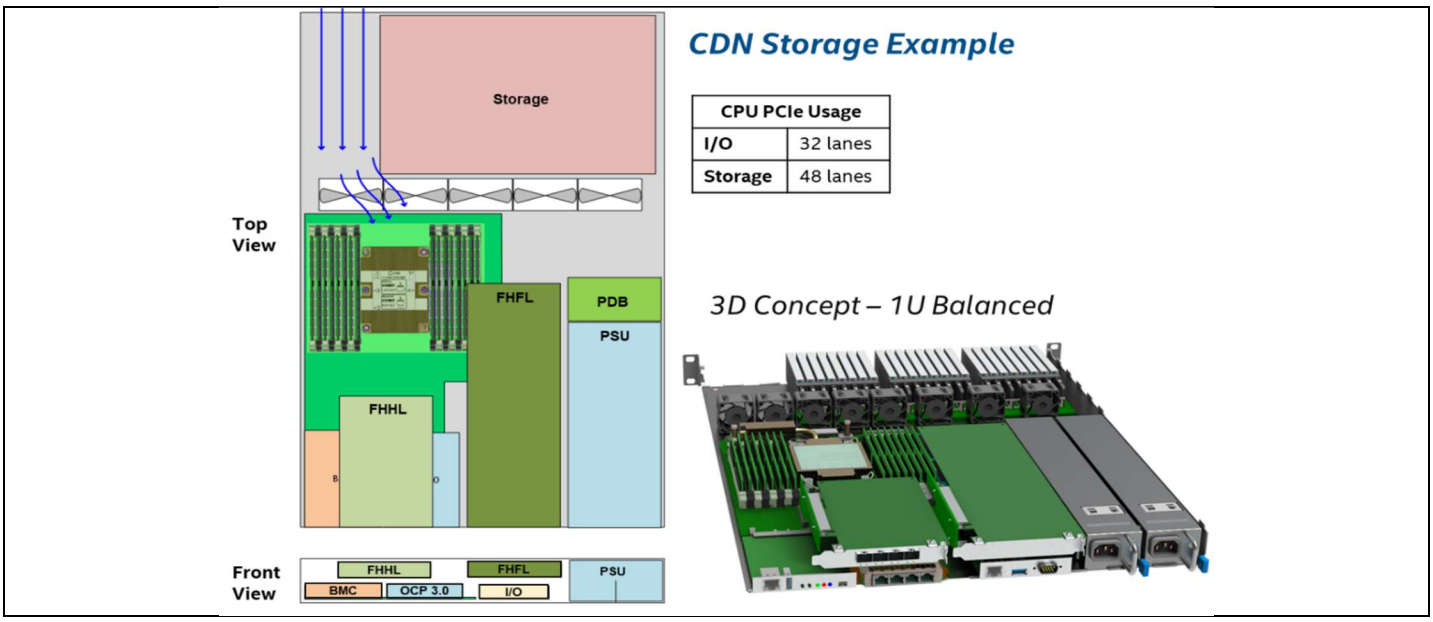


**Figure 4. IU Standard Depth Storage Configuration**

Short depth configurations (shown in Figures 5 and 6) pull the storage to the “front” for installation in servers typically located in telco remote edge access locations especially where space is a premium.

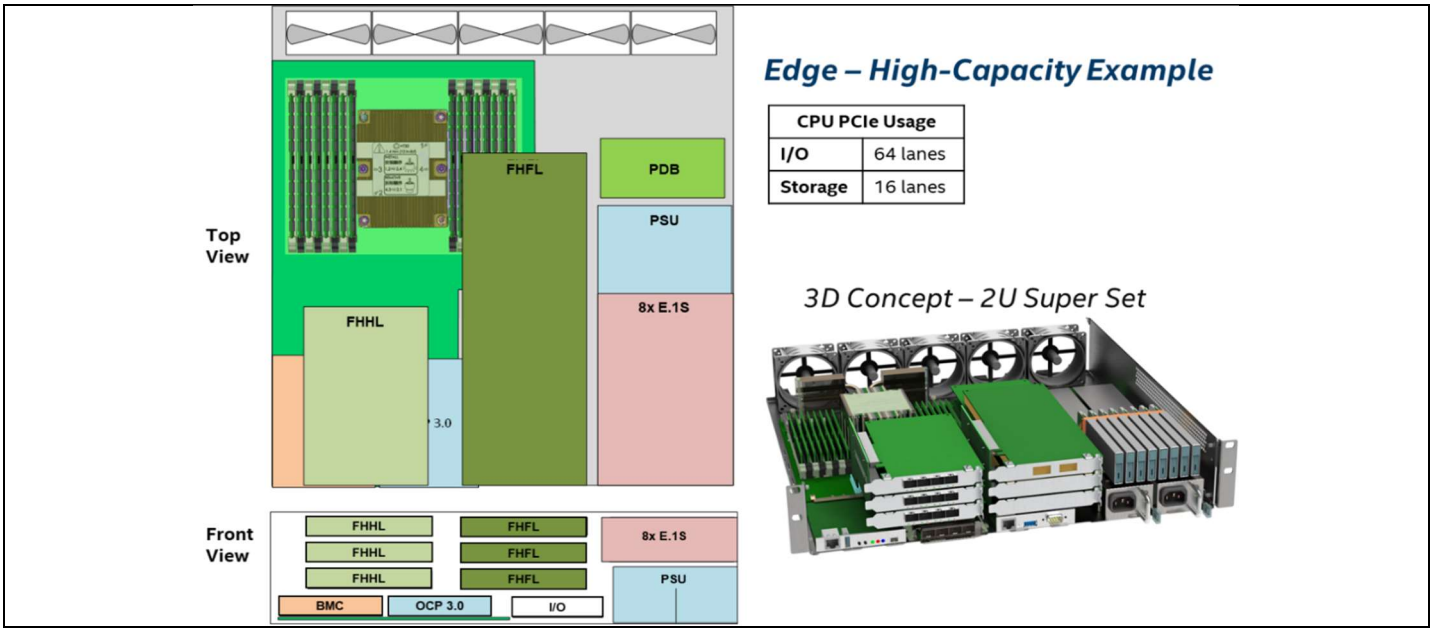


Figure 5. 2U Short Depth – I/O Priority

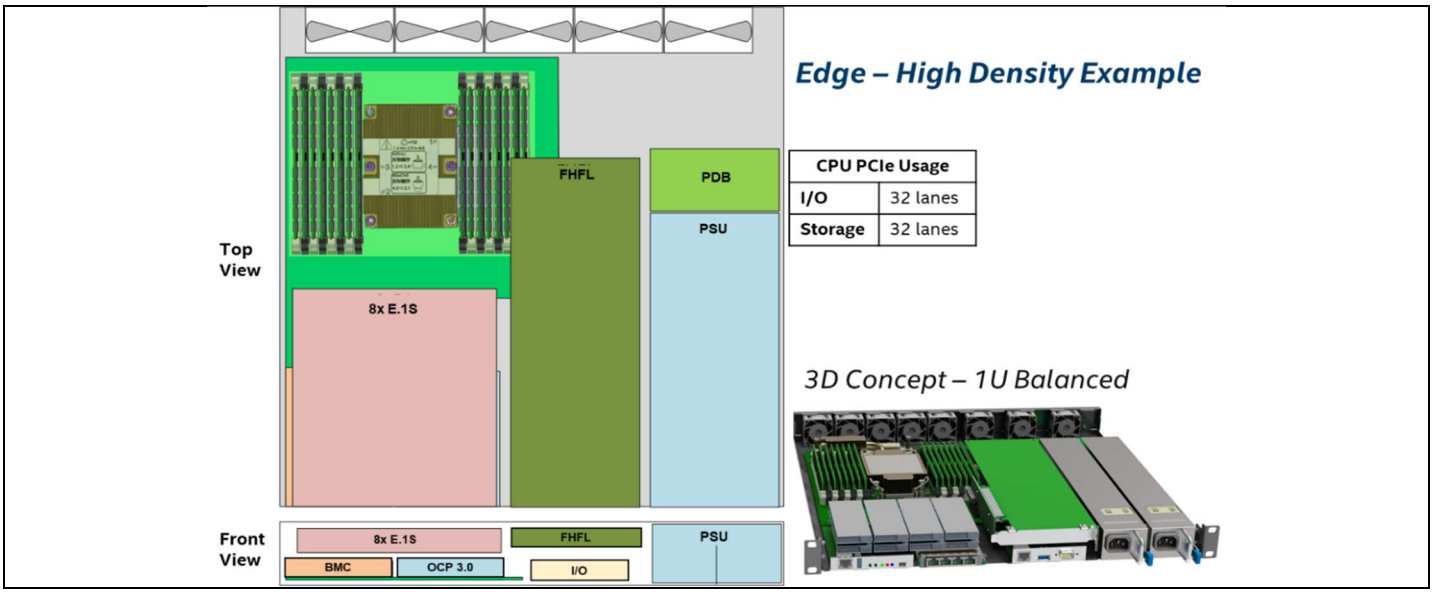


Figure 6. IU Short Depth – Balanced

## Technologies Implemented

Combining new technology and open standards in its modular, flexible design, this modular single-socket architecture is optimized for the 4th Gen Intel Xeon processor. The compute module is designed with a broad range of features that support XCC, MCC, and EE SKU variants.

The reference design features are detailed in the Table 1:

**Table 1. Features of the modular single-socket reference design**

| Feature | Description |
|---|---|
| CPU | 1S 4th Generation Intel® Xeon® Scalable processor SP–XCC, MCC (any non-HBM SKU)<br>· Up to 350W TDP on 2U systems<br>· Up to 240W TDP on 1U systems |
| PCH | Emmitsburg |
| Form Factor / Dimension (Board) | ~11" x ~11" |
| Memory | 16x DDR5 DIMMs, 4800MT/s (8 channels, 2DPC), VRoD<br>Optane Persistent Memory |
| DMI | Gen3 x4 (4GT/s) |
| LOM | Intel® i210 |
| PCIe* Generation / Lanes | PCIe* Gen5, 80 lanes<br>64 lanes provided through cabled connections |
| Rear PCIe* Risers | Two SFF-TA-1016 x 16 PCIe* Gen5 |
| Front Drive Cable Connectors | Two (x16)/Four (x8) SFF-TA-1016 PCIe* Gen5 |
| Front Storage Devices | 8x U.2 NVMe drive slots |
| On-board SATA Ports | Minimum 4 |
| OCP NIC | One OCP NIC 3.0 with a x16 G5 connection |
| M.2 Boot Drives | Dual Gen3 PCIe* x4 |
| BMC | AST2600 |
| Firmware Security (RoT) | Intel® PFR |
| Host USB Connection | One Front 3.0 / One Rear 3.0 |
| TPM | Plug-in 2.0 Module |
| Rear Serial Console | Type B USB |
| Video Port | Front and rear connectors |

4th Gen Intel Xeon processors offer new integrated features for security, improved acceleration and performance, and next generation memory support.

These features include:

**Table 2. Features of 4th Generation Intel® Xeon® Scalable processors**

| Feature | Description |
|---|---|
| AMX | Built-in AI Acceleration engine for improved performance in deep learning inference and training<br>• Target workloads and usages:<br>• Image recognition<br>• Recommendation systems<br>• Machine/language translation<br>• Reinforcement learning<br>• Natural language processing (NLP)<br>• Media processing and delivery<br>• Media analytics |
| DLB | New integrated IP to increase throughput with efficient load balancing across multiple cores<br>• Target workloads/Usages:<br>• IPSec security gateway<br>• VPP router<br>• UPF<br>• vSwitch<br>• Streaming to data processing<br>• Elephant flow handling |
| DSA | New integrated IP to accelerate applications reliant on data movement<br>**Target workloads/usages:**<br>• Virtualization: VM fast-checkpoint analysis<br>• Network: vSwitch network vitalization<br>• Storage: fast replication across non-transparent bridge<br>• Application usage examples: messaging, ERP, In-Memory Databases, Analytics |
| IAX | New integrated IP to accelerate applications reliant on data improvement<br>**Target workloads/usages:**<br>• Commercial in-memory databases<br>• Columnar Formats Big Data Analytics, Apache Parquet, Apache ORC |

| Feature | Description |
|---|---|
| | • Open-Source in-memory database/data stores, RocksDB, Redis, Cassandra, MySQL, PostfreSQL, MongoDB, Memached and more |
| QAT | Integrate IP to accelerate cryptography and data (de) compression<br>**Target workloads/usages:**<br>• Distributes storage systems (Ceph)<br>• File systems (BTRFS, ZFS)<br>• MSFT Azure Cosmos DB<br>• RocksDB<br>• Data lakes<br>• Apache spark, Hadoop<br>RDBMS<br>• http compression<br>• Memory infrastructure optimization |
| SGX | Trusted execution environment for increased protection of confidential data<br>**Target workloads/usages:**<br>Multi-party compute<br>• Blockchain<br>• Trusted multi-party compute<br>• Federated learning/Secure analytics<br>• Secure native application hosting<br>• Secure database<br>• Key management<br>• Secure networking |
| CXL 1.1. | Improve accelerator performance via memory coherency and direct accelerator memory access<br>**Target workloads/usages:**<br>• Accelerator Attach:<br>– Type 2 CXL device (.io, .mem, .cache - accelerator w/ private memory)<br>– Type 1 CXL device (.io, .cache - accelerator w/o private memory) |
| Intel® Optane Persistent Memory 300 Series | Enables larger capacities and performance improvements<br>**Target workload/usages:**<br>• Hybrid cloud, IaaS, and Virtualization<br>• Fast storage solutions<br>• AI/Analytics, Machine Learning Analytics<br>• IMDB and data analytics services |
| Next-gen IO Integrated PCIe* 5.0 | Increased IO bandwidth and support for coherent interface with Compute Express Link v1.1 |
| DDR5 | Next generation memory support with higher speeds and increased memory bandwidth for memory intensive workloads |

Edge workloads, like those listed in the Table 3 , take advantage of the 4th Gen Intel Xeon processor's integrated features and the modular single-socket design, making it ideal for many current Reference architectures and Intel® Select Solutions.

### Table 3. Edge Workloads Supported

| Workload | PCIe AIC 0 | PCIe AIC 1 | OCP AIC | Memory | Optane Persistent Memory | Storage NVMe | Boot Storage | LOM LAN on Motherboard | QAT Required |
|---|---|---|---|---|---|---|---|---|---|
| **5G Core** | E810-2CQDA2 | Not Used | E810-CQDA2 | 256GB – 32GB/Ch | 512GB | Not Used | 2 x 480GB SSD | 1G or 10G -> 25G | No |
| **vRAN - centralized virtualized DU** | E810-2CQDA2 | vRAN ACC100 | E810-CQDA2 | 128GB – 16GB/Ch | Not Used | Not Used | 2 x 480GB SSD | 1G or 10G | No |
| **vRAN - CU** | E810-2CQDA2 | Not used | E810-CQDA2 | 128GB – 16GB/Ch | Not Used | Not Used | 2 x 480GB SSD | 10G | Recommended |
| **vBNG** | E810-2CQDA2 | Not Used | E810-CQDA2 | 256GB – 32GB/Ch | Not Used | 2x 8TB NVMe | 2 x 480GB SSD | 1G or 10G | No |
| **CDN** | E810-2CQDA2 | Not Used | E810-CQDA2 | 256GB – 32GB/Ch | 1.5TB | 8x 16TB NVMe | 2 x 480GB SSD | 1G or 10G | Yes |
| **MEC** | E810-2CQDA2 | vRAN ACC100 | E810-CQDA2 | 256GB – 32GB/Ch | Not Used | 4x 2TB or Greater | 2 x 480GB SSD | 1G or 10G | Yes |
| **SASE** | E810-2CQDA2 | Not Used | Not Used | 256GB – 32GB/Ch | Not Used | Not Used | 1 x 480GB SSD | 1G or 10G | Yes |
| **SD-WAN** | E810-2CQDA2 | Not Used | Not Used | 128GB – 16GB/Ch | Not Used | Not Used | 1 x 480GB SSD | 1G or 10G | Yes |
| **OSS/BSS** | E810-2CQDA2 | Not Used | E810-CQDA2 | 256GB– 32GB/CH | Not Used | 2x 8TB or greater | 2 x 480GB SSD | 1G or 10G | No |
| **Open Cloud** | Not Used | Not Used | E810-CQDA2 | 256GB– 32GB/CH | Not Used | 4x 2TB or greater | 1x 480GB SSD | 1G or 10G | Recommended |
| **AI** | Not Used | Not Used | E810-CQDA2 | 256GB– 32GB/CH | 512GB | 1x 1.6TB NVMe | 1x 480GB SSD | 1G or 10G | Recommended |
| **Media Analytics** | Not Used | Not Used | E810-CQDA2 | 512GB– 64GB/CH | Not Used | 4x 4TB or greater | 2 x 480GB SSD | 1G or 10G | Yes |

## Benefits of Solution

Single-socket solutions have become increasingly prevalent in the past few years, with companies embracing the benefits of these solutions. For example, Lenovo, HPE, Dell, and Supermicro offer one socket platforms for enterprise and network servers.

The use of single socket offers the following benefits:

- Operational efficiencies through I/O balance and guaranteed NUMA affinity
- Simplified CPU pinning, workload placement, no stranded capacity, and efficient vCPU allocation
- Simpler workload orchestration
- Efficient space, TDP, and thermals especially at the edge
- Deployment consistency and simplicity
- Single socket delivers a performance/watt advantage when compared to 2S
- Optimized 1-Socket solutions allow cost savings of approximately $150 per board design versus 2-Socket with one CPU de-populated

Furthermore, this modular architecture allows customers to reduce development costs over multiple generations, as the same, or very similar, compute modules can be deployed across a variety of server product lines. Future-proof, the same design can be re-used with the next Intel Xeon processor family by simply replacing the motherboard. This means that Intel's ODMs' and OEMS' initial investments in overall system design are good for at least five years, significantly increasing ROI from a "one and done" product.

## Use Case Examples

The single-socket server has a broad range of uses across markets. For example, in networking and communications, it can be used for Edge, Telco cloud, data forwarding, data routing, 5G RAN and 5G Core.

In addition, across the Cloud and enterprise markets, the architecture can be implemented in IT Infrastructure/IaaS, value/mainstream digital services for next wave CSPs/FSIs etc., and general purpose/compute virtualization. Other use case examples include medical imaging, edge-based video analytics, and retail store analytics for the IOT market.

**Table 4. Single Socket: Target Market Segments and Application Examples**

| Markets | Applications |
|---|---|
| Networking and Communications | • Edge (analytics, security, storage, CDN)<br>• Telecommunications company cloud<br>• Data forwarding<br>• Data routing<br>• 5G RAN<br>• 5G Core |
| Cloud and Enterprise | • IT Infrastructure / IaaS<br>• Digital services for next wave SPs,<br>• FSI<br>• General Purpose Compute<br>• Edge |
| Internet of Things | • Medical imaging<br>• Edge-based video analytics<br>• Retail store analytics |

Single socket optimized designs are ideal for next generation Edge Reference Architectures. Today, there are tens of centralized data centers with a large number of servers. However, in the edge evolution, the world is shifting to distributed data centers, combined with a centralized infrastructure to improve latency, and application locality (i.e. closer content distribution). A single-socket, 2U short depth configuration can address many applications. 5G vRAN servers are thermally challenged and require short depth systems with front access. With this design, multiple cloud workloads can be addressed. For the enterprise, this cost-optimized system lets additional systems be easily added to a rack in "pay as you grow" scenarios. Networking and communications require simplified deployment and easy orchestration. Easy peripheral and accelerator expansion was also a design goal for IOT and SASE locations. With the newest AMX integrated instructions in the 4th Gen Intel Xeon processor for machine learning and analysis, edge servers can enhance applications with AI.

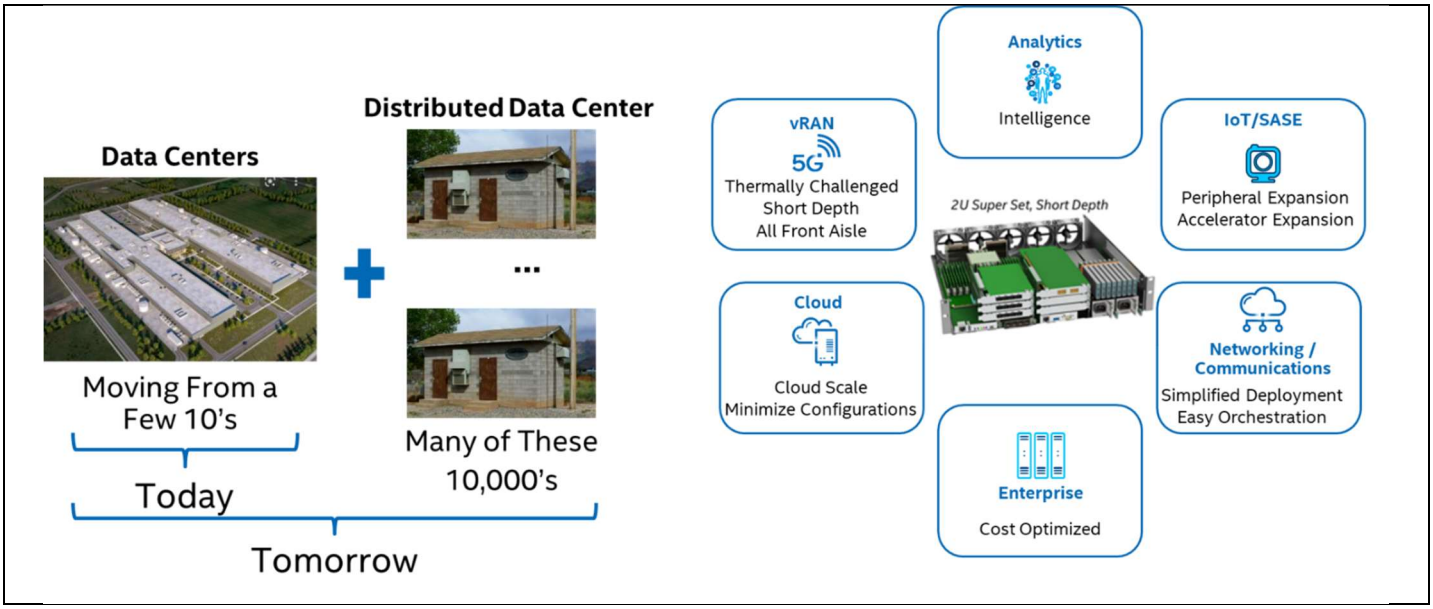


**Figure 7. Where and how is single socket being deployed?**

## Summary

A modular single-socket reference design allows customers to reduce development costs over multiple generations. The same or very similar compute modules can be deployed across a variety of server product lines. Future-proof, the same design can be re-used with the next Intel Xeon processor family by simply replacing the motherboard. This means that Intel's ODMs' and OEMs' initial investments in overall system design are good for several years, significantly increasing ROI from a "one and done" product.

Intel is delivering a boost to accelerate one socket designs across all Intel's target markets. This design is that vehicle – a modular, flexible, standards-based reference design providing a head-start to productize one socket solution for 4th Generation Intel Xeon Scalable processors and next generation Intel Xeon.

The modular single-socket system was designed in collaboration with Jabil. Contact Jabil for information on related products.

The Reference Design (including schematics and board layout files) is available on the Intel® Resource Design Center (Reference ID: 648338).

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