VAPP1340

Virtualize Active Directory, the Right Way!

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Agenda

1	Active Directory Overview
2	Why virtualize Active Directory?
3	Common Objections to Domain Controller Virtualization
4	Understanding Domain Controller Virtualization
5	Best Practices for Virtualizing Domain Controllers
6	New Features
7	DC “Safety” Considerations in DC Event
8	Protecting Active Directory with SRM – Conceptual Use Case

Active Directory Overview

- This is not an Active Directory class
- Windows Active Directory Multi-master Replication Conundrum
  - Write Originates from any Domain Controller
    - RODC is "special" -
      - Cannot perform write operations
    - Schema Update is "special"
      - Schema update operations happen on the Schema Master
  - Selective Partnership
    - The Case for Optimal Replication Topology
  - Changes MUST Converge
    - Eventually
    - Preferably On-Time
- The Additional Complexity of Multi-Domain Infrastructure
  - The Infrastructure Master
  - The Global Catalog
- Useful tool: Active Directory Replication Status Tool
  - http://www.microsoft.com/en-us/download/details.aspx?id=30005

Active Directory Overview

- How Do They Do That? – Overview of AD Replication
  - The Directory Service Agent GUID
    - Unique to a Domain Controller
    - Persistent over the life of a Domain Controller
    - Used in USNs to track DC's originating updates
  - The InvocationID
    - Used by DSA to identify a DC's instance of the AD database
    - Can change over time (e.g. during a DC restore operation)
  - Update Sequence Number (USN), aka "Logical Clock"
    - Used by DCs to track updates sent or received
    - Increases per write transaction on each DC
    - Globally unique in Forest
  - USN + InvocationID => Replicable Transactions
- What about Timestamps?
  - Conflict Resolution – Check the Stamps
    - Stamp = Version + Originating Time + Originating DSA

Why Virtualize Active Directory?

Why Virtualize AD?

Virtualization is main-stream	**"Virtualize First" – the new normal** **No longer a "black magic"**
Active Directory virtualization is FULLY supported	**All roles are suitable candidates** **Can't spell "Cloud" w/o "Virtual"**
Active Directory characteristics are virtualization-friendly	**Distributed, Multi-master** **Low I/O and resource requirements**
Domain Controllers are inter-changeable	**OK, maybe not the RODC ☺** **Facilitates rapid provisioning**
Physical Domain Controllers Waste Compute Resources **$$$$**	**A single DC cannot utilize compute resources available on modern server hardware**

Common Objections to DC Virtualization

The fear of the “stolen vmdk”	How about the “stolen server”? Or “stolen/copied backup tape”? Use array-, disk- or file-level encryption for added security
Privilege Escalation*	vCenter privileges do NOT elevate Windows or AD privileges
Have to keep the xyz Operations Master role holder physical	No technical reasoning for this Roles can be transferred or seized
Deviates from our build process or standards	Virtualization improves standardization Use templates for optimization

Best Practices

Best Practices for Virtualizing Domain Controllers

The "low-hanging fruit"

- Deploy across multiple datacenters
  - Multiple geographical locations and AD Sites
- Distribute the FSMO (Operations Masters) roles
  - First DC ALWAYS own all the roles
    - Can lead to high CPU utilization
  - Follow Microsoft Operations Master Role Placement Best Practices
    - http://technet.microsoft.com/en-us/library/cc754889.aspx
- Use EFFECTIVE Role-Based Access Control
  - Grant Domain Admin rights only to trusted operators
    - A Domain Admin's access CANNOT be restricted in the domain
    - Virtual infrastructure Admins do NOT require Domain Admin privileges
    - Domain Admins do NOT require Virtual infrastructure Admin privileges
- Enforce Well-Defined Administrative Practices
- To P2V or Not to P2V?
    - Follow our recommended practices http://kb.vmware.com/kb/1006996

Best Practices for Virtualizing Domain Controllers

Leverage VMware Availability Features

- vSphere HA
  - Complements ADDS native high-availability features
  - Reduces downtime for critical Operations Master roles
- vSphere DRS Rules
  - Efficient resource-balancing and utilization
  - Reduces resource wastage and improves consolidation
- Use Anti-affinity rules to keep DCs separated
  - Avoids “eggs-in-one-basket” failure scenario
- Use Host-Guest affinity rules to keep DCs on specific Hosts
  - Answers the “where’s my Domain Controller?” question
- vMotion
  - True agility
  - Improves maintenance and patching procedure - without downtime

Best Practices for Virtualizing Domain Controllers

Domain Controller Sizing

- Sizing domain controllers properly is key to good performance
  - Don't assume DCs sit idle and don't need a lot of resources.
  - Use capacity planning tools such as VMware Capacity Planner and/or Microsoft Assessment and Planning Toolkit to determine current state usage.
  - Resource requirements are highly dependent on total number of objects and rate of change in the environment.
- **CPU**
  - Domain controllers are not typically heavy consumers of CPU resources.
  - Actual CPU usage varies by environment and by use case.
    - CPU usage in branch office serving primarily authentication function likely to be lower than in larger offices.
  - General sizing guidance:
    - 1 – 10,000 users = 1 vCPU. Greater than 10,000 users = 2 vCPU
    - If unsure, start with 2 vCPUs and scale up as needed.

Best Practices for Virtualizing Domain Controllers

Domain Controller Sizing

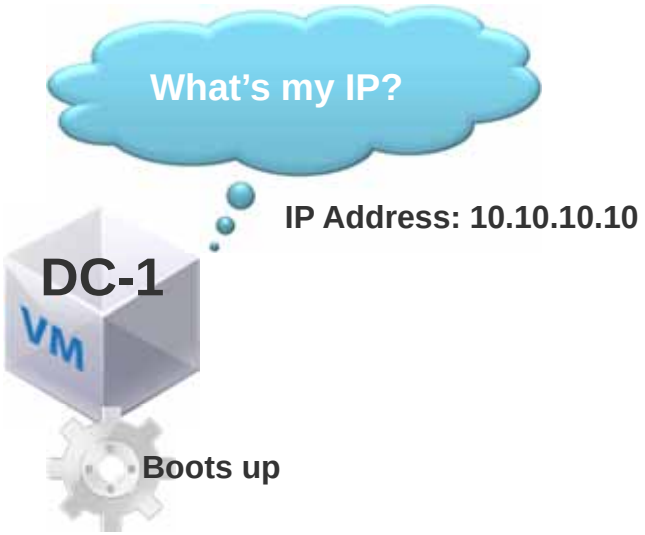
- **Memory**
  - Domain controllers are similar to database servers – can cache AD database in RAM for faster read performance.
  - Monitor "*Database/Database Cache % Hit*" counter for "*lsass*" process to determine current cache usage. Low hit rate likely indicates DC needs more RAM.
  - Large forests with millions of objects can consume large amounts of memory. Not unusual to see DCs with 32GB of RAM for very large forests.
- **Networking**
  - Domain controllers rely on replication to stay in sync.
  - Use VMXNET3 virtual NIC for best performance and lowest CPU utilization on domain controllers.
- **Storage**
  - Need enough space to store AD database (plus room to grow), plus OS files & any other software.
  - DCs not particularly I/O intensive. Can offload read I/O to RAM.

Best Practices for Virtualizing Domain Controllers

What's in a Name?

- ~ 75% of AD-related support calls attributable to DNS "issues"
- AD DEPENDS on effective name resolution
  - Clients and DCs reference objects by name/GUID
  - Internal AD processes depend on DNS
- The "Initial Replication" conundrum – get your DNS right
  - DCs MUST perform successful "initial synchronization" on boot-up
  - DNS service will not start if not successful
  - DCs cannot synchronize if name resolution not working
  - The "Repl Perform Initial Synchronizations" Curse Word
    - Against Microsoft's recommended practice
      - http://support.microsoft.com/kb/2001093
      - HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\NTDS\Parameters
        Value name: Repl Perform Initial Synchronizations
        Value type: REG_DWORD
        Value data: 0

Domain Controllers and DNS – Get it Right!



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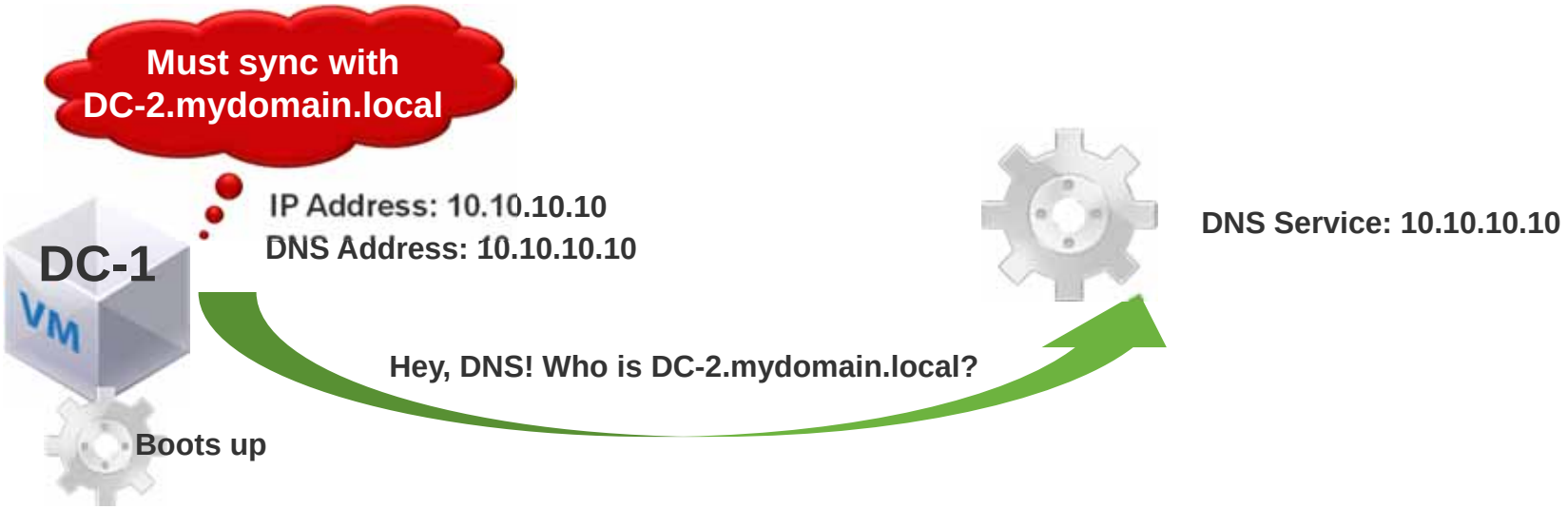

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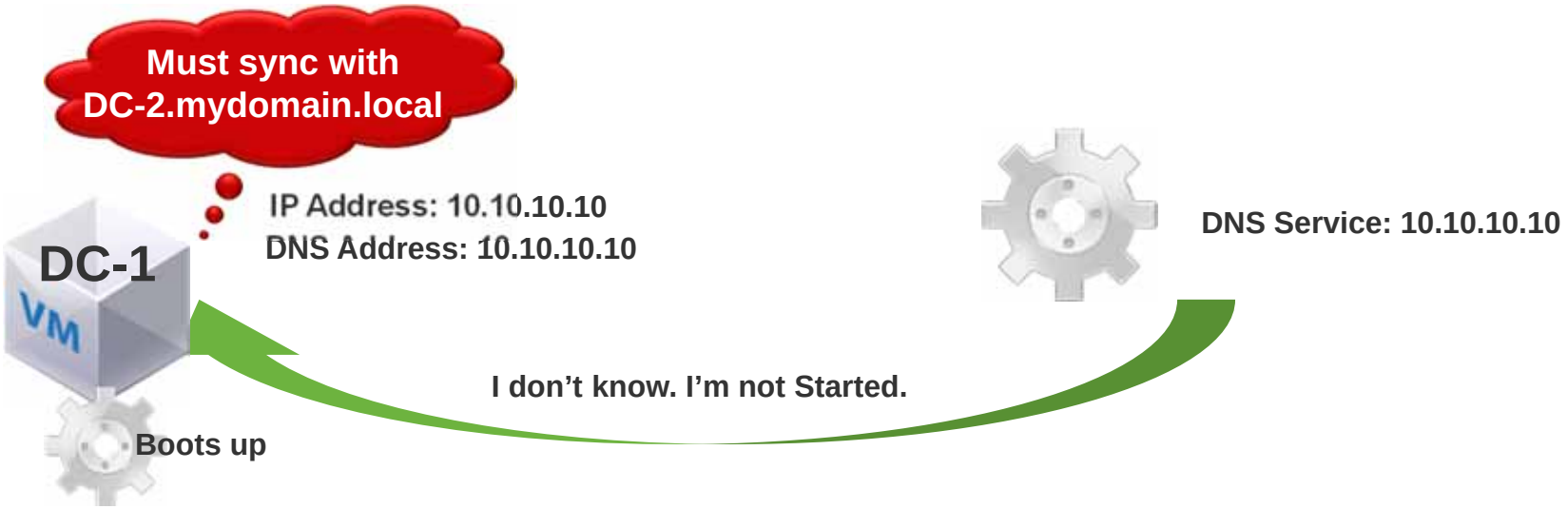

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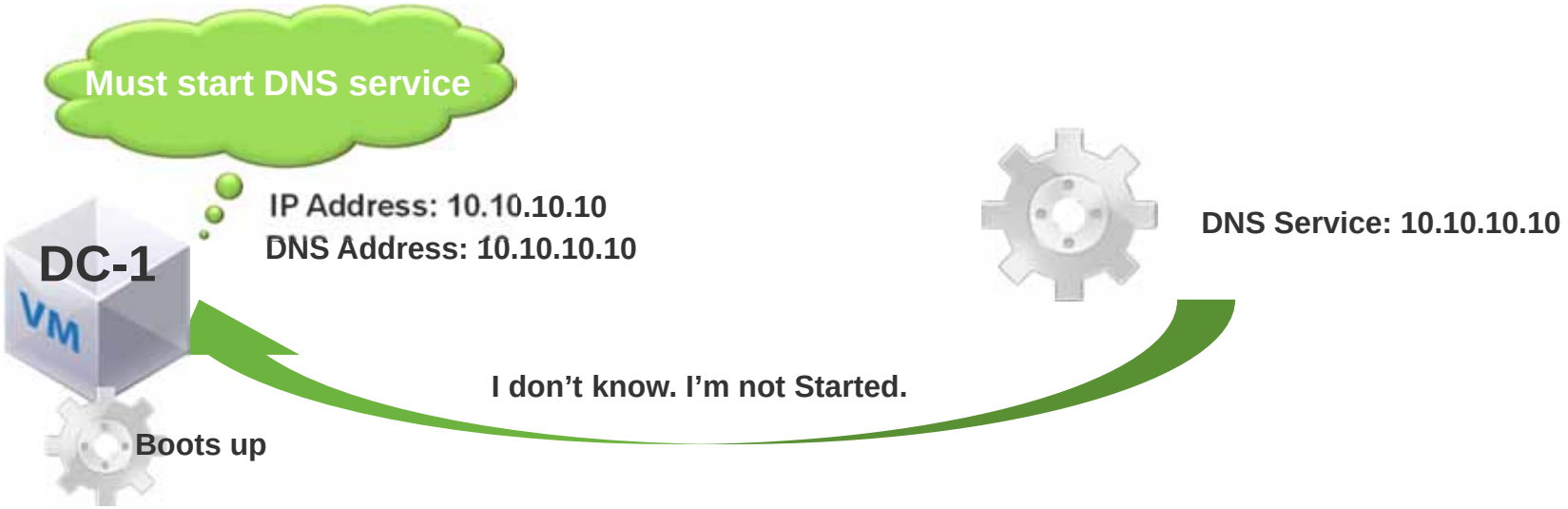

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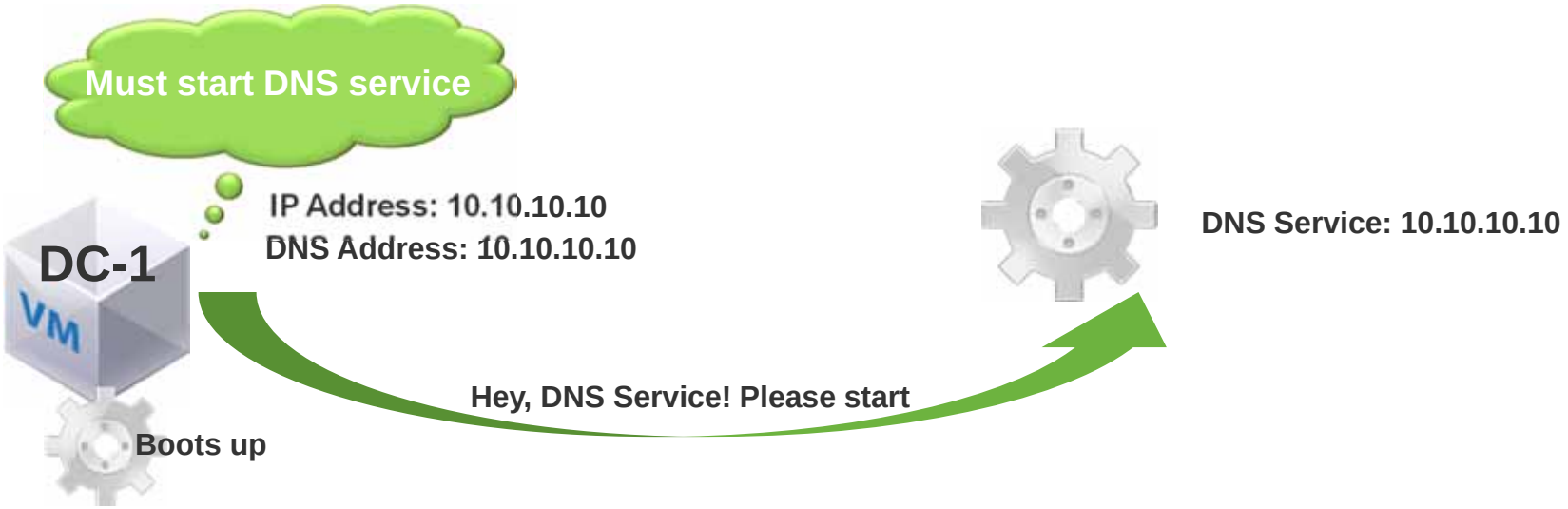

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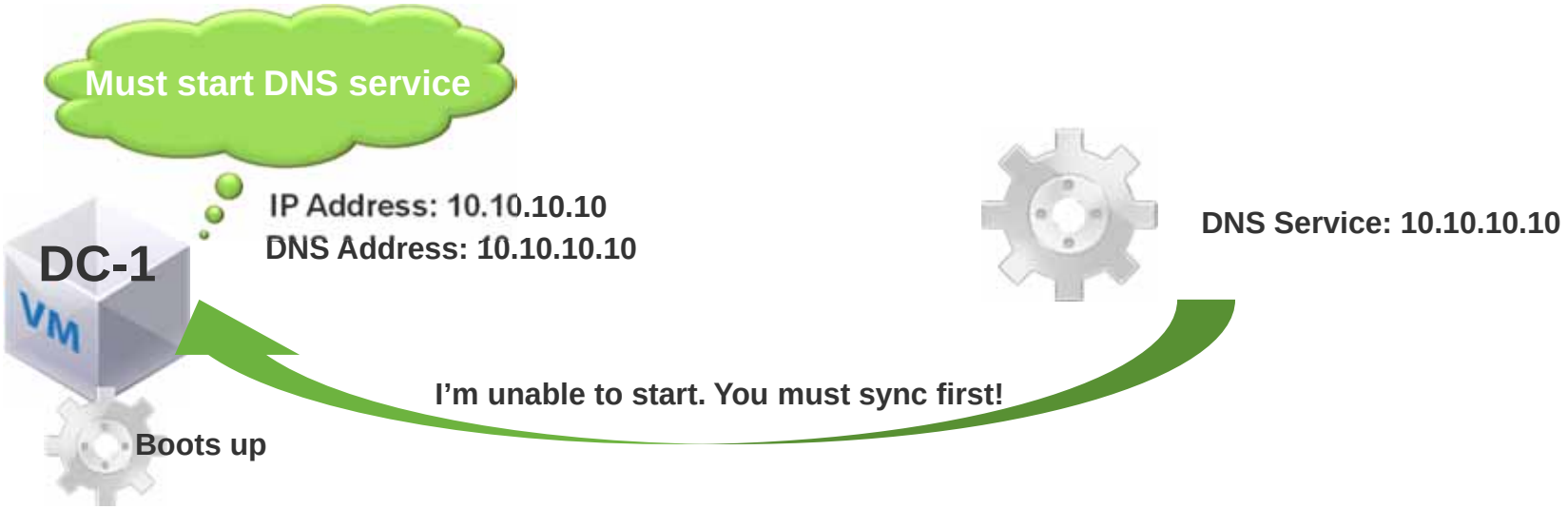


Domain Controllers and DNS – Get it Right!

Best Practices for Virtualizing Domain Controllers

What's in a Name?

- Native AD DNS or IP Address Management Appliance?
  - Native AD DNS is "Free"
  - Physical IPAM can complicate DR testing
  - Solution must be AD-aware
  - Should support dynamic SRV records registration – not a MUST
- Other Considerations
  - Avoid pointing DC to ONLY itself for DNS – see previous movie ☺
  - Distribute DNS servers across multiple sites
  - Include loopback (127.0.0.1) address in DNS list
    - Makes configuration and maintenance easier
  - Include ALL Suffixes in domain or forest – or use GlobalNames
    - Makes name resolution easier and more optimal
    - Depends on corporate administrative practices

Best Practices for Virtualizing Domain Controllers

It is about Time

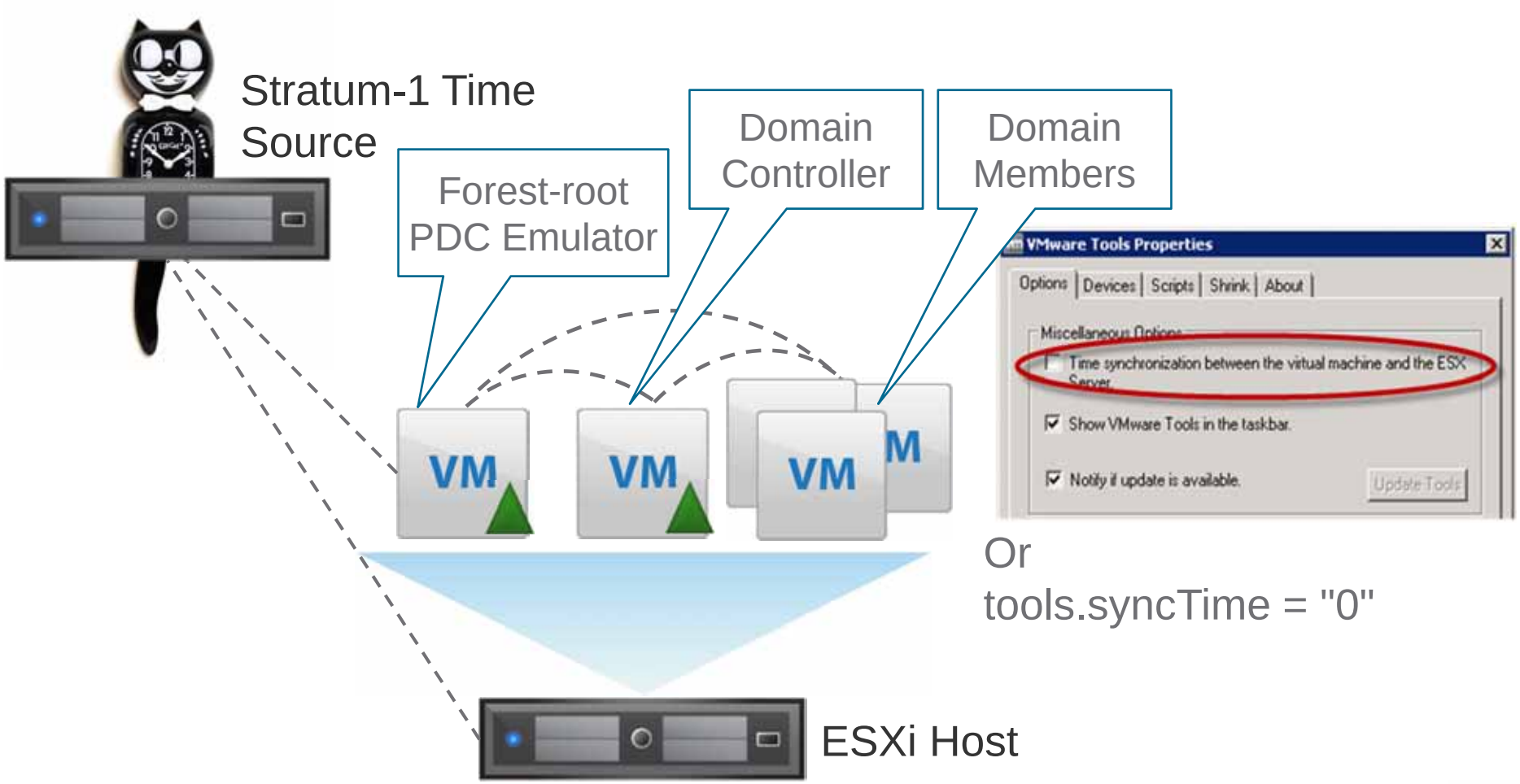
- ACCURATE timekeeping is essential to AD
  - Conflict resolution “tie breaker”
  - Kerberos authentication
  - W32Time is “good enough”
- Operating Systems use timer interrupts (ticks) to track elapsed time
  - Relies on CPU availability for accuracy
- Tickless timekeeping avoids problem of CPU saturation
  - Uses units of elapsed time since boot-up
  - Depends on fast, reliable “hardware counter”
- Host resource over-allocation will lead to contention
  - Idle guests may not schedule timer interrupts
  - Guest unable to schedule CPU time for interrupts, leading to backlog and drift
  - Guest may over-compensate for “drift” by discarding backlogs – Ping-Pong!

Best Practices for Virtualizing Domain Controllers

It is about Time

- vSphere includes time-keeping mechanism
- VMware Tools is the delivery vehicle
  - Resets Guest's clock to match Host's on boot-up
    - Even if Guest-Host clock synchronization is disabled
  - Reset Guest's clock when resuming from suspension or snapshot restore
    - This behavior can be disabled
- Synch with Host or Use Windows domain time hierarchy?
  - We have had a change of heart
    - Default guest time synchronization option changed in vSphere
    - Domain-joined Windows guests should use native time sync option
    - Domain Controllers should NOT be synced with vSphere hosts *
      - Unless when running VMKernel-hosted NTP daemon in vSphere (ESXi)
    - vSphere hosts should NOT be synced with virtualized DCs
    - Follow Microsoft's time sync configuration best practices
- VMtools STILL performs guest time correction during certain operations*

Proper Time Keeping – For Visual Learners



http://support.microsoft.com/kb/816042
http://kb.vmware.com/kb/1318
http://www.vmware.com/files/pdf/techpaper/Timekeeping-In-VirtualMachines.pdf

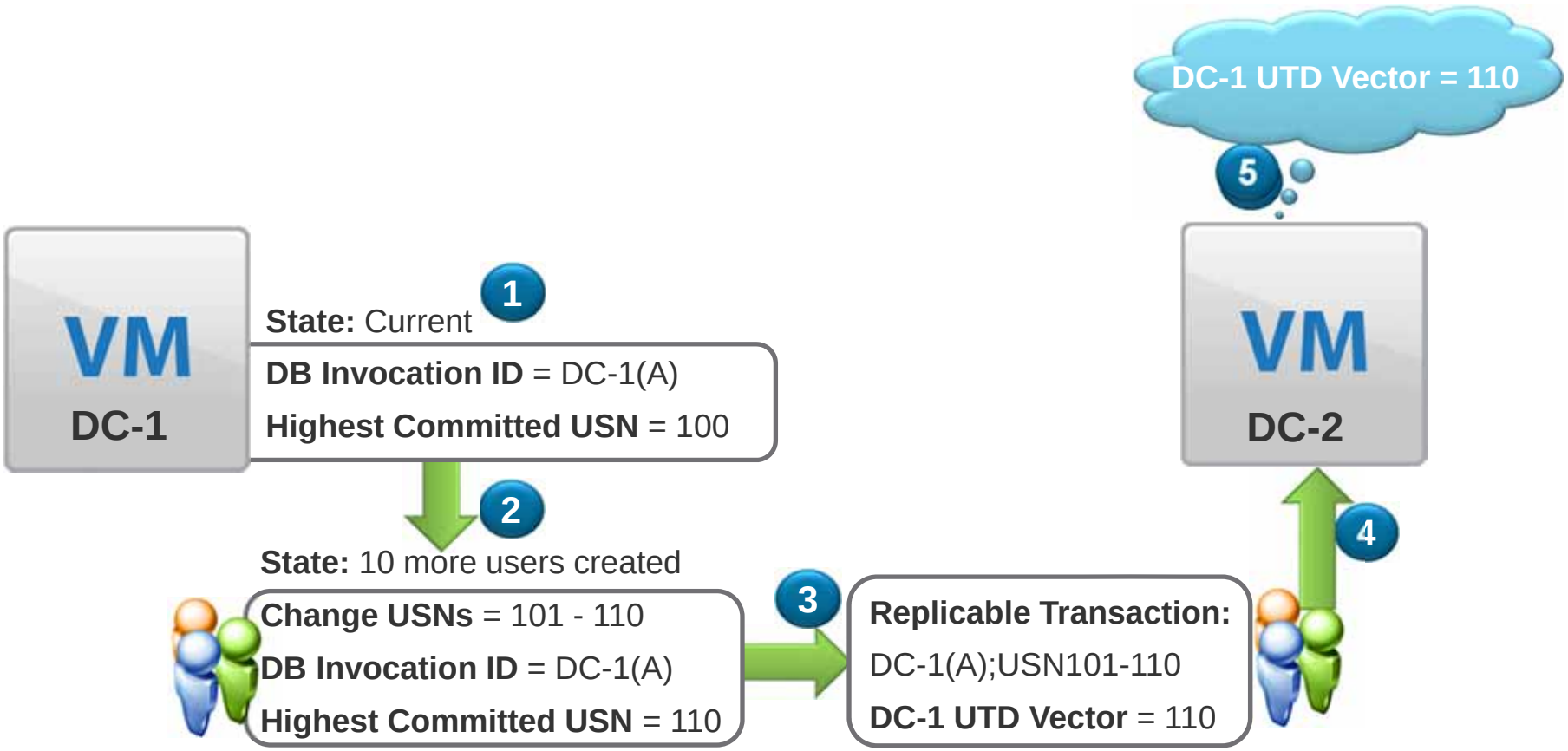
Historical Problems with Virtualizing Domain Controllers

- Virtual Disk – To cache or not to cache?
  - Not ~~our problem~~ a vSphere issue ☺
  - Force Unit Access – http://support.microsoft.com/kb/888794/en-us
  - Virtual Disk Corruption in Hyper-V – http://support.microsoft.com/kb/2853952
- AD is a distributed directory service that relies on a clock-based replication scheme
  - Each domain controller keeps track of its own transactions and the transactions of every other domain controller via Update Sequence Numbers and InvocationIDs
  - A domain controller which has been reverted to a previously taken snapshot, or restored from a VM level backup will attempt to reuse USNs for new transactions – USN Rollback
  - The local DC will believe its transactions are legit, while other domain controllers know they are not and refuse to allow incoming replication
- Why is USN Rollback so bad?

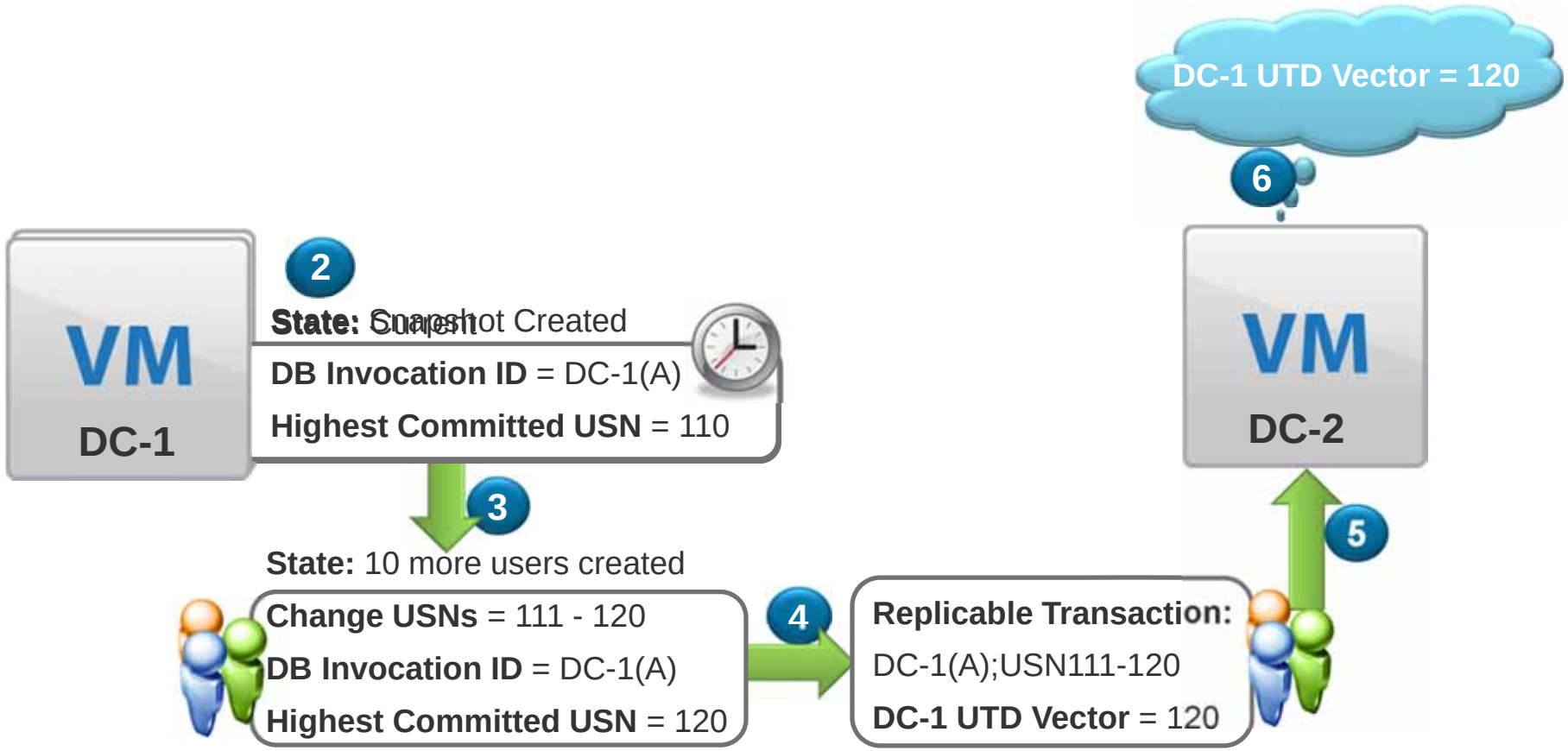
Way back when……

Why Some Fear Virtualizing DCs

Active Directory Replication – Steady State



Users Created After VM Snapshot



DC Reverted to Previous Snapshot

USN Rollback Effect after Reverting Snapshot

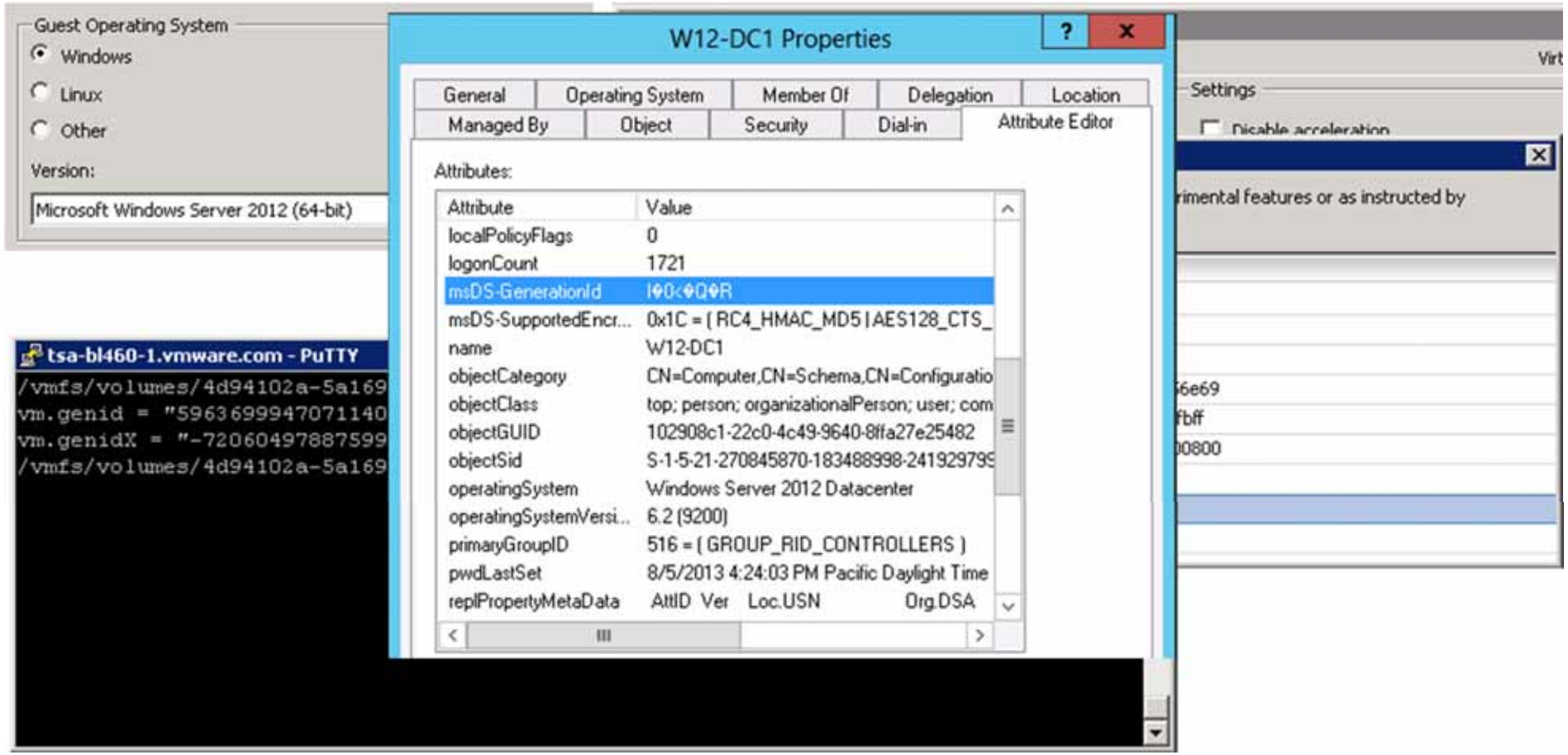
In the Present Time……

“Safely” Getting Over Your Fears

VM Generation ID

- Windows Server 2012 provides a way for hypervisor vendors to expose a 128-bit generation ID counter to the VM guest
  - Generation ID is communicated from the hypervisor to the guest through the VM GenerationID Counter Driver (not VMware Tools)
- VM GenerationID supported in vSphere 5.0 Update 2 and later
  - Exposed in VMX file as *vm.genid or vm.genidx*
  - Added to all VMs configured as Windows Server 2012
- VM GenerationID tracked via new Active Directory attribute on domain controller objects – *msDS-GenerationId*
  - Attribute is not replicated to other domain controllers
- Changes in VM Generation ID is first line of defense against USN Rollback
  - Reverting snapshots triggers VM GenID changes
  - VM GenID changes triggers Domain Controller “Safety” mechanism
- Provides 2 DISTINCT Benefits:
  - **Safety**
  - **Cloning**

Where is VM GenerationID Stored?



vSphere Operations that Trigger VMGenID Changes

Scenario	VM-Generation ID Change
VMware vSphere vMotion®/VMware vSphere Storage vMotion	No
Virtual machine pause/resume	No
Virtual machine reboot	No
vSphere host reboot	No
Import virtual machine	Yes
Cold clone	Yes
Hot clone NOTE: Hot cloning of virtual domain controllers is not supported by either Microsoft or VMware. Do not attempt hot cloning under any circumstances.	Yes
New virtual machine from VMware Virtual Disk Development Kit (VMDK) copy	Yes
Cold snapshot revert (while powered off or while running and not taking a memory snapshot)	Yes
Hot snapshot revert (while powered on with a memory snapshot)	Yes
Restore from virtual machine level backup	Yes
Virtual machine replication (using both host-based and array-level replication)	Yes

Domain Controller Cloning

Domain Controller Cloning

- DC Cloning enables fast, safer DC provisioning through clone operation
  - Includes regular VM cloning and manual VMDK copy operations
- DC Cloning Sequence
  - Prepare Source DC for cloning
    - Add the DC to the cloneable domain controllers AD group
    - Check for non-cloneable software
    - Create the DCCloneConfig.xml configuration file
  - Shut down Source DC*
  - Clone Source DC VM, using hypervisor based cloning operations
  - Power on New DC
    - VM GenerationID is evaluated
    - New VM GenerationID triggers DC Safeguard
      - RID Pool is discarded
      - invocationID is reset
    - New VM checks for existence of file DCCloneConfig.xml
      - If exists, the cloning process proceeds
    - New DC is promoted using the existing AD database and SYSVOL contents

Domain Controller Cloning Example

vSphere Host
W2K12-DC02: vm.genid = 001

Source DC:
msDS-GenerationId = 001
W2K12-DC02
192.168.11.41

Domain Controller Cloning Example

Administrator: Windows PowerShell

```
Windows PowerShell
Copyright (C) 2012 Microsoft Corporation. All rights reserved.

PS C:\Windows\system32> New-ADDCCloneConfigFile -Static -IPv4Address "192.168.11.42" -IPv4DNSResolver "192.168.11.40" -I
Pv4SubnetMask "255.255.255.0" -CloneComputerName "W2K12-DC03" -IPv4DefaultGateway "192.168.11.1"
Running in 'Local' mode.
Starting PDC test: Verifying that the domain controller hosting the PDC FSMO role is running Windows Server 2012 or late
r...
Passed: The domain controller hosting the PDC FSMO role (W2K12-DC01.id-lab.loc) was located and running Windows Server 2
012 or later.

Verifying authorization: Checking if this domain controller is a member of the 'Cloneable Domain Controllers' group...
Located the local domain controller: (W2K12-DC02.id-lab.loc).
Querying the 'Cloneable Domain Controllers' group...
Pass: The local domain controller is a member of the 'Cloneable Domain Controllers' group.

Starting test: Validating the cloning allow list.
NOTE: C:\Windows\NTDS\CustomDCCloneAllowList.xml is being used as the defined inclusion list.
No excluded applications were detected.
Pass: No excluded applications were detected.

No valid clone configuration files were found at any of the supported locations.

All preliminary validation checks passed.

Starting creation of the clone configuration file...
Finding the path to the Directory Service database...
The clone configuration file was generated at:
C:\Windows\NTDS\DCCloneConfig.xml
Generating the clone configuration file content...
The clone configuration file has been created.

PS C:\Windows\system32>
```

Domain Controller Cloning Example

vSphere Host
W2K12-DC02: vm.genid = 001

Source DC:
msDS-GenerationId = 001
W2K12-DC02
192.168.11.41

Domain Controller Cloning Example

vSphere Host
W2K12-DC02: vm.genid = 001
W2K12-DC03: vm.genid = 002

Source DC:
msDS-GenerationId = 001
W2K12-DC02
192.168.11.41

Clone DC:
msDS-GenerationId = 001
W2K12-DC02
192.168.11.41

Domain Controller Cloning Example

vSphere Host
W2K12-DC02: vm.genid = 001
W2K12-DC03: vm.genid = 002

Source DC:
msDS-GenerationId = 001
W2K12-DC02
192.168.11.41

Clone DC:
msDS-GenerationId = 002
W2K12-DC02
192.168.11.41

Domain Controller Cloning Example

vSphere Host

Source DC:
msDS-Gene
W2K12-DC0
192.168.11.4

DCCloneConfig - Notepad

File Edit Format View Help

```
<?xml version="1.0"?>
<d3c:DCCloneConfig xmlns:d3c="uri:microsoft.com:schemas:DCCloneConfig">
  <ComputerName>W2K12-DC03</ComputerName>
  <IPSettings>
    <IPv4Settings>
      <StaticSettings>
        <Address>192.168.11.42</Address>
        <SubnetMask>255.255.255.0</SubnetMask>
        <DefaultGateway>192.168.11.1</DefaultGateway>
        <DNSResolver>192.168.11.40</DNSResolver>
      </StaticSettings>
    </IPv4Settings>
  </IPSettings>
</d3c:DCCloneConfig>
```

Domain Controller Cloning Example

vSphere Host

Source DC
msDS-Ger
W2K12-DC
192.168.11

Domain Controller Cloning Example

vSphere Host
W2K12-DC02: vm.genid = 001
W2K12-DC03: vm.genid = 002

Source DC:
msDS-GenerationId = 001
W2K12-DC02
192.168.11.41

Clone DC:
msDS-GenerationId = 002
W2K12-DC03
192.168.11.42

Domain Controller Safety

Domain Controller Safeguard

- **DC Safeguard allows a DC that has been reverted from a snapshot, or restored from VM backup to continue to function as a member of the directory service**
  - VM GenerationID is evaluated during boot sequence and before updates are committed to Active Directory
- **After revert/restore:**
  - Boot-up or new AD update triggers VM GenerationID to be compared to value of msDS-GenerationId in local AD database
  - If the values differ:
    - The local RID pool is invalidated
    - New invocationID is set for the local AD database
  - New changes can be committed to the database and synchronized outbound
  - Changes lost due to revert/restore are synchronized back inbound
- **After VM Clone or Copy (without proper prep)**
  - DC is rebooted into directory service restore mode (DSRM)

DC Safeguard Example

vSphere Host

DC01 vm.genid = 001

DC01

VM GenID: 001

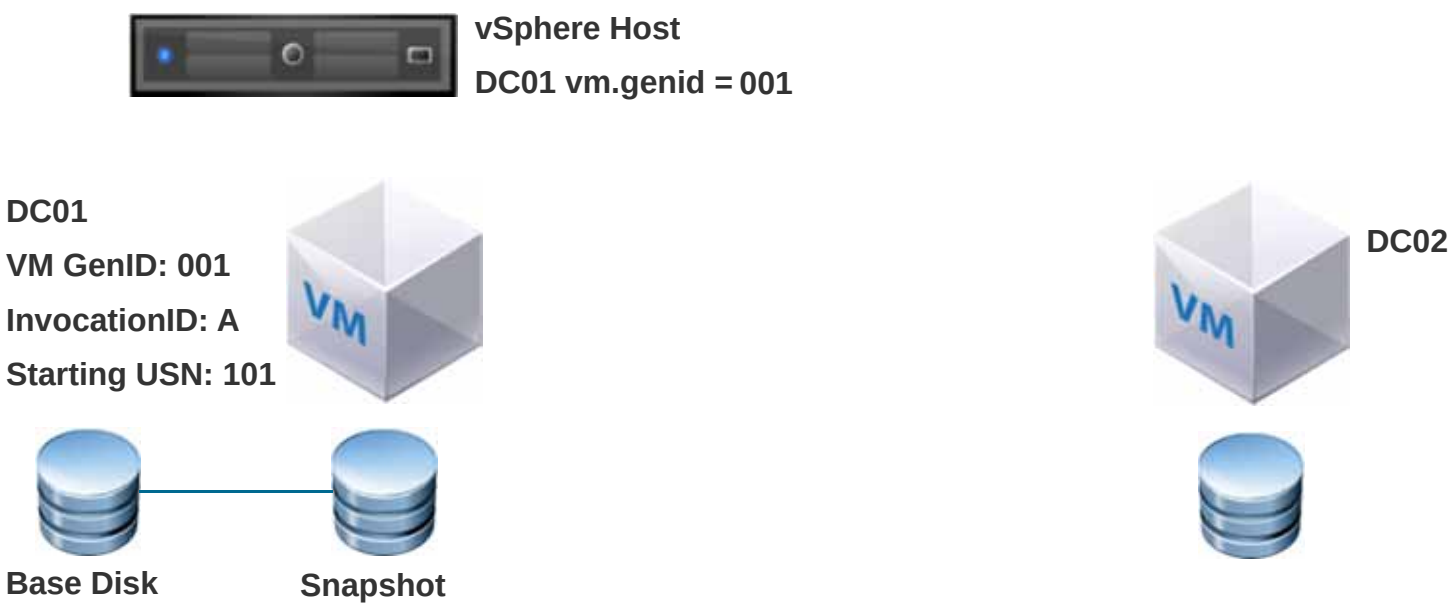
InvocationID: A

Starting USN: 101

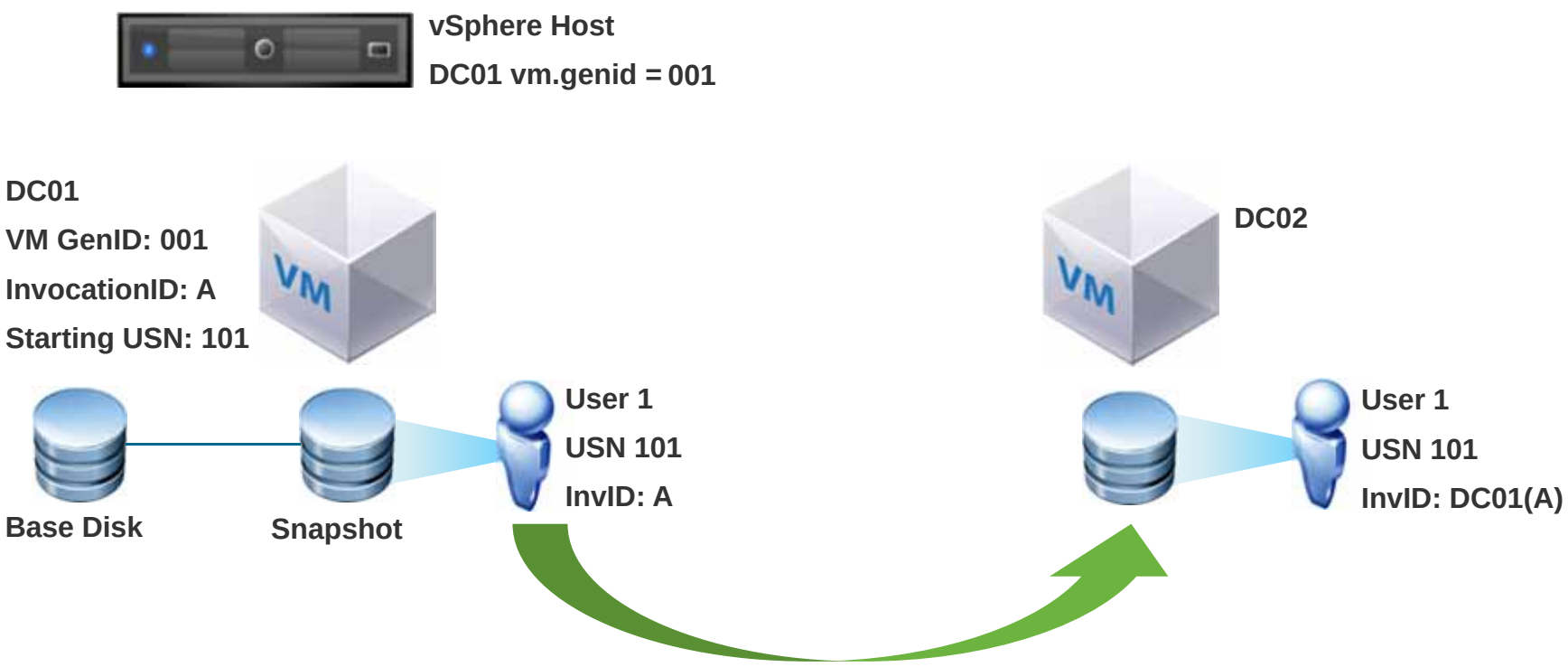
Base Disk

DC02

DC Safeguard Example



DC Safeguard Example



DC Safeguard Example

vSphere Host

DC01 vm.genid = 002

DC01

VM GenID: 001

InvocationID: A

Starting USN: 101

Base Disk

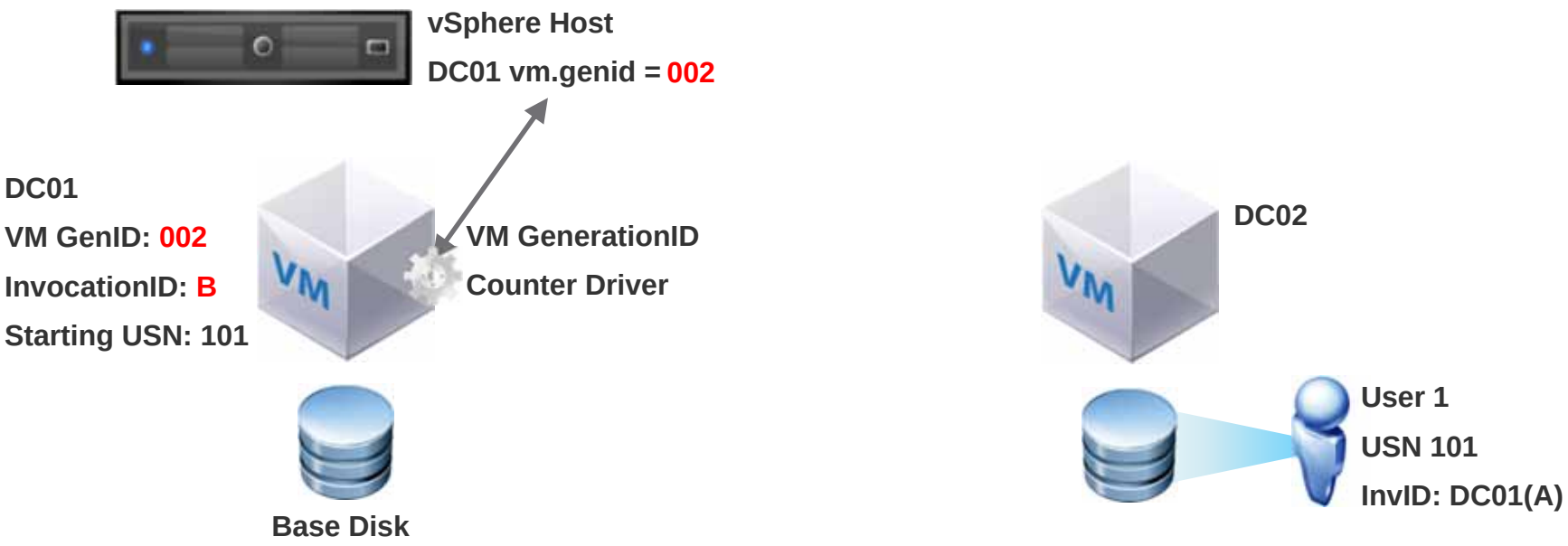
DC02

User 1

USN 101

InvID: DC01(A)

DC Safeguard Example



DC Safeguard Example

vSphere Host

DC01 vm.genid = 002

DC01

VM GenID: 002

InvocationID: B

Starting USN: 101

User 2

USN 101

InvID: B

Base Disk

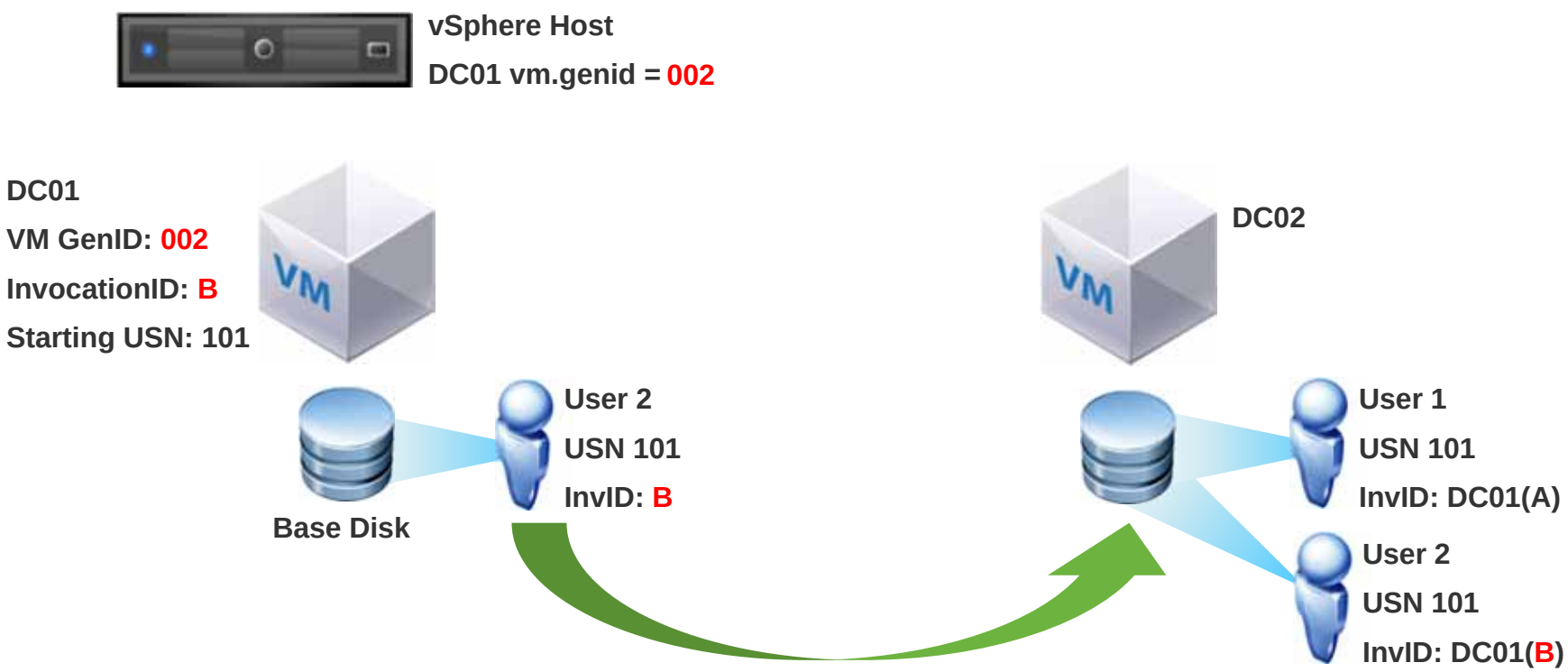
DC02

User 1

USN 101

InvID: DC01(A)

DC Safeguard Example



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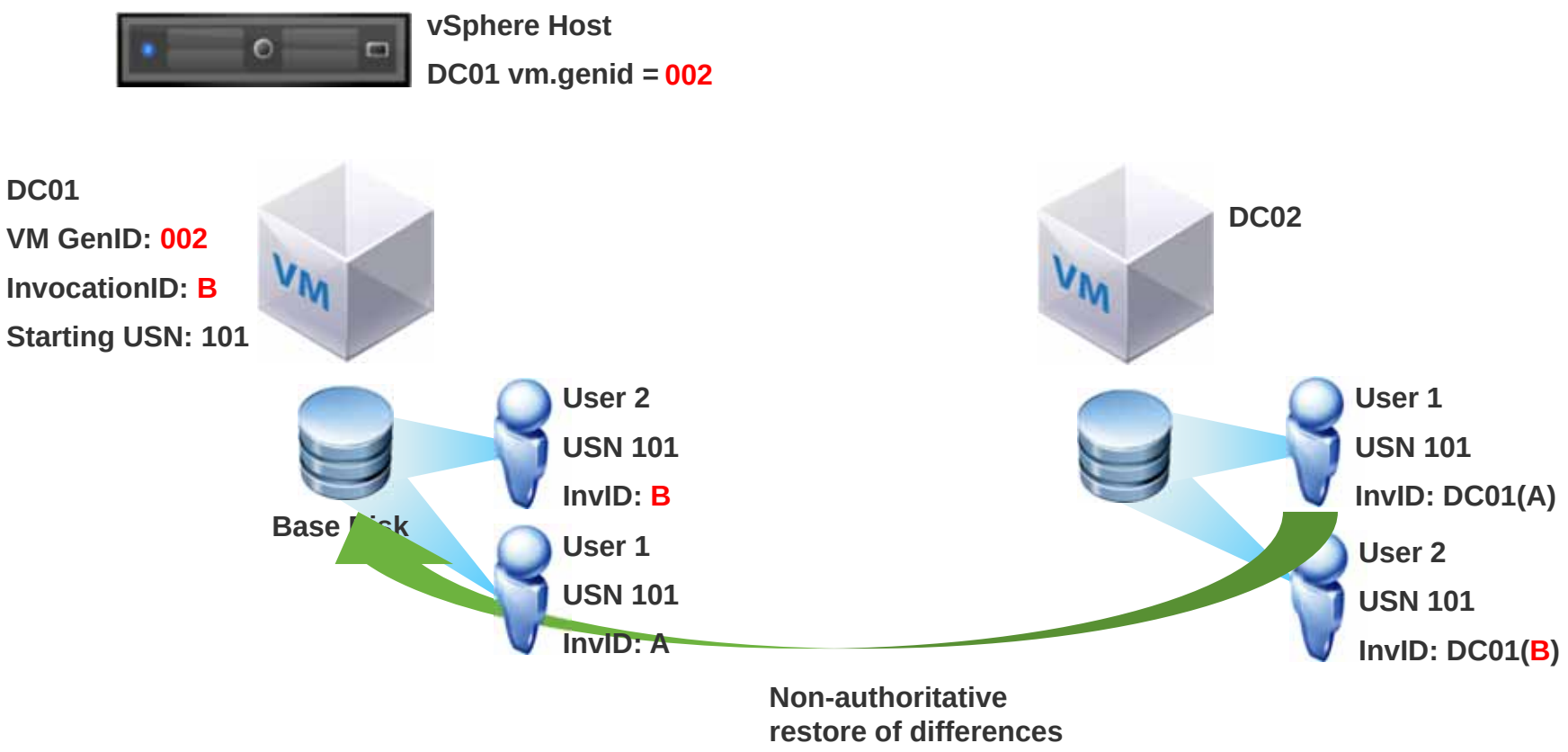
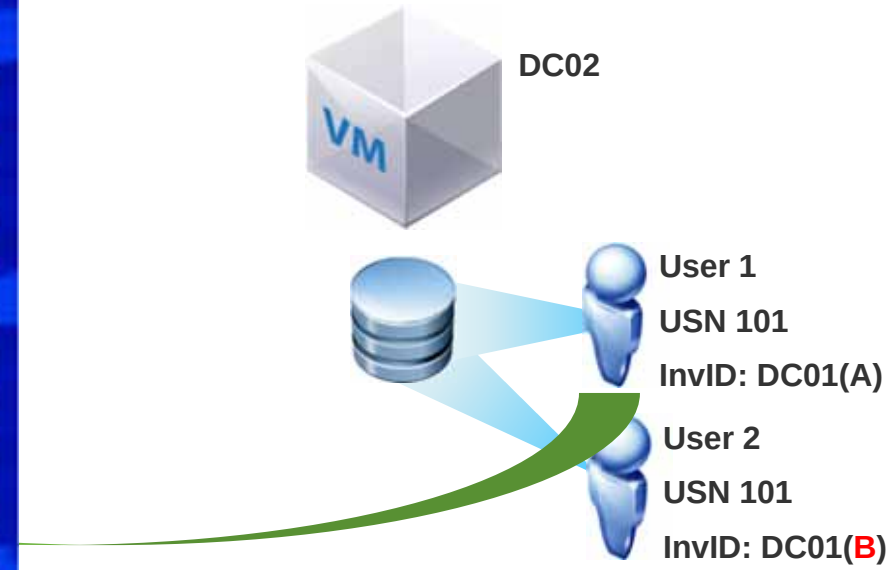


DC Safeguard Example



Non-authoritative
restore of differences

Domain Controller Safeguard

- **Just because you *can* take/revert a snapshot of a domain controller, does that mean you should?**
- **What are some valid reasons for using virtual machine snapshots with domain controllers?**
  - Backup software that takes “image level” backups typically rely on snapshots to ensure consistent backups.
  - Need to install software on a virtualized domain controller and want the ability to revert in case there are issues.
- **Even with this ability, remember that snapshots are *not* backups.**
  - It is often easier to deploy a new server & promote to domain controller rather than trying to restore a domain controller from a backup.
- **In general – it is unlikely you’ll frequently use this feature but good to know it’s there if you need it.**

Considerations When Using DC Cloning Features

- When performing DC Cloning operation:
  - Always shutdown reference domain controller prior to cloning
    - No Hot-clone! Besides, it's not supported.
  - Ensure that the reference DC holds no Operations Master Role
    - Specifically, you can't clone a RID-Master Role holder
  - You can clone the PDCe, but …..
    - You must power on the reference DC before powering on the new clone
  - DNS MUST be reachable during the cloning process
- When performing Mass DC cloning operation:
  - No "-CloneComputerName" or "-Static -IPv4Address" in dccloneconfig.xml
  - Ensure that DHCP is functional in the infrastructure
  - DON'T turn on the reference DC until you have finished all mass cloning
    - The dccloneconfig.xml file is automatically renamed as soon as Windows starts
    - Alternatively, convert the clone to a template and deploy new DCs from template
      - Re-usable template is only as good as the Tombstone Lifetime value of the domain
- Do **NOT** perform "Guest Customization" when cloning a DC
  - It breaks the "safety" feature!!!

General Considerations for Cloning/Safeguard Features

- Minimum vSphere/vCenter/ESXi version: 5.0 Update 2
- Guest Operating System version MUST be set to Windows Server 2012
  - VM Generation ID will not be generated for any lower version
- Leave “Cloneable Domain Controllers” AD security group empty in-between clone operations
  - Helps prevent unintended DC cloning
  - Helps enforce RBAC
    - Domain Admin populate group, vSphere Admin performs cloning, etc.
- Validate all software (think management/backup agents) for cloning
  - VMware Tools is safe for cloning
- If using Windows Backup, delete backup history on the clone, and take a fresh backup ASAP
- Clone DC Templates will become stale – think “Tombstone”
- Incorrect preparation will put clone in DSRM “Jail”
  - See - DC cloning fails and server restarts in DSRM (MS KB 2742844)

Key Take Aways…

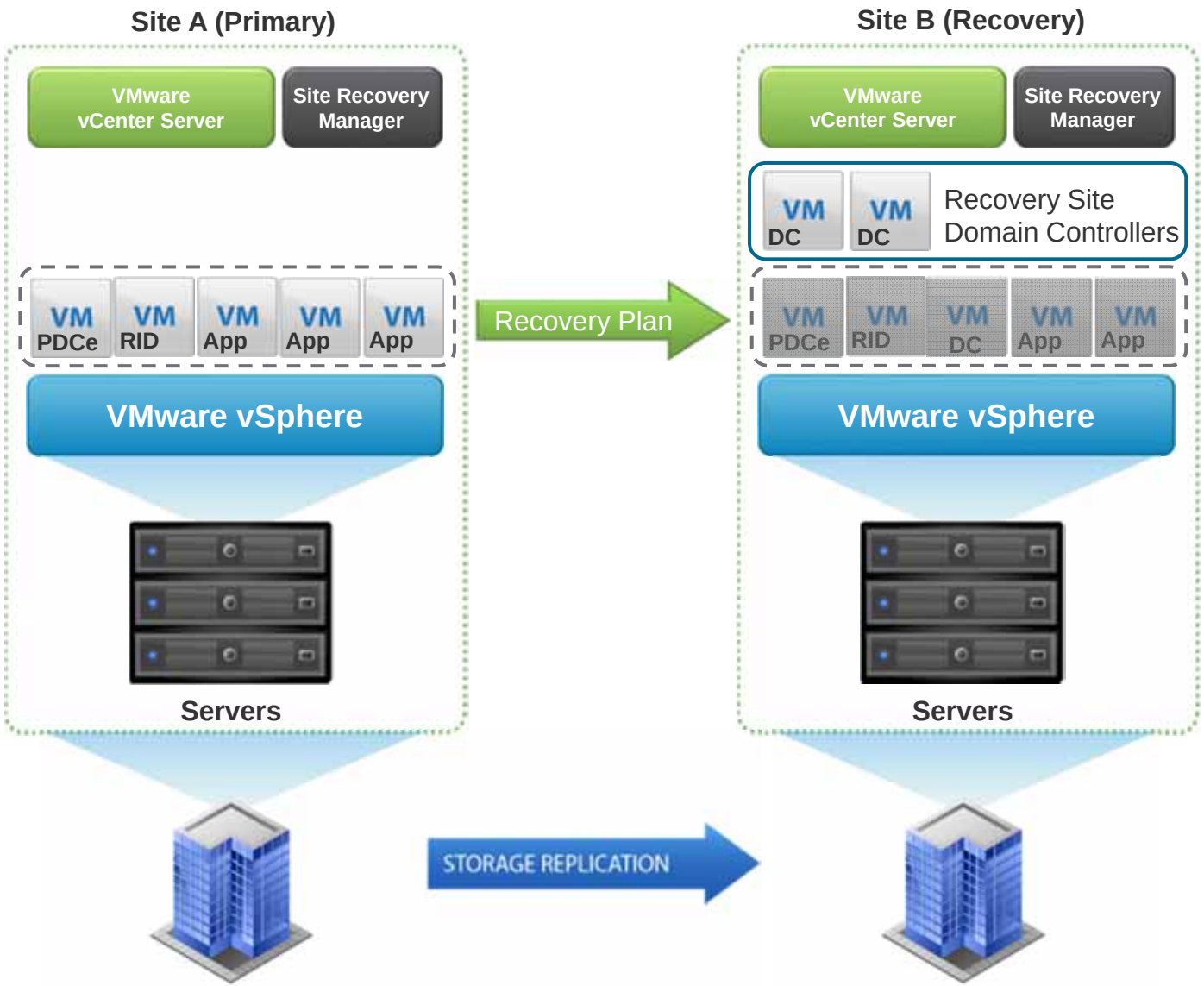
- Dangers which were once present when virtualizing DCs have mostly been resolved in Windows Server 2012
- Domain Controller virtualization is 100% supported
- Multi-master, distributed, and low resource utilization characteristics of Active Directory make domain controllers virtualization-friendly
- Physical and virtual Domain Controller best practices are identical
- Same considerations around Time, Security, DNS, Availability, etc
  - Physical Servers can experience clock drift, too
- Active Directory is natively highly available
  - vSphere High Availability complements it and help mitigate hardware failures
- Upgrade to Windows Server 2012 to bring domain controller safeguard and cloning to the party.

Effects of DC "Safety" on Disaster Recovery

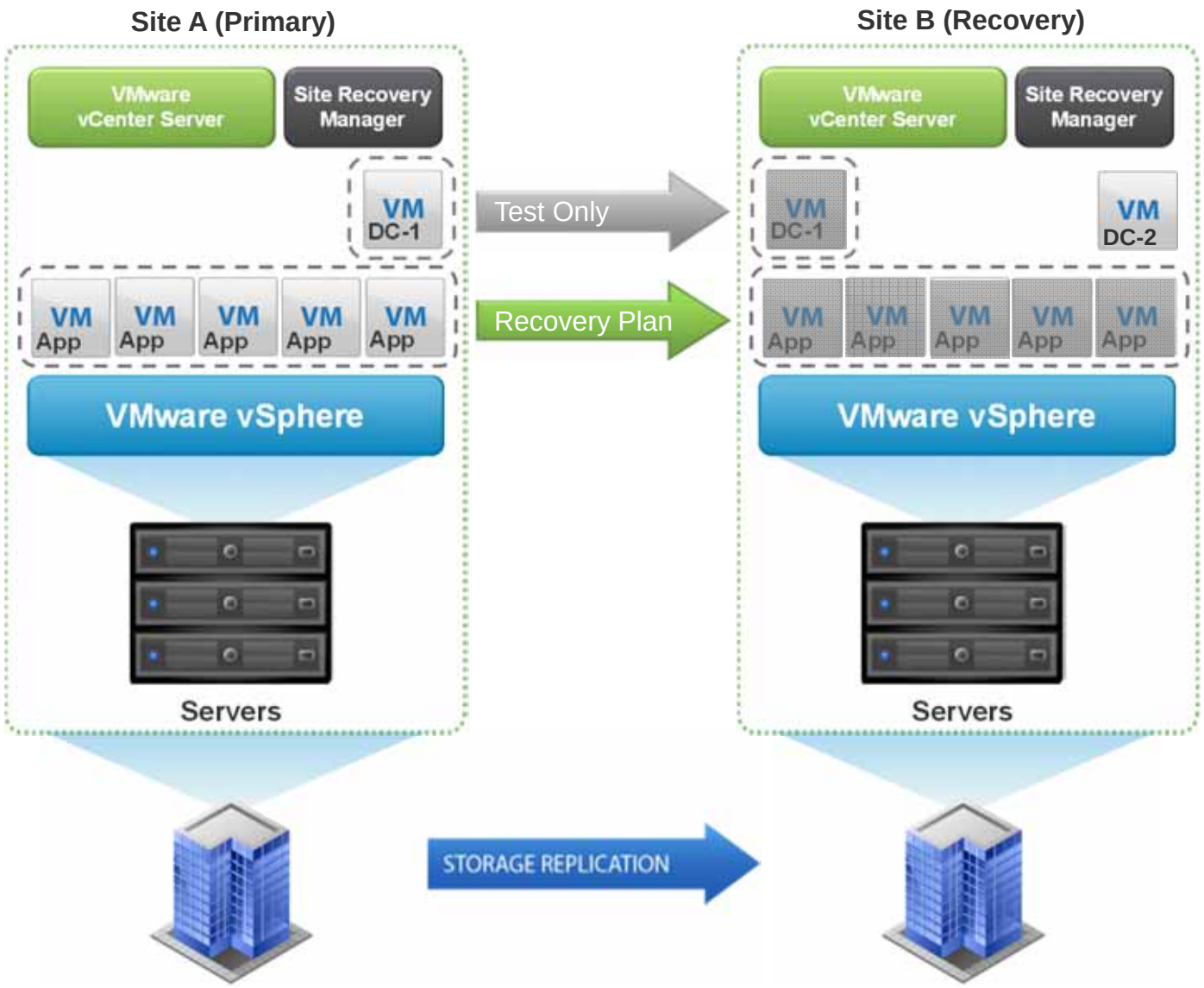
- Special considerations required for site-wide Disaster Recovery plan
  - Disaster connotes complete site (or AD) outage
  - Must recover multiple DCs or entire AD infrastructure
  - Recovery could be from backup or orchestrated (e.g. VMware SRM)
- Remember "DC Safety" workflow logic during a DC "recovery"
  - Hypervisor changes VM Generation ID of recovered DC
- What if one of the recovered DCs is the RID-Master?
  - RID Pool cannot be obtained while RID Master is down
  - RID Master cannot issue RID pools until it has replicated with other DCs
- Avoiding the conundrum
  - Always have DCs in multiple sites
  - Replicate RID-Master and PDCe (at least) to DR site as part of DR Plan
  - Restart Directory Service on RID-Master
    - *Use the Powershell command (**restart-service NTDS -force**)*
    - *Then force replication to another DC not impacted by outage (if available)*
  - Reboot RID-Master AFTER all other DCs have started
  - Or, just wait ….. For a sufficiently long time …. Yeah Right!

Protecting Active Directory with SRM

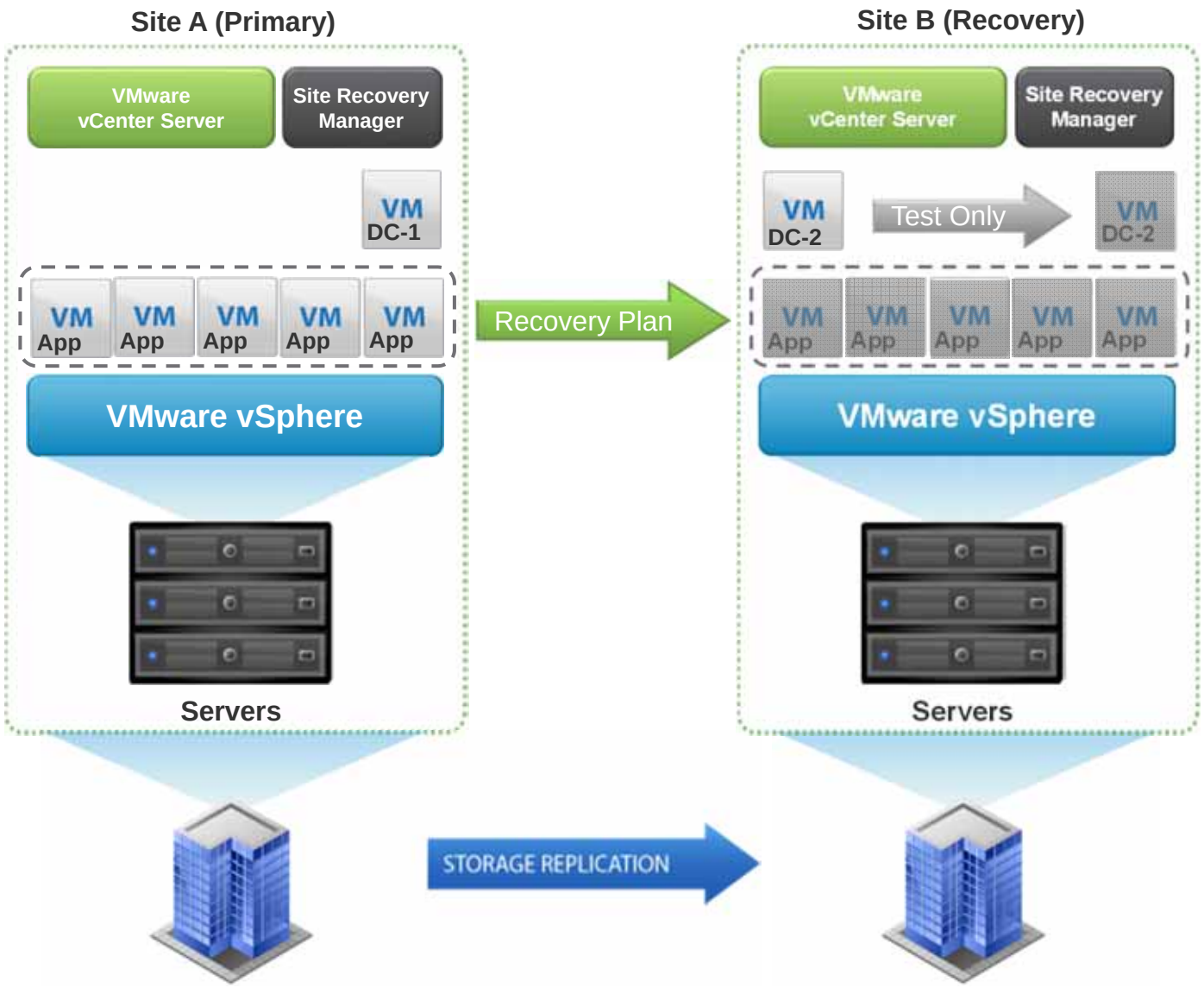
Protecting Operations Master Roles



Using Primary Site DC During DR Testing

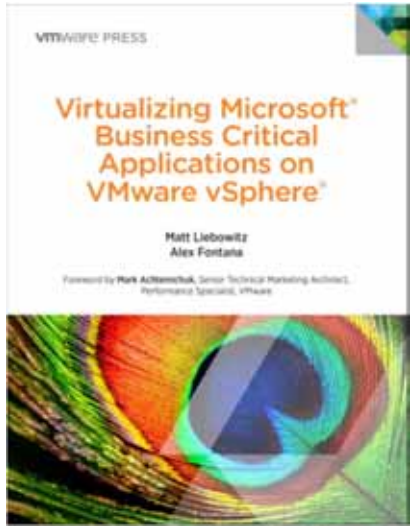


Cloning Recovery Site DC During RP Testing



Shameless Plug

- *Virtualizing Microsoft Business Critical Applications on VMware vSphere*
  - Authors: Matt Liebowitz, Alex Fontana



- Covers **Active Directory**, Exchange Server 2013, SQL Server 2012, and SharePoint Server 2013
- Not just technical – covers building a business case, objection handling, & more!
- Book signing – Tuesday at 12:00PM in VMworld Bookstore.

Thank You

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Virtualize Active Directory, the Right Way!

Deji Akomolafe, VMware
Matt Liebowitz, EMC Corporation

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