Accelerating Data Movement with Intel® Data Streaming Accelerator (Intel® DSA) on 4th Gen Intel® Xeon® Scalable Processor
Contents

▪ Value Prop – benefits of Intel DSA

▪ Workload targets for Intel DSA

▪ Metrics/results to help understand benefits of Intel DSA

▪ Software requirements, and how to integrate Software with Intel DSA
Intel DSA Overview & Benefits

**Intel DSA** – a data mover IP integrated on 4th Gen Xeon®

- Intel DSA Offloads data copy and data transformation operations (Move, DIF, CRC, Fill, Compare, Flush & Dual cast).

- **Freeing up CPU cycles (Increasing compute capacity).**

- **Accelerate data movement throughput**
  - ~30GB/s throughput in each direction per Intel DSA instance
  - Multiple Intel DSA instances per socket (E.g., up-to 4 Intel DSA in 4th Gen Intel® Xeon® XCC) providing up-to ~120GB/s throughput in each direction
  - Leverages AIA and IOMMU features for efficient offload and scalable sharing

- 1 Intel DSA device available on all 4th Gen Intel® Xeon® SKUs.
- 1 to 4 Intel DSA Accelerator devices supported on select 4th Gen Intel® Xeon® SKUs

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**Memory Copy without Intel DSA**

Cores move data; core cycles consumed

- Cycle 0: move x00 to y00
- Cycle 1: move x01 to y01
- Cycle 2: move x02 to y02
- Cycle 3: move x03 to y03
- Cycle 63: move x63 to y63

**Memory Copy with Intel DSA**

DSA moves data; core cycles freed

- Cycle 0: Ask DSA to move x00-x63 to y00-y63
Data movement and compute operations execute serially on CPU core(s)

Data movement offload to Intel DSA followed serially by compute on CPU core

Concurrent execution of data movement using Intel DSA and compute on CPU core
Intel DSA Value Proposition in Summary

Intel DSA offloads data movement operations from CPU – freeing up Cores.
* Increasing effective 4th Gen Intel® Xeon® Processor Performance and Perf/Watt

Intel DSA on 4th Gen Intel Xeon processor offers performance gains compared to prior gen (CBDMA)
* Establishing Intel DSA leadership in Data movement acceleration.

Intel DSA provides improved CPU latency @ as-low-as 6 KB Transfer Size
* making Intel DSA available for synchronous copy operations

Intel DSA delivers better throughput @ as-low-as 2KB Transfer Size
* making Intel DSA full capability available for smaller Transfer size

Intel DSA is integrated into industry leading framework SPDK, DPDK, Libfabric and more..
* making its deployment easy for Storage, Networking & more Applications
Intel DSA Performance

Function
- Optimizing streaming data movement and transformation operations

Business Value
- Accelerated data protection for NVMe/TCP improving efficiency for data storage applications via CPU offload

Software Support
- Intel® Data Mover Library

Use Cases
- Virtualization, fast replication across non-transparent bridge, ERP, In-Memory Databases

Performance gains vs not using these accelerators
- **Data Integrity (Throughput)**
  - Up to 1.7x higher IOPs for large packet sequential reads with built-in Intel® DSA vs. ISA-L software

Performance gains vs prior generation products
- **Data Integrity (Throughput & Latency)**
  - Up to 1.6x higher IOPs and 37% Latency reduction for large packet sequential reads with built-in Intel® DSA vs. prior generation


Your results may vary.
4th Gen Generational Accelerator Performance and Efficiency

Relative Perf and Perf/W
Higher is Better

Intel 4th Gen 8490H Perf and Perf/W vs 3rd Gen Xeon 8380

Intel® AVX512
NAMD (smtv)
LAMMPS (geomean of 10)
RocksDB (IAA vs ZTSD)
ClickHouse (IAA vs ZSTD)
SPDK 128K QD64 (large media files) vs OOB
SPDK 16K QD256 (database requests) vs OOB
Real Time Image Classification (AMX vs VNNI) RN50
Batch Image Classification (AMX vs VNNI) RN50
Real Time Object Detection (AMX vs VNNI SSD-RN34)
Batch Object Detection (AMX vs VNNI SSD-RN34)
QATzip (QAT vs zlib/OOB)

Intel® IAA
Intel® DSA
Intel® AMX

3rd Gen Xeon 8380

0.00 1.00 2.00 3.00 4.00 5.00 6.00

See slide #29 for configuration details

Your results may vary.
4th Gen Xeon Accelerators Efficiency

Baseline
4th Gen Xeon with No Acceleration

Relative Perf/W
Higher is Better

ClickHouse (IAA vs LZ4)
ClickHouse (IAA vs ZSTD)
HPL Linpack (AVX-512 vs AV2)
SPDK 128K QD64 (large media files) vs OOB
SPDK 16K QD256 (database requests) vs OOB
Real Time Image Recognition (AMX vs FP32) RN50
Batch Image Recog (AMX vs FP32) RN50
Real Time Object Detection (AMX vs FP32) SSD-RN34
Batch Object Detection (AMX vs FP32) SSD-RN34
NGINX (65K cps Perf) QAT vs OOB
QATzip (QAT vs zlib/OOB)

Your results may vary.

See slide #28 for configuration details
How to know if Intel DSA will help my workload

See “Related Specifications, Application Notes, and White Papers” under:

Intel DSA Software stack and requirements

**Applications**
- OvS
- mTCP
- Media Transport Lib
- NVMe-oF
- MLPerf

**Frameworks**
- DPDK
- SPDK
- VPP

**Libraries**
- OFI Libfabric
- Intel® MPI
- Intel® DML
- Linux Page Copy/Clear

**Virtualization (Guest)**
- QEMU/KVM

**OS & Kernel (Host)**
- Linux
- RedHat
- Ubuntu
- SLES15 SP4
- Azure Host

*up-streamed

*** Out-of-Tree Code / To-be released
Resources Link

**Software Support**

**Linux Driver:**
- Intel® Data Accelerator Driver -> [https://github.com/intel/idxd](https://github.com/intel/idxd)
- IDXD GitHub* repository -> [https://github.com/intel/idxd-driver](https://github.com/intel/idxd-driver)
- Accel-config (configuring DSA) -> [https://github.com/intel/idxd-config](https://github.com/intel/idxd-config)

- Opensource blog at 01.org
- Intel DSA preliminary external specification -> Intel DSA Specification

**Library:**
- Storage SPDK -> [https://spdk.io/doc/idxd.html](https://spdk.io/doc/idxd.html)
- OFI Libfabric -> [https://github.com/ofiwg/libfabric/releases (v1.17.x)](https://github.com/ofiwg/libfabric/releases (v1.17.x))

- Intel® Data Mover library (Intel® DML) v0.1.9-beta -> [https://intel.github.io/DML/](https://intel.github.io/DML/)
- mTCP: user-level TCP stack for multicore systems. -> [https://github.com/mtcp-stack/mtcp](https://github.com/mtcp-stack/mtcp)
- FD.io’s Vector Packet Processor (VPP) -> [https://s3-docs.fd.io/vpp/23.02/](https://s3-docs.fd.io/vpp/23.02/)
OVS-DPDK Perf Acceleration with Intel DSA

Intel Developer Zone Link: https://cdrdv2.intel.com/v1/dl/getContent/758697
What is DPDK?

A Data Plane Development Kit (DPDK) that consists of libraries to accelerate packet processing workloads running on a wide variety of CPU architectures.

DPDK’s robust community of member organizations and cross-industry partners spans: hardware vendors, physical and virtual network drivers, and other open-source organizations that consume DPDK.

See below for a full list of up and down-stream open-source projects that consume DPDK.

- **ANS** – Accelerated Network Stack
- **BESS** – Berkeley Extensible Software Switch
- **Butterfly** – Connects Virtual Machines
- **Catnip** – TCP Stack in Rust
- **DPVS** – Layer-4 load balancer
- **dperf** – Network load tester
- **FastClick** – Highspeed dataplane
- **F-Stack** – TCP Stack
- **IMTL** – Real time and low latency media transport library
- **Lagopus** – software OpenFlow 1.3 switch
- **Metronome** – adaptive packet retrieval in DPDK
- **MoonGen** – Packet generator
- **OpenDataPlane** – Open DataPlane DPDK platform implementation
- **YANFF** – NFF-Go -Network Function Framework for GO(former YANFF)

- **Open vSwitch** – Multilayer Open Virtual Switch
- **Packet-journey** – Userland router
- **Pktgen-dpdk** – Packet generator
- **PcapPlusPlus** – C++ packet parsing framework
- **Ruru** – Real-time TCP latency monitoring
- **Seastar** – open-source C++ framework
- **SPDK** – Storage Performance Development Kit
- **TLDK** – TCP Stack
- **TREx** – Stateful Traffic Generator
- **VPP** – Fast Data Project
- **WARP17** – Stateful Traffic Generator
- **mTCP** – User-level TCP Stack
- **OPNFV** – Open Platform for NFV

DPDK support for Intel DSA is described at http://doc.dpdk.org/guides/dmadevs/idxd.html.
Intel DSA Integration in DPDK/OVS

Phy-VM-Phy Datapath

Phy-VM-Phy Datapath with Intel DSA
Intel DSA : Protecting Data in the NVMe/TCP storage use case

What is SPDK? Storage Performance Development Kit (SPDK) is a set of tools and libraries for writing high-performance, scalable, user-mode storage applications.

- Intel Established & Lead
- Vibrant, Multi-vendor, Global Community
- Storage Tools, Libraries, Drivers, & Applications
- User-space, poll mode, lockless, asynchronous
- Significant performance and efficiency!
  - 14 Million NVMe IO/core/sec
- Rich Feature Set
- Broad adoption in Cloud & Enterprise
- Open Source & BSD Licensed

Participate/Learn More https://SPDK.io
SPDK Community insights

- 49 active contributors created 534 commits just last quarter
  - 14+ companies

- 200+ unique visitors to GitHub each day

- 2021 ‘SPDK, PMDK, & Intel® Platform Performance Analyzer Virtual Forum’:
  - US event over 500 attendees, spanning 130 companies and 35 universities
  - PRC event over 400 attendees, from around 200 companies and organizations

- Multiple third party maintainers

- ‘SPDK 2022 Hackathon’ completed – April 28th
SPDK Acceleration Framework

- A framework for abstracting general acceleration capabilities:
  - With HW engines like Intel DSA, IOAT, QAT, etc.
  - Designed for SW defined infra/storage: SW plug-in modules for environments without HW accelerators.
  - Asynchronous workflow: application uses CPU for other work while HW accelerator is moving/transforming data.

- Accelerated Functions: CRC32CC, copy, fill, compare, dual cast, copy_crc32c, de/compress

- SPDK provides libs/apps for organization building enterprise, SDS, object store solutions.

- NVMe-oF target: User-space storage target, presenting block devices over ethernet fabrics uses the accel FW to offload CRC32C digest calculation to DSA.

- Link to Documentation
  
  Other SPDK-based app of Accel FW: App replicating data over NTB use SPDK Accel FW for dualcast operation
Data Flow:
1. FIO submits I/O requests to SPDK NVMe/TCP target
2. Target reads data from NVMe SSDs
3. Target uses Intel DSA/ISA-L to calculate CRC32C data digest
4. Target sends I/O data + CRC32C data digest to FIO
How Do You Know if Intel DSA is Right for You?

- Look at where Intel DSA can be utilized for your workloads:
  - Performance acceleration - for Networking, Storage, Memory-management & AI/HPC/Applications.
  - Scalability - Build product with performance scaling need of 1 to 4 Intel DSA.
  - Efficiency – Significant core saving translating to Significant Performance/Watt improvements

- Specific Questions
  1. Where do you need efficient “data movement” for Storage, Networking and other applications?
  2. Where do you need consistent & efficient data movement for Perf/core & Perf/Watt Improvement?
  3. Connect with Intel for engagement and design-in and potential applications enablement support
More workload examples
Intel DSA Acceleration for Media Transportation
Workload Description: Media Transport

Use case - Smart Stadium

- SMPTE ST 2110 family of standards from SMPTE (Society of Motion Picture and Television Engineers) is a digital video transmission standards over IP networks.
- Intel® Media Transport library provides functions for video transmission & receiver for ST 2110
- After a video packet is received from NIC, RTP packet is processed, and the payload is copied to the raw video frame buffer
- Intel DSA engine accelerates this memory copy
Intel DSA Acceleration for Media Transport Library

Context

• Significant amount of CPU cycles are spent to copy the payload from RTP packets to video frame buffer.
• Offloading this to Intel DSA, increases the number of video streams @1080p,60FPS by 2.25X at iso core.
• At the same time, the maximum network bandwidth can be achieved with fewer cores when offloaded to Intel DSA.
• Use cases: media streaming from a stadium or a large gathering.


Intel DSA config: 1 instance, 4 engine per instance, 8 work queue per instance and ATS disabled per work queue
TX_Flush interval: 50 usec , Batch size: none , Size of copy 5MB. Your results may vary.
Notices & Disclaimers
Performance varies by use, configuration and other factors. Learn more on the Performance Index site.

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See backup for configuration details.

No product or component can be absolutely secure.

Your costs and results may vary.

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A More Energy Efficient Server Architecture

Up to 1.12x and 1.26x higher performance/W using 4th Gen Xeon Scalable with Intel Analytics Accelerator vs LZ4 and Zstd on ClickHouse
1-node, 2x pre-production 4th Gen Intel Xeon Scalable processor (60 cores) with integrated Intel In-Memory Analytics Accelerator (Intel IAA), Number of IAA device utilized=8(2 sockets active), on-pre-production Intel platform and software, HT On, Turbo Off, SNC off, Total Memory 1024GB(16x64GB DDR5 4800), microcode 0x2b0000a1, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, Ubuntu 22.04.1 LTS, 5.15.0-52-generic, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, Intel TF 2.10, AI Model=SSD El DSA), DSA device utilized=1(1 active socket), on pre-production Intel platform and software with DDR5 memory total 1024GB DDR5 (16x64 GB), microcode 0xb00000a1, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, Ubuntu 22.04.1 LTS, 5.15.0-52-generic, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, Intel TF 2.10, AI Model=ResNet50 Image Processing on SSD-ResNet34 on Object Detection
1-node, 2x pre-production 4th Gen Intel® Xeon® Scalable processor (60 core) with Intel® Advanced Machine Extensions (Intel AMX), on pre-production Supermicro SYS-221H-TNR with 1024GB DDR5 memory (16x64 GB), microcode 0xb00000c0, HT On, Turbo On, SNC Off, CentOS Stream 8, 5.19.16-301.fc37.x86_64, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, Intel TF 2.10, AI Model=ResNet 50 v1_1_5, best scores achieved: BS1 FP32 8 cores/instance (max. 15ms SLA), BS1 INT8 2 cores/instance (max. 15ms SLA), BS1 AMX 1 core/instance (max. 15ms SLA), BS1 AMX 3 cores/instance, BS1 INT8 5 cores/instance, BS1 AMX 5 cores/instance, using physical cores, tested by Intel November 2022.

Up to 1.42x and 1.53x higher performance/W using 4th Gen Intel Xeon Scalable with Advanced Matrix Extensions using AMX vs VNNI instructions on SSD-ResNet34 on Object Detection
1-node, 2x pre-production 4th Gen Intel® Xeon® Scalable processor (60 cores) with Intel® Advanced Machine Extensions (Intel AMX), on pre-production Intel platform with 1024GB DDR5 memory (16x64 GB), microcode 0xb00000a1, HT On, Turbo On, SNC Off, CentOS Stream 8, 5.19.16-301.fc37.x86_64, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, Intel TF 2.10, AI Model=SSD-ResNet34, best scores achieved: BS1 FP32 60 cores/instance (max. 100ms SLA), BS1 INT8 4 cores/instance (max. 100ms SLA), BS1 AMX 4 cores/instance (max. 100ms SLA), BS1 FP32 8 cores/instance, BS1 INT8 1 cores/instance, BS1 AMX 1 cores/instance, using physical cores, tested by Intel November 2022.

Up to 1.12x higher performance/W using 4th Gen Intel Xeon Scalable with QuickAssist Accelerator vs out-of-box software on NGINX TLS Handshake.
QAT Accelerator: 1-node, 2x pre-production 4th Gen Intel Xeon Scalable processor (60 cores) with integrated Intel QuickAssist Accelerator (Intel QAT), Number of QAT device utilized=4(1 socket active), on-pre-production Intel platform and software with DDR5 memory total 1024GB (16x64 GB), microcode 0xb00000a1, HT On, Turbo Off, SNC Off, Ubuntu 22.04.1 LTS, 5.15.0-52-generic, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, 1x Intel® Ethernet Network Adapter E810-2CQDA2, 1x100GbE, QAT engine v0.6.14, QAT v0.10.0.9, NGINX 1.20.1, OpenSSL 1.1.1L, IPP crypto v2021_5, IPSec v1.1, TLS 1.3 AES_128_GCM_SHA256, EC2HDE-X25519-RSA2K, 65K CPS target SLA, tested by Intel November 2022.

Out of box configuration: 1-node, 2x pre-production 4th Gen Intel Xeon Scalable processor (60 cores) with integrated Intel QuickAssist Accelerator (Intel QAT), Number of QAT device utilized=0, on-pre-production Intel platform and software with DDR5 memory total 1024GB (16x64 GB), microcode 0xb00000a1, HT On, Turbo Off, SNC Off, Ubuntu 22.04.1 LTS, 5.15.0-52-generic, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, 1x Intel® Ethernet Network Adapter E810-2CQDA2, 1x100GbE, NGINX 1.20.1, OpenSSL 1.1.1L, TLS 1.3 AES_128_GCM_SHA256, EC2HDE-X25519-RSA2K, 65K CPS target SLA, tested by Intel November 2022.

Up to 2.85x higher performance/W using 4th Gen Intel Xeon Scalable with QuickAssist Accelerator vs out-of-box zlib on QTzip compression
1-node, 2x pre-production 4th Gen Intel Xeon Scalable processor (60 cores) with integrated Intel QuickAssist Accelerator (Intel QAT), QAT device utilized=8(2 sockets active), on-pre-production Intel platform and software with DDR5 memory Total 1024GB (16x64 GB), microcode 0xb00000a1, HT On, Turbo Off, SNC Off, Ubuntu 22.04.1 LTS, 5.15.0-52-generic, 1x3.84TB P5510 NVMe, 10GbE x540-AT2, QAT v2010.9.1, QTzip v1.0.9, tested by Intel November 2022.

Data Center & AI Group
New Configuration: 1-node, 2x pre-production 4th Gen Intel® Xeon® Scalable processor (60 core), on pre-production SuperMicro SYS-221H-TNR and software with 1024GB DDR5 memory (16x64 GB), microcode Ox2b000000, HT On, Turbo On, SNC: 4, Ubuntu 22.04 LTS, 5.15-0.52-generic, 1x3.84TB P5510 NVMe, 10GbE x540, tcl core-9-64-bit branch, benchmark from AMD v213, tested by Intel November 2022.

LAMMPS
New Configuration: 1-node, 2x pre-production 4th Gen Intel® Xeon® Scalable processor (60 core), on pre-production SuperMicro SYS-221H-TNR and software with 1024GB DDR5 memory (16x64 GB) microcode Ox2b000000, HT On, Turbo On, SNC: 4, Ubuntu 22.04 LTS, 5.15-0.52-generic, 1x3.84TB P5510 NVMe, 10GbE x540, tcl core-9-64-bit branch, benchmark from AMD v213, tested by Intel November 2022.

ClickHouse
New Configuration: 1-node, 2x pre-production 4th Gen Intel® Xeon® Scalable processor (60 core) with integrated Intel In-Memory Analytics Accelerator (Intel IAA), on pre-production Intel platform and software, HT On, Turbo On, Total Memory 1024GB (16x64GB DDR5 4800), microcode Ox2b000000, Intel® AMX - core, using physical cores, tested by Intel November 2022.

QPZ
New Configuration: 1-node, 2x pre-production 4th Gen Intel® Xeon® Scalable processor (60 core), with Intel Quick Assist Accelerator (Intel QAT), on pre-production Intel platform and software with DDR5 memory Total 1024GB (16x64 GB), microcode Ox2b000000, HT On, Turbo On, SNC: 4, Ubuntu 22.04 LTS, 5.15-0.52-generic, 1x3.84TB P5510 NVMe, 10GbE x540, tcl core-9-64-bit branch, benchmark from AMD v213, tested by Intel November 2022.

Data Centers & AIGroup