

SQLIntersection PRECON03

Developer's Guide to Database Operations

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BRENT OZAR DOUG LANE JES BORLAND KENDRA LITTLE JEREMIAH PESCHKA

A cartoon illustration of the five speakers: Brent Ozar, Doug Lane, Jes Borland, Kendra Little, and Jeremiah Peschka. They are all depicted with expressive, energetic poses, suggesting a lively presentation. Brent is on the far left in a red shirt, Doug is next to him in a plaid shirt, Jes is in the center with arms raised in a red shirt, Kendra is to his right in a grey top with a red scarf, and Jeremiah is on the far right in a plaid shirt.

Microsoft CERTIFIED Master SQL Servers 2008 **Microsoft CERTIFIED Professional** **Microsoft CERTIFIED Professional** **Microsoft CERTIFIED Master** SQL Servers 2008 **Microsoft CERTIFIED IT Professional** Database Developer 2008 Database Administrator 2008

MVP Microsoft Most Valuable Professional x 4 **Microsoft Partner** Silver Data Platform **amazon web services** Partner Network

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“Welcome to
HyperGlobalMegaCorp!”



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Two new developers



Dev 1



Dev B



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There's no operational practices in place and no documentation.



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Dev 1

We're not sure
what happened
to the last
developers...

The soda
here sure is
delicious!



Dev B



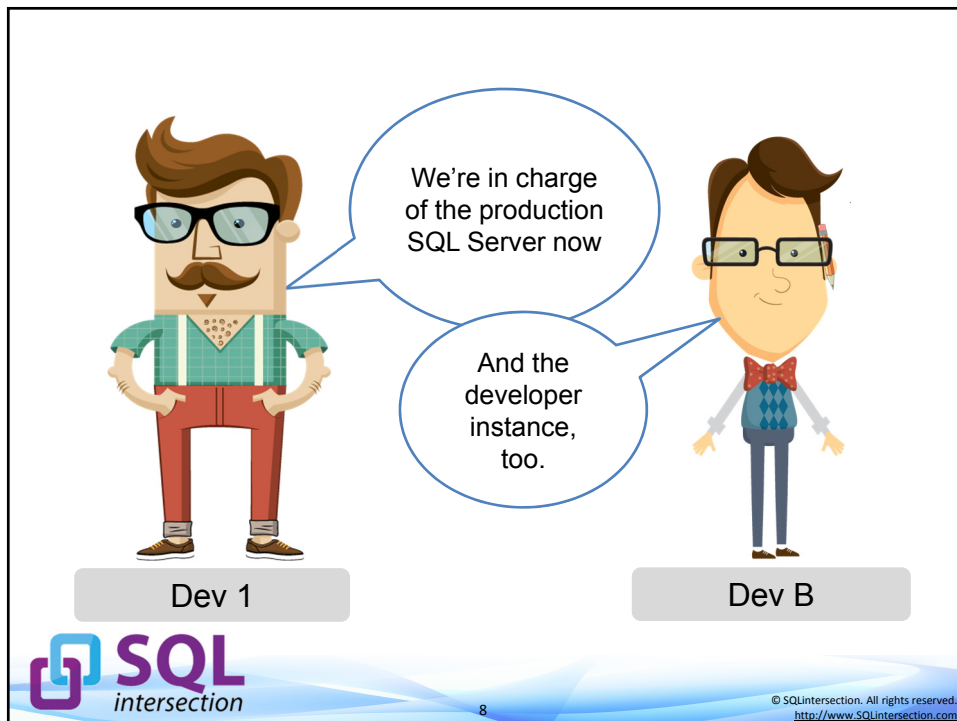
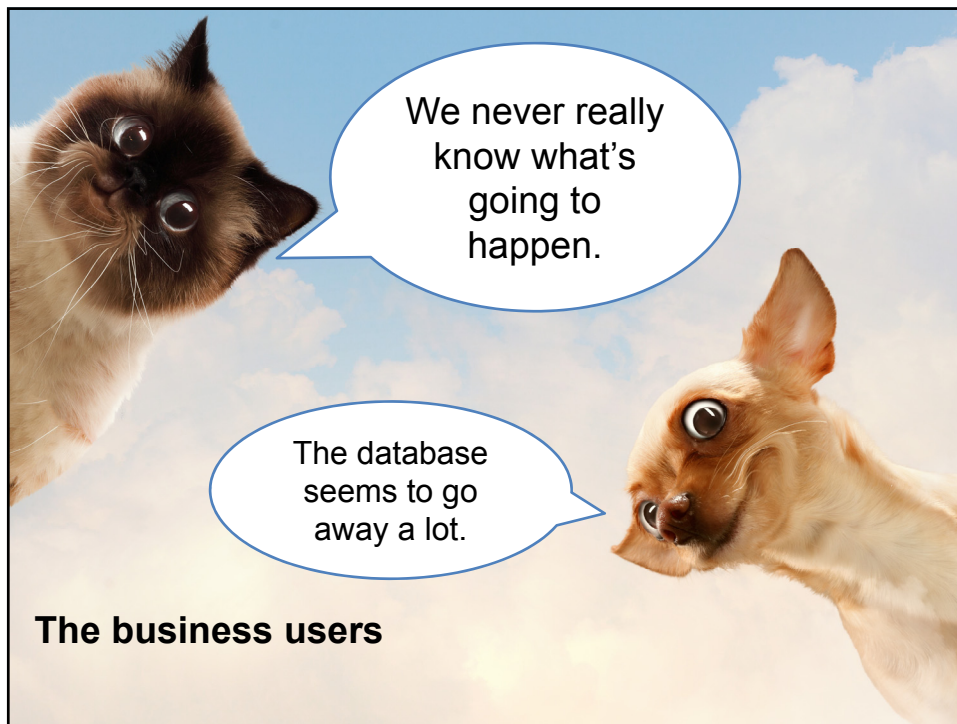
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Our mission:

It's up to us to help Dev 1 and Dev B



1. Sort out the insanity

- **Get the environment under control!**
- Identify bad settings and configuration
- Establish if anything is woefully under-provisioned or running the wrong version of software
- Make sure we have the right basic maintenance implemented
- Get a baseline of key performance indicators



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2. Build a process

- **The team shouldn't step all over each other**
- **Have an easy to follow list of**
 - Weekly tasks
 - Monthly tasks
 - Quarterly tasks
- **Avoid single points of failure**
 - Either person can take vacation at any time
- **Then start automating everything!**



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Along the way

- You'll learn
 - How to make your SQL Server faster and more reliable
 - Where to get free scripts to help you find health problems and bottlenecks
 - The knowledge to avoid common pitfalls
 - A plan to get SQL Server under control



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Links and more info:
BrentOzar.com/go/dbOps



Password:
automate

Visit within 3
months!



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Please evaluate



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Session: PRECON03

Developer's Guide to Database Operations

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



Thank you!

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Session PRECON03

Tackling an Unknown Environment

- OR -

How to apply mid 20th century
social psychology to the maintenance
of production databases

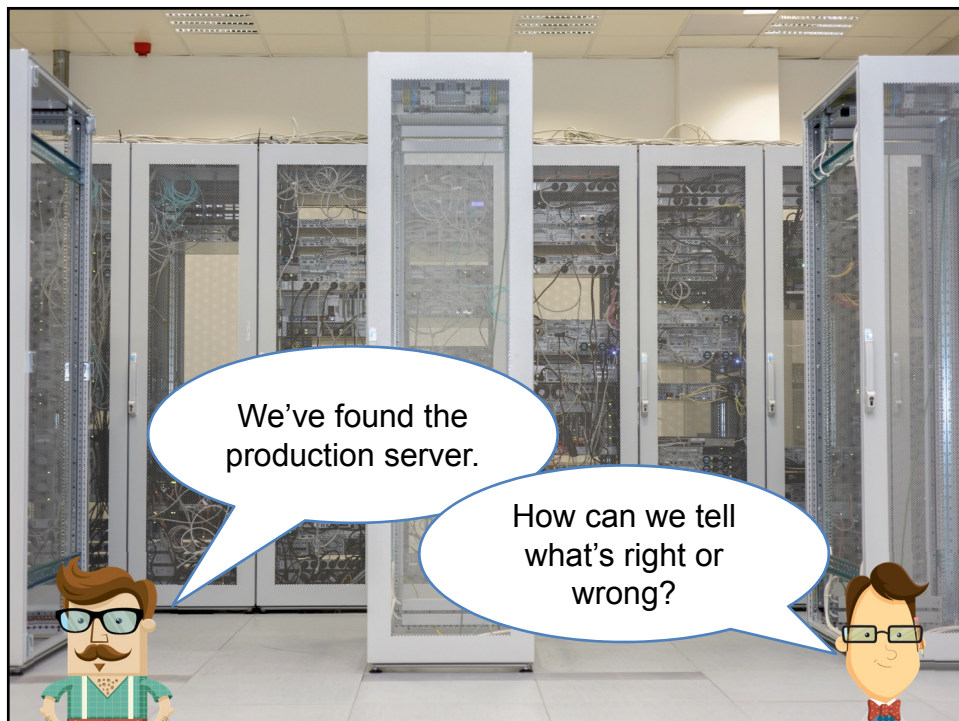
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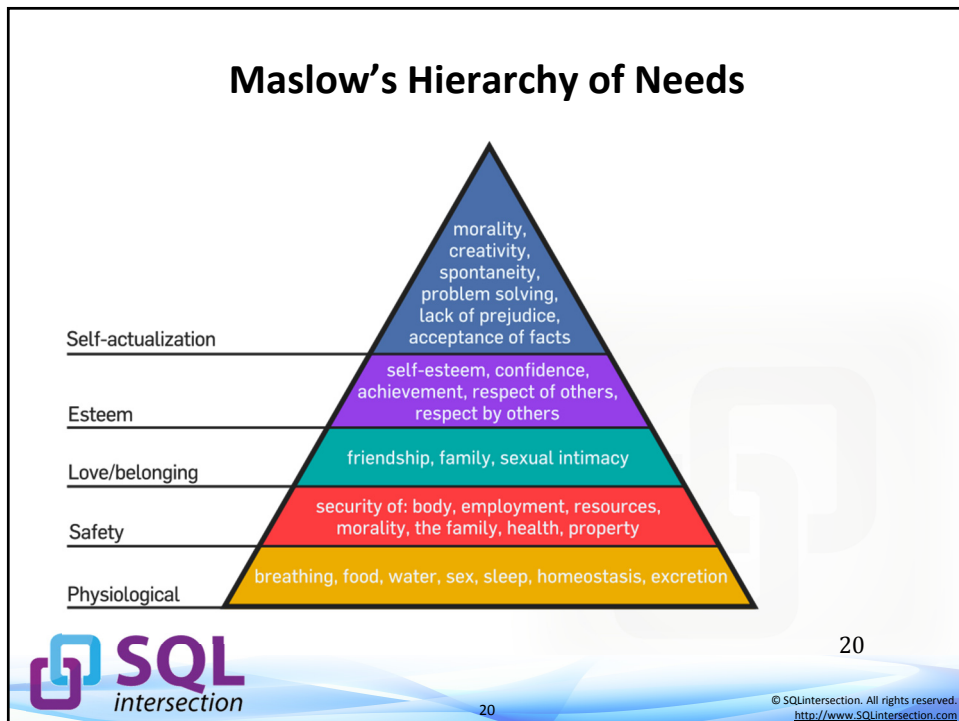
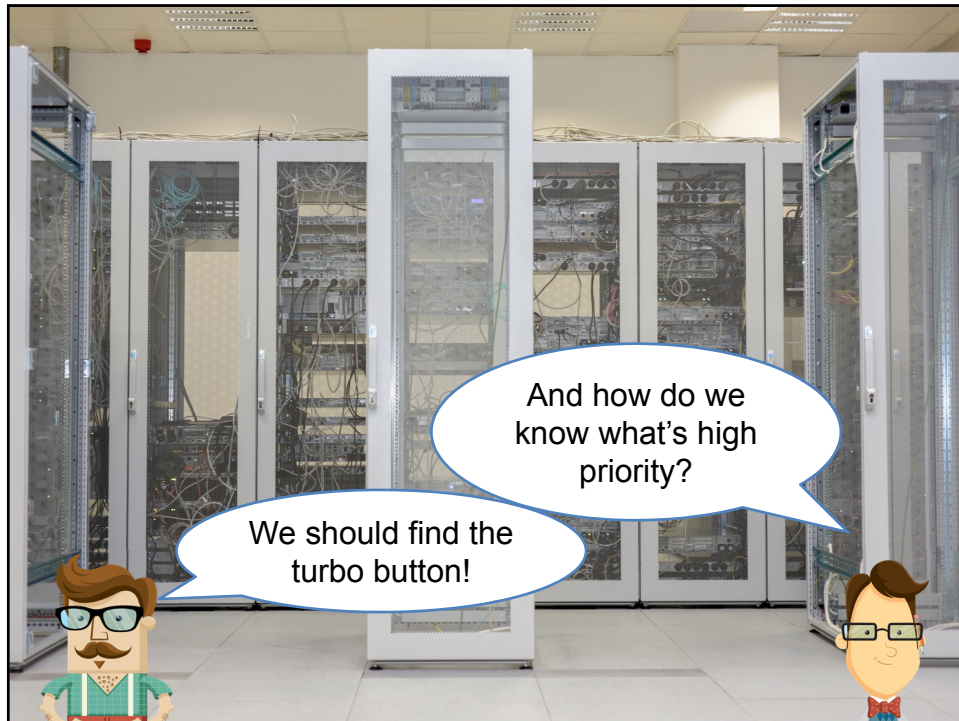
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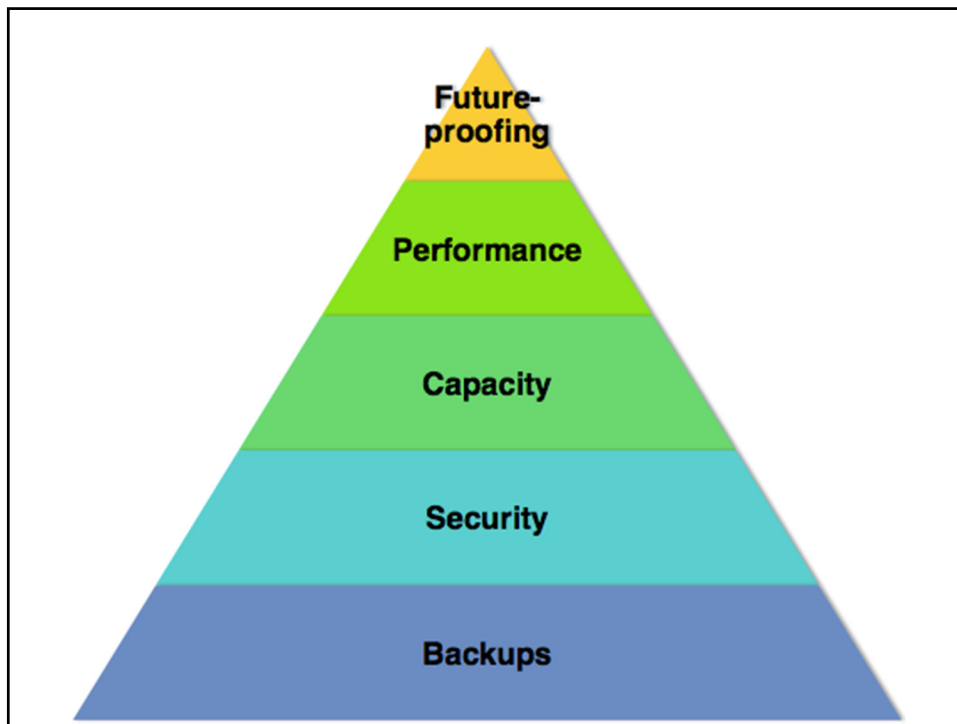
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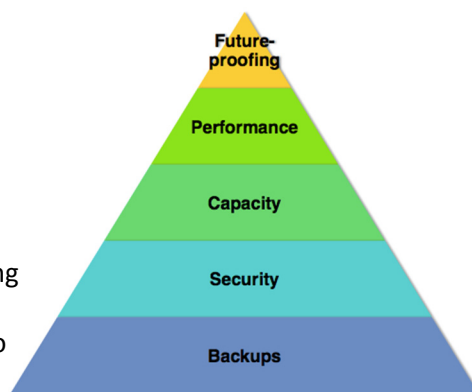
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Hierarchy of Database Needs

- **Futureproofing:** Preventing availability, security, and performance issues before they happen.
- **Performance:** Know your current bottlenecks and how to fix 'em.
- **Capacity:** Know when you're going to run out of space.
- **Security:** Know who has access to the data.
- **Backups:** You can't lose more data than the business is comfortable losing.



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Meet sp_Blitz®

Free stored procedure.

Identifies potential problems.

Creates a prioritized to-do list.

Download it at <http://brentozar.com/blitz>



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Dev 1

That sounds like exactly what we need!

Let's get started!



Dev B

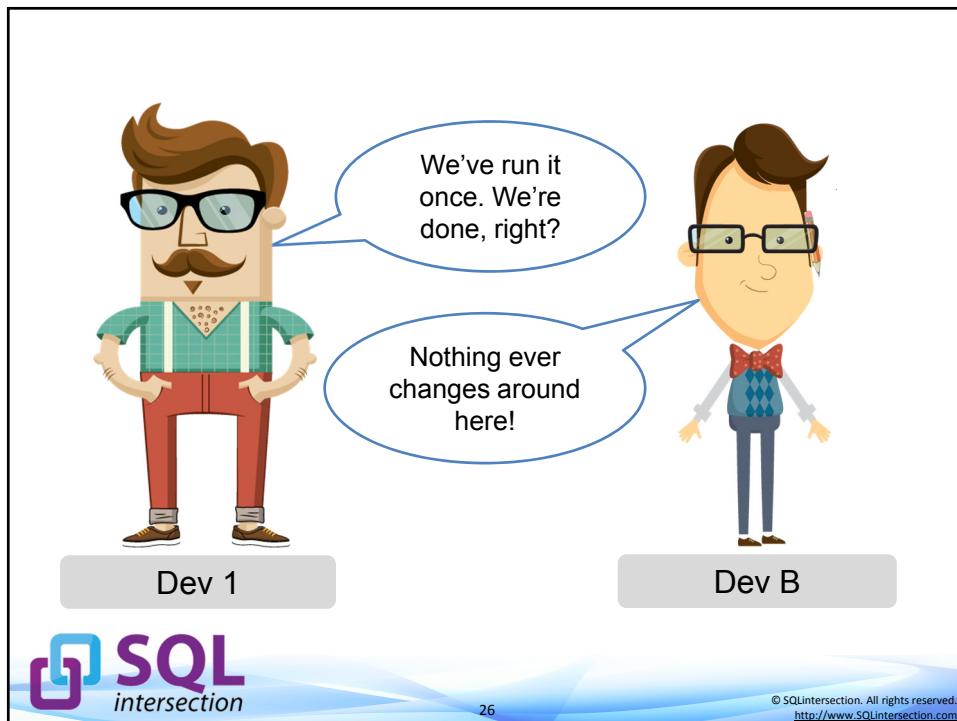


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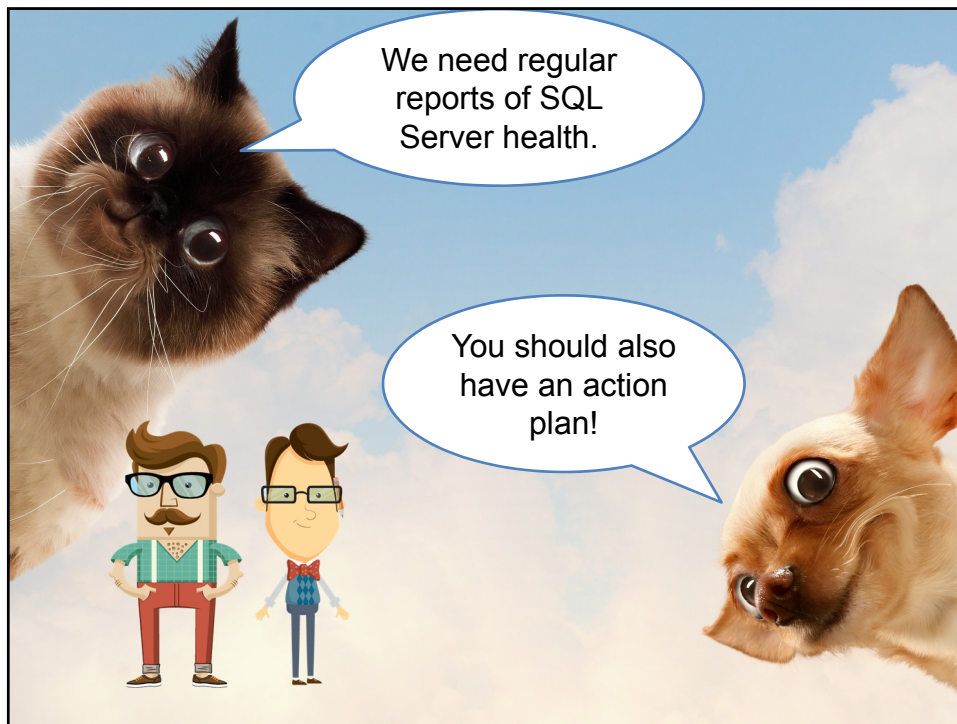
DEMO!



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Take control of your environment!

Complete?	Task	Frequency
	Automatically save sp_Blitz output to a central location.	Monthly
	Review and compare sp_Blitz® output over time • Have configuration options been changed? • Are there new administrators?	At least quarterly
	Develop an action plan based on sp_Blitz® results.	At least quarterly



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Beware Bad Technology

Kendra Little

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The developer thinks...

I should solve
problems with
code whenever
possible



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The IT Engineer thinks...

Mission critical systems
can't rely on outdated
hardware or software



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Listen to the IT Engineer

- **They have a real point here!**
- **When reliability and performance matter, you need the right:**
 - Hypervisor version (if you're using it)
 - Processor architecture
 - Memory allocation
 - Operating system
 - SQL Server Version
- **Business owners rely on YOU to monitor versions and warn of risks for old gear and old software**



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Look out for bad technology



Bad idea jeans →



Get version info fast

```
1 exec sp_Blitz @CheckServerInfo=1,  
2 @IgnorePrioritiesBelow=250;
```

Finding	Details
From Brent Ozar Unlimited	Thanks from the Brent Ozar Unlimited team. We hope you found this tool useful, and if y
Default Trace Contents	The default trace holds 1385 hours of data between Feb 3 2014 10:02PM and Apr 2 201
Drive C Space	35031.00MB free on C drive
Hardware	Logical processors: 2. Physical memory: 2GB.
Hardware - NUMA Config	Node: 0 State: ONLINE Online schedulers: 2 Processor Group: 0 Memory node: 0 Memo
Services	Service: SQL Full-text Filter Daemon Launcher (MSSQLSERVER) runs under service ac
Services	Service: SQL Server (MSSQLSERVER) runs under service account NT Service\MSSQLS
Services	Service: SQL Server Agent (MSSQLSERVER) runs under service account NT Service\S
SQL Server Last Restart	Apr 1 2014 8:43AM
SQL Server Service	Version: 12.0.1524.0. Patch Level: CTP. Edition: Enterprise Evaluation Edition (64-bit). A
Virtual Server	Type: (HYPERVISOR)
From Brent Ozar Unlimited	Thanks from the Brent Ozar Unlimited team. We hope you found this tool useful, and if y



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32 Bit Installations

- Super old processor architecture (x86 / 32 bit)
- Probably on dinosaur hardware (at risk of sudden death)
- Very different rules for tuning this processor architecture– and it doesn't scale as well
 - Identify by running:
 - If this is your SQL Server, don't try to tune it:
 - Start raising red flags



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SQL Server 2000

- **sp_Blitz® won't output full info for you– you'll find out pretty fast!**
- **You've got multiple challenges with this:**
 - Limitations to the technology's ability to scale
 - No support from Microsoft
 - Very limited tools in the market for monitoring and performance
 - No specialized training available for you
 - Limited range of operating systems
- **If performance and availability matters, you need to upgrade**



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SQL Server 2005 prior to SP4

- **End of support for this is in sight as well**
- **If you must run SQL Server 2005, you need to be on the very latest service pack**
 - It's all the Microsoft currently supports!
- **You should be regularly asking what the future will be for any servers running SQL Server 2005**



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Under-provisioned instances

- **Standard Edition Memory Limits:**
 - SQL Server 2008R2: 64GB
 - SQL Server 2012: 64GB
 - SQL Server 2014: 128GB
- **Memory is critical to performance of a SQL Server**
- **When performance matters, you should have a bare minimum of 76GB on SQL Server 2008R2 or 2012**
- **If you have Enterprise Edition or SQL Server 2014, you want more memory**

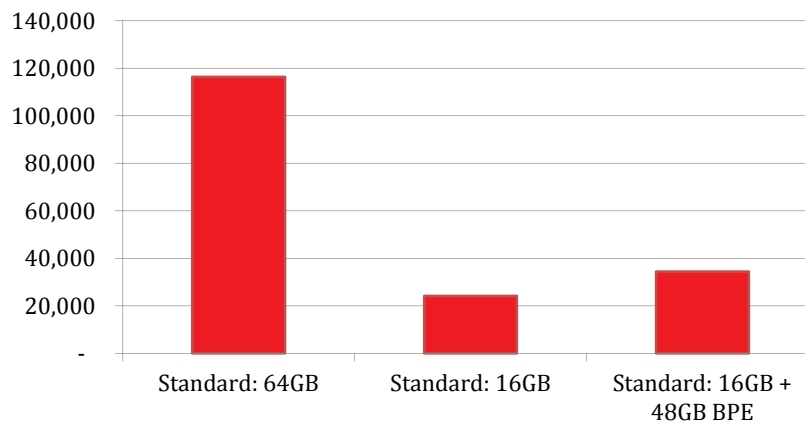


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Jeremiah's throughput scores

This is a "throw as much work at the server as you can" workload



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Avoid “stacked” instances

- **Look out for more than one SQL Server instance sharing a Windows installation**
- **They will compete for CPU and memory resources**
 - There is no good way to separate them from one another without using risky settings and putting yourself in a “1% configuration” scenario
 - Troubleshooting will be a nightmare
- **Instead: Virtualization, one instance per guest**



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Beware old hypervisors

- **Virtualization can work well, but having a recent version of your hypervisor makes a big difference**
 - CPU co-scheduling
 - NUMA node awareness for virtual machines
 - Memory and CPU limits for VMs
 - High availability features
- **VMware - vSphere should be 5 or higher**
- **Hyper-V – Windows Server should be 2012 or higher**



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Check your dependencies

Complete?	Task	Frequency
	Do you have 32 bit SQL Servers?	One Time Check
	Do you have SQL Server 2000 or prior?	One Time
	Do you have SQL Server 2005 lower than SP4?	One Time
	Identify virtualized SQL Servers using a VMware version lower than 5.0.	One Time
	Identify virtualized SQL Servers using Hyper-V lower than Windows 2012	One Time
	Identify production SQL Servers with < 72 GB of memory	One Time
	Identify SQL Servers with multiple "Stacked" instances on a single OS	One Time



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Classify the systems

- **Performance doesn't matter, but we can't kill it**
 - Make sure you won't need to change anything on the system, ever
 - These are great candidates for virtualization – the ageing hardware is a huge risk
- **"Oh, THAT database! We forgot about that!"**
 - Often small, but you can't always get rid of it
 - Can you consolidate this onto a shared instance?
- **The mystery machine**
 - Run traces to identify if it's still used



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When performance or reliability is important

- **Document:**
 - Risks of the current configuration
 - Features you could use to meet business needs with improved hardware / software
- **Look at the future:**
 - **Will this system need to exist in 5 years?**
 - **What will be the operational costs of keeping it online and performing adequately for that period of time?**
 - **Could that be reduced by improving the system?**



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Set standards by tier

Complete?	Task	Frequency
	If you have multiple SQL Servers, establish "Tiers". Examples: • Mission Critical – 24 x 7 uptime, very quick response times • Business Standard – Monday – Friday 6am-10pm uptime, 1 hour response time	Revisit at least annually
	Establish minimum configuration guidelines for each tier of servers. (Build these up over time. Start with at least standards for backups.)	Annually
	For lower tiers of servers, performance expectations should be lower and response times longer.	Annually



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Interview your virtualization admin

Which of these benefits do you have for each SQL Server Instance?	Y/N?
Cost savings at the hardware level	
Ability to move VMs between hosts	
Automatic failover when a host goes down	
Leverage extended features for Disaster Recovery	
License savings with 5-10 production SQL VMs	
Automatic load balancing across multiple hosts	

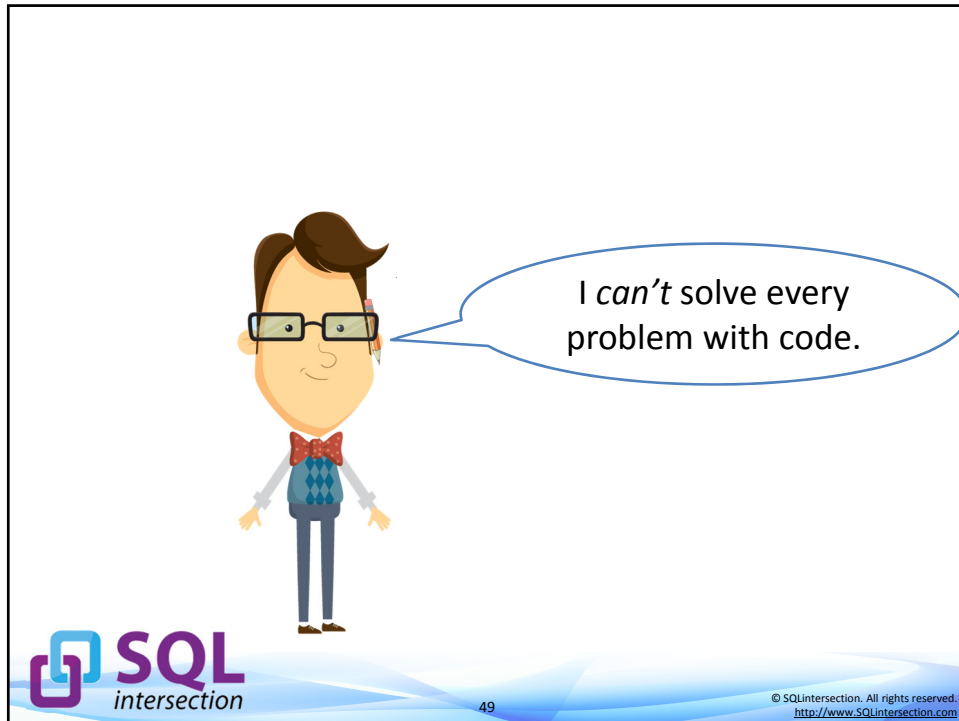
These answers may vary for each VM.



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**Do you have the right
environments?**



Budget like an IT Engineer

- **Think about the environments you need:**
 - Production
 - Pre-production (aka “staging”)
 - Disaster recovery
 - Integration
- **Isolate environments as much as possible**
(If every environment shares the same five drives in a RAID 5 configuration, how will you test anything?)



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Here's why those
environments matter...



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Outage due to Service Pack install

- **Service pack was tested and worked just fine on:**
 - Development VMs
 - Pre-production VMs
 - Least critical Production instances (non-clustered)
- **Then the service pack was applied to a critical production cluster**
 - SQL Server would not come online after failover
 - Took time to identify that the service pack had a cluster-specific issue. (Default database location was used by the patch and was set to a location the cluster could not reach—this happened on multiple clusters.)



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Lessons Learned

- **Don't have a unique OS configuration in production**
- **If you have a cluster in production, have at least ONE duplicate in Dev or Pre-Production**
- **Extend this as much as possible:**
 - Hardware (from NIC teaming to SSDs)
 - Filter Drivers
 - SQL Server version / Edition / Configuration
 - Windows version / Edition / Configuration



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Problem: Data corruption

- **SAN firmware/driver upgrade**
- **Online firmware upgrade**
- **Data corruption occurred**
 - Impacted production SQL Server database
 - Identifying and resolving the corruption took significant time



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Lessons learned

- **Don't assume everything in a SAN is redundant**
 - This is true across all vendors. (Even expensive, well supported SANs from major vendors can have outages or corruption incidents.)
 - Even when components are redundant, don't assume if one part fails it will failover to its partner seamlessly
- **Always be ready to handle data corruption, no matter what you're using for storage.**
- **Isolate upgrades to lower tier environments first whenever possible**



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PCI-Express SSD Installation

- **Sample card was purchased and tested in development environment**
 - Card performed exceptionally under load
- **Two cards were purchased for the production server**
 - Cards were mirrored using RAID 1
 - Saw repeat "15 second" IO latency errors in SQL Servers
 - Could not reproduce the errors on a single card– issues were specific to this card being mirrored when performing a certain type of writes



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Lessons learned

- **Test new technology in the configuration you will run with it – this means not going cheap on the staging server**
- **Use a wide variety of IO tests**
 - SQLIO is great, but it doesn't do everything
- **Mind your warrantee. (In our example, the cards were able to be returned.)**
- **Purchase enterprise support from the storage vendor**



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Ask *why* your environments are configured as they are

Complete?	Task	Frequency
	For production tiers of SQL Servers, do you also have: • Staging environment • Integration environment	Revisit at least annually
	Does your Staging environment “match” production? • Installation type (physical/virtual) • OS and SQL Server version • Hardware and storage • High availability features (clustering, etc) • Data transfer technologies (replication)	Annually
	How much work is it to keep environments “in sync” with one another? (Or would it be, if you had more environments?)	Annually



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We won't overhaul everything overnight.



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We have one goal



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Understand how to survive when everything goes

wrong



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**We don't know
anything right now.**

Let's get to work.



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**Step 1:
Are Backups Happening?**



“Most pilots learn,
when they go out and get in a
fighter, that the one thing you don’t
do –

**you don’t believe anything
anybody tells you about an
airplane.”**

- Chuck Yeager



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Three Ways to Check For Backups

1. Check for the last full backup
2. sp_Blitz®
3. Check for all full and log backups



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The Last Full Backup

The first question we need to ask is:

**When was the last time
we made a **complete**
copy of our data?**



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sp_Blitz®

sp_Blitz® checks to see if backups happened in the last two weeks.

Priority	FindingsGroup	Finding	DatabaseName	URL
1	Backup	Backups Not Performed Recently	AdventureWorks2012_CS	http://BrentOzar.com/go/nobak
1	Backup	Backups Not Performed Recently	AdventureWorksDW2012	http://BrentOzar.com/go/nobak
1	Backup	Backups Not Performed Recently	ContosoRetailDW	http://BrentOzar.com/go/nobak
1	Backup	Backups Not Performed Recently	master	http://BrentOzar.com/go/nobak
1	Backup	Backups Not Performed Recently	model	http://BrentOzar.com/go/nobak
1	Backup	Backups Not Performed Recently	msdb	http://BrentOzar.com/go/nobak

It also checks to see if there are database in a FULL recovery model without log backups.



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Now Check ALL Backups

- **This tells us everything about database backups.**
 - How frequently do they happen?
 - Have any backups happened off schedule?
 - Are we using a strange combination of tools?
- **You might find some odd things in here, but I doubt it.**



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DEMO



Three types of backup



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1 – Full Backup

- **A copy of the database.**
- **Includes all information from the database.**
 - Tables
 - Filegroups & Files
 - Programmability
 - Users (but not server level logins)
- **Does not include scheduled jobs or anything at the server level.**



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2 – Differential Backups

- **Captures changes since the last full backup.**
- **Benefits**
 - Can be smaller than a full backup
 - Can reduce time to restore
- **Drawbacks**
 - If you change a lot of data, the differential backup can end up the same size as the full backup.
 - Breaks the log chain – if you lose the differential, you can't restore.



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3 – Transaction Log Backup

- **A record of all changes made since the last backup.**
- **If you're in the **FULL** recovery model, these are a must.**
 - A transaction log backup resets the log file and marks the backed up transactions for re-use.
 - If you don't want transaction logs to grow, this is important!



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Step 2: Finding Maximum Data Loss



Important Details

- **We need to more details about losing data:**
 - How much data can we lose between backups?
 - How fast are backups happening?
 - How long does it take to restore each database?



How Much Data Can We Lose?

- **How can we tell?**
 - msdb.dbo.backupset
 - Examine time difference between backups
- **The difference between backup N finish and backup $N + 1$ start is the maximum data loss possible.**
 - This may vary depending on activity.



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What Causes Data Loss?

- Database corruption
- Storage failure
- Server failure
- Not backing up data
- Operator error
- Sunspots?



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How Fast Are Our Backups?

- **Measure backup speed**
 - Total backup file size / backup duration
- **Backup speed is influenced by many things:**
 - Current system activity
 - Throughput to the storage location



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How Long Does Recovery Take?

- **Try it and see!**
- **You can't predict how long recovery takes until you've practiced the process.**
- **How long will it take to:**
 - Restore on the same server?
 - Restore in the DR data center?
 - Rebuild a server from scratch and restore?



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DEMO



Quiz

- **Current database backup practice is to backup the file locally and then copy the file to a remote server.**
 - It takes 1 minute to backup a database locally.
 - It takes 5 minutes to copy the file off the server.
- **How much data could we lose?**



Now that we know
what we **have**,
let's find out what
the business **wants**.



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Step 3:
RPO & RTO



Question #1: How much data can we **lose** right now?



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Do you know?

- **This is called RPO – Recovery Point Objective**
- **This is typically documented as two numbers:**
 - High Availability - _____
 - Disaster Recovery - _____



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Assume Nothing



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Not Knowing is OK

- **RPO is a business decision.**
- **Ask the business for an answer.**
 - Get it in writing.
 - Discuss the feasibility with the business.
 - Make the business sign off on budget, etc.



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Question #2:

How long do we have to bring the database online **after** failure?



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The Worst Has Happened...

- We need to bring the database back online.
- This is called RTO – Recovery Time Objective.
- This is also documented as two numbers:
 - High Availability - _____
 - Disaster Recovery - _____



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This Is Also a Business Decision

- **Ask the business for an answer.**
 - Get it in writing.
 - Discuss the feasibility with the business.
 - Make the business sign off on budget, etc.
- **Don't let technology drive this decision.**
 - Technology can be expensive.
 - Technology may not meet long term business needs.



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Recovery Point Objective

Recovery Point Objective (RPO): “How many minutes of data can you lose in a worst case scenario?”

	Business Goal	IT Goal	Current
Zero			
1 Minute			
1 Hour			
1 Day			



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Recovery Time Objective

Recovery Time Objective (RTO): “How many minutes can you be offline in a worst case scenario?”

	Business Goal	IT Goal	Current
Zero			
1 Minute			
1 Hour			
1 Day			



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Answer Those Questions Three Times

- **High Availability**
 - Server failure
 - Windows crash
 - C: drive full
- **Disaster recovery**
 - Data center power failure
 - Meteor strike
 - Godzilla
- **“Oops” Deletions**
 - You left off the WHERE clause
 - Stored procedure update bug
 - End user mistake



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Recording Answers

- Record our technical answers from step 2.
- Record the business users' answers from step 3.

Does the real world match what the business wants?



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Step 4: Meeting RPO & RTO with Backups



The Business Tells Us What

- **The business users give us a list of what they want.**
- **Business requirements guide how we implement:**
 - Recovery model
 - Backup frequency
 - Backup type
 - Database recovery process



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We Figure Out How

- **It's our job to take business requirements and find the right technology.**



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Recovery Models

- **Verify the database recovery model.**
- **Recovery model needs to match business requirements.**
- **Three recovery models:**
 - SIMPLE
 - BULK LOGGED
 - FULL



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Recovery models compared

	Full backup needed?	Log backup needed?	Point in time restore possible?
SIMPLE	X		
BULK LOGGED*	X	X	
FULL	X	X	X

* This is weird. You'll probably never need it.
Let's pretend we never saw it.



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Lies about BULK LOGGED

- **It's minimally logged!**
 - Minimal logging could happen, if you design data loads correctly.
- **It still gets point in time recovery!**
 - If any bulk operations have happened since the last log backup, you lose point in time recovery.
- **It's the best of both worlds!**
 - Bulk logging adds extra complexity to data management. It's best avoided unless you like the bad kind of job security.



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Picking a Recovery Model

- **It's acceptable to lose large amounts of data?**
 - **SIMPLE** recovery model
- **We're loading huge amounts of data (and it can be reloaded)**
 - **SIMPLE** recovery model
- **We can only lose a small amount of data**
 - **FULL** recovery model
- **I care about data and want to keep my job**
 - **FULL** recovery model



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Common Use Cases

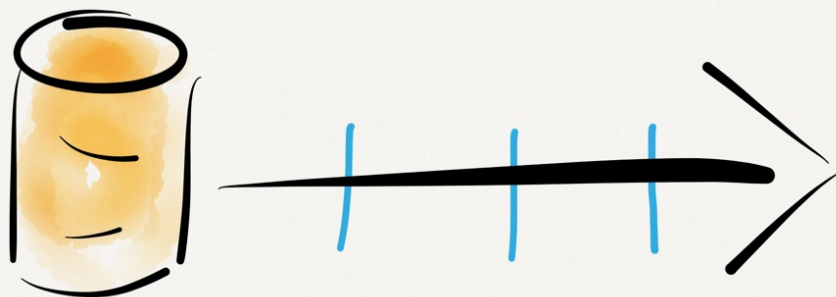
- Transactional databases are usually **FULL**.
- Almost everything in between is usually **FULL**, too.
- Data warehouses are usually **SIMPLE**.



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Creating a Backup Strategy



Strategies

- **Regular full backups are not optional**
- **Regular log backups are needed for databases in FULL recovery model**
- **Differential backups can reduce the time to recover**
 - Only backup the changes since the last full
 - Reduces the number of log backups that need to be restored



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Step 5: What Backups Can't Do



Some things aren't
possible using
nothing but backups.



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Zero Data Loss

- **You can restore with zero data loss if and only if:**
 - You have a valid full backup
 - You have any necessary differentials
 - You have any necessary transaction log backups
 - The **tail of the log** is still available
- **If there is storage failure, data will almost certainly be lost.**



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Tail of the Log?

- **The portion of the log file that hasn't been backed up.**
- **Recovering the tail of the log is critical if you don't want any data loss.**
- **Strategies:**
 - Use synchronous storage replication for safety.
This only works for short distances;
even a metro WAN requires dark fiber.
 - Use synchronous mirroring or AlwaysOn Availability Groups
This still requires fast connectivity.



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Zero Down Time

- **It takes time to restore a backup.**
- **Practice restores in a controlled environment to know how much downtime you'll have.**
- **Zero down time requires a huge investment in time and capital:**
 - Heavy duty automation
 - Multi-master writes
 - Synchronous storage replication



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What About A Lot of Databases?

- If you have a large number of databases on one server, cycling through them all can take time.
- Strategies to cope:
 - Multiple backup jobs
 - Cycle through based on database_id
Job 1 handles odd, Job 2 handles even



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Step 6: Moving Beyond Backups



Backups are a Start

- Without backups, we can't begin to meet RPO/RTO.
- But backups can only go so far.
- Business users might need:
 - Zero data loss
 - Zero down time
 - Multi-site failover



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High Availability	Disaster Recovery	"Oops" Deletions																																																																																										
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Robust Systems Need Collaboration

- **Work with The Business to understand RPO & RTO**
 - Document RPO & RTO in a language everyone will understand.
 - Everyone signs off on RPO & RTO
- **Help the business understand what is needed to accomplish RTO & RPO.**



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Recovery Time Objective (RTO) - Downtime				
	Zero-1 Sec	1 Minute	1 Hour	1 Day
Zero-1 Sec	>\$1,000,000 Multiple active servers with bidirectional replication (usually requires code change)	\$100k-\$500k Clustering w/SAN, synch AlwaysOn Availability Groups (EE), synch database mirroring	\$100k-\$250k Synch SAN replication, synch VM replication	
1 Minute			\$50k-\$250k Async AlwaysOn Avail Groups (EE), async DB mirroring (EE)	\$5k-\$100k Log shipping, async SAN replication, async VM replication
1 Hour			\$5k-\$100k Log shipping, async SAN replication, async VM	
1 Day				

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Comparison of SQL Server Availability Features												
	>\$1mm	\$100k-\$500k			\$100k-\$250k		\$50k-\$250k		\$5k-\$100k			
	Replication	Fallover Clustered Instances (FCI)	AlwaysOn Availability Groups - Synch	Database Mirroring - Synch	SAN Replication - Synch	VM Replication - Synch	AlwaysOn Availability Groups - Asynch	Database Mirroring - Asynch	Log Shipping	SAN Replication - Asynch	VM Replication - Asynch	
Recovery Point Objective (Data Loss)												
Data loss possible	Yes	No*	No*	No*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Typical RPO goal	Zero	Zero	Zero	Zero	Zero	Zero	1 Minute	1 Minute	1 Hour	1 Hour	1 Hour	1 Hour
Recovery Time Objective (Downtime)												
Fallover automatic or manual	Automatic	Automatic	Automatic	Automatic	Optional	Optional	Manual	Manual	Manual	Manual	Manual	Manual
Can be failed over by the DBA alone	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No
Easy to fail back and forth for patching	Some	Yes	Yes	Yes	No	No	Yes	Yes	Some	No	No	No
Multiple live writable servers	Optional	No	No	No	No	No	No	No	No	No	No	No
Fails over Agent jobs, SQL logins	No	Yes	No	No	Optional	Yes	No	No	No	Optional	Yes	Yes
3rd party apps fail over easily	No	Yes	Yes	Some	Yes	Yes	Yes	Some	No	Yes	Yes	Yes
Typical RTO goal	Zero	1 Minute	1 Minute	1 Minute	1 Hour	1 Hour	1 Hour	1 Hour	1 Day	1 Day	1 Day	1 Day
Groups of Databases												
Are the same point in time	No	Yes	No*	No	Yes	Yes	No	No	No	No	No	No
Fail over together	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hardware & Software Requirements												
SQL Server minimum version supported	Apps vary	Any	2012	2005	Any	Any	2012	2005	Any	Any	Any	Any
SQL Server minimum edition required	Apps vary	Any	Enterprise	Standard	Any	Any	Enterprise	Enterprise	Any	Any	Any	Any
May require application changes	Yes	No	No	No	No	No	No	No	No	No	No	No
Req storage for multiple copies of DBs	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Requires shared storage (SAN)	No	Yes	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes
Requires virtualization	No	No	No	No	No	Yes	No	No	No	No	No	Yes
Can use local solid state storage	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No
Performance												
Has noticeable performance impact	Maybe	No	Yes	Yes	Maybe	Maybe	Minimal	Minimal	No	Maybe	Maybe	Maybe
Can offload backups, DBCCs, reports	Yes	No	Yes	No	No	No	Yes	No	Some	No	No	No



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Plan for Success

- Start simple – use backups.
- Add complexity over time.
- A good HA/DR solution doesn't happen instantly.



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How do we answer the following questions?



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When should I manually back up a database?



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Before a change to the database

- **The first line of any change script should read:**
BACKUP DATABASE
 - If the database is too large, ask how you'll roll back your changes.
 - The goal is to be able recover from a bad action.
- **This will break your regular recovery chain**
 - Use your regular tools to backup the database.
 - Store this backup with the rest of your backups.
 - Make sure recovery scripts will work.



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How do I get a copy of my database into the dev lab?



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The Copy Only Backup

- A copy only backup doesn't break the log chain.
- **BACKUP DATABASE foo TO device WITH COPY_ONLY**
- Great for one time backups that won't break recoverability



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Operational Checklist



Check Your Backups

Complete?	Task	Frequency
	Backup validation	Monthly
	Measure backup performance & throughput	Weekly
	Check SQL Agent logs for errors	Weekly
	Clear backup history tables	Weekly



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Checklist

- **Validate backups are succeeding regularly**
- **Backup before significant changes**



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Database Setup

- **Full backups being performed regularly**
- **Is the database in FULL recovery?**
 - Configure log backups
 - Optionally: configure differential backups
- **Verify that the database is in restore scripts.**
- **After one week of typical usage:**
 - Verify that RPO/RTO numbers can be met.
 - Can the database be restored fast enough?



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Weekly Tasks

- **Run jobs to clear backup history tables.**
- **Measure backup performance:**
 - How fast are backups?
 - How long are they taking?



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Monthly

- **Verify backups by restoring to a separate server**
 - Perform this task at least once a month.
 - This should be scripted and happen automatically.
- **Validate backup success**
 - Check SQL Server Agent logs for failure.
 - Check SQL Server Error Log for failure.
 - Check Event Viewer for failure.
 - This should happen more frequently on high profile databases.



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SQLIntersection Session PRECON03

Find Your SQL Server's Bottlenecks

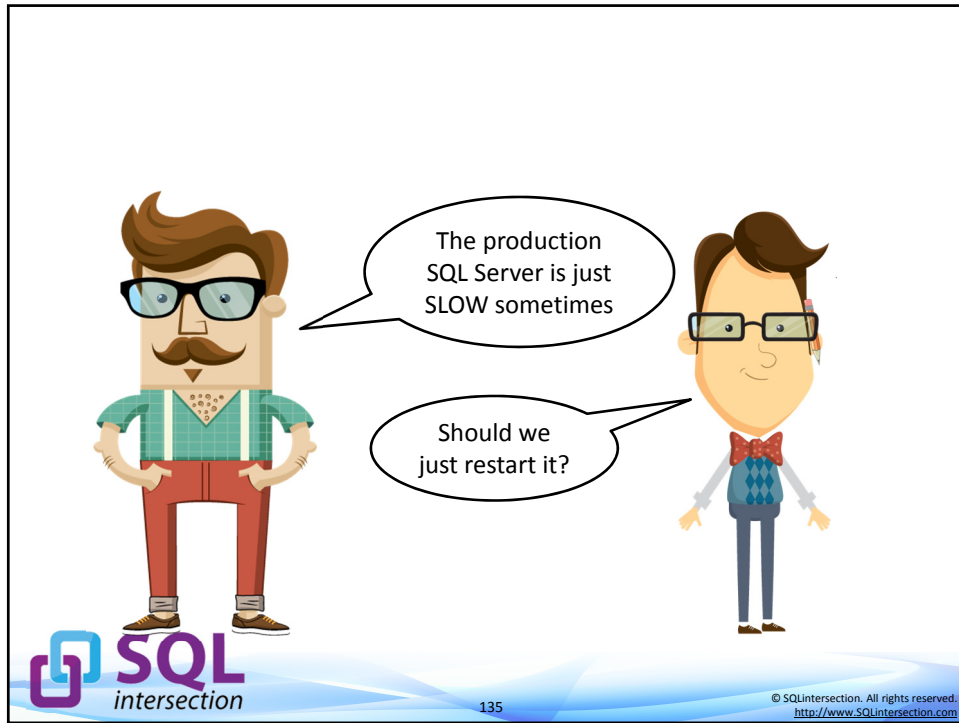
Jeremiah Peschka
jeremiah@brentozar.com



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Orlando, Florida – April 2014

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You're missing out on *wait statistics*



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Meet the SQLOS

- **SQL Server is uppity– it takes over work from the OS**
- **Why not let Windows do the work?**
 - Modern Windows prevents any single thread from taking over
 - Threads get a time-slice, then Windows pulls 'em off the processor (this thread has been pre-empted!)
- **SQL Server is different: threads co-operatively yield to each other**
- **SQL “Schedulers” manage the process of putting threads into action when another thread yields**



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Why yield?

- **CPU is limited**
- **When a query is waiting on another resource, it doesn't need to be active on the CPU**
- **Queries cycle through:**
 - Runnable
 - Running
 - Waiting
- **SQL Server tracks:**
 - How long it waits
 - What it's waiting for



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Wait statistics tell you...

- **Why things are slow**
 - How long queries wait on resources
 - Reading data from storage
 - Writing to the transaction log
 - Sending data back to a client
 - Getting a lock
 - Waiting for other threads to complete in a parallel operation
 - Or waiting to get on a CPU (signal wait/ runnable queue)
- **sys.dm_os_wait_stats**



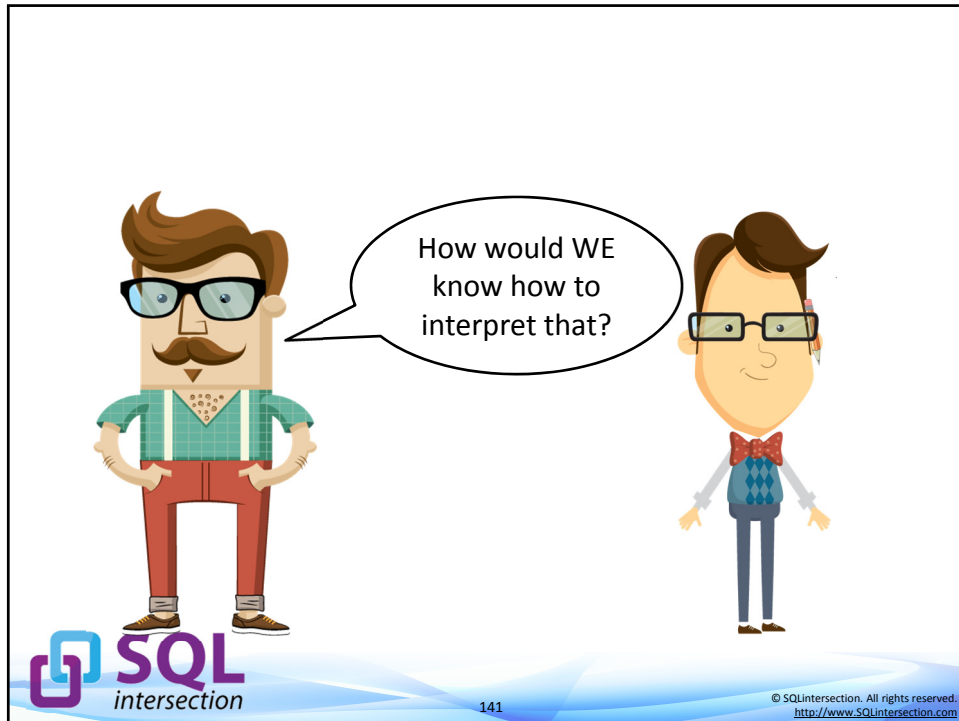
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Wait Type Reference



Are waits always bad?

- **Some waits are always bad**
 - Example: RESOURCE_SEMAPHORE
 - sp_Blitz® will detect this one and warn you
- **Some waits are sometimes bad**
 - Example: CXPACKET
 - This is where things get hard. How much is TOO much?



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Wait Type	What it means
CXPACKET	Parallel queries are occurring– which isn't necessarily a bad thing
SOS_SCHEDULER_YIELD	Waiting to get on a CPU to crunch some data (in the runnable queue)
PAGEIOLATCH_**	Waiting to pull data from storage into memory
WRITELOG	Flushing a write to the transaction log
ASYNC_NETWORK_IO	Sending data to the client (Network OR client app can be slow)
PAGELATCH_**	Protecting data in memory from inconsistencies (“Don’t scribble on my page while I’m using it!”) – could be Tempdb page contention
LCK_**	Waiting to get a lock– and can’t. Locks needed depends on isolation level, transaction status, and type of query (select vs modification)
LATCH_**	Contention over a page in memory. Often related to parallelism – but you have to check the subtype (“latch class”) to know for sure.



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This isn't just about hardware.
Query and index patterns cause
waits, too.



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Example pattern	Can lead to...	Can drive up waits, including...
Implicit conversion	Big index scans. (More IO, more CPU time.)	PAGEIOLATCH_** CXPACKET SOS_SCHEDULER_YIELD
Critical missing indexes	Big index scans. (More IO, more CPU time.)	
Cursors / while loops	Lots of little tiny writes. That's like a team of hornets hitting your transaction log.	WRITELOG
Duplicate indexes	Clog up your memory with duplicate structures, cause extra IO	PAGEIOLATCH_** ASYNC_IO_COMPLETION
"After" triggers	Make transactions take longer	LCK_** (which can lead to a big backlog of queries, which can lead to CXPACKET and PAGEIOLATCH_** waits)
Cascading updates and deletes on foreign keys	Secretly uses escalated isolation level to cascade to child tables	
App running giant reports	More data being sent to the app server than it can handle	ASYNC_NETWORK_IO



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Some special waits

Wait Type	What it means
PREEMPTIVE_OS_WRITEFILE	SQL Server is waiting to grow a file. Consider reducing by granting "Instant File Initialization" (BrentOzar.com/go/setup)
RESOURCE_SEMAPHORE	Memory pressure is impacting queries who need to do sorts, big joins, and parallelism. These queries may not even be able to start.
THREADPOOL	It's taking time to allocate new threads. Check your SQL Server Error log to see if you have messages that new queries haven't been picked up by a thread. Look at connection pooling, parallelism settings, and possibly blocking pileups.



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Wait Example #1 (30 second sample)

Wait Type	Wait Time (Seconds)	Number of Waits	Avg ms Per Wait
PAGEIOLATCH_SH	85.5	3,328	25.7
CXPACKET	55.7	11	5,061.8
LATCH_EX	14.4	1,180	12.2
PAGEIOLATCH_EX	0.4	16	25.3
WRITELOG	0.1	6	14

What would you look at next on this system?



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Wait Example #2 (30 second sample)

Wait Type	Wait Time (Seconds)	Number of Waits	Avg ms Per Wait
WRITELOG	35.8	2,217	16.1
PREEMPTIVE_OS_WRITEFILE	3.0	3	992.7
ASYNC_NETWORK_IO	2.8	8,150	0.3
PAGEIOLATCH_UP	-	2	-

What would you look at next on this system?



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Wait Example #3 (10 second sample)

wait_type	Wait Time (Seconds)	Signal Wait Time (Seconds)	Percent Signal Waits	Number of Waits	Avg ms Per Wait
LCK_M_U	294.9	0.1	0.0	49	6019.1
SOS_SCHEDULER_YIELD	13.6	13.6	100.0	4663	2.9
ASYNC_NETWORK_IO	1.9	0.6	31.6	207	9.1
LCK_M_S	1.9	0.1	5.3	17	113.2
PAGEIOLATCH_SH	0.8	0.0	0.0	36	21.2
PAGELATCH_SH	0.7	0.3	42.9	3604	0.2
LCK_M_X	0.7	0.0	0.0	15	47.1

What would you look at next on this system?



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BrentOzar.com/Responder

The screenshot shows the BrentOzar.com/Responder website. The header includes a search bar, a "Search" button, and links for "BLOG", "TEAM", and "CONTACT". The main navigation bar includes "HOME", "PROBLEMS", "SQL SERVER", "TRAINING", and "FIRST AID". The "PROBLEMS" link has the subtext "We Solve" and the "SQL SERVER" link has the subtext "Critical Care". The main content area is titled "SQL Server First Responder Kit" and includes a description of the kit, a checklist, and a download link. The footer includes the copyright notice: © SQLIntersection. All rights reserved. http://www.SQLIntersection.com

BRENT OZAR UNLIMITED™

HOME PROBLEMS SQL SERVER TRAINING FIRST AID

We Solve Critical Care™

SQL Server First Responder Kit

Disaster strikes your SQL Server: queries are stalled, applications are down, customers are calling in like crazy, and your boss is in a panic. What do you do?

What if the same thing happens, but you're on vacation? (Can you hear your cell phone ringing now?)

The SQL Server First Responder Kit helps you create a repeatable process to triage problems with your SQL Server. This kit helps you build a team who can respond to an injured server like skilled EMTs.

Get the SQL Server First Responder Kit Checklist

Why start from scratch? [Download our free SQL Server First Responder Kit Checklist \(pdf\) here.](#)

Build a Triage Process

Don't wait until disaster strikes to learn to respond to stress on a SQL Server. Instead, simulate

SQL Server First Responder Kit

Instance Name: _____
Triaged By: _____
Date and Time: _____

1. Can You Connect?

Connect to SQL Server and run:

```
SELECT name, user_access_desc, state_desc, log_reuse_wait_desc  
FROM sys.databases;
```

Did you connect successfully? _____

Anything notable in returned columns? _____

Problems connecting? _____

Try the dedicated admin connection: <http://BrentOzar.com/go/DAC>

2. What's running?

Check activity over a short sample using sp_AskBrent™:

```
EXEC dbo.sp_AskBrent;
```

Did you run this successfully? _____

Did it find running queries? _____

Demo:

The Terrible tempdb Workload



Terrible tempdb query

```
SELECT TOP(5000)
    a.name, replicate(a.status,4000) as col2
into #t1
FROM master..spt_values a
CROSS APPLY master..spt_values b
```

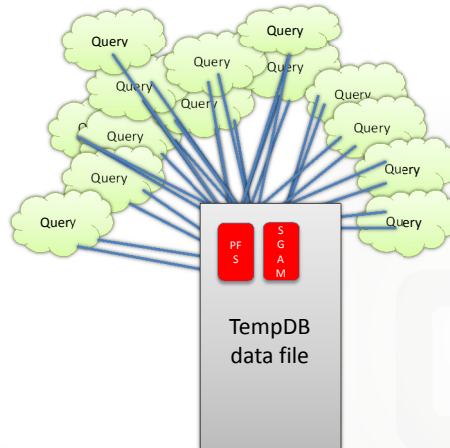
Wow. Just...
wow.



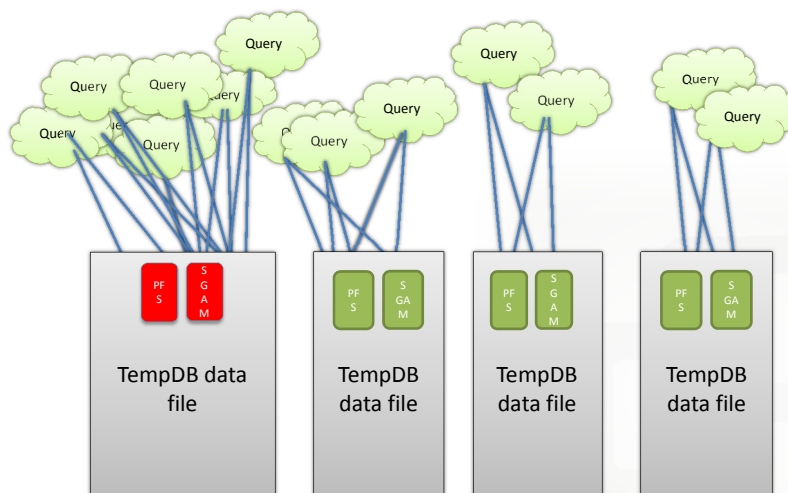
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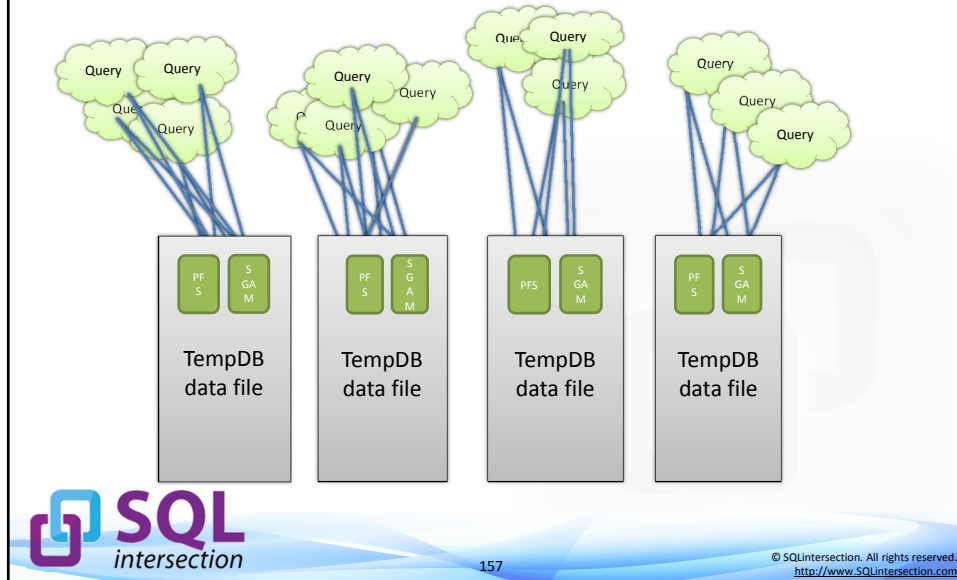
Allocating new objects: 1 TempDB data file



Four uneven tempdb data files



4 even tempdb data files



Default settings

sp_whoisactive

Results	Messages	dd hh:mm:ss.mss	session_id	sql_text	login_name	wait_info	CPU	tempdb_allocations	tempdb_current
1		00:00:00.26.236	53	<?query -- select cntx_value from sys.dm_os_perf...	sa	NULL	0	0	0
2		00:00:00.01.186	58	<?query -- SELECT TOP(5000) a.name, repl...	sa	(2ms)PAGELATCH_SH:tempdb:1(PFS)	226	3,106	2,330
3		00:00:00.00.983	59	<?query -- SELECT TOP(5000) a.name, repl...	sa	NULL	185	4,130	0
4		00:00:00.00.983	56	<?query -- SELECT TOP(5000) a.name, repl...	sa	(2ms)PAGELATCH_UP:tempdb:1(GAM)	201	4,130	2,170
5		00:00:00.00.610	54	<?query -- SELECT TOP(5000) a.name, repl...	sa	(2ms)PAGELATCH_SH:tempdb:1(PFS)	197	4,130	4,130
6		00:00:00.00.406	55	<?query -- SELECT TOP(5000) a.name, repl...	sa	(2ms)PAGELATCH_UP:tempdb:1(PFS)	85	2,082	2,082
7		00:00:00.00.096	57	<?query -- SELECT TOP(5000) a.name, repl...	sa	(19ms)PAGELATCH_UP:tempdb:1(GAM)	3	506	506

sp_AskBrent®

	Pattern	Sample Ended	Seconds Sample	wait_type	Wait Time (Seconds)	Signal Wait Time (Seconds)	Percent Signal Waits	Number of Waits	Avg ms Per Wait
1	WAIT STATS	2014-04-03 15:49:12.470	30	CXPACKET	515.9	64.3	12.5	725701	0.7
2	WAIT STATS	2014-04-03 15:49:12.470	30	PAGELATCH_UP	306.4	32.0	10.4	223612	1.4
3	WAIT STATS	2014-04-03 15:49:12.470	30	PAGELATCH_SH	65.8	30.2	45.9	177699	0.4
4	WAIT STATS	2014-04-03 15:49:12.470	30	LCK_M_X	16.1	0.4	2.5	372	43.3
5	WAIT STATS	2014-04-03 15:49:12.470	30	LCK_M_S	8.0	0.1	1.3	325	24.7
6	WAIT STATS	2014-04-03 15:49:12.470	30	LATCH_EX	3.3	1.3	39.4	7005	0.5
7	WAIT STATS	2014-04-03 15:49:12.470	30	PAGELATCH_EX	0.6	0.2	33.3	795	0.7
8	WAIT STATS	2014-04-03 15:49:12.470	30	LATCH_SH	0.1	0.0	0.0	135	0.5

	Pattern	Sample Time	Sample (seconds)	File Name	Drive	# Reads/Writes	MB Read/Written	Avg Stall (ms)	file physical name
1	PHYSICAL READS	2014-04-03 15:49:12.497	30	tempdev [ROWS]	S:	1	0.1	2	S:\MSSQL\Data\tempdb.mdf
2	PHYSICAL WRITES	2014-04-03 15:49:12.497	30	tempdev [ROWS]	S:	38	0.3	0	S:\MSSQL\Data\tempdb.mdf
3	PHYSICAL WRITES	2014-04-03 15:49:12.497	30	templog [LOG]	S:	1303	56.9	0	S:\MSSQL\Data\templog.ldf

8 tempdb data files, Cost Threshold at 50

sp_whoisactive

	dd hh:mm:ss.mss	session_id	sql_text	login_name	wait_info	CPU	tempdb_allocations	tempdb_current
1	00:00:00.58.110	54	<?query -- use CriticalAppDB --?>	sa	NULL	0	0	0
2	00:00:00.00.316	59	<?query -- SELECT TOP(5000) a.name, repl...	sa	(4ms)PAGELATCH_UP:tempdb:8(PFS)	125	2,906	679
3	00:00:00.00.273	58	<?query -- SELECT TOP(5000) a.name, repl...	sa	NULL	89	2,426	178
4	00:00:00.00.203	57	<?query -- SELECT TOP(5000) a.name, repl...	sa	(1ms)PAGELATCH_UP:tempdb:8(PFS)	89	1,930	0
5	00:00:00.00.166	56	<?query -- SELECT TOP(5000) a.name, repl...	sa	NULL	75	1,906	375
6	00:00:00.00.146	55	<?query -- SELECT TOP(5000) a.name, repl...	sa	NULL	41	1,514	0
7	00:00:00.00.076	60	<?query -- SELECT TOP(5000) a.name, repl...	sa	(5ms)PAGELATCH_UP:tempdb:8(PFS)	11	514	0

sp_AskBrent®

Pattern	Sample Ended	Seconds Sample	wait_type	Wait Time (Seconds)	Signal Wait Time (Seconds)	Percent Signal Waits	Number of Waits	Avg ms Per Wait
1 WAIT STATS	2014-04-03 16:00:34.100	30	PAGELATCH_UP	54.8	16.3	29.7	73573	0.7
2 WAIT STATS	2014-04-03 16:00:34.100	30	PAGELATCH_SH	14.2	6.3	44.4	18751	0.8
3 WAIT STATS	2014-04-03 16:00:34.100	30	SOS_SCHEDULER_YIELD	13.7	13.7	100.0	14116	1.0
4 WAIT STATS	2014-04-03 16:00:34.100	30	PAGELATCH_EX	7.8	3.0	38.5	6374	1.2
5 WAIT STATS	2014-04-03 16:00:34.100	30	LCK_M_X	1.6	0.4	25.0	634	2.6
6 WAIT STATS	2014-04-03 16:00:34.100	30	LCK_M_S	1.0	0.2	20.0	352	2.9
7 WAIT STATS	2014-04-03 16:00:34.100	30	WRITELOG	0.5	0.2	40.0	93	5.1
8 WAIT STATS	2014-04-03 16:00:34.100	30	PAGELATCH_UP	0.4	0.0	0.0	90	4.2

Pattern	Sample Time	Sample (seconds)	File Name	Drive	# Reads/Writes	MB Read/Written	Avg Stall (ms)	file physical name
1 PHYSICAL WRITES	2014-04-03 16:00:34.160	30	tempdev (ROWS)	S:	44	0.3	3	S:\MSSQL\Data\tempdev.mdf
2 PHYSICAL WRITES	2014-04-03 16:00:34.160	30	templog (LOG)	S:	3193	145.2	2	S:\MSSQL\Data\templog.ldf



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The Terrible Tempdb Workload

Configuration	Top Wait Stats (30 second sample)	Avg Batch Requests / Min
1 tempdb file (default) Cost threshold 5 (default)	CXPACKET 506.2 PAGELATCH_UP 317.6 PAGELATCH_SH 64.4	642
1 tempdb file (default) Cost threshold 50	PAGELATCH_UP 68.0 SOS_SCHEDULER_YIELD 14.8 PAGELATCH_SH 9.0	1,631
4 tempdb files cost threshold 50	PAGELATCH_UP 63.1 SOS_SCHEDULER_YIELD 18.7 PAGELATCH_SH 9.9	1,742
8 tempdb files cost threshold 50	PAGELATCH_UP 50.0 SOS_SCHEDULER_YIELD 21.9 PAGELATCH_SH 7.4	2,713
20 tempdb files cost threshold 50	PAGELATCH_UP 32.2 SOS_SCHEDULER_YIELD 27.8 PAGELATCH_SH 8.2	3,155
40 tempdb files cost threshold 50	SOS_SCHEDULER_YIELD 34.3 PAGELATCH_UP 17.6 PAGELATCH_EX 8.4	3,575
60 tempdb files cost threshold 50	SOS_SCHEDULER_YIELD 40.3 PAGELATCH_EX 10.5 PAGELATCH_SH 7.7	3,394



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Orlando, Florida – April 2014

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How did you know it wasn't slow storage?

- No PAGEIOLATCH waits
- Didn't see slow storage read and write times in sp_AskBrent



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- sp_Blitz® warns if you just have one, or if they're unevenly sized
- You can check your count anytime:
`exec tempdb..sp_helpfile`
 - Be proactive and don't just go with one tempdb data file– but don't go crazy.
 - For general guidelines:
BrentOzar.com/go/setup



Should we add tempdb files all the time?



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Free Tools!

- **First Responder Kit: BrentOzar.com/Responder**
 - This also has a “Wait Stats Since Startup” query
- **sp_whoisactive:**
 - Written by Adam Machanic.
 - Links to Adam’s site and a video to help get you started is at BrentOzar.com/go/active
- **sp_AskBrent®:**
 - BrentOzar.com/AskBrent



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Set up your performance troubleshooting process

Complete?	Task	Frequency
	Build your starter First Responder Kit – customize ours with what you’re comfortable with. Add items specific to your environment.	Once
	Get a buddy to test your First Responder Kit. Even if they’re not a SQL Server specialist, you need a backup! Make sure this can be used when you’re way.	Once
	When things are slow, run sp_WhoIsActive and look for wait stats on your queries	When performance is bad
	Take sp_AskBrent® samples and use the Wait Stats Decoder Chart to identify the biggest bottlenecks	When performance is bad



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Baseline

Complete?	Task	Frequency
	Document your waits since startup using our 'Triage Wait Stats in SQL Server' Script at BrentOzar.com/Responder. Start small: Start with your most critical system and don't over-engineer collecting info you aren't ready to use!	Once
	Take sp_AskBrent samples for 30 seconds (or perhaps longer) at critical periods and compare them to your baseline	Weekly



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Heavy Hitters: Examining Query Performance & Memory Utilization



Why look at memory?

- **Keep track of which indexes are in memory**
- **Verify that your indexing changes are working:**
 - New indexes are being used
 - New indexes are staying in RAM



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Why look at the plan cache?

- **Find expensive queries**
 - What's chewing up your CPU?
 - What's performing a lot of reads?
- **Find frequently run queries**
 - Fast queries that run constantly can hurt a server.
- **Watch the the plan cache**
 - Track query compile time
 - Track query use time
 - If queries leave the



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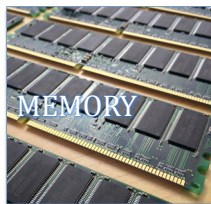
What happens when a query runs?



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SQL Server Architecture Basics

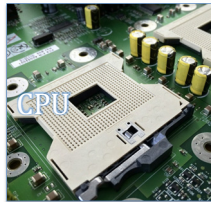
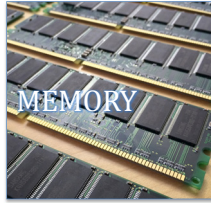


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SQL Server Architecture Basics

```
SELECT *  
FROM users
```

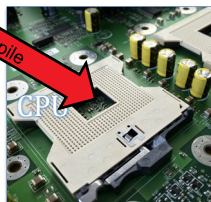


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SQL Server Architecture Basics

```
SELECT *  
FROM users
```

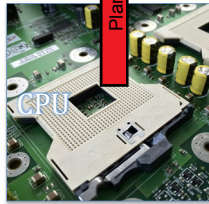
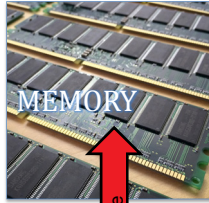


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SQL Server Architecture Basics

```
SELECT *  
FROM users
```

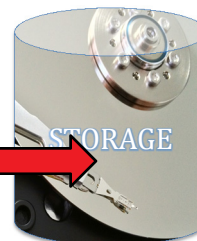
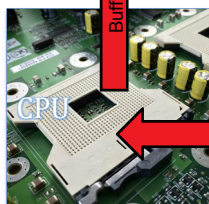
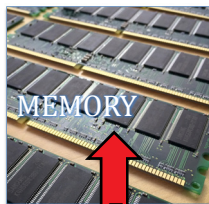


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SQL Server Architecture Basics

```
SELECT *  
FROM users
```



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More memory = bigger plan cache

- **Every query plan is cached.***
- **Caching plans is good:**
 - Generating plans is CPU intensive.
 - Plan re-use means we're effectively using memory and CPU.



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More memory = bigger plan cache

- **Every query plan is cached.***
- **Caching plans is good:**
 - Generating plans is CPU intensive.
 - Plan re-use means we're effectively using memory and CPU.

* Nearly every query. Things like RECOMPILE hints and optimize for ad hoc workloads change things.



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DEMO!



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When do plans LEAVE cache?

- **Memory is swept regularly by internal processes.**
 - The cost of that page of memory is decremented by every sweep.
 - Whenever a query is re-used, the cost is reset.
- **When the cost hits 0, a page becomes free-able.**
 - The page won't actually be freed until there's memory pressure.
 - A free-able page can still live in memory for hours or days.
- **Just because the data/index cache is full, that doesn't mean the plan cache will be cleared.**



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What about data?



How SQL Server reads data.

- **When a query runs:**
 - SQL Server checks memory for the right pages.
 - If the pages aren't in memory, they're read from disk.
 - Query results are returned to the user.
- **SQL Server only caches data and index pages.**
 - Query results are not cached.
 - View results are not cached.
 - Complex queries need to be recomputed.
- **If you have enough memory, all data will live in memory.**



Buffer Pool

- **Data and index pages come from the buffer pool.**
 - Technically plans live in here, too.
 - As do a lot of other things.
- **The buffer pool is the 'max server memory' setting.**
 - This defaults to ALL THE MEMORY!
- **SQL Server won't give up memory.**
 - If there's an OS level problem it will.
 - Unless you've configured it not to.



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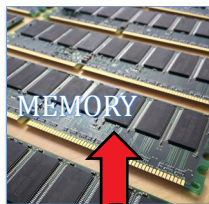
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Remember this?

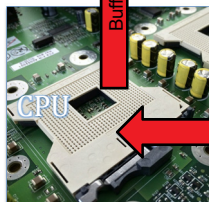
```
SELECT *  
FROM users
```



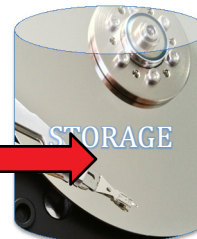
NETWORK



MEMORY



CPU



STORAGE

Buffer Pool

Query



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Tracking memory

- **We can track memory use:**
 - By database
 - By table
 - By index
- **A word of warning:**
 - On a big server, these queries take a lot of time.
 - You can't see current cost



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When does data leave the buffer pool?

- **Data and index pages use a slightly different model.**
- **It's called an LRU-K model.**
- **Basically:**
 - SQL Server tracks the two most recent uses.
 - When there's memory pressure, SQL Server will look for unmodified pages to remove from memory.
 - The least recently used pages are evicted.
- **You can't observe the LRU-K values:**
 - Observing this value changes it.
 - Schrödinger's data page.



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DEMO!



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Operational Checklist



Measure memory use

- **After code changes**
- **After index changes**
 - New indexes added
 - Old indexes modified or removed
- **Server hardware changes**



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Measure the plan cache

- **Code release**
 - Before code changes are deployed
 - Several business days after changes are deployed
- **Index changes**
 - Before index changes are deployed
 - After index changes are deployed
- **Hardware changes**
 - Only if CPU count or available memory for SQL Server changes



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After a code release

- **Capture a snapshot of the plan cache.**
 - Record the top poorly performing queries.
 - Measure multiple ways – CPU, I/O, duration
- **Record top memory hogs**
 - Memory use in each database that changed.
- **If index changes happened:**
 - Record which tables are using memory.
 - Record which indexes on those tables are using memory.



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SQLIntersection Session PRECON03

Monitoring with Built-in Tools

Jeremiah Peschka

jeremiah@brentozar.com



Agenda

- **Being Reactive**
 - Learning when danger strikes
 - Detecting failure
- **Being Proactive**
 - Tools at your disposal
 - Collecting information
 - Reporting on information



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Before we get started...



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What makes for an
effective alert?



An effective alert is:
**informative &
actionable**



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Three kinds of alert

1. Severity & error based alerts
2. SQL Server perfmon alerts
3. WMI query based alerts

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Responding to alerts

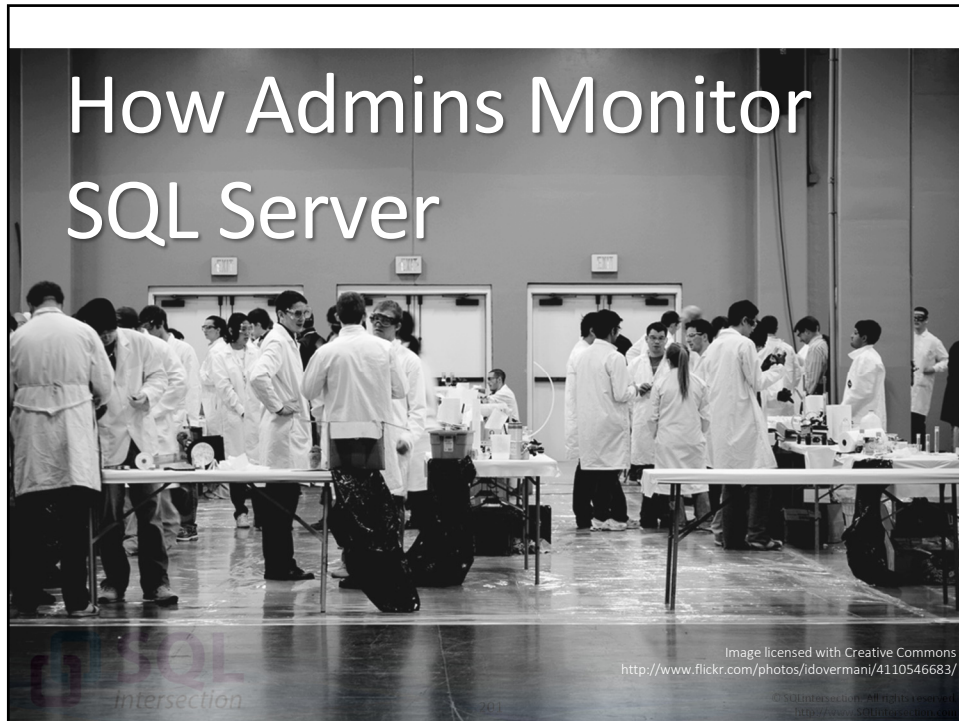


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Why start with alerts?

- Prepare for the worst
- Find out about failures as they happen
- Set the stage for more proactive warnings





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The Importance of Performance Counters

- Create narrow sets of related metrics.
- Correlate metrics across many applications.
 - Application metrics + OS metrics.
 - Monitor trends together.
- Collect important metrics at regular intervals.
Not unlike pokemon!



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The Devil in the Details



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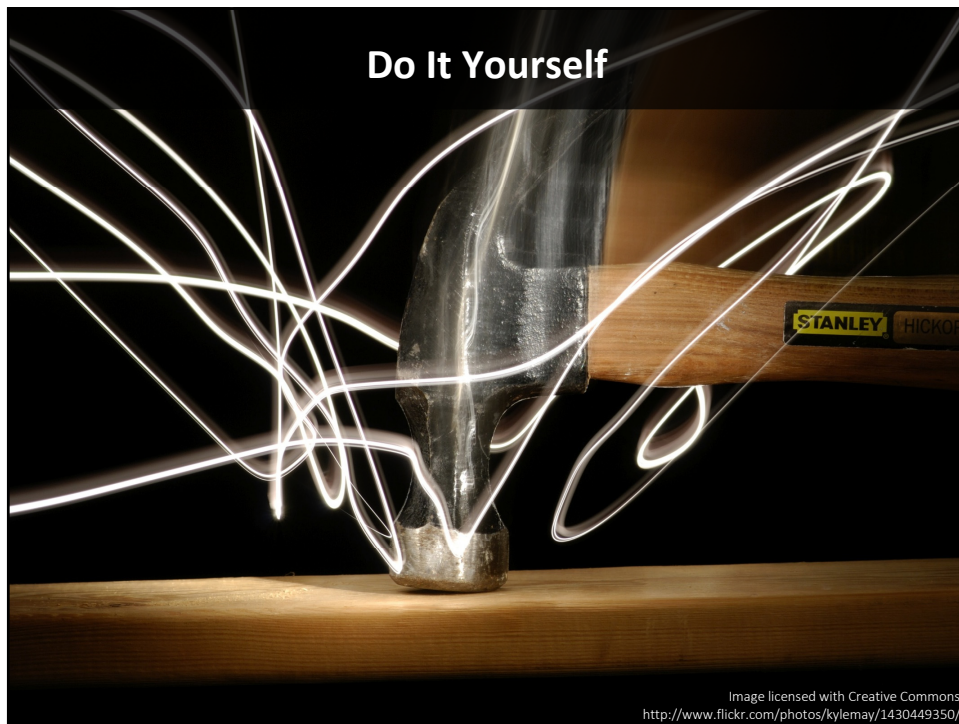




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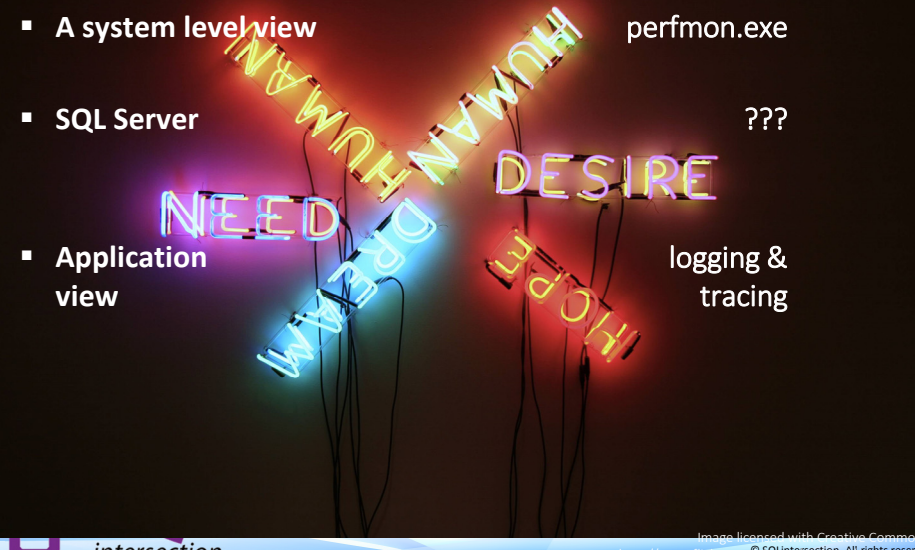
Neither way is right



- Sysadmin monitoring is reactive.
- Developer monitoring is real-time and expensive.
- Both approaches get something right.
- Neither one meets all of our needs.

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What do we need?



- A system level view
- SQL Server
- Application view

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Monitoring Waits

- **Just like an engine, SQL Server needs monitoring.**
- **Sample and record waits periodically.**
 - Hey, it's just like perfmon!
 - Some waits can be ignored.
- **Correlate slow performance to sampled data.**
 - Adjust granularity to meet requirements.
 - Not perfect, but it's free.
 - You can also analyze this in Excel!

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Monitoring Disks

- **Every time we read or write, SQL Server records data.**
 - `dm_os_virtual_file_stats`
 - Records read and write stalls since start up
- **What's a stall?**
 - The time it takes from issuing an operation to getting a response.
- **What's it mean?**
 - Everyone's using the disks.
 - We're doing a lot of random I/O.
 - The SSDs are wearing out.



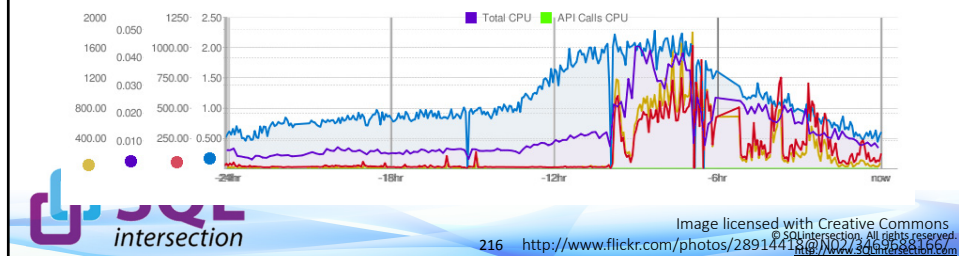
What do we do with
that info?

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Beautiful Alerts

- **Provide context with alerts.**
 - Collect relevant data from SQL Server.
 - You know what's probably wrong, so grab the right info to make a decision.
- **Include graphs of activity in alerts.**
- <http://brentozar.com/go/visualalert>



Watch for Anomalies

- Only you know the appropriate values for your application.
- Figuring out what's normal is hard; make a computer do it.
- <http://codeascraft.com/2013/06/11/introducing-kale/> + <https://github.com/Iristyle/PerfTap> = SQL Server Anomaly Detection

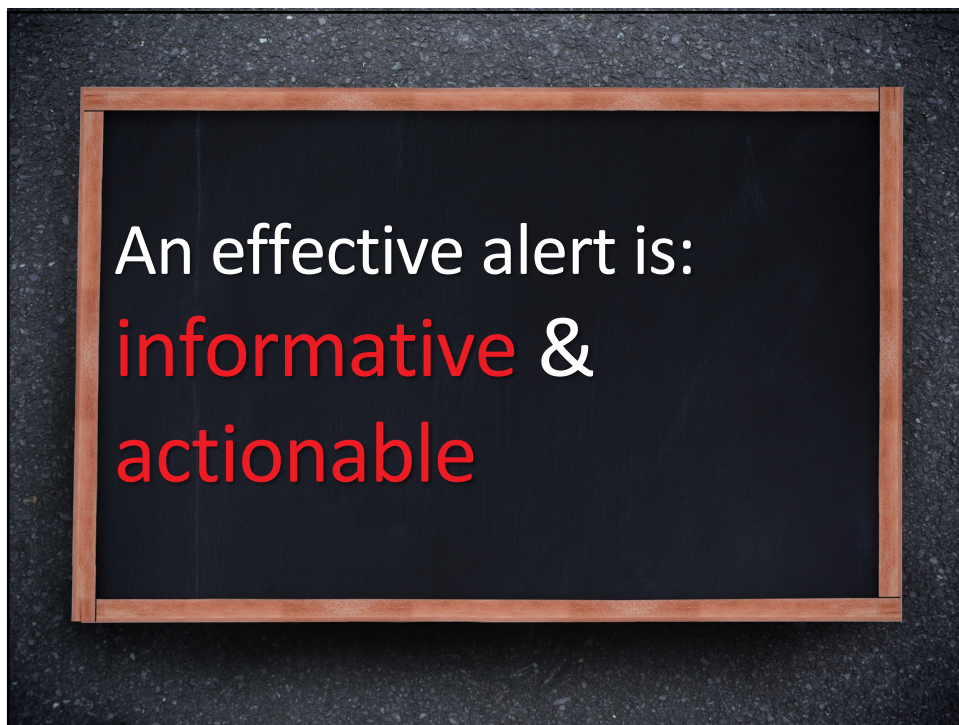


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Watch for Anomalies







Set Up Monitoring

Complete?	Task	Frequency
	Decide on your monitoring tools & technology.	Once
	Test monitoring technology against a recorded workload. Verify that you can spot problems.	Once
	Set up monitoring for waits, disks, and queries. Set up alerts for high severity issues.	Once
	Create custom monitoring scripts to spot production problems.	Once



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Set Up the *Right* Maintenance

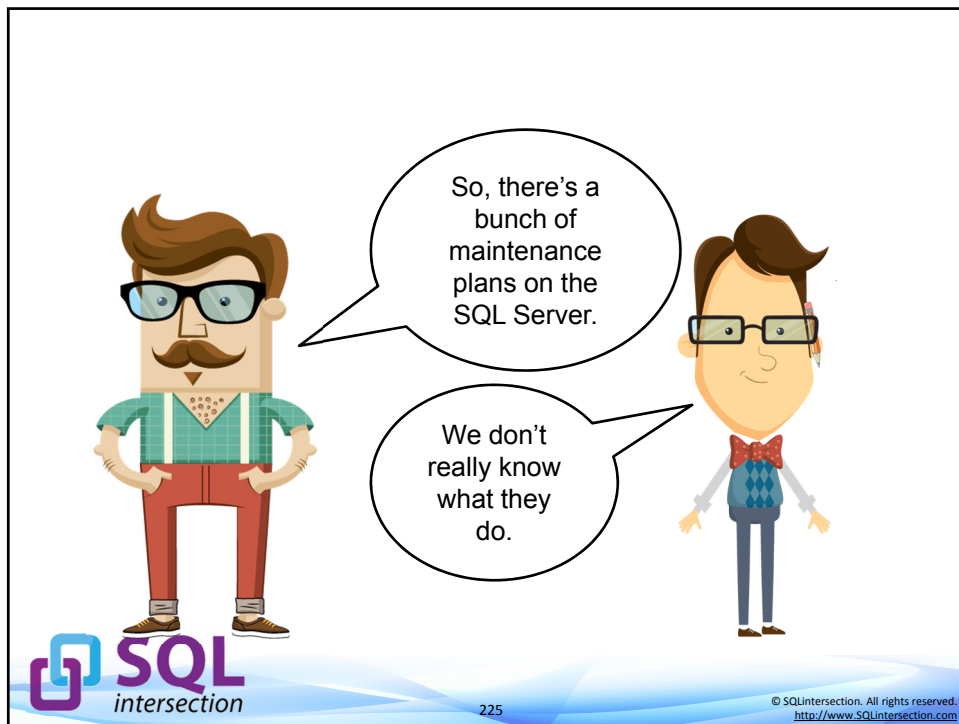
Kendra Little
Kendra@BrentOzar.com



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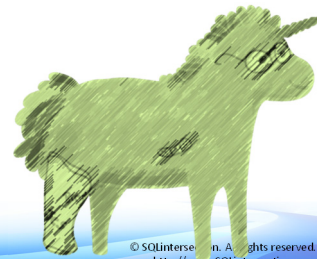
You do maintenance to
make SQL Server healthy



Bad maintenance makes SQL Server sicker



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The right maintenance varies

- Concurrency/Availability requirements
- Number of databases
- Size of databases
- Type and speed of storage
- SQL Server licensing
- Availability of secondary servers
- and... time available to manage the maintenance



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Setting you up right

- **This is a two-parter:**
- **8 Rules of Maintenance**
 - Bad Practices that will kill you
 - What to do instead
- **How to Choose the Right Tools for Maintenance**
 - Should you use Maintenance Plans?
 - What other options do you have?

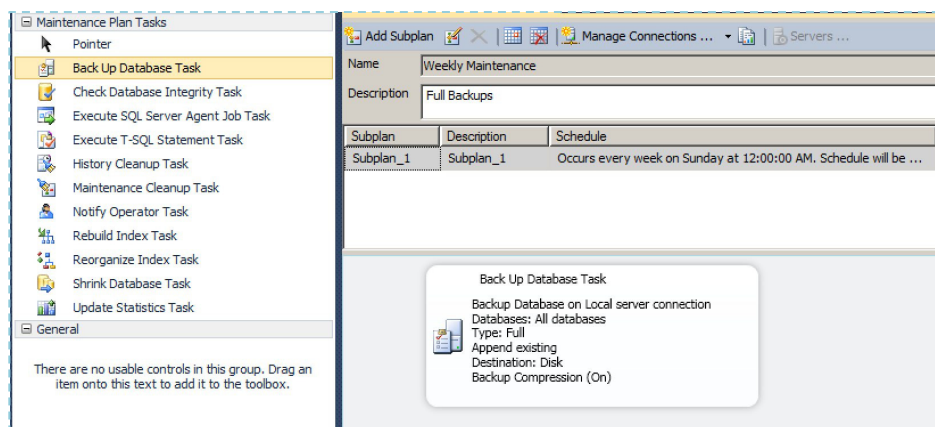


8 rules of maintenance

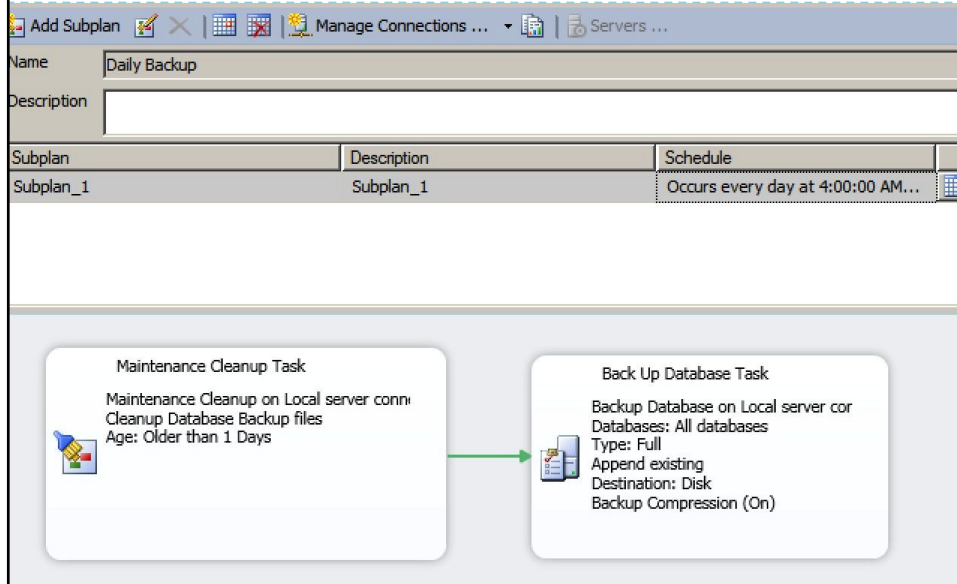
Avoid killer patterns



What's wrong with this picture?



What's wrong with THIS picture?



Rule 1: Backups must ~~meet~~ beat RPO and RTO

If RPO is 5 minutes, a log backup every 5 minutes isn't fast enough!



Rule 1: Backups must meet beat RPO and RTO

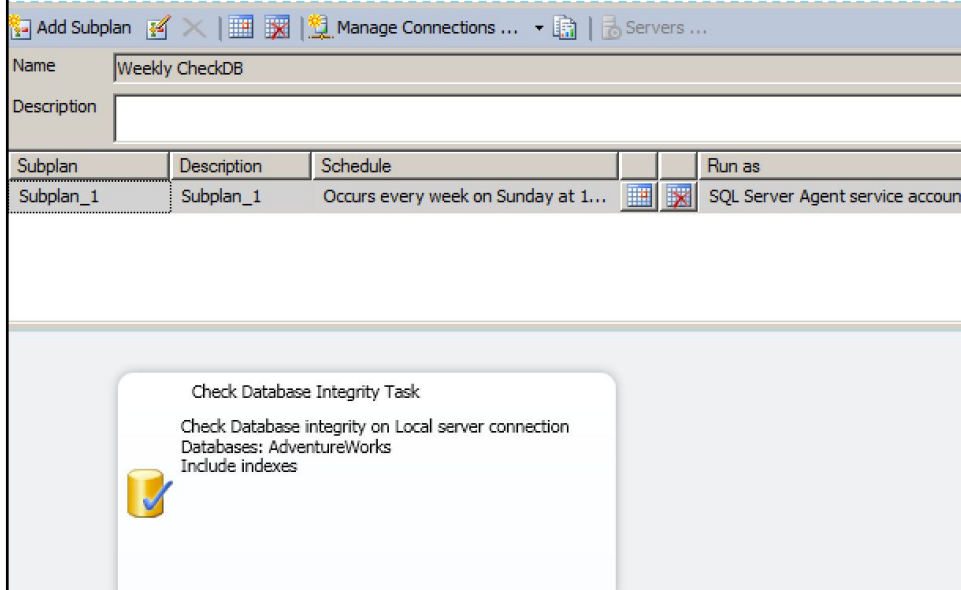
- You must regularly *test your restore process*
- Don't forget backups for system databases
 - master, model, msdb
 - Most people do nightly full backups
- Factors to check:
 - Backup types, frequency
 - Backup compression (for speed)
 - Instant file initialization (restore time)
 - Backup storage (no USB, please!)
 - Backup availability (number of copies)



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What's wrong with this picture?



Rule 2: CheckDB is required

- **Run CheckDB regularly**
 - User AND system databases (even tempdb)
- **Most people run CheckDB on system databases nightly (should be very quick)**
- **User databases are typically checked weekly**



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CheckDB on Very Large Databases

- **For VLDBs with high performance requirements:**
 - DBCC CHECKTABLE, CHECKALLOC, and CHECKCATALOG may be run individually
 - The PHYSICAL_ONLY option may be used at times (but don't do it always)
 - CheckDB may be offloaded by:
 - Restoring a full backup to another server
 - Running CheckDB
- **You CANNOT eliminate the need to run CheckDB with logshipping, database mirroring, or even AlwaysOn Availability Groups.**



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Rule 3: Don't let big tasks overlap

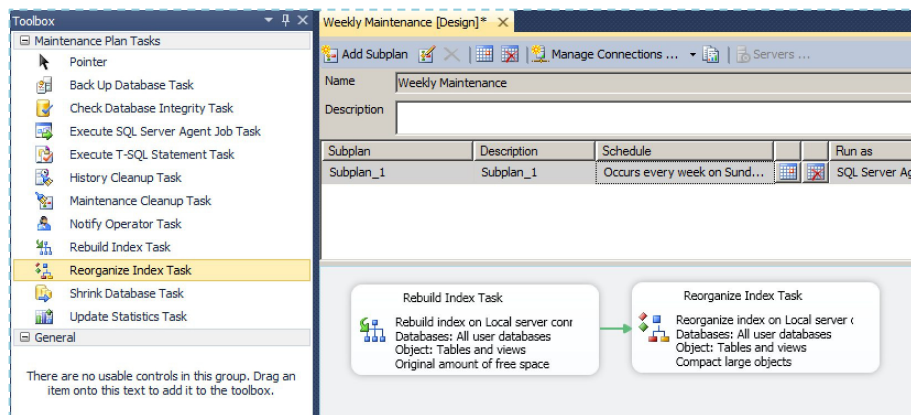
- **Don't let storage and processor intensive tasks overlap:**
 - CheckDB
 - Full Database Backups
 - Index Rebuilds
- **This applies to multiple instances using the same storage, too!**
- **Note: It's OK for log backups to overlap with other tasks**



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What's wrong with this picture?



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Concept recap: Indexes

- **An index is a data structure**
- **Tables may have:**
 - One clustered index (the table itself)
 - Many nonclustered indexes (helpers to make queries faster)
- **Indexes take up space on disk AND in memory**



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Rule 4: Know index options

- **REBUILD index**
 - Creates an entire new structure (all or nothing)
 - The whole table is unavailable during the process (unless Enterprise Edition, you specify ONLINE, and the data types in the index allow an online operation)
 - Applies a 'fill factor'
- **REORGANIZE index**
 - Works through the 'leaf' levels of the index
 - Can be stopped midway without rolling the process back
 - Does not apply a new/changed 'fill factor'



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Controversy: “Does index fragmentation matter?”



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Index maintenance, simplified

- **When you have a regularly scheduled downtime window, you can usually get away with a simple maintenance plan**
- **Otherwise:**
 - Don't use maintenance plans for index maintenance
 - Use well tested free scripts (coming up!) in a SQL Server maintenance job
 - Only reindex where fragmented
- **ola.hallengren.com**



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Rule 5: Be smart about fillfactor

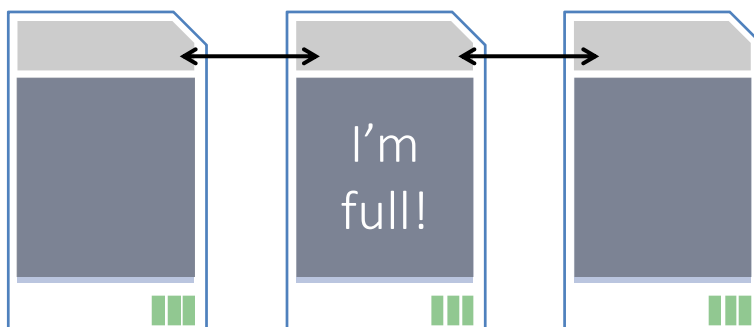
- **You can specify how much free space SQL Server leaves on a page after you rebuild or reorganize and index**
 - That can prevent page splits on inserts/updates/deletes
 - The trade off: wasting space on disk and in memory
- **Avoid mistakes:**
 - Don't set this at the instance level
 - Don't set this on every index in a database
- **BrentOzar.com/go/fillfactor**



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We've got pages full of data



...more data needs to get in



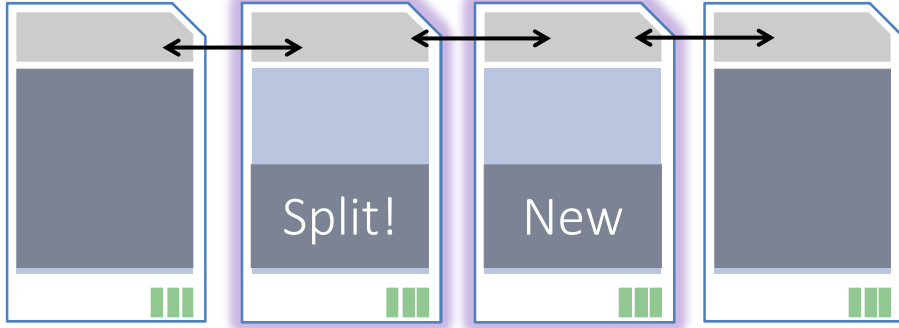
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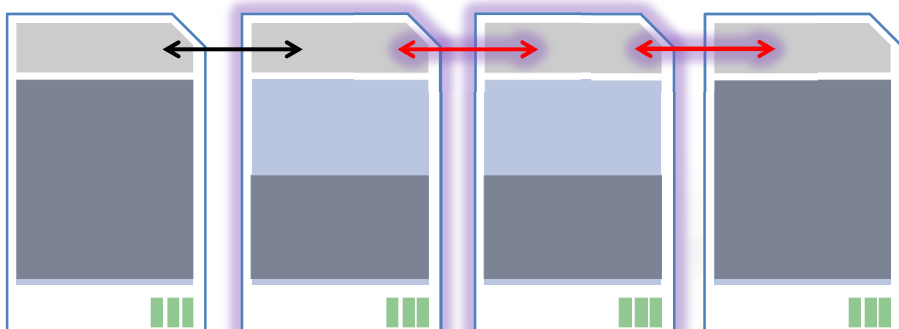


Page split!

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intersection

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Gotta update those links, too.

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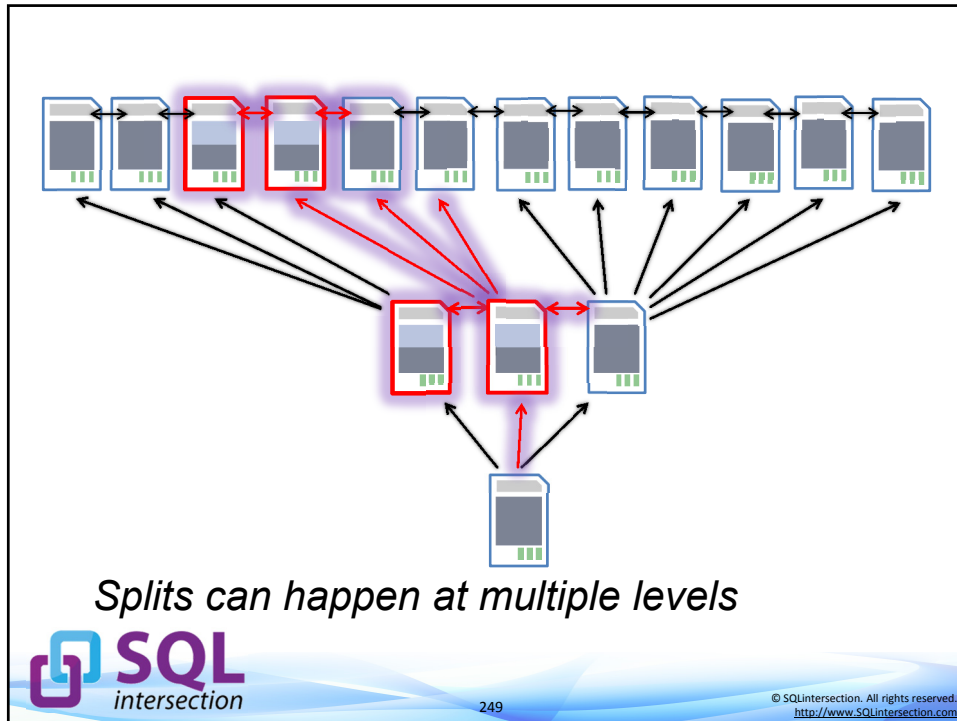
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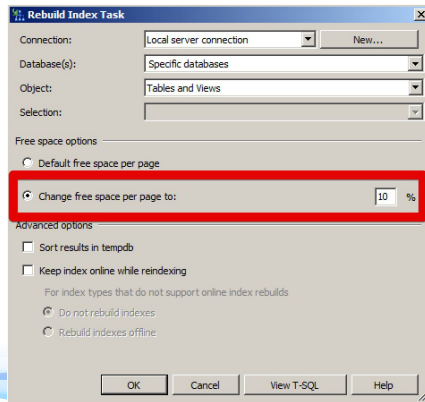
Splits are expensive.
And they leave fragmentation
behind!

Warning: fillfactor settings are confusing

Maintenance plans specify % to LEAVE EMPTY

The TSQL command specifies % TO FILL

Getting this backward kills performance!



```
ALTER INDEX [IXName]
ON [dbo].[Table]
REBUILD
WITH (FILLFACTOR = 90)
```

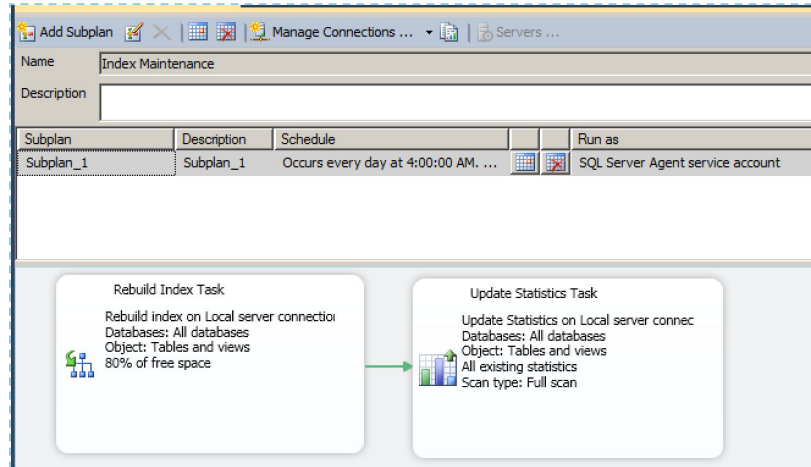
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Prescription for fillfactor

- **Lower gradually, and only when needed**
- **If performance matters, once a month:**
 - Query to find out which indexes that have been frequently rebuilt
 - Plan a change to rebuild those indexes with a slightly lower fillfactor (decrease by 5 – 10%)
- **If performance doesn't really matter, do nothing**

What's wrong with THIS picture?



Concept recap: Statistics

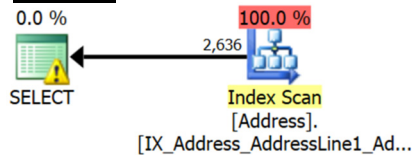
- **Statistics aren't the same thing as indexes!**
- **Statistics guide SQL Server's choices on which indexes to use and how (scan, seek, lookup)**
- **Statistics are estimates of:**
 - What data is within an index or column(s)
 - How the data is distributed

Which execution plan is better?

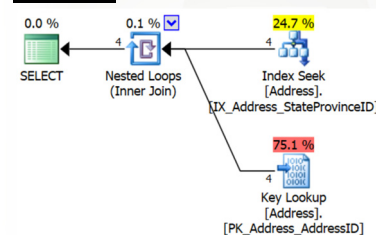
Optimize this query:

```
SELECT City  
FROM Person.Address  
Where StateProvinceID=@P1
```

Plan #1



Plan #2

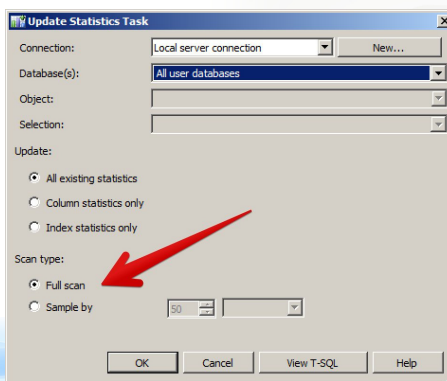


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Rule 6: Avoid the Update Statistics task

- **Danger:** Maintenance plans default to updating all statistics with fullscan
 - This is like mowing your lawn with a chainsaw
 - No option to dynamically choose the sample level



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A 'middle road' for statistics updates

- **Things to consider:**

- Many databases work fine with ZERO statistics maintenance because of the 'auto update statistics' database setting. (Always leave that on.)
- An index 'rebuild' leaves perfect statistics for that index (doesn't help column statistics or other indexes)

- **Solutions:**

- Easy: Do nothing unless you find a problem
- Medium: Update statistics nightly or weekly with sp_updatestats (database level command)
- Hard: use the @UpdateStatistics option on Ola Hallengren's IndexOptimize stored procedure



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Rule 7: Automate failure notification

- **Every SQL Server Agent job should notify someone if it fails (even maintenance)**

- **Pitfall:**

- Avoid notifying on job completion
- If you're concerned the mail will stop working improve your monitoring: have failure events ALSO written to the Windows application log, and have a monitoring tool pick up those messages



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Elements to notification

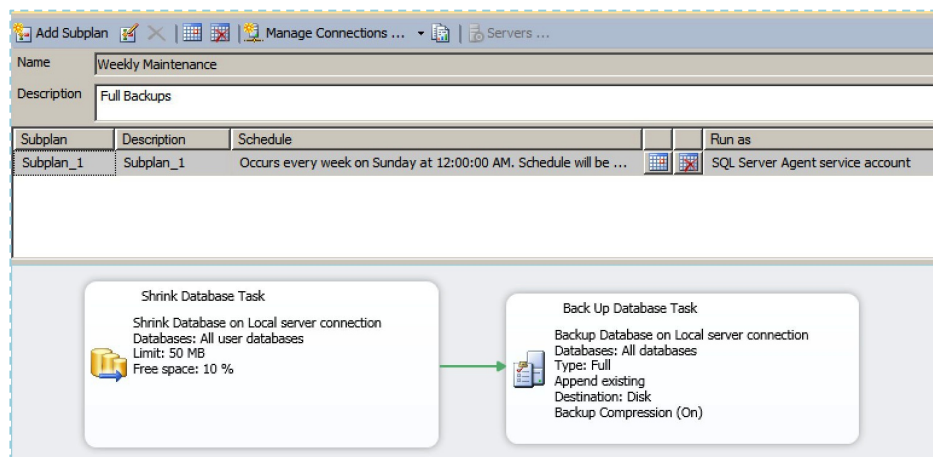
- **Database mail**
 - Configure with SMTP server, test
- **SQL Server Agent Operator**
- **SQL Server Agent Properties**
 - Enable database mail on the agent
 - Set failsafe operator
 - Restart the SQL Server Agent, then test
- **Individual SQL Agent Job Properties**
 - Configure to notify on failure
- **sp_Blitz™ : BrentOzar.com/blitz**



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What's wrong with this picture?



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Rule 8: Don't include bad tasks

- **Some things aren't good for maintenance plans OR regularly scheduled jobs:**
 - Shrink tasks
 - Clearing (dumping) the procedure cache
 - Clearing the buffer pool



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8 Rules of maintenance

1. Backups must ~~meet~~ beat RPO and RTO
2. CheckDB is required
3. Don't let big tasks overlap
4. Know index maintenance options
5. Be smart about fillfactor
6. Update statistics carefully
7. Automate failure notification
8. Don't include bad tasks



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Maintenance Toolkit

(With tips for implementing custom scripts)



Database mail

- Lets your maintenance tell you about problems
- Always configure this

But don't let this be your only monitoring solution!



I have no
idea if it's
working.



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Maintenance plans

Pros

- Visual GUI
- Easy (ish?)
- Handy options like “run against every database” and “ignore offline databases”

Cons

- Doesn't tell you what you **SHOULD** do
- Includes tasks and defaults you shouldn't use
- Brute force approach (Rebuild every index regardless of fragmentation, etc)



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SQL Server Agent jobs

Pros

- Supports TSQL, PowerShell, or CMDEXEC steps
- Used by maintenance plans in the background—so you have to learn this anyway

Cons

- You bring the TSQL
- Can't pass state between job steps or jobs (it's a very simple machine)



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Windows scheduled tasks

- Created in windows, executed on a schedule
- These are very simple, but:
 - People forget about them
 - There's inevitably a conflict with SQL Agent jobs
- Recommendation:
- Look for them if you've inherited a server
- *Migrate any tasks to the SQL Server Agent or other servers if they exist.*



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Multi-server connections

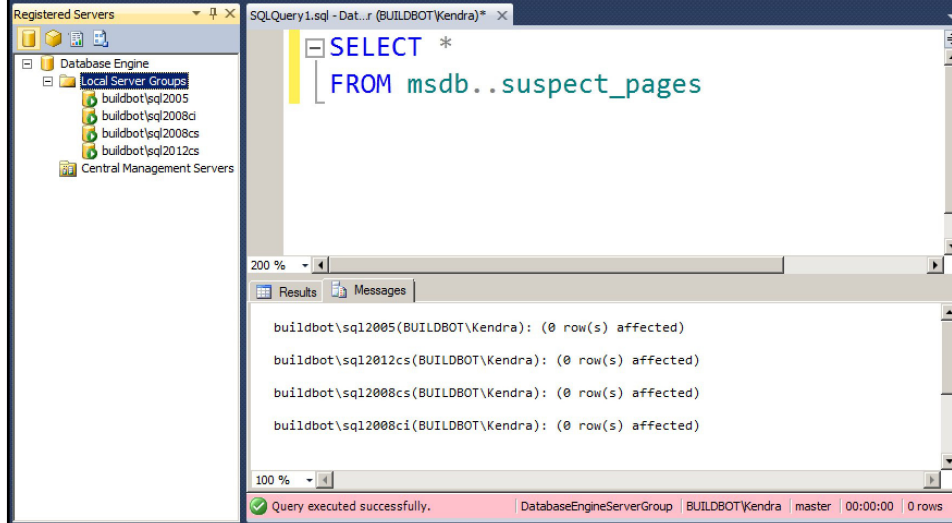
- Quickly run maintenance-related queries across many instances (SSMS 2008+)
- Steps:
 - Register SQL Server instances in SSMS
 - Highlight the group name
 - Click new query window – it will connect to ALL the instances in the group (be careful out there!)
- Free SSMS 2012 download (select Management Studio from download options): <http://www.microsoft.com/en-us/download/details.aspx?id=35579>



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Example: Check suspect pages on four instances



Free maintenance scripts

- **Best in show: Ola Hallengren's scripts**
- **Includes jobs for:**
 - Backups (full, log, differential)
 - CheckDB
 - Index maintenance (including "smart" statistics maintenance options)
 - Pruning old msdb backup and job history
 - Cleaning up its own text log files
- **Free, very high quality**
- **You must take the time to customize, configure, and test**



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Ola Hallengren's maintenance

Ola.Hallengren.com

The screenshot shows a web browser window with the URL `ola.hallengren.com/frequently-asked-questions.html`. The page title is "SQL Server Maintenance Solution". On the left, there is a "Menu" section with links: Home, SQL Server Backup, SQL Server Integrity Check, SQL Server Index and Statistics Maintenance, Downloads, Frequently Asked Questions (highlighted), Version History, Organizations that Use the Solution, Sign Up for the Newsletter, License, and Contact. Below the menu is an "Awards" section featuring a "SQL SERVER 2011" award badge. The main content area is titled "Frequently Asked Questions" and "Getting Started". It includes a section "How do I get started with the SQL Server Maintenance Solution?" with a list of five steps: 1. Download MaintenanceSolution.sql, 2. In the script, find this line: SET @BackupDirectory = N'C:\Backup' and replace C:\Backup with the path to your backup directory, 3. Execute MaintenanceSolution.sql. This script creates all the objects and jobs that you need, 4. Go into [SQL Server Agent] / [Jobs] and start the jobs that have been created. Verify that these jobs are completing successfully. Verify that the backup files are being created. Check the output files in the error log directory, 5. Schedule the jobs. Below this is a section "Do the objects need to be created in the master database?" which states that objects can be created in any database: master, msdb, or a utility database for database administrative scripts. It provides a T-SQL snippet: `USE [master]` and a note to change the line of code in MaintenanceSolution.sql to point to the database in which the objects will be created. The page footer includes "All rights reserved. SQLIntersection.com".

The screenshot shows a web page titled "Examples" with a sub-header "A. Rebuild or reorganize all indexes with fragmentation on all user databases". It contains the following T-SQL code:

```
EXECUTE dbo.IndexOptimize
@Databases = 'USER_DATABASES',
@FragmentationLow = NULL,
@FragmentationMedium = 'INDEX_REORGANIZE,INDEX_REBUILD_ONLINE,INDEX_REBUILD_OFFLINE',
@FragmentationHigh = 'INDEX_REBUILD_ONLINE,INDEX_REBUILD_OFFLINE',
@FragmentationLevel1 = 5,
@FragmentationLevel2 = 30
```

Below this is section "B. Rebuild or reorganize all indexes with fragmentation and update modified statistics on all user databases" with the following T-SQL code:

```
EXECUTE dbo.IndexOptimize
@Databases = 'USER_DATABASES',
@FragmentationLow = NULL,
@FragmentationMedium = 'INDEX_REORGANIZE,INDEX_REBUILD_ONLINE,INDEX_REBUILD_OFFLINE',
@FragmentationHigh = 'INDEX_REBUILD_ONLINE,INDEX_REBUILD_OFFLINE',
@FragmentationLevel1 = 5,
@FragmentationLevel2 = 30,
@UpdateStatistics = 'ALL',
@OnlyModifiedStatistics = 'Y'
```

Section "C. Update statistics on all user databases" contains the following T-SQL code:

```
EXECUTE dbo.IndexOptimize
@Databases = 'USER_DATABASES',
@FragmentationLow = NULL,
@FragmentationMedium = NULL,
@FragmentationHigh = NULL,
@UpdateStatistics = 'ALL'
```

Section "D. Update modified statistics on all user databases" contains the following T-SQL code:

```
EXECUTE dbo.IndexOptimize
@Databases = 'USER_DATABASES',
@FragmentationLow = NULL,
@FragmentationMedium = NULL,
```

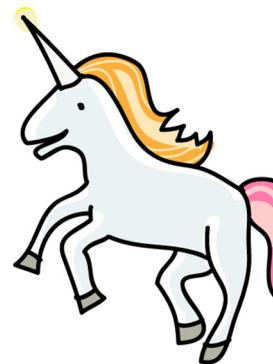
The page footer includes "All rights reserved. http://www.SQLIntersection.com" and a page number "272".

Set up the right maintenance



Check your maintenance against the rules

1. Backups must ~~meet~~ beat RPO and RTO
2. CheckDB is required
3. Don't let big tasks overlap
4. Know index maintenance options
5. Be smart about fillfactor
6. Update statistics carefully
7. Automate failure notification
8. Don't include bad tasks



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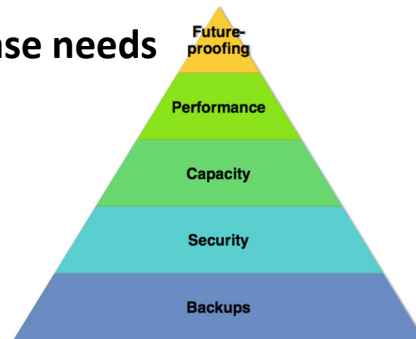
Developer's Guide to Database Operations

Jeremiah Peschka and Kendra Little

Help@BrentOzar.com



Ozar's hierarchy of database needs



- **Futureproofing:** Preventing availability, security, and performance issues before they happen.
- **Performance:** Know your current bottlenecks and how to fix 'em.
- **Capacity:** Know when you're going to run out of space.
- **Security:** Know who has access to the data.
- **Backups:** You can't lose more data than the business is comfortable losing.



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Assess your risks honestly

	July 2014	Oct 2014	April 2014	Jan 2015
Future Proofing	What's that?			
Performance	C			
Capacity	A			
Security	Danger!			
Backups	B			



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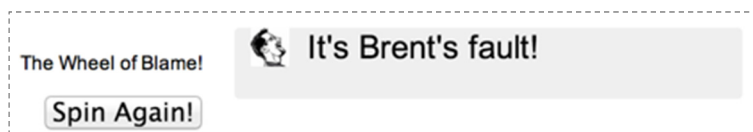
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Won't this make us look bad?

- Possibly
- A key to operations is focusing on *improvement*
- Consider making your own Wheel of Blame:
<http://jsfiddle.net/BrentO/2rxxs/embedded/result/>



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Orlando, Florida – April 2014

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Get things in order (one-time tasks)

Get this under control first



Initial data collection

Complete?	Task
	Run sp_Blitz® for the first time and save off output. This will help you collect the information you need to review on many of the following slides.
	Identify high risk sp_Blitz® items, review the information on the URLs. Even though we're pointing out specific things to look for in the following slides, don't skip things!
	Question all non-default sp_configure settings and trace flags. • Ask if there is a documented reason why these are enabled and if they are required by the application using SQL Server. • If not, make a plan to test and return to a configuration using more standard settings • Want to know what's normal to change in a "vanilla" setup? See BrentOzar.com/go/setup



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Find and fix backup anti-patterns

Complete?	Task	Frequency
	Are you deleting too many backup files to meet your RPO and RTO? (Full, Log, and Differential)	Once
	Are you keeping enough copies of backup files on reliable storage? (Full, Log, and Differential)	Once
	Can you copy and restore to the backup files fast enough to meet your RPO and RTO? Include: Copy time, restore time, scripting time for commands to a given point in time. Note: Test copy time on block-compression storage devices after the devices have a good amount of data populated	Once



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Check for Corruption

Complete?	Task	Frequency
	Automate CheckDB against system databases nightly (including tempdb)	Once
	Automate CheckDB against user databases at least weekly, potentially nightly if appropriate. Offload to a system using a backup/restore technique if needed.	Once
	Validate that large maintenance tasks, like full backups, CheckDBs, and index maintenance can't overlap	Once



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Clean up suspicious activities

Complete?	Task	Frequency
	Find tasks shrinking any databases. This might be data files, log files, or tempdb. Identify why these steps exist and make a plan to remove the job. This may require adding disk space, modifying growth settings, and improving monitoring: it's all worth it.	Once
	Identify any jobs and clear about the buffer pool or regularly clear out the procedure cache. Is there a reason those jobs exist? Look into removing them.	Once
	Look for any other jobs that modify SQL Server Configuration on a daily basis. Is there a documented, proven reason those steps are necessary? Question them closely.	Once



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Check your dependencies

Complete?	Task
	Do you have 32 bit SQL Servers?
	Do you have SQL Server 2000 or prior?
	Do you have SQL Server 2005 lower than SP4?
	Identify virtualized SQL Servers using a VMware version lower than 5.0.
	Identify virtualized SQL Servers using Hyper-V lower than Windows 2012
	Identify production SQL Servers with < 72 GB of memory
	Identify SQL Servers with multiple “Stacked” instances on a single OS



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Set standards by tier

Complete?	Task
	If you have multiple SQL Servers, establish “Tiers”. Examples: • Mission Critical – 24 x 7 uptime, very quick response times • Business Standard – Monday – Friday 6am-10pm uptime, 1 hour response time
	Establish minimum configuration guidelines for each tier of servers. (Build these up over time. Start with at least standards for backups.)
	For lower tiers of servers, performance expectations should be lower and response times longer.



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Interview your virtualization admin

Which of these benefits do you have for each SQL Server Instance?	Y/N?
Cost savings at the hardware level	
Ability to move VMs between hosts	
Automatic failover when a host goes down	
Leverage extended features for Disaster Recovery	
License savings with 5-10 production SQL VMs	
Automatic load balancing across multiple hosts	

These answers may vary for each VM.



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Assess your environment configuration

Complete?	Task	Frequency
	For production tiers of SQL Servers, do you also have: • Staging environment • Integration environment	Revisit at least annually
	Does your Staging environment “match” production? • Installation type (physical/virtual) • OS and SQL Server version • Hardware and storage • High availability features (clustering, etc) • Data transfer technologies (replication)	Annually
	How much work is it to keep environments “in sync” with one another? (Or would it be, if you had more environments?)	Annually



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Set up monitoring

Complete?	Task	Frequency
	Decide on your monitoring tools & technology.	Once
	Test monitoring technology against a recorded workload. Verify that you can spot problems.	Once
	Set up monitoring for waits, disks, and queries. Set up alerts for high severity issues.	Once
	Create custom monitoring scripts to spot production problems.	Once

Set up your performance troubleshooting process

Complete?	Task	Frequency
	Build your starter First Responder Kit – customize ours with what you're comfortable with. Add items specific to your environment.	Once
	Get a buddy to test your First Responder Kit. Even if they're not a SQL Server specialist, you need a backup! Make sure this can be used when you're way.	Once
	When things are slow, run sp_WhoIsActive and look for wait stats on your queries	When performance is bad
	Take sp_AskBrent® samples and use the Wait Stats Decoder Chart to identify the biggest bottlenecks	When performance is bad

Baseline

Complete?	Task	Frequency
	Document your waits since startup using our 'Triage Wait Stats in SQL Server' Script at BrentOzar.com/Responder. Start small: Start with your most critical system and don't over-engineer collecting info you aren't ready to use!	Once
	Take sp_AskBrent samples for 30 seconds (or perhaps longer) at critical periods and compare them to your baseline	Weekly



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Choose your maintenance tools

Complete?	Task	Frequency
	Configure Database Mail, enable it on the SQL Server Agent, and make sure it's working: Create a SQL Server Agent job with one step that is: Print 'hello' Set the job to notify the operator when it completes Run the job, make sure you get the email	Once
	Choose your approach: Maintenance Plans Have a defined, regular downtime interval Don't have time to work with TSQL commands Custom Scripts Everyone else!	Once
	Audit Windows Scheduled Tasks on all SQL Servers and plan tasks for migration.	Once



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Maintain indexes (tread lightly)

Complete?	Task	Frequency
	Look for jobs that are rebuilding indexes more than once daily. Is there a known reason why that has to be that way?	One time setup
	Look for fillfactor < 90%. Is there a documented, proven reason why that is needed? Free tool to identify: BrentOzar.com/BlitzIndex	One time setup
	Implement weekly index maintenance Default to <i>light</i> index maintenance – remember that overreacting to fragmentation can be worse than the fragmentation itself	One time setup
	Optional: automate statistics maintenance. If you choose to do this, either: • Run sp_updatestats against the database before index maintenance • Or use the integrated tools in Ola Hallengren's index maintenance (preferred)	One time setup



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Ongoing tasks

Automate ALL THE THINGS



Check your backups

Complete?	Task	Frequency
	Verify databases are being backed up	Weekly
	Measure backup performance & throughput	Weekly
	Check SQL Agent logs for errors	Weekly
	Clear backup history tables	Weekly
	Verify backups by restoring to another server	Monthly
	Can a test restore of the database be completed within RTO?	Monthly



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Ongoing configuration management

Complete?	Task	Frequency
	Automate running sp_Blitz® and saving output to a central location.	Monthly
	Identify high risk sp_Blitz® items and review if these change	Monthly
	Review and compare sp_Blitz® output over time • Have configuration options been changed? • Are there new administrators?	At least quarterly
	Develop an action plan based on sp_Blitz® results.	At least quarterly



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Review process and architecture at least annually

- Review your instance tiers and response times
- Interview your virtualization admin
- Revisit your environment architecture– would you benefit from having staging / disaster recovery / differently configured environments?
- Review your First Responder Kit and troubleshooting process
 - Can you bring more people into the rotation?
 - Can you automate more tasks?



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Links and more info: BrentOzar.com/go/dbOps



Password:
automate

Visit within 3
months!



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Please evaluate



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

Session: PRECON03

Developer's Guide to Database Operations

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



Thank you!