PASS SUMMIT2019

Hardware 301

Choosing Database Hardware for SQL Server 2019

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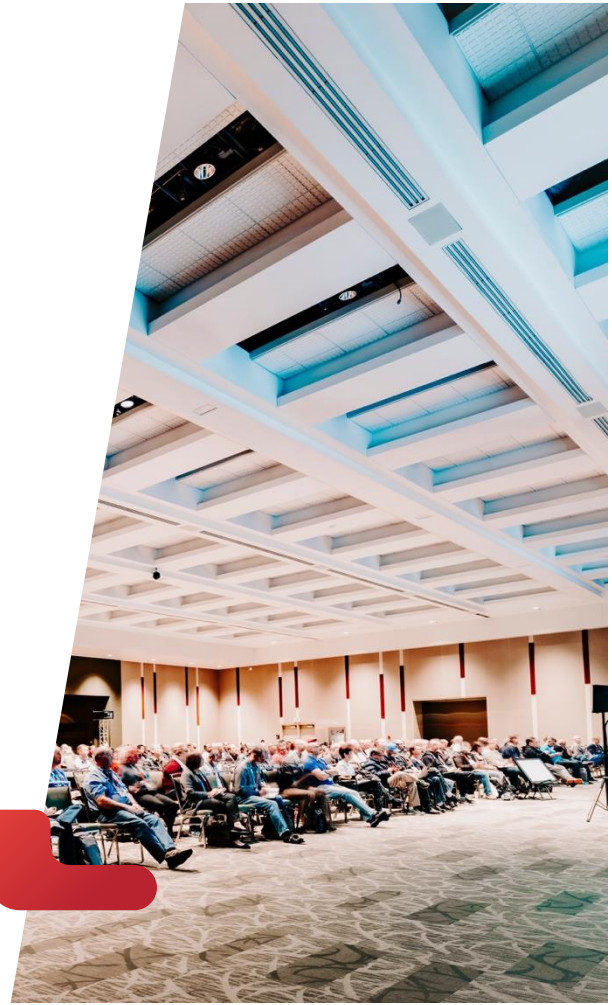

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Author

Numerous articles, and blog posts
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Course author

Sixteen SQL Server related courses on Pluralsight https://bit.ly/2hbg5SW

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Beer brewer

I do all-grain beer brewing with a stainless steel, three vessel system

I Know How to Brew Beer...

Agenda

1. The importance of database hardware
2. Hardware selection criteria
3. Intel vs. AMD
4. Capacity vs. performance
5. Processor selection

The Importance of Database Hardware

Database servers are mission critical assets

Performance and scalability problems are immediately noticeable. It can be very difficult to compensate for poor hardware choices. Poor hardware selection can also result in excessive SQL Server license costs.

Modern Server Hardware is Affordable

Old hardware is bad…

Don’t reuse old hardware for a new version of SQL Server. This is foolish, false economy

SQL is hardware-intensive

Economizing on hardware is usually a bad idea, due to the cost of SQL Server core licenses

Good Hardware is Not a Panacea!

Bad workloads will still win

Poorly designed applications and databases can easily overwhelm the best hardware and storage

More margin for error

Fast hardware and storage gives you more headroom and better performance

The details actually matter

Think About Your Workload

What type of workload is it?

OLTP, DW/Reporting, mixed

This will affect your hardware and storage choices

Bare metal or virtualized?

Try to avoid general purpose, high core count virtualization hosts for SQL Server usage

SQL Server 2019 License Costs

Edition	Server License	Core License
Standard	$899.00	$1,793.00
Enterprise	Not Available	$6,874.00

- 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 2019 License Limits

Enterprise Edition

OS limit for memory

OS Limit for sockets/cores

Standard Edition

128GB per instance plus some more for Columnstore and In-memory OLTP.

Lesser of 4 sockets or 24 cores

Bare metal: Physical cores

Virtualized: Virtual cores

No change from SQL Server 2017

Choosing Between Intel and AMD

Performance

Intel has small advantage in ST performance

AMD has advantage in MT performance, memory density, and PCIe capacity

Cost

Intel processors are significantly more expensive than AMD processors

Security

Intel has many more known security exploits

Intel Performance Advantages

Clock Speed

Higher clock speeds that help ST performance

Intel has AVX-512 and DL Boost (not used by SQL Server)

Optane PMEM

Cascade Lake-SP has Optane PMEM support

This will slow DRAM to 2666

Workload type

Intel CPUs are better suited for OLTP workloads

Current Intel Server Processor Families

Xeon E Family (14nm Coffee Lake), launched in Q2 2019

- E-2200 Series (Value/mainstream uniprocessor)

2nd Gen Xeon Scalable Family (14nm Cascade Lake-SP)

- Bronze 32xx Family, Silver 42xx Family
- Gold 52xx Family, Gold 62xx Family, Platinum 82xx Family

3rd Gen Xeon Scalable Family (14nm Cooper Lake-SP) - Q2 2020

- Gold 53xx Family, Gold 63xx Family, Platinum 83xx Family

Don't use Cooper Lake for SQL Server!

Intel Server Processor Family Tree

Year	Process	Model Families	Processor Code Name
2008	45nm	Xeon 3400, 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)
2021	10nm	Xeon Platinum, Gold, Silver ?	Ice Lake (H1 2021)
2022	10nm	???	Sapphire Rapids (H1 2022)

Actual TPC-E Result Comparison

Two-socket Lenovo SR650

(2) Intel Xeon Plat 8280, (56C/112T)
1.5TB DDR4-2933 RAM

7012.53 TPC-E System Throughput
125.22 score/core
Total System cost: $638,052
https://bit.ly/2C8SpsC

One-socket Lenovo SR655

(1) AMD EPYC 7742, (64C/128T)
1TB DDR4-3200 RAM

6716.88 TPC-E System Throughput
104.95 score/core
Total System cost: $671,566
https://bit.ly/2WHwdiz

AMD Performance Advantages

Higher IPC	Storage bandwidth	Workload type
More modern chiplet architecture, much larger L3 cache	128 PCIe 4.0 lanes per socket	AMD CPUs are better suited for DW workloads
DDR4-3200 memory, 8 memory channels/socket	PCIe 4.0 has 2X the bandwidth of PCIe 3.0	Well-suited for virtualization hosts

AMD Server Processor Family Tree

Year	Process	Model Families	Processor Core (Microarchitecture)
2010	45nm	Opteron 6100	Magny-Cours (K10)
2011	32nm	Opteron 6200	Interlagos (Bulldozer)
2012	32nm	Opteron 6300	Abu Dhabi (Piledriver)
2017	14nm	EPYC 7001	Naples (Zen) - Q2 2017
2019	7nm	EPYC 7002	Rome (Zen 2) - Q3 2019
2020	7nm+	EPYC 7003 ?	Milan (Zen 3) - Q4 2020
2022	5nm ?	EPYC 7004 ?	Genoa (Zen 4)

Actual TPC-H Result Comparison

Two-socket HPE DL380 Gen10

(2) Intel Xeon Plat 8180, (56C/112T)
512GB DDR4-2666 RAM

1,009,065 QphH (1000 Scale Factor)
18,019 QphH/Core
Total System cost: $472,069
https://bit.ly/2Wzehqo

One-socket HPE DL325 Gen10

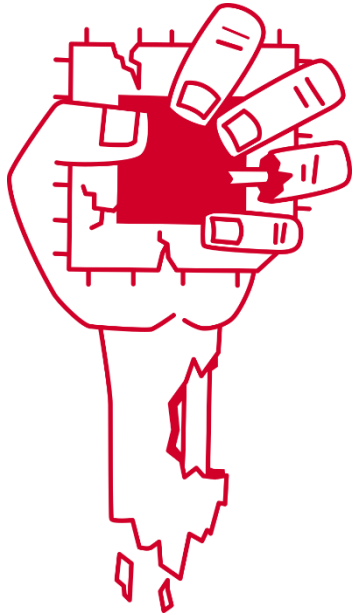
(1) AMD EPYC 7502P, (32C/64T)
512GB DDR4-3200 RAM

743,750 QphH (1000 Scale Factor)
23,242 QphH/Core
Total System cost: $252,286
https://bit.ly/36pQOMO

AMD EPYC 7002 vs. Cascade Lake-SP

Measure	AMD EPYC 7002	Cascade Lake-SP	AMD Advantage
Max Cores	64	28	129%
PCIe Lanes 1P	128	48	167%
PCIe Lanes 2P	160	96	67%
PCIe Generation	4.0	3.0	100%
Effective PCIe 3.0 Lanes 2P	320	96	233%
DDR4 Memory Speed	3200 MHz	2933 MHz	9%
Max Memory Capacity	4 TB	1 TB	300%
Memory Channels	8	6	33%
Optane DC PMEM	No	Yes	No

Some Scary Logos



Processor Security Vulnerabilities

NetCat: Network cache attack. DDIO and RDMA vulnerability.

Intel only: https://bit.ly/2MNAr51

ZombieLoad: Side channel attack that exploits hyper-threading

Intel only: https://bit.ly/31L1r9v

Foreshadow: Speculative execution attack on SGX enclaves and VMs

Intel only: https://bit.ly/2JnAZw8

Meltdown: Rogue data cache load

Intel only: https://bit.ly/2MJyVRc

Spectre: Bounds check bypass, branch target injection

Intel and AMD (limited): https://bit.ly/2pPTKl2

Processor Security Guidance

Microsoft SQL Server Guidance: https://bit.ly/2JG6hhR

Windows Server Guidance: https://bit.ly/2JG7jdJ

AMD Product Security: https://bit.ly/34yYjPZ

Intel Product Security Center Advisories: https://intel.ly/2JJYLCH

Intel vs. AMD Processor Security: https://bit.ly/2oSq8DB

ZombieLoad Info: https://bit.ly/3edDvDa

Server Capacity

Several measures of server capacity

- CPU capacity is multi-threaded performance of all CPU cores
- Memory capacity is max memory amount and total throughput
- I/O capacity is number and generation of PCIe lanes and total IOPS

These are different aspects of the capacity of the server

- How many concurrent queries can it support?
- How much memory throughput can it support?
- How much sequential I/O throughput can it support?

Peterbilt Truck

Server Performance

Several measures of server performance

- CPU performance is single-threaded performance of one CPU core
- Memory performance is memory speed and latency
- I/O performance is I/O latency and I/O bandwidth

These are different aspects of the performance of the server

- How fast is a single-threaded query?
- How fast can you read/write from the buffer pool?
- How fast can you read/write from storage?

Tesla Model 3 Performance

How Do You Compare Processors?

One method is to use actual TPC-E benchmark scores

- Find the best actual score for a given processor family (flagship score)
- Adjust the actual score for core count and base clock speed differences

What these estimated TPC-E scores mean

- Total score measures the 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

Estimated TPC-E Score Calculation

Comparing two processors from the same generation

- Intel Xeon Platinum 8280 has 28 cores and a base clock of 2.7 GHz
  - Official TPC-E score of 7,012.53. Score/core is 125.22
- Intel Xeon Gold 6250 has 8 cores and a base clock of 3.9 GHz
  - Estimated TPC-E score of 2,893.02. Score/core is 180.81

Let's do the math!

- Core count adjustment: 8/28 = .2857
- Base clock speed adjustment: 3.9 GHz/2.7 GHz = 1.444
- 7012.53 times .2857 times 1.444 = **2,893.02 Estimated Score**

Cascade Lake-SP System Metrics (2P)

Processor SKU	TPC-E Score	Total Cores	Score/Core	License Cost
Intel Xeon Gold 6258R	7,012.53	56	125.22	$384,944.00
Intel Xeon Platinum 8270	6,511.64	52	125.22	$357,448.00
Intel Xeon Gold 6248R	6,678.60	48	139.14	$329,952.00
Intel Xeon Gold 6242R	5,751.02	40	143.78	$274,960.00
Intel Xeon Gold 6254	5,175.92	36	143.78	$247,464.00
Intel Xeon Gold 6246R	5,046.05	32	157.68	$219,968.00
Intel Xeon Gold 6256	4,007.16	24	166.96	$164,976.00
Intel Xeon Gold 6250	2,894.06	16	180.88	$109,984.00
Intel Xeon Gold 5222	1,409.93	8	176.24	$ 54,992.00

EPYC Rome System Metrics (1P)

Processor SKU	TPC-E Score	Total Cores	Score/Core	License Cost
AMD EPYC 7H12 (WC-only)	7,761.73	64	121.28	$439,936.00
AMD EPYC 7742	6,716.88	64	104.95	$439,936.00
AMD EPYC 7642	5,149.61	48	107.28	$329,952.00
AMD EPYC 7542	4,328.66	32	135.37	$219,968.00
AMD EPYC 7F72	3,582.34	24	149.26	$164,976.00
AMD EPYC 7F52	2,612.12	16	163.26	$109,984.00
AMD EPYC 7272	1,623.25	12	135.27	$ 82,488.00
AMD EPYC 7F32	1,380.69	8	172.59	$ 54,992.00

Bad CPU Choice vs. Good CPU Choice

Processor Choice	TPC-Score	Total Cores	Score/Core	License Cost
(2) Intel Xeon Silver 4208	1,558.34	16	97.40	$109,984.00
(2) Intel Xeon Gold 5222	1,409.93	8	176.24	$ 54,992.00

Identical two-socket server (Example: Dell PowerEdge R740)

- Bad choice has two, Xeon Silver 4208 (Total 16C/32T)
  - Processor cost is $417.00 each
  - We saved $1,608.00 on hardware by choosing this processor
- Good choice has two, Xeon Gold 5222 (Total 8C/16T)
  - Processor cost is $1,221.00 each. Nearly double ST performance
  - **We saved $54,992.00 on software by choosing this processor**

Recent Articles

AMD EPYC 7002 Series Processors and SQL Server

- https://bit.ly/2p2JNRk

Is Intel Doomed in the Server CPU Space?

- https://bit.ly/32tpgTA

Using Intel Optane Storage for SQL Server

- https://bit.ly/2sJNQQK

Intel Optane Technology and SQL Server

- https://bit.ly/2DU9AiE

Hardware References

Processor Selection for SQL Server

- https://bit.ly/2F3aVlP

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

Thank You

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