Is Storage the Root Cause of Your Performance Woes… or Not?

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https://www.github.com/sqlbek/

PURESTORAGE®

Got 99 Problems… Is Performance One?

- User complaints
- Monitoring alerts

SQL Server has 99,999 occurrence(s) of I/O requests taking longer than 15 seconds to complete…

“Check the Storage!
I bet that it’s being slow!”

Where To Start?

- Lifec
- Diag
- Look

SQL
Serv

Intermediate Level

Prerequisites:

Introductory/basic knowledge of storage, infrastructure, and virtualization.

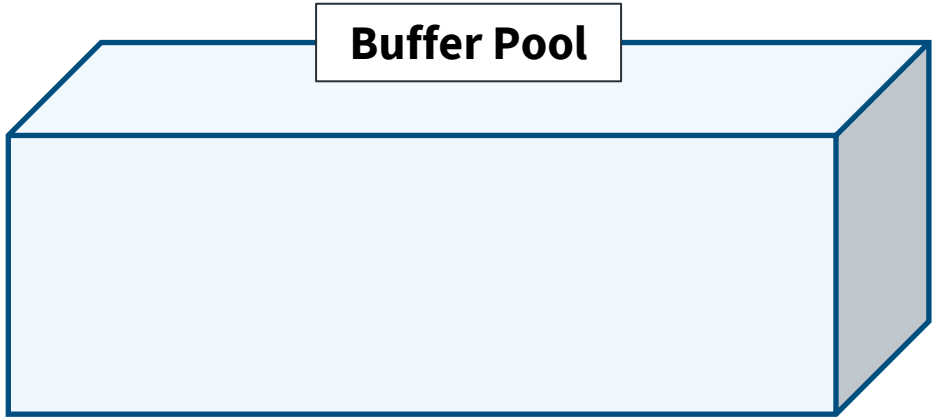
Fast moving “survey” session.

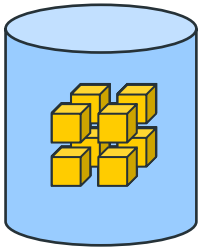
Will see some advanced topics too.

“Basics” will be glossed over.

Lifecycle of a Read & Write

A Physical Read





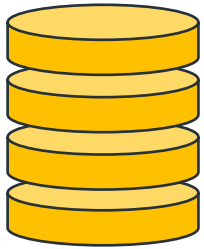
Data File

SELECT

UPDATE

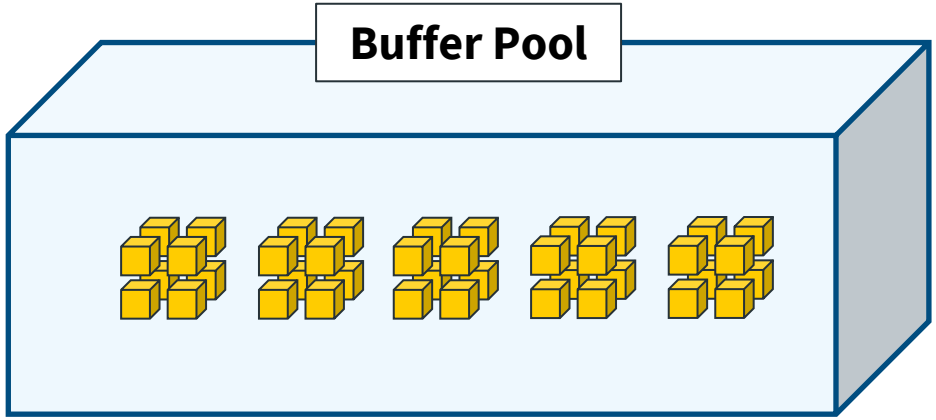
DELETE

INSERT

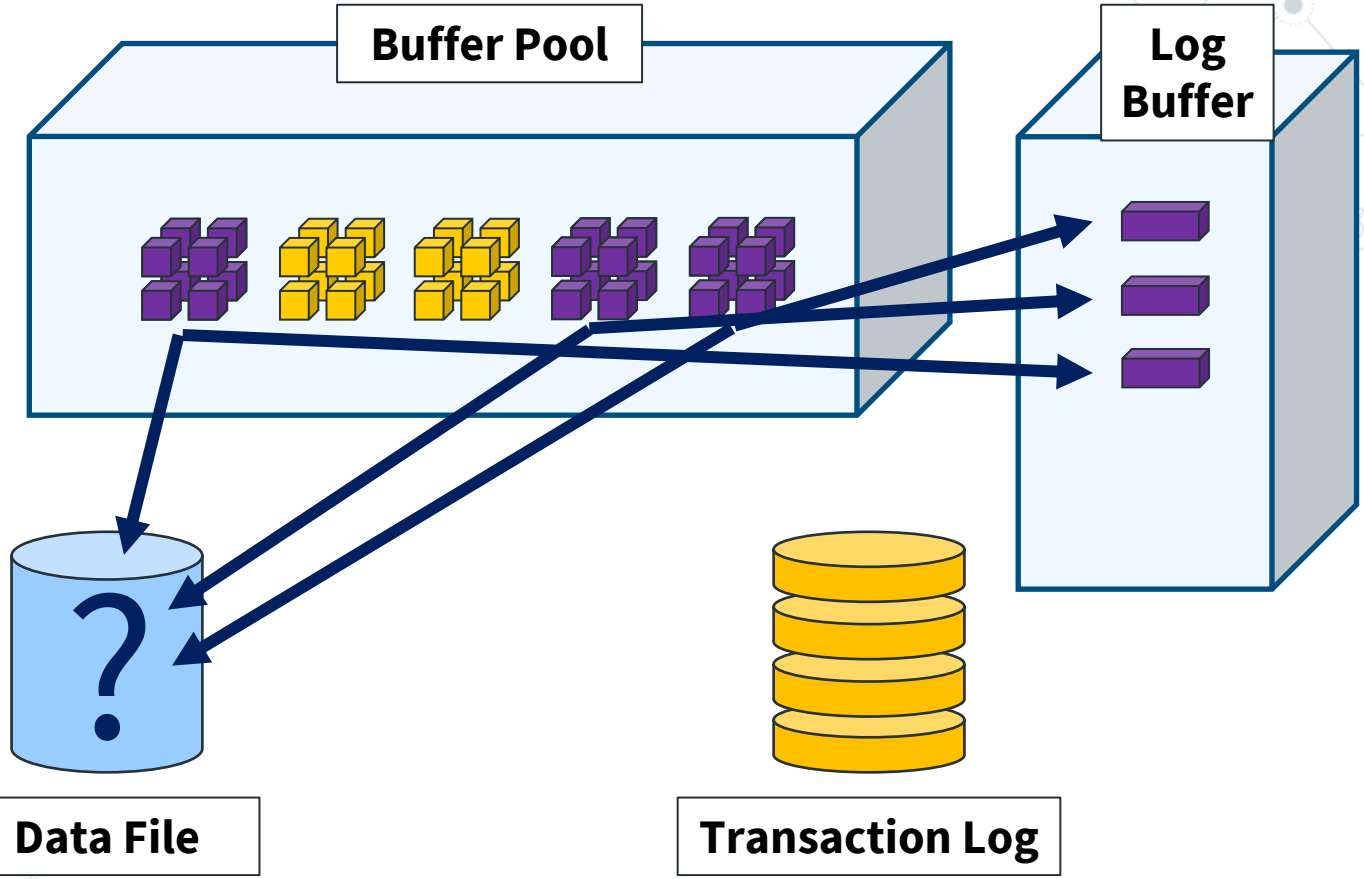


Transaction Log

A Logical Read



Modify Data

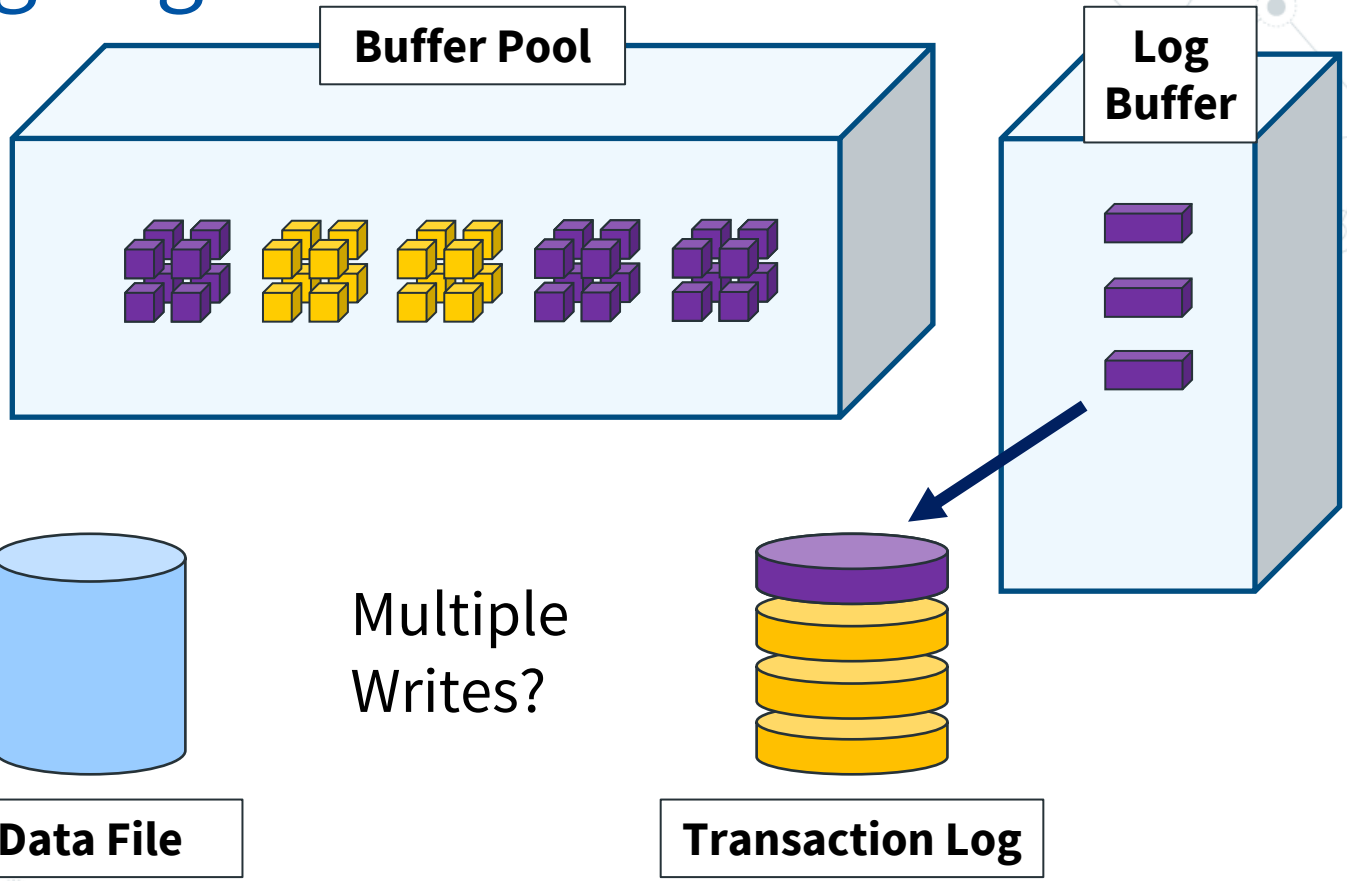


Flushing Log Buffer

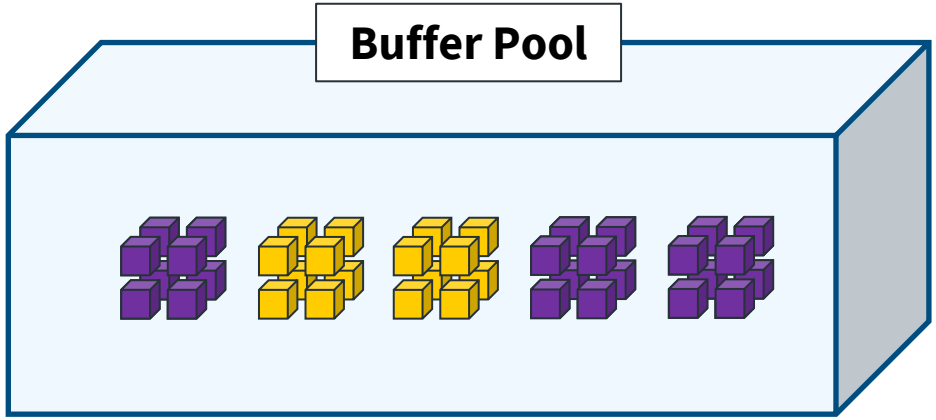
Transaction Commit

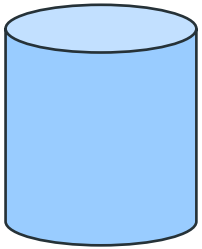
Buffer @ 60KB

(plus others)



Writing to the Data File… Finally



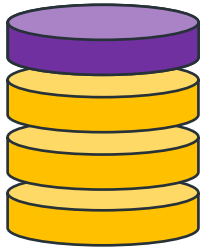


Data File

Checkpoint

Lazy write

Eager write



Transaction Log

Remember

SQL Server uses
Write Ahead Logging

Data changes are
NOT IMMEDIATELY
written to the data file

Diagnosing Storage Performance Within SQL Server

Sub-Agenda

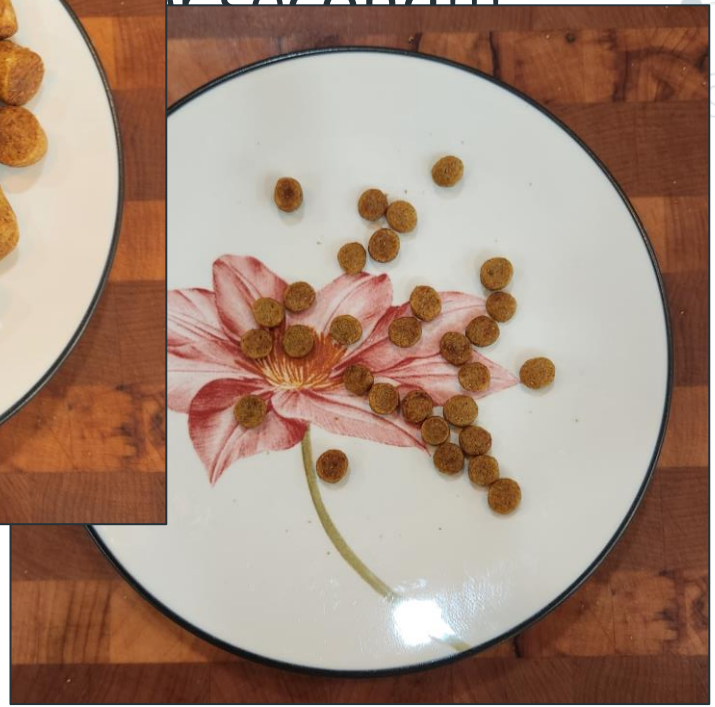
- Storage Terminology Refresher
- Workload Composition
- Digging in When “Storage is Slow…?”

Storage Terminology Refresher

- **Latency**
  - How fast to read or write
  - Ex: X miliseconds (ms)
- **Throughput**
  - How much volume of data over time
  - Ex: X megabytes per second
- **IOPs**
  - How many I/O operations over time
  - Ex: X IOPS per second

IOPs “Alone” Are Crap

“We can do [illegible] second!!!”



What [illegible]

I can [illegible] dog treats a second!

Size Matters

- What is the size of I/O?
  - 4 KB I/O = 39 MB /sec
  - 10 MB I/O = 97 GB / sec
- SQL Server I/O sizes vary on operation

Operation	I/O Block Size
Transaction Log Write	512 bytes -> 60 KB
Checkpoint/ Lazy Writer	8 KB -> 1 MB
Read-Ahead Scans	128 KB -> 512 KB
Bulk Loads	256 KB
Backup/Restore *(default)*	1 MB (*MAXTRANSFERSIZE*)

What Is Your Workload Composition?

- Read-Heavy
  - OLAP or Reporting
  - What about OLTP?
- Write-Heavy
  - ETL loading
- TempDB-Heavy
  - Effectively BOTH

Read Heavy Workload

- Is your data is already in the buffer pool?
- If you keep thrashing to disk, give your SQL Server more RAM
- Your queries are reading too much – tune them!

Lets Dive Into SQL Server I/O To Improve T-SQL Performance

https://www.youtube.com/watch?v=fDd4lw6DfqU

Write Heavy Workload

- Writing is “two-phased”
  - Log buffer written immediately
  - Data pages written later

- How are you doing your DML?
  - Single record at a time?
  - Everything at once?
  - In chunks?

Before Digging In

Why do you consider it slow in the first place?

Do you have a baseline?

- Query Dura
- Number of Queries/Sec
- Application Duration

Common Ways to Find Evidence

- Perfmon Counters
- DMV Information
- SQL Server Waits

Perfmon Counters

- Latency
  - Avg. Disk sec/Read & Avg. Disk sec/Write
- Average I/O Size
  - Avg. Disk Bytes/Read & Avg. Disk Bytes/Write
- IOPs
  - Disk Reads/sec & Disk Writes/sec

I/O “Adjacent” Perfmon Counters

- Page Life Expectancy…?
- Checkpoint pages/sec
  vs
  Log Bytes Flushed/sec

sys.dm_io_virtual_file_stats

- Number of X's and Total Y's
  - Calculate averages
  - Derive Latency, Throughput, IOPs
- Data is cumulative
  - Reset on SQL Server service start

Common I/O “Related” Wait Types

- IO_COMPLETION / ASYNC_IO_COMPLETION
- PAGEIOLATCH_XX
- BACKUPIO
- ASYNC_NETWORK_IO… ?

WRITELOG Wait Type

- Duration of Log Flush operation
- Synchronous Availability Group?
  - HADR_SYNC_COMMIT can “hide” WRITELOG

General Things to Keep in Mind

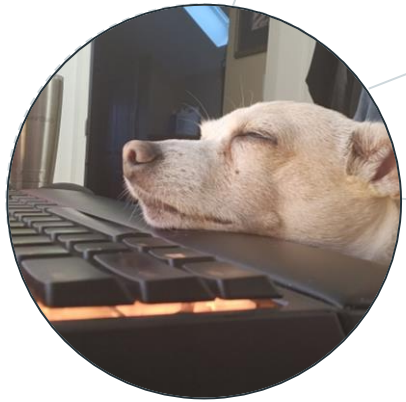
- Average I/O size matters
  - Larger I/O ops will take longer
- Typically:
  - OLTP = smaller I/O sizes w. lower latency
  - OLAP = higher I/O sizes w. higher latency
- Transaction Log needs **very low** write latency

Demo

Frankly…

Your T-SQL code is probably doing too much I/O.

Tune your code.



Lets Dive Into SQL Server I/O To Improve T-SQL Performance

https://www.youtube.com/watch?v=fDd4lw6DfqU

Looking Beyond the SQL Server Layer

You checked the storage yet?

It’s fine – we moved your lousy code to the wicked-fast “orange” storage array, remember?

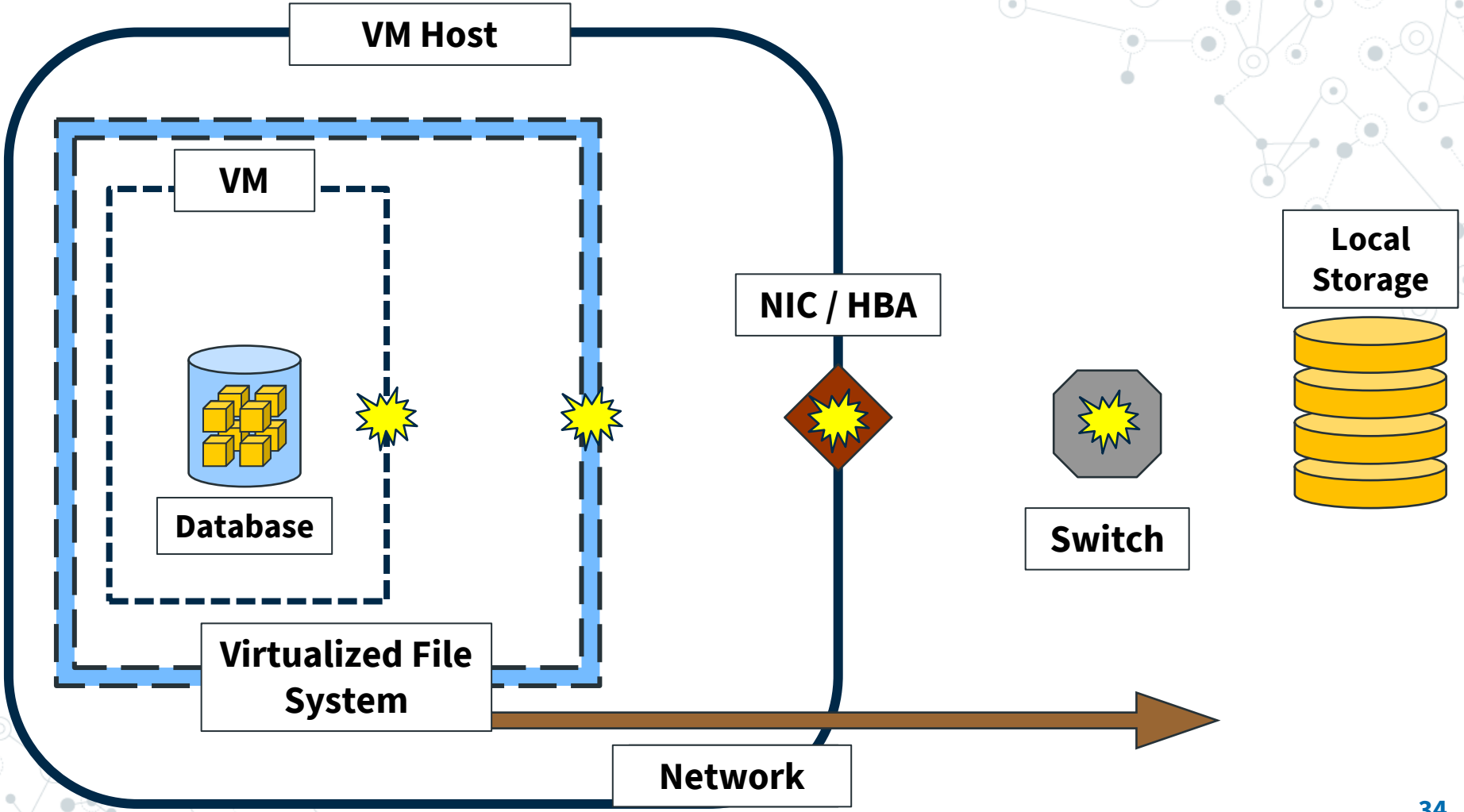
Now leave me alone, it’s time for my contractually scheduled nap …

Wait, whut? Contractually scheduled… nap?!

Visibility

What can SQL Server and the Operating System see?

What is beyond the Operating System?


VM Host
VM
Database
Virtualized File System
NIC / HBA
Switch
Local Storage
Network

What is the Path of Your I/O?

- Operating System
- Virtualization Layer…?
- Physical Hardware
- Storage Interconnect

Operating System

- Power Plan
- Filter Driver
- Other applications?

Virtualization Layer

- Power Plan
- VMFS Datastore
- Non-storage bottleneck
  - Co-Stop & Ready Time
- Are you following SQL Server on VMware Best Practices?

Physical Hardware

- Server Model
  - PCIe bus
- Host Bus Adapter
  - HBA Drivers
- Network Interface Card
  - iSCSI

Storage Interconnect

- iSCSI
  - MPIO & Routing
- FibreChannel
  - Zoning
- Network Attached
  - NFS or SMB?

And now a special topic…

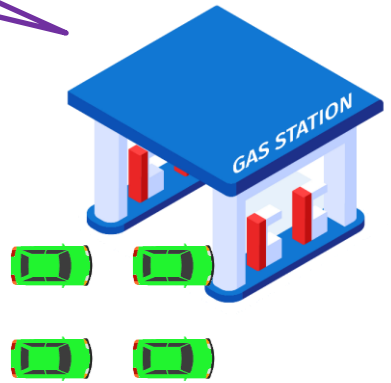
Queuing…

What I Four

Queue is a Line . . .

You can't wait here! Go home and come back later.

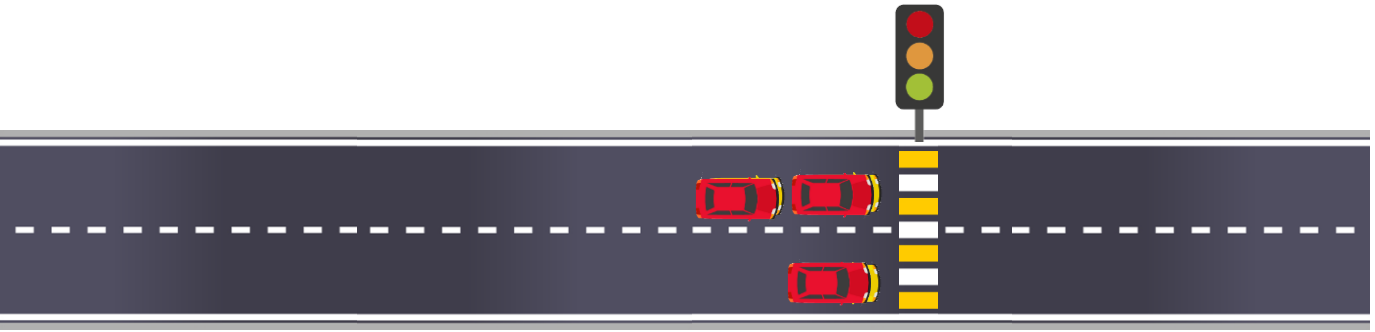
Four (4) Fuel Pumps

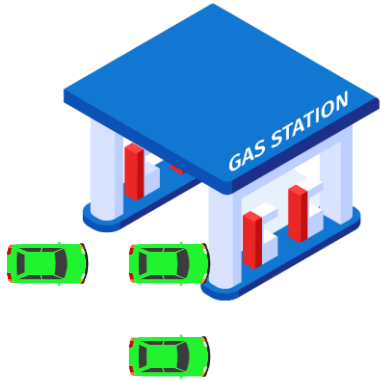


Current Queue Length?

HBA
Queue Depth = 3

Four (4) Fuel Pumps





Current
Queue Length?

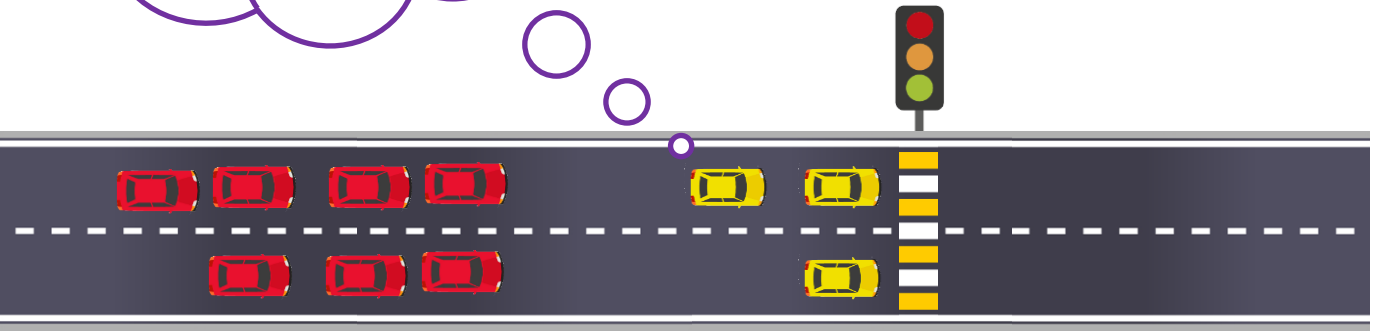
Queue Depth

- “Traffic signals” that buffer the flow of I/O
  - Queues help to not overwhelm lousy legacy storage
- But what if you have modern, cutting-edge **FAST** storage?
  - Do default values defined “long ago” still make sense?

  *(*cough* **cost threshold for parallelism** *cough*)*

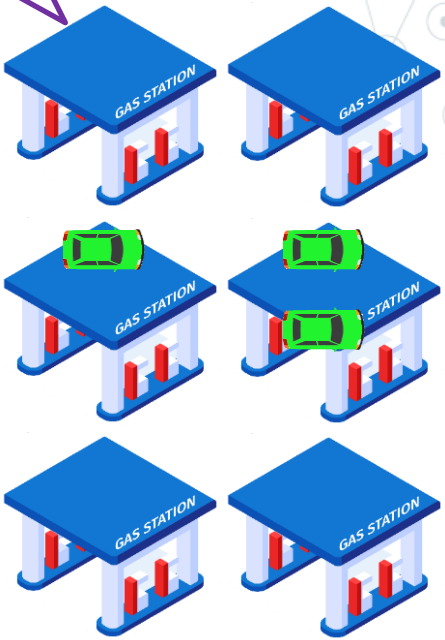
Why hasn't anyone changed the light timings?

HBA
Q.D = 3



Where is everyone?

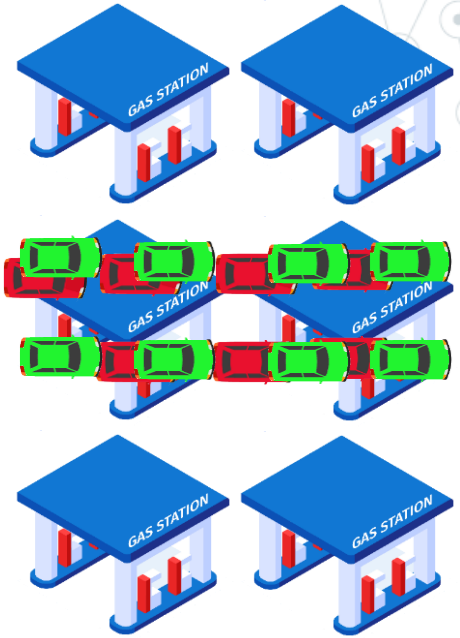
6x gas stations
24 pumps



HBA
Q.D = 24

Light's green, I can keep going!

6x gas stations
24 pumps

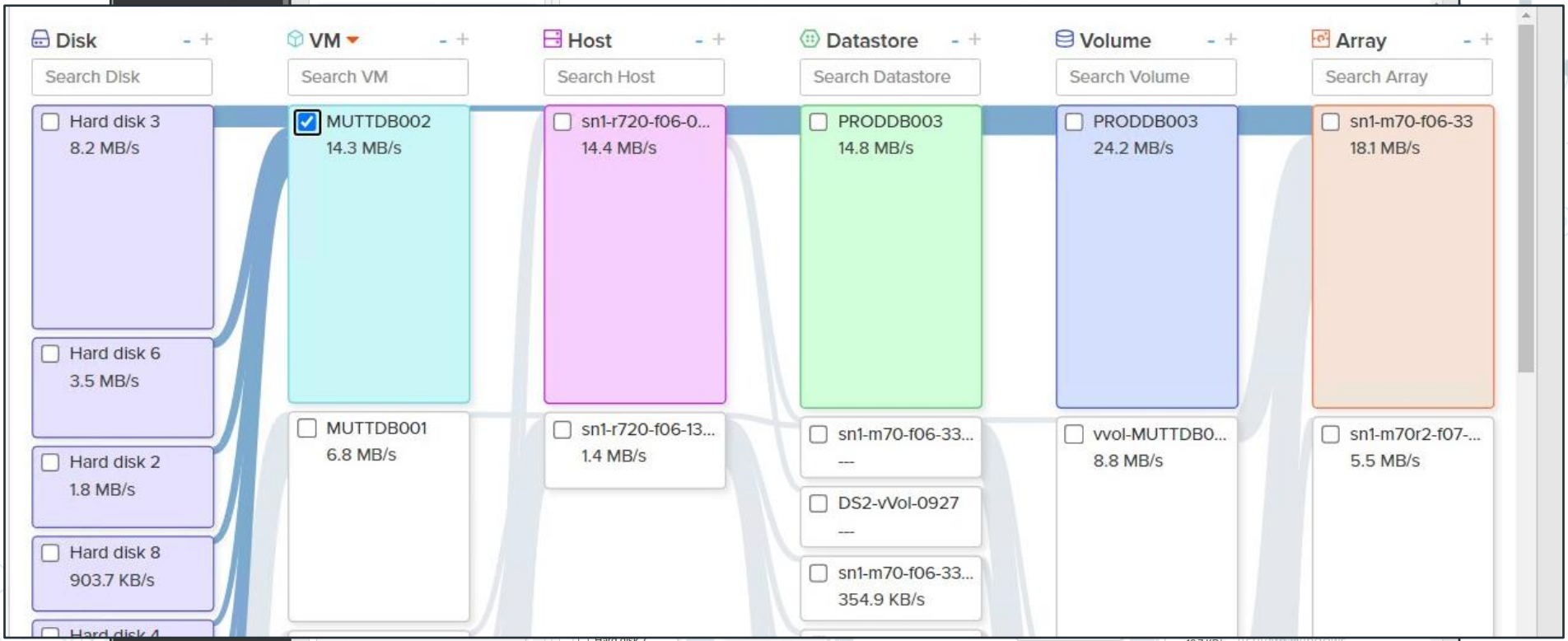


Queue Depth - Check

- Virtual Disk Controllers
- Host Bus Adapters (and drivers)
- Storage Device/LUN
  - There may be other queues to in your stack

Monitoring Tools

- Remember the limits of Perfmon & DMVs
- 3rd Party Monitoring Tool
  - Worth the investment!!!
  - Monitoring SQL Server Without Breaking the Bank - Gianluca Sartori
- Often only report on a single layer


Pure1
VM Topology
DASHBOARD
Overview
Assessment
Software Lifecycle
vc02.fsa.lab
Datacenter
cluster-prod
Search
Generate Report
Show Historical
Clear
Avg
Max
Read Bandwidth
Last 3 hours
Disk
VM
Host
Datastore
Volume
Array
Search Disk
Search VM
Search Host
Search Datastore
Search Volume
Search Array
Hard disk 3
8.2 MB/s
Hard disk 6
3.5 MB/s
Hard disk 2
1.8 MB/s
Hard disk 8
903.7 KB/s
MUTTDB002
14.3 MB/s
MUTTDB001
6.8 MB/s
sn1-r720-f06-0...
14.4 MB/s
sn1-r720-f06-13...
1.4 MB/s
PRODDB003
14.8 MB/s
sn1-m70-f06-33...
DS2-vVol-0927
sn1-m70-f06-33...
354.9 KB/s
PRODDB003
24.2 MB/s
vvol-MUTTDB0...
8.8 MB/s
sn1-m70-f06-33
18.1 MB/s
sn1-m70r2-f07-...
5.5 MB/s
SUPPORT
Knowledge Base
Documentation
14.3 MB/s
14.3 MB/s
14.4 MB/s
14.8 MB/s
24.2 MB/s
18.1 MB/s
SUM

Conclusion

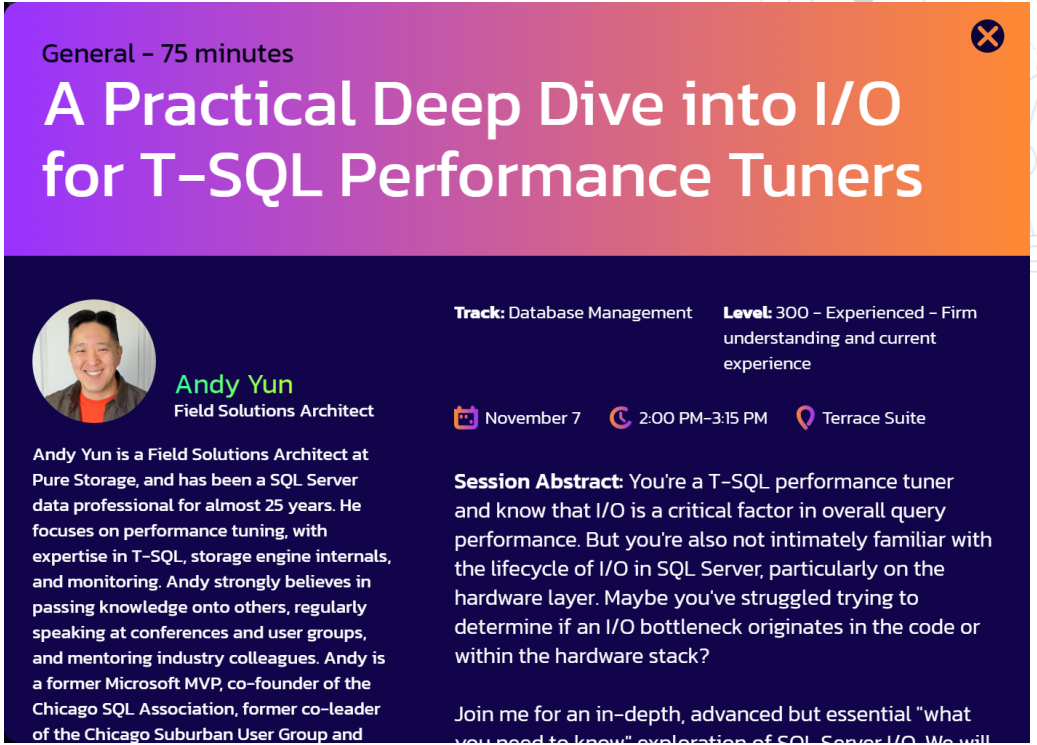
Summary

- How Reads & Writes work in SQL Server
- Perspectives from SQL Server
- Perspectives beyond SQL Server

Want To Learn Even More?

- PASS Summit
- Livestreamed!

  Nov 7 @ 2PM PST



Remember

Don’t need to know the entire hardware stack.

Do remember there are many elements in the stack needing investigation.

“Please just tune your $#%! code already”

Learn More: Resources

How to examine IO subsystem latencies from within SQL Server: Paul Randal

https://www.sqlskills.com/blogs/paul/how-to-examine-io-subsystem-latencies-from-within-sql-server/

Capturing IO latencies for a period of time: Paul Randal

https://www.sqlskills.com/blogs/paul/capturing-io-latencies-period-time/

Measuring SQL Server File Latency: Anthony Nocentino

https://www.nocentino.com/posts/2021-10-06-sql-server-file-latency/

Outside the Big SAN Box: Identifying Storage and SAN Latency in SQL Server: Kendra Little

https://littlekendra.com/2016/06/16/outside-the-big-san-box-analyzing-storage-and-san-latency-in-sql-server-dear-sql-dba/

What Virtual Filestats Do, and Do Not, Tell You About I/O Latency: Erin Stellato

https://sqlperformance.com/2013/10/t-sql-queries/io-latency

https://github.com/sqlbek

Learn More: Resources

Troubleshoot slow SQL Server performance caused by I/O issues: Microsoft CSS

https://learn.microsoft.com/en-us/troubleshoot/sql/database-engine/performance/troubleshoot-sql-io-performance

VMware Storage Queue Tuning: David Klee

https://www.youtube.com/watch?v=jZrQarlMWTI

Understanding log buffer flushes: Itzik Ben-Gan

https://sqlperformance.com/2018/11/sql-performance/understanding-log-buffer-flushes

Top 5 Misleading SQL Server Performance Counters: Kendra Little

https://littlekendra.com/2017/06/05/top-5-misleading-sql-server-performance-counters/

Sequential Throughput Speeds and Feeds: Glenn Berry

https://sqlperformance.com/2014/12/io-subsystem/sequential-throughput-speeds-and-feeds

https://github.com/sqlbek

Learn More: Resources

It’s not you, it’s me (I/O troubleshooting): Monica Rathbun

https://sqlperformance.com/2017/04/sql-performance/its-not-you-its-me

Knee-Jerk PerfMon Counters : Page Life Expectancy: Paul Randal

https://sqlperformance.com/2014/10/sql-performance/knee-jerk-page-life-expectancy

Knee-Jerk Wait Statistics: PAGEIOLATCH_SH: Paul Randal

https://sqlperformance.com/2014/06/io-subsystem/knee-jerk-waits-pageiolatch-sh

Monitoring SQL Server Without Breaking the Bank: Gianluca Sartori

https://www.youtube.com/watch?v=VRo3FziwXVA

Lets Dive Into SQL Server I/O To Improve T-SQL Performance: Andy Yun

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https://github.com/sqlbek

Thank You!

Any Questions?

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https://sqlbek.wordpress.com
https://github.com/sqlbek

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