

SQLintersection

Session: Tuesday, 11:15AM-12:15PM

Hardware 301

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SQL
intersection

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- **Consultant/Trainer/Speaker/Author**
- **Principal Consultant, [SQLskills.com](http://www.SQLskills.com)**
 - Blog: <http://www.SQLskills.com/blogs/Glenn>
 - Twitter: @GlennAlanBerry
 - Regular presenter at worldwide conferences on hardware, scalability, and DMV queries
 - Author of SQL Server Hardware
 - Chapter author of Professional SQL Server 2012 Internals and Troubleshooting
 - Chapter author of MVP Deep Dives Volumes 1 and 2
- **Instructor-led training: Immersion Events**
- **Online training: pluralsight  <http://pluralsight.com/>**
- **Consulting: health checks, hardware, performance, upgrades**



- **Team of world-renowned SQL Server experts:**
 - Paul S. Randal (@PaulRandal)
 - Glenn Berry (@GlennAlanBerry)
 - Jonathan Kehayias (@SQLPoolBoy)
 - Kimberly L. Tripp (@KimberlyLTripp)
 - Erin Stellato (@ErinStellato)
 - Tim Radney (@TRadney)
- **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...



Agenda

- The importance of database hardware
- The importance of processor selection for SQL Server 2017
- Preferred Intel Xeon Processors
- 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 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!
- **Be aware of SQL Server hardware licensing limits**
 - They are different for different versions and editions of SQL Server
- **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 1950X		
Code Name	Threadripper	Max TDP	180.0 W
Package	Socket SP3r2 (4094)		
Technology	14 nm	Core Voltage	1.424 V

AMD RYZEN THREADRIPPER

Specification AMD Ryzen Threadripper 1950X 16-Core Processor

Family	F	Model	1	Stepping	1
Ext. Family	17	Ext. Model	1	Revision	ZP-B1

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

Clocks (Core #0)

Core Speed	3692.67 MHz
Multiplier	x 37.0
Bus Speed	99.79 MHz
Rated FSB	

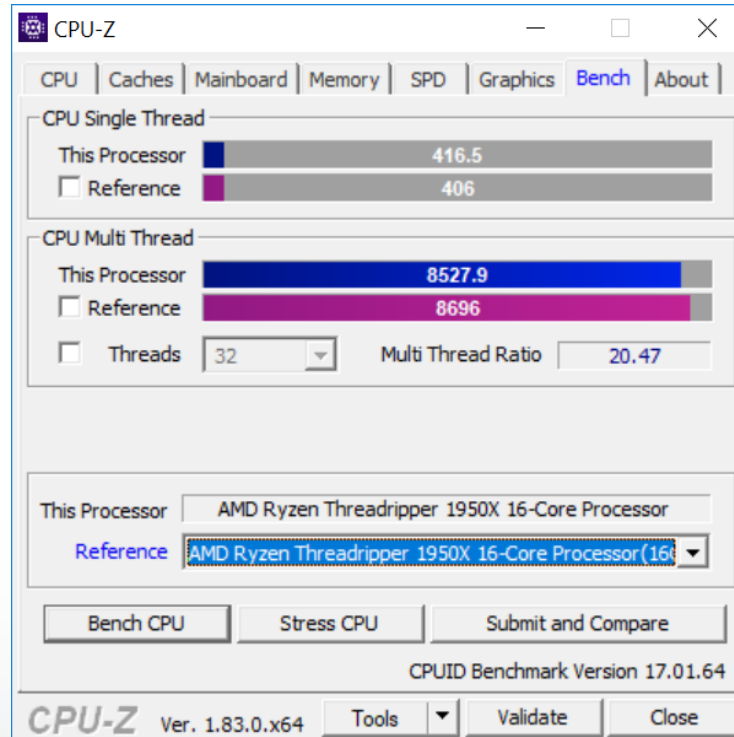
Cache

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. 1.83.0.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 8180M processors
 - Example: Fujitsu PRIMEQUEST 3800B (<http://bit.ly/2vaWonu>)
- **What are the major cost components of a server like this?**
 - (224) Windows Server 2016 Standard Edition licenses are \$12,348.00
 - (8) Intel Xeon 8180M Platinum processors are \$104,088.00
 - 12TB of DDR4-2666 RAM is \$184,320.00
 - (224) SQL Server 2017 Enterprise Edition licenses are \$1,596,672.00

Intel Server Processor Family Tree

Year	Process	Model Families	Turbo Speed
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)
2018	14nm	Xeon Platinum, Gold, Silver	Cascade Lake-SP (Q3 2018)

Current Intel Server Processor Families

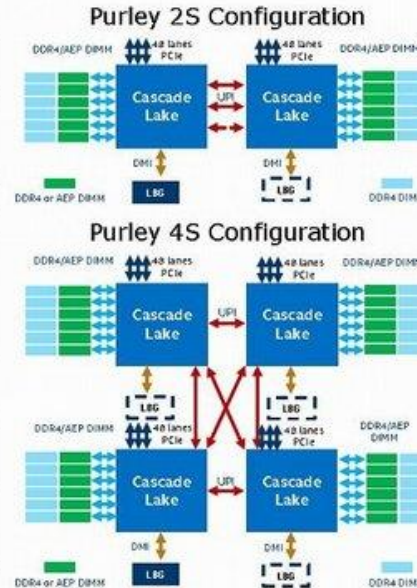
- **Xeon E3 v6 Family (14nm Kaby Lake), introduced in Q1 2017**
 - E3-1200 v6 Series (Value/mainstream uniprocessor)
- **Xeon Scalable Family (14nm Skylake-SP), introduced in Q3 2017**
 - **Bronze 3xxx Family** (Entry level two-socket)
 - **Silver 4xxx Family** (Enhanced two-socket)
 - **Gold 5xxx Family** (Entry level two or four-socket)
 - **Gold 6xxx Family** (Enhanced two or four-socket)
 - **Platinum 8xxx Family** (Two, four or eight-socket)
- **Avoid Xeon Silver and Bronze families for SQL Server usage!**

Upcoming 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 6154 Processor. The browser address bar shows the URL: https://ark.intel.com/products/120495/Intel-Xeon-Gold-6154-Processor-24_75M-Cache-3_00-GHz. The page features a blue header with the Intel logo and navigation links. The main content area displays the processor's name, specifications, and a table of essentials and performance metrics.

Intel Xeon Gold 6154 Processor
24.75M Cache, 3.00 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 [Export specifications](#)

Product Collection	Intel® Xeon® Scalable Processors
Code Name	Products formerly Skylake
Vertical Segment	Server
Processor Number	6154
Status	Launched
Launch Date ?	Q3'17
Lithography ?	14 nm
Recommended Customer Price ?	\$3543.00

Performance

# of Cores ?	18
# of Threads ?	36
Processor Base Frequency ?	3.00 GHz
Max Turbo Frequency ?	3.70 GHz
Cache ?	24.75 MB L3

Intel Xeon Major Generational Differences

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

Preferred Skylake-SP Processors – High Core Count

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 8170	26/35.75 MB	2.1 GHz	3.7 GHz	\$7,405.00
Platinum 8168	24/33 MB	2.7 GHz	3.7 GHz	\$5,890.00
Gold 6154	18/22 MB	3.0 GHz	3.7 GHz	\$3,543.00
Gold 6142	16/22 MB	2.6 GHz	3.7 GHz	\$2,946.00

Preferred Skylake-SP Processors – Low Core Count

Model	Cores/L3 Cache	Base Speed	Turbo Speed	Price
Gold 6132	14/19.25 MB	2.6 GHz	3.7 GHz	\$2,111.00
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

Preferred Broadwell-EP Processors – High Core Count

Model	Cores/L3 Cache	Base Speed	Turbo Speed	Price
E5-2699A v4	22/55 MB	2.4 GHz	3.6 GHz	\$4,938.00
E5-2698 v4	20/50 MB	2.2 GHz	3.6 GHz	\$3,226.00
E5-2697 v4	18/45 MB	2.3 GHz	3.6 GHz	\$2,702.00
E5-2697A v4	16/40 MB	2.6 GHz	3.6 GHz	\$2,891.00
E5-2690 v4	14/35 MB	2.6 GHz	3.6 GHz	\$2,090.00

Preferred Broadwell-EP Processors – Low Core Count

Model	Cores/L3 Cache	Base Speed	Turbo Speed	Price
E5-2687W v4	12/30 MB	3.0 GHz	3.5 GHz	\$2,141.00
E5-2640 v4	10/25 MB	2.4 GHz	3.4 GHz	\$ 939.00
E5-2667 v4	8/25 MB	3.2 GHz	3.6 GHz	\$2,057.00
E5-2643 v4	6/20 MB	3.4 GHz	3.7 GHz	\$1,552.00
E5-2637 v4	4/15 MB	3.5 GHz	3.7 GHz	\$ 996.00

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 server as a replacement for some two-socket servers
- **AMD EPYC 7000 Series Data Sheet**
 - <http://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 7351	16/64 MB	2.4 GHz	2.9 GHz	\$1,100.00
EPYC 7251	8/32 MB	2.1 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 Skylake-SP 2P System Metrics – HCC

Model	Raw TPC-E Score	Total Cores	Score/Core	License Cost
Platinum 8180	6,598.36	56	117.83	\$399,168.00
Platinum 8170	5,146.72	52	98.98	\$370,656.00
Platinum 8168	6,108.20	48	127.25	\$342,144.00
Gold 6154	5,090.16	36	141.39	\$256,608.00
Gold 6142	3,921.31	32	122.54	\$228,096.00

Comparative Skylake-SP 2P System Metrics – LCC

Model	Raw TPC-E Score	Total Cores	Score/Core	License Cost
Gold 6132	3,431.15	28	122.54	\$199,584.00
Gold 6146	3,619.67	24	150.81	\$171,072.00
Gold 6144	2,629.34	16	164.33	\$114,048.00
Gold 6128	1,922.95	12	160.17	\$ 85,536.00
Gold 5122	1,357.38	8	169.63	\$ 57,024.00

Comparative Broadwell-EP 2P System Metrics – HCC

Model	Raw TPC-E Score	Total Cores	Score/Core	License Cost
E5-2699A v4	5,387.06	44	122.44	\$313,632.00
E5-2698 v4	4,489.22	40	112.24	\$285,120.00
E5-2697 v4	4,223.95	36	117.34	\$256,608.00
E5-2697A v4	4,234.35	32	132.64	\$228,096.00
E5-2690 v4	3,713.81	28	132.64	\$199,584.00

Preferred Broadwell-EP 2P System Metrics – LCC

Model	Raw TPC-E Score	Total Cores	Score/Core	License Cost
E5-2687W v4	3,673.00	24	153.04	\$171,072.00
E5-2640 v4	2,448.66	20	122.43	\$142,560.00
E5-2667 v4	2,611.91	16	163.24	\$114,048.00
E5-2643 v4	2,081.36	12	173.44	\$ 85,536.00
E5-2637 v4	1,428.39	8	178.54	\$ 57,024.00

Bad CPU Choice vs. Good CPU Choice

Model	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**
- **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>

Modern Data Retrieval Hierarchy

- **Typical 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

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, version 1709 or newer

NV-DIMM



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 \$16.00/GB for 32GB RDIMMs

Memory Performance Considerations

- **Populating one DIMM per memory channel gives best performance**
 - 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
 - Using 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 settings**
 - CPU-Z: <http://bit.ly/QhR6xF>
 - HWiNFO64: <http://bit.ly/2mmAARf>

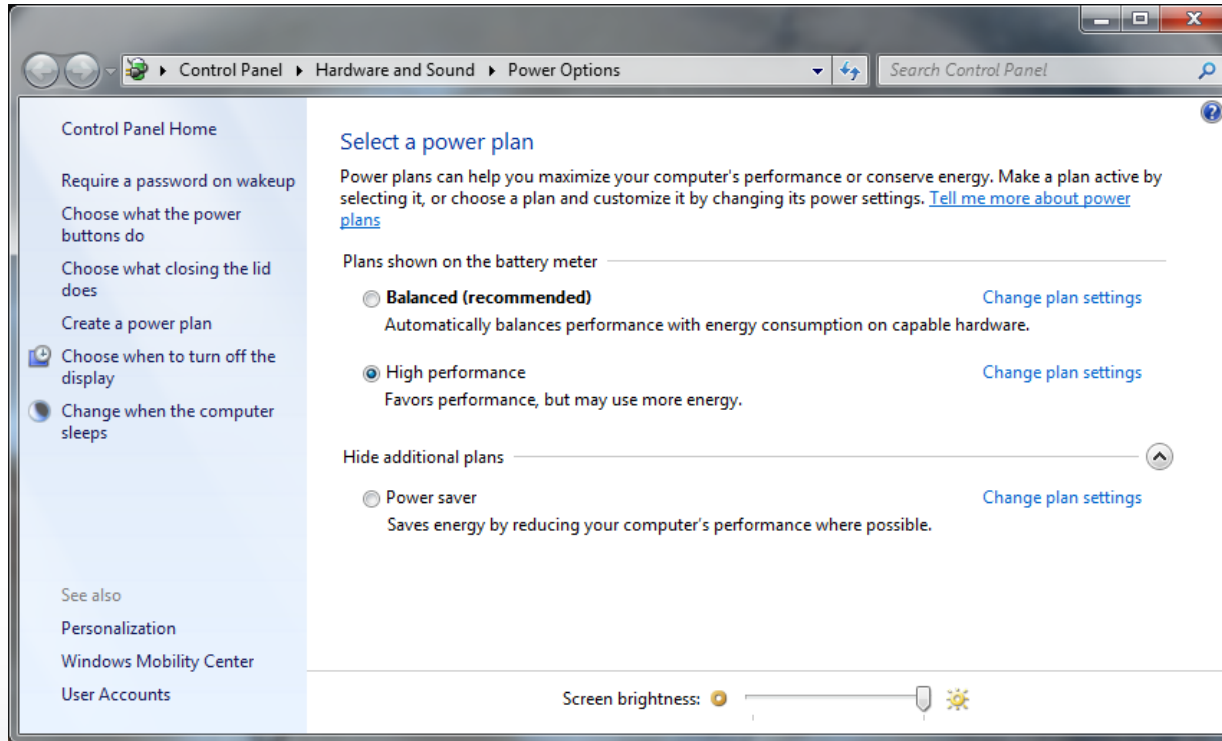
Key Performance-Related BIOS/UEFI Settings

- **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

References

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

Additional References

- **Two Pluralsight courses on Scaling SQL Server 2012/2014**
 - Scaling SQL Server 2012 – Part 1 (<http://bit.ly/2FA9ols>)
 - SQL Server: Scaling SQL Server 2012 and 2014: Part 2 (<http://bit.ly/2FDAtWY>)
- **Microsoft Visual Studio Dev Essentials**
 - Free access to SQL Server 2017 Developer Edition
 - Free three month Pluralsight subscription (<http://bit.ly/1q6xbDL>)
- **Microsoft IT Pro Cloud Essentials**
 - Lots of free Azure usage credits, MCP exam voucher,
 - Free three month Pluralsight subscription (<http://bit.ly/2443SAd>)

Questions?



Don't forget to complete an online evaluation on EventBoard!

Hardware 301

Diving Deeper into Database Hardware

**Your evaluation helps organizers build better conferences
and helps speakers improve their sessions.**



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Thank you!

Reminder: Intersect with Speakers and Attendees

- **Tweet tips and tricks that you learn and follow tweets posted by your peers!**
 - Follow: #SQLIntersection and/or #DEVIntersection
- **Join us – Tuesday Evening – for SQLafterDark**
 - Doors open at **7:00 pm**
 - Trivia game starts at **7:30 pm**
 - Winning team receives something fun!*
 - Raffle at the end of the night
 - Lots of great items to win including a seat in a SQLskills Immersion Event!*
 - The first round of drinks is sponsored by SentryOne and SQLskills



Save the Date

www.SQLintersection.com



Week of December 2, 2018
We're back in Vegas baby!

