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EMC VNX and Avamar Deduplication Backup Bring Smooth Sailing to Your Virtualization Odyssey

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Management Summary

In the ancient Greek poem the *Odyssey*, the hero Odysseus takes ten years to travel by sea to his home on Ithaca after the Trojan War. He was held captive by the nymph Calypso on her island and later captured by the one-eyed Cyclops. Odysseus encountered numerous adventures along the way, such as skirting the treacherous rocks of the mesmerizing Sirens by tying himself to the ship's mast. He finally arrived on Ithaca, slayed the greedy young men courting his wife Penelope, and rejoined his household.

The Odyssey is also a metaphor for the journey of virtualizing your data center. The benefits of the journey are worth it, including higher utilization, lower hardware costs, greater flexibility, and ultimately higher IT quality of service. The virtualization odyssey takes time and challenges will arise along the way, though it does not have to take ten years, nor does it have to involve long struggles with demigods and monsters. With good planning and smart technologies and processes, enterprises can make steady progress in virtualizing a data center, typically in phases, and avoid situations known colloquially as "VM stall," where virtualization progress is slowed or ceased until underlying bottlenecks or other problems are resolved.

EMC has developed a first-rate combination of *VNX* unified storage and *Avamar* deduplication backup software optimized for supporting *VMware* virtual environments. VMware is the market-leading virtualization software. VNX and Avamar are tightly integrated with VMware at functional and management interfaces and deliver a palette of capabilities for addressing virtualization challenges. Read on for details about the benefits and challenges of virtualization and how EMC VNX and Avamar contribute to fair winds and smooth sailing on your virtualization odyssey.

Benefits of Virtualization

Many consider virtualization the greatest thing since sliced bread. And, in a way, virtualization is analogous to sliced bread. When a loaf of bread comes pre-sliced, it is easy to use and share. Take one slice to make toast, two slices for a sandwich, eight to make French toast for a family breakfast, and so on, until the loaf is consumed. Virtualization software "slices" or partitions a physical server into multiple virtual machines and enables it to run multiple applications independently. In traditional IT environments, each host server is dedicated to one application and compute resources are poorly utilized – generally around 5 to 10 percent. This is like eating only one or two slices from a bread loaf and letting the rest go stale. Virtualization solves this problem through server consolidation and boosts utilization to the range of 60 to 80 percent or better. It reduces hardware acquisition costs and operating expenses, such as power, cooling, floor space, maintenance, and support.

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Moreover, it is amazingly simple to provision a new virtual machine. An administrator can set one up in minutes, as compared to days or weeks to buy and install a new physical server in a data center.

Faster provisioning makes IT more responsive to changing business requirements and facilitates to an agile and more competitive enterprise. Virtual machines can migrate between servers, even in real time without disrupting production applications. This turns hardware upgrades and workload balancing into easier, non-disruptive tasks. The ability to recover a virtual machine to any hardware platform streamlines recoveries. All of this contributes to higher availability.

Virtualization is also a cornerstone of cloud computing, or in less celestial jargon, IT as a Service (ITaaS). Cloud computing is where IT is heading because the concept promises the ultimate in flexibility, quality of service, and cost effectiveness. Private clouds and public clouds are already being implemented today, and many more will be as the technology components develop and mature. Virtualization is a significant and essential step toward cloud computing.

At an enterprise data center, the transition to a virtual environment typically happens in phases. It starts with lower-risk applications like test and development, Web servers, and file and print servers, and eventually move to business-critical and customer-facing applications. As enterprises try out and develop expertise in server virtualization and experience the benefits, the footprint expands.

Challenges of Virtualization

Virtualization brings a different set of challenges than a purely physical environment. Virtualization adds a software abstraction layer on top of server hardware that partitions the system and enables it to support multiple instances of operating systems and applications. This change is significant and structural and requires a corresponding change in IT management processes and tools. Key areas to address include capacity planning, resource monitoring and management, VM sprawl, I/O bottlenecks, storage management, data protection, and backup.

Capacity planning in a virtual environment is more challenging because the infrastructure is shared and utilization rates are higher. In a traditional environment where each server hosts a single application, resource utilization is low and workloads are less likely to bump up against system limits. Capacity planning means buying a new server or storage capacity when needed, and having the foresight to do it before applications begin to slow down noticeably or reach a physical limit. In a virtual environment where multiple workloads run per host server, resources are operating at closer to maximum and administrators have to monitor performance issues more closely. Capacity planning, in this context, means correctly sizing resources and adding CPU, memory, I/O, storage capacity, or whole systems when needed, as well as ensuring a balance among these components to avoid resource bottlenecks that prevent the system from being fully utilized. VM migration between servers is a valuable feature that facilitates workload balancing, system maintenance, and recovery, though it also means the infrastructure is more fluid and, thus, more challenging to track and manage. In short, virtual environments are denser, more dynamic, and operate closer to the edge of resource limits, which delivers the benefits of virtualization but also requires more stringent management and controls.

Monitoring and management tools and processes need to be adapted for virtual environments. Administrators must be able to monitor and troubleshoot on a per-VM basis, which means monitoring performance at the hypervisor layer, as well as operating system, application, network, and storage. Tools should be integrated with the virtualization software to ensure visibility, coordination, and to leverage its capabilities fully. As the environment grows, alerts and automation help greatly to keep up with management tasks.

VM sprawl is a well-known problem in virtualized environments. It is so easy to create new VMs – a matter of a few keystrokes and mouse clicks – that there is an inclination to create too many and overload system resources. Each VM consumes CPU, memory, I/O, and storage. It is not free. However, compared to the long and deliberate process of requisitioning, purchasing, and installing a new physical server, it easy to overlook the real cost of provisioning VMs and allow them to proliferate uncontrolled. The solution is to establish a formal request and approval process, limit access, and decommission VMs that are no longer needed and return their freed resources to the available pool. VM sprawl also accentuates the needs for good capacity planning and resource monitoring.

I/O Bottlenecks, in particular, are common resource constraints in virtual environments. With multiple workloads sharing the same network or host bus adapters, network links and storage systems, traffic can become congested and slow down application performance. Management features like VM migrations and even VM snapshots put more traffic on I/O channels. So, it is important to size I/O correctly and regularly monitor I/O performance to identify and remedy bottlenecks.

Storage management is critical because it has a significant impact on performance and cost in a virtual environment. As the end of the I/O stream and the only part of the system with physically moving parts (i.e., disk drives), storage performance directly affects application workloads. Maintaining sufficient capacity in the wake of VM sprawl, snapshots, and natural data growth is essential to avoid incapacitating out-of-space conditions. Finally, storage is a dear resource and the efficient use of storage is consequential to the total infrastructure cost of a virtual environment.

The rules of data protection and backup and recovery change in a virtual environment because of workload density and the added hypervisor layer. With multiple application workloads running on a physical server, there are less CPU, memory, and I/O resources available for replication, copies, and backup. Backup, in particular, presents a challenge. With multiple workloads to back up within a limited time window, this process can overrun the backup window and slow production activities during business hours or cause some data to be unprotected. Above-average data growth in virtual environments compounds this problem. Since VMs can move between physical servers, it is more challenging to track the backup status of workloads and ensure backup service levels are met. There is also the question of whether to run agents at the guest (i.e., application and OS) or image (i.e., VM encapsulated file) level, where each has its advantages.

If the challenges of virtualization are not addressed strategically and effectively, they can lead to a situation known as *VM stall*. Like Odysseus' seven-year captivity on Calypso's island, this is where the progress of virtualizing a data center slows or ceases until the underlying problems are resolved. VM stall is not inevitable; rather, it is the result of insufficient planning and investment in the optimal technologies, processes, and skills for managing a virtual environment.

But why get stuck on an island and delay the full benefits of virtualization? And why spend more time and money to address these challenges after the fact? We recommend tackling the challenges of virtualization beforehand to facilitate smooth sailing on your virtualization odyssey.

VNX Unified Storage

The EMC *VNX* series unified storage[1] platform has a feature set well-suited for virtual environments, including unified SAN and NAS, redundancy, scalability, high performance, resource efficiency, simplified management, and support for *VMware* and Microsoft *Hyper-V*. The VNX series includes multiple products spanning the midrange: *VNX5100*, *VNX5300*, *VNX5500*, *VNX5700*, and *VNX7500*.

VNX supports SAN and NAS, also known as "block" and "file" storage, which gives users choice among FC, iSCSI, FCoE, CIFS, and NFS for their virtual environments. Networked storage is a best practice for virtualization because it can be shared among multiple servers. It enables storage consolidation and advanced capabilities, such as VMware *vMotion*, for online VM migration between *ESXi* servers. Most enterprises choose SAN storage for best performance in a virtual environment, though some opt for NAS for its manageability benefits. The VNX can serve virtual and physical infrastructure in the same system, as most enterprises will continue to have a hybrid storage environment in its data centers.

The VNX architecture has built-in redundancy with no single points of failure. In fact, EMC claims "five 9s" availability based on actual field performance. As virtual environments consolidate more workloads and application data sets into fewer systems, high availability becomes more important for maintaining application uptime and business continuity. VNX features include dual active/active controllers, automatic failover and failback, mirrored write cache with de-stage to disk in the event of power failure, RAID 0, 1, 0/1, 3, 5, and 6. The system supports internal monitoring, call-home, remote diagnostics, and non-disruptive software up-

[1] See **The Clipper Group Navigator** dated February 21, 2011, entitled *New EMC VNX Unified Storage Family Offers the Best of CLARiiON and Celerra for the Midrange* and available at http://www.clipper.com/research/TCG2011008.pdf.

grades and field hardware replacement.

The VNX architecture is also modular and scalable. Virtual environments drive storage growth at an above average pace, so storage scalability is essential for maintaining adequate capacity. The VNX expands incrementally by adding Disk Array Enclosures (DAE) and disk drives (small form-factor SAS; large form-factor SAS, NL-SAS, and flash (SSD[2])). The largest VNX7500 expands to a maximum capacity of up to 1,000 drives (or 1,974TBs with 2TB drives), reaching well into the high-end range of the storage market.

Virtual environments are more sensitive to storage performance because they concentrate multiple workloads onto a shared I/O path. Mixing operations from multiple workloads also turns disk-friendly sequential operations into cache-centric random operations. Storage arrays need to deliver solid performance, especially for random I/Os, to maintain acceptable application performance.

VNX optimizes performance with a "Flash 1st" strategy that includes features like *FAST VP* (Fully Automated Storage Tiering for Virtual Pools) and *FAST Cache*. Beyond standard cache memory, VNX supports FAST Cache, which allocates up to 2 TB of flash drive capacity as read-write cache, which gives a major boost to random I/O performance. The feature monitors I/O activity and automatically moves frequently accessed data in 64KB blocks into flash-based cache to deliver a faster system response time. FAST VP provides automated storage tiering. This feature analyzes I/O patterns, categorizes them based on access frequency, and automatically moves 1GB increments between tiers of SAS, NL-SAS, and flash drives to optimize performance and resource efficiency. FAST VP and FAST Cache can be used simultaneously, though each requires dedicated flash drives. VNX also offers high-speed 8Gb per second FC and 10GbE connections for host connectivity.

Resource efficiency features are designed to reduce actual capacity requirements and cost in the VNX. *Virtual provisioning* is a thin provisioning feature that presents a large virtual capacity to the host while allocating actual capacity incrementally from a shared pool as it is consumed. It also supports fully-allocated thick provisioning for maximum performance. FAST VP is another efficiency tool. Many enterprises find that by using storage tiers with a mix of flash and disk drives, they can optimize performance while lowering drive costs. *File deduplication* and *compression* reduces space consumed in NAS environments, while *block compression* reduces space for inactive LUNs in SAN environments. (There's more on deduplication in the next section on Avamar.)

Storage administrators need to have visibility into the virtual environment, and VMware administrators should have some control over storage resources. EMC *Unisphere* is the centralized management console for VNX systems, as well as EMC's *CLARiiON*, *Celerra*, and *RecoverPoint/SE*. Unisphere is virtualization-aware and provides a view extending into VMware *vSphere*. It automatically discovers ESXi Servers and VMs and maps them to physical volumes on an EMC storage array. *Virtual Storage Integrator*, a vSphere Client plug-in for Unisphere, allows VMware administrators to discover and identify VNX storage devices, provision and mount new data stores, and manage multipathing with EMC *PowerPath*. *Unisphere Analyzer* is an optional feature for monitoring and analyzing storage performance and is useful for spotting and managing I/O bottlenecks. All of these tools help address the challenge of monitoring and management of storage resources in a virtual environment.

Furthermore, VNX is integrated with the *vStorage API for Array Integration (VAAI)*. This is a set of APIs that allows VMware ESXi hosts to coordinate with storage arrays and offload I/O-intensive operations, such as copies and writing zeroes. For thin provisioning, it assists with dead space reclamation and limits the impact of an out-of-space condition to the related VM, instead of all VMs in the data store. These capabilities help make the most of storage and I/O resources and keep costs down. VNX supports also *VMware Site Recovery Manager (SRM)*, a plug-in for vCenter that automates failover and failback between sites and makes disaster recovery faster and more reliable. The VNX replication software *MirrorView* can then participate in the automated recovery process, facilitating data protection in a virtual environment.

Avamar Deduplication Backup Software and System

EMC Avamar[3] is uniquely suited for virtual

[2] SSD=Solid State Disk.

[3] See **The Clipper Group Navigator** dated June 8, 2010, entitled *EMC NetWorker and Avamar — An Integrated Pair*

environments and offers deep integration with VMware. It solves several virtualization challenges related to backup and recovery.

- ***Very fast daily full backups*** through variable-length client-side and global deduplication, backup to disk, and VMware integration.
- ***Fast, one-step recovery*** through daily "full" backup and changed-block restore through VMware integration.
- ***Virtualization-aware backup monitoring and management*** through integration with VMware vCenter.
- ***Guest, image, and off-host backup*** through applications and VMware integrations.
- ***Dramatically reduces backup storage capacity requirement and cost*** through variable-length deduplication.
- ***Virtual Avamar server option via Avamar Virtual Edition virtual appliance,*** which leverages an existing VMware ESX server's disk, storage, CPU, and memory**.**
- ***Backup of physical and virtual environments*** because most enterprises will continue to have both.

Client-Side Deduplication Backup

Avamar reduces backup data at the client before transferring it across a network for storage on disk. It uses a variable-length, sub-file deduplication algorithm to minimize the amount of data being transported and, therefore, also minimizes network bandwidth and storage requirements. Through a sophisticated identification and communication process, Avamar eliminates redundant backup data within and across protected systems, wherever they exist in the enterprise. According to EMC, Avamar reduces the required daily network bandwidth consumption by up to 99% and cumulative backend storage can be reduced by up to 50 times (depending on the nature of the data) across sites and servers.

Avamar supports client-side deduplication of databases related to applications, such as Microsoft *Exchange*, *SQL*, and *SharePoint*, *Oracle*, IBM's *DB2* and *Lotus Domino, and others*. Avamar is tightly integrated with VMware for backing up virtual machines. Avamar automatically backs up servers in remote offices and even desktop and laptop PCs over a WAN connection to an enterprise's main data center, thereby consolidating the backup process.

Deduplicating data in this way minimizes the impact of backup on virtualized servers, so backups are faster and more reliable and enterprises can maintain high utilization rates on virtualized servers without being constrained by the backup process. Avamar does a full backup initially as a baseline and all subsequent backups are incremental. It organizes data so that each incremental is presentable as a logical full backup and restores are a one-step process. This eliminates the tedious process of restoring the last "good full" and subsequent "incrementals" to reach the desired recovery point.

Disk-based backup has become mainstream because of its speed and reliability advantages over tape. Tape may be too slow or unreliable to meet the data protection requirements of the business.[4] It requires physical handling and can be misplaced or damaged during loading, unloading, or transport. In contrast, disk is a faster storage medium, especially because it can process random reads and writes immediately. It does not require handling and is resilient through RAID and redundant components. Disk-based storage can be checked daily for data integrity – something that is not done with tape. Moreover, data deduplication solutions, like Avamar, make disk-based backup feasible by effectively shattering the cost barrier.

Backup Across the Enterprise

In addition to virtual environments, Avamar is particularly effective for remote and branch office consolidated backup, desktops and laptops, file servers, and NAS systems.

Avamar's client-side deduplication enables fast, daily full backups for remote office servers and desktop/laptop systems via existing WAN links. Avamar automatically backs up systems to an enterprise's main data center, thereby consolidating the backup process. Backup and recovery becomes more manageable and reliable by leveraging the data center IT experts and eliminating reliance on non-technical remote workers and failure-prone local tape devices. Avamar also offers an easy-to-use interface that enables desktop/laptop users to recover their own data quickly without involving the IT help

for Traditional and Deduplication Backup and available at http://www.clipper.com/research/TCG2010028.pdf.

[4] However, tape is still the lowest-cost option for long-term data archiving. Avamar can export deduplicated backup data to tape for long-term preservation.

desk, which boosts user productivity and frees IT staff to work on other projects.

For NAS systems, the Avamar NDMP Accelerator provides fast, daily full backups and eliminates the need for recurring level-0 "dumps" that often exceed the available backup time window for completion. By eliminating this backup bottleneck, Avamar facilitates greater NAS utilization and performance without limiting the amount or size of files on the NAS device.

Avamar also supports disaster recovery, since deduplicated backup data can be efficiently replicated to an offsite location via existing WAN links.

While many enterprises will retain traditional backup applications for some environments, if only because their backup processes are so well entrenched, Avamar can serve as the backup application for an entire data center or distributed enterprise – both physical and virtual environments.

VMware Integration

Avamar is integrated with VMware vCenter Server. The Avamar management console accesses vCenter Server directly, discovers new VMs automatically, and displays their current backup status, whether guest or image backup or unprotected. Administrators have instant visibility to apply the appropriate backup policies. This capability is very helpful for backup management in a world of VM sprawl and migrating VMs. For example, if a server administrator creates a new VM in response to a user request, the backup administrator can automatically discover it and apply a backup policy. With this baseline protection in place, he can inquire with the server administrator about the level of data protection it should have going forward.

Avamar supports both guest- and image-level backups for VMware environments.

- ***Guest-level backup*** is similar to traditional backup for physical servers. It uses the same backup agents, except agents run in the VMs on an ESXi server. If 20 VM workloads are running on a physical server, 20 backup agents also are running. Guest-level backup is the most familiar to traditional backup administrators and offers a sense of continuity in transitioning to a virtual environment. Application consistency is available for guest-level backups using agents that integrate with specific applications like SQL or Oracle. File-level restore for *Windows*, *Linux*, and *Solaris* environments is available, as well. The disadvantage of guest-level backup is, with multiple agents running simultaneously during the backup window; the agents compete for resources and can overload the system, limiting physical server consolidation. However, while Avamar agents typically use 15% more CPU than traditional backup agents, Avamar backups complete up to 10 times faster, reducing the total client CPU utilization by up to 85% over a seven-day period compared to traditional methods and making daily full guest backups faster and more efficient.
- ***Image-level backup*** leverages the VMware *vStorage APIs for Data Protection (VADP)* for off-host backup of VMDK (virtual machine disk) files that encapsulate the entire virtual server, including VM configuration, operating system, and application. Backup agents are not required to run in each VM, as the case with guest-level backup. Rather, the ESXi Server takes a snapshot copy of each VM and presents it to a proxy server running Avamar agents (the proxy itself is a VM). Backup jobs flow directly over the network from the storage array through the proxy to an Avamar Data Store. The VNX also supports *vProxy Server Load Balancing* that automatically distributes backup jobs round robin among multiple proxy servers, to speed up the backup process and make the most of available resources. The image-level approach facilitates faster backups, is non-disruptive to production applications, and allows VMware to consolidate more workloads per physical server. Recoveries can be full VMDK files or individual files (but only for Windows).

Related to image backup is a VMware feature called *Changed Block Tracking* that timestamps changes to block data in VMDK files and makes this information available through VADP. Avamar leverages Changed Block Tracking to further speed backup and recovery times. Avamar identifies the blocks that changed from last backup to the current state of the VM, and restore only those blocks – speeding restores to the production environment by 30 times, compared to traditional restores, according to EMC.

When choosing between guest-level and image-level backup for your workloads, image-level is preferable because it is non-disruptive, offers greater resource efficiency, more addresses more virtualization challenges, but there are limitations, such as application consistency, where in-guest is the viable alternative.

Virtual Avamar Servers

The *EMC Avamar Virtual Edition for VMware* is a virtual appliance for backup, recovery, and disaster recovery. Avamar Virtual Edition enables users to deploy Avamar deduplication technology in an easy and repeatable fashion on VMware ESXi Server hosts. Each virtual appliance supports up to 2TBs of deduplicated backup capacity (which under a typical traditional backup schedule would require approximately 70TBs of tape or disk storage) and leverages the existing VMware shared server and storage infrastructure to minimize costs and simplify management. Avamar Virtual Edition supports vMotion for deployment flexibility and up to two virtual appliances per ESXi server. By supporting replication between Avamar virtual appliances or from Avamar virtual appliances to physical Avamar servers (discussed next), it provides an alternative for offsite tape shipments and eliminates the risk of losing unencrypted data.

EMC also offers physical *Avamar Data Store* servers packaged as an all-in-one solution consisting of EMC Avamar software running on preconfigured, EMC-certified hardware. The Avamar Data Store is available in a scalable multi-node model or a single-node model. The advantages of a packaged solution include streamlined purchasing, deployment, and on-site setup.

Conclusion

The cost, flexibility, and business agility benefits of virtualization far outweigh its challenges. With thoughtful planning and the right technologies, you can enjoy smooth sailing on your virtualization odyssey and avoid getting caught up on the rocks of VM stall. So, take a close look at EMC VNX unified storage and Avamar deduplication backup software and system for your virtual environment. They are more than storage and backup elements for your infrastructure; they can also bring features and integration with VMware that solve your virtualization challenges. Avamar is also a great solution for backup, recovery, and disaster recovery of data residing in remote/branch offices, desktops/laptops, and NAS systems. Together this combination can transform your infrastructure and accelerate your virtualization odyssey.

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