

Virtualisation* and SAN Basics for DBAs

*See, I used the “S” instead of the zed. I’m pretty smart for a foreigner.

Brent Ozar - @BrentO



BrentOzar.com/go/san

BrentOzar.com/go/virtual



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SAN Storage Best Practices for SQL Server

Using SQL Server on SAN storage doesn't always guarantee fast performance. Before the SQL Server installation starts, you need to get the SAN configuration right. Here's my posts on how to get things started right.

How to Configure Your SAN Storage for SQL Server

Database administrators usually see the SAN as a black box. We ask the SAN administrators for a few arrays, and they just ask us what size we need. Configuring storage for SQL Server is more complex than other applications, but thankfully we've got a lot of help. Your SAN vendor has already put a lot of work into documenting how to set up arrays on your SAN controller specifically for SQL Server. Here's the most common vendor document repositories:

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UPCOMING EVENTS

Today's Agenda

- ◆ How Virtualisation Changes:
 - ◆ CPU
 - ◆ Memory
 - ◆ Monitoring
- ◆ SAN
 - ◆ Specific Guidelines
 - ◆ General Guidelines



Virtualisation is not here
to make things **faster**.

Virtualisation is here
to make things **cheaper**.

Cheaper Can Mean:

- ◆ Less hardware
- ◆ Less software
- ◆ Less licensing
- ◆ Less management time

The SQL Server DBA's Role

- ◆ Embrace cheaper and easier
- ◆ Work within virtualisation's rules
- ◆ Work around the hardware limits
- ◆ Try not to leave performance on the datacenter floor

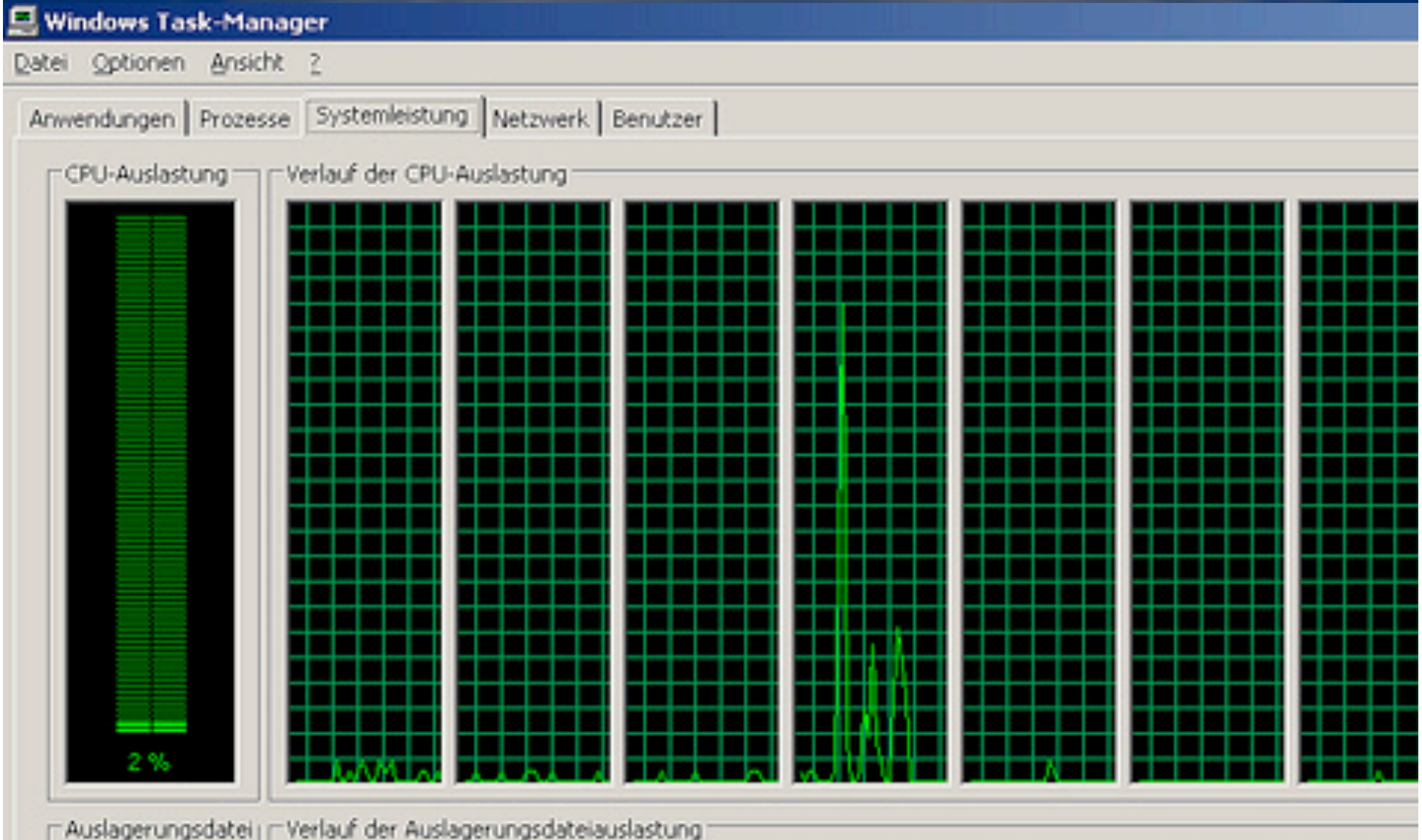
Virtualisation Changes:

- ◆ CPU (and Licensing)
- ◆ Memory
- ◆ Monitoring
- ◆ Storage
- ◆ HA/DR

CPU Pop Quiz

What % CPU average
does your CIO want to see?

You're doing it wrong.



CPU Speed A.V.M.

- ◆ How many virtual cores do we need?
- ◆ How many idle real cores are available?
- ◆ How fast is each physical core?
(Think power saving CPUs)
- ◆ Do we get the same percentage of each?
- ◆ Did we run our last instruction on the same cores?

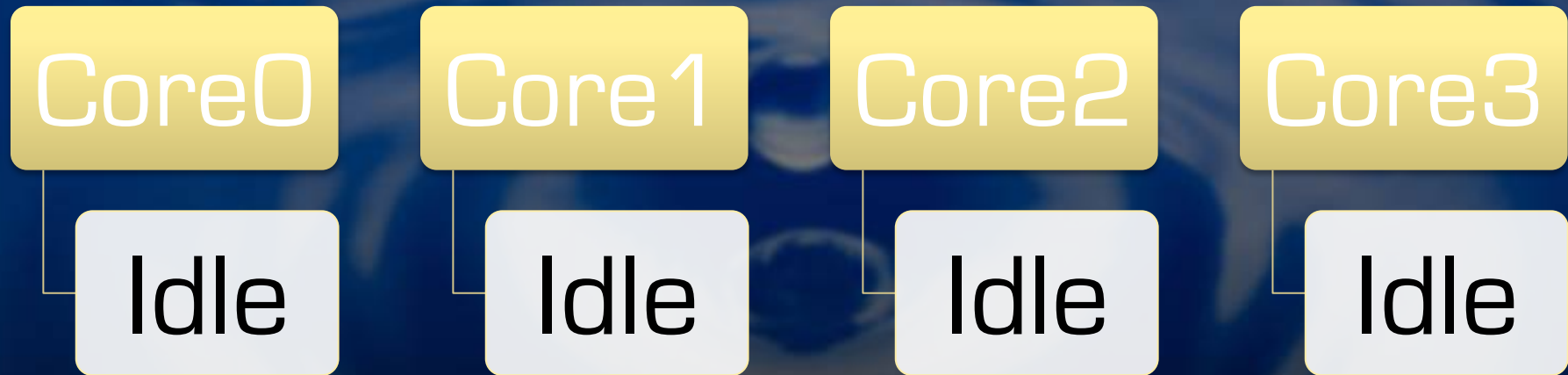
Our Scenario

- ◆ 4-core host
- ◆ Mostly sits idle
- ◆ Just two guests: SQL and APP

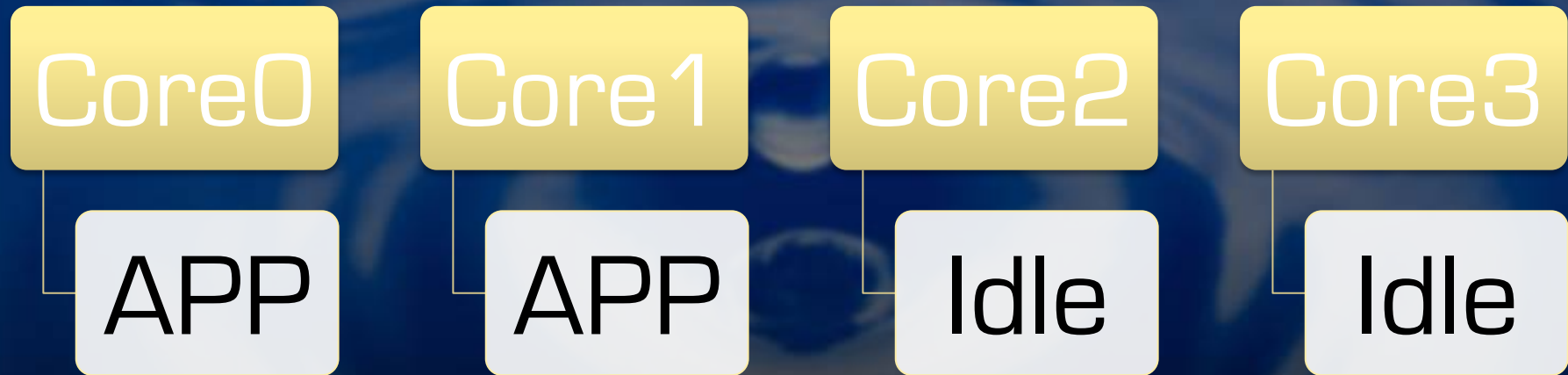
Step 1: Working



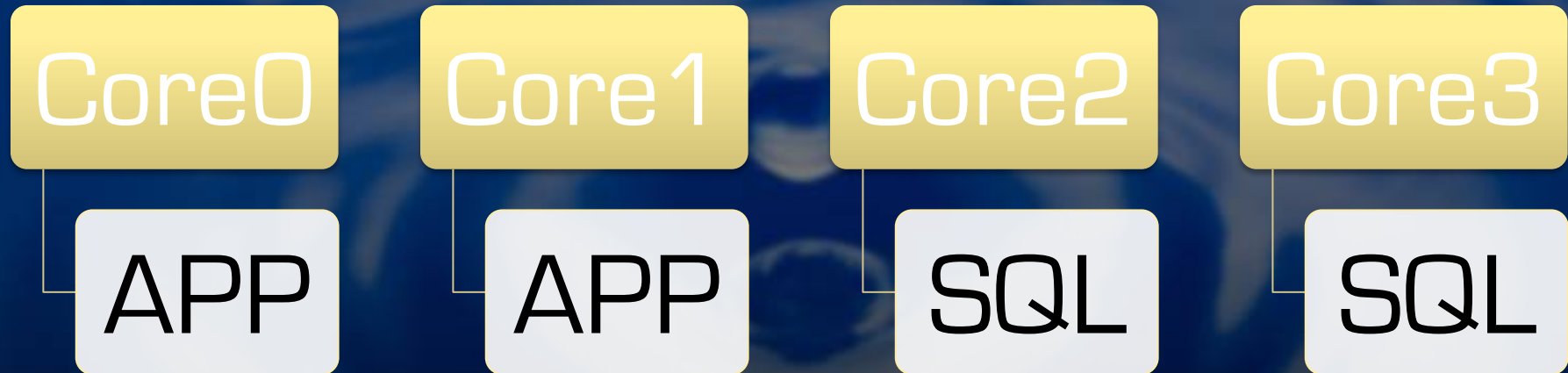
Step 1: Waiting



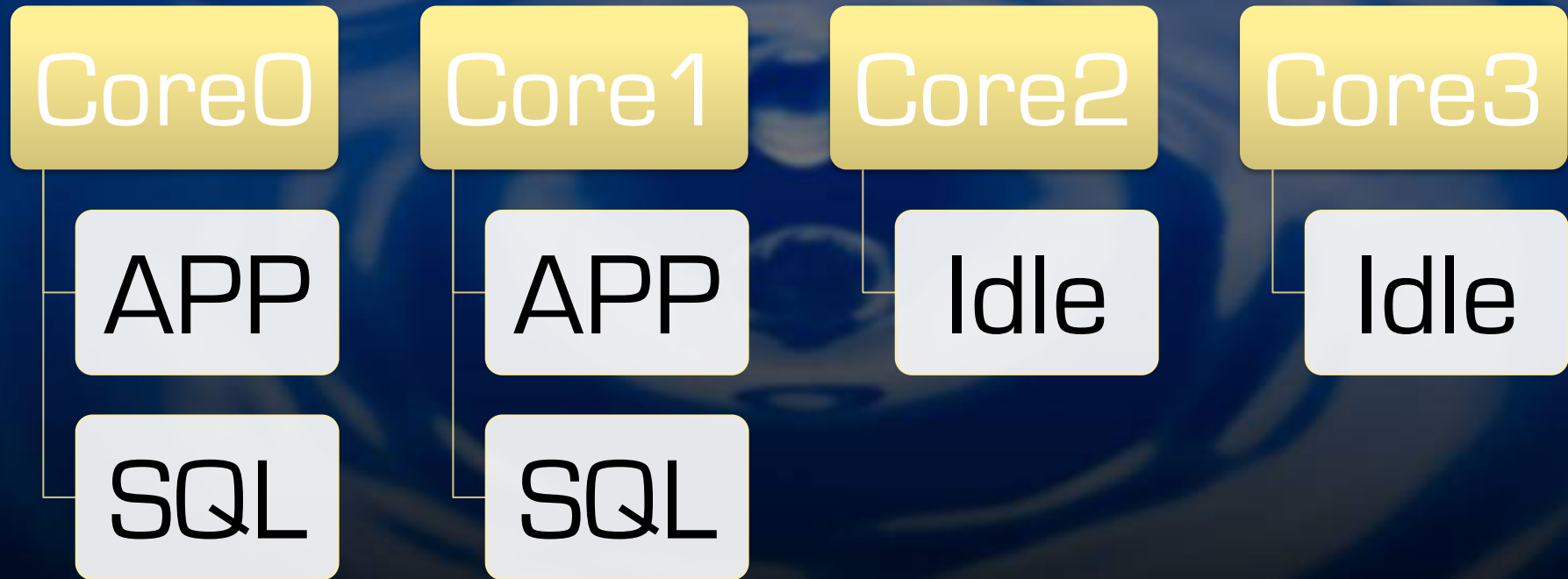
Step 2: Sharing



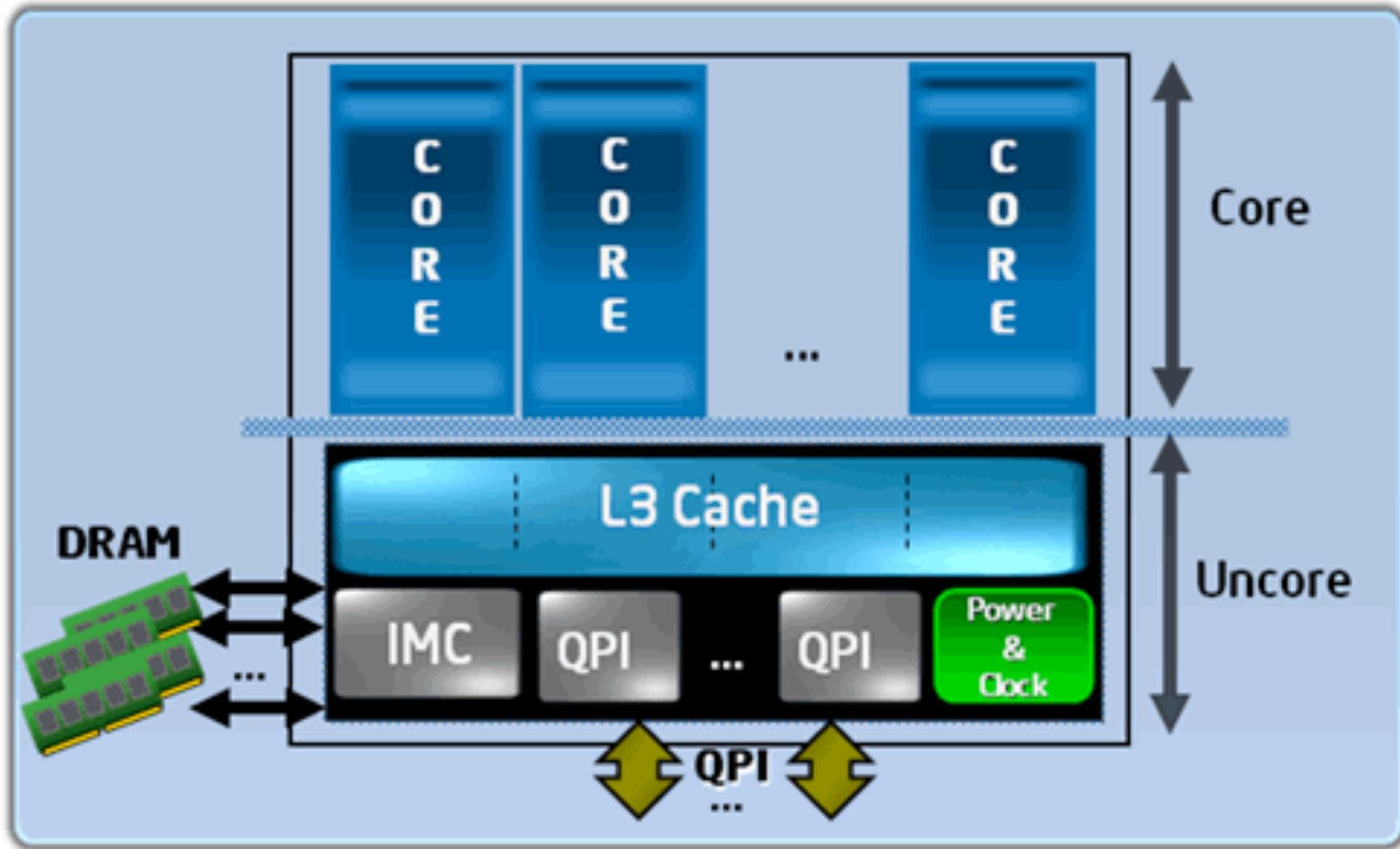
One Approach: Cache Miss



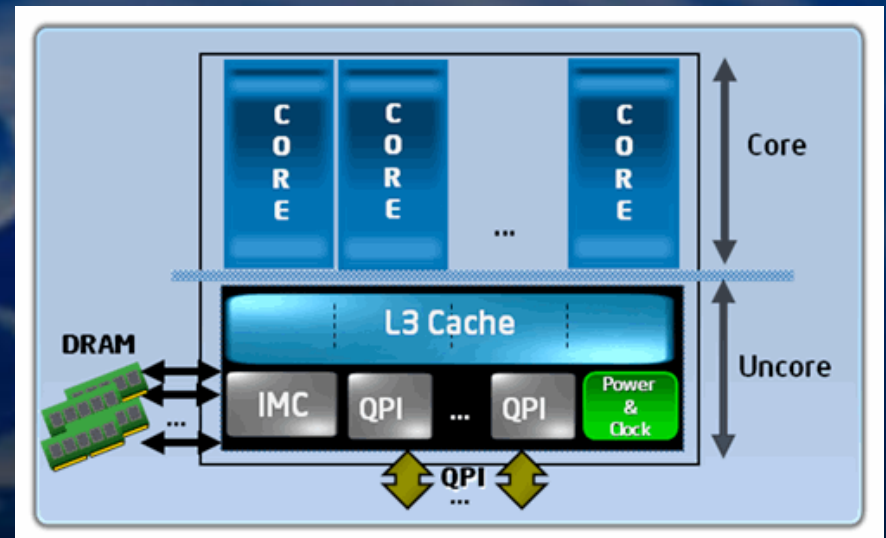
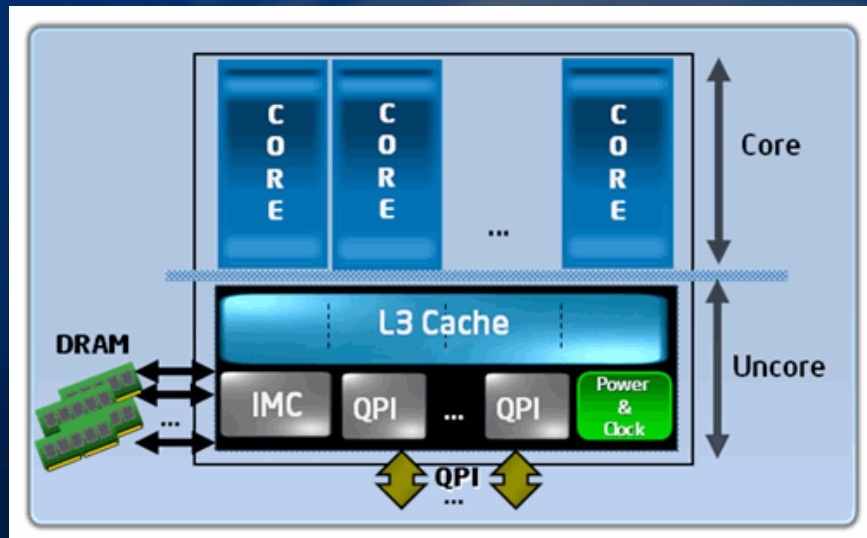
Another Approach: Wait



Many Cores, One Cache



Uh Oh...





HP Support document

» Business Support Center

HP Passport Sign-in

User ID:

Password:

» [Register](#)

» [Learn more...](#)

Go »

Tasks

- » [Download drivers and software](#)
- » [Troubleshoot a problem](#)
- » [Setup, install, and configure](#)
- » [Discover and use a product](#)
- » [Perform regular maintenance](#)
- » [Upgrade and migrate](#)
- » [Recycle and dispose](#)

» Resources

- » [Customer Self Repair](#)
- » [Diagnose problem or Chat \(HP Instant Support\)](#)
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SUPPORT COMMUNICATION - CUSTOMER ADVISORY

Document ID: c01817145

Version: 1

Advisory: HP ProLiant DL385 G5p Servers - Performance May Be Intermittently Impacted when Using the 04/01/2009 or 5/7/2009 Revision of the System ROM and iLO 2 Firmware Version 1.70, 1.75, 1.77, or 1.78

NOTICE: The information in this document, including products and software versions, is current as of the Release Date. This document is subject to change without notice.

Release Date: 2009-07-21

Last Updated: 2009-07-21

DESCRIPTION

The HP ProLiant DL385 G5p server performance may be intermittently impacted when running a version of the System ROM dated May 7, 2009 (5/7/2009) or April 1, 2009 (4/1/2009) and running HP Integrated Lights-Out 2 (iLO 2) Firmware Version 1.70, 1.75, 1.77, or 1.78.

If an HP ProLiant DL385 G5p server is using the System ROM and iLO 2 firmware versions listed above, the server may intermittently experience degraded performance. The degraded performance is caused by the processors running at the lowest power state (p-state). The processors will remain in the lowest power state regardless if the workload warrants an increase in the processor power state. After this occurs, the processor power state will never increase. The processor will display a frequency of only 800 MHz in the operating system and other utilities even if the server is under a heavy workload or if the processor p-state power management is disabled.

Note: After this condition occurs, the processor power state will not increase until the server is power-cycled or until the System ROM is updated. Rebooting the server may resolve the issue.

SCOPE

Any HP ProLiant DL385 G5p server running a version of the System ROM dated May 7, 2009 (5/7/2009) or April 1, 2009 (4/1/2009) and one of the following iLO 2 firmware versions:

Scotty! We Need More Power!

If an HP ProLiant DL385 G5p server is using the System ROM and iLO 2 firmware versions listed above, the server may intermittently experience degraded performance. The degraded performance is caused by the processors running at the lowest power state (p-state). The processors will remain in the lowest power state regardless if the workload warrants an increase in the processor power state. After this occurs, the processor power state will never increase. The processor will display a frequency of only 800 MHz in the operating system and other utilities even if the server is under a heavy workload or if the processor p-state power management is disabled.

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CPU-Z From CPUID.com

CPU-Z

CPU | Caches | Mainboard | Memory | SPD | Graphics | About

Processor

Name	Intel Core i5 2400		
Code Name	Sandy Bridge	Brand ID	
Package	Socket 1156 LGA		
Technology	32 nm	Core Voltage	1.680 V
Specification	Intel(R) Core(TM) i5-2400 CPU @ 3.10GHz (ES)		
Family	6	Model	A
Ext. Family	6	Ext. Model	2A
Instructions	MMX, SSE (1, 2, 3, 3S, 4.1, 4.2), EM64T, VT-x, AES, AVX		

Clocks (Core #0)

Core Speed	3092.9 MHz
Multiplier	x 31.0 (16 - 31)
Bus Speed	99.8 MHz
Rated FSB	

Cache

L1 Data	4 x 32 KBytes	8-way
L1 Inst.	4 x 32 KBytes	8-way
Level 2	4 x 256 KBytes	8-way
Level 3	6 MBytes	12-way

Selection: Processor #1

Cores: 4 Threads: 4

CPU-Z Version 1.55.2

Validate OK

VM SQL CPU Best Practices

- ◆ Use the newest version of hypervisor
- ◆ Minimize number of virtual cores
- ◆ Check CPU speeds & cache with CPUID
- ◆ Strip out unnecessary virtual hardware
 - ◆ Floppy drives, CD drives, etc
- ◆ Remove all background services
 - ◆ Screen savers, Acrobat, file sync tools, antivirus(?)
- ◆ Monitor for throttling, other guests
- ◆ Avoid affinity masking

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 - ◆ **Memory**
 - ◆ Monitoring
- ◆ SAN
 - ◆ Specific Guidelines
 - ◆ General Guidelines

Memory Pop Quiz



Exactly how much memory
does your SQL Server need?

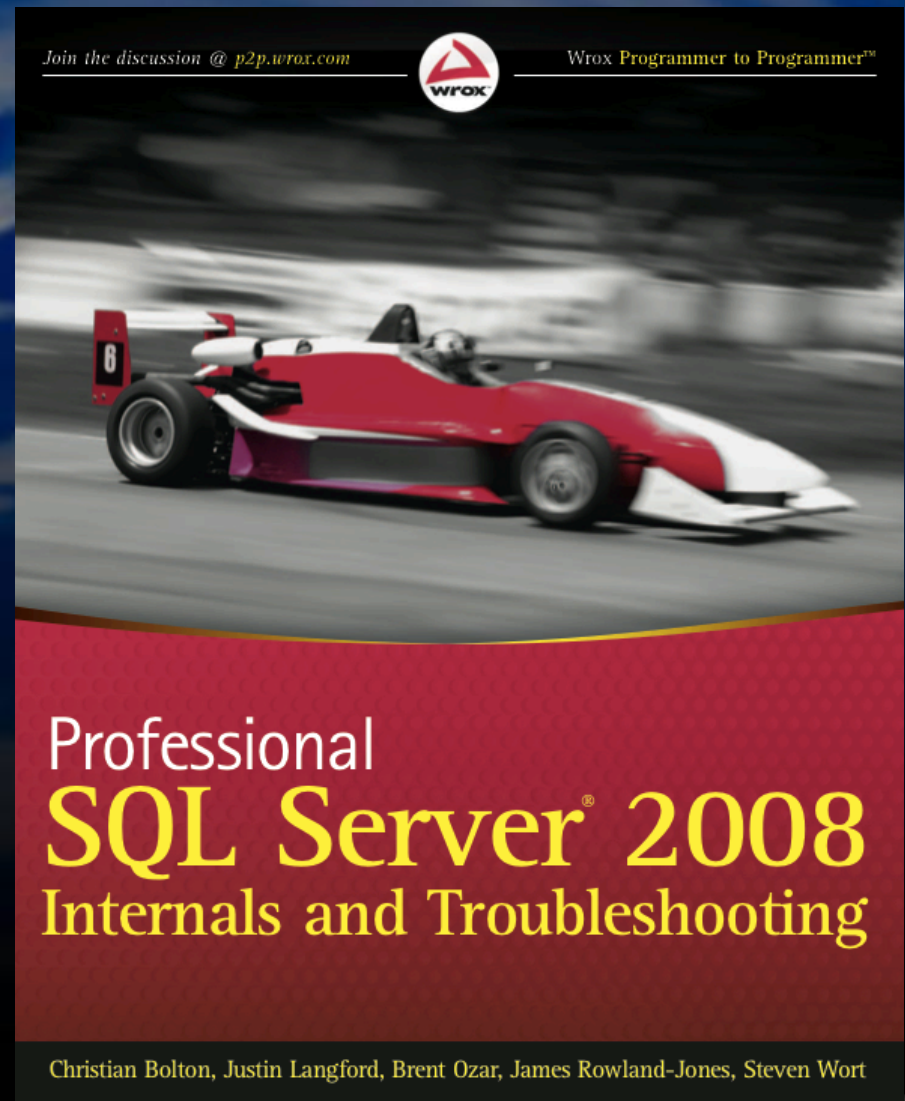
We suck at this.



©SQLskills.com 2010 Photo Source: <http://www.flickr.com/photos/trojanguy/3361498441/>

Shameless Plug: See Page 50

- ◆ Perfmon Memory Manager Counters:
 - ◆ Total Server Memory (KB)
 - ◆ Target Server Memory (KB)
- ◆ Buffer pool only
- ◆ If Target > Total, there's memory pressure.



How the Magic Happens

- ◆ Hypervisor dedupes, compresses memory (VM, XS prototype)
- ◆ Balloon driver fakes memory pressure (HV, VM, XS)
- ◆ Worst case scenario: host page file (VM)

VMware RAM Best Practices

- ◆ VMware:
 - ◆ Set a memory reservation
 - ◆ Set SQL's min/max memory appropriately
- ◆ MS Hyper-V:
 - ◆ Avoid dynamic memory for SQL Servers today (works great for virtual desktops though)

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New Perfmon Counters

- ◆ VMware ESX 3.5 – manual download
- ◆ VMware vSphere 4.0 – built in
- ◆ No extra permissions required
- ◆ Most VMware sysadmins don't even know about them

VM Processor Counters

- ◆ % Processor Time
- ◆ Host Processor Speed (MHz)
- ◆ Limit (MHz)
- ◆ Reservation (MHz)

VM Memory Counters

- ◆ Memory Limit (MB)
- ◆ Memory Reservation (MB)
- ◆ Memory Ballooned (MB)
- ◆ Memory Swapped (MB)
- ◆ Just for curiosity:
 - ◆ Memory Shared (MB)
 - ◆ Memory Shared Saved (MB)

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 - ◆ General Guidelines



Who trusts their
SAN administrators?

A blue background with a water droplet creating ripples. The droplet is in the center, and the ripples spread outwards. The text is white and positioned in the lower half of the image.

Know who else
doesn't trust SAN admins?



Your SAN vendor.



Country/region [select]

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IBM Midrange System Storage Implementation and Best Practices Guide

An IBM Redbooks publication



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Abstract

This IBM® Redbooks® publication represents a compilation of best practices for deploying and configuring IBM Midrange System Storage™ servers, which include the DS4000® and the DS5000 family of products. This book is intended for IBM technical professionals, Business Partners, and customers responsible for the planning, deployment, and maintenance of the IBM Midrange System Storage family of products. We realize that setting up DS4000 and DS5000 Storage Servers can be a complex task. There is no single configuration that will be satisfactory for every application or situation.

First, we provide a conceptual framework for understanding the hardware in a Storage Area Network. Then we offer our guidelines, hints, and tips for the physical installation, cabling, and zoning, using the Storage Manager setup tasks. After that, we turn our attention to the performance and tuning of various components and features, including numerous guidelines. We look at performance implications for various application products such as DB2®, Oracle, Tivoli® Storage Manager, Microsoft® SQL server, and in particular, Microsoft Exchange with IBM Midrange System Storage servers.

Then we review the various tools available to simulate workloads and to measure, collect, and analyze performance data. We also consider the AIX® environment, including High Availability Cluster Multiprocessing (HACMP™) and General Parallel File System (GPFS™). Finally, we provide a quick guide to the storage server installation and configuration using best practices. This edition of the book also includes guidelines for managing and using the DS4000 and

This IBM® Redbooks® publication represents a compilation of best practices for deploying and configuring IBM Midrange System Storage™ servers, which include the DS4000® and the DS5000 family of products. This book is intended for IBM technical professionals, Business Partners, and customers responsible for the planning, deployment, and maintenance of the IBM Midrange System Storage family of products. We realize that setting up DS4000 and DS5000 Storage Servers can be a complex task. There is no single configuration that will be satisfactory for every application or situation.

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7.3 Microsoft SQL Server

In this section we describe various considerations for Microsoft SQL server and the Midrange Storage Subsystem environment. Review the information in 4.1, “Windows 2008” on page 126 for information specific to Windows OS. As with all guidelines, these settings must be checked to ensure that they suit your specific environment. Testing your own applications with your own data is the only true measurement.

We cover the following topics:

- ▶ Allocation unit size and SQL Server
- ▶ RAID levels
- ▶ Disk drives
- ▶ File locations
- ▶ Transaction logs
- ▶ Databases
- ▶ Maintenance plans

7.3.2 RAID levels

Redundancy and performance are required for the SQL environment.

- ▶ RAID 1 or RAID 10 must be used for the databases, tempdb, and transaction logs.
- ▶ RAID 1, RAID 5, or RAID 10 can be used for the maintenance plans.

7.3.3 File locations

As with all database applications, the database files and the transaction logs must be kept on separate logical drives and separate arrays, for best protection. Also, the tempdb and the backup area for any maintenance plans must be kept separate as well. Limit other uses for these arrays to minimize contention.

It is not a good idea to place any of the database, transaction logs, maintenance plans, or tempdb files in the same location as the operating system page file.

7.3.4 User database files

General guidelines for user database files are as follows:

- ▶ Create the databases on a physically separate RAID array. The databases are being constantly being read from and written to; therefore, using separate, dedicated arrays does not interfere with other operations such as the transaction logs, or maintenance plans. Depending upon the current size of the databases and expected growth, either a RAID 1 or RAID 10 array can give best performance and redundancy. RAID 5 can also be used, but with a slightly lower performance. Data redundancy is critical in the operation of the databases.
- ▶ Consider the speed of the disk, which will also affect performance. Use the 15K RPM disks rather than 10K RPM disks. Avoid using SATA drives for the databases.
- ▶ Spread the array over many drives. The more drives that the I/O operations are being sent to, the better the performance. Keep in mind that best performance is between 5 to 12 drives.

Midrange storage array settings: Use the following settings, as appropriate:

- ▶ Segment size 64 K or 128 K (dependent on I/O profile)
- ▶ Read cache on
- ▶ Write cache on
- ▶ Write cache with mirroring on
- ▶ Read ahead multiplier enabled (1)



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- [HP LeftHand Documentation for SQL Server](#) – unfortunately, HP doesn't have the best navigation for their support docs, so this link goes straight to Google, which makes searching HP's documentation easier.
- [IBM SAN Storage Redbooks for SQL Server](#) – IBM calls their best technical documents Redbooks.
- [NetApp SQL Server Resource Guide](#) – those are NetApp's favorite documents. For a complete list, check out the [NetApp Technical Library](#).

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UPCOMING EVENTS

[Sept 30-Oct 2 – SQLBits](#) - York, UK - doing sessions on virtualization & storage.

[Nov 8-11 - PASS Summit](#) - Seattle, WA - doing sessions on virtualization & professional development.

[More Upcoming Events](#)



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DS4800, WP101126, **SQL Server** 2005 with **IBM** System Storage™ DS8000 & DS4000 **Best Practices** Guide, 11/03/2007, David Hartman ...[www-03.ibm.com/support/techdocs/.../WP-ByProduct?...4...](#) - [Cached](#)

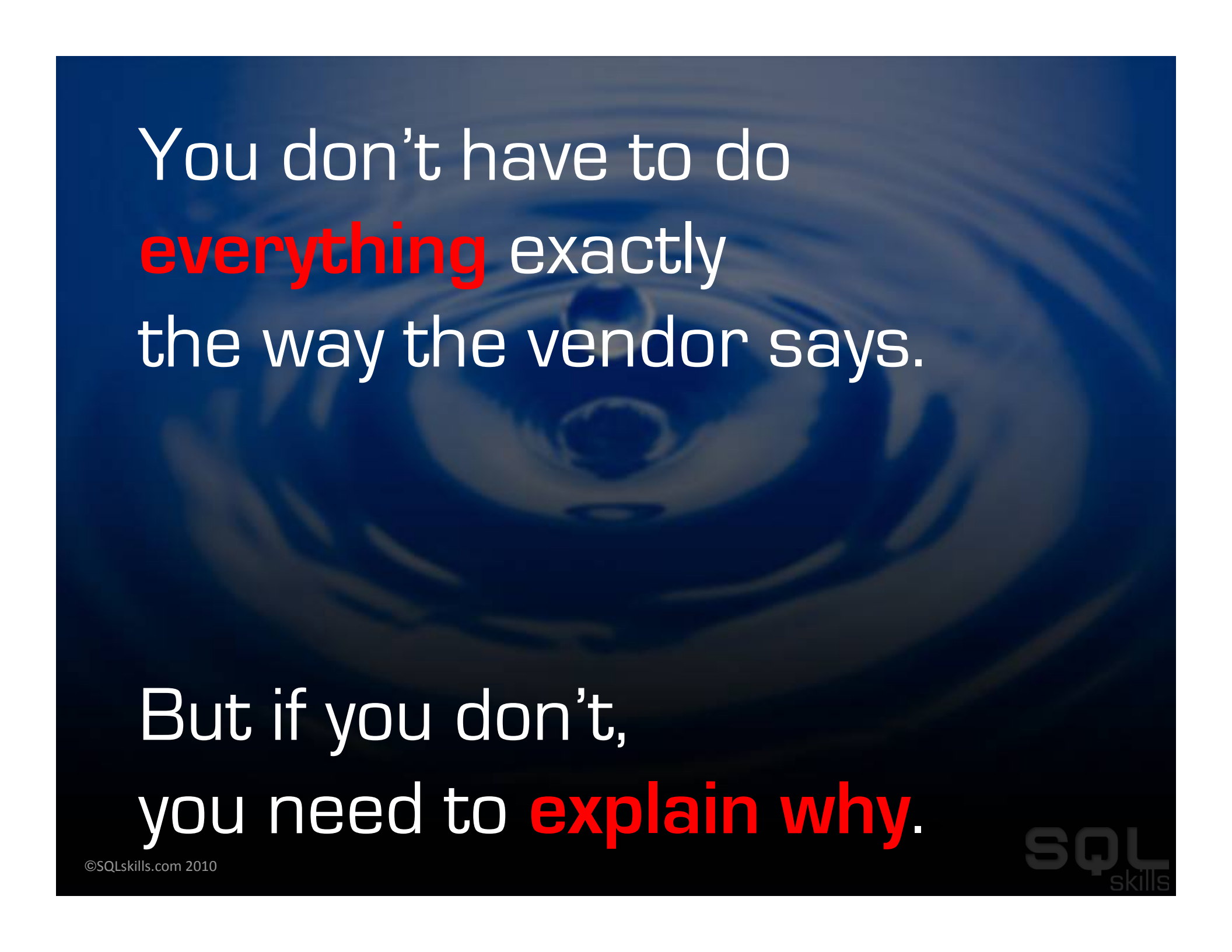
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DS4800, WP101491, **SQL Server** 2008 with **IBM** System Storage™ DS8000, DS5000, and DS4000 **Best Practices** Guide, 06/08/2009, David Hartman ...[www-03.ibm.com/support/techdocs/.../WP-ByProduct?...4...](#) - [Cached](#)

[\[PDF\] IBM Midrange System Storage Implementation and Best Practices Guide](#)

File Format: PDF/Adobe Acrobat

5.5 iSCSI SAN boot for RHEL5.3 on **IBM** system x servers 7.3 Microsoft **SQL Server** 11.5 SVC with DS4000/DS5000 **best practices**[www-03.ibm.com/techdocs/toc/6-04000.pdf](#) - [Cached](#)



You don't have to do
everything exactly
the way the vendor says.

But if you don't,
you need to **explain why**.

Sample TempDB Section

- ▶ The speed of the disk will also affect performance. Whenever possible, use the 15K rpm disks rather than 10K rpm disks. Avoid using SATA drives for the transaction logs.
- ▶ Set the original size of the transaction log file to a reasonable size to prevent the file from automatically expanding as more transaction log space is needed. As the transaction log expands, a new virtual log file is created, and write operations to the transaction log wait while the transaction log is expanded. If the transaction log expands too frequently, performance can be affected.
- ▶ Set the file growth increment percentage to a reasonable size to prevent the file from growing by too small a value. If the file growth is too small compared to the number of log records being written to the transaction log, then the transaction log might need to expand constantly, affecting performance.
- ▶ Manually shrink the transaction log files rather than allowing Microsoft SQL Server to shrink the files automatically. Shrinking the transaction log can affect performance on a busy system due to the movement and locking of data pages.

COALESCE

- ◆ Takes first non-null value
- ◆ `SELECT COALESCE(Field1, Field2, Field3)`
 - ◆ Field1 = null, Field2 = null, Field3 = 'Brent'
Return value will be 'Brent'
 - ◆ Field1 = null, Field2 = 'Rob', Field3 = 'Brent'
Return value will be 'Rob'

How SAN Guidelines Really Work

```
SELECT COALESCE(  
    YourTestedAndProvenSetting,  
    VendorGuideline,  
    GeneralGuideline)  
    AS WhatToDo  
FROM dbo.Internet  
WHERE source = 'Trusted'
```


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RAID 5 and RAID 10



General RAID Guidelines

- ◆ RAID 10 everywhere you can afford it
- ◆ When you can't it, RAID 5* in this order:
 - ◆ TempDB data files
 - ◆ TempDB log files
 - ◆ User database data files
 - ◆ User database log files
 - ◆ Backup target
- ◆ Avoid RAID 0, not even for TempDB, unless you are okay with an outage.

RAID 0, 5, 10 Explained

◆ RAID 0:

- ◆ Only one copy of your data, spread out across a lot of drives
- ◆ Lose one drive, and you must restore

◆ RAID 10:

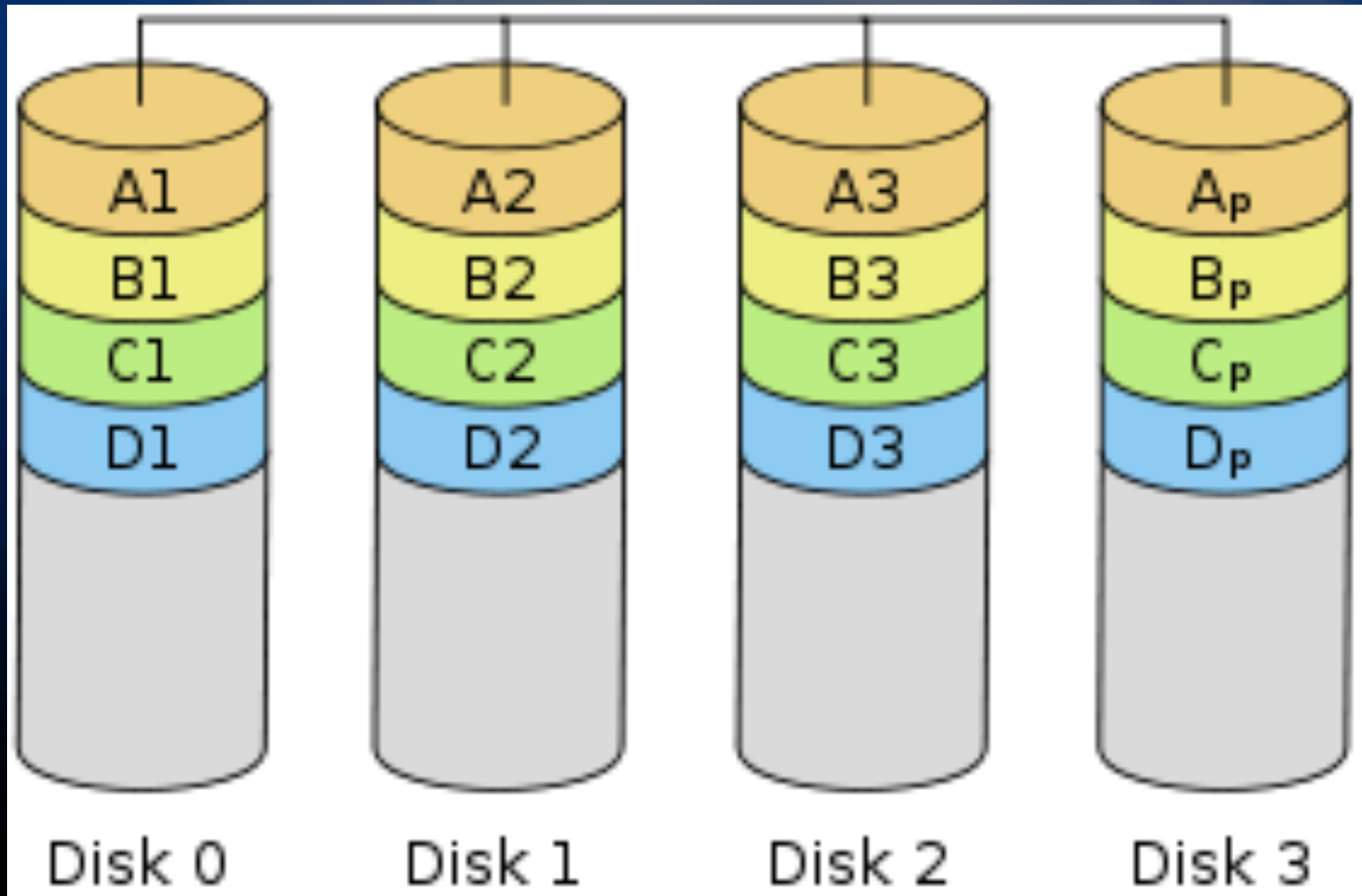
- ◆ Two copies of your data

◆ RAID 5:

- ◆ Only one copy of your data, but there's an extra drive for parity*
- ◆ Lose one drive, and it'll rebuild w/a spare drive
- ◆ Lose two drives, and you must restore

* - before you raise your hand and say I'm wrong, smart guy, lemme finish. I'm teaching this slowly – I'll explain 3 slides later.

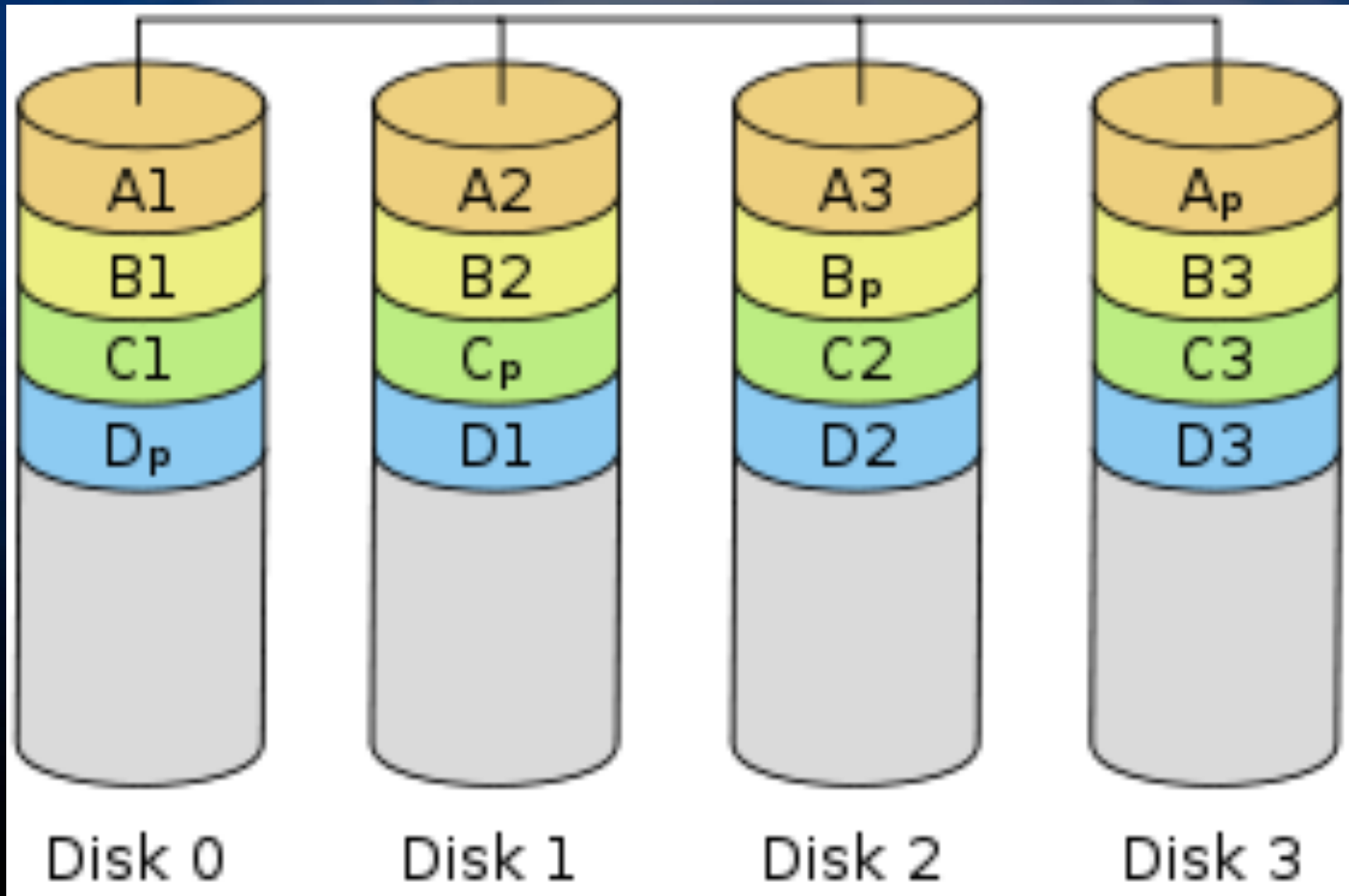
Why RAID 5 Has Slower Writes



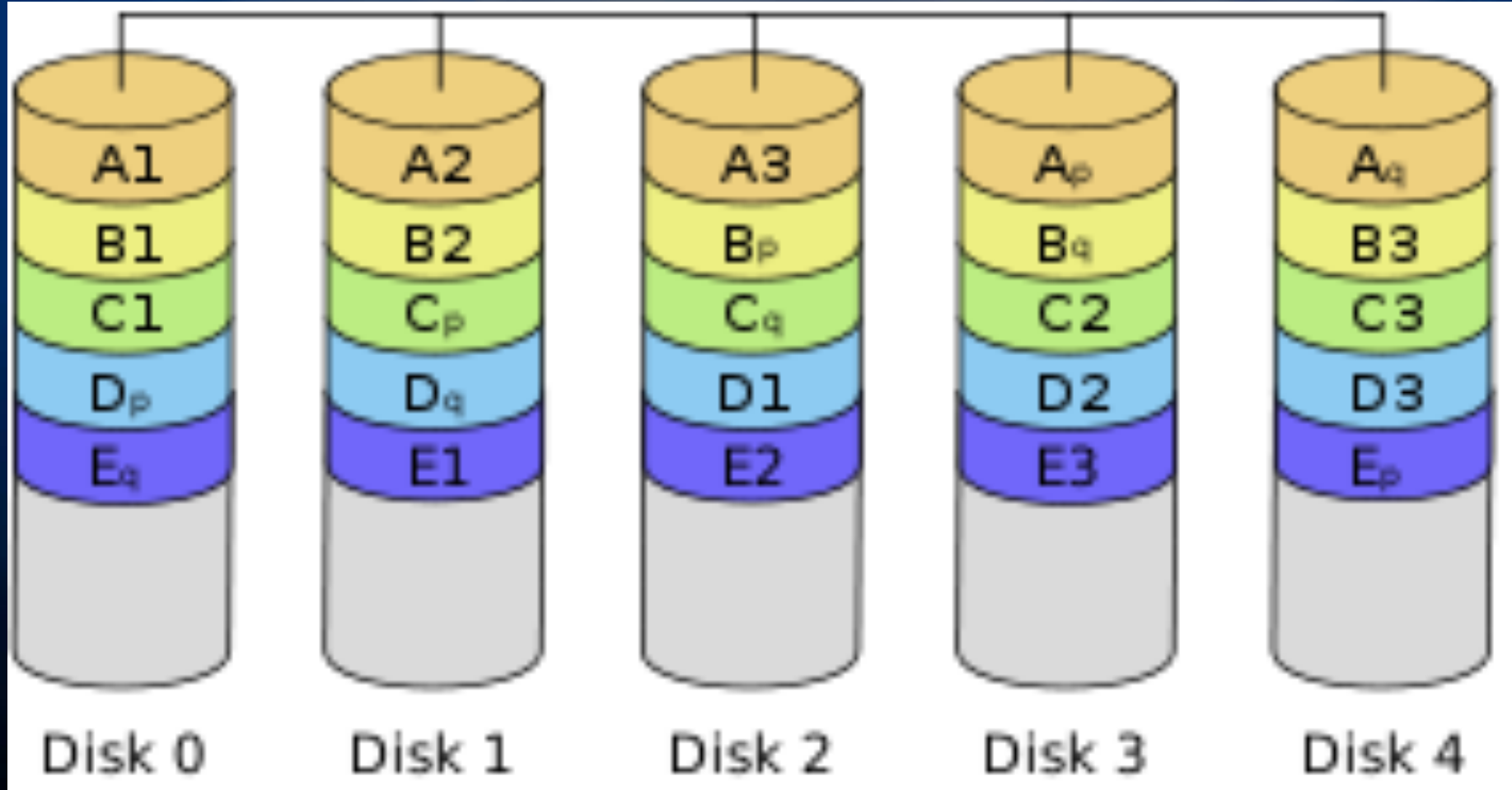
Way Oversimplified Parity

- ◆ Drive A Sector 1 = "100"
- ◆ Drive B Sector 1 = "150"
- ◆ Drive C Sector 1 = "50"
- ◆ Parity = "300"

How RAID 5 Really Works



RAID 6: RAID 5 with Extra Parity



If you have ten 1TB drives to use:

RAID 5:

- ◆ One copy of your data, less one drive for parity
- ◆ **9TB** of usable space

RAID 10:

- ◆ Two copies of your data
- ◆ **5TB** of usable space

If you need 5TB of usable space:

RAID 5:

- ◆ One copy of your data, plus one drive for parity
- ◆ **6 hard drives** required

RAID 10:

- ◆ Two copies of your data
- ◆ **10 hard drives** required

General Shared vs Dedicated

- ◆ Shared Arrays:
“Should I use one big pool of drives shared between lots of servers, or dedicate specific drives to specific servers?”
- ◆ Shared LUNs (Drive Letters):
“Should I put my data and log files on the same drive letter?”

Shared vs Dedicated Arrays

- ◆ If you have all these, dedicated is OK:
 - ◆ A trusted SAN admin
 - ◆ SAN performance monitoring software
 - ◆ Correctly configured active/active multipathing
 - ◆ More than a terabyte of data in one database
- ◆ If not, consider a **big** shared pool of drives.
 - ◆ Share pools with dissimilar server load types, not similar load types & times
 - ◆ Know your neighbor's backup & virus scan times

Shared vs Dedicated LUNs

- ◆ LUN = Windows drive letter*
- ◆ Consider data & logs on same LUN if:
 - ◆ You're using SAN snapshots and the mfr says to
 - ◆ It's all one big pool of drives anyway
- ◆ Consider dedicated LUNs for data & logs if:
 - ◆ You're using filegroups & partitions
 - ◆ You're considering filegroup backups
 - ◆ You can use tiered storage (SATA + FC + SSD)
 - ◆ You're going to micromanage performance (and I think that's a good thing)

General TempDB LUN Guidelines

- ◆ My default: always use a separate LUN
- ◆ May need to improve its performance separately from the user databases
- ◆ Need to avoid SAN replication for it
- ◆ My preference: one pool of SATA RAID 10 for all my SQL Server TempDBs
 - ◆ Cheap
 - ◆ Huge capacity
 - ◆ Similar load patterns

General iSCSI vs Fiber Channel

- ◆ Use the fastest interface you can:
 - ◆ 10GB iSCSI
 - ◆ 8GB Fiber
 - ◆ 4GB Fiber
 - ◆ 2GB Fiber
 - ◆ 1GB iSCSI
- ◆ The slower interface you have, the more you need multipathing.
- ◆ Know your controller's connections.
 - ◆ You can probably connect more there too.

General Purchasing Guideline

- ◆ Until you can prove your bottleneck isn't your connectivity, don't buy more drives.
- ◆ SQLIO tutorial:
<http://www.BrentOzar.com/go/sqlio>

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 - ◆ CPU
 - ◆ Memory
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You Are Here: [Home](#) » [SQL Server Articles](#) » SAN Storage Best Practices for SQL Server

SAN Storage Best Practices for SQL Server

Using SQL Server on SAN storage doesn't always guarantee fast performance. Before the SQL Server installation starts, you need to get the SAN configuration right. Here's my posts on how to get things started right.

How to Configure Your SAN Storage for SQL Server

Database administrators usually see the SAN as a black box. We ask the SAN administrators for a few arrays, and they just ask us what size we need. Configuring storage for SQL Server is more complex than other applications, but thankfully we've got a lot of help. Your SAN vendor has already put a lot of work into documenting how to set up arrays on your SAN controller specifically for SQL Server. Here's the most common vendor document repositories:

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