



BCA1995

Design, Deploy, Optimized SQL Server on VMware ESXi 5

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Disclaimer

- **This session may contain product features that are currently under development.**
- **This session/overview of the new technology represents no commitment from VMware to deliver these features in any generally available product.**
- **Features are subject to change, and must not be included in contracts, purchase orders, or sales agreements of any kind.**
- **Technical feasibility and market demand will affect final delivery.**
- **Pricing and packaging for any new technologies or features discussed or presented have not been determined.**

Agenda

- **Introductions**
- **SQL Server on VMware Overview**
- **Tier 1 Workloads – Architecting for Performance**
 - Resource Allocation
 - Monitoring and Troubleshooting
 - SQL Server Guest Tuning
- **Database and Licensing Consolidation**
- **Availability & Recovery Options**
- **More Information**

Virtualizing Business Critical Applications

CIOs and IT Operations Want To Virtualize More

- ✓ Infrastructure efficiency
- ✓ Simpler management
- ✓ Built-in availability
- ✓ Greater agility



Head of IT
Operations

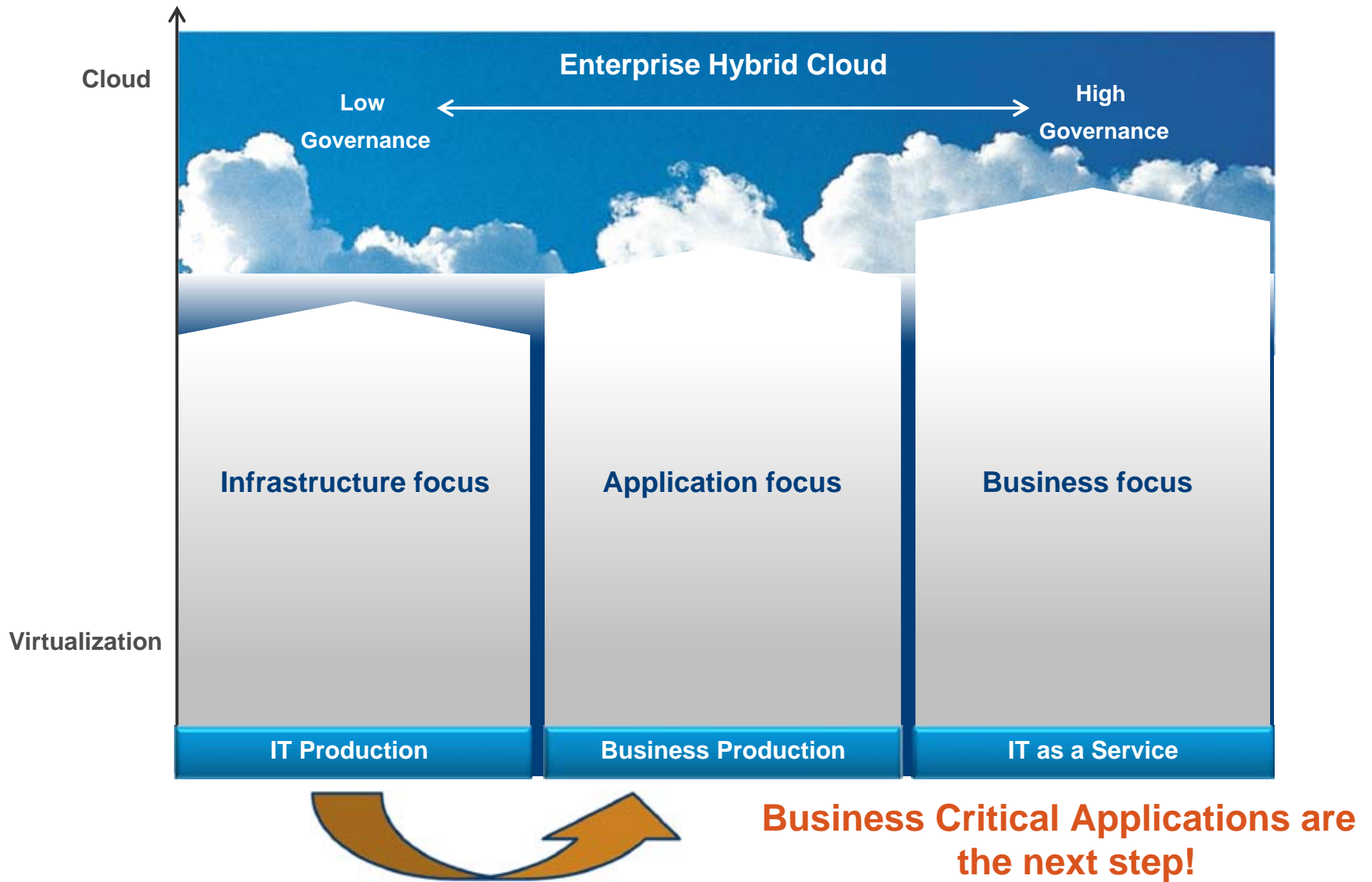
But Sometimes Application Owners Need Convincing

- ❓ Will my app perform well?
- ❓ Will my ISV support me?
- ❓ What's in it for me? Will my application run better?



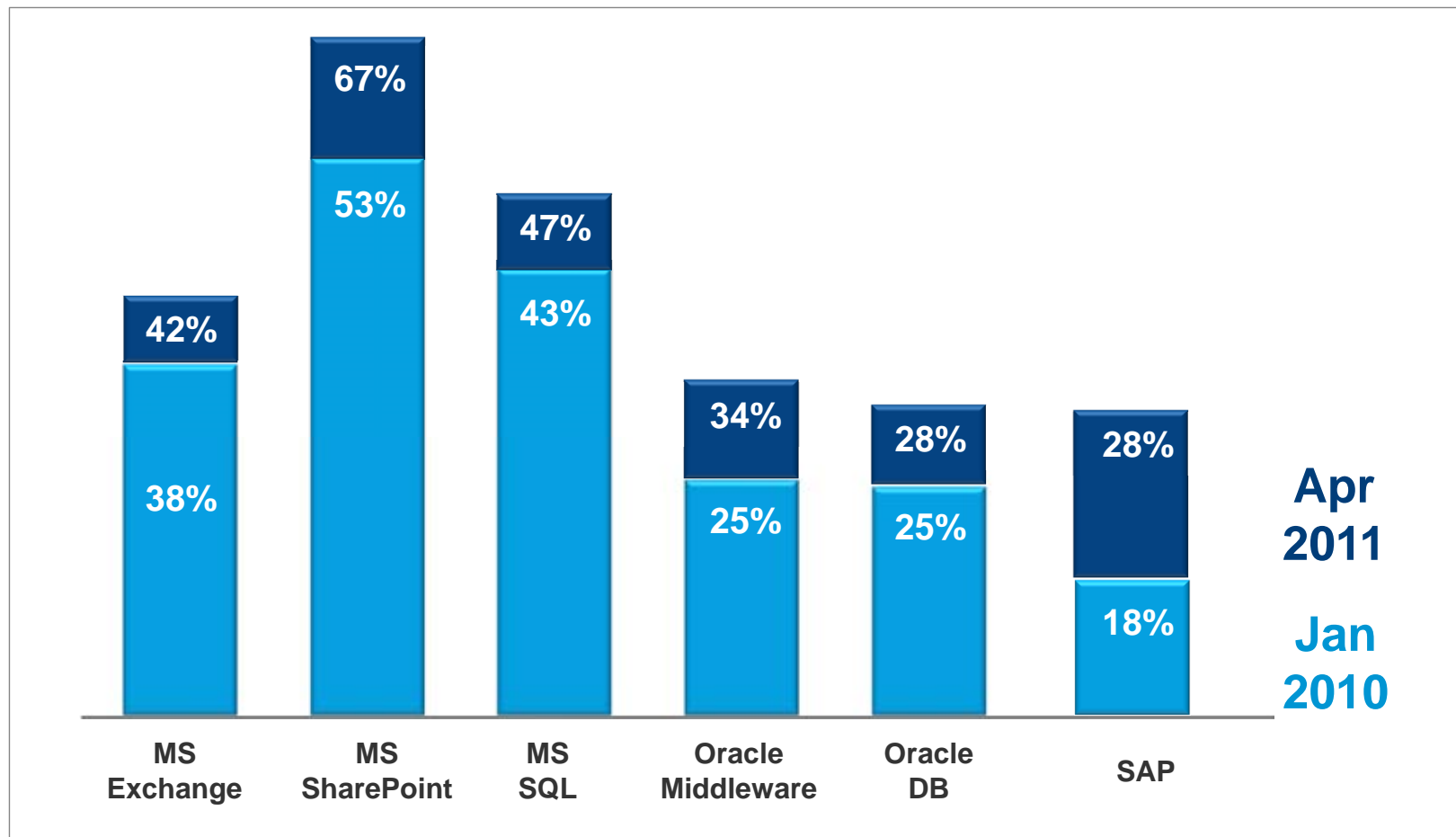
Application
Owner

Journey to IT Transformation – Accelerate and Amplify



The Trend Is Clear

% of Workload Instances Running on VMware in Customer Base



Source: VMware customer survey, Jan 2010 and April 2011 interim results,
Data: Total number of instances of that workload deployed in your organization and the percentage of those instances that are virtualized

Benefits of SQL Server on VMware

Server Consolidation

- Utilize all your server processor cores
 - Consolidate SQL Servers with minimal impact to applications
 - Consolidate SQL Server licenses
-

Operational Advantages

- Rapidly respond to changing workloads
 - Enhance testing and troubleshooting using cloned production virtual machines
 - Isolate database virtual machines from security threats
-

Higher availability with less complexity

- Reduce planned downtime due to hardware or BIOS updates with VMware vMotion™
- Reduce unplanned downtime due to hardware failure or resource constraints
- Implement simple and reliable SQL Server disaster recovery

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Maximum Scalability and Performance With vSphere 5

Application's Performance Requirements

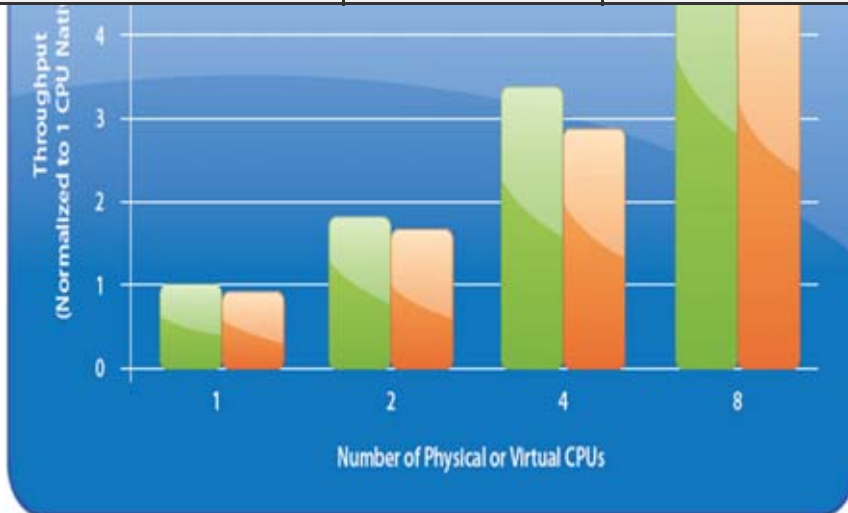
% of Applications	95% of Apps Require		ESX 1	ESX 2	VMware Inf. 3.0/3.5	VMware vSphere 4	VMware vSphere 5
	CPU	1 to 2 CPUs	1 VCPUs	2 VCPUs	4 VCPUs	8 VCPUs	32 VCPUs
	Memory	< 4 GB at peak	2 GB per VM	3.6 GB per VM	16/64 GB per VM	256 GB per VM	1,000 GB per VM
	Network	<2.4 Mb/s	<.5Gb/s	.9 Gb/s	9 Gb/s	30 Gb/s	>36Gb/s
	IOPS	< 10,000	<5,000	7,000	100,000	300,000	1,000,000

SQL Server Scale Up and Scale Out Testing (TPC E)

Scale Up

- At 1 & 2 vCPUs, ESX is 92 % of native performance

Metric	Physical Machine	Virtual Machine
Throughput in transactions/second	3557	3060
Avg. response time of all transactions	234 milliseconds	255 milliseconds
Disk I/O throughput (IOPS)	29 K	25.5 K
Disk I/O latencies	9 milliseconds	8 milliseconds

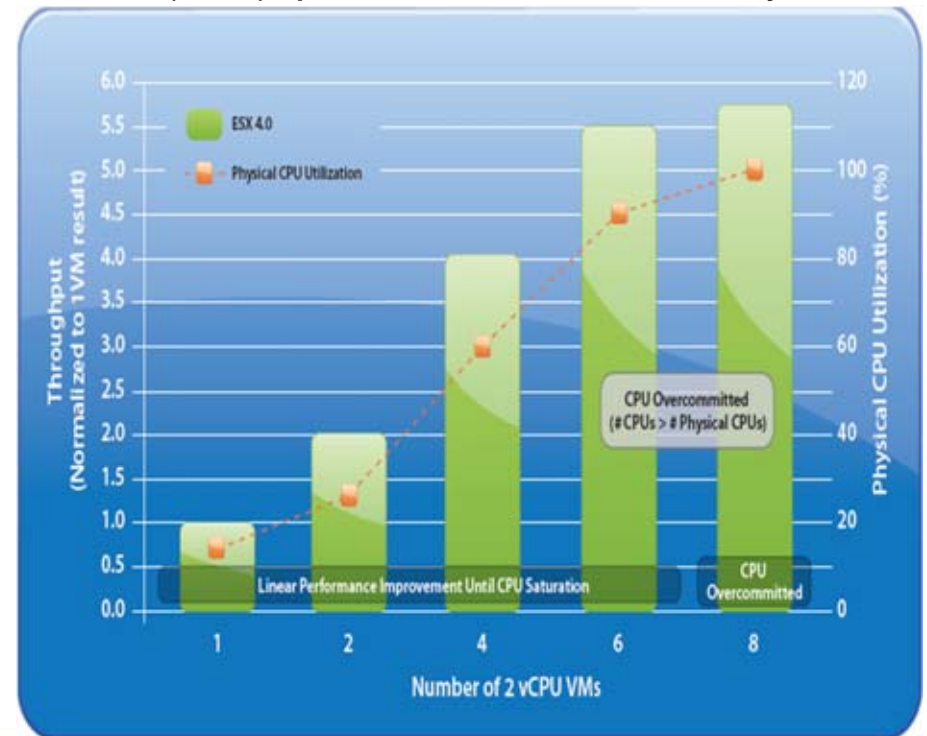


Scale Out

- Throughput increases linearly as we add up to 8-vCPUs in four virtual

Aggregate throughput in transactions/second	Host CPU utilization	Disk I/O throughput (IOPS)
2760	100%	23K

(1.5x), performance increases by 1.4x



SQL Server Workloads

OLTP

- Large amount of small queries
 - Sustained CPU utilization during working hours
 - Sensitive to peak contentions (slow downs affects SLA)
-

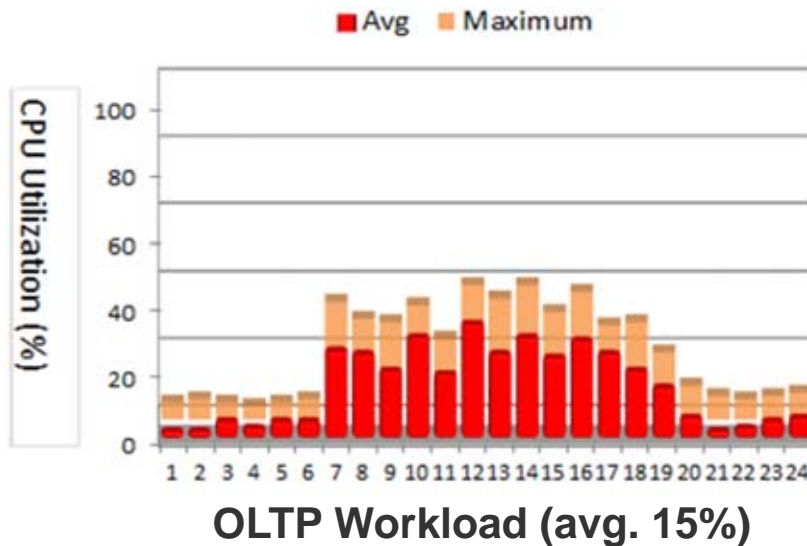
Batch / ETL

- Generally Write intensive
 - May generate many chatty network around trips
 - Typically runs during off-peak hours, low CPU utilization during the normal working hours
 - Can withstand peak contention, but sustain activity is key
-

DSS

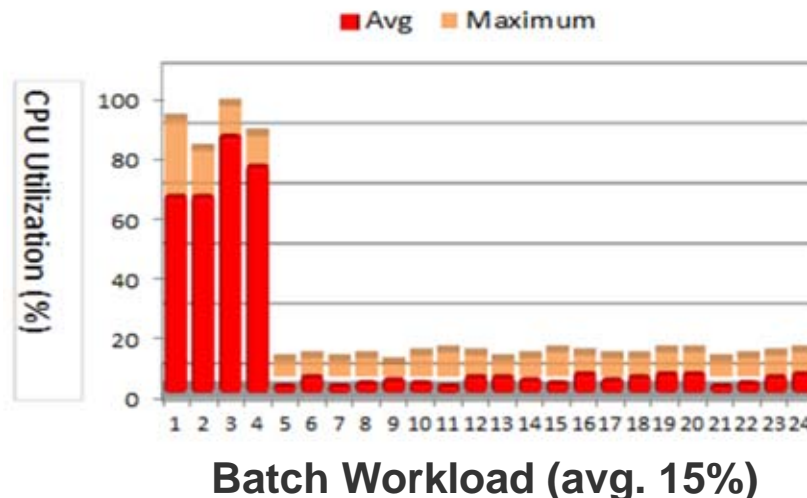
- Small amount of large queries
- CPU, memory, disk IO intensive
- Peaks during month end, quarter end, year end
- Can benefit from inter-query parallelism with large number of threads

OLTP vs. Batch Workloads



■ What this says:

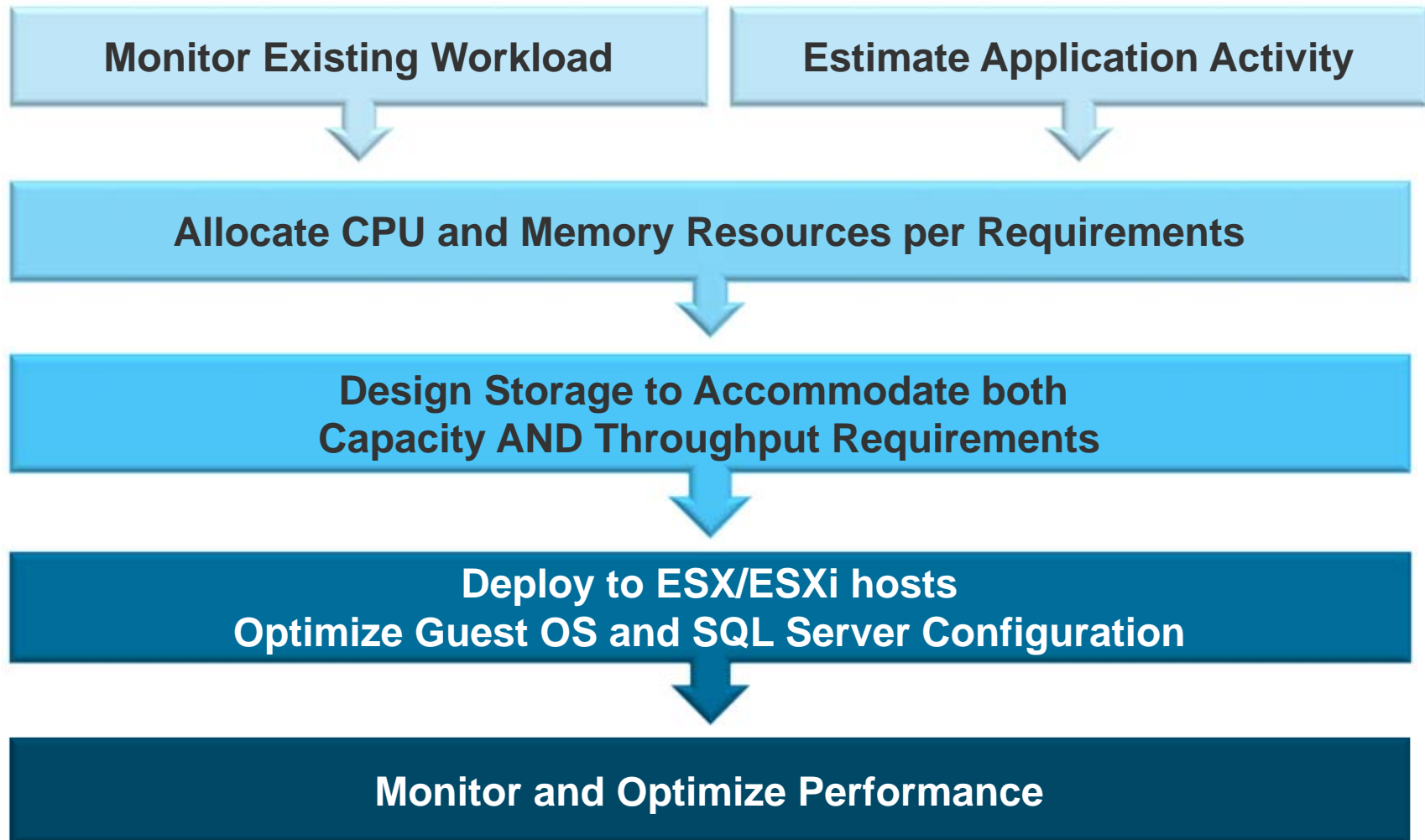
- Average 15% Utilization
- Moderate sustained activity (around 28% during working hours 8am-6pm)
- Minimum activities during none working hours
- Peak utilization of 58%



■ What this says:

- Average 15% Utilization
- Very quiet during the working day (less than 8% utilization)
- Heavy activity during 1am-4am, with avg. 73%, and peak 95%

SQL Performance Lifecycle





Resource Allocation

Virtual Machine Resource Allocation

■ Virtual CPUs

- Allocate the minimum requirement and adjust as needed; use HotAdd.
- Avoid pCPU overcommitment with tier 1 production workloads
 - However, if overcommitting CPU, monitor %RDY, %MLMTD, and %CSTP
- Keep NUMA node size in mind with sizing virtual machines



■ Virtual Memory

- “Right-size” memory allocations for efficient use of host memory
- Use vSphere 5 to take advantage of memory compression
- Avoid pCPU overcommitment with tier 1 production workloads
 - If overcommitting memory, monitor SWAP /MB: r/s, w/s and MCTLSZ



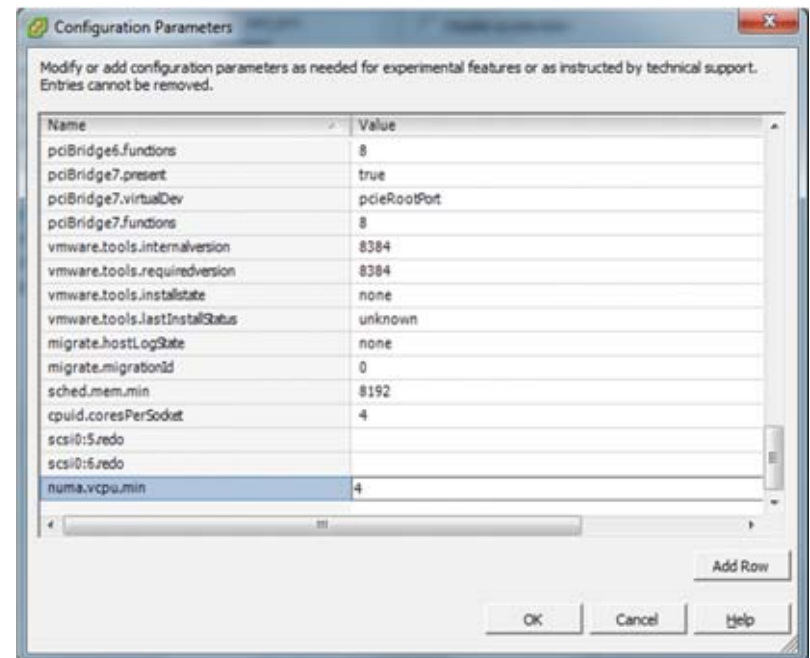
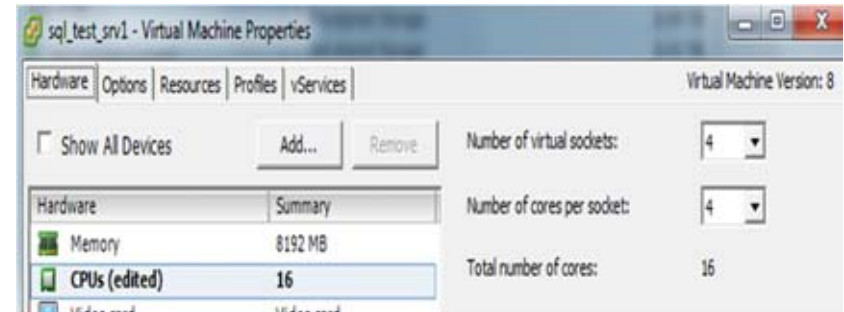
■ Storage

- Understand I/O requirements for each application to avoid performance degradation due to under-provisioned storage
- Use redundant paths to storage – Dual host-bus adapters or teamed network interface cards connected to separate switching infrastructures



Virtual NUMA in vSphere 5

- **Extends NUMA architecture to guest operating system**
- **Enabled through multi-core UI**
 - On by default for 8+ vCPU multi-core VM
 - Existing VMs are not affected through upgrade
 - For smaller VMs, enable by setting configuration parameter `numa.vcpu.min=4`
- **Virtual NUMA is off by default if CPU hot-add is turned on**
- **SQL Server**
 - Automatically detect NUMA architecture
 - Starts up w/ node to CPU affinity
 - SQL Server process and memory allocation optimize for NUMA architecture

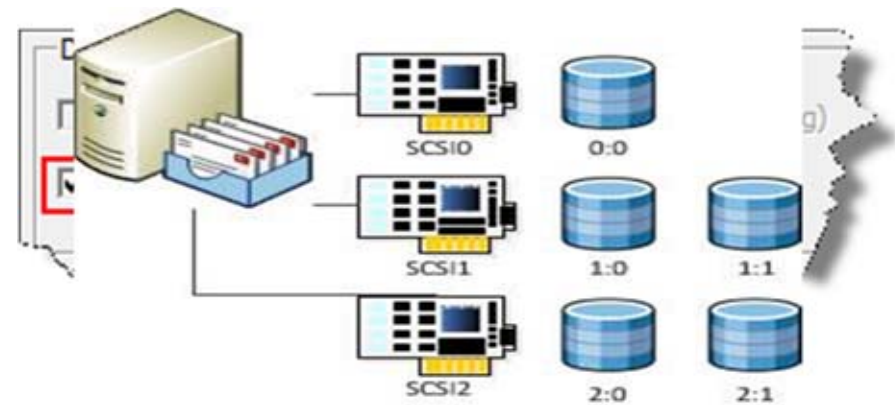


Storage



■ General Best Practices

- **Deploy application VMs on shared storage** – allows vSphere features like VMotion, HA, and DRS
- **Create VMFS file systems from vCenter** to ensure partition alignment
- When using VMFS for data storage **format VMDK files as *eagerzeroedthick*** (specifically for database and log files)
- **Use multiple vSCSI adapters** and evenly distribute target devices
- Windows versions prior to 2008 will require **partition alignment** from within the guest



Storage – VMFS vs. RDM



- **Generally similar performance:**

http://www.vmware.com/files/pdf/performance_char_vmfs_rdm.pdf

VMFS	RDM
Better storage consolidation – multiple virtual disks/VMs per VMFS LUN. But still can assign one VM per LUN	Enforces 1:1 mapping between VM and LUN
Consolidating VMs in LUN – less likely to reach ESX LUN Limit of 255	More likely to hit ESX LUN limit of 255
Manage performance: combined IOPS of all VMs in LUN < IOPS rating of LUN	Not impacted by IOPS of other VMs

- **When to use RDM:**

- Required for clustering (Quorum disk) e.g. SQL Failover Clustering
- Required by storage vendor for SAN management tools (e.g. backup , snapshots)
- **Otherwise use VMFS**

- **For database layout**

- Follow same guidelines as physical - separate LUNs for data and redo/log
- For Tier 1 production maintain 1:1 mapping between VM and LUN (VMFS or RDM)
- Should be joint effort between DBA, VMware, and Storage admins

Resource Allocation Summary

- Use and monitor CPU and Memory overcommitment carefully; avoiding overcommitment for Tier 1 workloads is optimal
- Storage I/O is a crucial element of performance
- With correct storage/disk sizing designed to deliver required IOPS generated by application + correctly configured storage array...**I/O performance on VMware should not be an issue**
- For mission critical SQL Server databases, design as on physical (1:1 VM to LUN mapping)
- **But note:** smaller databases running tier 2 workloads (e.g. departmental servers), possible to consolidate LUN with multiple VMs...depends on IOPS (potential Storage IO Control use case)

SQL Server Guest Tuning

SQL Server In-Guest Memory Best Practices

- Use large pages in the guest (start SQL Server w/ Trace flag –T834)
- Enable Lock Pages in Memory privilege for SQL Server Service account
- Set ‘Max Server Memory’ and ‘Min Server Memory’
 - SQL Max Memory =
VM Memory (Provision=Reserved)
(minus) → – VM overhead
– (NumOfSQLThreads*ThreadStackSize)
– (1GB*CEILING(NumOfCores/4))
– (Any memory required for other apps)
 - NumOfSQLThreads = $256 + (\text{NumOfProcessors} - 4) * 8$
 - ***If NumOfProcessor > 4, else 0**
 - ThreadStackSize = 1MB on x86
= 2MB on x64
= 4MB on IA64

SQL Server In-Guest Storage Best Practices

- Follow SQL Server storage best practices
 - <http://technet.microsoft.com/en-us/library/cc966534.aspx>
- Plan for **performance** instead of capacity, use large number of small drives
- Ensure correct “sector alignment”
 - Incorrect setting can result in up to 50% perf hit
 - 64K most common, Windows 2008 aligns sectors by default
- Pre-allocate data files to avoid autogrow during peak time
- Use multiple data files for data and tempdb (start w/ 1 file per CPU core)
- Database file placement priority (fastest to slowest drive)
 - T-log > TempDB data > Data
- Place tempdb, data, and log files on separate LUNs
- Use IOMeter to measure I/O performance
- Perform routine maintenance w/ index rebuild/reorg, dbcc checkdb



Monitoring and Troubleshooting

In-guest SQL Server Monitoring

■ Perfmon

- SQL Server specific counters: \SQLServer:*\
 - VMware Tools includes a Perfmon DLL that provides visibility into host CPU, memory, and disk usage
 - <http://vpivot.com/2009/09/17/using-perfmon-for-accurate-esx-performance-counters/>

■ SQL Server Profiler

- Monitor SQL Server performance at T-SQL statement level
- Runs in three modes: interactive, batch, replay
- Common events of interests
 - SQL:BatchStarting/SQL:BatchCompleted, RPC:Starting/RPC:Completed, Errors and Warnings (All), SP:StmtStarting/Completed, SQL:StmtStarting/Completed

■ SQL Server Dynamic Management Views (DMVs)

- Monitor the internal health of SQL Server
- Sys.dm_*

■ See [Troubleshooting Performance Problems in SQL Server 2008](#)

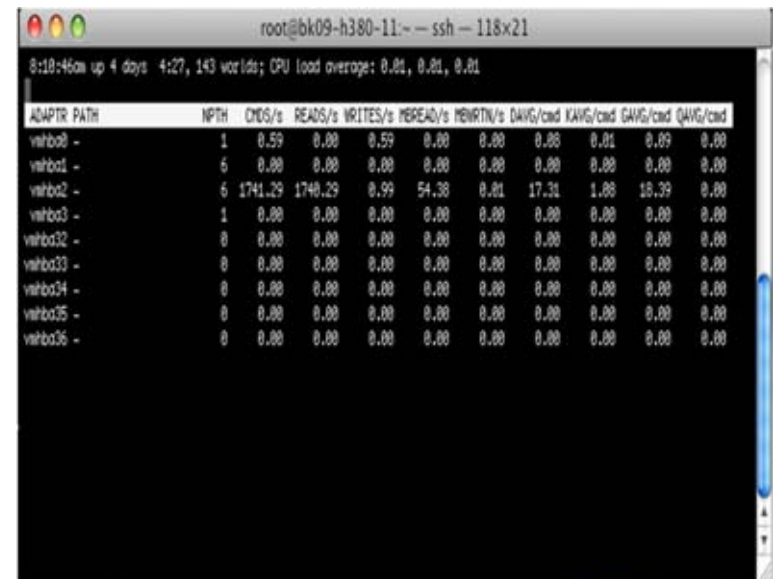
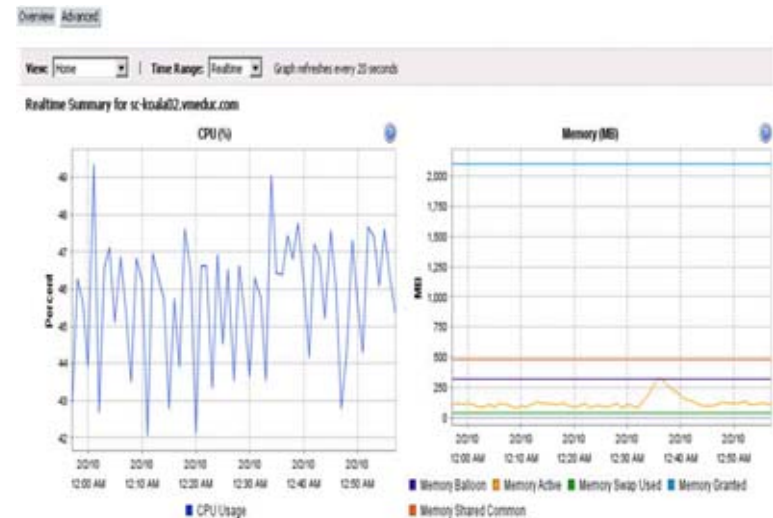
Host Level Monitoring

■ vSphere Client:

- GUI interface, primary tool for observing performance and configuration data for one or more ESX/ESXi hosts
- Does not require high levels of privilege to access the data

■ Resxtop/Esxtop

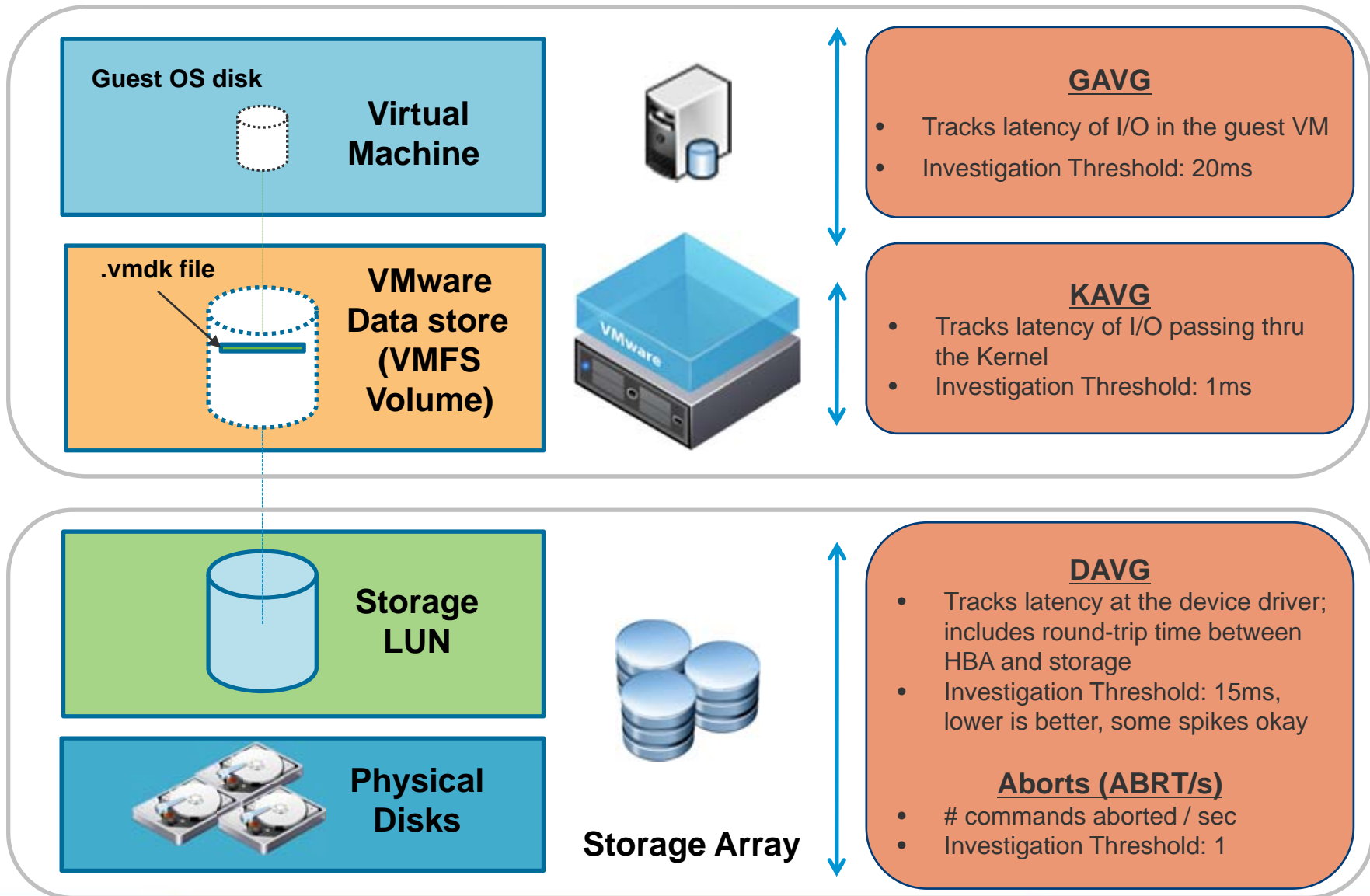
- Gives access to detailed performance data of a single ESX/ESXi host
- Provides fast access to a large number of performance metrics
- Requires root-level access
- Runs in interactive, batch, or replay mode



Key Metrics to Monitor for ESX

Resource	Metric	Host / VM	Description
CPU	%USED	Both	CPU used over the collection interval (%)
	%RDY	VM	CPU time spent in ready state
	%SYS	Both	Percentage of time spent in the ESX Server VMKernel
Memory	Swapin, Swapout	Both	Memory ESX host swaps in/out from/to disk (per VM, or cumulative over host)
	MCTLSZ (MB)	Both	Amount of memory reclaimed from resource pool by way of ballooning
Disk	READs/s, WRITEs/s	Both	Reads and Writes issued in the collection interval
	DAVG/cmd	Both	Average latency (ms) of the device (LUN)
	KAVG/cmd	Both	Average latency (ms) in the VMkernel, also known as “queuing time”
	GAVG/cmd	Both	Average latency (ms) in the guest. $GAVG = DAVG + KAVG$
Network	MbRX/s, MbTX/s	Both	Amount of data transmitted per second
	PKTRX/s, PKTTX/s	Both	Packets transmitted per second
	%DRPRX, %DRPTX	Both	Drop packets per second

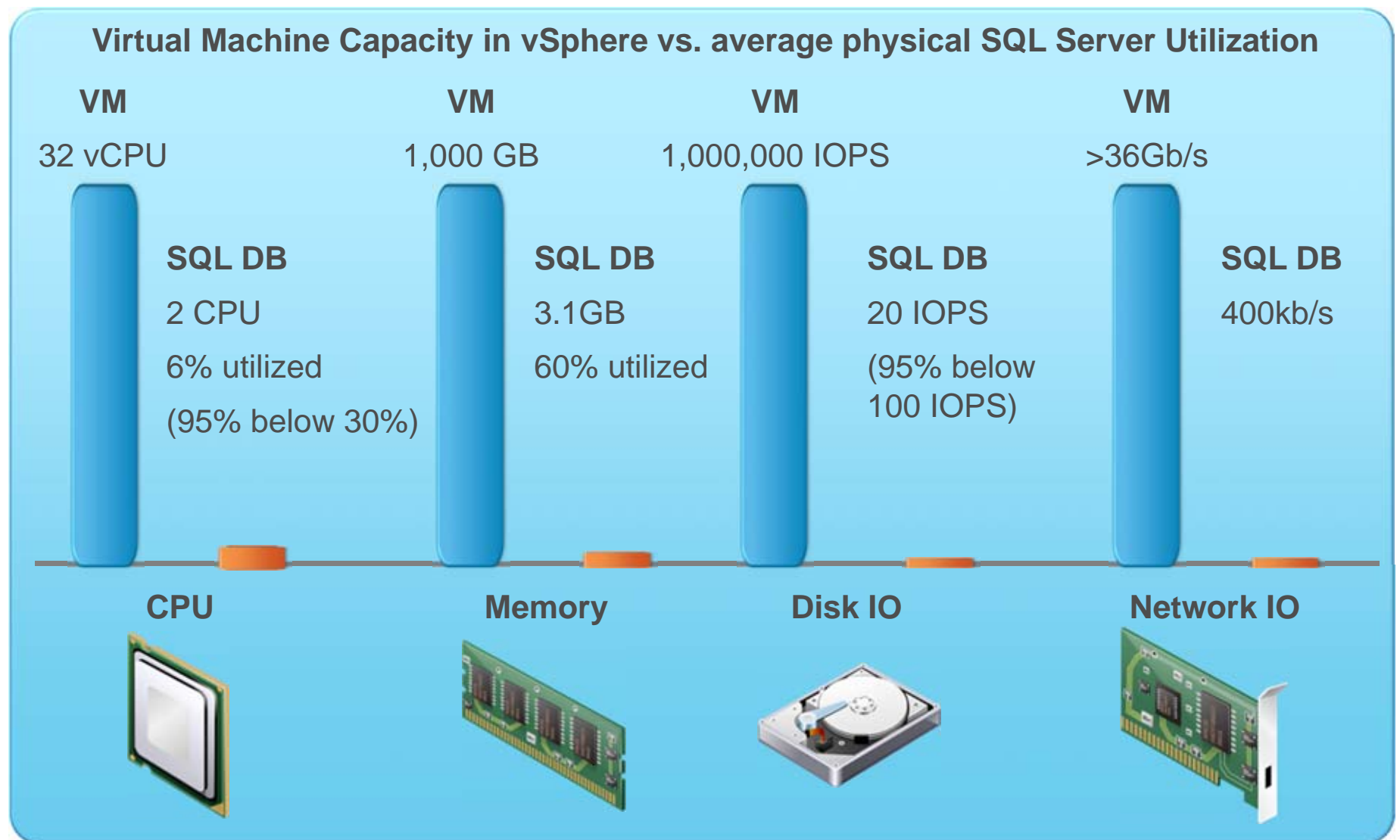
Logical Storage Layers: from Physical Disks to vmdks



Agenda

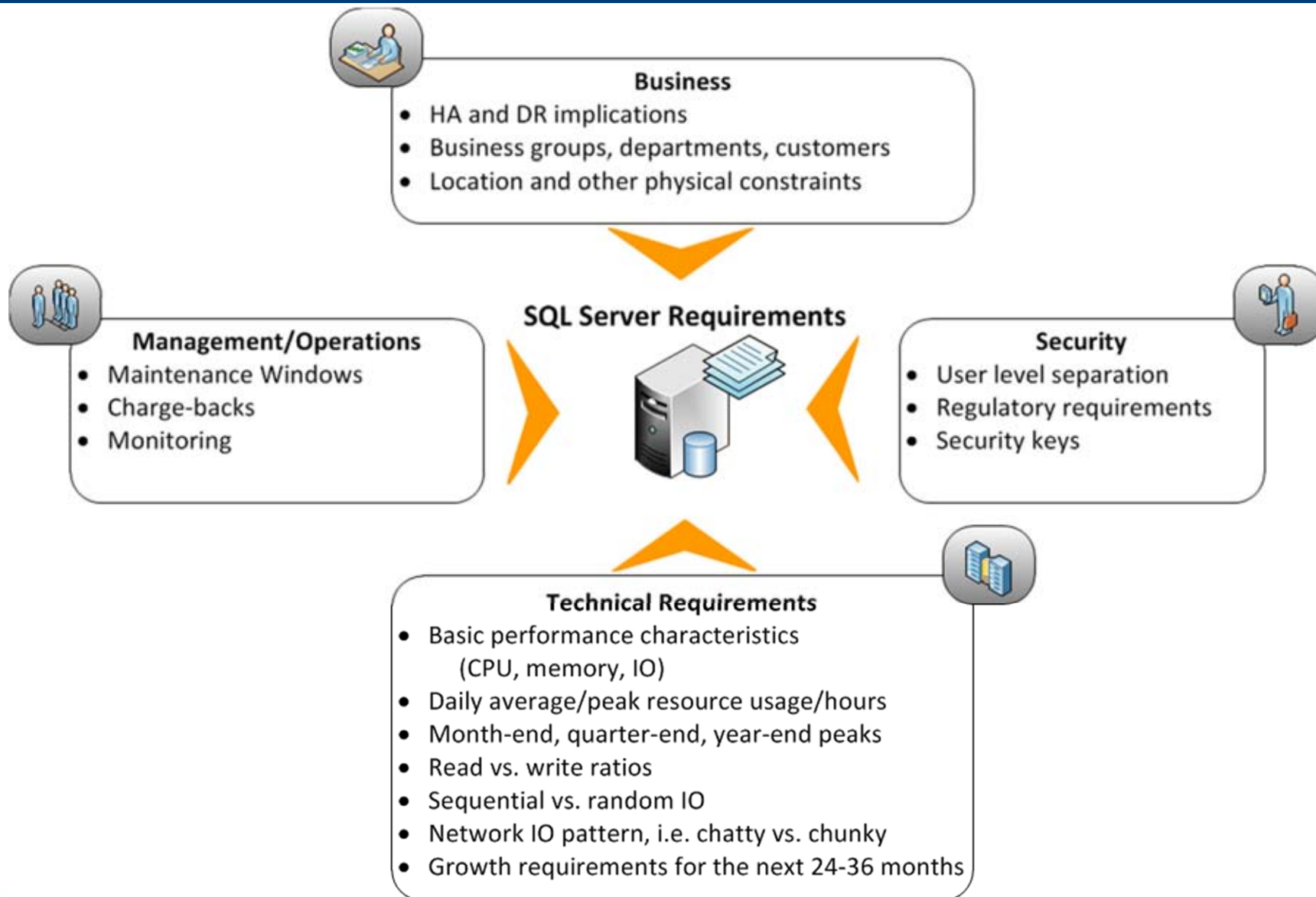
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The Average SQL DB Fits Easily in VM (vSphere 5)



Source: VMware Capacity Planner analysis of >700,000 servers in customer production environments

SQL Server Requirements – The Big Picture

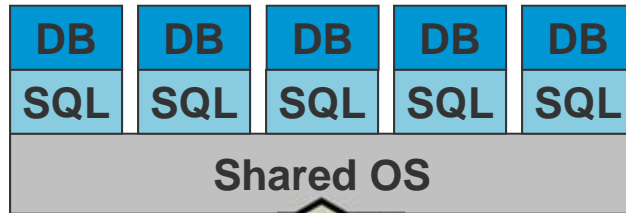


Classify and Prioritize Potential Migration Targets

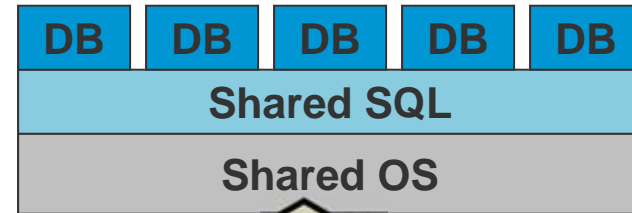
- **Business value/cost impact of the migration, including:**
 - Timing of vendor agreements/support contracts
 - Hardware renewals
- **Resource allocation/utilization**
- **Potential risk**
 - Ease of operational transition
 - Ease of technical transition
- **Application dependencies**
- **Migration impact (what outage is appropriate/acceptable for the application)**

Conventional DB Consolidation is Difficult

Multi-Instanced



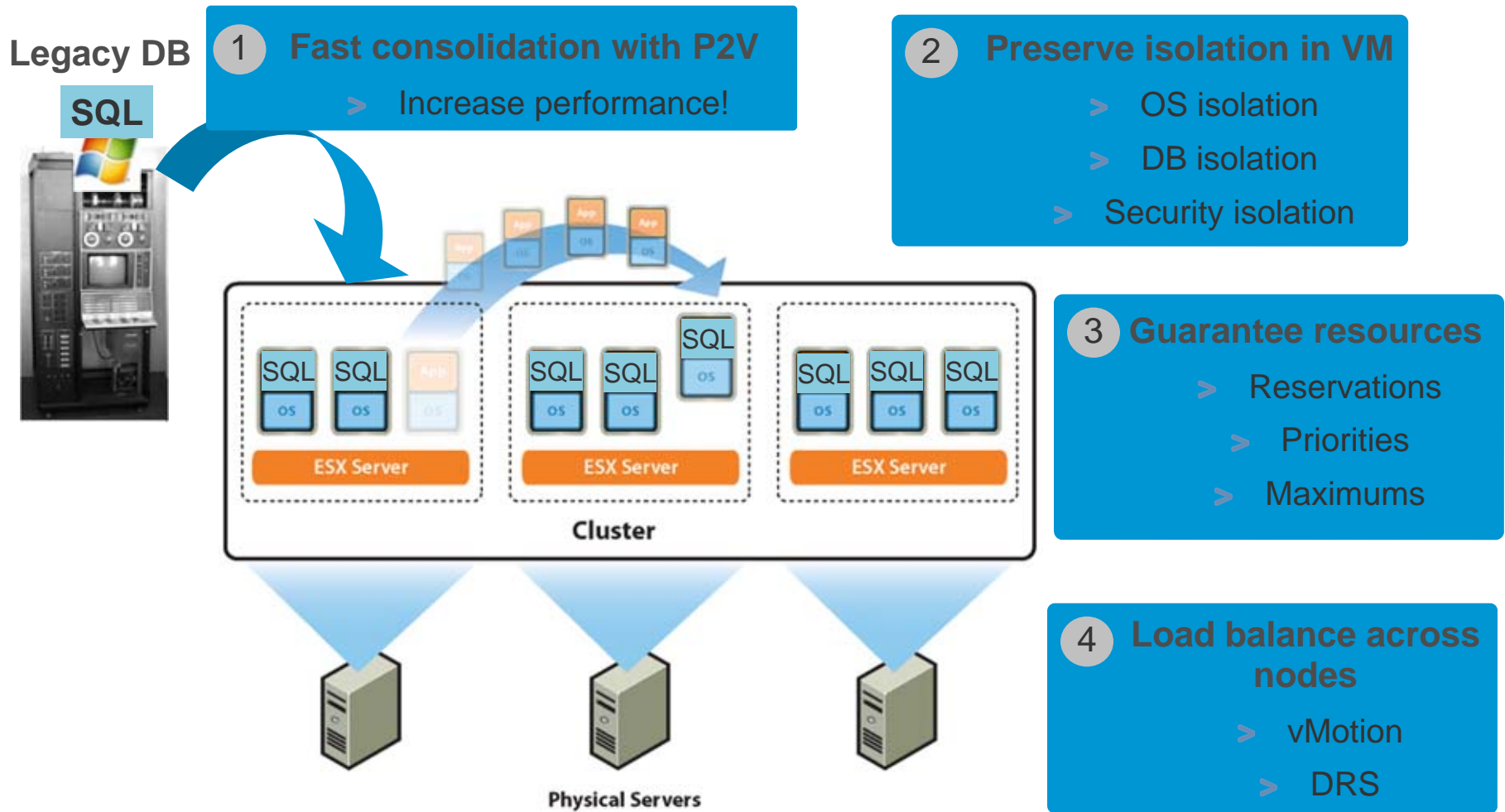
- No OS isolation (configuration, security, fault)
- Resource isolation requires Windows Resource Manager
- No load balancing across physical nodes



- No OS isolation (configuration, security, fault)
 - No Database isolation
- Resource isolation requires SQL Resource Governor
- No load balancing across physical nodes

- **Remediation is a continual, painful, effort-consuming process!**

Ideal Platform for DB Consolidation



- Requires no changes to the applications that are using SQL Server!

Scale-up versus Scale-out Virtual Deployment

Scale-Up Approach

- Multiple databases or SQL instances per VM
- Fewer VMware ESX VMs
- Single point of failure
- Larger VM
 - SMP overheads
- OS bottleneck, especially for 32-bit environments



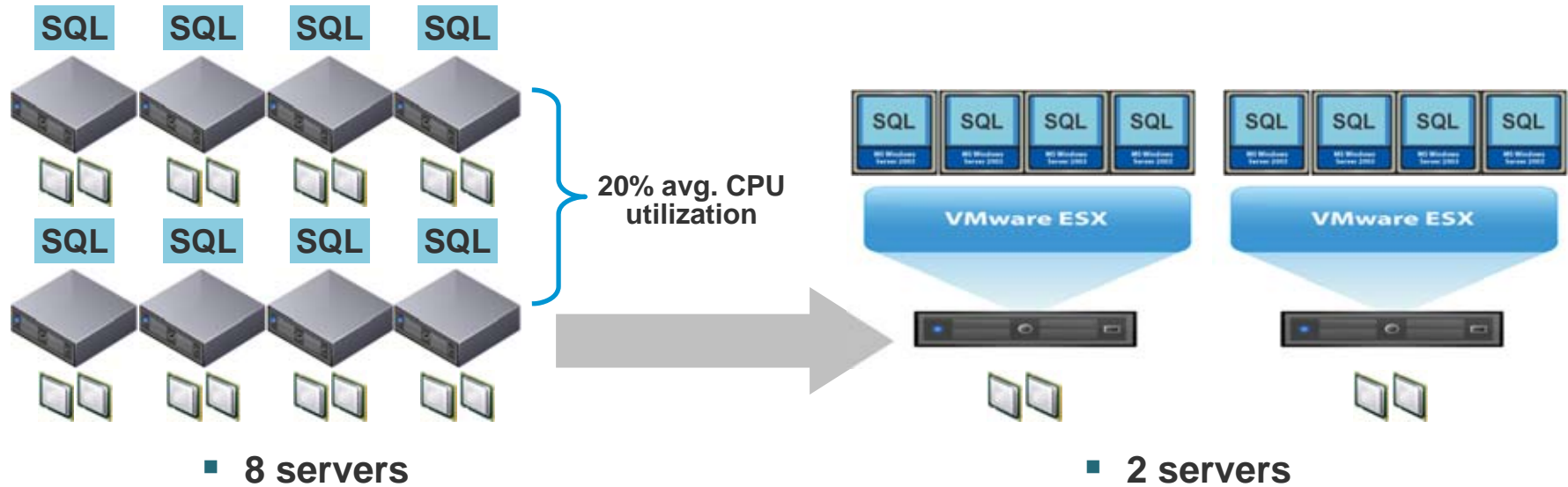
Scale-Out Approach

- Single database per VM
- Better SQL Instance and workload isolation
 - DSS vs. OLTP separation
- Easier change management
- DRS more effective with smaller VMs
- Faster migration



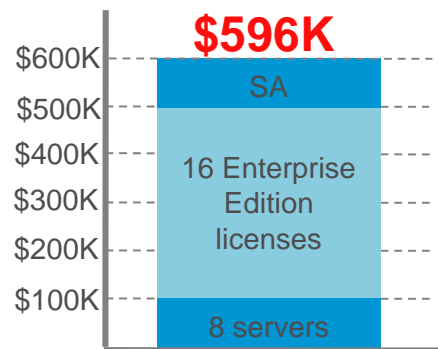
SQL Licensing Consolidation

SQL Server 2008 R2 Consolidation Example

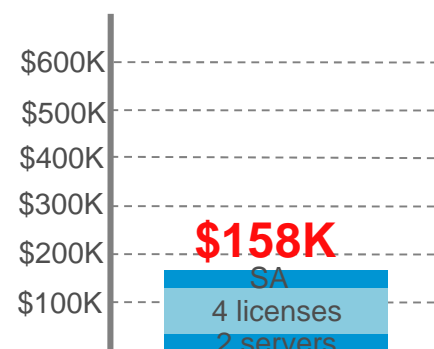


16 processors = 16 licenses

4 processors = 4 licenses



>70% cost reduction



*Note: Use Datacenter Edition if running more than 4 instances

SQL Server Licensing Facts

- **Always refer to official Microsoft documentation:**

http://download.microsoft.com/download/2/7/0/270B6380-8B38-4268-8AD0-F480A139AB19/SQL2008R2_LicensingQuickReference-updated.pdf

- **Licenses apply to physical servers not VMs; you can apply multiple licenses to a server**

- **There are two licensing models: Server/CAL and Per-Processor**

- If the customer already owns CALs, Server-based licensing is usually cheaper
- Per-Processor licensing can be expensive...pay for the built in CAL over and over

- **When VMs move licenses don't necessarily move with them**

- With Standard Edition, licenses can only proactively move **once every 90 days in a non-failover situation**. Additional licenses may be needed to accommodate "vMotion extras"
- With Enterprise and Datacenter Editions, you have unlimited license mobility rights

- **Consolidation Rules**

- Enterprise Edition – 4 VMs per license without SA; unlimited with SA*
- DataCenter Edition – Unlimited VMs per license

* Unlimited only applies if upgrading from SQL 2008 EE + SA (terms expire with the next release of SQL Server (expected Q4/11 – Q1/12))

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Business-level Approach

- What are you trying to protect?
- What are your RTO/RPO requirements?
- What is your Service Level Agreement (SLA)?
- How will you test/verify your solution?

Local Site Options

vSphere 5 Availability Features

■ VMware vMotion

- Can reduce virtual machine planned downtime
- Relocate SQL virtual machines without end-user interruption
- Perform host maintenance any time of the day

■ VMware DRS

- Will monitor state of virtual machine resource usage
- Can automatically and intelligently locate virtual machine
- Can create a dynamically balanced SQL deployment

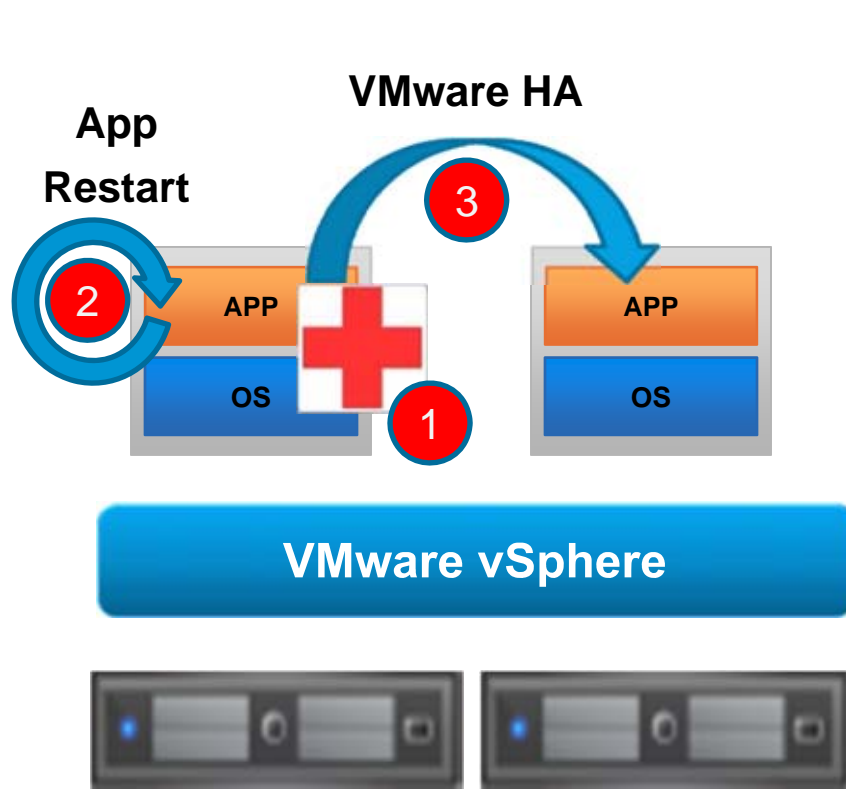
■ VMware HA

- Does not require Microsoft Clustering
- Uses VMware Host Clusters
- Automatically restarts failed SQL virtual machine in minutes
- Heartbeat detects hung virtual machines
- Application HA can provide availability at the SQL Server service level!

App-Aware HA Through Health Monitoring APIs

Leverage 3rd party solutions that integrate with VMware HA
(e.g. Symantec ApplicationHA) –

<https://www.gosavo.com/vmware/Document/Document.aspx?id=1688158&view=>



1 Database Health Monitoring

- Detect database service failures inside VM

2 Database Service Restart Inside VM

- App start / stop / restart inside VM
- Automatic restart when app problem detected

3 Integration with VMware HA

- VMware HA automatically initiated when
 - App restart fails inside VM
 - Heartbeat from VM fails

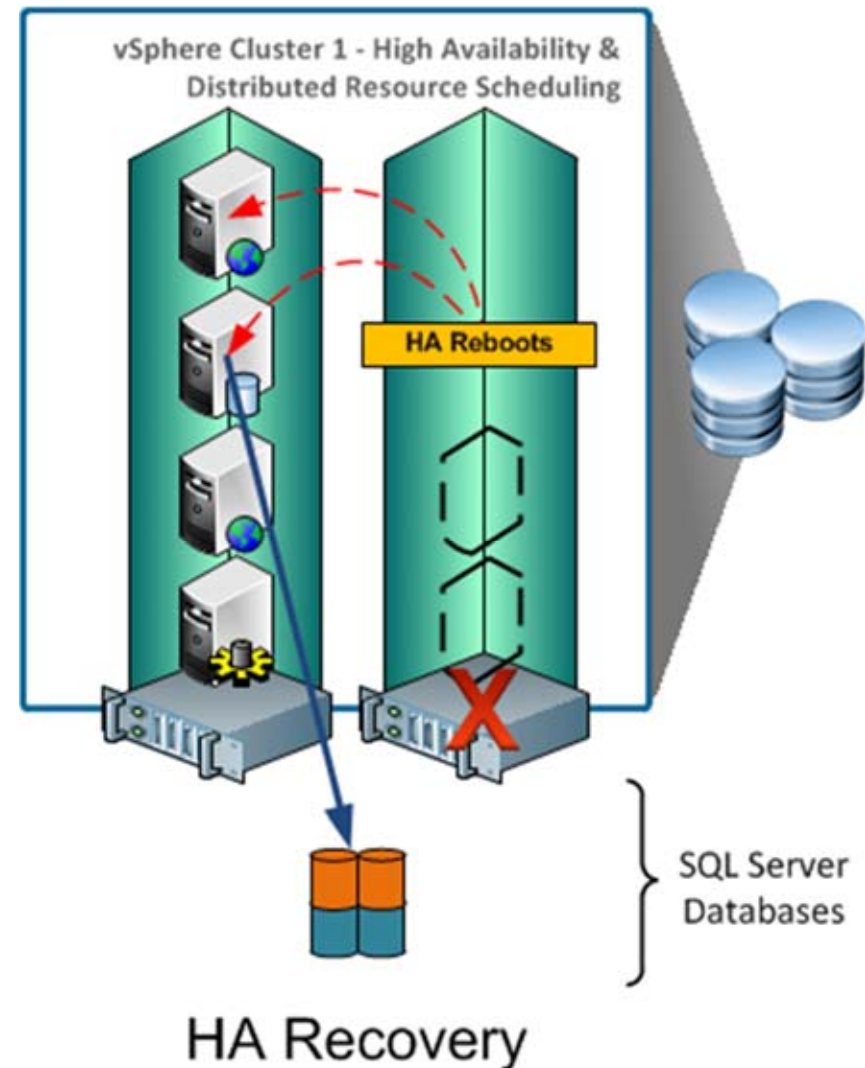
Standalone SQL Server VM with VMware HA, DRS, & vMotion

■ Highlights:

- Quickly restore service after host failure
- Simple to configure and easy to manage
- Can use Standard Windows and SQL Server editions

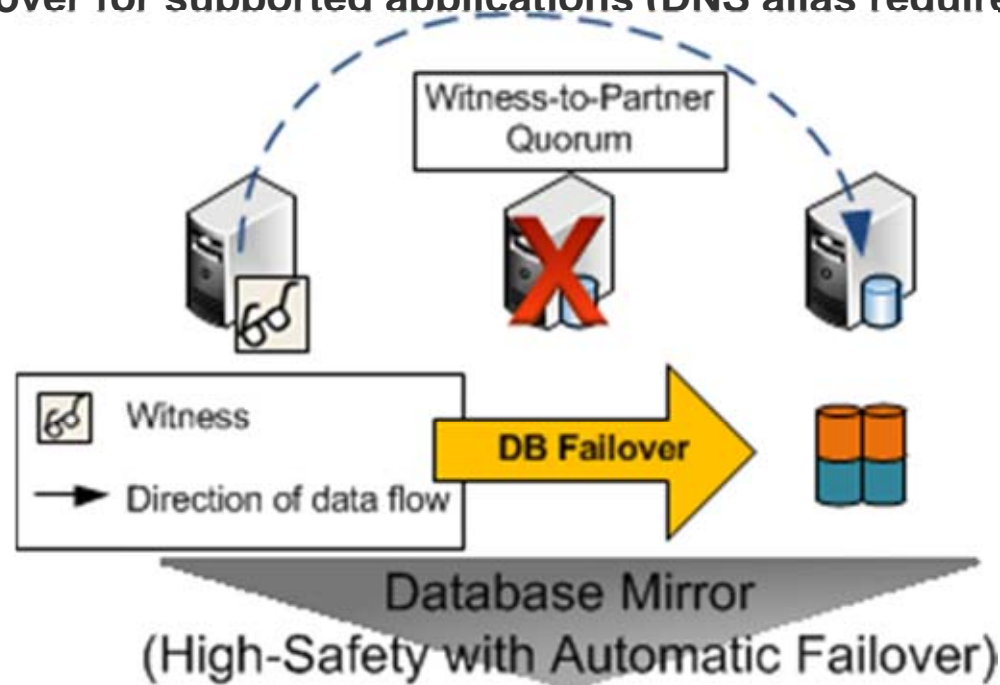
■ Note:

- **Protection against hardware failures only**
- **Does not provide application-level protection**



What is SQL Server Database Mirroring?

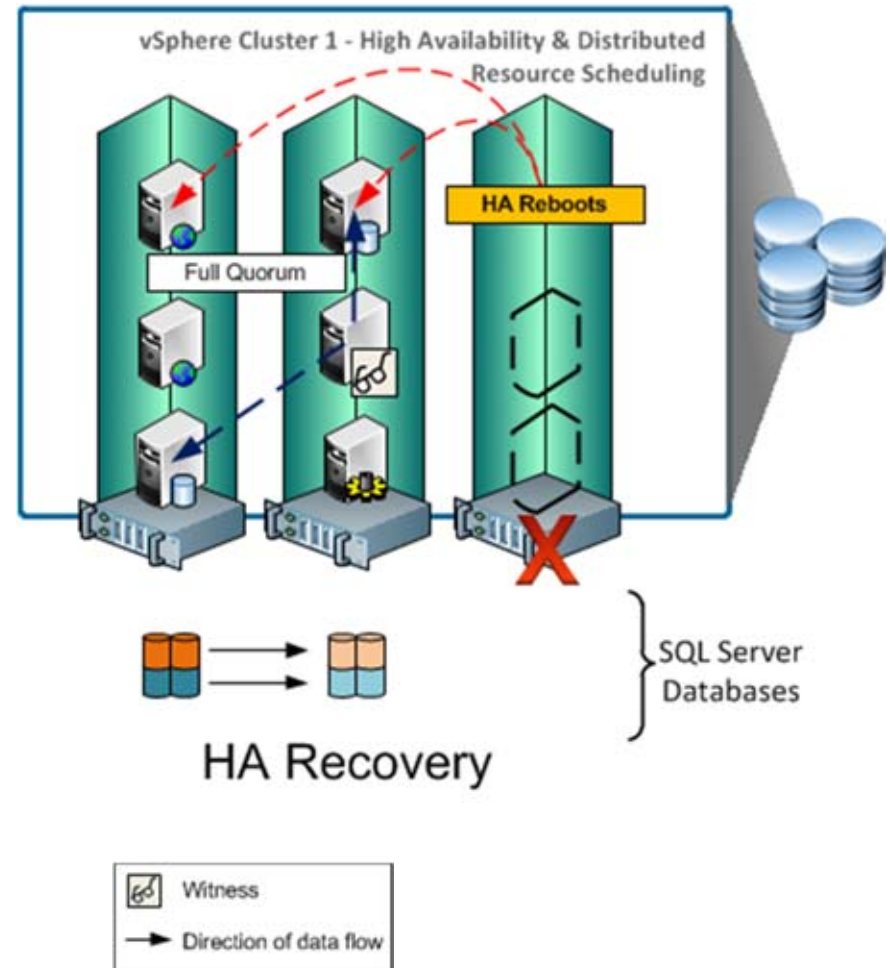
- Database-level replication over IP..., no shared storage requirement
- Same advantages as failover clustering (service availability, patching, etc.)
- Two copies of the data..., protection from data corruption (unlike failover clustering)
- Automatic failover for supported applications (DNS alias required for legacy)



Mirror Failover

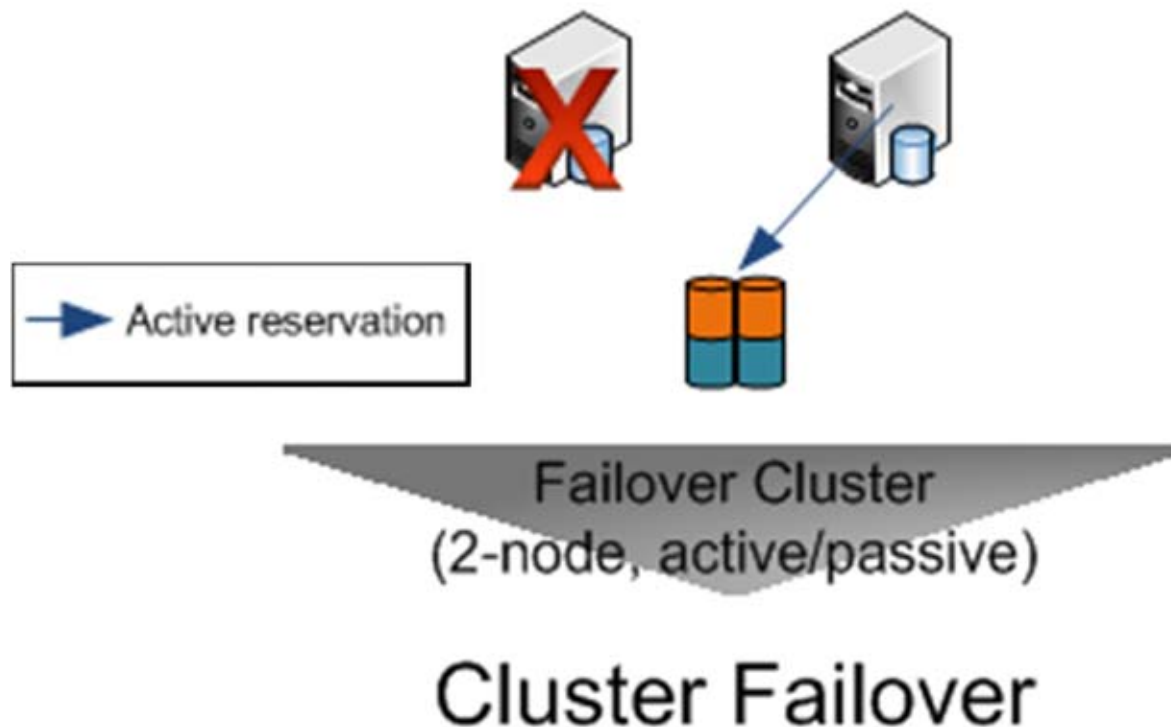
VMware HA with Database Mirroring for Faster Recovery

- Protection against HW/SW failures and DB corruption
- Storage flexibility (FC, iSCSI, NFS)
- RTO in few seconds
- VMware HA + Database Mirroring
 - Seamless integration, VMs rejoins mirroring session after VMware HA recovery
 - Can shorten time that database is in unprotected state
 - Reduces synchronization time after VM recovery



What is Microsoft Failover Clustering?

- Provides application high-availability through a shared-disk architecture
- One copy of the data, rely on storage technology to provide data redundancy
- Automatic failover for any application or user
- Suffers from restrictions in storage and VMware configuration



Expanding Support For Microsoft Clustering On VMware



New

	Microsoft Clustering on VMware	vSphere support	Enable HA*	vMotion DRS support	MSCS Node Limits	Storage Protocols support				Shared Disk	
						FC	In-guest iSCSI	Native iSCSI	FCoE	RDM**	VMFS**
Shared Disk	MSCS with Shared Disk	✓	✓	✓		✓	✓			✓	✓
	Exchange Single Copy Cluster	✓								✓	✓
	SQL Clustering	✓								✓	✓
Non-shared Disk	Network Load Balance	✓	✓	✓	Same as	✓	✓	✓	✓	N/A	N/A
	Exchange CCR	✓								N/A	N/A
	Exchange DAG	✓								N/A	N/A

Shared Disk Configurations: Supported on vSphere with additional considerations for storage protocols and disk configs

Non-Shared Disk Configurations: Supported on vSphere just like on physical

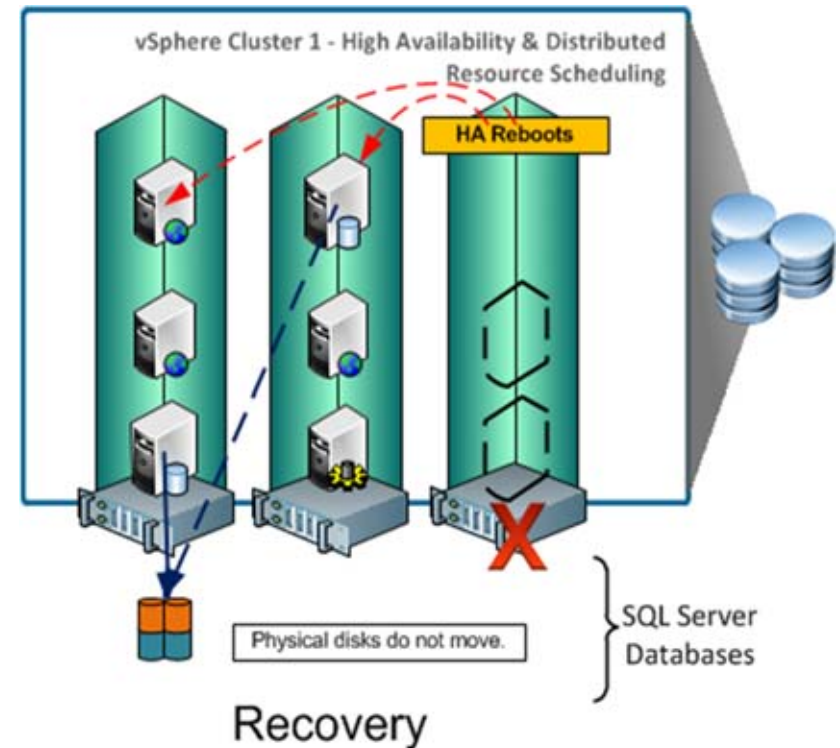
* Use affinity/anti-affinity rules when using vSphere HA

** RDMs required in "Cluster-across-Box" (CAB) configurations, VMFS required in "Cluster-in-Box" (CIB) configurations

VMware Knowledge Base Article: <http://kb.vmware.com/kb/1037959>

VMware HA with Failover Clustering

- Supports two-node cluster
- Failover cluster nodes can be physical or virtual or any combination of the two
- Host attach (FC) or in-guest (iSCSI)
- Supports RDM only
- VMware HA + Failover Clustering
 - Seamless integration, VMs rejoins clustering session after VMware HA recovery
 - Can shorten time that database is in unprotected state
 - Use DRS affinity/anti-affinity rules to avoid running cluster VMs on the same host

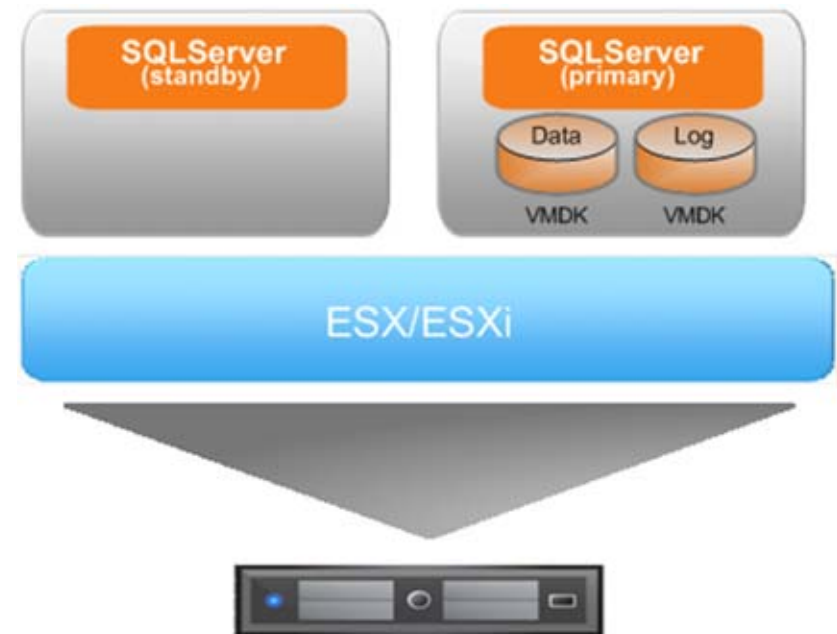


Failover clustering now supported with VMware HA with vSphere 4.1 and 5.0

http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1037959

Rolling Patch Upgrade

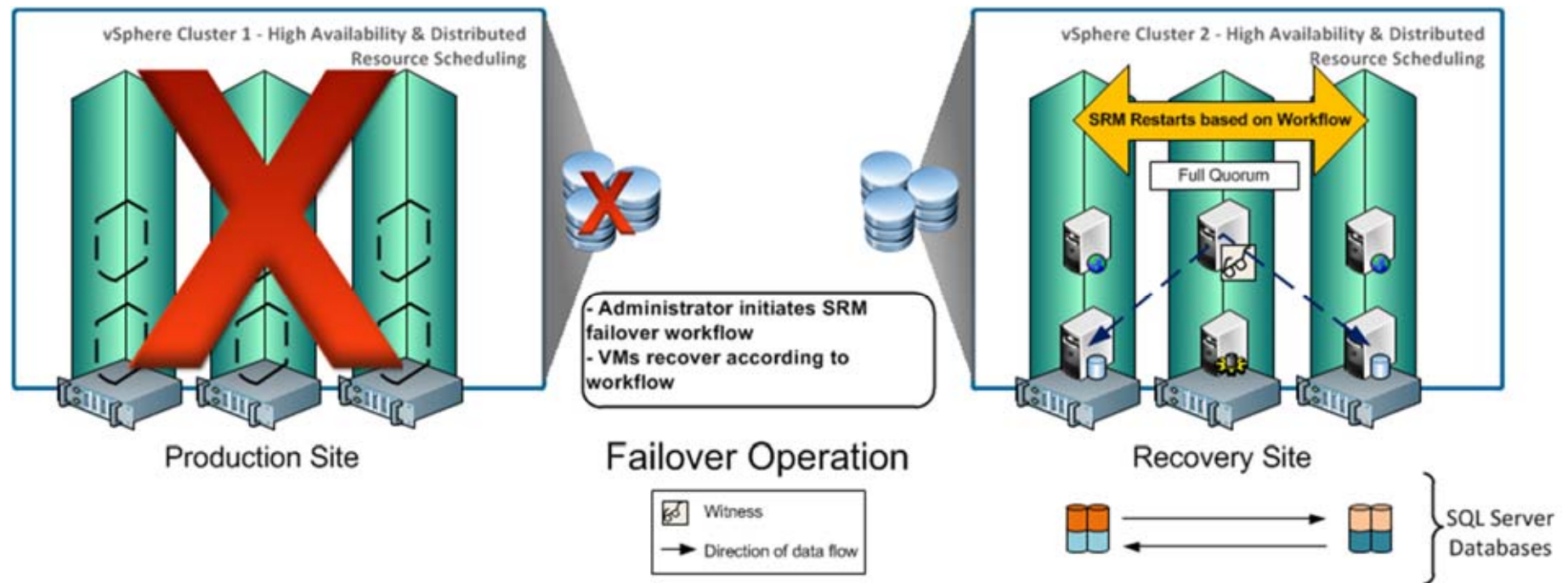
- OS and SQL Server rolling patch upgrade using standby VM
- Minimize down time for software upgrade
- Works for VMFS and RDM
- **Process Flow**
 - Patch standby VM
 - On primary VM
 - Stop client connections
 - Detach SQL Server database(s)
 - Remove virtual disk(s)
 - On standby VM
 - Attach virtual disk(s) to standby VM
 - Attach SQL Server database(s)
 - Enable client connections to assume primary role
 - Patch old primary



Remote Site Options

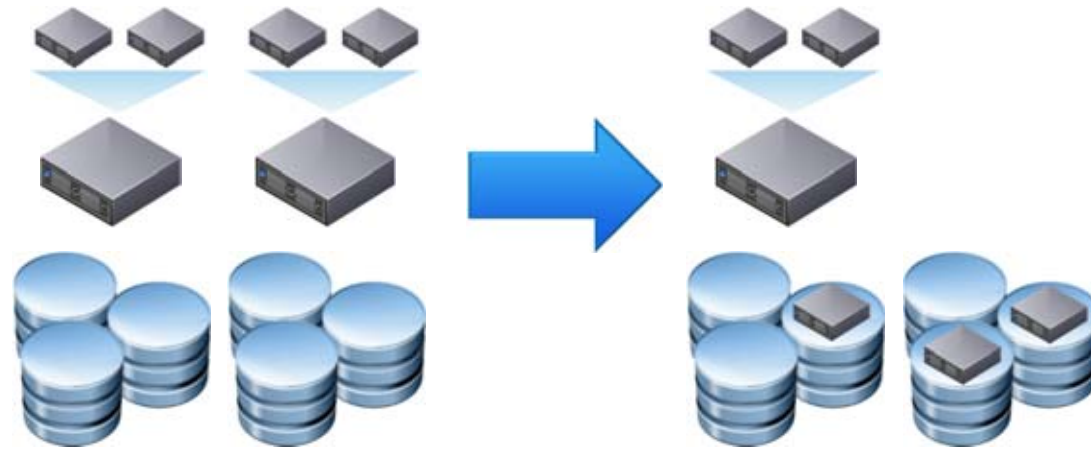
VMware vCenter SRM with SQL Server Database Mirroring

- Database Mirroring provides local availability
- Storage or ESX host replication keeps DR facility in sync
- During a site failure, the admin has full control of recovery
- After workflow is initiated, SRM automates the recovery process
- The entire process can be tested without actually failing over services!



Technology – vSphere Replication

- Adding native replication to SRM

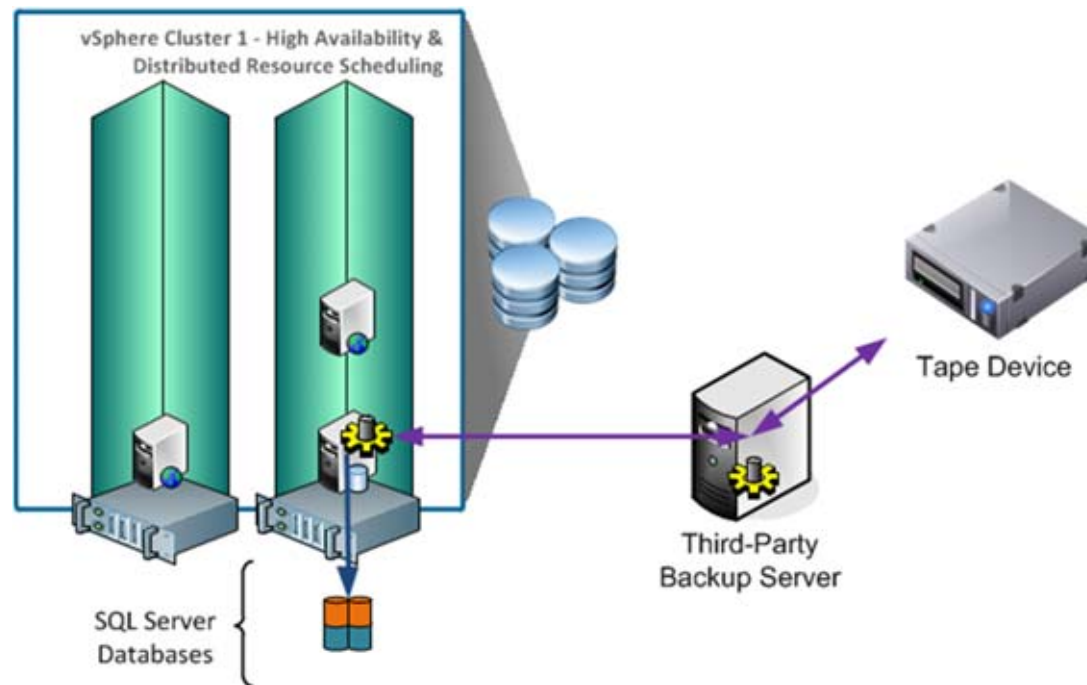


- Virtual machines can be replicated regardless of the underlying storage
- Can use local disk, SAN, NFS, even VSA, but can not work with Storage DRS
- Enables replication between heterogeneous datastores
- Replication is managed as a property of a virtual machine
- Efficient replication minimizes impact on VM workloads

Backup and Recovery

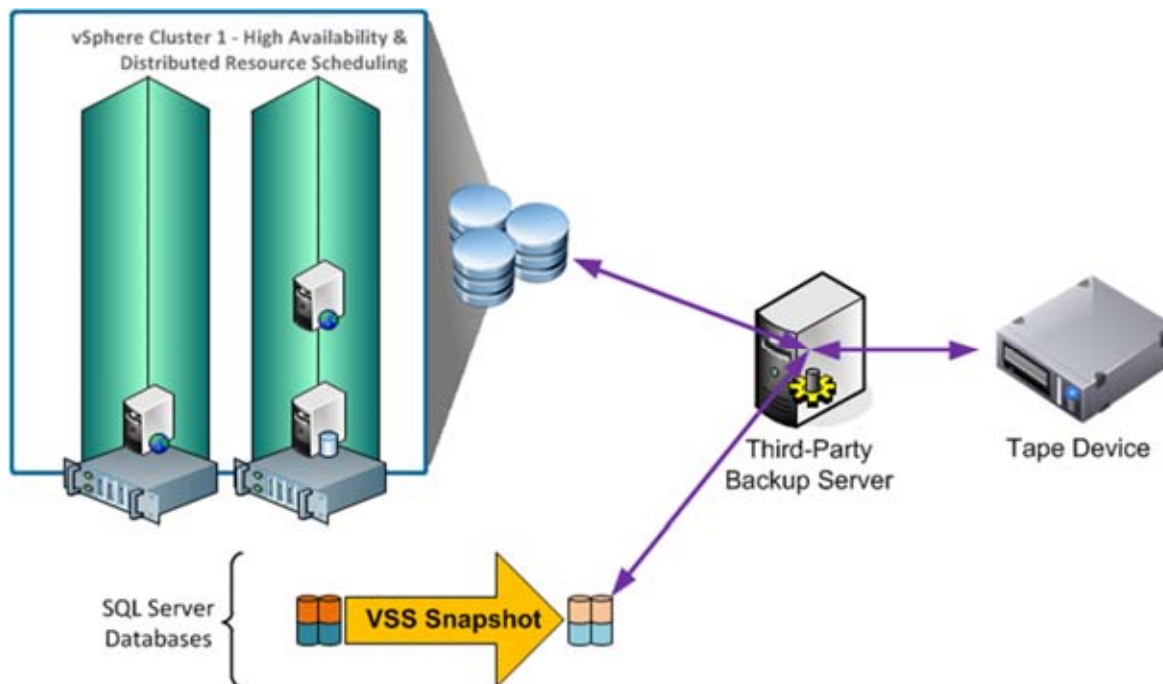
In-guest SQL Server-Aware Backup Solution

- Standard method for physical or virtual
- Agent runs in the VM guest and handles database quiescing
- Data is sent over the IP network
- Can affect CPU utilization in the guest OS



Array-based Backup

- Backup vendor software coordinates with VSS to create a supported backup image of the SQL Server databases
- Snap-shotted databases can later be streamed to tape as flat files with no IO impact to the production SQL Server



Summary

- Understand what the business expects for availability and recovery
- For hardware failure protection, VMware HA offers a low cost, much simpler alternative to Failover Clustering
- Database Mirrors can be combined with HA for faster recovery of database servers
- vCenter Site Recovery Manager allows for the failover of entire datacenters!
- Failover Clustering IS supported on VMware virtual machines with some caveats (storage protocol, RDM, no vMotion/DRS)
- Either agent-based or array-based backups can be used to protect virtual SQL Servers

Agenda

- Introductions
- SQL Server on VMware Overview
- Tier 1 Workloads – Architecting for Performance
 - Resource Allocation
 - Monitoring and Troubleshooting
 - SQL Server Guest Tuning
- Database and Licensing Consolidation
- Availability & Recovery Options
- **More Information**

Resources

- Visit us on the web to learn more on specific apps
 - <http://www.vmware.com/solutions/business-critical-apps/>
 - Best Practices, Reference Architectures, and Case Studies
 - Microsoft Apps (Exchange, SQL, SharePoint)
 - Oracle
 - SAP
- Visit our Business Critical Application blog
 - <http://blogs.vmware.com/apps/>

Partner Reference Architectures



- EMC Solutions for Tiered Storage for Microsoft SQL Server 2008 – <http://www.emc.com/collateral/software/technical-documentation/h5993-solutions-tiered-storage-ms-sql-server-2008-clariion-windows-esx-ref-arch.pdf>
- EMC Virtual Infrastructure for Microsoft Applications – Data Center Solution – <http://www.emc.com/collateral/software/technical-documentation/h6189-virtual-infrastructure-ms-apps-symmetrix-vmx-vmware-vsphere-ref-arc.pdf>
- EMC Business Continuity for Microsoft SQL Server 2008 – <http://www.emc.com/collateral/software/technical-documentation/h6791-business-continuity-sql-server-celerra-mirrorview-vmware-ra.pdf>



- Disaster Recovery of Exchange, SQL Server, and SharePoint Server Using VMware vCenter SRM, NetApp SnapManager and SnapMirror, and Cisco Nexus Unified Fabric – <http://media.netapp.com/documents/tr-3822.pdf>
- Running Microsoft Enterprise Applications on VMware vSphere, NetApp Unified Storage, and Cisco Unified Fabric – <http://media.netapp.com/documents/tr-3785.pdf>

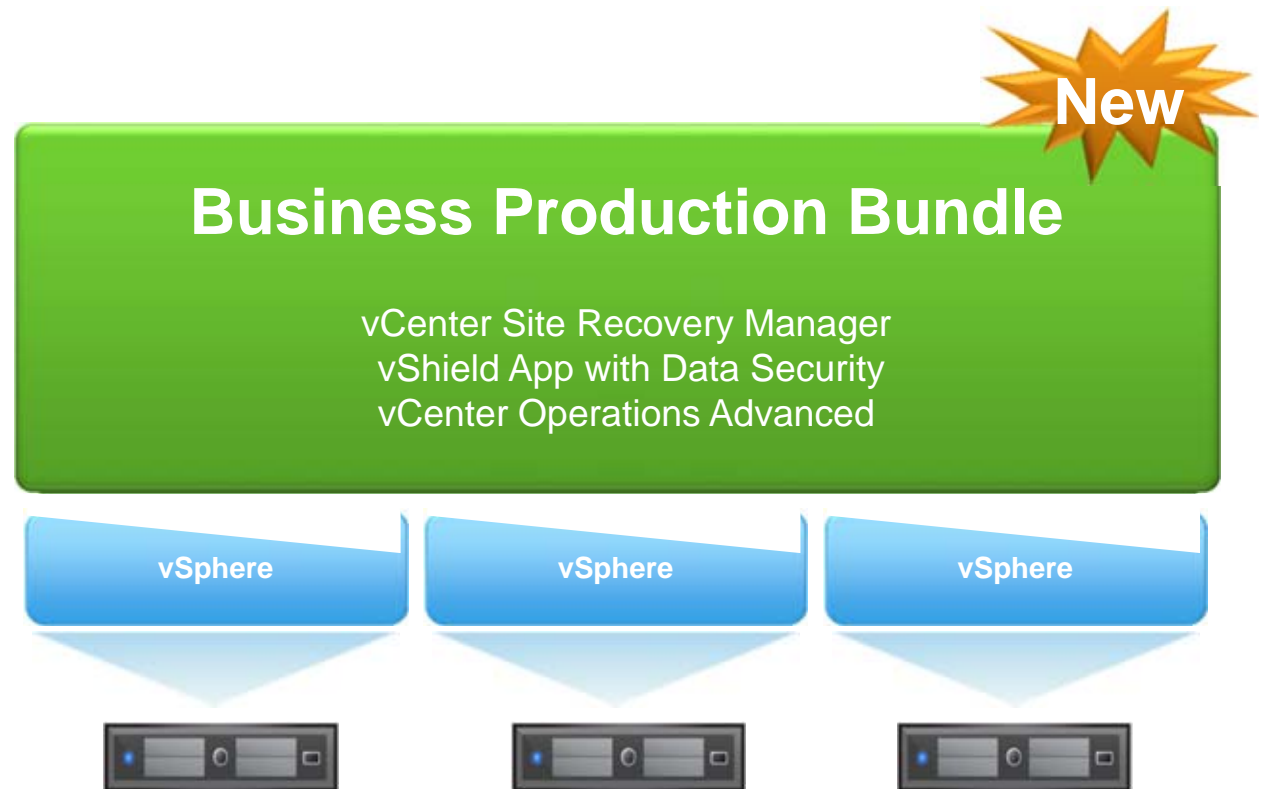


- Microsoft SQL Server in a VMware Environment on Dell PowerEdge R810 Servers and Dell EqualLogic Storage – <http://i.dell.com/sites/content/business/solutions/whitepapers/en/Documents/poweredge-r810-and-equallogic.pdf>
- Virtualize Microsoft SQL Server For Improved Performance With PowerEdge 11th Gen. – <http://i.dell.com/sites/content/business/solutions/whitepapers/en/Documents/virtualize-sql-server.pdf>
- Bus. Continuity for SQL Server and VMware on Dell PowerEdge Servers and Storage – <http://i.dell.com/sites/content/shared-content/solutions/en/Documents/business-continuity-for-sql-and-vmware-on-dell.pdf>

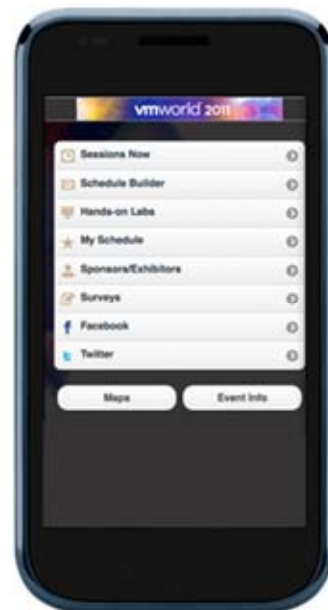
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- ✓ Automated Operations



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