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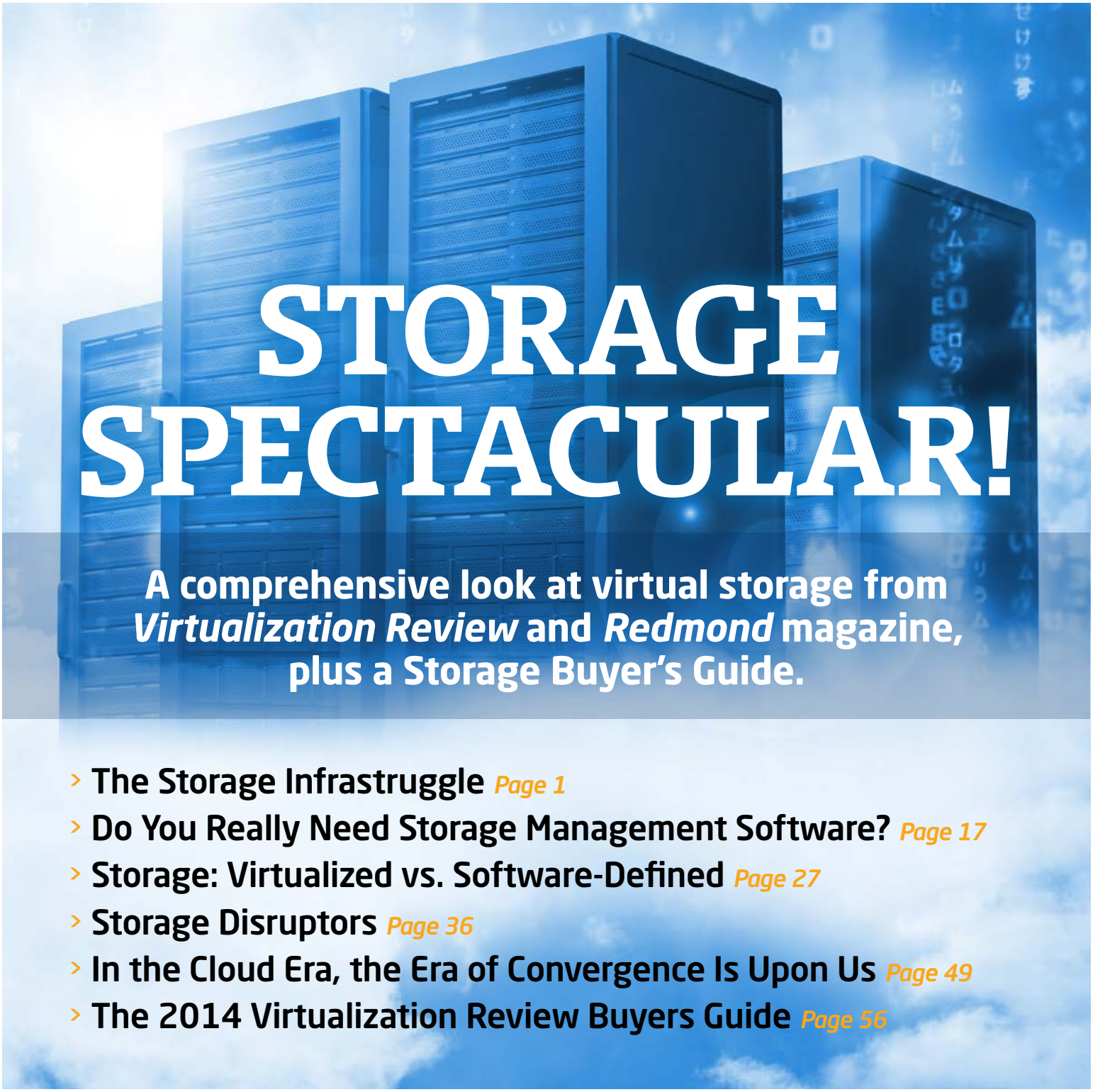
Redmond VIRTUALIZATION REVIEW



STORAGE SPECTACULAR!

A comprehensive look at virtual storage from *Virtualization Review* and *Redmond* magazine, plus a Storage Buyer's Guide.

The Storage Infrastruggle

Vendors are battling for the future of your storage spend, but are they sidestepping the key drivers of storage cost?

By Jon Toigo

While touting "new," flash-heavy "server-side" topologies and so-called "software-defined architectures" as evolutionary replacements for the "legacy" SANs and NAS appliances that companies deployed in their previous refresh cycles, the industry continues to ignore the more fundamental drivers of storage inefficiency and cost: lack of management both of infrastructure and of data.

You would think from news reports that the storage industry was on its last legs. Vendor revenues from sales of everything from hard disk drives to external storage arrays, storage area networks (SANs) and network attached storage (NAS) appliances are either flat or declining ever so slightly. Seagate and Western Digital have hit a patch of doldrums in which the trends of prior years—the doubling of drive capacities every 18 months and the halving of cost per GB every year—have frozen in their tracks. Even the redoubtable EMC, NetApp and IBM are experiencing purchasing slowdowns at customer shops that shouldn't be happening if the capacity demand explosion that analysts say accompanies server virtualization is to be believed.

SMI-S was developed by a committee of vendors with no vested interests in making it easy for customers to manage a competitor's rig in the same fabric infrastructure as their own equipment.

There are some new-ish technologies on the market, like flash storage, and magnetic tape is enjoying a great renaissance. However, much of the noise emanating from the storage industry these days is, well, just noise.

Instead of tackling the real problem of data management through effective archive and data hygiene strategies, the industry has been proposing tactical and short-term technical fixes like data reduction, de-duplication and compression. While these technologies can help squeeze more junk into the storage junk drawer, they are proving to be limited as to their utility and are obfuscatory when it comes to holistic infrastructure management.

On the second score, infrastructure management—or that ever oxymoronical term, storage management—there have been no real breakthroughs. The Storage Networking Industry Association's effort to improve storage management beyond what could be done with Simple Network Management Protocol (SNMP), produced the Storage Management Interface – Specification or (SMI-S) in the early Aughts. Unfortunately, SMI-S was developed by a committee of vendors with no vested interests in making it easy for customers to manage a competitor's rig in the same fabric infrastructure as their own equipment. It has proven to be somewhat daunting and expensive for vendors to implement, so consumers demonstrated little interest in or enthusiasm for paying extra for SMI-S connectivity.

For a time, using World Wide Web Consortium (W3C) standards like REST for storage management looked to be the solution. Since the

late 1990s, the software and operating system folks were embracing REST to request specific infrastructure services, but lacking REST enablement, infrastructure equipment was incapable of responding to requests—until X-IO, then Xiotech, released its Intelligent Storage Element (ISE) array. The company went so far as to place its very slick RESTful management APIs onto an open web site, and then it invited the industry to use the technology without license fees or other charges. A small but impressive user community formed around the technology, sharing apps they had written to leverage the ISE REST interface and to enable on-the-fly storage provisioning to physical and virtual workloads. Alas, big-brand vendors ignored this opportunity, and they nearly unanimously vocalized support for RESTful management (IBM's Project Zero in 2009 is one example) while delivering no capabilities in their gear.

When Q1 2014 went into the record books, ... both financial and industry analysts and pundits squealed in equal measures of pain and delight, forecasting a coming "SAN-pocalypse."

With a lack of intelligent management either of data or storage infrastructure, with data (mostly in the form of files—and mostly duplicated files) amassing at alarming rates, and with carbon robots (human server administrators) preferring a "disk-storage-for-every-thing-model" for platforming data, the financial futures of both HDD and array vendor looked exceedingly bright. But, as of the recent quarter, not so much.

When Q1 2014 went into the record books, IBM's storage business was down 23 percent quarter over quarter, and EMC's was down 22 percent. Other players were already flat or under water in terms of revenue or market share growth. When Seagate and Western Digital released their earnings in April (see Fig. 1), again down in single digits quarter over quarter, both financial and industry analysts and pundits squealed in equal measures of pain and delight, forecasting a coming "SAN-pocalypse."

The delighted ones were those seeking the advent of an all-silicon storage infrastructure based on abundant and inexpensive flash memory. These voices found comrades among the industry analysts who were busily creating specialty research services around "server-side" storage topologies, such as those advanced by Google and Facebook, or architectures like vSAN from VMware.

However, truth be told, things are not as bad in the disk world as they are made out to be by certain vendors and their paid analysts

and bloggers. In the first quarter of 2014, the two leading drive manufacturers together shipped a combined 99.7 exabytes of disk capacity, which they expect to grow by another 102.7 Exabytes (combined) by the end of the third quarter this year. Not counting Q4, that totals some 200-plus exabytes of capacity shipping through end of year. Compared to the 21.2 exabytes of total external disk capacity deployed in 2010, according to IDC, we are talking serious growth in

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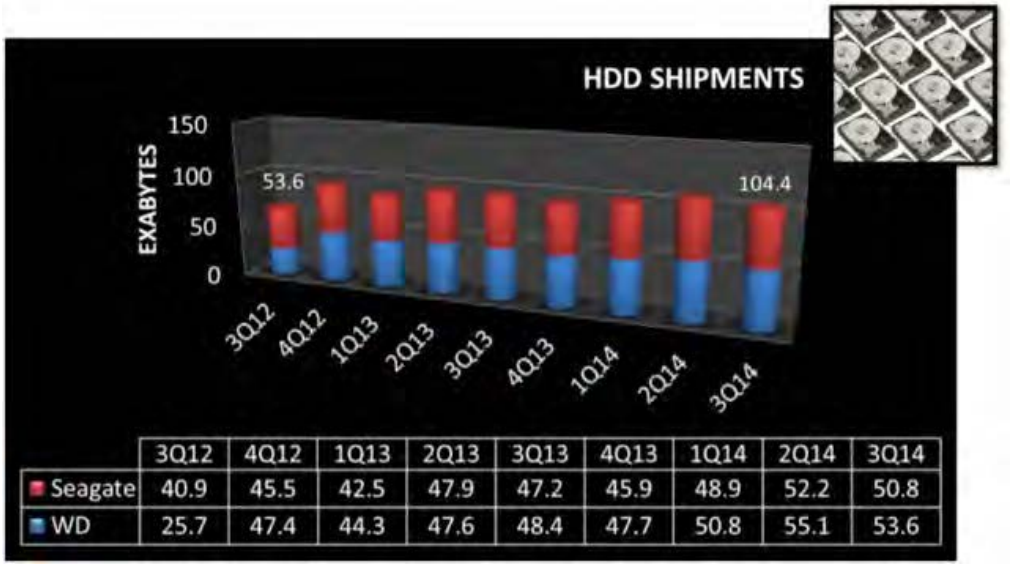

	3Q12	4Q12	1Q13	2Q13	3Q13	4Q13	1Q14	2Q14	3Q14
Seagate	40.9	45.5	42.5	47.9	47.2	45.9	48.9	52.2	50.8
WD	25.7	47.4	44.3	47.6	48.4	47.7	50.8	55.1	53.6

Figure 1. HDD shipments from Seagate and Western Digital.

Source of this and the following graphics: Aggregated Data from Seagate Technologies and Western Digital earnings calls, April 2014.

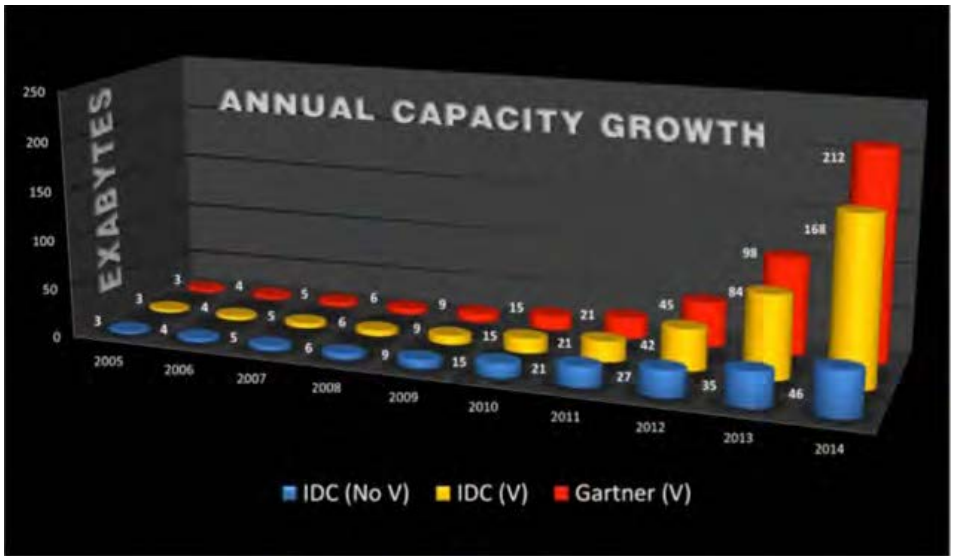

Figure 2. In 2011, IDC projected annual capacity growth demand to accelerate at about 40 percent per year through 2014, taking capacity requirements from 21 exabytes in 2010 to 46 exabytes in 2014.

capacity shipments quite sufficient to meet both IDC's original capacity demand growth estimates (about 40 percent per year; see Fig. 2) and their revised estimates from last summer covering the impact of server virtualization (about 300 percent per year; see Figs. 3, 4).

We are talking serious growth in capacity shipments.

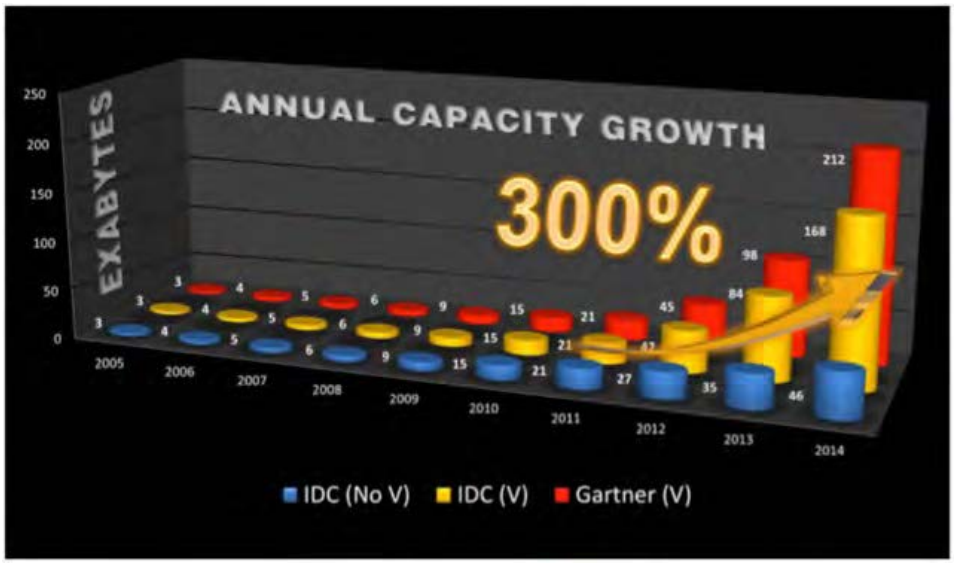

Figure 3. In summer 2013, IDC stated that in environments with virtual servers, capacity demand would increase to about 300 percent per year, resulting in 168 exabytes of capacity demand by 2014 (mostly driven by need to replicate data in DAS or server-side storage repositories behind every server that might host a given virtual machine and its workload).

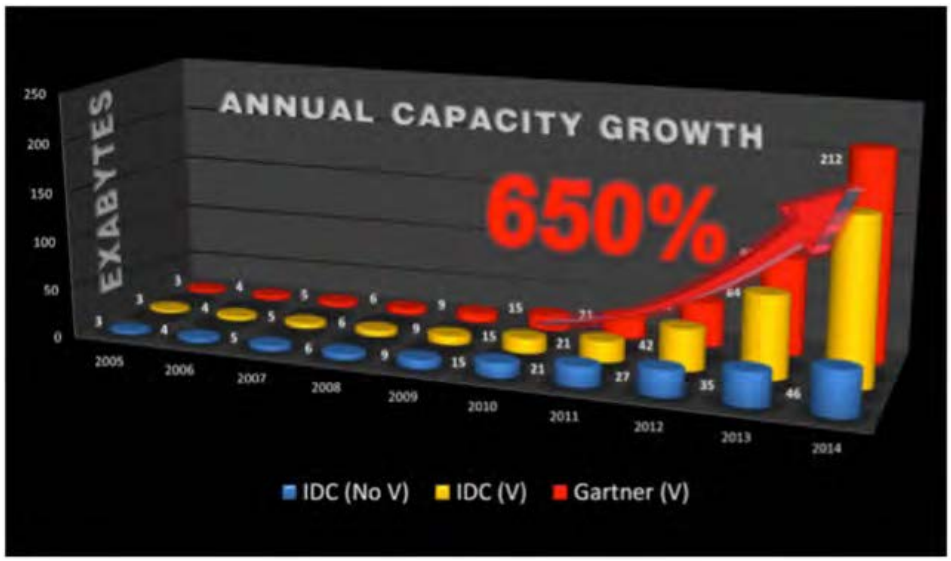

Figure 4. Also in 2013, Gartner revised its estimates to take into account the impact of server virtualization on storage capacity demand, forecasting a 650 percent growth in capacity demand through 2015, requiring 212 exabytes of external storage to hold all of the replicated, backed up, and remotely hosted bits.

So, if data is poised to grow, driving up capacity demand, why are array vendor revenues flat or declining? First, companies are seeking to keep their current equipment in play longer (5 to 7 years rather than 3 to 5 years) and many are sourcing warranty and maintenance from third parties rather than original equipment vendors, saving substantial cost.

When companies do set out to buy new gear, they brag that they have vendors over a proverbial barrel and have found many ways to shave points off of MSRP stickers. Sometimes, it is as easy as holding out until near the end of the vendor's fiscal quarter before placing an order, and playing hardball on pricing in order to get the deal you want from a sales rep desperate to make his (or her) quota. The buyer's market also helps to explain why sales volumes may not be as far off the mark as revenues.

When companies do set out to buy new gear, they brag that they have vendors over a proverbial barrel.

The same phenomenon seems to be playing out for flash memory-based storage, as well. A proliferation of VC-funded flash product vendors followed the high dollar acquisitions of Texas Memory Systems and a few others by more established hardware vendors a few years back. Now, there may well be too many vendors in the market, all pursuing cutthroat pricing and other gimmicks to obtain market share. It's a situation that may well cause an implosion in the near future. The "flash-is-destined-to-replace-disk" evangelists may be in line for an attitude readjustment if and when the "Great Implosion" occurs.

In the meantime, flash-with-disk seems to be a more sensible approach to gaining market share than a flash-replaces-disk play. Consider that two years ago, HP set a new disk array speed record, according to Storage Performance Council performance testing and measurement, by delivering in excess of 400,000 Inputs/Outputs per Second (IOPS) using its flagship array. Inside, the array operated roughly 1,900 disk drives in parallel (and consumed between 7 and 21 watts per disk) to accomplish this feat. A scant two months later, flash/HDD hybrid array maker X-IO used only about 264 disks and 100 solid state disks (SSDs) to achieve more than 600,000 IOPS. The acquisition and operating costs of the X-IO rigs were substantially lower than the HP 3PAR array, showing the benefits of "hybrid" flash plus disk" solutions from a performance and cost standpoint.

Today, it is possible to aggregate flash technology and disk technology and to use them together in different combinations, whether or not these cobbles were implemented by a vendor in a specific kit. Version 10 of DataCore Software's flagship storage virtualization software, SANsymphony-V, enables different types of storage, including flash and DRAM silicon storage, fast/low capacity disk, and slower/high capacity disk to be abstracted, pooled and allocated in an automated and fully manageable way. Users of SANsymphony-V don't need to rip and replace existing storage infrastructure with specialized server-side storage topologies in order to support VMware environments; with storage virtualization, these storage topologies can be built from virtual volumes that are presented to VMs and that move with them from physical host to physical host.

Software-defined storage advocates claim that they abstract away from commodity storage hardware all of the "value-add" software that vendors run on array controllers.

Unfortunately, DataCore confronts some serious market headwinds. For one thing, VMware and others are advancing a concept of "software-defined storage" that is intended to knock DataCore (and perhaps IBM with its SAN Volume Controller or SVC, another storage virtualization play) out of the box, together with legacy SANs and traditional disk.

Software-defined storage advocates claim that they abstract away from commodity storage hardware all of the "value-add" software that vendors run on array controllers and license to consumers to increase the cost of otherwise commodity arrays. With software-defined, these services are placed in a software abstraction layer from where they can be parsed out to applications for use with their storage, regardless of vendor brand.

Storage virtualization software, like DataCore's, or storage virtualization appliances like IBM's SVC, also provide service abstraction and aggregation into an "uber-controller." In a very real sense, they were the original software-defined storage technology. But, unlike the newfangled SDS products, storage virtualization engines also do something else: they aggregate storage capacity. The capacity of all virtualized storage targets is pooled together, usually into some sort of intelligent schema of pools organized by capacity or performance characteristics. When an application workload (whether physical or virtual) requires storage, the administrator can

quickly cobble together a virtual volume comprising a mix of silicon and fast disk resources (analogous to a hybrid storage array) for performance and capacity disk resources for long-term retention. This virtual volume is then presented to the requesting application.

Moreover, these virtual volumes can be provided with services ranging from thin provisioning to various data protection schemes (continuous data protection, snapshots, mirroring, synchronous and asynchronous replication, etc.) So, virtual volumes may be created "on the fly" to meet the access, availability and preservation requirements of the workload data.

It remains to be seen whether storage virtualization vendors will be able to use the gravity of VMware and other software-defined storage vendors to sling-shot themselves to a broader and more stable orbit around enterprise storage.

These virtual volumes can also transition from physical host to physical host while maintaining, transparently, all of the routing to physical storage devices in the back end. DataCore, for one, has some extraordinarily robust interconnect load balancing software to facilitate re-routing of storage device interconnects whether across SAS/SATA, Fibre Channel or Ethernet/iSCSI.

Still, a steady assault on the notion of virtualization, first by the array hardware vendors and now by the software-defined storage vendors—who don't "virtualize" physical storage resources; only services—have helped to constrain the penetration of storage virtualization technology to only about 16 percent of today's enterprise storage, according to research sponsored by infrastructure management technology vendor, Virtual Instruments. It remains to be seen whether storage virtualization vendors will be able to use the gravity of VMware and other software-defined storage vendors to sling-shot themselves to a broader and more stable orbit around enterprise storage.

While we are on the subject, Virtual Instruments is a storage infrastructure monitoring and management solutions provider that is also struggling to keep a toehold in storage. As previously mentioned, the failure of the industry to adopt common management standards (such as SNMP, SNIA's SMI-S or W3C's REST) that work across all array platforms means that storage infrastructure management is stuck somewhere between the black arts and the wild west.

To a small extent, companies like Virtual Instruments, as well as storage resource management (SRM) software firms including IBM Tivoli, Symantec, and a few others, continue to strive to solve the problem of a lack of coherent storage resource management using proprietary techniques and tools. The storage virtualization and software-defined storage vendors have figured out ways to collectivize and allocate storage services, but do nothing to monitor and assist in the proactive management of the underlying hardware and plumbing of storage. This disconnect threatens to destabilize storage infrastructure at any time, calling into question the stability of all applications that are built on top of this platform.

Storage 2014 is a hodge-podge of new and old technologies with vendors seeking to at least preserve market share through a multi-front battle of ideas and rhetoric.

So, in a nutshell, Storage 2014 is a hodge-podge of new and old technologies with vendors seeking to at least preserve market share through a multi-front battle of ideas and rhetoric—and in a very few number of cases, actual technological advances. It is an infrastruggle, intended to position certain concepts as visionary goals and to contextualize hardware and software products as the stepping stones for realizing those goals. In other words, things haven't changed a lot, despite the marketecture about transformation and evolution. VR

Jon Toigo is a 30-year veteran of IT, and the Managing Partner of Toigo Partners International, an IT industry watchdog and consumer advocacy. He is also the chairman of the Data Management Institute, which focuses on the development of data management as a professional discipline. Toigo has written 15 books on business and IT and published more than 3,000 articles in the technology trade press. He is currently working on several book projects, including The Infrastruggle (for which his blog at VirtualizationReview.com and this article is named).

A Brief History: Storage from the 1980s to the Present

Viewed as an evolutionary trek from isolated islands of data storage to shared storage architecture, the key milestones of contemporary storage for distributed computing environments are relatively easy to identify (see Fig. A). While the IBM RAMAC drive is often identified as the breakthrough in random access near line storage, following its debut in the late 1950s, disk technology really took off in distributed computing environments with the introduction of 5.25 inch drives (from Seagate in 1983), enabling internal server storage, and the introduction of RAID in 1987, which enabled collection of disks to be used together as a single volume.

Early on, there was a bifurcation in storage architecture, with some vendors focused on file storage and others focused on block storage. (In fact, all storage is block storage, but no one talked about that.) The file server with disk-based file systems evolved into an appliance in which the controller was essentially a "thin" server to which external and usually RAIDed-disk was directly attached.

Block storage took another path. First, internal disk evolved into direct-attached RAID arrays for reasons of performance and capacity. Next, multi-ported controllers with multiple caches were added to arrays to enable their sharing among multiple servers.

In 1997, Digital Equipment Corporation developers (shortly following the acquisition of DEC by COMPAQ Computer Corporation) published a concept paper describing a method for interconnecting multiple shared arrays into a

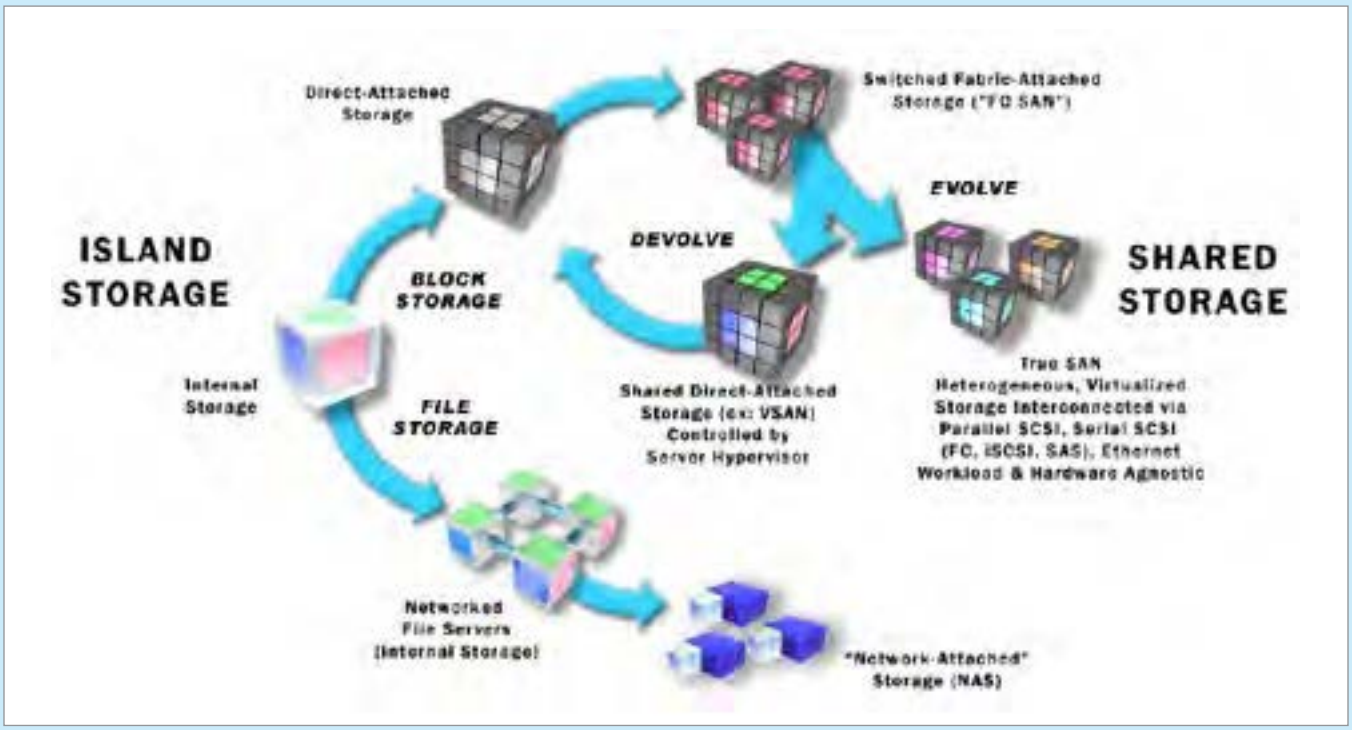

Figure 1. Storage milestones over the decade – IBM introduced its RAMAC drives in the late 1950s, but it wasn't until the 1980s that disk storage technologies and capacities truly took off.

A Brief History: Storage from the 1980s to the Present *(Continued)*

network to enable the connection of even more storage equipment without a loss of performance. This Enterprise Network Storage Architecture (ENSA) became the foundation of the Fibre Channel Fabric, called a SAN despite the fact that FC created a fabric rather than a true network in the accepted definition of the term.

NAS for files and SANs for block data became the primary options for enterprise data storage from the late 1990s until the present day. However, technology advances and management problems have dovetailed to drive the storage narrative in interesting ways for the past five years or so.

One technology advance was storage virtualization, basically a set of methods for aggregating the capacity of heterogeneous FC, iSCSI and SAS/SATA-attached storage arrays into a common pool. Widely viewed as a fulfillment of the original ENSA vision, this pooled storage resource makes block storage capable of rapid allocation as "virtual storage volumes" that may be assigned to specific server workloads and their data or deployed simply as universal storage tiers representing different performance characteristics and price points.

With the advent of storage virtualization, distributed storage appeared to be on the threshold of commoditization. The name on the storage array product no longer mattered, since all storage was simply included in a storage pool. Moreover, value-add software used by vendors to discriminate (and increase the cost of) their products from those of their competitors was usurped by the storage virtualization software layer, with this abstraction layer providing value-added services on demand to any virtual volume that required them.

Hardware vendors were generally unsupportive of the commoditization of their hardware via storage virtualization. Some created virtualization schemes of their own that commoditized competitor gear, or embraced an alternative concept of virtualization that they called software-defined storage. The main difference between software-defined and virtualized storage is that the former does not aggregate the capacity of attached storage. Software-defined storage, like storage virtualization, does provide a location in a software abstraction layer where some value-added services are aggregated and applied selectively to storage volumes.

Storage architectures like VMware's vSAN are conceived as "server-side" software-defined storage plays. They are appropriately viewed in the evolutionary framework in Fig. A as a "devolutionary" rather than an evolutionary development in storage architecture, returning to a model of shared direct-attached storage that visionaries have been trying to put in the rear view mirror for over a decade. While the argument can be made that FC fabrics are also direct-attached shared storage, virtualized SANs are much closer to the original ENSA vision and a worthy evolutionary target.

The key difference at present between server-side software defined storage and virtualized SANs is that the latter is both storage hardware and workload agnostic (it works with all brands of storage hardware and with all workload, whether virtualized or not and irrespective of the hypervisor used on the server). This "Swiss army knife" approach enables virtualized storage to meet the needs of the broadest range of enterprise IT storage requirements. By contrast, current generation server-side software-defined storage leaves proprietary hardware vendors in control of their own storage kits and work to provide storage services only to those storage devices that are under control of the server hypervisor with the software-defined storage layer. — *JT*

Tape's Renaissance

Magnetic tape, which recently enjoyed its 60th anniversary as a data storage medium, is currently enjoying a renaissance in many data centers. Innovations in tape technology provide a partial explanation, but so do mounting issues of data volume and storage cost.

Tape technology has managed to hold its own in the storage market, despite the pronouncements of many analyst doomsayers over the years, mostly by co-opting disk technologies. Tape has followed the lead of disk by borrowing disk tech such as gigantic magneto-resistive read/write heads and partial response maximum likelihood (PRML) signal conversion methods, both of which enable data bits to be stored on smaller amounts of media coating while remaining capable of proper signal detection.

It was believed that this pattern of advancement had ended when perpendicular magnetic recording (PMR) was introduced in hard disk drives some 35 years after its discovery by Shun-ichi Iwasaki at the Tohoku University in Japan in 1982, enabling a huge leap forward in recording density. PMR required a rigid surface that tape, by its nature, could not provide. So, as disk jumped from hundreds of gigabytes in capacity to terabytes courtesy of PMR, tape lagged behind.

However, in 2010, FUJIFILM applied a new media coating based on Barium Ferrite (BaFe) rather than metal particles coated to prevent oxidation. Since BaFe particles didn't require the additional coating, a significant reduction in particle size for holding data bits was enabled, increasing bit density. BaFe particles are also hexagonal disc-shapped and allow for perpendicular recording by virtue of particle structure. IBM and FUJIFILM demonstrated a BaFe tape cartridge, using the dimensions and tape length of a standard LTO cartridge, that provided 35 TB of storage without compression. Subsequent tests demonstrated uncompressed capacities in excess of 40TB.

To date, Oracle was first to use BaFe media and have produced an industry leading 8.5 TB enterprise cartridge. IBM and the LTO manufacturers have also brought large capacity tape into the market using the capacity enabling coating technology. Tape watchers claim that we are about 18 months away from seeing the BaFe II tape media with the dramatically larger densities.

But that isn't holding things up. Another innovation, not in media, drive or robotics technology, but in media formatting, has entered the market and created a groundswell of interest. The Linear Tape File System (LTFS), introduced by IBM in 2011, provided the means to apply a file system structure to tape media and enabled tape to become a production storage medium once again expecially for "long block" files such as broadcast video, human genome data, satellite telemetry, surveillance video, and geophysical testing and mapping data.

LTFS, which is now available in three "flavors" – single drive, library edition and enterprise edition, works with tape drive technologies that allow media partitioning (LTO 5 or better, and current generation Oracle and IBM tape). The LTFS software can be downloaded from IBM (or for free from the LTO consortium in the case of single drive edition), then easily deployed to servers running Linux, Apple, or Windows operating systems. On the server, LTFS integrates with the server file system and provides the necessary functionality to write metadata and data to tape partitions. The metadata partition signals the start point of the file on tape and stores data about the file, while the data partition contains the file data

Tape's Renaissance *(Continued)*

itself. The barcode used to identify the tape cartridge serves as a "file folder" name in a standard display of server storage.

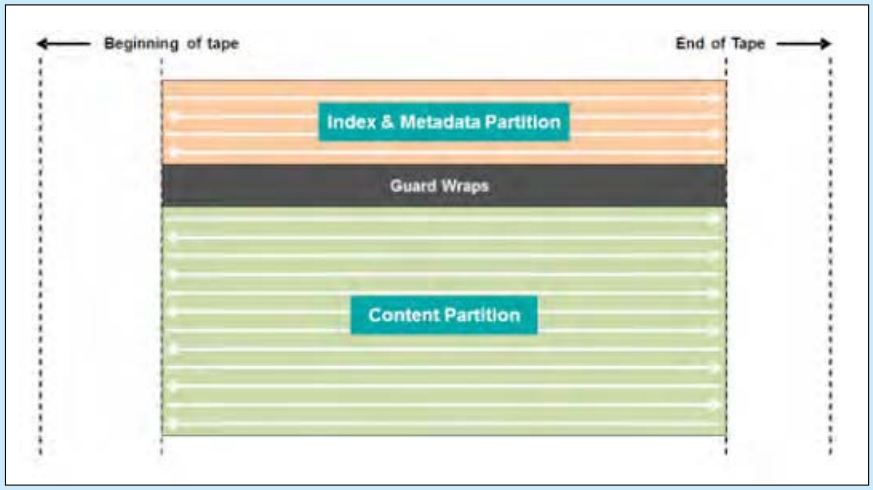

Figure 1

The advent of the free-of-charge single drive edition of LTFS sent many tape vendors scrambling to develop pre-engineered LTFS servers for sale to companies that lacked the time or resources to build their own. A premiere provider of LTFS head technology is Crossroads Systems, whose StrongBox appliance had previously been used to stage tape library management software. Two innovations by Crossroads Systems that were engineered by IBM into later versions of LTFS software included a capability to rename the user unfriendly file folder name from the cartridge identifier bar code to a more intelligible moniker (i.e. "Accounting Files 2012"), and a means to cache a part of each file stored to tape on server disk. That way, the server could begin shipping a requested file across a network while the back end tape library took the necessary time – between 20 ms and two minutes, depending on the size of the library – to find the cartridge containing the requested file, to place it into a drive and to spin the drive up to the start point of the requested file.

That bit of "spoofing" to insulate the user from the "world wide wait" of LTFS file access speed made the technology the darling, especially, of the media and entertainment sector, which produces long block files (videos) that are occasionally requested for playback, but are

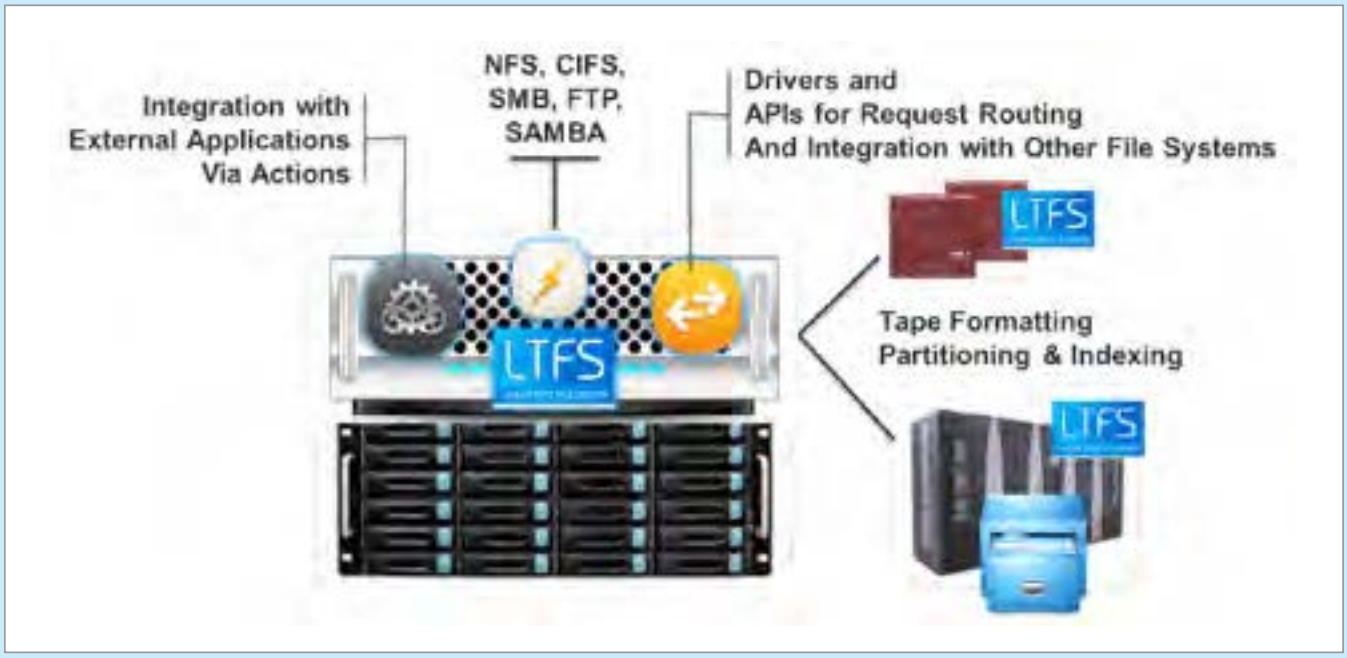

Figure 2

Tape's Renaissance *(Continued)*

seldom if ever modified. Access to the contents of the LTFS repository is generally made in the same manner as access to any network file server—via NFS or CIFS/SMB or HTTP or FTP; the key difference is that the LTFS filestore, which uses tape instead of disk, is capable of storing hundreds of petabytes of data on only a few raised floor tiles while consuming only a few light bulbs of electricity.

In 2013, after several LTFS appliance products had entered the market, tape technology vendor Spectra Logic took another tangent on LTFS. Noting the proliferation of small block files, particularly in web services, and looking at the developments in the cloud storage space, especially the advent of object storage, the vendor took the initiative to combine an object content storage paradigm with LTFS file storage, creating the Black Pearl server. Black Pearl takes objects directly from client application workflow and copies them to disk at the server, where the objects are indexed and stored into object "buckets". The buckets themselves are long block files and can be written effectively to LTFS storage on a Spectra Logic library behind the server. The resulting combination of object storage and tape file storage technology is enjoying a growing number of participating software clients.

The combination of improved tape capacities and new mechanisms for making tape storage usable in the context of contemporary computing are helping to drive a tape renaissance. But, these technological improvements may ultimately have less to do with the continued success of tape than simple economics. Independent studies released last year by INSIC and the Clipper Group looked at the comparative costs of tape and disk-based archives. Disk was found to be 500 times more expensive than tape as an archive medium based on energy costs alone.

From the standpoint of its use as a backup medium, tape continues to labor under the impression that the storage medium is to blame for performance issues that have more to do with backup software itself. Among other advantages, LTFS may actually provide a solution to the woes of tape backup, enabling the replacement of backup software altogether with a simple "safety copy" file write to LTFS tape. Several vendors are said to be looking into this architecture and the term "flape" is beginning to be heard in storage conferences, referring to the use of flash memory storage as an initial data capture medium and the use of tape as a retention platform for file data whose re-reference and modification frequency characteristics have slowed significantly (usually the case within 30 days of file creation). Tape is also beginning to appear as a long term low cost file storage medium in cloud storage service providers such as Permivault and Deternity.

The runway ahead for tape is suddenly looking a lot longer than analysts previously thought. Watch this space. —*JT*

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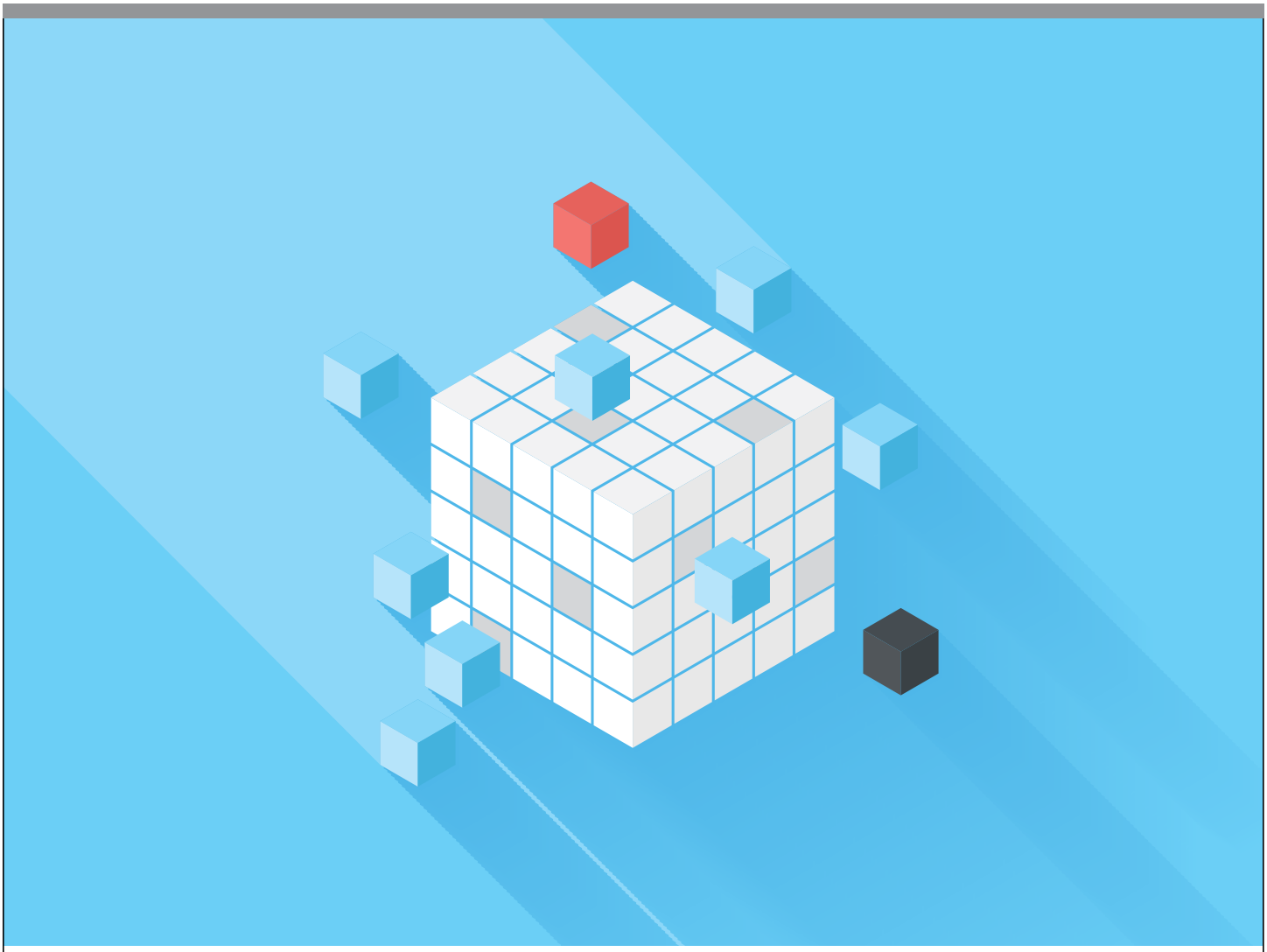


Do You Really Need Storage Management Software?

Local storage, virtualized storage, storage in the cloud. It's a mystery as to how you know what you have available on your sprawled-out systems. That's where storage management solutions come to the rescue. By Brien M. Posey

There's been something of a debate as to the importance of storage management software. Some claim that it's by far the most important piece of an organization's storage infrastructure. Others claim that storage management software really isn't all that important, and you can get by without it. Given that this topic has been the subject of such spirited debate, I wanted to chime in on its importance and as I do, I will talk about some key features to look for, and I will talk about some of the features that you probably don't need.

Storage Management, At Its Essence

For those who might not be completely familiar with the concept of storage management software, it's a general term for a management application that helps manage and monitor all of the storage an organization is using. There are a number of different storage management vendors, and each vendor, obviously, has its own feature set. However, there are two basic capabilities that are more or less universal.

The single greatest disadvantage to storage management software is that when you invest in it you might be paying for capabilities that you already have.

The first of these capabilities is unified storage management. Manually managing a few storage arrays is typically no big deal. However, keeping track of numerous arrays is a different story. Storage management software generally allows you to view all of your storage arrays through a single interface.

The second capability most vendors offer is storage reporting. The reporting engines vary widely from one vendor to the next, but, typically, the reporting software will show you the amount of free space on each array, which arrays are receiving the highest level of read and write IOPS, and which—if any—arrays are experiencing health problems.

Keep in mind these are the most basic storage management software capabilities. Many vendors offer feature sets that go well beyond the basics.

Hardware Considerations

The single greatest disadvantage to storage management software is that when you invest in it you might be paying for capabilities you already have. Some vendors offer storage management products with feature sets that are very similar to those that are built into most modern storage hardware appliances. For example, some

products offer storage deduplication as a feature, but most modern storage arrays offer hardware-level deduplication.

Obviously, when you're speaking in generalities as I am in this article, there are few absolute truths. In most cases, however, if a feature is supported both at the hardware level and at the management software level, you're going to be better off using the feature at the hardware level.

Take storage deduplication, for example. If a storage appliance is capable of performing native storage deduplication, then the appliance probably has a CPU that's dedicated to the task of data deduplication. Because deduplication is being performed at the hardware level, you don't have to worry about burdening your servers by making them perform deduplication.

If a storage appliance is capable of performing native storage deduplication, then the appliance probably has a CPU that's dedicated to the task of data deduplication.

Another argument to using hardware-level features whenever possible is that doing so makes it easier to get technical support. Imagine the vendor finger pointing that could occur in a support situation if your storage appliance natively supports deduplication, but you chose to allow the storage management software to handle the deduplication process instead.

While these are compelling reasons for performing deduplication at the hardware level whenever possible, there are a couple of important things to remember. First, I'm only using deduplication as an example. There are many other features that sometimes exist at the hardware level and as a storage management software feature. Second, there are no absolutes. Sometimes there are situations that make it more prudent to use a feature at the software level rather than enabling the feature at the hardware level.

To show you what I mean, let's go back to my earlier example of deduplication being performed either at the hardware or at the software level. Hardware-based deduplication has the advantage of offloading the deduplication workload from production servers (among other things). The disadvantage, however, is that the deduplication process doesn't occur until the data reaches the storage appliance (or possibly even after the data has been written if post process deduplication is being used). That's all well and good, unless network bandwidth is a big limiting factor. If your servers and your storage are separated by a low bandwidth link, then you're

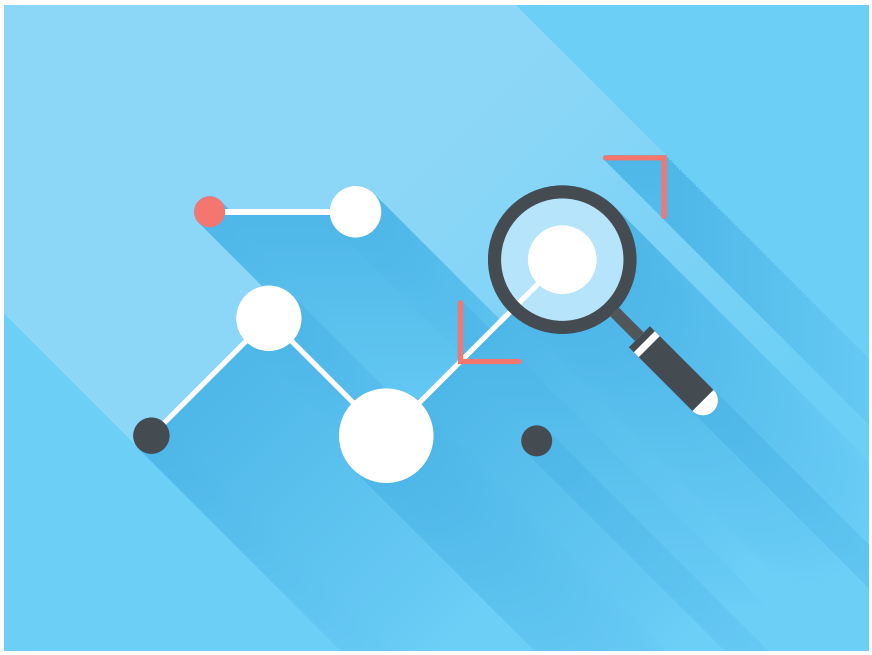
probably going to be better off performing server-side deduplication so that you can minimize the amount of data flowing across the network connection.

It's worth noting that some vendors also support a global deduplication plan in which data is deduplicated at the server side, and then a second round of deduplication occurs on the storage appliance as a way of eliminating cross-server redundancy (such as eliminating system files that exist on multiple servers).

Keying in on Features

It's worth noting that some vendors also support a global deduplication plan.

So now that I've spent a bit of time debating whether redundant features should be enabled at the hardware or the software level, I'll go back and talk about some key storage management software capabilities. In doing so, I want to talk about some of the more beneficial features that you should look for in a storage management application, and why those features are important.



Unified Management Console

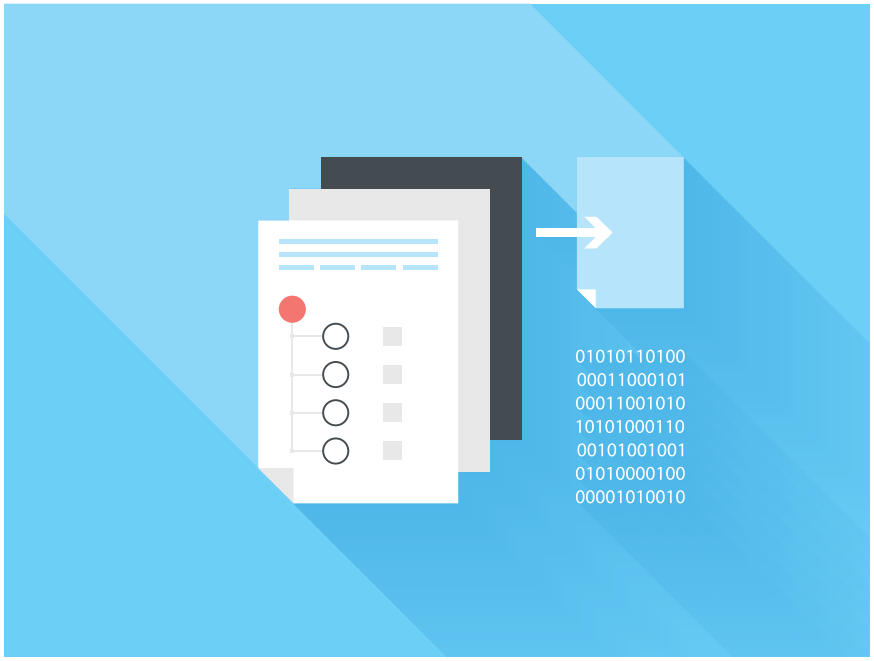
As previously mentioned, one of the key features of almost any storage management application is a unified management console that allows the administrator to see all of the storage hardware through a single pane of glass. Why is this feature important?

On small networks, it might not be. Such a feature might be convenient, but not essential. After all, centralized management delivers the greatest benefit when there are too many storage devices present for them to be managed manually.

So what about large networks? Some organizations might already have centralized storage management without having to invest in a third-party utility because some storage vendors provide storage management tools that can manage multiple storage devices.

Large organizations are likely to see the biggest benefit from a unified storage management console when they use heterogeneous storage. The management utilities provided by the storage vendors are nice, but more often than not they're vendor-specific. If you use storage devices of varying makes and models then a third-party, unified storage management console will probably be beneficial to you.

Large organizations are likely to see the biggest benefit from a unified storage management console when they use heterogeneous storage.



Reporting and Alerting

As previously mentioned, the reporting mechanism is another storage management feature worth considering. The utilities provided by storage vendors typically offer reporting functions and they might even offer some alerting capabilities. In my opinion, in order for a third-party storage management utility to be worth the price, it must have reporting and alerting capabilities that go beyond those provided by the storage vendors.

When it comes to a storage management utility's reporting capabilities, it's extremely important to make sure the reports that can be generated are actually useful to you. Over the years I've seen software vendors design products capable of generating an insane number of reports. Oftentimes I've found that when a vendor boasts about the sheer number of reports its product can produce, many of the reports aren't anything useful in real-world situations. Such reports are seemingly included only to make the product's reporting capabilities sound impressive.

In some cases, having a product that includes an excessive number of report templates can be counter-productive. Personally, I've used products that included so many report templates it became difficult to find the report template I wanted to use.

Ideally, a good storage management application should also be able to monitor your storage connectivity.

What types of reports should a good storage management product be able to deliver? Obviously, the product should be able to tell you how much space is free and how much space has been consumed on each array. You should ideally be able to view these figures in gigabytes or as a percentage (37 percent capacity remaining), and you should be able to retrieve this type of information for every storage device in your organization.

In order to be useful, the reporting engine should also be able to track storage consumption on a per-array basis, and should be able to warn you of potential shortages well in advance. Similarly, the software should help you track down any free LUNs within your organization so you can reclaim that capacity.

Although a storage management application should be able to assist an administrator with long-term growth and capacity planning, it should also be able to assist with ensuring reliability and performance. For instance, the reporting engine should be able to identify the busiest arrays or the busiest LUNs and help track down excessively high levels of resource contention in virtual server environments.

Ideally, a good storage management application should also be able to monitor your storage connectivity. By doing so, the software can tell you which links are being over-saturated, which ones are being under-utilized and how you might be able to move things around to achieve better overall performance.

As I mentioned earlier, any storage management tool should be able to generate alerts to tell you when a LUN is getting low on space. However, "low on space" is a relative term. Some administrators might want to know when a LUN is down to 30 percent of its original capacity, while others might not want to be notified until only 10 percent of the space remains. As such, notification thresholds need to be customizable.

In addition, a good storage management utility shouldn't lock an administrator into a preset collection of rules and alerts. The software should give administrators the tools to build their own rules to go along with or to replace the built-in rules. Furthermore, the rule templates need to provide granularity. Granular rules might, for example, allow an administrator to more closely monitor storage that's used by a mission-critical application.

A good storage management utility shouldn't lock an administrator into a preset collection of rules and alerts.

Before I move on, there's one last capability I want to discuss. A good reporting engine should not only be able to tell you how much space you're using, but also how that space is being consumed. An administrator should never have to look at a disk and wonder where their space went. The storage management product should be able to tell them which users are consuming the most disk space, which data is consuming the most space, and what data was most recently added. Such reporting is relatively common for file server data, but some storage monitoring products are application-aware and can provide usage data for application databases.

Provisioning and Performance

While some storage management products act primarily as monitoring and reporting tools, others actually include storage-provisioning capabilities. There are storage management tools that will allow you to build a LUN on raw storage space, or even create a virtual hard disk.

Some of these tools take things a step further by offering features and capabilities designed to improve storage performance and reliability. I talked about deduplication features earlier, but deduplication is only one such feature.

Some storage management products are able to create storage tiers that dynamically move storage blocks based on the current business need.

Another example of a way some storage management products are able to improve performance is by taking control of storage routing. Some products are able to detect the connectivity paths that exist between a server and its storage and intelligently route storage traffic along the most efficient path based on the current utilization of each segment. Similarly, such products may offer multi-path I/O capabilities, which allow a server to take advantage of redundant links in order to improve overall data throughput.

Although such features are no doubt useful, they must be implemented with caution. I once saw an improperly configured system on which the hardware and the software both thought they were controlling storage traffic. The result was glacially slow performance and a lot of dropped packets. This was one of those situations in which an administrator needed to make a conscious decision as to whether routing should be handled by the hardware or by the software.

Some storage management products are able to create storage tiers that dynamically move storage blocks based on the current business need, in an effort to deliver the best possible performance. Obviously, each vendor does things a little bit differently, but the basic idea is that the storage management software keeps track of how frequently each storage block is read. If the system determines a block is in high demand, then the block will be automatically and transparently moved to solid-state storage so the block can be read at the highest speed possible.

Automatic storage tiering is another feature an organization might be able to take advantage of without purchasing storage

management software. Windows Server 2012 R2 has a built-in storage tiering feature that works in a manner that's very similar to what I just described. Similarly, some of the storage array vendors offer this type of functionality at the hardware level either through solid-state storage or through memory caching.

Although some of the features I've discussed might exist in your server OS or in your storage hardware, it's possible that storage monitoring software might do a better job of combining some features than what you might get if you were to use a piecemeal solution. Let me give you an example.

Small organizations can probably get by just fine without a storage management product.

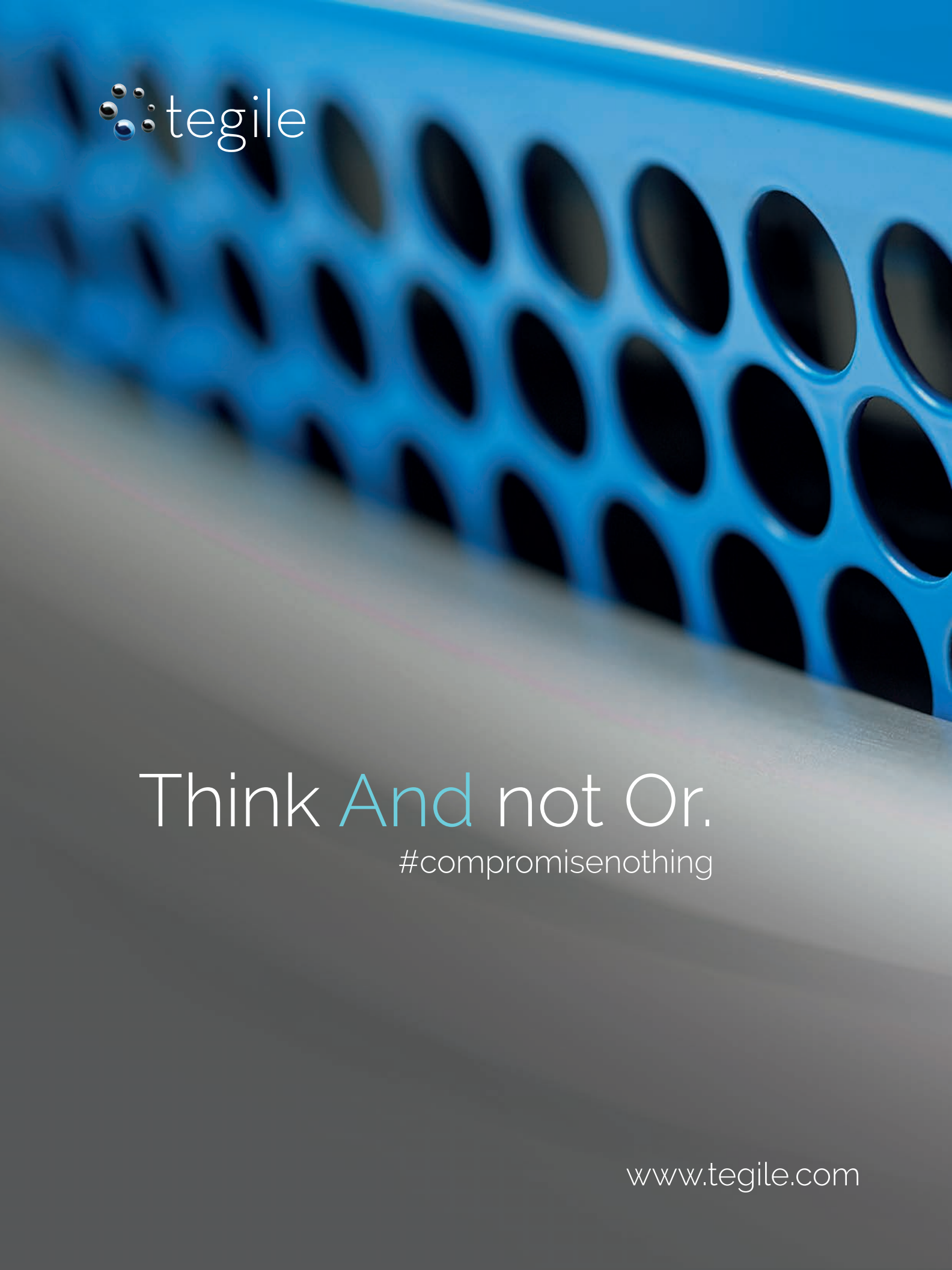
Earlier I discussed the deduplication feature. Although there are numerous variations, deduplication is typically based on the removal of redundant storage blocks. As such, some files will end up sharing a common copy of a storage block.

Now, imagine you also decided to enable a storage tiering feature that automatically moves frequently accessed blocks to solid-state storage. If one particular block is shared by multiple files, then that block might be used more often than some of the other blocks. By moving these shared blocks to solid-state storage, the system could potentially improve the access time for several files at once. This is what I mean when I say some product features might work especially well when used in conjunction with one another.

Back to the Top

I'd like to wrap things up by going back to my original question: Should you consider investing in third-party storage management software, or is it OK to continue using your existing solution?

Small organizations can probably get by just fine without a storage management product. Similarly, large organizations that use storage hardware provided by a common vendor might be better off using the vendor's own storage management tools rather than relying on third-party tools. This is because the hardware vendor tools are going to be optimized for use with its own hardware and might even expose features that a third-party management solution would not. But for midsize too large organizations with storage products from multiple vendors, a good storage management product would probably make the administrator's life much easier. VR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STORAGE: Virtualized vs. Software-Defined

Is there a difference between these two seemingly similar storage concepts? Yes, and it has to do with how that storage is managed. By Brien M. Posey

One of the things I've learned in the decades I've worked in IT is that IT has more buzzwords than just about any other industry. Sometimes these buzzwords get so overhyped and misused that they become almost meaningless. Take the term cloud as an example. A cloud used to refer to a service running on the Internet. Today, it's possible to have multiple private clouds running in your own datacenter. The term has become so ambiguous that I even heard a radio commercial for a Canadian car dealership in which Bluetooth smartphone connectivity was being referred to as cloud technology.

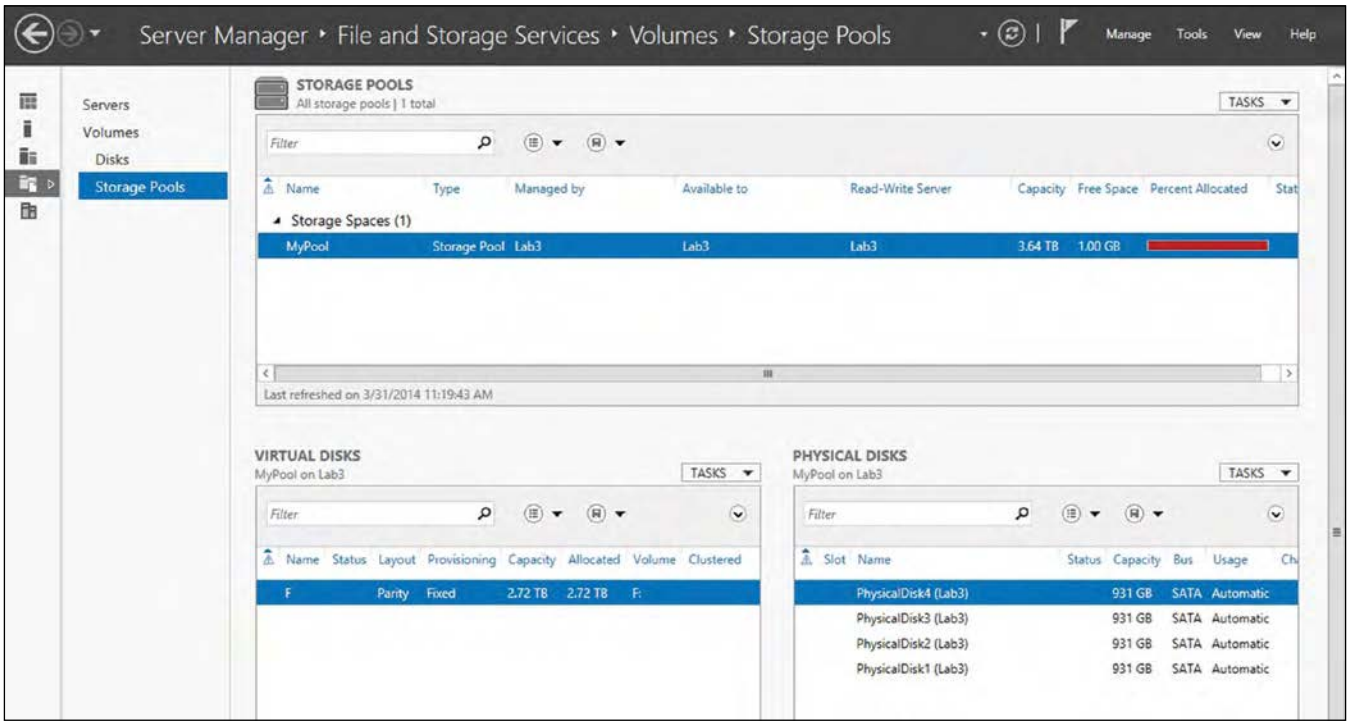

Figure 1. A storage pool is a collection of physical drives.

Another ambiguous IT buzzword (or buzz phrase) is Big Data. Most often it seems to refer to large sets of unstructured data, but I've had people tell me the definition is incorrect and that Big Data refers solely to compressed video files.

Certainly, cloud and Big Data aren't the first IT buzzwords to be overhyped, misused and abused, nor will they be the last. Right now the buzz phrase of the moment seems to be software-defined. As far as I can tell, VMware Inc. kick-started the overuse of this phrase a couple of years ago with its software-defined datacenter concept, but the software-defined trend has rapidly proliferated to other vendors and technologies.

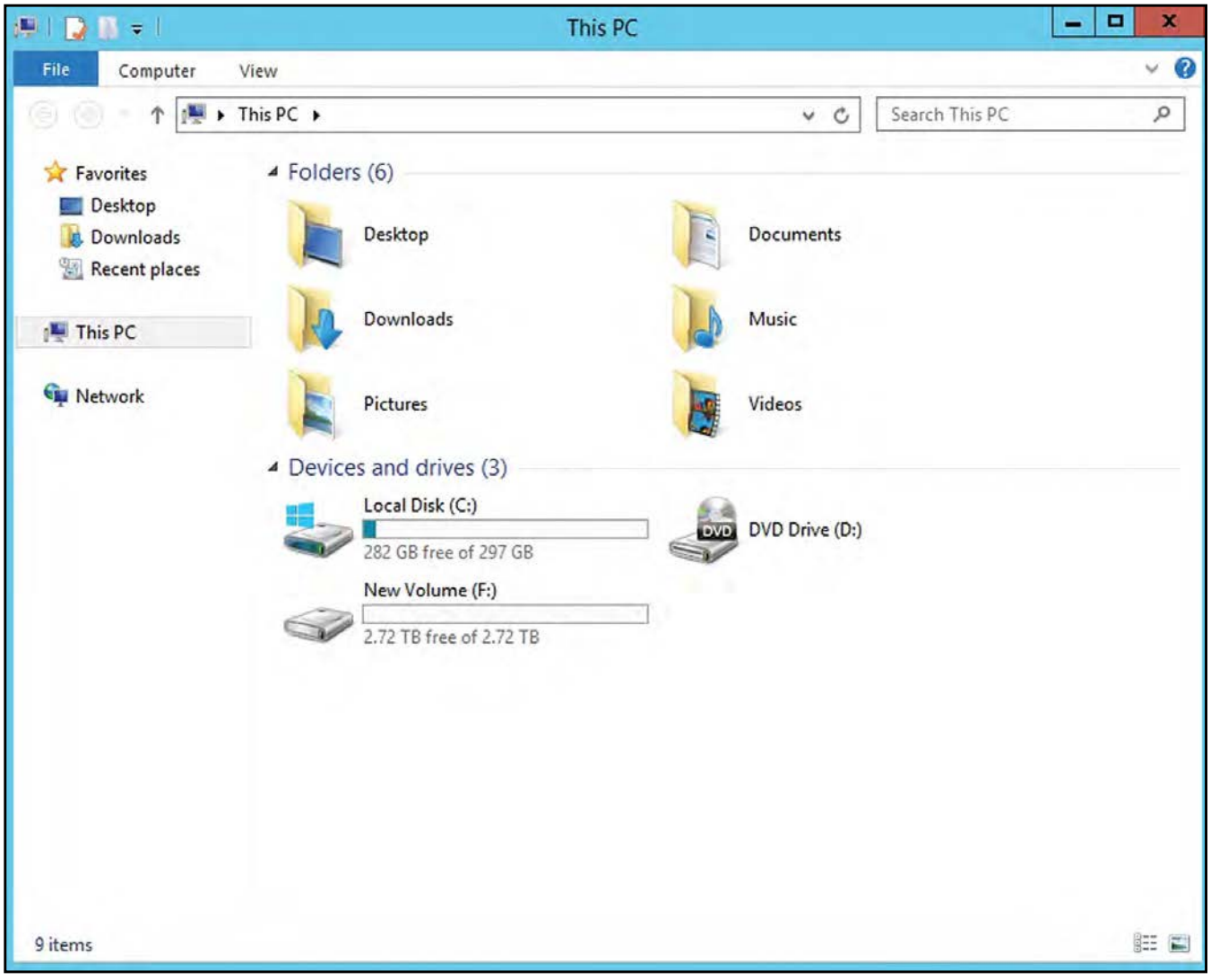

Figure 2. Windows Explorer doesn't differentiate between physical and virtual storage.

I don't want to get off on a rant, but like so many other buzzwords and buzz phrases, there's a fair amount of confusion about the software-defined trend, especially when it comes to software-defined storage. The phrase itself, software-defined storage (often shortened to SDS), seems to have a number of different (and sometimes almost contradictory) meanings. So what is SDS, and how does it differ from storage virtualization?

I think the best way to answer this question is to take an objective look at storage virtualization, and what it entails. After all, storage virtualization is a well-defined term with a meaning that seems to be generally accepted. After a crash course in storage virtualization, I will talk about SDS and how it might differ from storage virtualization.

Storage virtualization typically refers to storage abstraction.

First, What Storage Virtualization Is

Storage virtualization typically refers to storage abstraction. In other words, there's a software layer sitting between the server (usually a VM, but not always), and this software layer provides the server with a different view of the underlying storage than what actually exists in the physical world. This allows the full storage capacity to be combined or sub divided on an as-needed basis.

Suppose, for example, that a physical host contained five 1TB drives. A storage virtualization component might make it appear as though the host contains a single 5TB volume, rather than five separate disks.

OK, I realize some of you are screaming, "Come on Posey. You don't need software-defined storage for that. You can accomplish the same thing with a RAID controller." This is very true. A RAID controller can be used to manipulate disks so they appear as one. Keep in mind, however, that disk consolidation is really only one example of how storage virtualization can be used.

Before I get into a discussion of some of the other things that can be done with storage virtualization, I want to point out that storage virtualization and RAID controllers can sometimes be at odds with one another. Typically, the job of storage virtualization is to create a pool of physical resources that can be used on an as-needed basis, with tremendous flexibility. A RAID controller, on the other hand, links disks together at the hardware level.

Recently, VMware released a new Virtual SAN (vSAN) feature. In spite of the feature's name, the vSAN feature is really a storage virtualization feature. What's interesting about it is that VMware recommends RAID controllers be configured to provide JBOD storage so that the vSAN can control each disk independently, as opposed to provisioning storage at the hardware RAID level.

To give you a more concrete example of how storage virtualization works, think about how Microsoft has implemented storage virtualization in Windows Server 2012 R2. Windows Server 2012 R2 provides storage virtualization support, even without Hyper-V being installed.

To give you a more concrete example of how storage virtualization works, think about how Microsoft has implemented storage virtualization in Windows Server 2012 R2.

The Windows Server 2012 R2 storage virtualization feature is exposed through the Server Manager. You can access it by clicking on File and Storage Services, followed by Storage Pools. Incidentally, the File and Storage Services role is installed by default when you deploy Windows Server 2012 R2.

The Storage Spaces container allows you to create a collection of storage pools. A storage pool is really nothing more than a logical grouping of physical storage devices. For example, if you look at Figure 1 (p. 22), you can see I've created a storage pool called MyPool. This pool contains four physical drives.

There are a few things worth paying attention to in the figure. First, even though the screen capture only contains a single storage pool, Windows allows you to create multiple storage pools. You can create different pools for different purposes. For instance, you might create a pool of high-speed disks for use with applications that require a high rate of disk I/O. Similarly, you could create a pool of commodity storage for use in situations where a lot of capacity is needed, but not a lot of performance.

It's also important to keep in mind each physical disk can only belong to a single storage pool. In the case of the server shown, I would not be able to create another storage pool because all of the disks within the server have already been assigned to the existing storage pool.

Something else I want to point out in Figure 1 is that the disks installed in the system match one another. Even so, it doesn't have to

be this way. You can mix and match disks of different sizes and different capabilities within a storage pool. In fact, it's quite common for a single storage pool to contain a combination of traditional hard disks and solid-state disks. I'll talk more about that later.

The reason why you can mix and match disks of various capacities within a single storage pool is because of the way the Windows OS uses the disks. Remember, Windows Storage Spaces is a storage virtualization feature. This means with the exception of some relatively obscure Windows PowerShell cmdlets, this is the only place in the entire OS where the raw physical disks are exposed (unless you choose not to include the disks in a storage pool, then they're visible throughout the system).

Let me say right off the bat that SDS sometimes refers to storage virtualization. The two terms are often used interchangeably. Even though storage virtualization tends to have a fairly narrow definition, SDS does not.

Rather than making direct use of the disks included within the storage pool, Windows requires the administrator to create virtual disks on top of the storage pool. It's the virtual disks that serve as a layer of abstraction between the physical storage and the rest of the OS.

Throughout much of their history, Windows virtual disks have been associated with VMs. Even though there's a way to associate a virtual disk with a Hyper-V VM, the virtual disks created through Windows Storage Spaces aren't specifically intended for use with VMs. In fact, if you look at Figure 1, you'll notice a drive letter has been assigned to the existing virtual disk. If you open Windows Explorer, you'll see that this virtual disk is treated as a physical disk by the rest of the OS. It's very difficult to tell the difference between a virtual disk and a physical disk outside the interface shown.

To show you what I mean, take a look at Figure 2 (p. 24). Here, Windows Explorer displays all of the disks within the system. Windows Explorer makes no distinction between physical and virtual disks. In the figure, disk C: is a physical disk and F: is a virtual disk, and yet they look and behave similarly to one another.

So, why does Windows use virtual disks? As the figures show, Windows allows you to combine the capacity of multiple physical hard disks into a single virtual hard disk (or into a collection of virtual hard disks). There's more to it than that, however. When you create a virtual hard disk through the interface shown in Figure 1, you're able to define the virtual hard disk structure at the software

level. Windows allows you to create virtual disks that use underlying stripe sets, two-way mirrors, three-way mirrors or parity sets. When you create a virtual disk, Windows provides options for the underlying virtual disk structure based on the disks present within the storage pool. For example, if the storage pool contains only two physical disks, then you obviously wouldn't be able to create a parity set, but you could create a two-way mirror.

Similarly, if a storage pool contains three disks of varying capacities, then it would be possible to create a parity set, but the size of the parity set would be limited by the size of the smallest disk within the storage pool. The remaining capacity on the larger disks wouldn't be wasted, however. You could create additional virtual hard disks within the remaining capacity.

Tiered storage automatically places the most frequently read storage blocks on solid-state storage so that those blocks can be read with maximum efficiency.

Earlier I mentioned that storage pools can contain a mixture of traditional and solid-state hard disks. The reason why Microsoft allows you to do this is because Windows Server 2012 R2 supports the creation of storage tiers. Tiered storage automatically places the most frequently read storage blocks on solid-state storage so that those blocks can be read with maximum efficiency. Less-frequently accessed blocks remain on traditional storage. Storage tiers also reserve a portion of the solid-state storage capacity for use as a write-back cache. The write back cache smoothes out write operations by allowing data to be first written to high-speed storage, and then copied to the slower, but higher capacity storage when the I/O load decreases.

What Makes Software-Defined Storage So Special?

Now that I've spent a considerable amount of time talking about storage virtualization, let's talk about SDS. Let me say right off the bat that SDS sometimes refers to storage virtualization. The two terms are often used interchangeably. Even though storage virtualization tends to have a fairly narrow definition, SDS does not. The term has been used to describe a wide variety of approaches to storage management.

I'm not even going to try to delve into an exhaustive and fully comprehensive list of every technology that has been referred to as SDS. There are so many different ways the term has been used that I think building a comprehensive list would probably be a futile effort. Even so, I want to tell you about some of the more common ways the term has been used.

Although I personally disagree with this one, I've heard the term SDS used to refer to virtual disks or to VMware virtual disk volumes. I'm assuming the basis behind this is that virtual disks do create a layer of abstraction between a physical or a virtual server and the underlying physical storage. Even so, referring to a virtual disk as SDS seems like a bit of a stretch.

Another usage for the term SDS is that it sometimes applies to clustered file systems. At first, this one might seem a little bit counter-intuitive because it doesn't really have much to do with virtualization in the traditional sense, and yet this definition still somehow seems more plausible than simply referring to a standard virtual disk as SDS.

Another usage for the term SDS is that it sometimes applies to clustered file systems.

The basis behind a clustered file system is that technologies such as the Microsoft Distributed File System (DFS) present users with a completely different view of a file system than what exists in the physical world. The view the user sees might include files and folders scattered across a variety of resources. In some cases, the underlying servers might also use redundant copies of data as a way of providing fault tolerance or performance improvements through load balancing.

I've also heard the use of technologies such as storage profiles or Storage QoS referred to as SDS. In case you aren't familiar with storage profiles, they're a mechanism offered by both VMware and Microsoft as a way of classifying storage. The basic idea is that by implementing these storage classifications, it becomes easier to place a VM on the most appropriate storage type. For example, in a vSphere environment, there's a feature called Policy Driven Storage that helps an administrator select a datastore based on a VM's storage requirements.

Storage QoS is a Microsoft feature that can be used to throttle storage I/O as a way of preventing a VM from consuming a disproportionate share of the hardware's IOPS capabilities. In my opinion, features such as storage profiles and storage QoS do not constitute SDS by themselves, although those features could conceivably be aspects of SDS.

As you can see, there's quite a bit of disagreement within the industry as to what SDS really means. I think some of the uses I've

mentioned in this article get it partially right, but are too narrow in scope.

In my opinion (which you might disagree with), storage virtualization refers to the pooling of storage resources in a way that allows the capacity to be used on an as-needed basis. SDS, on the other hand, seems to be more about abstracting storage capabilities rather than storage capacity. As such, storage QoS, storage profiles and clustered file systems might be considered SDS features, but they're not the very definition of SDS.

It's All in the Capabilities

Storage QoS, storage profiles and clustered file systems might be considered SDS features, but they're not the very definition of SDS.

Although I've weighed in on the differences I perceive between storage virtualization and SDS, the IT industry has yet to adopt a solid definition for SDS. Of course, I think this will change over time. Even so, I think that there will always be a degree of overlap between SDS and storage virtualization.

If you consider my definition in which storage virtualization refers to capacity, while SDS is more about storage capabilities, the overlap seems completely natural. After all, what good are storage capabilities without capacity? But over time, I think these two terms will become far less ambiguous. VR

Brien Posey is a seven-time Microsoft MVP with more than two decades of IT experience. Reach him at brienposey.com.

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STORAGE DISRUPTORS

Look who wants to be your enterprise storage provider. Microsoft is among a number of new providers upsetting the status quo by offering software defined storage, cloud-based data protection, flash-based arrays and converged Web scale infrastructure.

By Jeffrey Schwartz

Advances in enterprise storage for years were largely relegated to higher-capacity drives and arrays and occasional boosts in throughput. Established players including EMC Corp., Hewlett-Packard Co., Hitachi Data Systems, IBM Corp. and NetApp had set the agenda for high-end storage with numerous others serving the mid-range and low end of the market and remain formidable forces. But look who's now putting the squeeze on these players. They're facing competition from companies such as Fusion-io Inc., GridStore Inc., Nasuni Corp., Nimble

Storage Inc., Nutanix, Pure Storage Inc., SimpliVity Corp., SolidFire, Unitrends Inc. and Violin Memory Inc., plus many others that only a few years ago had yet to release their first products.

Even Microsoft has become a key player. Having acquired storage array supplier StorSimple two years ago and InMage last month, the company took a major step forward toward trying to disrupt the status quo of how enterprises store and protect their data (see "Microsoft Makes Aggressive Push into Storage," p. 14). In addition, Microsoft continues to advance its Storage Spaces technology in Windows Server that virtualizes commodity disks. VMware Inc. has competing software for its virtualization suite called Virtual SAN (vSAN).

"We have really been able to throw some heavy, heavy workloads at these all flash arrays, and by every measure it has far exceeded our expectations."

Jack Hogan, CTO, Lifescript

These are the storage disruptors because these players are reshaping how IT decision makers are planning their storage architectures and roadmaps. Moreover, they're changing the economics of storage as data growth reaches an all-time high. Many of the newer storage providers have respectable revenues and customer bases and have attracted huge interest from venture capital investors. Some have gone public or have become M&A targets.

SanDisk Corp. in June agreed to acquire flash storage vendor Fusion-io, led by CEO and former HP CTO Shane Robson, for $1.1 billion. Over the past year, Nimble and Violin have gone public though both of their shares declined sharply before starting to bounce back more recently. Pure Storage in April raised $225 million bringing its total funding to $470 million and a stated market value of $3 billion. Perhaps seeing how Nimble and Violin have struggled out of the gate, CEO Scott Dietzen recently was quoted as saying Pure Storage isn't ready to go public.

There are three main catalysts driving these changes. First is the growing presence of flash-based solid-state drive (SSD) arrays in datacenters providing application performance unthinkable a few years ago, as noted in last fall's cover story ("Flash Invasion," November 2013). Most of the players have both pure flash arrays and hybrid systems that accommodate both hard disk drives (HDDs) and SSDs. Established players including EMC and NetApp also now offer flash in their portfolios. EMC last month bolstered its XtremeIO arrays with the ability to instantly create in-memory snapshots for petabyte-scale applications that require real-time performance. The company also optimized the flash option on its high-end VMAX

platform. And in June NetApp released its largest scale flash array to date, the FAS8080 EX, which it says scales to approximately 4 million IOPS.

The second driver is cloud storage, which is emerging as a tier that in many cases is replacing tape or secondary locations with drive arrays. Almost every storage hardware and software vendor is enabling the cloud as a storage tier or a target for backup and recovery and long-term archiving. Third is the vision every hardware and software infrastructure provider is evolving toward—software-defined datacenters (SDDCs). Components of the SDDC are software-defined networking (SDN) and software-defined storage (SDS). SDS also powers the growing crop of converged systems, combining compute, storage and networking into a single system. Cisco, Dell Inc. and HP offer converged systems along with newer players Nutanix and SimpliVity.

It's early days for SDS, which uses software to decouple the storage functions from specific physical hardware.

Software-Defined Storage

It's early days for SDS, which uses software to decouple the storage functions from specific physical hardware, in some ways like server virtualization has done for creating virtual compute infrastructure and orchestration. Experts say there are many ways to look at SDS. One is around disaggregating the traditional SAN and storage arrays around system-level storage such as Microsoft Storage Spaces in Windows Server or VMware vSAN.

Others describe SDS as software bundled with hardware that can orchestrate and intelligently manage the tiers using APIs that leverage applications and plug-ins to OSes and virtual machines (VMs). Because SDS is still emerging, like any technology, there's still plenty of hype around it, experts warn. There are also a lot of nuanced interpretations.

Underscoring that point, analyst Anil Vasudeva, president and founder of IMEX Research, compared SDS to server virtualization during a recent webinar panel discussion presented by Gigaom Research. "Software-defined storage is a hypervisor for storage," Vasudeva says. "What a hypervisor is to virtualization for servers, SDS is going to do it for storage. [Of] all the benefits of virtualization, the reason why it took off was basically to create the volume-driven economics of the different parts of storage, servers and networks under the control of the hypervisor."

Prominent storage expert and fellow panelist Marc Staimer, president and chief dragon slayer of Dragon Slayer Consulting, had a somewhat different view. "In general, server virtualization was a way to get higher utilization out of x86-hardware," counters Staimer. "The concept of a hypervisor, which originally came about with storage virtualization, didn't take off because of what happened with storage virtualization [and] the wonderful storage systems that were being commoditized underneath a storage virtualization layer. What you're seeing today is commoditizing the hardware with software-defined storage."

"We were very intentional about the software-defined storage stack when we started designing this from the ground up."

Siddhartha Roy, Principal Group Program Manager, Microsoft

Siddhartha Roy, principal group program manager for Microsoft (which sponsored the Gigaom Research webinar), says it's early days for SDS, especially among enterprises. "Enterprises will be a lot more cautious for the right reasons, for geopolitical or compliance reasons. It's a journey," Roy says. "For service providers who are looking at cutting costs, they will be more assertive and aggressive in adopting SDS. You'll see patterns vary in terms of percentages but the rough pattern kind of sticks."

SDS deployments may be in their early stages today, but analyst Vasudeva says it's going to define how organizations evolve their storage infrastructures. "Software-defined storage is a key turning point," he says. "It may not appear today, but it's going to become a very massive change in our IT and datacenters and in embracing the cloud."

Both analysts agree that the earliest adopters of SDS in cloud environments, besides service providers, will be small and midsize businesses. For Microsoft, its Storage Spaces technology in Windows Server is a core component of its SDS architecture. Storage Spaces lets administrators virtualize storage by grouping commodity drives into standard Server Message Block 3.0 pools that become virtual disks exposed and remoted to an application cluster.

"That end to end gives you a complete software-defined stack, which really gives you the benefit of a SAN array," Roy says. "We were very intentional about the software-defined storage stack when we started designing this from the ground up."

Flash Expansion

Less than a year after our cover story on flash, its presence in the datacenter appears to be extending rapidly. While flash arrays are far from pervasive, they're not a novelty in the datacenter, either. Even a growing number of midsize organizations are deploying flash arrays. Take Lifescript, a Web publisher focused on women's health. The Mission Viejo, Calif.-based content producer generates terabytes of storage and because of the volume of e-mail newsletters it produces and distributes, performance is critical.

Less than a year after our cover story on flash, its presence in the datacenter appears to be extending rapidly.

Lifescript is an early adopter of flash drives in its datacenter. A longtime EMC shop, Lifescript started using 3PAR storage about six years ago, when it was an early upstart that was able to provide Web scale performance with its hybrid array of a small amount of flash and Fibre Channel drives. Lifescript Chief Technology Officer Jack Hogan found the data growth from all of the content its properties produce was starting to require more capacity and greater performance. Knowing that some all-flash SSD arrays were emerging, Hogan decided to consider his options.

At the time, 3PAR storage wasn't available in a pure flash array configuration suited for Lifescript's requirements, though Hogan says it has since come out with one. Lifescript ended up deploying Pure Storage's FA-420 all-flash array, equipped with 22TB of raw storage and with compression and deduplication it can store close to 100TB, according to Hogan.

"We are now running 100 percent of our production storage on Pure Storage all-flash SAN arrays," Hogan says. "Ultimately, we were able to pay for the implementation of that by consolidating our datacenter [and] removing the 3PAR storage on the floor. It took up a lot of power and space and to add more throughput, we needed more spindles, which meant we would need more space and power."

It has markedly improved the throughput of its Exchange Server and business intelligence (BI) applications based on SQL Server Enterprise Edition, according to Hogan. For example, BI jobs that took six hours to process in the past now complete in 20 minutes. "We have really been able to throw some heavy, heavy workloads at these all-flash arrays, and by every measure it has far exceeded our expectations," he says. With the SSD capacity Lifescript acquired, the company is utilizing about 30 percent, Hogan notes.

"What we figured out when we started the company five years ago was that by coupling low-cost flash with data-reduction technologies, you can actually make it a viable mainstream storage technology," says Matt Kixmoeller, a vice president at Pure Storage.

Many storage vendors are extending their APIs to enable SDS or more automation of storage, such as provisioning specific tiers based on specific policies, conditions and applications. Pure Storage has APIs for OpenStack-based cloud infrastructure and supports VMware APIs. While it doesn't support Microsoft Storage Spaces to date, Kixmoeller says it supports Microsoft Volume Shadow Copy Service (VSS) for integration with applications such as Exchange, SharePoint and SQL Server. It also supports Microsoft Multipath I/O (MPIO), where it can automate via CLI. "But there's no official plug-in to the Microsoft management stack yet," Kixmoeller says.

"By coupling low cost flash with data reduction technologies you can actually make it a viable mainstream storage technology"

Matt Kixmoeller, Vice President, Pure Storage

One flash array vendor that does boast tight integration with Windows Server and Hyper-V environments is Violin. Microsoft and Violin forged a close technical partnership two years ago, where the team in Redmond helped co-develop the Windows Flash Server. Microsoft wrote custom code in Windows Server 2012 R2 and Windows Storage Server 2012 R2 that interfaces with the Violin Windows Flash Array, launched in April.

The Windows Flash Array, designed to ensure latencies of less than 500 microseconds, comes with an OEM version of Windows Storage Server. "Customers do not need to buy Windows Storage Server, they do not need to buy blade servers, nor do they need to buy the RDMA 10GB embedded NICs," says Eric Herzog, CMO and senior vice president of business development. "Those all come prepackaged in the array ready to go and we do Level 1 and Level 2 support on Windows Server 2012 R2," Herzog says.

The April launch of the Violin Windows Flash Server carried a 64TB configuration with a street price of $395,000. Violin last month added a new entry-level 16TB system, which starts at $140,000. "We've added all of these capacities, which lets us go after smaller companies and departmental-level deployments," Herzog says. "It can easily fit two SQL Server databases, maybe three, depending on the size of the database. You can pay as you grow. You don't have to add new hardware, just purchase a license key." The entry-level system can scale in capacity to 64TB.

While Pure Storage and Violin emphasize pure flash arrays, most others—including those that offer traditional HDD-based systems—are offering hybrid solutions that have a mix of spinning disks and flash-based SSDs. Companies are largely competing on their software IP. Yet, as the economics of flash continue to become more appealing, expect suppliers to tip the balance of their hybrid arrays toward SSDs.

Seeing increased demand for flash, Nimble Storage, a fast-growing storage provider that offers hybrid arrays, in June launched its CS700 array available with an all-flash shelf. The company says this new system, which incorporates the Nimble Cache Accelerated Sequential Layout architecture and a cloud management platform it calls InfoSight, is suited for VDI and high-transactional databases. Each node supports 16TB and it can scale to four nodes, or 64TB. With the full array, it can scale to a petabyte of capacity.
Nimble claims the new array supports 500,000 IOPS. "It's not just about the specs, it's how we get there," says Ajay Singh, vice president of product management at Nimble. "Candidly, not that many workloads need 500,000 IOPS and tens of terabytes of capacity. In a typical environment you might have a small percentage of your data that needs that. Another big chunk that needs a balance of IOPS and capacity, and then another big chunk that just ends capacity, so one way we're different is with the same architecture—we let you get all of those workloads in one system."

Also driving SDS and changing the enterprise storage scene is converged infrastructure.

Web Scale and Converged Infrastructure

Also driving SDS and changing the enterprise storage scene is converged infrastructure, which consists of network, server and storage in a combined system. Cisco made a big push into converged infrastructure with its UCS platform adding server blades to its network gear. Cisco's push into the server market wasn't taken kindly by Dell and especially onetime partner HP, which both followed suit with their own converged infrastructure offerings.

Dell has made its share of acquisitions of storage and networking companies over the years but recently has turned to Nutanix to develop the Dell XC Series of Web-scale Converged Appliances set for release in the fourth quarter. Nutanix had a large presence at the Microsoft TechEd conference in Houston back in May where it showcased its Virtual Computing Platform. Powered by the Nutanix OS

(NOS), the Web-scale appliances have a control fabric with multi-cluster management that's the basis of the converged compute, storage and networking system.

"We have eliminated the storage tier all together," says Laura Padilla, Nutanix director of strategic alliances. "There's no SAN and there's no external NAS. As customers go to more virtualized workloads, the whole concept of networked storage is somewhat of a mismatch of virtualization. The reason being is in a networked storage model where there's an external network tier, the hardware can become a bottleneck to performance and security."

"We have eliminated the storage tier altogether. There is no SAN and there's no external NAS. As customers go to more virtualized workloads, the whole concept of networked storage is somewhat of a mismatch of virtualization."

Siddhartha Roy, Principal Group Program Manager, Microsoft

Earlier this year, Nutanix added support for Windows Server 2012 R2 and Hyper-V in its offering. It already had supported VMware and KVM-based hypervisors. Gridstore is another up-and-coming provider of Web-scale storage infrastructure that supports Hyper-V. In fact, the company earlier this year decided to focus exclusively on the Microsoft datacenter platform. "We fit into Windows as a device driver, it's very clean and easy to fit in that level," says Kelly Murphy, founder and CTO of Gridstore. "With VMware and ESX, it is not easy and clean, so it was that technical aspect, as well."

Like Nutanix, Gridstore describes its infrastructure as Web scale, though it hasn't adopted a converged systems approach. Gridstore hardware is pure storage arrays that combine both HDDs and SDDs. At the Microsoft Worldwide Partner Conference (WPC) last month in Washington, D.C., Gridstore launched a larger 48TB node that can scale up to 250 systems, or 12PB. The company also says its hardware will integrate with Microsoft System Center and its Cloud OS platform.

Cloud As a Target

As the price of cloud storage declines almost monthly, more and more companies are using the cloud as a second or third tier of their storage infrastructures. All of the major storage software and backup and recovery providers support cloud storage in some way, though most have preferred providers or methods of connectivity.

Unitrends Inc., perhaps the most established of the disruptors, is among a number of vendors that offer storage appliances linked to the public cloud for disaster recovery. Its current offering uses the

company's own cloud service. Chief Technology Officer Mark Campbell hints that Unitrends will offer connectivity to other clouds down the road. While Campbell says with its own cloud it can provide 24x7 "white glove" service, many customers will want lower-cost alternatives, especially for less-critical systems and data.

"The cost advantage we perceive will continue to get better with the public cloud with services such as Azure," Campbell says. So we want to make sure we're offering different levels of SLAs and different levels of providing for our customers going forward."

"A few years ago, storage was as boring as heck."

– Enterprise Strategy Group analyst Mark Peters.

Whether it's SDS, flash, the growth of Web scale and converged systems or the cloud, few will argue that storage in the enterprise isn't going through a transition. Who will win and lose and set the agenda for next-generation storage is very much in play, but it's clear that unconventional players like Microsoft are moving aggressively into storage (see "Microsoft Makes Aggressive Push into Storage," p. 14), hoping to rearrange the deck. As some say traditional SAN and NAS are becoming legacy systems, others are giving them a new lease on life.

"A few years ago, storage was as boring as heck," says Enterprise Strategy Group analyst Mark Peters. "Hearing about new developments was like the release of new tires for cars. Now we have all kinds of fun things going on." **VR**

Jeffrey Schwartz is editor of Redmond.

The ONLY Storage Purpose-built for Hyper-V

Gridstore software-defined storage solutions accelerate application performance up to 4 times at 1/2 the cost of traditional SANs.

Unique in the market as being designed from the ground up for Hyper-V and Windows 2012 environments, Gridstore's innovative solutions address the primary storage challenges that impact application performance in virtual environments.

Gridstore 3

- Delivers Superior Cost/Performance
- Provides simplified management via tight integration with Microsoft management tools
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- Patented Server-Side Virtual ControllerTM Technology (SVCT) eliminates the I/O blender effect at the source
- Delivers the industry's only end-to-end storage Quality of Service (QoS) to guarantee performance for the most important applications.

High-performance storage starts with as little as 36TB yet grows to 3PB, providing the ideal cost-effective solution for clients of all sizes.

Microsoft Makes Aggressive Push into Storage

Microsoft is aiming to commoditize hardware with software-defined storage hardware as a gateway to the cloud.

Not that Microsoft is new to storage. Redmond has long offered storage replication in data protection and support for storage interfaces such as iSCSI. Microsoft has also partnered with leading storage vendors including EMC Corp., Hewlett-Packard Co. and NetApp. But now between the enhancements to Storage Spaces in Windows Server 2012 R2 and its push into hardware, Microsoft is becoming a storage company itself.

Microsoft's push into hardware promises to draw more users to its Microsoft Azure Storage cloud service. It remains to be seen how much emphasis the company will place on advancing its storage ambitions. "Microsoft has to determine if it really wants to push this," Enterprise Strategy Group analyst Mark Peters says. "It's such a big company with so many marketing mixes."

In recent months, Microsoft has indicated it has big plans for StorSimple, a provider of storage appliances it acquired two years ago. And at press time, Microsoft announced it has acquired InMage, which provides turnkey replication, backup and business continuity appliances designed for hybrid cloud environments. Microsoft will integrate InMage into its Azure Recovery Manager product line, giving it a more extensive line of storage hardware.

Azure Recovery Manager first debuted earlier this year as Hyper-V Recovery Manager, which initially provided disaster recovery to a secondary datacenter. Microsoft renamed it at TechEd when it added to the new offering the ability to connect to the Azure cloud as an alternative to requiring another datacenter. The service, released to preview in late June and set for general availability later this year, monitors clouds with System Center Virtual Machine Manager remotely and continuously. All links with Azure are encrypted in transit with the option for encryption of replicated data at rest. Microsoft says administrators can recover VMs in an orchestrated manor to enable quick recoveries, even in the case of multi-tier workloads.

With the InMage Scout offering now added to the mix, Microsoft says Azure Recovery Manager will get a major boost. Scout continuously captures changes to data in real time from production servers in memory before it's written to disk and either backs it up or replicates it. It's designed to provide recovery of data for operations with near-real-time recovery time objectives. It supports Windows Server, Linux, and Unix physical machines and Hyper-V, VMware ESX, and Xen virtual machines.

Following the closing of the acquisition of the company last month, Microsoft pulled the InMage-4000, a converged compute storage system, from the lineup. That appliance was available with up to 48 physical CPU cores, 96 threads, 1.1TB of memory and 240TB of raw storage capacity. It supported 10GigE storage networking and built-in GigE Ethernet connectivity. Microsoft said it will reintroduce a similar device at an unspecified date. Meanwhile, when combined with Azure Recovery Manager, Scout will allow customers to use its public cloud or a secondary site for disaster recovery.

Giving its StorSimple line a boost, Microsoft in July announced it is launching the Azure StorSimple 8000 Series, which consists of two different arrays that offer tighter integration with the Azure public cloud. While the Microsoft StorSimple appliances always offered links to the public cloud in-

Microsoft Makes Aggressive Push into Storage *(Continued)*

cluding Amazon Web Services S3, the new Azure StorSimple boxes with disks and flash-based solid-state drives (SSDs) only use Azure Storage. Azure Storage becomes an added tier of the storage architecture, enabling administrators to create virtual SANs in the cloud just as they do on-premises. Using the cloud architecture, customers can allocate more capacity as needs require.

"The thing that's very unique about Microsoft Azure StorSimple is the integration of cloud services with on-premises storage," said Marc Farley, senior product marketing manager for StorSimple at Microsoft, during a press briefing to outline the new offering. "The union of the two delivers a great deal of economic and agilit benefits to customers."

Making the new offering unique, Farley explained, is the two new integrated services: the Microsoft Azure StorSimple Manager in the Azure portal and the Azure StoreSimple Virtual Appliance. "It's the implementation of StorSimple technology as a service in the cloud that allows applications in the cloud, to access the data that has been uploaded from the enterprise datacenters by StorSimple arrays," Farley said.

The StorSimple 8000 Series lets customers run applications in Azure that access snapshot virtual volumes, which match the VMs on the arrays on-premises. It supports Windows Server and Hyper-V, as well as Linux and VMware-based VMs.

The aforementioned new StorSimple Manager consolidates the management and views of the entire storage infrastructure consisting of the new arrays and the Azure Virtual Appliances. Administrators can also generate reports from the console's dashboard, letting them reallocate storage infrastructure as conditions require.

Farley emphasized that the new offering is suited for disaster recovery, noting it offers "thin recoveries." Data stored on the arrays in the datacenter can be recovered from copies of the data stored in the Azure Virtual Appliances. With the acquisition of InMage, it appears Microsoft will emphasize those appliances for pure disaster recovery implementations.

The StorSimple 8000 arrays support iSCSI connectivity as well as 10Gb/s Ethernet and inline deduplication. When using the Virtual Appliance, administrators can see file servers and create a virtual SAN in the Azure cloud.

"If you can administer a SAN on-premises, you can administer the virtual SAN in Azure," Farley said.

Microsoft is releasing two new arrays: the StorSimple 8100, which has 15TB to 40TB of capacity (depending on the level of compression and deduplication implemented) and the StorSimple 8600, which ranges from 40TB to 100TB with a total capacity of 500TB when using Azure Virtual Appliances.

The StorSimple appliances are scheduled for release this month. Microsoft hasn't disclosed pricing but the per-gigabyte pricing will be more than the cost of the Microsoft Azure Blob storage offering, taking into account bandwidth and transaction costs.

Microsoft is extending its push into others areas of storage, too, such as disaster recovery and file management. Microsoft recently released Azure Site Recovery preview, which lets organizations use the public cloud as an alternate to a secondary datacenter or hot site and it has introduced Azure Files for testing. Azure Files exposes file shares using SMB 2.1, making it possible for apps running in Azure to more easily share files between VMs using standard APIs, such as ReadFile and WriteFile, and can be accessed via the REST interface to enable hybrid implementations (see "Windows File Shares in the Cloud," p. 24). *–J.S.*

Microsoft's Expanding Storage Portfolio

Key components of Microsoft's storage offerings and technology

Azure StorSimple 8000 Series: These latest SAN arrays due out this month are equipped with both HDDs and SSDs. Enterprise customers can deploy the arrays for primary storage, which are tightly integrated with the Microsoft Azure public cloud service. In Azure, customers can use the StorSimple Virtual Appliance for tiered storage. The arrays support inline deduplication, compression and automatic tiering with a choice of 10Gbps Ethernet and iSCSI connectivity. The arrays sit between physical and virtual application servers and the StorSimple Virtual Appliance in the Azure cloud. The new rollout contains the following components:

- StoreSimple 8100: 15TB to 40TB local, 200TB with cloud
- StoreSimple 8600: 40TB to 100TB Local, 500TB with cloud

InMage Scout: Microsoft last month announced it has acquired InMage, a supplier of Scout, which are cloud-based business continuity appliances. Microsoft said it will integrate it with its new Azure Recovery Manager. Scout continuously captures changes to data in real time from production servers in memory before it's written to disk and either backs it up or replicates it. It's designed to provide recovery of data for operations with near-real-time recovery time objectives. It supports Windows Server, Linux, and Unix physical machines and Hyper-V, VMware ESX, and Xen virtual machines.

Microsoft Storage Spaces: Introduced in Windows Server 2012 and Windows 8. Storage Spaces introduced storage virtualization to the OS, which aggregates and isolates physical disks while providing resilient storage, failover clustering, and thin provisioning.

Microsoft Storage Server: This version of Microsoft's Windows Server lets OEM partners and customers create NAS appliances customized for specific hardware.

In the Cloud Era, the Era of Convergence Is Upon Us

What exactly is convergence and what is making vendors scramble to get included in this category? By Arun Taneja

The era of IT infrastructure convergence is upon us. Every major vendor has some type of offering under this category. Startups and smaller players are also "talking" convergence. But what exactly is convergence and why are all the vendors so interested in getting included in this category? We will explain below the history of convergence, what it is, what it is not, what benefits accrue from such systems, who the players are, and who is leading the pack in true convergence.

The overall IT stack today looks like a mishmash of technologies.

Legacy Architectures Gone Wild

The fact is the fundamental makeup of IT infrastructure has remained the same for thirty years, maybe more. We have the compute layer, the networking layer and the storage layer. Each layer has innovated in its own way and at its own pace but the layers have stayed intact. One could argue that the compute layer has followed Moore's law, the networking layer a quasi-Moore's law and the storage (or at least the HDD performance portion of it) a "flat line" law.

The issues created by the so-called I/O gap are well known and I will assume the reader is up to speed on its impact. As the amount of data kept growing at astronomical rates and the variety of data went from almost pure text to text, audio and video in a variety of formats, we kept throwing more and more hardware at the problem. We did this by simply adding more servers, each with more cores and higher speeds; networks with bigger switches and more bandwidth; and storage with more HDDs and more powerful controllers.

By the middle of the past decade, however, these infrastructures were at a breaking point, in spite of many "surrounding" technologies that surfaced in the 2000-2003 timeframe that kept them for utter collapse. And given the tsunami of data coming at us today it is only a question of time before the classic infrastructure will simply collapse on itself. But before we look at the "revolutionary" alternatives, let's look at some of these surrounding technologies, as they play an important role in the future of computing, regardless.

The fundamental makeup of IT infrastructure has remained the same for 30 years, maybe more.

Technologies That Mitigate Infrastructure Issues

Technologies that have made the largest positive impact and allowed the current three-layer infrastructure to stay put, albeit in a wobbling state, include server and storage virtualization, data deduplication, compression, WAN Optimization, and flash in variety of implementations, including hybrid arrays and disk-based backup appliances. Of course, a list such as this would necessarily have to include cloud computing, cloud storage, and Hadoop (along with all its associated products) even if we would be hard pressed to call them "surrounding" technologies. I would also put scale-out architectures on that list.

Each of these technologies, in its own unique way, has helped keep the balance. For instance, server virtualization brought consolidation and agility; storage virtualization delivered improvements in provisioning speed, capacity utilization, and management; data deduplication and compression enabled HDDs to be used economically for backup and restore and brought associated improvements in RTO's and RPO's and DR; and WAN Optimization made sure remote office employees didn't feel like second class citizens of the enterprise anymore. Of course, flash is on its way to revolutionizing application performance; cloud computing is fundamentally changing how we consume compute and storage resources and Hadoop is helping extract information out of mounds of collected data so better business decisions can be made.

With the exception of cloud computing and Hadoop, however, all these technologies have been bolted on to the traditional three-layer architecture of the 1970's. As a result, the overall IT stack today looks like a mishmash of technologies, essentially with compute, networking and storage layers surrounded by the plethora of new technologies mentioned above. This raises the question: Is this the best way to run the railroad? The answer, as you guessed, is a definite no. Two essential approaches have appeared on the horizon: convergence, and what we call hyperconvergence. We will look at each in more detail.

Convergence Defined

As the amount of data kept growing at astronomical rates, we kept throwing more and more hardware at the problem.

In a bid to simplify the IT infrastructure, a number of vendors, especially the legacy players, started bundling specific configurations of compute, networking, storage and server virtualization and pre-testing them for interoperability and performance for targeted workloads. The first one to market was VCE, a joint collaboration of VMware, Cisco and EMC, with Cisco providing compute and networking components. Specific configurations were pre-tested for strict interoperability and performance for workloads, such as SAP or MS Exchange or VDI, etc. Management was simplified by adding software that viewed the unit as a whole; however, if a layer was not performing adequately, regular tools that came with that layer were used to diagnose and change configurations.

I think of this type of configuration as taking three atoms and combining them to create a molecule. You buy, deploy, run, and manage the unit as a molecule. If you buy the right model number for the task, the probability that it will deliver the right SLA for the applications is higher than if you bought these layers separately from three different vendors and put them together yourself. The burden of deciding which models were appropriate to mix together to do a specific job was taken off the buyer. This simplification is far from trivial. With customers looking to deploy cloud-scale infrastructures, one could drop these molecules into place, knowing they work at a specific level of performance. Management became easier and deployment time went down from weeks or months to days. Just as importantly, the TCO was impacted favorably.

Over the past three years, all major players have jumped into this fray that the market calls Convergence. HP offers CloudSystem Matrix; NetApp worked with Cisco and VMware to offer FlexPod; Dell combined PowerEdge servers, EqualLogic arrays and Force10

network switches to deliver their converged solution as Active Infrastructure; and IBM offers PureFlex Systems, which combine IBM POWER and x86 server blades and Storwize V7000 storage with networking, server virtualization and management components.

While these converged systems provided ease of purchase, deployment and use along with significantly improved sharing of resources, a fundamentally different phenomenon was taking place in the market. At Taneja Group we call this hyperconvergence and consider it to be distinct from convergence. Alternatively, one could think of hyperconvergence as a continuation and maturation of convergence but we prefer to keep the categories separate on the fundamental assumption that players along the convergence axis cannot simply improve their products and become hyperconverged, without serious architectural changes. In other words, we believe that true hyperconvergence can only be achieved by starting with a clean slate and not by mixing existing pieces.

Given the tsunami of data coming at us today, it is only a question of time before the classic infrastructure will simply collapse on itself.

So what is hyperconvergence and how is it different from convergence?

Hyperconvergence Defined

We believe hyperconvergence occurs when you fundamentally architect a new product with the following requirements:

1. A genuine integration of compute, networking, storage, server virtualization, primary storage data deduplication, compression, WAN optimization, storage virtualization and data protection. No need for separate appliances for disk-based data protection, WAN optimization or backup software. Full pooling and sharing of all resources. A true datacenter building block. Just stack the blocks, and they reform into a larger pool of complete datacenter infrastructure.

2. No need for separate acceleration or optimization solutions to be layered on or patched in. Performance (auto-tiering, caching and capacity optimizations all built in). As such, no need for separate flash arrays or flash caching software.

3. Scale-out to web scale, locally and globally, with the system presenting one image. Manageable from one or more locations. Radical improvement in deployment and management time due to automation.

4. VM centricity, i.e. full visibility and manageability at VM level. No LUNS or volumes or other low level storage constructs.

5. Policy-based data protection and resource allocation at a VM level.

6. Built-in cloud gateway, allowing the cloud to become a genuine, integrated tier for storage or compute, or both.

With today's converged systems one would have to add separate backup appliances, backup software, WAN optimization appliances, flash arrays, flash cashing software, cloud gateways, and more, to get to the conceptual equivalent of the above. But one would still not achieve VM-centricity, or web scale or space and power savings, or the ability to manage all these pieces as a whole. One could get close but no cigar. This is why we believe hyperconvergence is a separate and distinct category. According to our definition, we believe three systems in the market fall into this category: Nutanix, SimpliVity and Scale Computing.

Management, even at the global level, becomes trivial, compared to managing traditional architectures or, for that matter, Converged architectures.

Nutanix came to market first with a "built from scratch" hyperconverged system that met most of the requirements from day 1. Missing initially was data deduplication and global management capability, which Nutanix added recently in rev 4.0. The Nutanix Virtual Computing Platform is VMware-based but Hyper-V was added as an option in rev 4.0. One can now build a cluster using VMware-based nodes and a separate cluster, using Hyper-V nodes, and manage the whole, globally, as one instance.

SimpliVity took a slightly different tack. Given that many of its developers came from Diligent Technologies (now IBM), the purveyor of in-line data deduplication appliances, SimpliVity started with the premise that data should be reduced to its smallest size at inception and kept that way for the entire lifecycle, whether it is being moved, stored or analyzed, except when it needs to be viewed by a user. In order to ensure that this capability stood out, SimpliVity developed a special PCIe card to handle the number crunching required by the deduplication algorithms, without impacting the ingest performance.

Nutanix, on the other hand, wanted to stay true to a 100 percent commodity hardware strategy, so they chose post-processing data deduplication for HDD to ensure zero impact on performance. For

main memory and flash storage, Nutanix chose in-line data deduplication, which makes these small capacities effectively much larger.

Regardless of the differences, both products meet the essential premise of hyperconvergence and the differences between them are architectural and can only be evaluated in a hands-on evaluation.

Scale Computing, on the other hand, is targeted at the lower end of the market and uses KVM as the hypervisor. Given the open source nature of KVM, Scale was able to more tightly integrate KVM into the architecture (more so than one could with VMware or Hyper-V). At least at this point in time Scale does not offer data deduplication but most other requirements of HyperConvergence are met in full. For smaller IT shops where IT specialists are rare, the ability to buy the whole infrastructure as a unit and manage it as such can be a gift from the heavens.

The best way to think of hyperconverged systems is to think of them as "infrastructure in a box."

Benefits of hyperconvergence

The best way to think of hyperconverged systems is to think of them as "infrastructure in a box." You can start with the minimum number of nodes the vendor requires—two for Nutanix and SimpliVity and three for Scale Computing. All functionality we've mentioned as requirements is included in each node. Installation and deployment times are trivial. You decide on the importance of each VM you wish to run and assign each a priority, which will determine how much resource is to be made available to that VM, in terms of IOPs, throughput, latency, degree of protection, RTO/RPO, etc. The system does the rest. All relevant data is available on a VM by VM basis.

If more resource is needed, given the mix and resource requirements of all VMs, the system alerts the operator that one or more additional nodes are needed. Adding the nodes is simple. The cluster recognizes the additional nodes automatically and storage and compute resources become available instantly. If remote clusters are installed, the clusters can recognize each other and present a single image to the IT administrator. All data is presented at the VM level and there are no low level storage tasks (provisioning, LUN creation, virtualization, expansion/contraction of volumes, balancing workloads, etc. etc.) to be performed. As such, the server virtualization administrator can easily manage the entire cluster, without requiring strict storage experience.

Management, even at the global level, becomes trivial, compared to managing traditional architectures or, for that matter, Converged

architectures. All data exchange across the WAN happens efficiently, using WAN optimization methods, and only unique data is sent across and even that in a compressed fashion.

We believe this level of functionality and integration can only happen if one starts with a clean slate. It is hard, if not impossible, to make this happen with equipment from ten or more vendors, each with its own idiosyncrasy. This is why we believe hyperconvergence may conceptually be viewed as an evolution of convergence, but in reality it is more "revolutionary" than not, even if most components of the technology it uses are well defined and mature.

The pain of managing large infrastructures has become so acute that hyperconvergence presents almost a panacea.

Where Does Virtual SAN Fit In?

VMware announced Virtual SAN as a product that essentially allows a number of compute nodes with local HDD and flash storage (DAS) to pool their storage resources and make the pool available to all applications, running as VMs. vCenter becomes the central place to manage the entire cluster (no separate storage console). Configurations as large as 32 nodes were announced and the product is being targeted at midsize and large enterprises for all but tier-1 workloads. All vSphere services are available, including vSphere Data Protection Advanced, vCenter Site Recovery Manager, vMotion, Storage vMotion, DRS, etc.

The Future of Hyperconverged Solutions

If the current reception to hyperconverged solutions by midsize and large IT is any indication, hyperconverged solutions will cut deeply into traditional architecture-based solutions. And they will do so very quickly. The pain of managing large infrastructures has become so acute that hyperconvergence presents almost a panacea. The combination of workload unpredictability, the pace at which new data is coming into the enterprise, and the requirement to deliver results instantly, all point to a new architecture that adapts and adjusts automatically, with little or no human intervention.

While traditional architectures keep improving in all these dimensions, incremental improvements are just not enough. hyperconverged solutions could not have arrived at a more opportune time. VR

Arun Taneja is founder, president and consulting analyst of the Taneja Group, an analyst firm specializing in storage and storage-centric server technologies.

The 2014 *Virtualization Review* Buyers Guide

A comprehensive list of cloud and virtualization companies and products

By Michael Domingo

commvault
solving forward®

The Simpana® software VM Backup, Recovery, and Cloud Management Solution Set is more than just fast, easy-to-use enterprise-class VM backup and recovery—it's the way to get more out of your total cloud and VM infrastructure. A component of the CommVault® Simpana® software single platform, this solution lets you apply cost-optimized VM backup and recovery that scales to meet the needs of every VM workload. It streamlines management of your VM platform with a policy-based approach to ensure no VM goes unprotected, while optimizing VM resource utilization. The Simpana VM Backup, Recovery, and Cloud Management Solution Set's advanced features go way beyond protection to help you build and maintain private, public and hybrid clouds. It bridges multiple hypervisors and cloud platforms and self-service provisioning and management of VMs and cloud instances—so you can better leverage your investment in VM and cloud infrastructure.

GRIDSTORE

Gridstore™ is the leader in software-defined storage whose data storage solutions are purpose-built for virtualization and designed to accelerate applications in virtualized environments and a key component in enabling the Cloud Data Center. Using its patented Server-Side Virtual Controller™ Technology (SVCT) to eliminate the I/O blender effect and accelerate applications Gridstore delivers vmOptimized™ Storage that self-optimizes to each application or VM across both virtual and physical environments. The new nodes quadruple the capacity available on a per-node basis, and can expand to 250 total nodes with 12PB.

Leveraging a grid architecture, Gridstore delivers the first end-to-end storage QoS to ensure the performance of the most important Apps or VMs is never compromised. The storage grid, that uses Gridstore's performance optimized nodes or capacity optimized nodes, starts with as few as 3 nodes and then can grow one or more at a time to deliver a cost effective scale-as-you-grow solution.

tegile

Tegile's patented IntelliFlash™ technology accelerates performance and enables inline deduplication and compression of data so each array has a usable capacity far greater than its raw capacity. Tegile's award-winning solutions enable customers to better address the requirements of server virtualization, virtual desktop integration and database integration than any other offerings. Featuring both NAS and SAN connectivity, Tegile flash arrays deliver a comprehensive set of data management capabilities and support different storage media (hard disks, dense flash, high-performance flash) under a single storage operating system. The user has the flexibility to decide the amount of flash storage needed to meet the specific performance needs of their applications and get the performance of flash with the economics of disk storage. Visit us at www.tegile.com or follow us on Twitter @tegile.

Veeam Backup & Replication v7
Veeam Backup & Replication™ provides fast, flexible, and reliable recovery of virtualized applications and data. It unifies backup and replication in a single solution, increases the value of backup and reinvents data protection for VMware vSphere and Microsoft Hyper-V virtual environments.

Veeam Backup & Replication™ is Modern Data Protection - Built for Virtualization™ and the cloud. It delivers powerful, easy-to-use and affordable data protection for VMware and Hyper-V. You'll never have to update another agent, recover another virtual machine from scratch or explain why you're still missing your backup windows.

Veeam Backup Ĥ Replication provides fundamental and far-reaching benefits over legacy backup tools to:
• Reduce backup and recovery time by 95%
• Reduce admin time by 90%
• Reduce costs by up to 70%
http://www.veeam.com/vm-backup-recovery-replication-software.html

Veeam Management Pack v7 for System Center
Take control of your virtual environment and be assured that your critical applications and services are running smoothly. When you virtualize your applications, you need full visibility into the virtual layer. Veeam® Management Pack™ v7 extends System Center's monitoring capabilities to include Microsoft Hyper-V and VMware vSphere environments, as well as the Veeam Backup Ĥ Replication™ infrastructure. Veeam Management Pack's app-to-metal visibility is what makes it the best third-party management pack for System Center.

Veeam Management Pack integrates seamlessly with Microsoft System Center, providing complete visibility of your virtual, physical and Veeam Backup Ĥ Replication infrastructures from a single console. With Veeam MP, you can visualize relationships and dependencies in topology views, drill down in-context, get real-time data and fix problems fast.

Benefits:
• Find problems before they harm critical business applications
• Reduce downtime to enable your always-on business and ensure SLA compliance
• Maximize System Center ROI by adding visibility into virtual and backup environments
• Ensure your virtualized applications are always available and your VMs are protected
• Accurately predict and prepare for growth in your virtual environment http://www.veeam.com/system-center-management-pack-vmware-hyperv.html

ISE 700 Series are the only true hybrid storage system that uses SSD and HDD as a single pool of storage, creating the ideal balance of price, performance, and capacity. They include patented Continuous Adaptive Data Placement (CADP) software, which analyzes the behavior of application I/O and automatically places hotspot data onto SSD only if measurable performance gains will be achieved. Otherwise, CADP keeps the data on high-performance HDD, ensuring the more expensive SSD resources are fully optimized and available for performance-driven data.

This is a fundamental advantage of X-IO ISE hybrid technology; out of the box and without setting up any performance policies, it provides the greatest levels of application performance with the most efficient use of storage resources

Application Virtualization

2X ApplicationServer XG 10.6 - 2X Software
$75 per user ■ 2x.com

AccessNow - Ericom Software
Contact for price ■ ericom.com

AdminStudio Suite 2013 - Flexera Software LLC
Contact for price ■ flexerasoftware.com

Application Delivery Solution - Radware Ltd.
Contact for price ■ radware.com

Application Jukebox - Numecent
Contact for price ■ numecent.com

AppZero Cloud - AppZero
Contact for price ■ appzero.com

Aternity for VDI - Aternity Inc.
Contact for price ■ aternity.com

Cameyo 2.0 - Cameyo
Free ■ cameyo.com

eG Enterprise 5.7 - eG Innovations Inc.
Contact for price ■ eginnovations.com

ElectricCommander - Electric Cloud
Contact for price ■ electric-cloud.com

Quest Workspace ChangeBASE 6.0 - Quest Software
Contact for price ■ quest.com

Scense 8 - Scense B.V.
Contact for price ■ scense.com

Spoon Server - Spoon.net
Contact for price ■ spoon.net

Server Virtualization

Dell vStart 50, 100, 200 series - Dell Inc.
Contact for price ■ dell.com

FabricCache QLE 10000 - QLogic Corp.
Contact for price ■ qlogic.com

FlashArray 400 Series - Pure Storage Inc.
Contact for price ■ purestorage.com

FlashSoft for vSphere - SanDisk Corp.
$3,900 ■ sandisk.com/products/flashsoft/vsphere/

FlexSuite QLE2600 and QLE8300 - QLogic Corp.
Contact for price ■ qlogic.com

HC3 - Scale Computing
$25,499 for 15-30 Virtual Workloads Compute Resources, 96GB RAM, three Quad-Core Intel CPUs, 6x1GbE or 3x10GbE Storage Resources, 12 SATA or SAS drives, 6TB to 24TB RAW storage ■ scalecomputing.com

Memory Channel Storage - Diablo Technologies
Contact for price ■ diablo-technologies.com

Oracle VM 3.2 - Oracle Corp.
Oracle VM has no license fee, only a support fee ■ oracle.com

PROMISE VTrak S3000 - PROMISE Technology
Contact for price ■ promise.com

Proxmox Virtual Environment - Proxmox Server Solutions GmbH
Contact for price ■ proxmox.com

Red Hat Enterprise Virtualization for Servers 3.2 - Red Hat Inc.
Free, fully supported 60-day trial; $2,994 Standard Subscription for one year ■ redhat.com

Riverbed Granite 2.5 - Riverbed Technology
Contact for price ■ riverbed.com

ScaleMP vSMP Foundation 4.0 - ScaleMP Inc.
Contact for price ■ scalemp.com

Virtuozzo Containers - Parallels IP Holdings GmbH
Contact for price ■ parallels.com

V-locity 3 - Condusiv Technologies Corp.
Contact for price ■ condusiv.com

Desktop Virtualization & VDI

Accela - Cisco Systems Inc. (via WHIPTAIL, recently acquired)
Contact for price ■ cisco.com

AMAX Virtual Desktop Series - AMAX Information Technologies Inc.
Contact for price ■ amax.com

Moka5 for BareMetal - Moka5 Inc.
Contact for price ■ mokafive.com

Ceedo Enterprise - Ceedo Technologies Ltd.
Contact for price ■ ceedo.com

Connection Broker 7.6 - Leostream
Contact for price ■ leostream.com

Desktone Desktop-as-a-Service - VMware Inc.
Call for pricing ■ desktone.com

Desktop Cloud Computing Appliance Gen 2 - V3 Systems
Contact for price ■ v3sys.com

IO Offload Engine - GreenBytes
Contact for price ■ getgreenbytes.com

Invicta - Cisco Systems Inc. (via WHIPTAIL, recently acquired)
Contact for price ■ cisco.com

Konect Elite - desktopsites Inc.
From $490 per year for a five-user pack to $17,500 per year for 250-user pack ■ desktopsites.com

Leostream Connection Broker - Leostream
Contact for price ■ leostream.com

Leostream Cloud Desktops - Leostream
Starts at $10/month per desktop ■ leostreamdesktops.com

N-series - NComputing
Contact for price ■ ncomputing.com

NexentaVSA for View 1 - Nexenta Systems Inc.
$35 per seat license, 100 seat minimum ■ nexenta.com

Nimble CS Series CS260 - Nimble Storage
Starts at $38,000 ■ nimblestorage.com

P10PS Series Desktop Touchscreen - GVision USA Inc.
Contact for price ■ gvision-usa.com

Pano System for VDI 6.0 - Pano Logic Inc.
$1,399 for five-seat starter kit, includes software and five endpoint zero-client devices ■ panologic.com

ProfileUnity FlexApp - Liquidware Labs Inc.
Contact for price ■ liquidwarelabs.com

Red Hat Enterprise Virtualization for Desktops 3.0 - Red Hat Inc.
Free 60-day trial; $4,494 Standard Subscription for one year ■ redhat.com

RES Automation Manager 2012 - RES Software
Contact for price ■ ressoftware.com

RES Baseline Desktop Analyzer - RES Software
Contact for price ■ resssoftware.com

RES Dynamic Desktop Studio - RES Software
Contact for price ■ ressoftware.com

RES Virtual Desktop Extender - RES Software
Contact for price ■ ressoftware.com

RES Workspace Manager 2012 - RES Software
Contact for price ■ ressoftware.com

SmartVDI Host Platforms - ClearCube Technology Inc.
Contact for price ■ clearcube.com

Stratusphere FIT - Liquidware Labs
$6.95 per user for 180 days ■ liquidwarelabs.com

Stratusphere UX - Liquidware Labs
$39 per year ■ liquidwarelabs.com

Symantec Workspace Streaming 7.5 - Symantec Corp.
Contact for price ■ symantec.com

SysTrack 6.1 - Lakeside Software Inc.
Contact for price ■ lakesidesoftware.com

Teradici PCoIP Hardware Accelerator APEX 2800 - Teradici Corp.
$2,395, available via distributors ■ teradici.com

Thin Browse - ThinLaunch Software LLC
$39 per user for 1-50 users ■ thinlaunch.com

Thin Desktop - ThinLaunch Software LLC
$29 per device for 1-50 users ■ thinlaunch.com

ThinPrint Server Engine 9 - Cortado AG
Starts at $29.95 per user annually, with volume discounts ■ thinprint.com

Unidesk 2.0 - Unidesk Corp.
Starts at $150 per managed desktop, with volume discounts ■ unidesk.com

V3 Desktop Cloud Orchestrator 1 - V3 Systems
Contact for price ■ v3sys.com

VDI-in-a-Box - Citrix Systems Inc.
Starts at $975 for a 5-pack ■ citrix.com

Login VSI - Login VSI
Contact for price ■ loginvsi.com

Verde 7 - Virtual Bridges Inc.
Contact for price ■ vbridges.com

vIO - GreenBytes
Contact for price ■ getgreenbytes.com

Virtual Desktop Platform - VDIworks
Contact for price ■ vdiworks.com

vSpace Management Center - NComputing
Contact for price ■ ncomputing.com

vSpace Server - NComputing
Contact for price ■ ncomputing.com

vSTAC VDI Appliance - Pivot3 Inc.
Contact for price ■ pivot3.com

WorkSpace iQ - Centrix Software Ltd.
Contact for price ■ centrixsoftware.com

WorldDesk for Enterprise - WorldDesk
Contact for price ■ myworldesk.com

Mobile Virtualization & Bring Your Own Device

2X Client for RDP/Remote Desktop - 2X Software
Free ■ 2x.com

Biscom VMware File Transfer Appliance - Biscom Inc.
Contact for price ■ biscom.com

Citrix Receiver - Citrix Systems Inc.
Free with Citrix XenDesktop, Citrix XenApp and Citrix CloudGateway ■ citrix.com

Cortado Corporate Server - Cortado AG
$119 per user, or $4.97 per month ■ corporateserver.cortado.com

Dell Wyse Cloud Client Manager - Dell Wyse
Contact for price ■ wyse.com

Dell Wyse PocketCloud - Dell Wyse
Contact for price ■ wyse.com

Intelligent Mobile Edge - Extreme Networks
Contact for price ■ extremenetworks.com

Moka5 - Moka5 Inc.
Contact for price ■ mokafive.com

Parallels Access - Parallels IP Holdings GmbH
$79.99 per year ■ parallel.com/access

System Center 2012 Configuration Manager - Microsoft Corp.
Contact for price ■ microsoft.com

vLogix Mobile - Red Bend Software
Contact for price ■ redbend.com

Thin-Client & Zero-Client Computing

2X OS 7.3 - 2X Software
Free ■ 2x.com

AG7600 - Computer Lab International Inc. (CLI)
Contact for price ■ computerlab.com

Devon Terminal Operating System - Devon IT
Contact for price ■ devonit.com

JC6100C Cloud Computing Model - Computer Lab International Inc. (CLI)
Contact for price ■ computerlab.com

NoTouch Desktop 2.34.0 - Stratodesk Corp.
Contact for price ■ stratodesk.com

Remote Desktop Reporter - RDPSoft
$199 per monitored Terminal Server; with volume discounts ■ rdpsoft.com

UD2, UD3, UD5, UD9 Series - IGEL Technology
Contact for price ■ igel.com

Userful MultiSeat Linux Zero Clients - Userful Corp.
Contact for price ■ userful.com

Virtualization Management & Optimization

AppSense User Virtualization Platform - AppSense Ltd.
Contact for price ■ appsense.com

Aptare StorageConsole Platform - Aptare Inc.
Contact for price ■ aptare.com

Argent for VMware - Argent Software
Contact for price ■ argentsoftware.com

Aternity Frontline Performance Intelligence Platform - Aternity Inc.
Contact for price ■ aternity.com

athene - Metron-Athene Inc.
Contact for price ■ metron-athene.com

AX Series - A10 Networks Inc.
Contact for price ■ a10networks.com

Axxia Network Accelerator - LSI Corp.
Contact for price ■ lsi.com

BlueCat IPAM Solutions - BlueCat Networks
Contact for price ■ bluecatnetworks.com

Bocada vpConnect 8 - Bocada Inc.
Contact for price ■ bocada.com

CA LISA Platform - CA Technologies
Contact for price ■ ca.com

CiRBA - CiRBA Inc.
Contact for price ■ cirba.com

Cisco Nexus 1010 and 1010-X Virtual Services Appliances - Cisco Systems Inc.
Contact for price ■ cisco.com

Cisco Virtual Network Management Center 1.3 - Cisco Systems Inc.
Contact for price ■ cisco.com

CloudPhysics - CloudPhysics Inc.
Contact for price ■ cloudphysics.com

Desktop Central 8 - ManageEngine
Contact for price ■ manageengine.com

dsNet Manager - Cleversafe Inc.
Contact for price ■ cleversafe.com

Embrane heleos - Embrane Inc.
Contact for price ■ embrane.com

EMC Isilon Scale-Out Storage Platform - EMC Corp.
Contact for price ■ isilon.com

EnhanceIO SSD Cache Software - Stec Inc.
Contact for price ■ stec-inc.com

Enterprise Manager Virtual Edition - F5 Networks Inc.
$9,995 ■ f5.com

Equalizer OnDemand - Coyote Point Systems
$3,595 ■ coyotepoint.com

Foglight for Virtual Desktops - Quest Software, a Division of Dell Inc.
Contact for price ■ quest.com

Grid Engine - Univa Corp.
Contact for price ■ univa.com

HIPAA Essential - SilverSky
Contact for price ■ www.silversky.com

Hitachi Command Suite 7.3 - Hitachi Data Systems Corp.
Contact for price ■ hds.com

Hosted Monitoring for In-House IT Departments - LogicMonitor Inc.
Contact for price ■ logicmonitor.com

Hotlink Hybrid Express - Hotlink Corp.
$300/year per Amazon EC2 Instance; free version supports 10 Amazon EC2 Instances ■ hotlink.com

Hotlink SuperVISOR - Hotlink Corp.
$1,500/year per host; free version supports 3 hosts/15 VMs ■ hotlink.com

HP Insight Control for VMware vCenter Server 7 - Hewlett-Packard Co.
Free when managing HP Storage under support contract; contact for other pricing options ■ hp.com

HyTrust Appliance - HyTrust Inc.
Contact for price ■ hytrust.com

IgniteVM 8.2 - Confio Software
Contact for price ■ confio.com

Intigua - Intigua
Contact for price ■ intigua.com

ioTurbine Fusion-io - Fusion-io Inc.
Contact for price ■ fusion-io.com

IP Address Management Freeware - Infoblox Inc.
Free ■ infoblox.com

Librato - Librato
Contact for price ■ metrics.librato.com

MozyPro - Mozy Corp.
Contact for price ■ mozy.com

Netuitive 6.0 - Netuitive Inc.
Contact for price ■ netuitive.com

NetWrix Change Reporter - NetWrix Corp.
Contact for price ■ netwrix.com

Novell Endpoint Lifecycle Management Suite - Novell
Contact for price ■ novell.com

OmniCube - SimpliVity Corp.
Contact for price ■ simplivity.com

OnCommand Management Software Portfolio - NetApp
Contact for price ■ netapp.com

OneFabric Data Center Manager - Enterasys Networks Inc.
Contact for price ■ enterasys.com

PAN Manager Software - Egenera Inc.
Contact for price ■ egenera.com

PCI Compliant Hosting - Layered Technologies Inc.
Contact for price ■ layeredtech.com

PerfectDisk - Raxco Software Inc.
$599.99 per host with unlimited guests ■ raxco.com

PHD Virtual Monitor - PHD Virtual Technologies
Contact for price ■ phdvirtual.com

PlateSpin Migrate - NetIQ Corp.
Contact for price ■ netiq.com

Precise Transaction Performance Management - Precise
Contact for price ■ precise.com

Riverbed Virtual Cascade - Riverbed Technology
Contact for price ■ riverbed.com

Simpana - CommVault
Contact for price ■ commvault.com

Simplify Desktop - triCerat Inc.
Contact for price ■ tricerat.com

SolarWinds Mobile Admin - SolarWinds Inc.
$699/seat, $2,995 unlimited seats ■ solarwinds.com

Splunk App for Citrix - Splunk Inc.
Free ■ splunk.com

Spotlight on SQL Server Enterprise - Quest Software, a Division of Dell Inc.
Contact for price ■ quest.com

StorageCraft ShadowControl ImageManager 5.0.5 - StorageCraft Technology Corp.
ShadowControl ImageManager is included with the ShadowProtect license; additional licensing is required for individual jobs featuring ShadowStream, intelligentFTP and HeadStart Restore technology ■ storagecraft.com

Stratusphere FIT - Liquidware Labs Inc.
Contact for price ■ liquidwarelabs.com

StruxureWare for Data Centers - Schneider Electric
Contact for price ■ schneider-electric.us

Terra Alta - Akamai Technologies
Contact for price ■ akamai.com

Unified Communications - Avaya Inc.
Contact for price ■ avaya.com

up.time 7 - Uptime Software Inc.
$99 per element monitoring ■ uptimesoftware.com

Vblock System 700 - VCE
Contact for price ■ vce.com

vCapacity 3.3 - Reflex Systems LLC
Contact for price ■ reflexsystems.com

Veritas Dynamic Multi-Pathing for VMware - Symantec Corp.
Starts at $900 per processor and is licensed based on processor type and number of cores ■ symantec.com

VirtualWisdom - Virtual Instruments Inc.
Contact for price ■ virtualinstruments.com

VMTurbo Operations Manager - VMTurbo Inc.
Contact for price ■ vmturbo.com

WorkSpace iQ - Centrix Software Ltd.
Contact for price ■ centrixsoftware.com

Xangati Management Dashboard 5 - Xangati
Contact for price ■ xangati.com

Zenoss Service Dynamics - Zenoss Inc.
Contact for price ■ zenoss.com

Cloud Infrastructure & Platform

6fusion IaaS Marketplace - 6fusion Inc.
Contact for price ■ 6fusion.com

AppCluster for Public Cloud - Sanbolic Inc.
$8,000 per server ■ sanbolic.com

AppFog CenturyLink - AppFog Inc.
Contact for price ■ appfog.com

Apprenda Open Platform as a Service - Apprenda Inc.
Contact for price ■ apprenda.com

Application Services - AT&T
Contact for price ■ att.com/hosting

Aria Subscription Billing Platform - Aria Systems
Contact for price ■ ariasystems.com

Arista 7050 Series with EOS 4.10 - Arista Networks Inc.
$13,495 ■ aristanetworks.com

Arista 7100 Series with EOS 4.10 - Arista Networks Inc.
$12,995 ■ aristanetworks.com

Arista 7150S Series with EOS 4.10 - Arista Networks Inc.
$12,995 ■ aristanetworks.com

Arista 7500 Series with EOS 4.10 - Arista Networks Inc.
$68,990 ■ aristanetworks.com

AvailabilityGuard/Cloud - Continuity Software
Starts at $1,000 per physical server ■ continuitysoftware.com

BIG-IP Global Traffic Manager - F5 Networks Inc.
$23,995 ■ f5.com

BIG-IP WAN Optimization Manager - F5 Networks Inc.
$4,995 ■ f5.com

BIG-IP WebAccelerator - F5 Networks Inc.
$9,995 ■ f5.com

Bluelock Virtual Datacenters - Bluelock
Contact for price ■ bluelock.com

BMC Cloud Lifecycle Management - BMC Software Inc.
Contact for price ■ bmc.com

Canopy - Canopy
Contact for price ■ canopy-cloud.com

CAStor - Caringo Inc.
Contact for price ■ caringo.com

Chef - Opscode Inc.
Contact for price ■ opscode.com/chef

Citrix CloudPlatform - Citrix Systems Inc.
Contact for price ■ citrix.com

Cloud Computing Services - Expedient Data Centers
Contact for price ■ expedient.com

Cloud Foundry - Pivotal
Contact for price ■ cloudfoundry.org

Cloud Hosting - Hosting.com
Contact for price ■ hosting.com

Cloud Intelligent Network - Cisco Systems Inc.
Contact for price ■ cisco.com

Cloud Management Portal - Virtacore Systems Inc.
Contact for price ■ virtacore.com

Cloud CORE - Geminare Inc.
Contact for price ■ geminare.com

CloudPhysics - CloudPhysics Inc.
Contact for price ■ cloudphysics.com

CloudBees Platform as a Service - CloudBees Inc.
Contact for price ■ cloudbees.com

Cloudera Enterprise - Cloudera Inc.
Contact for price ■ cloudera.com

CloudFrames - CloudFounders
Contact for price ■ cloudfounders.com

CloudHub - MuleSoft Inc.
Contact for price ■ mulesoft.com

Cloudify - GigaSpaces Technologies Inc.
Free ■ gigaspaces.com

CloudSwitch Enterprise - CloudSwitch Inc.
Contact for price ■ cloudswitch.com

CumuLogic Cloud Application Platform for Enterprises - CumuLogic Inc.
Contact for price ■ cumulogic.com

Data Center Fabric - Xsigo
Contact for price ■ xsigo.com

Datacenter Transformation and Outsourcing - Cloud Solutions - Unisys
Contact for price ■ unisys.com

Dell Active System Manager - Dell Inc.
Contact for price ■ dell.com

Dell - Dell Multi-Cloud Manager - Dell Inc.
Contact for price ■ dell.com

Engine Yard Cloud - Engine Yard Inc.
Contact for price ■ engineyard.com

Enterprise Cloud - Terremark, a Verizon Company
Contact for price ■ terremark.com

Enterprise Cloud Computing - Savvis, a CenturyLink Company
Contact for price ■ savvis.com

Enterprise Cloud Services - Hewlett-Packard Co.
Contact for price ■ hp.com

Enterprise Cloud Services - SunGard Availability Services
Contact for price ■ sungardas.com

Eucalyptus Cloud - Eucalyptus Systems Inc.
Contact for price ■ eucalyptus.com

GoGrid Big Data Solutions - GoGrid
Contact for price ■ gogrid.com

Hitachi Content Platform - Hitachi Data Systems Corp.
Contact for price ■ hds.com

Hybrid Clouds - Virtacore Systems Inc.
Contact for price ■ virtacore.com

IBM Platform HPC Cloud - IBM Platform Computing
Contact for price ■ ibm.com

iCloudRecovery - Geminare Inc.
Contact for price ■ geminare.com

iland Cloud Services - iland
Contact for price ■ iland.com

iland LabCloud - iland
Contact for price ■ iland.com

IntalioJCreate - Intalio Inc.
Contact for price ■ intalio.com

Joyent SmartDataCenter - Joyent Inc.
Contact for price ■ joyent.com

Leostream Cloud Desktops - Leostream Corp.
$20 per desktop ■ leostreamdesktops.com

LongJump Platform as a Service - LongJump
Contact for price ■ longjump.com

Managed Hosting Service - Terremark, a Verizon Company
Contact for price ■ terremark.com

mCloud Helix - Morphlabs Inc.
Contact for price ■ morphlabs.com

Moab Cloud Suite - Adaptive Computing Inc.
Contact for price ■ adaptivecomputing.com

NaviCloud Platform - NaviSite Inc.
Contact for price ■ navisite.com

Nebula - Nebula Inc.
Contact for price ■ nebula.com

NephoScale Cloud Services - NephoScale
Contact for price ■ nephoscale.com

Nutanix Virtual Computing Platform - Nutanix
Contact for price ■ nutanix.com

OpenShift Enterprise PaaS Solution - Red Hat Inc.
Contact for price ■ redhat.com

OpSource Managed Hosting - OpSource Inc.
Contact for price ■ opsource.net

Oracle Exalogic Elastic Cloud - Oracle Corp.
Contact for price ■ oracle.com

Oracle Fabric Manager - Oracle Corp.
Contact for price ■ oracle.com

OS33 for SMBs - OS33 Inc.
Contact for price ■ os33.com

PAN Cloud Director - Egenera Inc.
Contact for price ■ egenera.com

Parallels Automation for Cloud Infrastructure - Parallels IP Holdings GmbH
Contact for price ■ parallels.com

Rackspace Open Cloud - Rackspace U.S. Inc.
Contact for price ■ rackspace.com

Riverbed Stingray Traffic Manager Application Delivery Controller-as-a-Service - Riverbed Technology
Contact for price ■ riverbed.com

Sales Cloud - Salesforce.com Inc.
Contact for price ■ salesforce.com

SoftLayer Private Clouds - SoftLayer Technologies Inc.
Contact for price ■ softlayer.com

Software as a Service - Savvis, a CenturyLink Company
Contact for price ■ savvis.com

Stackato - ActiveState Software Inc.
Call for pricing ■ activestate.com

Stratosphere Cloud Computing Platform - Datapipe Inc.
Contact for price ■ datapipe.com

Tier 3 Enterprise Cloud Platform - Tier 3 Inc.
Contact for price ■ tier3.com

VM6 Manage Cloud Platform - VM6 Software Inc.
Contact for price ■ vm6software.com

XAP Elastic Application Platform - GigaSpaces Technologies Inc.
Contact for price ■ gigaspaces.com

xStream Enterprise Cloud - Virtustream Inc.
Contact for price ■ virtustream.com

Cloud Storage

Abiquo - Abiquo Inc.
Contact for price ■ abiquo.com

AcerCloud - Acer Inc.
Contact for price ■ cloud.acer.com

Aryaka - Aryaka
Contact for price ■ aryaka.com

Asigra Cloud Backup - Asigra Inc.
Contact for price ■ asigra.com

AT&T Synaptic Storage as a Service - AT&T
Contact for price ■ att.com

Ayrris - Appistry Inc.
Contact for price ■ appistry.com

Box - Box
Contact for price ■ box.com

Carbonite Business - Carbonite
Contact for price ■ carbonite.com

Cloud-Integrated Enterprise Storage - StorSimple Inc.
Contact for price ■ storsimple.com

CloudAlly - CloudAlly
Contact for price ■ cloudally.com

CloudArray - TwinStrata Inc.
Starts at $0.19 per gigabyte ■ twinstrata.com

CloudScaler - Caringo Inc.
Contact for price ■ caringo.com

Elastic Content Protection - Caringo Inc.
Contact for price ■ caringo.com

iCloud - Apple Inc.
Contact for price ■ apple.com

MagFS - Maginatics
Contact for price ■ maginatics.com

n5 Storage System - NexGen Storage Inc.
$55,000 ■ nexgenstorage.com

NexentaStor - Nexenta Systems Inc.
Contact for price ■ nexenta.com

Panzura CloudFS File System - Panzura
Contact for price ■ panzura.com

ProfitBricks Infrastructure as a Service - ProfitBricks
Contact for price ■ profitbricks.com

Riverbed Whitewater Cloud Storage Gateway - Riverbed Technology
Contact for price ■ riverbed.com

SF6010 - SolidFire
Contact for price ■ solidfire.com

Symform Cloud Storage Network - Symform Inc.
Contact for price ■ symform.com

Cloud Security

2X SecureRemoteDesktop - 2X Software
$29.95 ■ 2x.com

Access Manager - NetIQ Corp.
Contact for price ■ netiq.com

BIG-IP Access Policy Manager - F5 Networks Inc.
Contact for price ■ f5.com

BIG-IP Application Security Manager - F5 Networks Inc.
Contact for price ■ f5.com

BIG-IP Edge Gateway - F5 Networks Inc.
Contact for price ■ f5.com

CA CloudMinder - CA Technologies
Contact for price ■ ca.com

Check Point SMB Cloud-Managed Security Services - Check Point Software Technologies Inc.
Starts at $19 per month ■ checkpoint.com

Cloud Backup Services and Recovery Offerings - EVault Inc.
Contact for price ■ evault.com

CypherX - Afore Solutions
Starts at $150 per subscriber ■ aforesolutions.com

CloudPassage Halo - CloudPassage Inc.
Contact for price ■ cloudpassage.com

Dome9 Business Cloud - Dome9 Security Ltd.
Contact for price ■ dome9.com

KONA Security Solutions - Akamai Technologies
Contact for price ■ akamai.com

Governance Controls - RightScale Inc.
Contact for price ■ rightscale.com

HighCloud Security - HighCloud Security
$3,000/10-pack, with volume discounts ■ highcloudsecurity.com

Okta - Okta Inc.
Contact for price ■ okta.com

Oxygen Cloud Enterprise - Oxygen Cloud Inc.
Contact for price ■ oxygencloud.com

Panda Cloud Protection - Panda Security
Contact for price ■ pandasecurity.com

QualysGuard Cloud Platform 7.4 - Qualys Inc.
Contact for price ■ qualys.com

QualysGuard Private Cloud Platform - Qualys Inc.
Contact for price ■ qualys.com

Security Solutions for Cloud Providers - Fortinet Inc.
Contact for price ■ fortinet.com

Managed Security Service - SilverSky
Contact for price ■ silversky.com

StillSecure Cloud NSA 1 - StillSecure
Contact for price ■ stillsecure.com

Cloud Software

AppZero Application Migration - AppZero
$500 per source machine ■ appzero.com

Acumatica Cloud ERP - Acumatica
Contact for price ■ acumatica.com

Asigra Cloud Backup - Asigra Inc.
Contact for price ■ asigra.com

Centrix WorkSpace Universal - Centrix Software Ltd.
$70/user per year ■ centrixsoftware.com

Cloud Cruiser Enterprise Edition - Cloud Cruiser
Contact for price ■ cloudcruiser.com

CloudTest Platform - Soasta
Contact for price ■ soasta.com

Dell Wyse WSM - Wyse Technology Inc.
Contact for price ■ dellwyse.com

Embotics vCommander - Embotics Corp.
Contact for price ■ embotics.com

Enterprise Cloud for HR and Finance - Workday Inc.
Contact for price ■ workday.com

Fusion Tables - Google Inc.
Contact for price ■ google.com

HotLink Hybrid Express - HotLink Corp.
Contact for price ■ hotlink.com

Intacct Financials - Intacct Corp.
Contact for price ■ intacct.com

Komodo IDE 7.1 - ActiveState Software Inc.
Contact for price ■ activestate.com

NetSuite ERP - NetSuite Inc.
Contact for price ■ netsuite.com

Oracle Cloud Application Foundation - Oracle Corp.
Contact for price ■ oracle.com

Oracle Taleo Enterprise Cloud Service - Oracle Corp.
Contact for price ■ oracle.com

Pano System for Cloud 1.0 - Pano Logic Inc.
$999 server license for up to 200 users; $149 each for Pano Zero Client ■ panologic.com

Piston Enterprise OpenStack - Piston Cloud Computing Inc.
Contact for price ■ pistoncloud.com

Puppet Enterprise - Puppet Labs
Contact for price ■ puppetlabs.com

QuickBooks Enterprise Solutions Hosting Service - Intuit Inc.
$54.99/user per month ■ intuit.com

SAP Cloud Business Applications - SAP AG
Contact for price ■ sap.com

Virtustream xStream - Virtustream Inc.
Contact for price ■ virtustream.com

Z-Business Enterprise Editions - Zuora Inc.
Contact for price ■ zuora.com

Zenoss Service Dynamics - Zenoss Inc.
Contact for price ■ zenoss.com

Zoho Business Apps - Zoho Corp. Pvt. Ltd.
Contact for price ■ zoho.com

Business Continuity

Acronis Backup & Recovery - Acronis International GmbH
Contact for price ■ acronis.com

Actifio 100T - Actifio
Contact for price ■ actifio.com

Actifio 6 - Actifio
Contact for price ■ actifio.com

Altaro Hyper-V Backup 3 - Altaro Software
$395 Standard (up to five VMs); $545 Unlimited ■ altaro.com

Avance - Stratus Technologies
Contact for price ■ stratus.com

AvailabilityGuard/SAN - Continuity Software
Starts at $20,000 ■ continuitysoftware.com

Backup Exec 2012 V-Ray Edition - Symantec Corp.
Contact for price ■ symantec.com

Bluelock Recovery-as-a-Service - Bluelock
Contact for price ■ bluelock.com

CA ARCserve Backup - CA Technologies
Contact for price ■ arcserve.com

Cloud Recovery/Auto Failover - Geminare Inc.
Contact for price ■ geminare.com

CrashPlan PROe - Code 42 Software Inc.
Contact for price ■ code42.com

DocRetriever for SharePoint - Dell Inc.
Contact for price ■ appassure.com

Double-Take Availability - Vision Solutions Inc.
Contact for price ■ visionsolutions.com

FalconStor CDP with RecoverTrac - FalconStor Software
Contact for price ■ falconstor.com

Eaton UPS Backup Power and Monitoring - Eaton Corp.
Contact for price ■ eaton.com

EVault Data Backup Software - EVault Inc.
Contact for price ■ evault.com

everRun MX - Stratus Technologies
Contact for price ■ stratus.com

EX Series - ExaGrid Systems Inc.
Contact for price ■ exagrid.com

FalconStor Virtual Tape Library (VTL) - FalconStor Software
Contact for price ■ falconstor.com

FarStone Total Backup Recovery Server 8 - FarStone Technology Inc.
Contact for price ■ farstone.com

ftServer - Stratus Technologies
Contact for price ■ stratus.com

HotLink DR Express - HotLink Corp.
$25/month per protected VM ■ hotlink.com

iland Continuity Cloud - iland
Contact for price ■ iland.com

MailRetriever for Exchange - Dell Inc.
Contact for price ■ appassure.com

NetBackup - Symantec Corp.
Contact for price ■ symantec.com

nScaled Recovery-as-a-Service - nScaled Inc.
Contact for price ■ nscaled.com

NTP Software Universal File Access - NTP Software
Contact for price ■ ntpsoftware.com

onQ Appliance - QuorumLabs Inc.
Contact for price ■ quorumlabs.com

Ontrack Data Recovery Services - Kroll Ontrack Inc.
Contact for price ■ krollontrack.com

OpenGear IM4200 - Opengear Inc.
Contact for price ■ opengear.com

Paragon Drive Backup Server - Paragon Technologies GmbH
Contact for price ■ paragon-software.com

PHD Virtual Backup and Replication - PHD Virtual Technologies
$550 per socket ■ phdvirtual.com

PHD Virtual CloudHook - PHD Virtual Technologies
Contact for price ■ phdvirtual.com

PHD Virtual ReliableDR - PHD Virtual Technologies
$250 per VM ■ phdvirtual.com

PlateSpin Forge - NetIQ Corp.
Contact for price ■ netiq.com

rCloud - Doyenz Inc.
Contact for price ■ doyenz.com

Replicator for SharePoint - Metalogix International GmbH
$13,500 per license ■ metalogix.com

Scout SSE - InMage Systems
$399 ■ inmage.com

Scout Cloud - InMage Systems
Contact for price ■ inmage.com

SEP sesam - SEP AG
Contact for price ■ sep.de/us/home

StorageCraft ShadowProtect Virtual 4.2.5 - StorageCraft Technology Corp.
$215 for perpetual; $25 for MSPs ■ storagecraft.com

StorageCraft Cloud Services - StorageCraft Technology Corp.
Starts at $0.35/GB monthly, $0.28/GB a month for partners ■ storagecraft.com

StoragePoint - Metalogix International GmbH
$3,995 per TB ■ metalogix.com

STORServer Virtual Machine Backup - STORServer Inc.
Contact for price ■ storserver.com

Trustyd Remote Backup Appliance - Trustyd
Contact for price ■ trustyd.com

Unitrends Enterprise Backup - Unitrends
Contact for price ■ unitrends.com

Tintri ReplicateVM - Tintri Inc.
Contact for price ■ tintri.com

Veeam Backup Management Suite - Veeam Software
Contact for price ■ veeam.com

Veritas Cluster Server - Symantec Corp.
Contact for price ■ symantec.com

vmPRO - Quantum Corp.
Contact for price ■ quantum.com

vmPRO 4000 - Quantum Corp.
Contact for price ■ quantum.com

vmProtect - Acronis International GmbH
$599 per CPU or per socket ■ acronis.com

vRanger - Dell Inc.
$769 per CPU ■ quest.com/vranger/

Zenith BDR-G12 - Zenith Infotech Ltd.
Contact for price ■ zenithinfotech.com

Zerto Virtual Replication 2.0 - Zerto
Contact for price ■ zerto.com

Zetta DataProtect - Zetta Inc.
Contact for price ■ zetta.net

Virtualization Automation

Cloud Lifecycle Management - BMC Software
Contact for price ■ bmc.com

ioTurbine - Fusion-io Inc.
$3,900 ■ fusionio.com

JAMS - MVP Systems Software Inc.
Contact for price ■ jamsscheduler.com

rPath Cloud Engine - rPath Inc.
Contact for price ■ rpath.com

vProfile 3.3 - Reflex Systems LLC
Pricing is about $595 per socket ■ reflexsystems.com

Storage Virtualization

6000 Flash Memory Array - Violin Memory Inc.
Contact for price ■ violin-memory.com

AssuredSAN Pro 5000 Series - Dot Hill Systems Corp.
Contact for price ■ dothill.com

Avere FXT Series Edge Filer 1 - Avere Systems Inc.
Starts at $25,000 ■ averesystems.com

BrickStor - RackTop LLC
Contact for price ■ racktopsystems.com

Brocade DCX 8510 Backbones - Brocade Communications Systems Inc.
Contact for price ■ brocade.com

Cloud Storage Assurance - Geminare Inc.
Contact for price ■ geminare.com

Coraid EtherDrive SRX Storage Arrays - Coraid Inc.
Contact for price ■ coraid.com

Coraid EtherDrive VSX Storage Appliance - Coraid Inc.
Contact for price ■ coraid.com

DNF Storage - Dynamic Network Factory Inc.
Contact for price ■ dnfstorage.com

Drobo B1200i - Drobo Inc.
Contact for price ■ drobo.com

Emulex LightPulse Gen 5 Fibre Channel Host Bus Adapters - Emulex Corp.
Contact for price ■ emulex.com

FalconStor Network Storage Server - FalconStor Software
Contact for price ■ falconstor.com

HUS VM Storage Virtualization System - Hitachi Data Systems Corp.
$156,000 ■ hds.com

Hyper ISE - X-IO Technologies
Contact for price ■ x-io.com

InMage Scout - InMage Systems
Contact for price ■ inmage.com

Melio - Sanbolic Inc.
Contact for price ■ sanbolic.com

Nasuni Storage - Nasuni Corp.
Contact for price ■ nasuni.com

Nimbus E-Class - Nimbus Data Systems Inc.
Contact for price ■ nimbusdata.com

Nimbus S-Class - Nimbus Data Systems Inc.
Contact for price ■ nimbusdata.com

Gemini All Flash Arrays Nimbus Data Systems Inc.
Contact for price ■ nimbusdata.com

NST5000 - Nexsan Corp.
Contact for price ■ nexsan.com

Nutanix Virtual Computing Platform - Nutanix Inc.
$120,000 ■ nutanix.com

PernixData FVP - PernixData Inc.
$7,500 ■ pernixdata.com

Promise VTrak S3000 - Promise Technology Inc.
Contact for price ■ promise.com

Pure Storage FlashArray 400 Series - Pure Storage Inc.
Contact for price ■ purestorage.com

SANsymphony-V - DataCore Software
Starts at under $10,000 for two licenses ■ datacore.com

Scale Computing HC3 - Scale Computing
Starts at under $25,000 for 3-node cluster ■ scalecomputing.com

SkyEagle - Skyera Inc.
$1.99/GB, or $0.49/GB with data reduction technologies ■ skyera.com

SSDNow E100 Enterprise SSD - Kingston Technology Corp.
Contact for price ■ kingston.com

StarWind iSCSI SAN and NAS - StarWind Software Inc.
Contact for price ■ starwindsoftware.com

StarWind Native SAN for Hyper-V - StarWind Software Inc.
Contact for price ■ starwindsoftware.com

STEC PCIe Solid State Accelerator (SSA) - STEC Inc.
Contact for price ■ stec-inc.com

StoneFly IP SAN - StoneFly Inc.
Contact for price ■ stonefly.com

StorageX - Data Dynamics Inc.
$500 per TB ■ datadynamicsinc.com

StorSimple Appliances - StorSimple Inc.
Contact for price ■ storsimple.com

Tintri VMstore - Tintri Inc.
Contact for price ■ tintri.com

VeloBit HyperCache 2 - VeloBit Inc.
$1,250 per CPU ■ velobit.com

ViSX Performance Storage Appliance - Astute Networks Inc.
$32,000 ■ astutenetworks.com

WD Arkeia Network Backup - Arkeia Software and Western Digital Technologies
Contact for price ■ arkeia.com

Tegile Zebi - Tegile Systems Inc.
HA2400, $168,000; HA2800, $235,000 ■ tegile.com

Network Virtualization

BlackDiamond X Series - Extreme Networks
Contact for price ■ extremenetworks.com

Bluesocket vWLAN - ADTRAN Inc.
Contact for price ■ adtran.com

Citrix NetScaler SDX - Citrix Systems Inc.
Contact for price ■ citrix.com

Dell Networking S6000 - Dell Inc.
Contact for price ■ dell.com

Ethernet Switch Systems - Mellanox Technologies
Contact for price ■ mellanox.com

IBM Distributed Virtual Switch 5000V - IBM System Networking
$819 per socket ■ ibm.com/networking

IBM RackSwitch G8264 - IBM System Networking
$37,999 ■ ibm.com/networking

IBM RackSwitch G8316 - IBM System Networking
$35,999 ■ ibm.com/networking

Microsoft Hyper-V Server 2012 - Microsoft Corp.
Contact for price ■ microsoft.com

Netronome NFP 6xxx - Netronome
Contact for price ■ netronome.com

QLogic 8200 Series Converged Network Adapters - QLogic Corp.
Contact for price ■ qlogic.com

Riverbed Steelhead Appliances - Riverbed Technology
$995 ■ riverbed.com

Virtualization Security

Barracuda Spam & Virus Firewall - Barracuda Networks Inc.
Contact for price ■ barracudanetworks.com

Bitdefender - Bitdefender
Contact for price ■ bitdefender.com

Ixia BreakingPoint Actionable Security Intelligence - Ixia
Contact for price ■ ixiacom.com

Catbird vSecurity 5.1 - Catbird Networks Inc.
Contact for price ■ catbird.com

Certes TrustNet Manager - Certes Networks Inc.
Contact for price ■ certesnetworks.com

Check Point Security Gateway - Check Point Software Technologies Ltd.
Contact for price ■ checkpoint.com

CloudLink Secure VSA - AFORE
Starts at $4,000 ■ aforesolutions.com

Digital Guardian - Verdasys
Contact for price ■ verdasys.com

ESET Endpoint Solutions - ESET North America
Contact for price ■ eset.com/us/business/eset-for-business

FortiGate-3950B - Fortinet Inc.
Contact for price ■ fortinet.com

FortiGate Virtual Appliances - Fortinet Inc.
Contact for price ■ fortinet.com

GigaVUE-HD8 - Gigamon
Contact for price ■ gigamon.com

Porticor Virtual Private Data System 1.12 - Porticor Ltd.
$99/month per appliance; $599 for AWS, VMware ■ porticor.com

PowerBroker for Virtualization and Cloud - BeyondTrust Inc.
Contact for price ■ beyondtrust.com

QualysGuard Virtual Scanner Appliance - Qualys Inc.
Contact for price ■ qualys.com

Invincea FreeSpace Enterprise - Invincea Inc.
Contact for price ■ invincea.com

Safe Access 6.0 - StillSecure
Contact for price ■ stillsecure.com

Symantec Critical System Protection - Symantec Corp.
Contact for price ■ symantec.com

Symantec Endpoint Protection - Symantec Corp.
Contact for price ■ symantec.com

Tripwire VIA Platform - Tripwire Inc.
Contact for price ■ tripwire.com

Ultra Protect (Netilla) - Ultra Electronics AEP Networks Ltd.
Contact for price ■ aepnetworks.com

vGW Virtual Gateway 5 - Juniper Networks Inc.
Contact for price ■ juniper.net

VM Fortress - Tresys Technology LLC
Contact for price ■ tresys.com

vTrust - Reflex Systems LLC
Pricing is about $595 per socket ■ reflexsystems.com

WatchGuard XTMv Series - WatchGuard Technologies Inc.
Contact for price ■ watchguard.com

Websense Triton - Websense Inc.
Contact for price ■ websense.com

Virtualization Training

Ascolta Training
Contact for price ■ ascolta.com

Capella University
Contact for price ■ capella.edu

DeVry University
Contact for price ■ devry.edu

Hatsize Corp.
Contact for price ■ hatsize.com

Intense School
Contact for price ■ intenseschool.com

InfoSec Institute
Contact for price ■ infosecinstitute.com

ITT Technical Institute
Contact for price ■ itt-tech.edu

Kaplan University
Contact for price ■ kaplan.edu

Learning Tree International
Contact for price ■ learningtree.com

Learn iT!
Contact for price ■ learnit.com

MeasureUp
Contact for price ■ measureup.com

NetCom Learning
Contact for price ■ netcomlearning.com

QuickStart Training
Contact for price ■ quickstart.com

University of Phoenix
Contact for price ■ phoenix.edu

VR