

SQLintersection

Hardware 301

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SQL
intersection

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 - Author of SQL Server Hardware
 - Chapter author of Professional SQL Server 2012 Internals and Troubleshooting
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- **Instructor-led training: Immersion Events**
- **Online training: pluralsight  <http://pluralsight.com/>**
- **Consulting: health checks, hardware, performance, upgrades**



- **Team of world-renowned SQL Server experts:**
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 - Glenn Berry (@GlennAlanBerry)
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- **Instructor-led training: Immersion Events and onsite**
- **Online training: pluralsight  <https://www.pluralsight.com/>**
- **Consulting: health checks, hardware, performance, upgrades**
- **Remote DBA: system monitoring and troubleshooting**
- **Conferences: PASS Summit, SQLIntersection**

I Know How to Brew Beer...



Some Examples...



Some Competition Results



Agenda

- The importance of database hardware
- The importance of processor selection for SQL Server 2017
- Preferred Intel Xeon processors
- The resurgence of AMD
- Memory considerations

The Importance of Database Hardware

- **Database servers are mission critical assets that affect performance**
 - Performance and scalability problems are immediately noticeable
- **Very difficult to compensate for poor hardware choices**
 - Insufficient total CPU capacity or single-threaded performance
 - Insufficient memory capacity can cause extra I/O pressure
 - Inadequate I/O performance and capacity can cripple the system
- **Wise hardware selection can save on SQL Server 2017 license costs**
 - Physical core counts are the cost driver for SQL Server 2012+ core licensing
 - It is possible to save more on SQL Server 2017 license costs than your new hardware costs (with proper planning)

SQL Server 2017 and Hardware Selection

- **Nobody will ever complain that a database server is too fast!**
 - You will be blamed for poor performance and have to deal with it
- **New server hardware is very affordable compared to SQL Server licenses**
 - Don't reuse old database hardware for a new version of SQL Server!
 - This is foolish, false economy
- **Be aware of SQL Server hardware licensing limits**
 - They are different for different versions and editions of SQL Server
 - This also comes into play with virtualization and consolidation
- **Don't be afraid to point out the age and performance of your hardware**
 - Your organization may not be aware of existing hardware performance issues

SQL Server 2017 Licensing Costs

Edition	Server License	Core License
Standard	\$931.00	\$1,859.00
Enterprise	Not Available	\$7,128.00

- **Minimum of four core licenses per physical processor**
- **Minimum of four core licenses per virtual machine**
- **Server licenses require Client Access Licenses (CALs)**
 - CALs are \$209.00 each
 - Each user/device must have a CAL to access any SQL Server
 - Once the user/device has a CAL, they can access any SQL Server

SQL Server 2017 License Limits

■ Enterprise Edition

- Operating system maximum for memory
 - 24TB on Windows Server 2016, 4TB on Windows Server 2012 R2
- Operating system maximum for sockets and physical cores

■ Standard Edition

- 128GB of RAM for Database Engine (per instance)
 - 32GB for In-Memory OLTP (per DB), 32GB for Columnstore (per instance)
- Limited to lesser of 4 sockets or 24 physical cores (non-virtualized)
- Limited to lesser of 4 sockets or 24 virtual cores (virtualized)
- No change from SQL Server 2016 SP1 limits

CPU-Z

CPU-Z

CPU Caches Mainboard Memory SPD Graphics Bench About

Processor

Name AMD Ryzen Threadripper 2950X

Code Name Colfax Max TDP 180.0 W

Package Socket SP3r2 (4094)

Technology 12 nm Core Voltage 1.424 V

Specification AMD Ryzen Threadripper 2950X 16-Core Processor

Family F Model 8 Stepping 2

Ext. Family 17 Ext. Model 8 Revision PIR-B2

Instructions MMX(+), SSE, SSE2, SSE3, SSSE3, SSE4.1, SSE4.2, SSE4A, x86-64, AES, AVX, AVX2, FMA3, SHA

Clocks (Core #0)

Core Speed 4166.66 MHz

Multiplier x 41.75

Bus Speed 99.80 MHz

Rated FSB

Cache

L1 Data 16 x 32 KBytes 8-way

L1 Inst. 16 x 64 KBytes 4-way

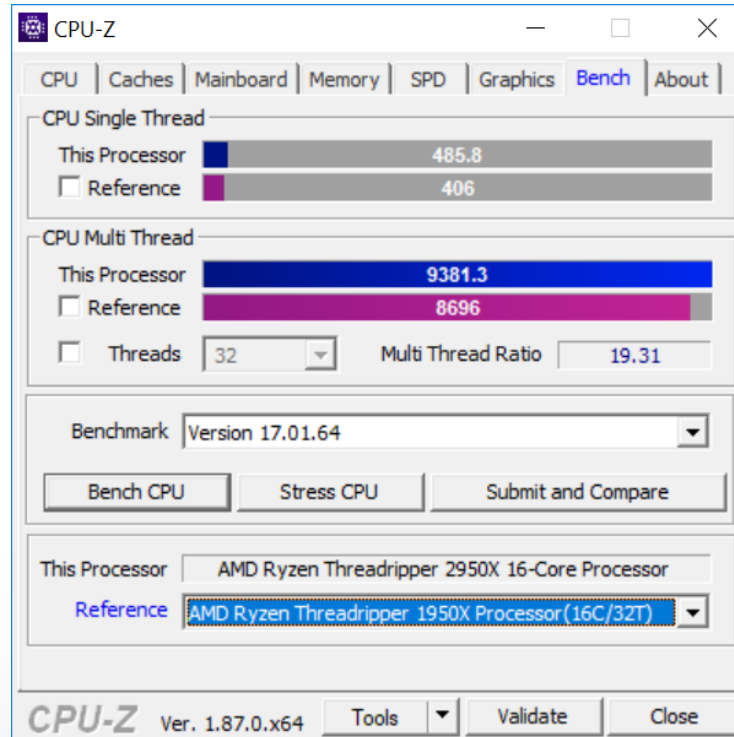
Level 2 16 x 512 KBytes 8-way

Level 3 4 x 8 MBytes 16-way

Selection Socket #1 Cores 16 Threads 32

CPU-Z Ver. 1.87.0.x64 Tools Validate Close

CPU-Z Benchmark



Demo

CPU-Z Benchmark

How Large Can You Go on Commodity Hardware?

- **What is the largest commodity server you can currently buy?**
 - Eight-socket server with (8) Intel Xeon Platinum 8280L processors
 - Example: Fujitsu PRIMEQUEST 3800B (<https://bit.ly/2vaWonu>)
- **What are the major cost components of a server like this?**
 - (224) Windows Server 2019 Standard Edition licenses are \$13,608.00
 - (8) Intel Xeon 8280L Platinum processors are \$104,088.00
 - 24TB of DDR4-2666 RAM is \$393,216.00
 - (224) SQL Server 2017 Enterprise Edition licenses are \$1,596,672.00
 - Total cost: \$2,146,744.00 (SQL Server 2017 licenses are 74.4% of total)

A Typical Two-Socket Server

- **What would a more typical two-socket server cost?**
 - Two-socket server with (2) Intel Xeon Gold 6244 processors
 - Example: Dell PowerEdge R740 (<https://dell.to/2GAAp11>)
 - 16 physical cores (32 logical cores), 512GB of DDR4-2933 RAM
- **What are the major cost components of a server like this?**
 - (16) Windows Server 2019 Standard Edition licenses are \$972.00
 - (2) Intel Xeon Gold 6244 processors are \$5,850.00
 - 512GB of DDR4-2666 RAM is \$3,600.00
 - (16) SQL Server 2017 Enterprise Edition licenses are \$114,048.00
 - Total cost: \$124,470.00 (SQL Server 2017 licenses are 91.6% of total)

Intel Server Processor Family Tree

Year	Process	Model Families	Processor Code Name
2008	45nm	Xeon 3400, 3500, 5500, 7500	Nehalem-EP, Nehalem-EX (2010)
2010	32nm	Xeon 3600, 5600, E7-4800	Westmere-EP, Westmere-EX (2011)
2011	32nm	Xeon E5-2600	Sandy Bridge-EP (2012)
2012	22nm	Xeon E5-2600 v2, E7-4800 v2	Ivy Bridge-EP, Ivy Bridge-EX (2013)
2014	22nm	Xeon E5-2600 v3, E7-4800 v3	Haswell-EP, Haswell-EX (Q2 2015)
2016	14nm	Xeon E5-2600 v4, E7-8800 v4	Broadwell-EP, Broadwell-EX (Q4 2016)
2017	14nm	Xeon Platinum, Gold, Silver	Skylake-SP (Q3 2017)
2019	14nm	Xeon Platinum, Gold, Silver	Cascade Lake-SP (Q2 2019)

Current Intel Server Processor Families

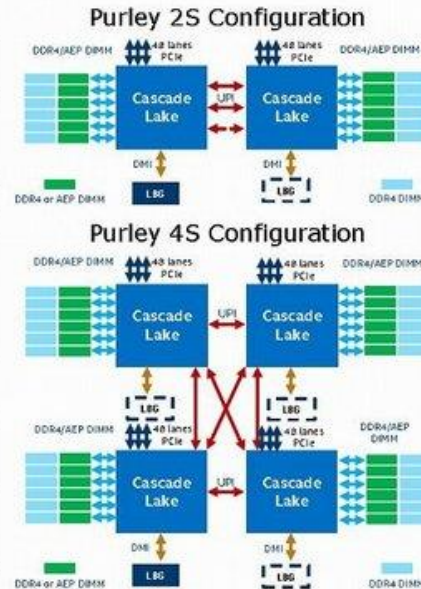
- **Xeon E Family (14nm Coffee Lake), introduced in Q2 2018**
 - E-2100 Series (Value/mainstream uniprocessor)
- **2nd Gen Xeon Scalable Family (14nm Cascade Lake-SP) - Q2 2019**
 - **Bronze 3200 Family** (Entry level two-socket)
 - **Silver 4200 Family** (Enhanced two-socket)
 - **Gold 5200 Family** (Entry level two or four-socket)
 - **Gold 6200 Family** (Enhanced two or four-socket)
 - Platinum 8200 Family (Two, four or eight-socket)
 - Platinum 9200 Family (Cascade Lake-AP)
- **Avoid Xeon Silver and Bronze families for SQL Server usage!**

New Intel Xeon “Cascade Lake”

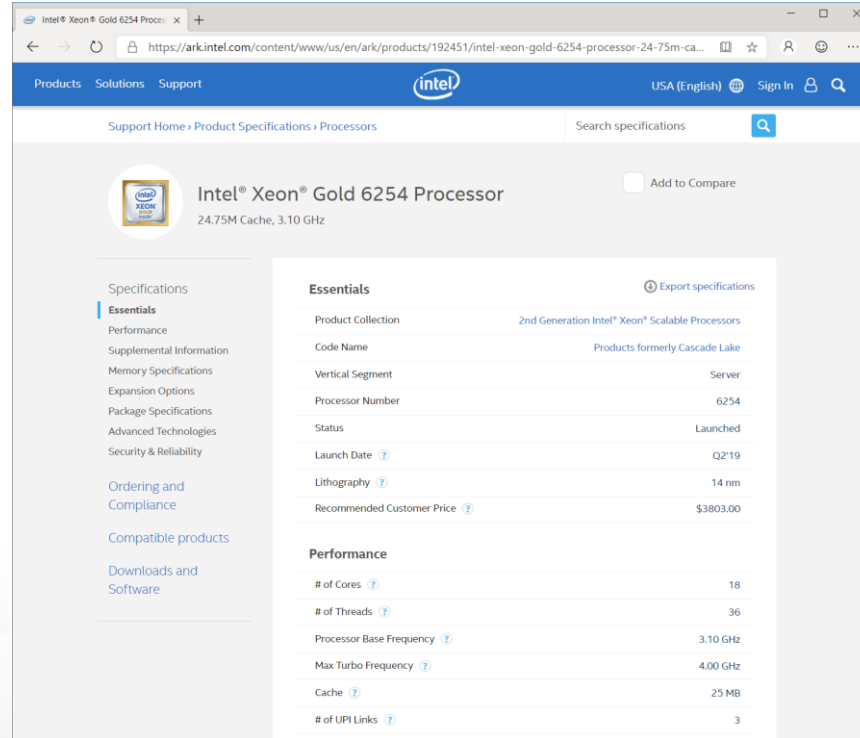
PURLEY REFRESH WITH CASCADE LAKE OVERVIEW

CPU	Cascade Lake: Drop in to Purley Platform
New Capabilities	Vector Neural Network Instructions (VNNI) Frequency and architecture improvements and DDR-T/Apache Pass DIMM Support on select SKUs
Socket	Socket P
Scalability	1S, 2S, 4S
Memory	6 channels DDR4 RDIMM and LRDIMM per CPU, 12 DIMMs per socket, 16Gb DDR4 based DIMMs supported, up to 2666 MT/s 2DPC, up to 2933 MT/s 1DPC and Apache Pass DIMM Support on select SKUs
UPI (Ultra Path Interconnect)	Up to 3 links per CPU x20, speed: 9.6 and 10.4 GTS
PCIe	PCIe Gen 3: 48 lanes per CPU (bifurcation support: x16, x8, x4)
PCH – Lewisburg	IE, eSPI, Integrated Intel Ethernet Connection: up to 4x10Gb/1Gb ports, Up to 14 SATA 3, Up to 14 USB 2.0, Up to 10 USB 3.0, Up to 20 ports PCIe* 3.0 (8 GT/s)

New capabilities relative to Skylake/Purley in **Bolded Blue**



Intel ARK Database



The screenshot shows the Intel ARK Database page for the Intel Xeon Gold 6254 Processor. The page is displayed in a web browser window with the URL <https://ark.intel.com/content/www/us/en/ark/products/192451/intel-xeon-gold-6254-processor-24-75m-ca...>. The page features a blue header with the Intel logo and navigation links for Products, Solutions, and Support. A search bar is located in the top right corner. The main content area displays the processor's name, "Intel Xeon Gold 6254 Processor", along with its specifications: "24.75M Cache, 3.10 GHz". A sidebar on the left provides a navigation menu with links to Specifications, Essentials, Performance, Supplemental Information, Memory Specifications, Expansion Options, Package Specifications, Advanced Technologies, Security & Reliability, Ordering and Compliance, Compatible products, Downloads and Software, and Add to Compare. The main content area is divided into two sections: Essentials and Performance. The Essentials section lists key specifications such as Product Collection, Code Name, Vertical Segment, Processor Number, Status, Launch Date, Lithography, and Recommended Customer Price. The Performance section lists core and thread counts, base and turbo frequencies, cache size, and UPI links.

Intel Xeon Gold 6254 Processor
24.75M Cache, 3.10 GHz

Specifications

- Essentials
- Performance
- Supplemental Information
- Memory Specifications
- Expansion Options
- Package Specifications
- Advanced Technologies
- Security & Reliability
- Ordering and Compliance
- Compatible products
- Downloads and Software

Essentials

Product Collection	2nd Generation Intel Xeon Scalable Processors
Code Name	Products formerly Cascade Lake
Vertical Segment	Server
Processor Number	6254
Status	Launched
Launch Date	Q2'19
Lithography	14 nm
Recommended Customer Price	\$3803.00

Performance

# of Cores	18
# of Threads	36
Processor Base Frequency	3.10 GHz
Max Turbo Frequency	4.00 GHz
Cache	25 MB
# of UPI Links	3

Intel Xeon Major Generational Differences

- **Intel Xeon Processor E5-2600 Product Family Technical Overview**
 - <https://intel.ly/2wOgLXa>
- **Intel Xeon Processor E5-2600 V2 Product Family Technical Overview**
 - <https://intel.ly/2vwPhRn>
- **Intel Xeon Processor E5-2600 V3 Product Family Technical Overview**
 - <https://intel.ly/2cXPciz>
- **Intel Xeon Processor E5-2600 V4 Product Family Technical Overview**
 - <https://intel.ly/2dUCXEU>
- **Intel Xeon Processor Scalable Family Technical Overview**
 - <https://intel.ly/2wFnTpp>
- **2nd Generation Intel Xeon Processor Scalable Family Technical Overview**
 - <https://intel.ly/2U2Afz9>

Preferred Cascade Lake-SP Processors

Model	Cores/L3 Cache	Base Speed	Turbo Speed	Price
Platinum 8280	28/38.5 MB	2.7 GHz	4.0 GHz	\$10,009.00
Platinum 8270	26/36 MB	2.7 GHz	4.0 GHz	\$7,405.00
Platinum 8268	24/35.75 MB	2.9 GHz	3.9 GHz	\$6,302.00
Gold 6248	20/27.5 MB	2.5 GHz	3.9 GHz	\$3,072.00
Gold 6254	18/24.75 MB	3.1 GHz	4.0 GHz	\$3,543.00
Gold 6246	12/24.75 MB	3.3 GHz	4.2 GHz	\$?????.00
Gold 6244	8/24.75 MB	3.6 GHz	4.4 GHz	\$2,925.00
Gold 5222	4/16.5 MB	3.8 GHz	3.9 GHz	\$1,221.00

Preferred Skylake-SP Processors

Model	Cores/L3 Cache	Base Speed	Turbo Speed	Price
Platinum 8180	28/38.5 MB	2.5 GHz	3.8 GHz	\$10,009.00
Platinum 8168	24/33 MB	2.7 GHz	3.7 GHz	\$5,890.00
Gold 6154	18/24.75 MB	3.0 GHz	3.7 GHz	\$3,543.00
Gold 6146	12/24.75 MB	3.2 GHz	4.2 GHz	\$3,286.00
Gold 6144	8/24.75 MB	3.5 GHz	4.2 GHz	\$2,925.00
Gold 6128	6/19.25 MB	3.4 GHz	3.7 GHz	\$1,691.00
Gold 5122	4/16.5 MB	3.6 GHz	3.7 GHz	\$1,221.00

AMD EPYC 7000 Series Processors

- **Based on Zen architecture (Q2 2017)**
 - 14nm process, up to 32 cores (plus SMT), up to 64MB L3 cache
 - 128 PCIe 3.0 lanes, Infinity Fabric, eight DDR4 memory controllers
- **Viable competition for Intel in the server space!**
 - Very high core counts, memory density, and PCIe 3.0 lane capacity
 - May be very well-suited for DW workloads
 - One-socket AMD server as a replacement for typical Intel two-socket server
- **AMD EPYC 7000 Series Data Sheet**
 - <https://bit.ly/2urJDA6>

Preferred AMD EPYC 7000 Processors

Model	Cores/L3 Cache	Base Speed	Turbo Speed	Price
EPYC 7601	32/64 MB	2.2 GHz	3.2 GHz	\$4,000.00
EPYC 7451	24/64 MB	2.3 GHz	3.2 GHz	\$2,400.00
EPYC 7371	16/64 MB	3.1 GHz	3.6 GHz	\$1,550.00
EPYC 7261	8/32 MB	2.5 GHz	2.9 GHz	\$ 400.00

How Do You Compare Processors for SQL Server?

- **One method is to use actual TPC-E benchmark scores**
 - Find the best actual score for a given processor family (flagship score)
 - Server vendors only make submissions for the flagship processor
 - Adjust the actual score for core count and base clock speed differences
 - Calculate the estimated total score and estimated score/core
- **What these estimated TPC-E scores mean**
 - Total score measures CPU capacity of the system
 - Score/core measures single-threaded performance of that processor
 - These numbers are very useful for sizing calculations for upgrades, consolidation, and virtualization

Demo

TPC-E Adjustment Calculation Example

Comparative Cascade Lake-SP 2P System Metrics

Model	Raw TPC-E Score	Total Cores	Score/Core	License Cost
Platinum 8280	7,012.53	56	125.22	\$ 399,168.00
Platinum 8270	6,511.64	52	125.22	\$ 370,656.00
Platinum 8268	6,455.98	48	134.50	\$ 342,144.00
Gold 6248	4,637.92	40	115.95	\$ 285,128.00
Gold 6254	5,175.92	36	143.78	\$ 256,608.00
Gold 6242	4,155.57	32	129.86	\$ 228,096.00
Gold 6246	3,673.23	24	153.05	\$ 171,072.00
Gold 6244	2,671.44	16	166.97	\$ 114,048.00
Gold 5222	1,409.93	8	176.24	\$ 57,024.00

Comparative Skylake-SP 2P System Metrics

Model	Raw TPC-E Score	Total Cores	Score/Core	License Cost
Platinum 8180	6,606.75	56	117.97	\$ 399,168.00
Platinum 8170	5,153.27	52	99.10	\$ 370,656.00
Platinum 8168	6,115.96	48	127.42	\$ 342,144.00
Gold 6154	5,096.64	36	141.39	\$ 256,608.00
Gold 6142	3,926.30	32	122.69	\$ 228,096.00
Gold 6132	3,435.51	28	122.70	\$ 199,584.00
Gold 6146	3,624.27	24	151.01	\$ 171,072.00
Gold 6144	2,642.70	16	165.17	\$ 114,048.00
Gold 6128	1,925.40	12	160.45	\$ 85,536.00
Gold 5122	1,359.10	8	169.88	\$ 57,024.00

Bad CPU Choice vs. Good CPU Choice #1

Processor	TPC-E Score	Total Cores	Score/Core	License Cost
(2) Xeon E5-2609 v4	693.79	16	43.36	\$114,048.00
(2) Xeon E5-2637 v4	1,428.79	8	178.54	\$ 57,024.00

- **Identical two-socket server (Example: Dell PowerEdge R730)**
- **Bad choice has two, Xeon E5-2609 v4 eight-core processors**
 - <http://intel.ly/2A78Ymy>
- **Good choice has two, Xeon E5-2637 v4 four-core processors**
 - <http://intel.ly/2DnAgVU>

Bad CPU Choice vs. Good CPU Choice #2

Processor	TPC-E Score	Total Cores	Score/Core	License Cost
(2) Xeon Bronze 3106	641.80	16	40.11	\$114,048.00
(2) Xeon Gold 5122	1359.10	8	169.89	\$ 57,024.00

- **Identical two-socket server (Example: Dell PowerEdge R740)**
- **Bad choice has two, Xeon Bronze 3106 eight-core processors**
 - <https://intel.ly/2EzIHIF> (processor cost is \$306.00 each)
- **Good choice has two, Xeon Gold 5122 four-core processors**
 - <https://intel.ly/2L7Ufw0> (processor cost is \$1221.00 each)

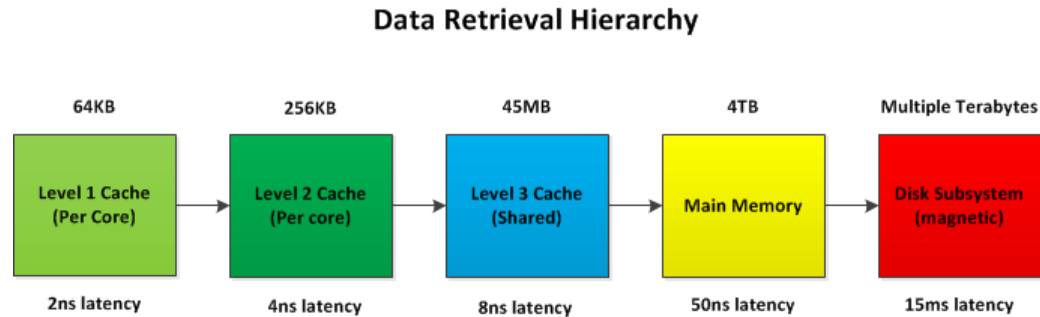
Bad CPU Choice vs. Good CPU Choice #3

Processor Choice	TPC-E Score	Score/Physical Core	SQL EE Cost
(2) Xeon Silver 4208	1,558.34	97.40	\$ 114,048.00
(2) Xeon Gold 5222	1,409.93	176.24	\$ 57,024.00

- **Identical two-socket server (Example: Dell PowerEdge R740)**
- **Bad choice has two, Xeon Silver 4208 eight-core processors**
 - <https://intel.ly/2G5YrwX>
- **Good choice has two, Xeon Gold 5222 four-core processors**
 - <https://intel.ly/2D5wtiW>

Legacy Data Retrieval Hierarchy in a Server

- Latency increases as you go further down the stack

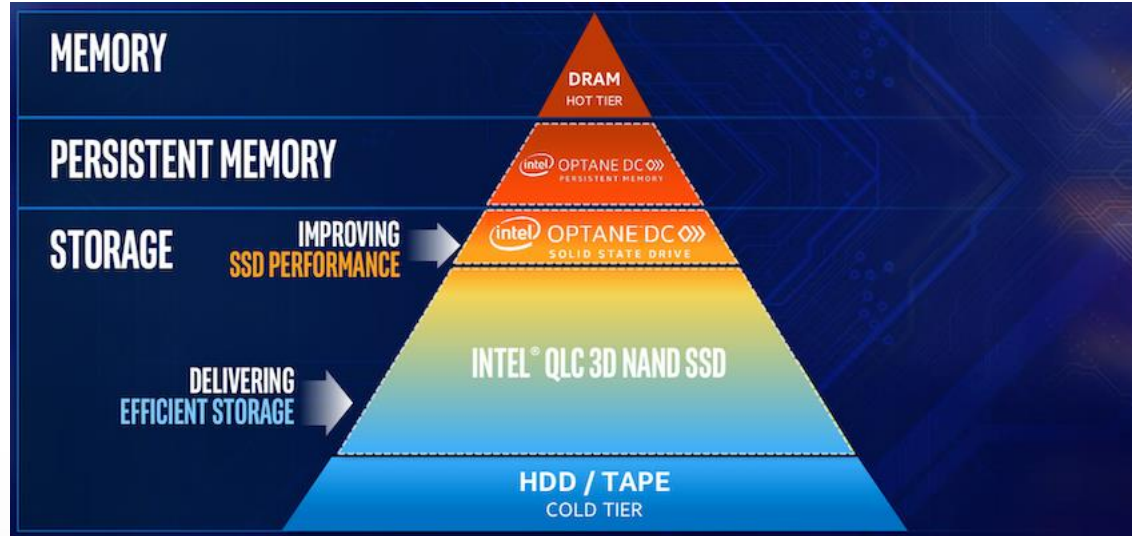


Modern Data Retrieval Hierarchy

■ Modern data retrieval hierarchy in a database server

- Level 1 (L1) cache, 64KB per core, 2ns latency
- Level 2 (L2) cache, 1MB per core, 4ns latency
- Level 3 (L3) cache, 38.5MB shared across all cores, 8ns latency
- Main DRAM memory, 24TB for entire server, 50ns latency
- Persistent Memory (PM), DAX mode, 800ns latency
- Persistent Memory (PM), Block mode mode, 6.5μs latency
- Intel Optane DC P4800X storage device, 10μs latency
- PCIe NVMe flash NAND storage device, 65μs latency
- SAS/SATA AHCI flash NAND storage device, 400μs latency
- SAS/SATA magnetic, terabytes for entire server, 15ms latency

Data Retrieval Pyramid



Important New Hardware Developments

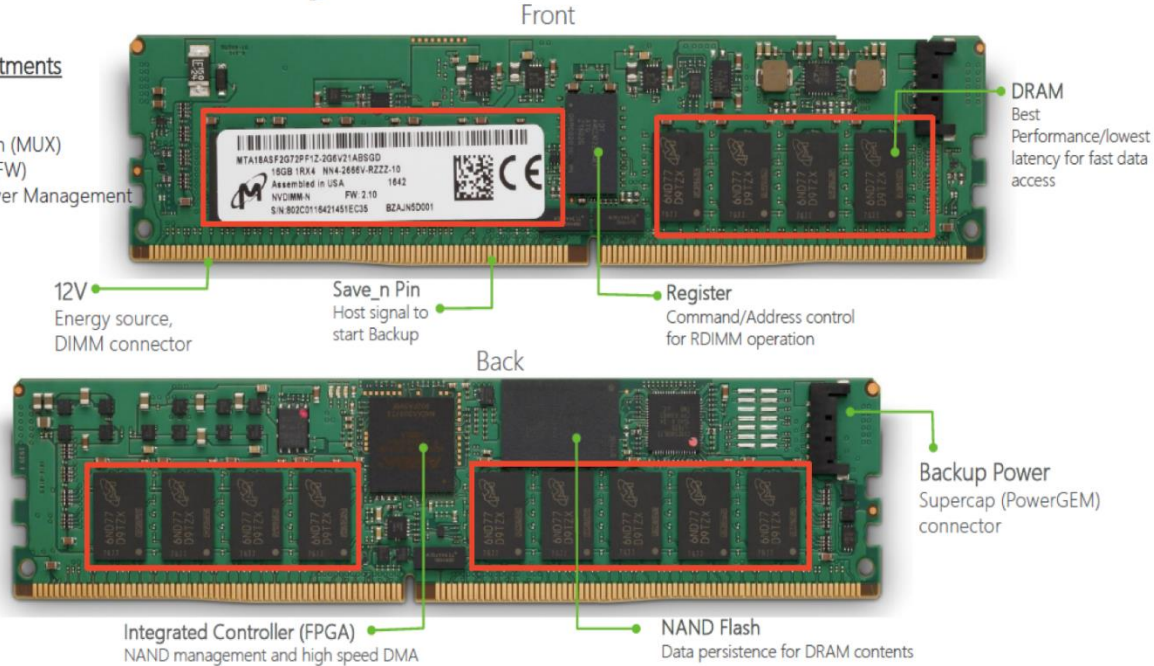
- **NV-DIMMs**
- **Intel Optane DC Persistent Memory**
- **Intel Optane DC Storage**
- **Intel “Cascade Lake-SP” processors**
- **AMD EPYC “Rome” processors**

NV-DIMM

NVDIMM Anatomy

Main components

- RDIMM
- NAND
- Bus Isolation (MUX)
- Controller (FW)
- Backup Power Management



NV-DIMM Installation



Persisted Log Buffer Feature

- **New feature in SQL Server 2016 Service Pack 1**
 - Uses NVDIMM persistent memory for second, 20MB transaction log file
 - Caches the “tail of the log”, dramatically reduces LOGWRITE waits
- **Requires a direct access (DAX) volume on an NVDIMM device**
 - Storage class memory mapped to a DAX volume
- **Persisted Log Buffer limitations**
 - Does not work with TDE or on an AG Primary
 - Does work on AG Secondary
 - Does not work with virtualization
 - Exception: Hyper-V on Windows Server 2019 or newer
 - Exception: vSphere 6.7 or newer

Intel Optane DC Persistent Memory

- **Intel 3D Xpoint-based DIMMs (“Apache Pass”)**
 - DDR4 memory interface and form factor
 - Available in 128GB, 256GB, and 512GB capacities
 - Addressable in application direct mode (persistent)
 - Addressable in memory mode (volatile)
 - Requires OS support (Windows Server 2019)
- **Supported by new Cascade Lake-SP processors**
 - New two-socket server will support up to 6TB of 3D XPoint DIMMs
 - Supported by VMware vSphere 6.7
 - Supported by SQL Server 2019 on Linux

Intel Optane DC Persistent Memory



Intel Optane DC Storage

- **Intel 3D Xpoint-based storage (Intel Optane DC P4800X Series)**
 - HHL AIC and 2.5" U.2 15mm form factors
 - PCIe NVMe 3.0 x4 interface
 - Available in 375GB, 750GB, and 1.5TB capacities
 - Supported by all versions of SQL Server
- **Several advantages compared to “write-intensive” NAND flash storage**
 - Much lower latency (<10μs). Much better durability (30 DWPD)
 - Much better random I/O performance at low queue depths
 - No performance deterioration as drive fills up (No TRIM or GC needed)
- **Very well-suited for heavy tempdb workloads**

Intel Optane DC Storage



Intel Cascade Lake-SP Processors

- **Completely compatible with Skylake-SP server models**
 - Same core counts, cache size, and I/O speeds as Skylake-SP
 - Process tuning, targeted performance improvements and higher clock speeds
 - Architectural improvements from targeted instruction set enhancements
 - Supports Intel Optane DC persistent memory
 - Hardware enhancements for protection against side-channel attacks
- **Cascade Lake-SP is a useful upgrade**
 - Has a relatively small performance increase compared to Skylake-SP
 - Released in Q2 2019

Cascade Lake Mitigations for Side-Channel Methods

Variant	Side-Channel Method	Mitigation on Cascade Lake
Variant 1	Bounds Check Bypass	OS/VMM
Variant 2	Branch Target Injection	Hardware + OS/VMM
Variant 3	Rogue Data Cache Load	Hardware
Variant 3a	Rogue System Register Read	Firmware
Variant 4	Speculative Store Bypass	Firmware + OS/VMM or runtime
Variant 5	L1 Terminal Fault	Hardware

- **Cascade Lake-SP will provide better performance compared to software mitigations used for previous processor families**

- <https://intel.ly/2EU2sBS>

AMD EPYC Rome Series Processors

- **Based on Zen 2 architecture (Q2 2019)**
 - 7nm process, up to 64 cores (plus SMT), up to 512MB L3 cache
 - 4TB of 3200MHz DDR4 RAM per socket
 - 128 PCIe 4.0 lanes, Infinity Fabric, eight DDR4 memory controllers
 - Limited to one and two-socket servers
- **Strong competition for Intel in the server space!**
 - Very high core counts, memory density, and PCIe 4.0 lane capacity
 - Expected to be 70-80% faster than previous AMD EPYC “Naples” processors
 - May have better single-threaded performance than Intel Cascade Lake-SP

General Memory Considerations

- **Physical DRAM is faster than any other lower storage layer**
 - Much lower latency and higher throughput. Don't skimp on memory!
- **Having a large SQL Server buffer pool cache reduces physical reads**
 - More data in the buffer pool (logical instead of physical reads)
 - Can reduce the frequency of lazy writes and checkpoints
 - Can help even out the write workload to data files
- **Feasible goal is to have your entire workload fit into RAM**
 - Windows Server 2016 has 24TB RAM limit
 - ECC DDR4-2666 RAM is about \$7.50/GB for 32GB RDIMMs

Memory Performance Considerations

- **Populating one DIMM per memory channel gives best performance**
 - This is more relevant for Broadwell and older
 - This gives highest memory bandwidth (2400 MT/s vs. 1866 MT/s)
 - This means eight DIMMs in a two-socket, Intel Xeon E5-2600 v4 server
 - If your working set fits in the buffer pool with one DIMM per channel...
- **Populating all DIMM sockets reduces your memory bandwidth**
 - Even “slower” memory is much faster than any type of storage
 - Don’t let this information convince you to skimp on memory
- **Server vendors have detailed guidance on memory configuration**
 - <http://dell.to/2p6y6XD>

Hardware Configuration Tips

- **Take the time to confirm hardware configuration best practices**
 - Correct BIOS/UEFI settings
 - Current BIOS and firmware versions
 - Current device driver versions
 - Use vendor specific drivers instead of generic Microsoft drivers
 - Correct PCIe slot placement and usage
 - Appropriate memory module placement and usage
- **Take advantage of free utility programs to confirm performance**
 - CPU-Z: <https://bit.ly/QhR6xF>
 - HWiNFO64: <https://bit.ly/2mmAARf>

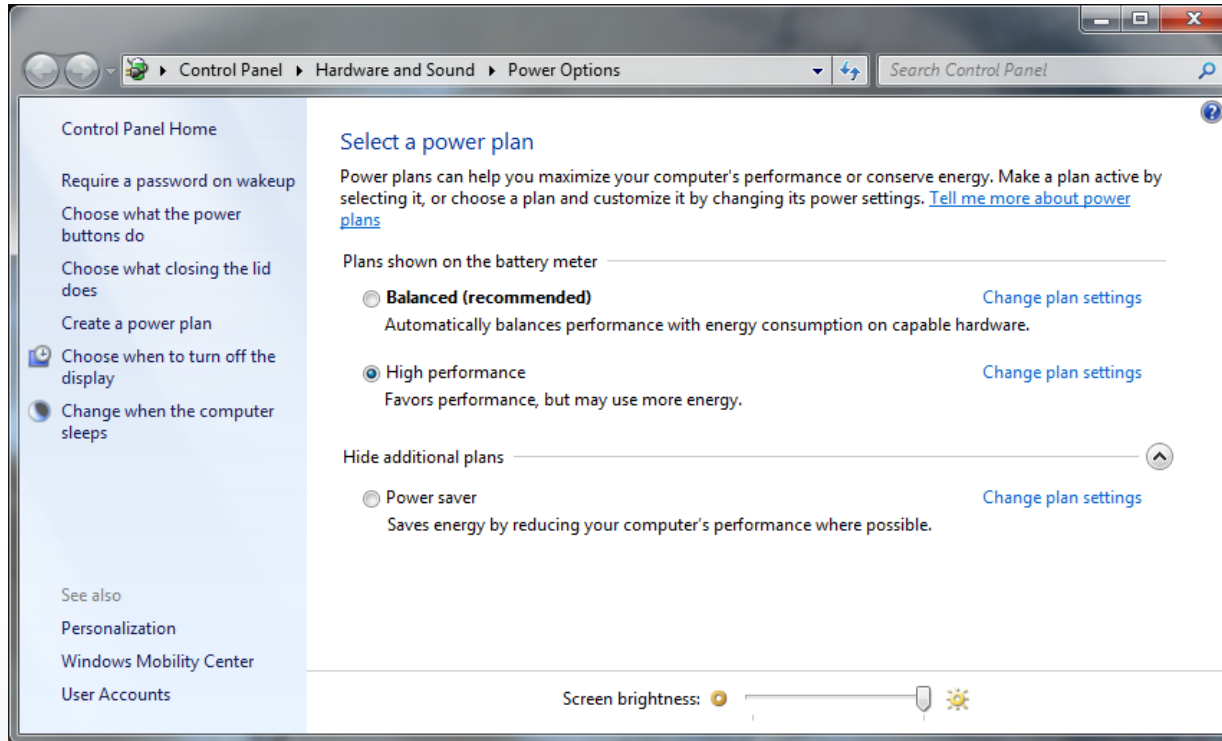
Key Performance-Related BIOS/UEFI Settings

- **Intel Turbo Boost or AMD Turbo Core should always be enabled**
 - Absolutely no performance downside from enabling
- **Hyper-Threading (HT) should be enabled in most situations**
 - HT gives you 25-30% more capacity for OLTP workloads
 - HT can hurt performance for some DW workloads (pretty rare)
 - Make sure to test with your workload before disabling HT
- **Processor power management should be set to OS control**
 - BIOS-level power management will override the Windows Power Plan
 - Use CPU-Z to check what speed the processor cores are actually running at
- **Make sure hardware virtualization is enabled if using virtualization**
 - This will enable VT-x and VT-d support

Power Management Effects

- **Power management has a significant negative effect on performance**
 - Can be in the 20-25% range, depending on the workload
- **Three types of power management**
 - Hardware-level, hypervisor-level, and Windows Power Plan-level
 - Hardware overrides hypervisor, hypervisor overrides guest OS power plan
- **Processor clock speed is reduced to save on electrical power usage**
 - Clock speed is increased in response to increase in processor load
 - Takes 100-150ms for full speed increase (depending on processor)
- **Intel Speed Shift reduces the time required to throttle up to 20-30ms**
 - Requires Skylake or newer CPU, Windows 10 or Windows Server 2016

Windows Power Plan Setting



Hardware Selection and Configuration Review

- **Processor selection is critically important for SQL Server**
 - It drives most other hardware and storage choices
 - It directly affects performance, scalability and licensing costs
- **Modern Intel processors are usually the best choice for SQL Server**
 - Better single-threaded performance and lower licensing costs
 - AMD EPYC 7000 series may be a viable choice for some workloads
- **Consider your workload type as you choose your hardware**
 - Different workload types benefit from specific hardware choices
- **Be aware of what edition of SQL Server 2017 you will be using**
 - This affects your hardware choices due to license limits

Recent Articles

- **Using Intel Optane Storage for SQL Server**
 - <https://bit.ly/2sJNQQK>
- **Why You Shouldn't Use an Intel Xeon Silver Processor for SQL Server**
 - <https://bit.ly/2Y6yVh2>
- **Intel Optane Technology and SQL Server**
 - <https://bit.ly/2DU9AiE>

Hardware References

- **Processor Selection for SQL Server**
 - <https://bit.ly/2F3aVIP>
- **Intel ARK Database for Intel Xeon Processors**
 - <https://intel.ly/2HH00iK>
- **AMD EPYC Server Processors**
 - <https://bit.ly/2u1pXaQ>
- **Serve the Home**
 - <https://bit.ly/2xdhnU3>

Additional References

- **Two Pluralsight courses on Scaling SQL Server 2012/2014**
 - Scaling SQL Server 2012 – Part 1 (<https://bit.ly/2FA9ols>)
 - SQL Server: Scaling SQL Server 2012 and 2014: Part 2 (<https://bit.ly/2FDAtWY>)
- **Microsoft Visual Studio Dev Essentials**
 - Free access to SQL Server 2017 Developer Edition
 - Free three month Pluralsight subscription (<https://bit.ly/1q6xbDL>)
- **Microsoft Azure Essentials**
 - Lots of free Azure usage credits, MCP exam voucher,
 - Free three month Pluralsight subscription (<https://bit.ly/2lxaH8w>)

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 - Performance Troubleshooting using Waits and Latches with Paul Randal
 - Modernize Your Applications with Azure SQL Managed Instance with Tim Radney and David Pless
 - SQL Server Indexes: What, Why, and HOW! with Kimberly L. Tripp
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