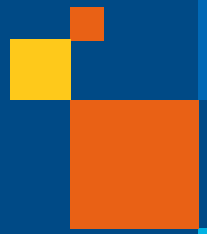
AI on Intel® Xeon® processors

Partner Enablement Package

Addressing customers' AI business challenges with Intel® Xeon® based solutions



Contents

Why Partner With Intel?

At Intel, our goal is to improve lives and outcomes for everyone and every enterprise on this planet

But we aren't doing this alone!

Together with our partners, we are creating real value for our customers by **bringing AI everywhere** and minimizing the risks in AI solution deployment

Unlock Business Transformation in a Digital-First Economy: Become an Artificial Intelligence Disruptor

When you partner with Intel, you partner with a complete AI ecosystem

Our broad portfolio of AI-enabling technologies and collaboration with hardware, software, and solution ecosystem partners delivers real world solutions and differentiated business outcomes for industries, companies, and communities.

Helping you to grow your business.

Intel Leads the Way in AI

More than **300** AI-accelerated ISV features throughout 2024[1]

More than **100M** processors with AI accelerators through 2025[1]

Intel® Xeon® install base of **100M+** provisions AI workloads alongside other workloads[2]

Join Us On the Journey to Bring AI Everywhere

[1] https://www.intel.com/content/www/us/en/products/docs/processors/core-ultra/ai-pc-acceleration.html

[2] AI Intel® Xeon® Sales Card

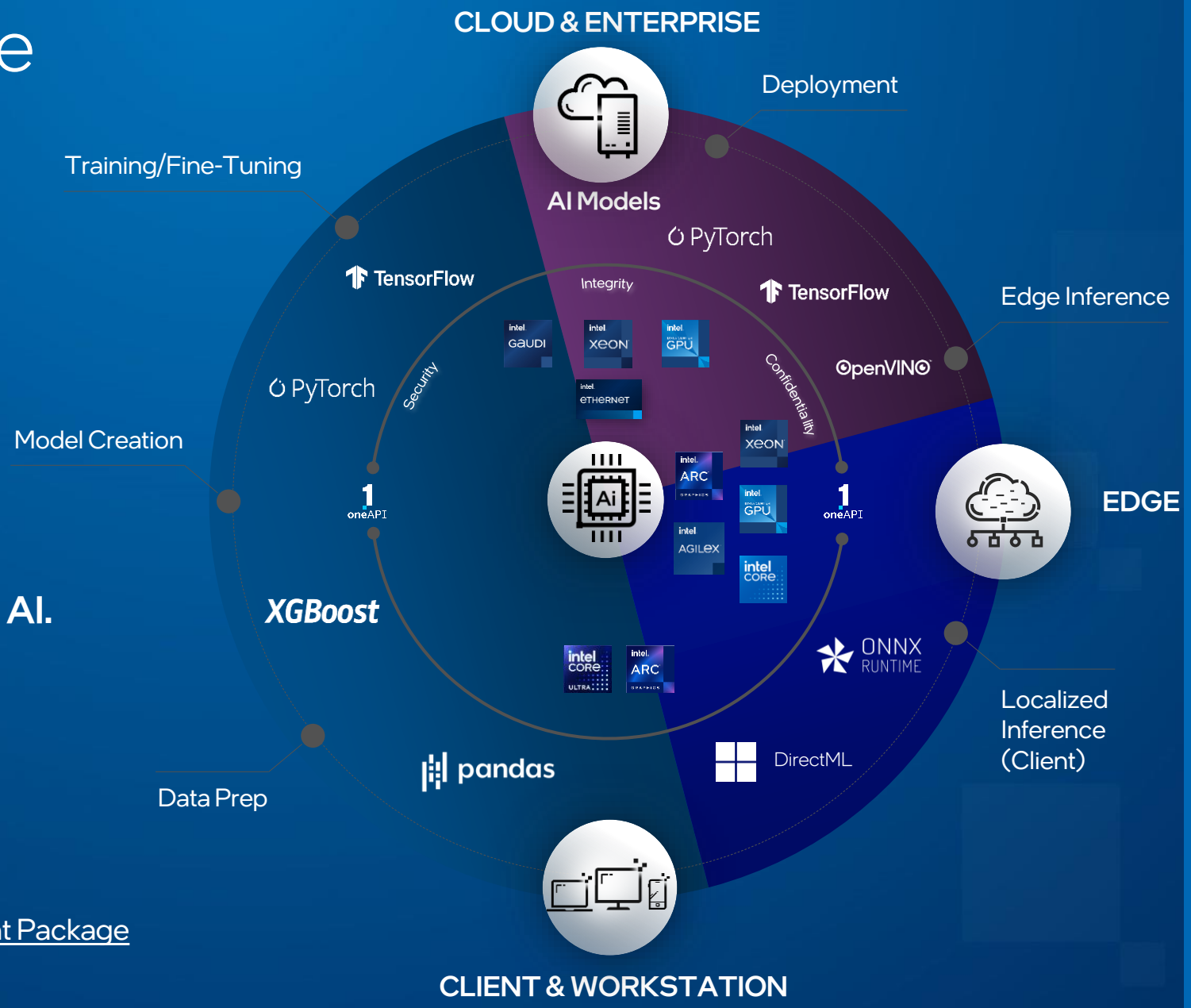
Bringing AI Everywhere

In today's hypercompetitive environment, enterprises that embrace AI are pulling ahead.

Intel infrastructure is engineered for enterprise AI, empowering you to maximize your investments and realize your vision at a lower cost. And, with enterprise-ready solutions and open, optimized software, you can go to market fast, even with sensitive and regulated data.

It's time to think differently about enterprise AI.

- Partner Guide:
  Assessing Today's Enterprise AI Opportunity Landscape
- Infographic:
  Optimize Enterprise AI Results with Intel



LEARN MORE

- Enterprise AI / Generative AI Partner Enablement Package
- AI Partner Enablement Package

Note: Intel® Core™ Ultra processors integrate NPU low power inference engine from 15th Gen processors onwards.

Why Choose Intel® Xeon® for Developing an AI Solution

90%

Enterprise Apps will be Infused with AI by 2025[1]

Enterprise AI

100M+

Intel® Xeon® Install Base

Intel® Xeon®

100%

of Fortune 500 Global Companies use Enterprise Virtualization[2] Technologies & Services

Virtualization

5th Gen Intel® Xeon®
with Built-in AI
+
Enterprise ISV
Products & Services

Better Together

READ MORE

Bringing AI Everywhere
Business Brief | The AI Guide | Infographic

Deploy AI Everywhere
Business Brief | Video

1 Forbes : https://www.forbes.com/sites/gilpress/2019/11/22/top-artificial-intelligence-ai-predictions-for-2020-from-idc-and-forrester/#4fef9821315a
2 Source: VMware: https://www.vmware.com/files/pdf/VMware-Corporate-Brochure-BR-EN.pdf

The AI Hierarchy: Mapping ML, Deep Learning, and GenAI with Intel

Discover how Intel® processors fuel AI workloads across inference, training, and next-gen generative AI applications

intel XEON

30-year history of machine learning on CPUs

- Regression
- Classification
- Clustering
- Decision Trees
- Data Generation

intel XEON

Meet Customer SLAs with general-purpose hardware

- Image Processing
- Computer Vision
- Natural Language Processing
- Recommender Systems

intel XEON

Inference

<20B Parameters

intel GAUDI

Training + Inference

Small to Large LLMs

- Subset of AI that focuses on creating new, original content

AI

Machine Learning

Deep Learning

GenAI

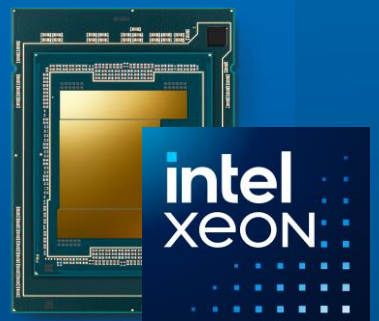
Intel® products: The Best Solutions for AI Transformation

Use Intel products to avoid high costs and long wait times while adopting AI

5th Gen and Intel® Xeon® 6 P-core Processors are the Best CPU for AI

Leverage unique Intel® AMX and MRDIMMs

- Reduce TCO up to 74 percent[1]
- Consolidate servers up to 10:1[2]
- Realize up to 1.38x superior LLM inferencing performance vs. AMD[3]



Get the best AI performance out of the box with the most common ML and DL tools.

Run AI on sensitive data with confidence using Intel® TDX, Intel® SGX, and hardened security ecosystem

Use Intel® Gaudi® accelerators to right size your acceleration deployments

Accelerate the most demanding dedicated inferencing workloads with the best price/performance ratio vs. NVIDIA H100[4]

intel GAUDI

Add Intel® Ethernet products to enhance performance and scale out

Optimize performance for AI and high-performance computing (HPC) applications, reduce TCO and capital expenditures (CapEx) by up to 20% for massive AI clusters[5]

Consume less power vs. NVIDIA Mellanox ConnectX-6[6]

intel ETHERNET

[1] See [9T10] at intel.com/processorclaims: Intel® Xeon® 6. Results may vary.
[2] See [7T21] at intel.com/processorclaims: Intel® Xeon® 6. Results may vary.
[3] See [9A231] at intel.com/processorclaims: Intel® Xeon® 6 vs. AMD EPYC Turin. Results may vary.
[4] See intel.com/processorclaims: Intel® Gaudi® AI Accelerator. Results may vary.
[5] See [9T3] at intel.com/processorclaims: Intel® Xeon® 6. Results may vary.
[6] See Massed Compute FAQ, "Power Consumption Differences Between NVIDIA Mellanox InfiniBand Adapters and Ethernet Ad for NVIDIA A40 GPUs"

Scalable Systems for AI

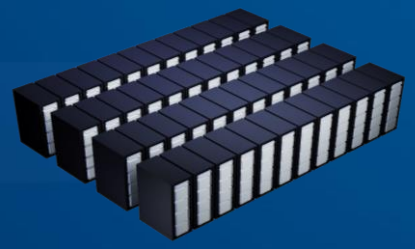
From Cloud & Data Center to the Edge, Intel® Xeon® processors provides optimized performance, scale and efficiency at a cost-effective price

Training and Fine-Tuning

Training | Peak Inference | Mainstream Inference/ Fine-Tuning | Baseline Inference | Endpoint Inference

Inference and Deployment

Cloud Data Center | Edge | Client

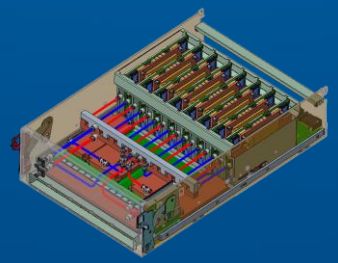


Cluster and Data Center Scale

intel. GAUDI

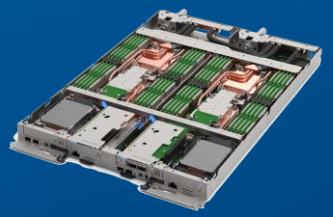
Multi-node Deployment per Rack

intel. GAUDI | intel. XEON | intel. XEON MAX SERIES



Multi-GPU or Multi-socket CPU

intel. XEON | intel. XEON MAX SERIES | intel. DATA CENTER GPU FLEX SERIES



Single-Socket CPU or Single GPU

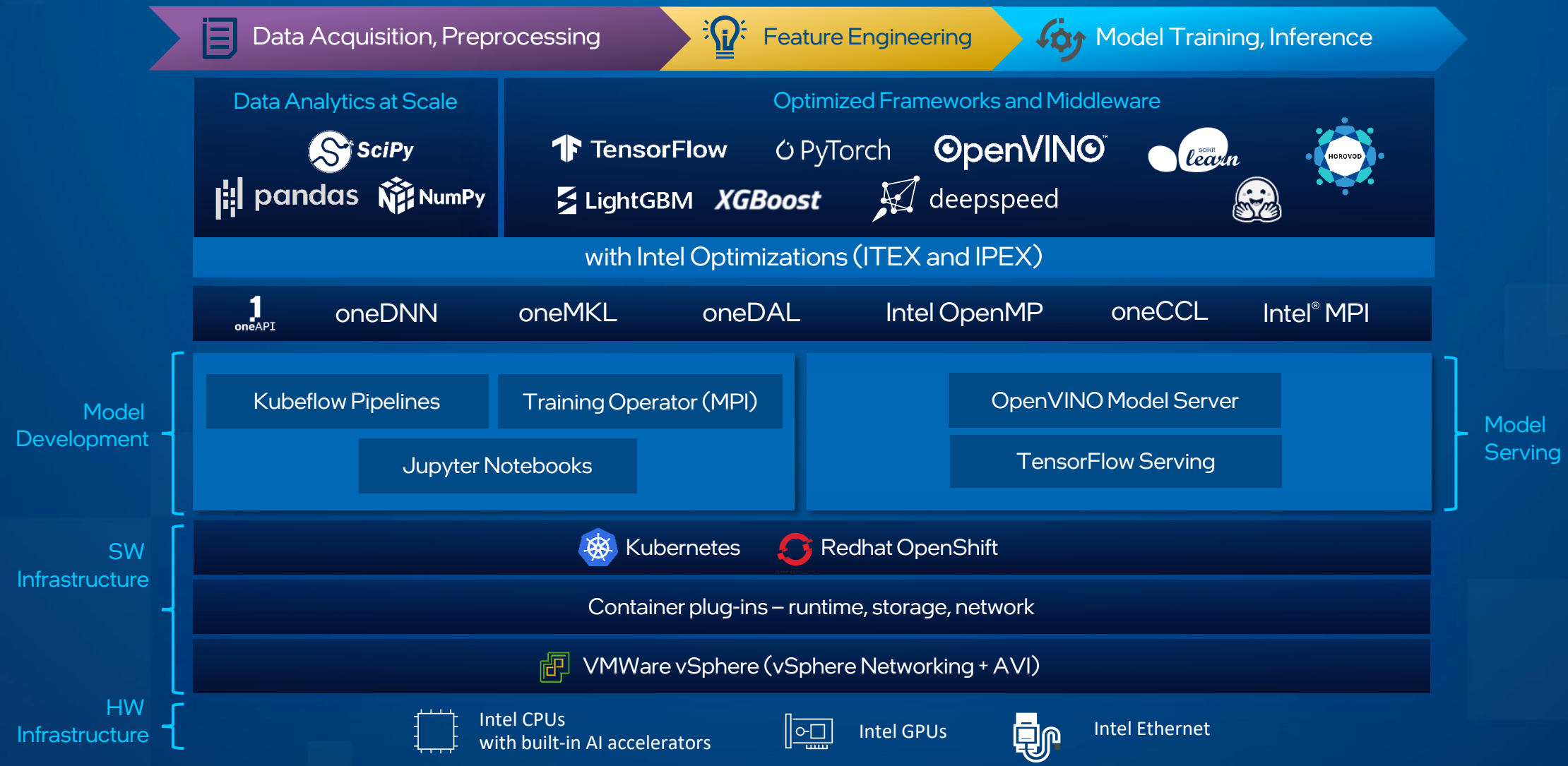
intel. XEON | intel. DATA CENTER GPU FLEX SERIES | intel CORE ULTRA

Client CPU

intel CORE ULTRA | intel. ARC GRAPHICS

intel. ETHERNET

Intel® AI Software is Enterprise Ready



Intel® Xeon® Processors

ACCESS NOW >

- Sales Play Pitch: Power Your AI Transformation with Intel
- Sales Play Pitch: Modernize Your Data Center to Achieve Unprecedented Levels of Performance and Efficiency

Report: CPUs are Key to Enterprise AI

Intel® Xeon® - The Processor Designed for AI

Efficiently run AI inference

5th Gen Intel® Xeon® processor

The flexibility of Intel® Xeon® with the built-in DL performance of an AI accelerator

- Up to **29% higher training** and up to **42% higher inference** performance than our previous generation[1]
- Up to **2.69x higher performance than AMD** EPYC 9654 (96C) and 9754 (128C) processors[2]

Build and deploy AI everywhere

Intel AI software suite of optimized open-source frameworks and tools

Enables out of the box AI performance and E2E productivity

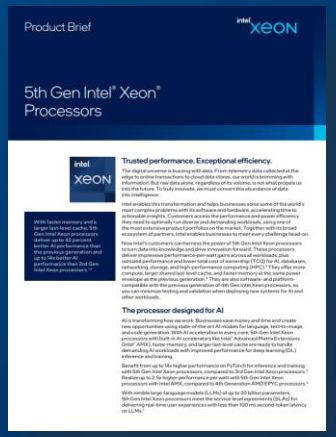
- **5x improvement** on GPT-J in 10 weeks through software optimizations alone[3]
- Optimizing larger models up to **70B parameters** to meet customer SLAs
- Optimized 300+ DL models and 50+ ML and Graph Models

Open Ecosystem

Extensive Intel AI products and partnership

Accelerate end customer time to market

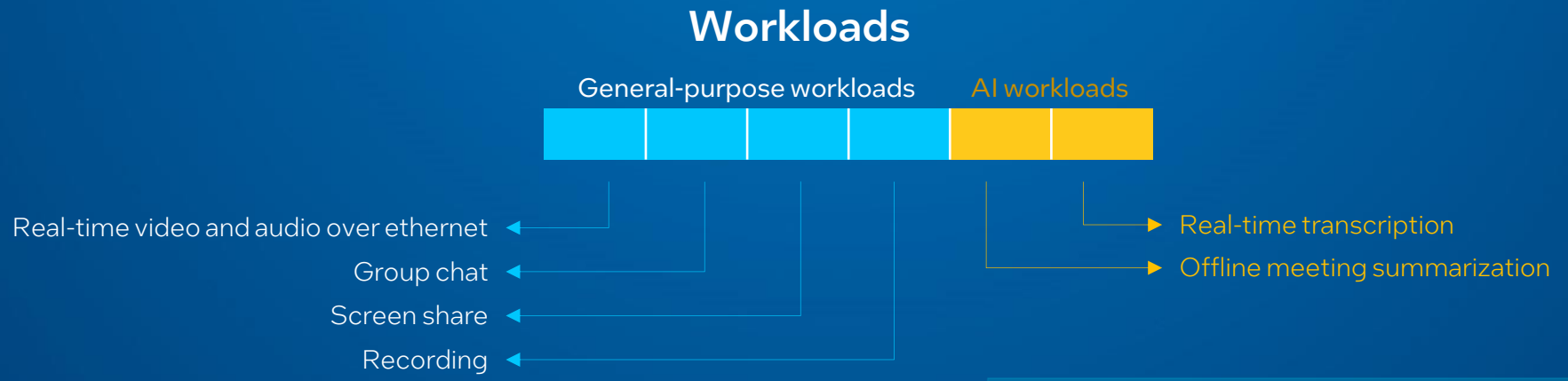
READ MORE

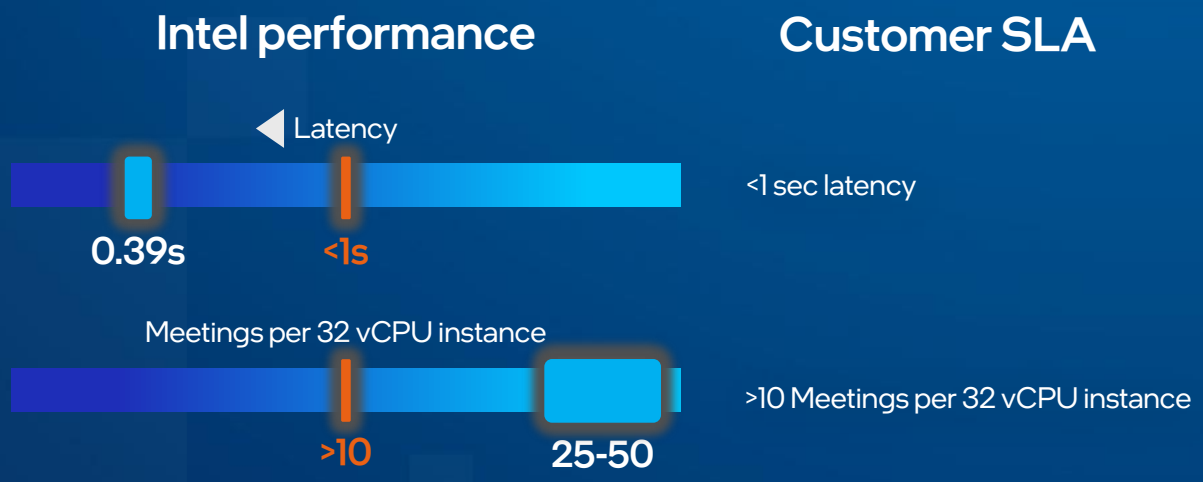


1. Based on performance gains of 1.1x to 1.29x for training (ResNet50v1.5, BERT-Large, SSD-ResNet34, RNN-T, MaskRCNN, and DLRM) and 1.19x to 1.42x for inference (ResNet50v1.5, BERT-Large, SSD-ResNet34, RNN-T (BF16 only), Resnext101 32x16d, MaskRCNN (BF16 only), DistilBERT) compared to 4th Gen Intel® Xeon® processor. See A15-A16 at intel.com/processorclaims: 5th Gen Intel® Xeon® Scalable processors. Results may vary.
2. Based on performance gains of 1.19x to 2.69x with Intel® Advanced Matrix Extensions (Intel® AMX) for inference on GPT-J, LLaMA-2 13B, DLRM, DistilBERT, BERT-Large, and ResNet50v1.5 compared to AMD EYPC 9654 and 9754. See A201, A202, A208-A211 at intel.com/processorclaims: 5th Gen Intel Xeon Scalable processors. Results may vary..

Intel® Xeon® Processor delivers TCO Value for Mixed General-Purpose and AI Workloads

Case Study: Video Conferencing Service





Intel engineers collaborating with the customer's technical team were able to beat the latency SLA at **0.39 seconds** and were able to support anywhere between **25-50 meetings on a single 32 vCPU instance**.

See more AI Customer Success Stories on Intel® Xeon®

Accelerate AI Workloads with Intel® Advanced Matrix Extensions (Intel® AMX)

Intel AMX is a **built-in accelerator** that enables 4th and 5th Gen Intel® Xeon® processors to optimize deep learning (DL) training and inferencing workloads. With Intel® AMX, 4th and 5th Gen Intel® Xeon® processors can quickly pivot between optimizing general computing and AI workloads.

Up to **10x higher performance** and **7x higher performance** per watt for inferencing workloads compared to 3rd Gen Intel® Xeon® processors[1]

READ MORE

Get Started with Intel® AMX

AI framework optimizations

Tuning Guide

Quick-start Guide

AI reference kits

[1]See linked Solution Brief above for configurations. Results may vary.

USE CASE EXAMPLES

Recommender systems

Deliver a customized end-user experience, whether recommending movies and books or showing targeted ads. Create a DL-based recommender system that accounts for real-time user behavior signals and context features such as time and location.

Natural Language Processing

With a global market projected to reach 80.68 billion USD by 2026,11 NLP applications, including chatbots and sentiment analysis, are critical for businesses to support and scale various functions, including sentiment analysis, chatbots, and machine translation.

Retail e-commerce software solutions

Grow revenue and deliver an exceptional customer experience by minimizing transaction time and effortlessly handling peak demands with DL inference and training, in addition to AI-optimized frameworks like PyTorch and TensorFlow.

Drive Revenue Growth and Improve Customer Experience with Faster, More Effective AI

Leadership performance with the world's best CPU for AI

READ MORE
Leadership Performance

5th Generation Intel® Xeon® processors with Intel® Advanced Matrix Extensions (Intel® AMX) Outperform AMD EPYC[1]

5th Gen Intel® Xeon® delivers up to

2.2x Higher BERT Large Performance than 4th Gen AMD EPYC[1]

Save up to

$883,000[1]

Reduce TCO Across Your Server Fleet for AI

Up to **41%** Lower TCO than 4th Gen AMD EPYC while running a BERT Large workload[1]

Fewer servers to manage

23 Servers with 5th Gen Intel® Xeon® Scalable processors[1]

vs

50 Servers with 4th Gen AMD EPYC processors[1]

READ MORE
AMD Benchmarks

[1]See linked AMD Benchmarks paper above for configurations. Results may vary.

SOLVE COMMON PROBLEMS

Better inform business decisions to drive revenue growth

Reduce repetitive tasks, costs, and time for your business

Improve customer retention and acquisition

Faster analysis for large amounts of data

Enable more responsive smart assistants and chatbots

Improve text prediction speed and accuracy

5th Gen Intel® Xeon® Outperforms Competition Around The Clock

1.70x on HammerDB MySQL OLTP

2.26x on offline batched image classification inference

2.34x on batched recommendation system inference

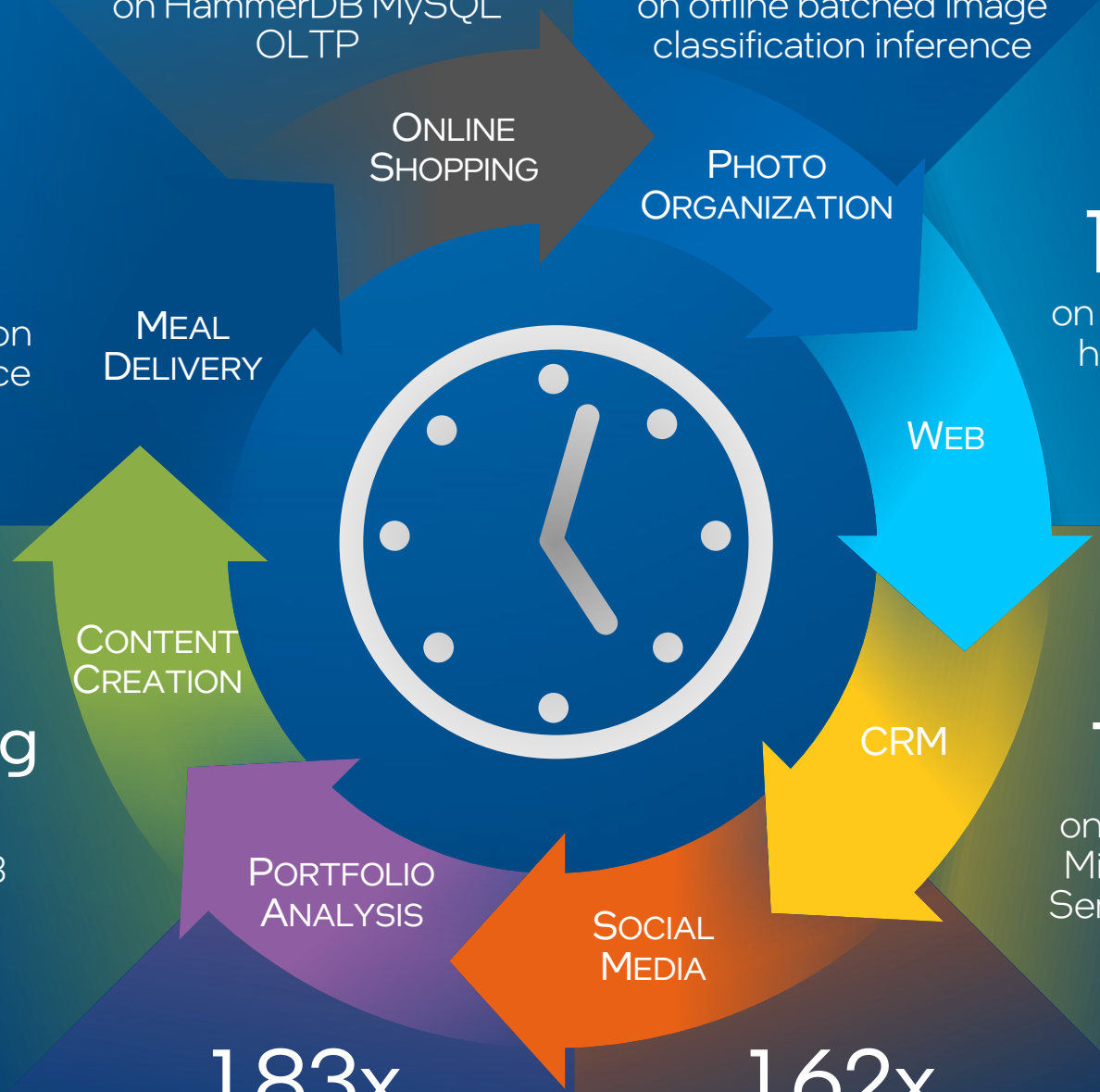
1.66x on NGINX TLS handshakes

Delivering Gen AI on Llama2 13B inferencing

1.93x on HammerDB Microsoft SQL Server + Backup

1.83x on Monte Carlo simulations

1.62x on RocksDB



5th Gen Intel® Xeon® Benchmarks

Compares are relative to 4th Gen EPYC 9654 on AI; relative to 4th Gen EPYC 9554 on all else
See backup for workloads and configurations. Results may vary.

5th Gen Intel® Xeon® TCO advantages over AMD

A comparison against 50 4th Gen AMD EPYC 9554 servers

	Web NGINX TLS	Data Services RocksDB	Data Services MySQL	HPC Monte Carlo	AI - NLP DistilBERT
5th Gen Intel® Xeon® Servers	31 servers	31 servers	30 servers	28 servers	15 servers
Fleet Energy Saved*	489.7 MWh	1218.1 MWh	684.0 MWh	585.8 MWh	1496.5 MWh
Reduced CO2 Emissions*	207,611 kg	516,402 kg	289,967 kg	248,352 kg	634,428 kg
TCO Savings*	$444K	$471K	$509K	$561K	$1,300K
TCO Delta	21% savings	22% savings	24% savings	27% savings	62% savings

*Estimated over 4 years
See backup for workloads and configurations. Results may vary.

AI Case Studies on Intel® Xeon® Processors

REAL WORLD RESULTS

Healthcare

Winning Health has introduced the WiNGPT solution based on 5th Gen Intel® Xeon® Scalable processors, through working with Intel, the **inference performance has been increased by over 3X** compared with the platform based on the 3rd Gen Intel® Xeon® Scalable processors

卫宁健康 WINNING HEALTH

READ ARTICLE

Energy

Storm Reply chose the new **Amazon EC2 C7i instances supported by 4th Gen Intel® Xeon® Scalable processors** and Intel libraries for LLM modeling. After a HW evaluation process, they **matched the price-performance ratio of GPU-based options by using CPU-based instances**.

READ ARTICLE

Media & Entertainment

Gunpowder accelerated rendering times for **stunning visual effects** while lowering costs with as much as **52% better performance per dollar** compared to previous-gen instances with Intel® Xeon® processors[3]

GUNPOWDER®

READ THE CASE STUDY

Netflix delivered **fast and seamless streaming experiences** with **2x better AI-enabled video encoding** and significant cloud savings by upgrading AWS EC2 instances. Netflix achieved a **3.5x performance improvement per CPU** with Intel® Xeon® CPUs and software optimizations, at a lower cost than with GPUs[4]

NETFLIX

READ THE ARTICLE

Professional Services

Ropers Majeski increased worker productivity by **18.5%**, saving an average of **75 minutes** per user per day by automating email processing, document filing, and report generation with built-in AI acceleration from Intel® Xeon® CPUs[5]

ROPERS MAJESKI

READ THE CASE STUDY

Retail

Meituan uses vision AI services to **improve a wide range of customer experiences**, and achieved **70% cost savings** by migrating from GPUs to Intel® Xeon® CPUs and software for AI inference[6]

美团 Meituan

READ THE CASE STUDY

[1, 3, 4, 5, 6] See respective papers and blogs (linked above) for configuration details. Results may vary.

Introducing Intel® Xeon® 6 Processors

P-core

Optimized for **performance** in compute-intensive and AI workloads

Common platform foundation and **shared** software stack

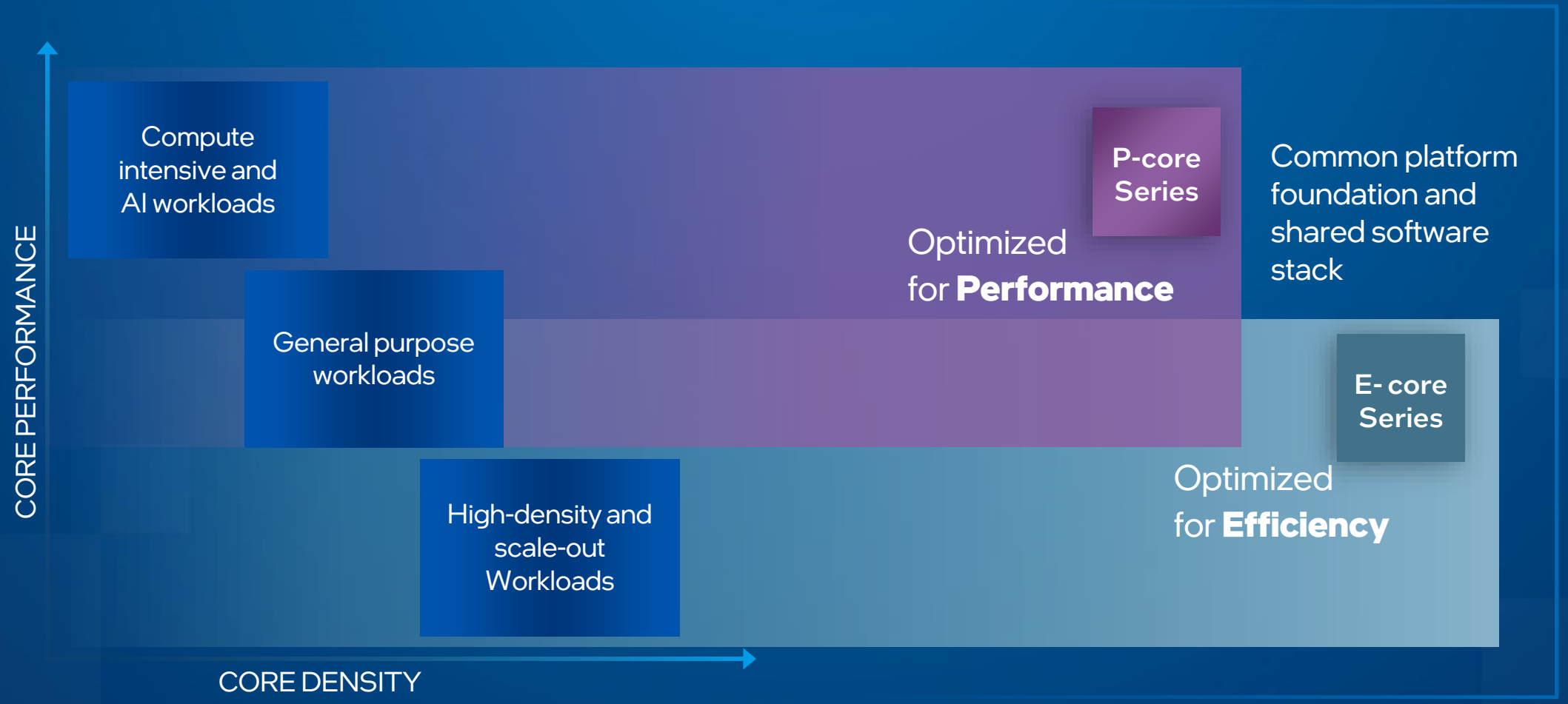
E-core

Optimized for **efficiency** in high-density and scale-out workloads

VISIT NOW > Intel® Xeon® 6 Website

Intel® Xeon® 6 Processors

The best processors to meet diverse performance and efficiency requirements



LEARN MORE >

Product Brief

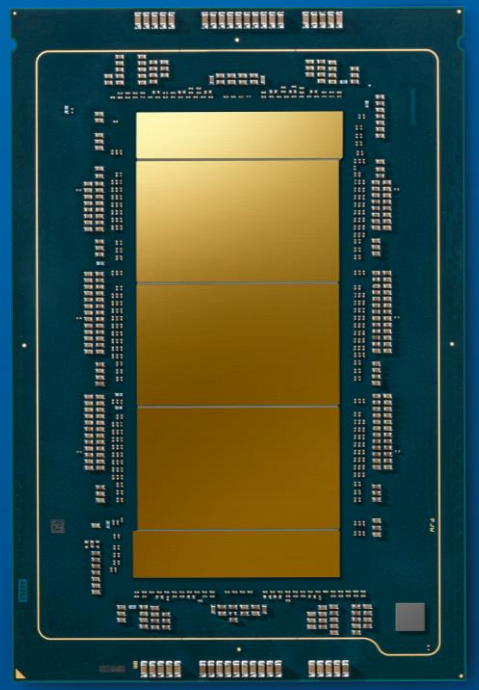
Infographic

Intel® Xeon® 6 processor with P-cores

AI | HPC | IaaS | General Compute

Intel® Xeon® 6 processors with P-cores

- Industry-leading Performance-cores (P-cores) are architected for compute-intensive workloads which benefit from multiple data elements being processed in parallel
- Choose from a range of SKUs with up to 128 cores and 12 memory channels for higher overall performance
- Maximize data throughput with the latest DDR5 and Multiplexed Combined Rank (MCR) DIMMs
- Scale AI everywhere with Intel Advanced Matrix Extensions (Intel AMX) to accelerate inferencing for INT8, BF16, and newly supported FP16 datatypes



2x

higher AI inference performance vs. 5th Gen Intel® Xeon® processors[1]

Up to

2.3x

higher HPC performance vs. 5th Gen Intel® Xeon® processors[1]

2x

higher average performance for general compute vs. 5th Gen Intel® Xeon® processors[1]

SOLUTION BRIEF >

- Intel® Xeon® 6 with P-cores for the Cloud

PRODUCT BRIEF >

- Intel® Xeon® 6 Processors with Performance-Cores (P-Cores) Deep Dive
- Intel® Xeon® 6700 with P-cores

[1]See [9G10, 9H10, 9A10] at intel.com/processorclaims: Intel® Xeon® 6. Results may vary.

Intel® Xeon® 6 with Performance Cores (P-cores)

Server Consolidation

With more cores, double the memory bandwidth, and AI acceleration in every core, Intel® Xeon® 6 processors with P-cores provide **twice the performance** for the widest range of workloads, including AI and high-performance computing (HPC).[1]

Lower your total cost of ownership (TCO) by migrating from 2nd Gen Intel® Xeon® processors (4208) to Intel® Xeon® 6 processors with P-cores (6952P).[1]

Recover your cost in **4 months**[1]

[1] See Optimize Your Data Center with Intel Xeon for TCO Savings for full configuration details. Results may vary.

Intel® Xeon® 6 with Efficient-cores (E-cores)

Free up space and power in the data center for new AI projects

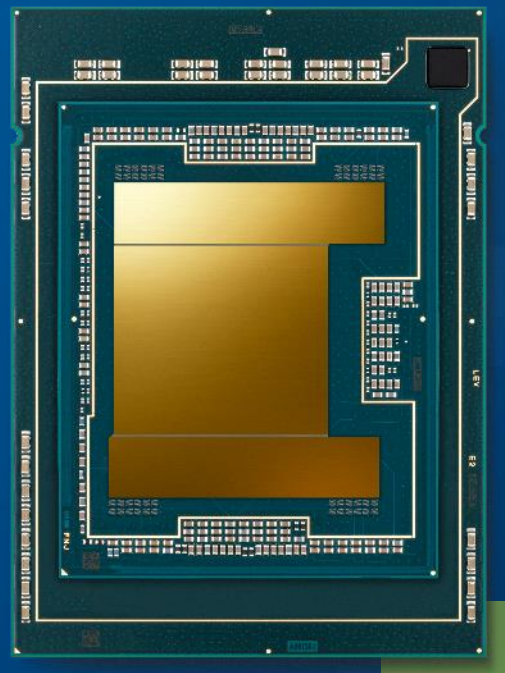
200 racks
2nd Gen Intel® Xeon® Processor

3:1
Rack consolidation
Over 4 years

80k MWh
Fleet energy saved

34k mt
Reduced CO2 emissions

66 racks
Intel® Xeon® 6700E



See [7T2] at intel.com/processorclaims: Intel® Xeon® 6.
Your costs and results may vary.

DEEP DIVE >

- Intel® Xeon® 6 Processors with Efficient-Cores (E-Cores)

Modernize for Datacenter Transformation

Make room to expand your AI infrastructure. Consolidate your data center with Intel® Xeon® processors to save space, reduce costs, and take on new workloads.

	From 2nd Gen Intel Xeon to Intel Xeon 6700 with P-cores			From 2nd Gen Intel Xeon to Intel Xeon 6900 with P-cores			
	8260-->6760P	6230-->6787P	5218R-->6760P	8260-->6979P	6240-->6980P	5220-->6972P	4208-->6952P
Reduce servers	50 to 14 (**72%**)	50 to 10 (**80%**)	50 to 12 (**76%**)	50 to 8 (**84%**)	50 to 6 (**88%**)	50 to 6 (**88%**)	50 to 3 (**94%**)
Reduce energy and CO_2	48%	51%	44%	56%	69%	59%	77%
Reduce TCO*	51%	60%	57%	62%	64%	72%	87%
Recover costs (months)	15	11	13	14	11	9	4

	From 2nd Gen Intel Xeon to Intel Xeon 6700 with E-cores			From 2nd Gen Intel Xeon to 5th Gen Intel Xeon			
	6252-->6710E	6252-->6740E	6252-->6780E	8260-->8558	6230-->8558	5218-->6538Y+	4214-->5520+
Reduce servers	50 to 21 (**58%**)	50 to 15 (**70%**)	50 to 11 (**78%**)	50 to 18 (**64%**)	50 to 15 (**70%**)	50 to 16 (**68%**)	50 to 15 (**70%**)
Reduce energy and CO_2	45%	53%	56%	33%	30%	47%	38%
Reduce TCO*	43%	53%	55%	45%	53%	55%	61%
Recover costs (months)	14	13	16	15	12	9	6

*Based on US energy costs, estimated over 4 years
Performance varies by use, configuration and other factors. | Please reference Intel Node TCO & Power Calculator

Modernize the Datacenter to Run AI Workloads More Efficiently

	1st Gen Intel Xeon to 5th Gen Intel Xeon		2nd Gen Intel Xeon to Intel Xeon 6 with P-cores (6700 series)
	Recommendation system DLRM	**Natural language processing (NLP)** BERT-Large	**Image Classification** ResNet50
Performance advantage per server	**15.4x**	**24x**	**9.9x**
Server consolidation	**50 to 4**	**50 to 3**	**10 to 1**
Fleet energy saved	1,259 MWh	1,697 MWh	30,044 MWh
Reduced CO_2 emissions	533 metric tons	719 metric tons	12,737 metric tons
TCO savings (estimated over 4 years)	$448K	$541K	$10.4M
% TCO savings*	Up to **67%**	Up to **77%**	Up to **68%**

- **Higher core counts**, featuring up to 86 P-cores on the 6700 series and up to 128 P-cores for 6900 series
- **Increased bandwidth** with MRDIMM memory support and delivering up to 504MB low-latency last-level cache in Intel Xeon 6 with P-cores
- Includes **built-in accelerators**, Intel® AMX and Intel® AVX-512
- Offers a **comprehensive software suite** across classical machine learning (ML) and small GenAI models
- **Strengthens security** with Intel® SGX, Intel® TDX and Intel TDX Connect (for Intel Xeon 6 with P-cores)

*Based on US energy costs, estimated over 4 years
Intel Xeon 6 leveraging MRDIMMs
See [T8, T7, 7T21] intel.com/processorclaims: 5th gen and Intel Xeon 6. Results may vary

Reduce Your Energy Consumption and Costs on New Server Purchases for AI

Intel® Xeon® processors deliver a significant performance advantage and lower TCO compared to AMD EPYC servers on AI workloads.

	Intel Xeon 6700P vs. AMD EPYC 9535 (Turin)		**Intel Xeon 6900P** vs. AMD EPYC 9755/9654 (Turin/Genoa)		**5th Gen Intel Xeon** vs. AMD EPYC 9554 (Genoa)	
	Vision Transformation INT8 (Batched)	**Stable Diffusion INT8 (Realtime)**	**Recommendation systems DLRM**	**Image classification ResNet-50**	**Natural language processing BERT-Large**	**Natural language processing DistilBERT**
Performance advantage (per server)	2.09x	1.53x	1.87x	4.91x	2.22x	3.49x
Server consolidation	**289 to 140**	**204 to 130**	**170 to 90**	**496 to 100**	**50 to 23**	**50 to 15**
Fleet energy saved	5,788 MWh	2,011 MWh	5,497 MWh	16,717 MWh	1,205 MWh	1,496 MWh
Reduced CO_2 emissions	2,454 metric tons	853 metric tons	2,330 metric tons	7,087 metric tons	5,109 metric tons	6,344 metric tons
TCO savings (estimated over 4 years)	$6.3M	$2.6M	$4.0M	$18.8M	$883K	$1.3M
% TCO savings*	Up to **52%**	Up to **31%**	Up to **46%**	Up to **74%**	Up to **41%**	Up to **62%**

*Based on US energy costs, estimated over 4 years
Intel Xeon 6 leveraging MRDIMMs
See [7T221, 7T222, 9T222, 9T10, T205, T206] intel.com/processorclaims: 5th gen and Intel Xeon 6. Results may vary

Access the Intel® Xeon® Processor Advisor Suite to calculate the best route to lower TCO and ROI

Ecosystem Enablement for AI on 5th Gen Intel® Xeon® and Intel® Xeon® 6 systems

Solutions, OEMs, and foundational software

	5th Gen Intel® Xeon® OEM and ISV AI-optimized solutions			
OEM	cisco	DELL Technologies	Lenovo	Red Hat
Deep Learning	Inferencing on Cisco UCS X-Series Inference Operations on UCS X-Series Cisco UCS X-Series M7 Blade Servers Creativity with GenAI	Dell PowerEdge R760, Cloudera		NLP applications on Red Hat OpenShift Red Hat OpenShift Data Science
GenAI	GenAI Advancements: Dell PowerEdge R760 UCS X-Series on Red Hat OpenShift AI Mainstreaming GenAI Inference Operations GenAI Inferencing with UCS X-Series M7 Creativity with GenAI	Dell PowerEdge R760	RH OpenShift Lenovo ThinkSystem SR650 V3	
RAG		Evaluating RAG with OpenVINO		

Intel recommended SKUs for AI

AI Workloads:

- Small and Medium LLM
- Classical ML (Non-DL)
- RAG
- Computer Vision
- NLP
- DLRM

CPU	Good	Better	Best
5th Gen Intel® Xeon®	8562Y+ 8548Y+	8568Y+ 8558P	8592+
Intel® Xeon® 6 with P-Cores	6960P 6737P 6730P	6740P 6747P	6787P

Foundational Software Enablement

Hypervisor

- Microsoft Hyper-V WS
- VMware ESXi
- Linux
- KVM

Operating System

- MS Windows Server
- Red Hat Enterprise Linux
- Ubuntu
- SUSE Linux Enterprise Server
- Linux Kernel

For specific versions check with the vendor as they become publicly announced.

Available AI systems

5th Gen Intel Xeon

Cisco
M7 c220, M7 c240, M7 x210c

Dell
R660, R660XS, R760, R760XA, R760XD2, R760XS, XR5610, XR7620, Xeon as Host CPU: XE9680

HPE
DL380G11, DL380aG11, SY480G11, ML350G11

Lenovo ThinkSystem
SR680a V3, HG660x V3, WA5480 G3 (China), WA7780 G3 (China)

Supermicro
SYS-821GE-TNHR, SYS-A21GE-NBRT, SYS-821GE-TNMR2, SYS-421GU-TNXR, SYS-421GE-NBRT-LLC, SYS-421GE-TNHR2-LCC, SYS-221GE-TNHT-LLC

Intel Xeon 6

Cisco
M8 c220, M8 c240, M8 x210c

Dell
R670, R770, R470, R570, Xeon as Host CPU: XE9780, XE7740

HPE
DL580G12, DL380G12, DL380aG12, DL360G12, DL340G12, DL320G12, SY480G12, ML350G12

Lenovo ThinkSystem
SR680a V4, HG660x V4, WA5480 G5 (China), SR650a V4

Supermicro
SYS-A22GA-NBRT, SYS-422GA-NBRT-LCC, SYS-822GA-NBRT, SYS-822GA-NGR3, SYS-522GA-NRT, SYS-422GL-NR

Call to Action

- Understand your partner / customers' usage model and performance needs FIRST
- When AI is just another workload in a mixed general purpose and AI environment, lead with the Intel® Xeon® processors that are already running your customers' business
- For dedicated AI deployments, Intel® Xeon® processors paired with Intel® Gaudi® AI Accelerators will deliver the optimal TCO

Access the Intel® Xeon® Processor Advisor Suite to calculate the best route to lower TCO and path to ROI for your partners

Additional Resources

Asset Type	Title and Link
Pitch Cards	5th Gen Intel® Xeon® Pitch Cards PUBLIC SET
Business Brief	Performance. Efficiency. Security. All Across Your Clouds

AI Enablement Zones

Access a comprehensive resource hub designed to help grow your business and solve your customers' most pressing business challenges. Find exclusive, value-added technical and sales enablement resources to help you build and sell solutions with Intel technology.

Technical Enablement

Sales & Marketing Enablement

Technical Enablement

Sales & Marketing Enablement

Technical Enablement

Sales & Marketing Enablement

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AI Use Case Benchmarks on 5th Gen Intel® Xeon®

Generative AI

GPT-J

- Up to 2.3x performance speedup and 1.81x higher performance/watt with 5th Gen Intel Xeon processor vs 3rd Gen Intel® Xeon on GPT-J first token latency (int8)[1]
- Up to 1.64x performance speedup and 1.30x higher performance/watt with 5th Gen Intel® Xeon processor vs 3rd Gen Intel® Xeon on GPT-J second token latency (int8)[1]

LLaMA

- Up to 2.1x performance speedup and 1.58x higher performance/watt with 5th Gen Intel Xeon processor vs 3rd Gen Intel® Xeon® on Llama 2 13B first token latency (int8)[2]
- Up to 1.48x performance speedup and 1.11x higher performance/watt with 5th Gen Intel® Xeon® processor vs 3rd Gen Intel® Xeon® on Llama 2 13B second token latency (int8)[2]

Recommender Systems

DIEN

- Up to 1.12x higher end-to-end recommendation Speedup with 5th Gen Intel® Xeon® processor compared with prior generation on Deep Interest Evolution Network (DIEN) Recommendation System[5]

DLRM

- Up to 8.7x higher batch Recommendation System inference performance (DLRM) and 6.2x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX BF16 vs. 3rd Gen Intel® Xeon® processor with FP32[6]

DLRM (Competitive)

- Up to 2.34x higher batched Recommendation System inference performance (DLRM) and 2.26x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX INT8 vs. AMD EPYC 9654 (Genoa)[7]
- Up to 1.90x higher batched Recommendation System inference performance (DLRM) and 1.72x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX INT8 vs. AMD EPYC 9754 (Bergamo)[7]

Natural Language Processing

BERT- Large

- Up to 9.9x higher real-time Natural Language Processing inference (BERT-large) performance and 7.7x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX BF16 vs. 3rd gen Intel® Xeon® processor with FP32[3]
- Up to 10x higher batch Natural Language Processing inference (BERT-large) performance and 7.1x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX BF16 vs. 3rd gen Intel® Xeon® processor with FP32[3]

DistilBERT

- Up to 7x higher real-time Natural Language Processing inference (DistilBERT) performance and 5.6x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX BF16 vs. 3rd gen Intel® Xeon® processor with FP32[4]
- Up to 10x higher batch Natural Language Processing inference (DistilBERT) performance and 8x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX BF16 vs. 3rd gen Intel® Xeon® processor with FP32[4]

Computer Vision

ResNet-50

- Up to 8x higher performance and 6.4x higher performance/watt on real-time image classification(ResNet50) inference (BF16) with 5th Gen Intel® Xeon® 8592+ (64c) vs. 3rd Gen Intel® Xeon® 8380 (fp32)[8]
- Up to 8.8x higher performance and 7.4x higher performance/watt on batch image classification(ResNet50) inference (BF16) with 5th Gen Intel® Xeon® 8592+ (64c) vs. 3rd Gen Intel® Xeon® 8380 (fp32)[8]

ResNet-34

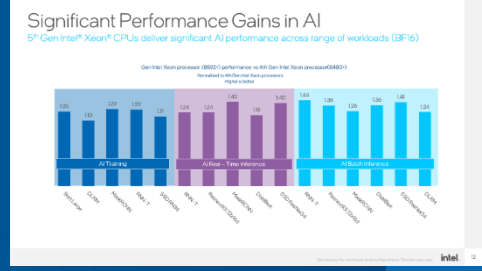
- Up to 14x higher real time object detection inference performance (SSD-ResNet34) and 9.6x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX BF16 vs. 3rd Gen Intel® Xeon® processor with FP32[9]
- Up to 13.8x higher batch object detection inference performance (SSD-ResNet34) and 10x higher performance/watt on 5th Gen Intel® Xeon® Platinum 8592+ with AMX BF16 vs. 3rd Gen Intel® Xeon® processor with FP32[9]

Machine Learning

- Up to 1.39x faster end-to-end Census workload performance using 5th Gen Intel® Xeon® processor compared to prior generation(FP32)[10]

[1,2] See [A1, A2] at intel.com/processorclaims: 5th Gen Intel® Xeon® Scalable processors. Results may vary
[3,4] See [A19, A24] at intel.com/processorclaims: 5th Gen Intel® Xeon® Scalable processors. Results may vary
[5,6,7,] See [A7, A20, A208] at intel.com/processorclaims: 5th Gen Intel® Xeon® Scalable processors. Results may vary
[8,9,] See [A26, A21] at intel.com/processorclaims: 5th Gen Intel® Xeon® Scalable processors. Results may vary
[10,] See [A8] at intel.com/processorclaims: 5th Gen Intel® Xeon® Scalable processors. Results may vary

Configuration details: AI performance



Performance varies by use, configuration and other factors. See backup for configuration details. Results may vary.

ResNeXT101_32x16d Inference: BS1, BSx

8592+: 1-node, 2x Intel(R) Xeon(R) Platinum 8592+, 64 cores, HT On, Turbo On, NUMA 4, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS EGSDCRB1.SYS.0105.D74.2308261933, microcode 0x21000161, 1x Ethernet Controller I225-LM, 1x 3.6T INTEL SSDPE2KX040T8, 1x 931.5G INTEL, CentOS Stream 9, 6.2.0-emr.bkc.6.2.3.6.31.x86_64. PyTorch: torch:2.1.0.dev20230825+cpu, oneDNN:v3.2.1 IPEX:2.1.0+git31b5ee1, Test by INTEL as of 09/07/2023.

8480+: 1-node, 2x Intel(R) Xeon(R) Platinum 8480+, 56 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS EGSDCRB1.SYS.0102.D37.2305081420, microcode 0x2b0004b1, 1x Ethernet Controller I225-LM, 1x 7.2G Cruzer Blade, 2x 3.7T INTEL SSDPE2KX040T8, 1x 894.3G INTEL SSDSC2KG96, CentOS Stream 8, 5.15.0-spr.bkc.pc.16.4.24.x86_64. PyTorch: torch:2.1.0.dev20230825+cpu oneDNN:v3.2.1 IPEX:2.1.0+git31b5ee1. Test by INTEL as of 09/05/2023.

ResNeXT101_32x16d, BS=1: 4cores/instance, BS=x: 1 instance/ numa node; Resnext101: ImageNet

RNN-T Inference : BS1, BSx

8592+: 1-node, 2x Intel(R) Xeon(R) Platinum 8592+, 64 cores, HT On, Turbo On, NUMA 4, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS EGSDCRB1.SYS.0105.D74.2308261933, microcode 0x21000161, 1x Ethernet Controller I225-LM, 1x 3.6T INTEL SSDPE2KX040T8, 1x 931.5G INTEL, CentOS Stream 9, 6.2.0-emr.bkc.6.2.3.6.31.x86_64. PyTorch: torch:2.1.0.dev20230825+cpu, oneDNN:v3.2.1 IPEX:2.1.0+git31b5ee1, Test by INTEL as of 09/07/2023.

8480+: 1-node, 2x Intel(R) Xeon(R) Platinum 8480+, 56 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS EGSDCRB1.SYS.0102.D37.2305081420, microcode 0x2b0004b1, 1x Ethernet Controller I225-LM, 1x 7.2G Cruzer Blade, 2x 3.7T INTEL SSDPE2KX040T8, 1x 894.3G INTEL SSDSC2KG96, CentOS Stream 8, 5.15.0-spr.bkc.pc.16.4.24.x86_64. PyTorch: torch:2.1.0.dev20230825+cpu oneDNN:v3.2.1 IPEX:2.1.0+git31b5ee1. Test by INTEL as of 09/05/2023.

RNN-T, BS=1: 4cores/instance, BS=x: 1 instance/ numa node; RNNT: LibriSpeech

DistilBERT Inference : BS1, BSx

8592+: 1-node, 2x INTEL(R) XEON(R) PLATINUM 8592+, 64 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS 2.0, microcode 0x21000161, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.2 LTS, 5.15.0-78-generic, Test by Intel as of 10/10/23.

8480+: 1-node, 2x Intel(R) Xeon(R) Platinum 8480+, 56 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS 2.0, microcode 0x2b0004d0, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.2 LTS, 5.15.0-78-generic, Test by Intel as of 10/25/23.

Software configuration: DistilBERT, Intel Model Zoo:https://github.com/IntelAI/models, gcc=12.3, OneDNN3.2, Python 3.9, PyTorch 2.0, IPEX 2.0, Transformer version 4.18.0, physical cores only.

MaskRCNN Inference: : BS1, BSx

8592+: 1-node, 2x Intel(R) Xeon(R) Platinum 8592+, 64 cores, HT On, Turbo On, NUMA 4, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS EGSDCRB1.SYS.0105.D74.2308261933, microcode 0x21000161, 1x Ethernet Controller I225-LM, 1x 3.6T INTEL SSDPE2KX040T8, 1x 931.5G INTEL, CentOS Stream 9, 6.2.0-emr.bkc.6.2.3.6.31.x86_64. PyTorch: torch:2.1.0.dev20230825+cpu, oneDNN:v3.2.1 IPEX:2.1.0+git31b5ee1, Test by INTEL as of 09/07/2023.

8480+: 1-node, 2x Intel(R) Xeon(R) Platinum 8480+, 56 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS EGSDCRB1.SYS.0102.D37.2305081420, microcode 0x2b0004b1, 1x Ethernet Controller I225-LM, 1x 7.2G Cruzer Blade, 2x 3.7T INTEL SSDPE2KX040T8, 1x 894.3G INTEL SSDSC2KG96, CentOS Stream 8, 5.15.0-spr.bkc.pc.16.4.24.x86_64. PyTorch: torch:2.1.0.dev20230825+cpu oneDNN:v3.2.1 IPEX:2.1.0+git31b5ee1. Test by INTEL as of 09/05/2023.

MaskRCNN, BS=1: 4cores/instance, BS=x: 1 instance/ numa node; Mask RCNN: COCO 2017

Resources and Configurations

- 5th Gen Intel® Xeon® Outperforms Competition Around The Clock
  - ResNet50v1.5
  - Intel® Xeon® 8592+: 1-node, 2x Intel(R) Xeon(R) Platinum 8592+, 64 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS 2.0, microcode 0x21000161, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.2 LTS, 5.15.0-78-generic. TensorFlow= Intel TF 2.13, OneDNN=3.2, Python 3.8, AI Model=ResNet50v1.5 Large(https://github.com/IntelAI/models/) , Batched Results: best scores achieved using BFloat16, INT8-AMX (BS >1),, Test by INTEL as of 10/10/2023.
  - AMD EPYC 9654: 1-node, 2x AMD EPYC 9654 96-Core Processor, 96 cores, SMT On, Turbo On, NUMA 2, Total Memory 1536GB (24x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS 1.5, microcode 0xa10113e, 2x Ethernet Controller 10G X550T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 5.15.125-0515125-generic, ZenDNN 4.1 TensorFlow 2.12.1, Python 3.8, AI Model=ResNet50v1.5 Large(https://github.com/IntelAI/models/) , Batched Results: best scores achieved using (BS >1),Test by INTEL as of 09/11/23.
  - NGINX TLS
  - Intel® Xeon® 8592+: 1-node, 2x 5th Gen Intel® Xeon® Scalable processor (64 core) with integrated Intel Quick Assist Technology (Intel QAT), QAT device utilized=4 (1 active socket), HT On, Turbo Off, SNC On, with 1024GB DDR5 memory (16x64 GB 5600), microcode 0x21000161, Ubuntu 22.04.3 LTS, 5.15.0-78-generic, 1x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, 1x Intel® Ethernet Network Adapter E810-2CQDA2, 1x100GbE, NGINX Async v0.5.1, OpenSSL 3.1.3, IPP Crypto 2021.8, IPsec MB v 1.4, QAT _Engine v 1.4.0, QAT Driver 20.l.1.1..20-00030, TLS 1.3 Webserver: ECDHE-X25519-RSA2K, tested by Intel October 2023.
  - AMD EPYC 9554: 1-node, AMD platform with 2x 4th Gen AMD EPYC processor (64 cores), SMT On, Core Performance Boost Off, NPS1, Total Memory 1536GB (24x64GB DDR5 4800), microcode 0xa10113e, Ubuntu 22.04.3 LTS, 5.15.0-78-generic, 1x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, 1x Intel® Ethernet Network Adapter E810-2CQDA2, 1x100GbE, NGINX Async v0.5.1, OpenSSL 3.1.3, TLS 1.3 Webserver: ECDHE-X25519-RSA2K,tested by Intel October 2023.

Resources and Configurations

▪ 5th Gen Intel® Xeon® Outperforms Competition Around The Clock

- **HammerDB Microsoft SQL Server + Backup**
- Intel® Xeon® 8592+: 1-node, 2x 5th Gen Intel® Xeon® Scalable processor 8592+ (64 cores) with integrated Intel Quick Assist Technology (Intel QAT), Number of IAA device utilized=8(2 sockets active), HT On, Turbo On, SNC off, Total Memory 1024GB (16x64GB DDR5 5600), microcode 0x21000161, 2x Ethernet Controller 10-Gigabit X540-AT2, 7x 3.5T INTEL SSDPE2KE032T807, QATZip 2.0.W.1.9.0-0008, Microsoft Windows Server Datacenter 2022, Microsoft SQL Server 2022, SQL Server Management Studio 19.0.1, HammerDB 4.5, tested by Intel October 2023.
- AMD EPYC 9554: 1-node, AMD platform with 2x 4th Gen AMD EPYC processor (64 cores), SMT On, Core Performance Boost On, NPS1, Total Memory 1536GB (24x64GB DDR5 4800), microcode 0xa10113e, 2x Ethernet Controller 10G X550T, 7x 3.5T INTEL SSDPE2KE032T807, Microsoft Windows Server Datacenter 2022, Microsoft SQL Server 2022, SQL Server Management Studio 19.0.1, HammerDB 4.5, tested by Intel October 2023.
- **RocksDB**
- Intel® Xeon® 8592+: 1-node, 2x 5th Gen Intel® Xeon® Scalable processor 8592+ (64 cores) with integrated Intel In-Memory Analytics Accelerator (Intel IAA), Number of IAA device utilized=8(2 sockets active), HT On, Turbo On, SNC off, Total Memory 1024GB (16x64GB DDR5 5600), microcode 0x21000161, 2x Ethernet Controller 10-Gigabit X540-AT2, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 6.5.0-060500-generic, QPL v1.2.0, accel-config-v4.0, iaa_compressor plugin v0.3.0, ZSTD v1.5.5, gcc 10.4.0, RocksDB v8.3.0 trunk (commit 62fc15f) (db_bench), 4 threads per instance, 64 RocksDB instances, tested by Intel October 2023.
- AMD EPYC 9554: 1-node, AMD platform with 2x 4th Gen AMD EPYC processor (64 cores), SMT On, Core Performance Boost On, NPS1, Total Memory 1024GB (16x64GB DDR5 4800), microcode 0xa10113e, 2x Ethernet Controller 10G X550T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 6.5.0-060500-generic, ZSTD v1.5.5, gcc 10.4.0, RocksDB v8.3.0 trunk (commit 62fc15f) (db_bench), 4 threads per instance, 28 RocksDB instances, tested by Intel October 2023.
- **Monte Carlo**
- Intel® Xeon® 8592+: 1-node 2x Intel® Xeon® 8592+, HT On, Turbo On, SNC2, 1024 GB DDR5-5600, ucode 0x21000161, Red Hat Enterprise Linux 8.7, 4.18.0-425.10.1.el8_7.x86_64, Monte Carlo v1.2, cmkl:2023.2.0 icc:2023.2.0 tbb:2021.10.0. Test by Intel as of October 2023.
- AMD EPYC 9554: 1-node, 2x AMD EPYC 9554, SMT On, Turbo On, CTDP=360W, NPS=4, 1536GB DDR5-4800, ucode= 0xa101111, Red Hat Enterprise Linux 8.7, Kernel 4.18,Monte Carlo v1.2, cmkl:2023.2.0 icc:2023.2.0 tbb:2021.10.0. Test by Intel as of March 2023

Resources and Configurations

- 5th Gen Intel® Xeon® Outperforms Competition Around The Clock
  - DLRM
  - Intel® Xeon® 8592+: 1-node, 2x Intel(R) Xeon(R) Platinum 8592+, 64 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS2.0, microcode 0x21000161, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.2 LTS, 5.15.0-78-generic. Framework=Pytorch 2.1, IPEX=2.1, Python 3.8, AI Model= DLRM(https://github.com/IntelAI/models/) , Batched Results: best scores achieved using BS>1, Precision=INT8-AMX, Test by INTEL as of 10/10/2023.
  - AMD EPYC 9654: 1-node, 2x AMD EPYC 9654 96-Core Processor, 96 cores, SMT On, Turbo On, NUMA 2, Total Memory 1536GB (24x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS 1.5, microcode 0xa10113e, 2x Ethernet Controller 10G X550T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 5.15.125-0515125-generic, Framework=Pytorch 2.1, IPEX=2.1, Python 3.8, AI Model= DLRM(https://github.com/IntelAI/models/) , Batched Results: best scores achieved using BS>1, Precision=INT8. Test by INTEL as of 09/11/23.
  - HammerDB MySQL
  - Intel® Xeon® 8592+: 1-node, 2x INTEL(R) XEON(R) PLATINUM 8592+, 64 cores, HT On, Turbo On, NUMA 2, Integrated Accelerators Available [used]: DLB 8 [0], DSA 8 [0], IAX 8 [0], QAT 8 [0], Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS 2.0, microcode 0x21000161, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, 2x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, Ubuntu 22.04.3 LTS, 5.15.0-84-generic, HammerDB Mv4.4, MySQL 8.0.33. Test by Intel as of 10/04/23.
  - AMD EPYC 9554: 1-node, 2x AMD EPYC 9554 64-Core Processor, 64 cores, HT On, Turbo On, NUMA 2, Integrated Accelerators Available [used]: DLB 0 [0], DSA 0 [0], IAX 0 [0], QAT 0 [0], Total Memory 1536GB (24x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS 1.5, microcode 0xa10113e, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, 2x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, Ubuntu 22.04.3 LTS, 5.15.125-0515125-generic, HammerDB v4.4, MySQL 8.0.33. Test by Intel as of 10/05/23.

Configurations: 5th Gen Intel® Xeon® TCO Advantages (1 of 6)

Claim: 5th Gen Intel® Xeon® delivers up to 24% lower TCO than the 4th Gen AMD Epyc while running a HammerDB MySQL OLTP database workload.

- Based on 5th Gen Intel® Xeon® delivers up to a 1.70x faster than the 4th Gen AMD Epyc while running a HammerDB MySQL OLTP workload. This performance drives a fleet reduction from 50 to 30
- servers which, over 4 years, saves: 684.0 MWH of energy, 289,967 kgCo2 emissions, and $508.9k of cost.
- 1-node, 2x INTEL(R) XEON(R) PLATINUM 8592+, 64 cores, HT On, Turbo On, NUMA 2, Integrated Accelerators Available [used]: DLB 8 [0], DSA 8 [0], IAX 8 [0], QAT 8 [0], Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS 2.0, microcode 0x21000161, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, 2x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, Ubuntu 22.04.3 LTS, 5.15.0-84-generic, HammerDB Mv4.4, MySQL 8.0.33. Test by Intel as of 10/04/23.
- 1-node, 2x AMD EPYC 9554 64-Core Processor, 64 cores, HT On, Turbo On, NUMA 2, Integrated Accelerators Available [used]: DLB 0 [0], DSA 0 [0], IAX 0 [0], QAT 0 [0], Total Memory 1536GB (24x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS 1.5, microcode 0xa10113e, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, 2x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, Ubuntu 22.04.3 LTS, 5.15.125-0515125-generic, HammerDB v4.4, MySQL 8.0.33. Test by Intel as of 10/05/23.

- For a 50 server fleet of AMD EPYC 9554, estimated as of October 2023:
- CapEx costs: $1.40M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $755.1K
- Energy use in kWh (4 year, per server): 47654, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394

- For a 30 server fleet of 5th Gen Intel® Xeon® 8592+ as of October 2023
- CapEx costs: $1.17M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $480.0K
- Energy use in kWh (4 year, per server): 58625, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394
- Costs based on Intel estimates andinformation from thinkmate.com as of October 2023.

Configurations: 5th Gen Intel® Xeon® TCO Advantages (2 of 6)

Claim: 5th Gen Intel® Xeon® delivers up to 22% lower TCO than the 4th Gen AMD Epyc while running a RocksDB database workload.

- Based on 5th Gen Intel® Xeon® delivers up to a 1.62x faster than the 4th Gen AMD Epyc while running a RocksDB database workload. This performance drives a fleet a reduction from 50 to 31 servers which, over 4 years, saves: 1,218 MWH of energy, 516,402 kgCo2 emissions, and $471.8k of cost.
- 1-node, 2x 5th Gen Intel® Xeon® Scalable processor 8592+ (64 cores) with integrated Intel In-Memory Analytics Accelerator (Intel IAA), Number of IAA device utilized=8(2 sockets active), HT On, Turbo On, SNC off, Total Memory 1024GB (16x64GB DDR5 5600), microcode 0x21000161, 2x Ethernet Controller 10-Gigabit X540-AT2, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 6.5.0-060500-generic, QPL v1.2.0, accel-config-v4.0, iaa_compressor plugin v0.3.0, ZSTD v1.5.5, gcc 10.4.0, RocksDB v8.3.0 trunk (commit 62fc15f) (db_bench), 4 threads per instance, 64 RocksDB instances, tested by Intel October 2023.
- 1-node, AMD platform with 2x 4th Gen AMD EPYC processor (64 cores), SMT On, Core Performance Boost On, NPS1, Total Memory 1024GB (16x64GB DDR5 4800), microcode 0xa10113e, 2x Ethernet Controller 10G X550T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 6.5.0-060500-generic, ZSTD v1.5.5, gcc 10.4.0, RocksDB v8.3.0 trunk (commit 62fc15f) (db_bench), 4 threads per instance, 28 RocksDB instances, tested by Intel October 2023.

- For a 50 server fleet of AMD EPYC 9554, estimated as of October 2023:
- CapEx costs: $1.36M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $809.5K
- Energy use in kWh (4 year, per server): 58531, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394

- For a 31 server fleet of 5th Gen Intel® Xeon® 8592+ as of October 2023
- CapEx costs: $1.21M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $491.3K
- Energy use in kWh (4 year, per server): 55111, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394
- Costs based on Intel estimates and information from thinkmate.com as of October 2023

Configurations: 5th Gen Intel® Xeon® TCO Advantages (3 of 6)

Claim: 5th Gen Intel® Xeon® delivers up to 21% lower TCO than the 4th Gen AMD Epyc while running a NGINX TLS Handshake workload.

- Based on 5th Gen Intel® Xeon® delivers up to a 1.66x faster than the 4th Gen AMD Epyc while running a NGINX TLS Handshake workload. This performance drives a fleet a reduction from 50 to 31 servers which, over 4 years, saves: 489.7 MWH of energy, 207,611 kgCo2 emissions, and $443.5k of cost.
- 1-node, 2x 5th Gen Intel® Xeon® Scalable processor (64 core) with integrated Intel Quick Assist Technology (Intel QAT), Integrated Accelerators Available [used]: DLB 2 [0], DSA 2 [0], IAA 2 [0], QAT 2 [0], HT On, Turbo Off, SNC On, with 1024GB DDR5 memory (16x64 GB 5600), microcode 0x21000161, Ubuntu 22.04.3 LTS, 5.15.0-78-generic, 1x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, 1x Intel® Ethernet Network Adapter E810-2CQDA2, 1x100GbE, NGINX Async v0.5.1, OpenSSL 3.1.3, IPP Crypto 2021.8, IPsec MB v 1.4, QAT _Engine v 1.4.0, QAT Driver 20.l.1.1..20-00030, TLS 1.3 Webserver: ECDHE-X25519-RSA2K, tested by Intel October 2023.
- 1-node, 9554: 1-node, AMD platform with 2x 4th Gen AMD EPYC processor (64 cores), SMT On, Core Performance Boost Off, NPS1, Total Memory 1536GB (24x64GB DDR5 4800), microcode 0xa10113e, Ubuntu 22.04.3 LTS, 5.15.0-78-generic, 1x 1.7T SAMSUNG MZWLJ1T9HBJR-00007, 1x Intel® Ethernet Network Adapter E810-2CQDA2, 1x100GbE, NGINX Async v0.5.1, OpenSSL 3.1.3, TLS 1.3 Webserver: ECDHE-X25519-RSA2K,tested by Intel October 2023.

- For a 50 server fleet of AMD EPYC 9554, estimated as of October 2023:
- CapEx costs: $1.41M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $698.7K
- Energy use in kWh (4 year, per server): 36386, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394

- For a 31 server fleet of 5th Gen Intel® Xeon® 8592+ as of October 2023
- CapEx costs: $1.21M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $453.4K
- Energy use in kWh (4 year, per server): 42889, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394
- Cost based on Intel estimates and information from thinkmate.com as of October 2023

Configurations: 5th Gen Intel® Xeon® TCO Advantages (4 of 6)

Claim: 5th Gen Intel® Xeon® delivers up to 27% lower TCO than the 4th Gen AMD Epyc while running Monte Carlo workload.

- Based on 5th Gen Intel® Xeon® delivers up to a 1.83x faster than the 4th Gen AMD Epyc while running a Monte Carlo workload. This performance drives a fleet a reduction from 50 to 28 servers which, over 4 years, saves: 585.8 MWH of energy, 248,352 kgCo2 emissions, and $561.0k of cost.
- 1-node 2x Intel® Xeon® 8592+, HT On, Turbo On, SNC2, 1024 GB DDR5-5600, ucode 0x21000161, Red Hat Enterprise Linux 8.7, 4.18.0-425.10.1.el8_7.x86_64, Monte Carlo v1.2, cmkl:2023.2.0 icc:2023.2.0 tbb:2021.10.0. Test by Intel as of October 2023.
- 1-node, 2x AMD EPYC 9554, SMT On, Turbo On, CTDP=360W, NPS=4, 1536GB DDR5-4800, ucode= 0xa101111, Red Hat Enterprise Linux 8.7, Kernel 4.18,Monte Carlo v1.2, cmkl:2023.2.0 icc:2023.2.0 tbb:2021.10.0. Test by Intel as of March 2023

- For a 50 server fleet of AMD EPYC 9554, estimated as of October 2023:
- CapEx costs: $1.36M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $739.3K
- Energy use in kWh (4 year, per server): 44505, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394

- For a 28 server fleet of 5th Gen Intel® Xeon® 8592+ as of October 2023
- CapEx costs: $1.09M
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $453.3K
- Energy use in kWh (4 year, per server): 58550, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394
- Costs based on Intel estimates and information from thinkmate.com as of October 2023.

Configurations: 5th Gen Intel® Xeon® TCO Advantages (5 of 6)

Claim: 5th Gen Intel® Xeon® delivers up to 46% lower TCO than the 4th Gen AMD Epyc while running a real-time Natural Language Processing inference (BERT-Large) workload.

- Based on 5th Gen Intel® Xeon® delivers up to a 2.44x faster than the 4th Gen AMD Epyc while running a real-time Natural Language Processing inference (BERT-Large) workload. This performance drives a fleet a reduction from 50 to 21 servers which, over 4 years, saves: 1231.2 MWH of energy, 521,941 kgCo2 emissions, and $982.9k of cost.
- Intel® Xeon® 8592+: 1-node, 2x Intel(R) Xeon(R) Platinum 8592+, 64 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS 2.0, microcode 0x21000161, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.2 LTS, 5.15.0-78-generic. Framework=Pytorch 2.0, IPEX=2.0, Python 3.8, AI Model=BERT Large(https://github.com/IntelAI/models/) , INT8-AMX , Real Time (BS=1) results while maintaining 130ms latency SLA, Test by INTEL as of 10/10/2023.
- 9554: 1-node, 2x AMD EPYC 9554 64-Core Processor, 64 cores, SMT On, Turbo On, NUMA 2, Total Memory 1536GB (24x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS 1.5, microcode 0xa10113e, 2x Ethernet Controller 10G X550T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 5.15.125-0515125-generic, Framework=Pytorch 2.0, IPEX=2.0, Python 3.8, AI Model=BERT Large(https://github.com/IntelAI/models/) , INT8, Real Time (BS=1) results while maintaining 130ms latency SLA. Test by INTEL as of 09/11/23.

- For a 50 server fleet of AMD EPYC 9554, estimated as of October 2023:
- CapEx costs: $1.36
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $766.9K
- Energy use in kWh (4 year, per server): 50021, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394

- For a 21 server fleet of 5th Gen Intel® Xeon® 8592+ as of October 2023
- CapEx costs: $801K
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $344.0K
- Energy use in kWh (4 year, per server): 60472, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394
- Costs based on Intel estimates and information from thinkmate.com as of October 2023.

Configurations: 5th Gen Intel® Xeon® TCO Advantages (6 of 6)

Claim: 5th Gen Intel® Xeon® delivers up to 62% lower TCO than the 4th Gen AMD Epyc while running real-time Natural Language Processing inference (DistilBERT) workload.

- Based on 5th Gen Intel® Xeon® delivers up to a 3.49x faster than the 4th Gen AMD Epyc while running a real-time Natural Language Processing inference (DistilBERT) workload. This performance drives a fleet a reduction from 50 to 15 servers which, over 4 years, saves: 1496.5 MWH of energy, 634,428 kgCo2 emissions, and $1,300k of cost.
- 1-node, 2x Intel(R) Xeon(R) Platinum 8592+, 64 cores, HT On, Turbo On, NUMA 2, Total Memory 1024GB (16x64GB DDR5 5600 MT/s [5600 MT/s]), BIOS 2.0, microcode 0x21000161, 2x Ethernet Controller X710 for 10GBASE-T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.2 LTS, 5.15.0-78-generic. Framework=Pytorch 2.0, IPEX=2.0, Python 3.8, AI Model=DistilBERT (https://github.com/IntelAI/models/) , INT8-AMX, Real Time (BS=1) results while maintaining 5ms latency SLA, Test by INTEL as of 10/10/2023.
- 1-node, 2x AMD EPYC 9554 64-Core Processor, 64 cores, SMT On, Turbo On, NUMA 2, Total Memory 1536GB (24x64GB DDR5 4800 MT/s [4800 MT/s]), BIOS 1.5, microcode 0xa10113e, 2x Ethernet Controller 10G X550T, 1x 1.7T SAMSUNG MZQL21T9HCJR-00A07, Ubuntu 22.04.3 LTS, 5.15.125-0515125-generic, Framework=Pytorch 2.0, IPEX=2.0, Python 3.8, AI Model=DistilBERT Large(https://github.com/IntelAI/models/) , INT8, Real Time (BS=1) results while maintaining 5ms latency SLA. Test by INTEL as of 09/11/23.

- For a 50 server fleet of AMD EPYC 9554, estimated as of October 2023:
- CapEx costs: $1.36
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $749.7K
- Energy use in kWh (4 year, per server): 46573, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394

- For a 15 server fleet of 5th Gen Intel® Xeon® 8592+ as of October 2023
- CapEx costs: $572K
- OpEx costs (4 year, includes power and cooling utility costs, infrastructure and hardware maintenance costs): $238.3K
- Energy use in kWh (4 year, per server): 55475, PUE 1.6
- Other assumptions: utility cost $0.1/kWh, kWh to kg CO2 factor 0.42394
- Costs based on Intel estimates and information from thinkmate.com as of October 2023.

Confidential Computing on 5th Gen Intel® Xeon® Scalable Processors

Confidential computing and supporting technologies

Confidential computing with 5th Gen Intel® Xeon® Scalable processors isolates workloads inside trusted execution environments (TEEs). It helps strengthen data privacy, regulatory compliance, data access control and sovereignty, and application and data security.

- Intel® Software Guard Extensions (Intel® SGX) offers hardware-based security that helps protect data in use via unique application-isolation technology. **Intel SGX is the most researched and most trusted execution environment for the data center, and it provides the smallest attack surface within the system.**
- Intel® Trust Domain Extensions (Intel® TDX) provides virtual machine (VM) isolation from cloud providers and other tenants, and it more readily supports existing applications.[1]
- Intel® Trust Authority takes Confidential Computing to the next level with a Zero Trust attestation SaaS that verifies the trustworthiness of compute assets at the network, edge, and in the cloud. Intel Trust Authority attests to the validity of Intel Confidential Computing environments.

Why it matters

Cloud: Confidently take advantage of the cloud while remaining compliant and in control of your data. Even confidential or regulated data can be protected when in use in the public cloud.

Collaboration: Confidential computing enables you to engage in multi-party analysis in a way that keeps each party's data private. Realize the benefits of shared analysis without losing privacy.

Regulatory compliance and data sovereignty: Confidential computing adds technological controls that help ensure data will be handled in compliance with proper procedures and regulatory frameworks.

Workloads: Confidential computing "armors-up" your workloads, helping protect sensitive data, content, and software intellectual property (IP) from advanced attack, tampering, and theft.

Learn more

- intel.com/confidentialcomputing
- intel.com/security-engines
- Accelerated AI inference with confidential computing
- Confidential computing is combating modern slavery
- Intel® Trust Authority | Intel Software (video)
- Securing Your Trust Boundary with Intel SGX and Intel TDX (video)

Business benefits

- Migrate workloads to the cloud with confidence
- Activate sensitive data in new services while maintaining privacy and regulatory compliance
- Enable beneficial multi-party data collaborations with full confidentiality
- Harden application security and strengthen compliance or data-sovereignty programs
- Customers can see up to 11% higher VM performance on 5th Gen Intel® Xeon® processors with Intel TDX vs. 4th Gen Intel® Xeon® processors without Intel TDX on integer, floating point and BERT-large[2]

Value differentiators

- **Isolation:** Separation of the TEE from the underlying software, admins, and other cloud tenants
- **Encryption and control:** Workload owner holds key to decrypt data, retaining control and preventing access by cloud provider or other entities
- **Verification:** Cryptographic confirmation that TEE is genuine and correctly configured, and that software is exactly as expected

Use cases

Protect data in use

- Data is routinely encrypted at rest and in transit. Confidential computing helps protect it while in use in the CPU and memory.

Sectors (often heavily regulated)

- Healthcare
- Financial
- Ad tech
- Government
- Retail
- Industrial and edge

Confidential artificial intelligence (AI)

Collaborative analytics

Privacy-preserving ad tech

Privacy-preserving blockchains

Data and software IP control

[1] Intel TDX will be available on select 4th Gen Intel® Xeon® Scalable instances through four leading cloud providers. Previews have begun with select providers. Check with your provider for availability. Intel TDX becomes generally available with 5th Gen Intel® Xeon® Scalable processors.
[2] See [S1] at intel.com/processorclaims: 5th Gen Intel® Xeon® processors. Results may vary.