Storage + Compute = Hyper-converged

Hyper-converged systems pack direct-attached storage into servers and then cluster them. But you may be sacrificing best of breed for convenience.

SNAPSHOT 1
Virtual server storage still poses some problems

SNAPSHOT 2
Capacity and cool features top VM storage shopping lists

EDITOR'S NOTE / CASTAGNA
No clear choices in blizzard of storage options

DATA PROTECTION
Repurpose backup data for other apps

STORAGE REVOLUTION / TOIGO
VMs vs. storage strife exposed

HOT SPOTS / SINCLAIR
The secret side of solid-state storage

SOLID-STATE STORAGE
Server-side solid-state is the fastest flash fix for performance fans

READ-WRITE / TANEJA
Third choice beyond hybrid and all-flash systems
The day you get back, challenges will be solutions

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In a blizzard, it’s hard to see a single snowflake. And with the avalanche of new data storage technology that has swirled around data centers the past couple of years, it can be pretty tough to pick out that exemplary piece of engineering innovation and dexterity. They say no two snowflakes are alike (how “they” came to that conclusion, I’ll never know) and, similarly, this data storage maelstrom is marked by a staggering number of new products and product categories. In other words, it’s tough to figure out.

If you haven’t cast your company’s lot with the cloud, software-defined storage, hyper-converged systems or any of the other storage buzzwords du jour, you’re not alone. Just as a whipping snowstorm can reduce one’s visibility, the flurry of new—or re-invented—storage techs that we’ve been weathering can also make it hard to discern distinct shapes in the storage market.

There are a couple of reasons for these conditions and the uncertainty they bring. As I’ve noted a few times in this column, there really is a lot of stuff going on in the world of storage these days. There probably isn’t one single reason why there’s so much activity on so many fronts, but the success and penetration of server virtualization has certainly upset the status quo in data centers. Add to that the ever-growing data stores that most companies continue to stash away, toss in some mobility and cloud economics, and there are plenty of reasons why smart storage people are rethinking the way things have been done and how they can be done better. Also figuring into the picture is the inevitable IT cycle of consolidating operations and services to manage them centrally … until somebody realizes that distributing those processes and services makes more sense. I’m not sure if we’re entering the consolidating or distributing phase as there’s evidence of both in the new storage lineup, but whatever it is, it’s a factor for sure.

Another reason why the situation remains so unsettled and potentially perplexing is that we haven’t yet seen a single one—or even a small bunch—of these technologies rise to the top to take a market lead or even set a direction. That’s partly because some of these new techs look more like niche or specialized products than general-use storage, and because the technologies (in many cases) still have some significant limitations that have held them
back from more widespread acceptance.

Let’s break things down tech by tech—assuming hyper-converged systems, all-flash arrays, cloud storage and software-defined storage are the hottest recent developments in the storage sphere.

A LOT OF CONFUSION PERSISTS AROUND THIS STORAGE TECH MARKET, DESPITE THE EFFORTS OF VENDORS, ANALYSTS, JOURNALISTS AND JUST ABOUT EVERYBODY ELSE TO DEFINE IT.

- **Hyper-converged systems.** These are more than just storage, of course, but some companies are buying them, or at least evaluating them, when they’re ready to retire an older array. Hyper-convergence offers attractive advantages such as convenience, ease of use, fast deployment and so on, but many of these systems lock you into a single hypervisor, some have very limited scaling options and, if you plan to hook in physical or virtual servers outside of the hyper-converged ecosystem, you can forget about it; this is not your father’s networked storage. (See this month’s cover story, *Hyper-converged systems deliver storage in a bundle.*)

- **All-flash arrays (AFAs).** A lot of AFA vendors brag about how—through the magic of compression, deduplication and creative firmware engineering—they’ve brought down the price of all-flash arrays to just $3, $4 or $5 per gigabyte of capacity. That’s still a lot more than hard disk drive-based systems, and sometimes the compression/dedupe ratios used to derive the “effective capacity” are, shall we say, a tad optimistic. As much as AFAs have begun to look like good old enterprise arrays by adding snaps, replication and other big-boy features, their key attribute is blinding speed to feed your most performance-hungry applications.

- **Cloud storage.** Cloud storage is cheap and easy, expands and contracts as your needs change, and it helps you to avoid all kinds of costs like labor and developing specialized expertise. True? Well, sort of. But there are some serious tradeoffs to those benefits. If your capacity actually needs to contract at times, the cloud is a pretty attractive alternative, but in most companies, capacity grows and grows. It’s also true that storing data in the cloud helps you to avoid the cost of an on-premises storage system and the power and space it requires. But you’ll be paying to keep your data in the cloud forever. So what might seem cheap at first isn’t such a bargain when you multiply the costs by months or years or decades. And getting data in and out of a cloud storage service is still the chief bottleneck.

Sure, you can spin up virtual machines in the cloud and access that data without actually retrieving it, but that puts your servers in the cloud, too. A lot of companies are still very uneasy about shipping so much of their intellectual property into the ether.
Software-defined storage. A lot of confusion persists around this storage tech market, despite the efforts of vendors, analysts, journalists and just about everybody else to define it. It has a very enticing “we only have to buy software” air about it, but as everyone knows, storage is also about hardware. As the category has evolved into things like VMware’s EVO:RAIL software, it becomes clearer that while the software might be doing a lot of the defining, the hardware is still doing the heavy lifting. This product category still needs to sort itself out and be able to present more concrete benefits before it can shake off the niche label.

So, storage still needs a fair amount of sorting out. I have no doubt that each of the above technologies will mature and assume key roles in many companies’ storage infrastructures. But until they do, expect those blizzard conditions to persist.

RICH CASTAGNA is TechTarget’s VP of Editorial/Storage Media Group.
A LOT OF ink has been spilled by vendors and their evangelists extolling the benefits of various “preferred” solutions for speeding up slow-going virtualized workloads. Truth be told, the entire discussion has taken on a kind of Bizarro World characteristic that has mostly gone unnoticed and undocumented by the trade press. If, like me, you long for fact-based analyses of your IT problems, here’s a stab at a discussion of *storage in virtual server environments* that doesn’t conflate, confuse or otherwise draw false causal relationships between disparate data points.

**STORAGE BECOMES VIRTUALIZATION’S WHIPPING BOY**

Almost as quickly as server virtualization came into vogue as more than just a useful test-bench tool—that is, to facilitate the consolidation of servers through single-server multi-tenancy—we started hearing about the evil impact of legacy storage. Storage, as we’ve been told repeatedly, is directly responsible for the *slower performance of workloads* once they’re virtualized and instantiated in hypervisor environments.

Originally, a lot of the villainization of data storage focused on known deficits of contemporary storage products and topologies. Evil storage vendors had long insisted on deploying their boxes of disk drives with proprietary controllers hosting proprietary software functionality designed as much to lock in the consumer and lock out the competitor as to deliver any sort of superior capabilities. Combine that with the industry’s unwillingness to work and play well together on a common management approach that would enable the infrastructure to be maintained, scaled and configured holistically rather than on a box-by-box basis, and you have all the ingredients for cooking up a flawed and costly infrastructure. The above points are hardly debatable, of course. Things got so bad in the early 2000s that analysts actually encouraged their clients to source all storage from a single vendor in the hope that homogeneity would enable coherent management—a linchpin, together with data management, of any cost-containment strategy.

So, we can all agree that unmanageable storage was the root of many evils in IT. It meant oversubscription with...
underutilization, driving the need for more capacity and bigger Capex spends. And it required more IT personnel with specialized skills in storage architecture and administration to manage the gear and interconnects, so Opex spending was high and to the right.

IS STORAGE REALLY TO BLAME?
While we can agree that these characteristics of storage were undesirable and in need of remedy, they didn’t explain the problem of slow-performing virtual machines (VMs). Yet, VMware and other hypervisor vendors insisted on making a false correlation and causal relationship between the problem of virtual machine performance and proprietary storage. That resulted in approaches like VMware’s vaunted vStorage APIs for Array Integration in 2006 and even its more recent “software-defined storage” play, Virtual SAN, which continue to address the problem of slow VMs by attacking evil storage.

There may be some instances where storage latency—the speeds and feeds of storage devices and networks or fabrics that connect them with servers—can slow application performance. This is well understood and typically addressed through a combination of caching and parallelism; the former is used to collect writes at a fast storage layer, making the slower storage invisible to the application, while the latter increases the number of actuators working a task (such as I/O processing) so more work gets done in less time. We begin to try different strategies after we’ve identified that application I/O is encountering a log-jam somewhere on the pathway to the storage through the combination of software (APIs, command languages and protocols) and hardware (host bus adapters, cables, switch ports and device connections) that connects the app to its stored data. A simple indicator that a problem exists in this path is the existence of a greater than expected I/O queue depth, which is a lot of writes waiting to be written to the storage device.

WHEN PROCESSORS RUN HOT, IT USUALLY INDICATES A STRUGGLE TO RESOLVE A PROBLEM THAT EXISTS IN THE APPLICATION INSIDE THE VM OR IN THE HYPERVISOR SOFTWARE ITSELF.

Only, with most of the slow VM performance I’ve encountered at client sites and in our labs, storage queue depths are pretty shallow. The problem of slow VMs, in other words, cannot logically be laid at the doorstep of storage latency. At the same time, in most of these situations, the rate of processor cycling on the server hosting these slow-performing VMs tends to be extraordinarily high. When processors run hot like that, it usually indicates a struggle to resolve a problem that exists in the application inside the VM or in the hypervisor software itself. In short, the logjam exists above the layer of the storage I/O path.
YOUR HYPERVISOR COULD BE THE BOTTLENECK

So, evil, proprietary legacy storage may not be to blame for your slow VMs. It’s likely the problem is your hypervisor or virtualized application. This begs the question of why you would want to unplug all your existing storage—in many cases an infrastructure you’ve spent considerable energy and budget consolidating into a SAN or carefully deploying as NAS file servers in your network—only to replace it with direct-attached JBODs operating under your hypervisor vendor’s latest software controller kit.

The I/O blender effect is real. When you stack a bunch of VMs and simply let them run wild, blending lots of random I/O into an incoherent mess of writes that will, in short order, burn out your flash and clutter up your disk, you will likely have VM slowdowns. Again, this isn’t a problem with storage per se, but with your hypervisor strategy. Assuming you want to stick with your hypervisor, you may want to consider a more efficient way to organize and write data—whether using a log-structuring approach from a vendor like StarWind Software, an efficient software controller from PernixData or an uber-controller from DataCore Software—that doesn’t require you to change your underlying storage hardware infrastructure.

As for ripping and replacing your legacy storage for a server-side approach, the choice is yours. But be clear on why you’re doing it. My research has discovered little supporting data to suggest that displacing legacy storage with DAS will do anything to address slow virtual machine performance. Do yourself a favor and use some simple meters, available on every operating system, to examine processor activity and queue depth before you settle on a remediation strategy.

JON WILLIAM TOIGO is a 30-year IT veteran, CEO and managing principal of Toigo Partners International, and chairman of the Data Management Institute.
Hyper-converged systems deliver storage in a bundle

Hyper-converged systems include storage, servers and networking all in neat little nodes—but some assembly may be required.

BY CHRISS EVANS

HYPER-CONVERGED SOLUTIONS became one of the hottest technologies of 2014, gaining mainstream credibility with the release last year of EVO:RAIL, a suite of hyper-converged hardware solutions from VMware and its selected partners. Hyper-convergence has developed rapidly, so we’ll look at how it’s defined and why you should give some serious consideration to products in this market segment as you build out your data center storage infrastructure.

HYPER-CONVERGENCE EVOLUTION: BACK TO THE FUTURE

In the late 1990s/early 2000s Unix and x86 platforms emerged as mainframe replacements. In a contraction/expansion process that seems to reverberate regularly around the technology industry, closely coupled mainframe systems diverged into specializations based around networking, storage and servers. As server virtualization gained ground, divergence of technologies resulted in large organizations deploying huge teams of highly skilled (and well paid) technology specialists. This siloed approach resulted in technology sprawl and increasing operational costs, in many cases dwarfing the acquisition costs of the technologies themselves.
A **converged infrastructure** was the first step in simplifying the operational issues associated with the siloed model. Those products combined technologies from multiple vendors into a single stack of compute (servers), storage and networking, usually sold as a single stock keeping unit (SKU). Converged solutions reduce operational complexity by simplifying the technology choices that are deployed and by providing a single point for management and support—the proverbial “one throat to choke.” In most cases, converged infrastructure doesn’t offer the hardware platform at a cheaper cost, but the overall TCO is lower due to reduced operational costs.

**HYPER-CONVERGED INFRASTRUCTURE DEFINED**

Hyper-converged solutions take the integration process introduced with a converged infrastructure **one step further**. The physical components of storage and compute are combined into a single physical form factor, typically a rack-mounted server, using commodity DAS. Resiliency that would typically be achieved in storage systems through the use of dual-controller-type architectures is implemented in hyper-converged solutions by scaling out with multiple nodes—a feature that would already be in place to support server resiliency and failover for the hypervisor.

Hyper-converged offerings typically use commodity hardware (although some still have bespoke components) rather than custom ASIC or field-programmable gate array (FPGA) chips used in dedicated storage systems. As a result, the secret sauce or key differentiators of hyper-converged products are baked into the software, which is where the main benefits are derived.

All of today’s hyper-converged solutions are based on using a server hypervisor, including VMware vSphere, Microsoft Hyper-V and open source KVM.

**DISTRIBUTED STORAGE**

A **key feature of hyper-converged solutions** is the use of distributed storage. DAS components from each physical server are combined to create a logical pool of disk capacity that uses all resources in the scale-out node cluster. This scale-out technique provides a number of benefits, including:

- **Resiliency:** Data protection is implemented across multiple nodes, providing for the loss of any single disk or even an entire node.

- **Performance:** I/O for any single virtual machine (VM) can be distributed across an entire cluster of servers. This allows the aggregation of I/O bandwidth from many hard disk drives or solid-state drives to be combined. Where data is locally located with a VM, the latency of hyper-converged storage can be lower than accessing an external SAN-connected array.

The use of scale-out technology means local commodity DAS can be used in place of a more expensive dedicated SAN-based storage system. The storage component of hyper-convergence is implemented either as a VM across

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The use of scale-out technology means local commodity DAS can be used in place of a more expensive dedicated SAN-based storage system. The storage component of hyper-convergence is implemented either as a VM across
the infrastructure or, in the case of VMware, as a kernel module (VMware’s Virtual SAN technology). There’s wide debate on whether integrating storage into the kernel is a better solution than keeping it out. Kernel proponents (e.g., VMware) say this kind of solution is more resilient than VM-based implementations, as the storage features aren’t impacted by the activity of other virtual machines.

In contrast, those advocating VM-based storage will point to the benefits of separating storage from the hypervisor “operating system” in the same way that shared SAN storage removed data from the server. Claimed benefits include the ability to upgrade more flexibly, fault isolation (storage doesn’t take compute down), and performance and security isolation. In either case, the best solution will be in the quality of the implementation.

SOFTWARE-ONLY VS. HARDWARE HYPER-CONVERGED PRODUCTS
Before we discuss some of the benefits (and disadvantages) of using hyper-converged solutions, we should pause a moment and discuss the delivery model. Hyper-converged solutions can be delivered either as appliances, providing both the hardware and the software, or as software-only products.

Products that ship as appliances have a number of distinct advantages over pure software offerings:

- **Integration tested.** Vendors have performed all the integration testing with individual components to ensure the configuration runs efficiently. This means, for example, that the most appropriate host bus adapter and SCSI controllers will be implemented and validated for performance and reliability. As systems are upgraded, vendors have a smaller subset of hardware to test, making the upgrade process easier to control.

- **Performance benchmarked.** Vendors can benchmark their own solutions, providing good guidelines as to how many VMs a configuration can be expected to support. This gives users more control over the specific model(s) and quantities they need to purchase to meet a defined requirement.

Software-only solutions proponents say their products remove the “hardware” tax that vendors charge for performing all the component validations. For organizations that are already comfortable with a specific hardware supplier, a software-only solution lets them simply deploy on hardware that may already be in place or that can be acquired more cheaply under an existing supplier agreement. The downside is the loss of that “one throat to choke,” so diagnosing specific problems (as has been seen with VMware VSAN and SCSI controllers) can be a significant problem.

HYPER-CONVERGED BENEFITS AND DISADVANTAGES
Whether in appliance or software-only form factors, hyper-converged infrastructure products offer users appealing benefits but, as expected, they also have some disadvantages.
Ease of deployment. This is probably the most widely quoted cost and resource saving of hyper-convergence. Hyper-converged solutions can typically be installed and powered up within a matter of hours, rather than the days and weeks needed to implement a large-scale virtual server solution from scratch. This saving is typically more likely to be experienced by smaller organizations that can’t afford dedicated engineering teams to put solutions together. Deployment benefits, of course, were among the strongest attractions of the first converged infrastructure solutions to appear.

Lower cost. It’s debatable whether hyper-converged solutions are cheaper than deploying a custom virtual server solution, at least from a hardware perspective. However, when operational costs are also taken into consideration, hyper-converged solutions typically result in lower costs for many organizations.

Ease of management. Hyper-converged solutions can offer users easier management than custom solutions. For example, over time hyper-converged nodes can be retired from a cluster as new ones are added, providing a continuous upgrade path. In addition, vendors are working to improve the ecosystems of their products by adding or improving monitoring and alerting functions that allow them to provide pro-active support on hardware failures.

Resource depletion. Because nodes in a hyper-converged solution provide both compute and storage, which itself can be divided into capacity and performance, there’s always a risk that additional capacity for compute or storage will need to be purchased before the other is fully utilized. Vendors have attempted to address this issue by delivering multiple node configurations and supporting asymmetric node configurations, allowing many different node types to be mixed within the same configuration.

BEST USE CASES FOR HYPER-CONVERGED SYSTEMS
As with any storage technology purchase decision, an evaluation of hyper-converged solutions must start with how they may fit into one’s data center environment. Initially, these products were adopted primarily by small to midsize enterprises, especially those strapped for resources and looking for simplified operations. From an application perspective, there are no restrictions to the applications that can be deployed, although those requiring high performance may not be as suitable (some vendors are addressing performance issues). So companies are using hyper-converged systems for all types of workloads, making it a challenge to traditional vendors selling individual component architectures. On the other hand, hyper-converged systems may be appropriate for more discreet tasks, such as supporting virtual desktop infrastructure environments or hosting other types of standalone applications.

SAMPLER OF HYPER-CONVERGENCE PRODUCTS
The market of true hyper-converged players is actually quite small, with a few notable appliance vendors and a range of software-only vendors.
**Nutanix (appliance).** Nutanix Inc. is probably the best known appliance-based hyper-converged provider. The company was founded in 2009 and shipped its first products in 2011 under the branding of “No SAN” long before the term hyper-converged became part of the IT lexicon.

Nutanix’s main product is the **Virtual Computing Platform (VCP)**, a scale-out, node-based product originally built on VMware’s vSphere ESXi hypervisor that now supports Hyper-V and KVM. VCP implements storage functionality with a feature called the Nutanix Distributed Filesystem (NDFS), a Google File System-like distributed storage layer that uses features such as MapReduce to implement data deduplication and other space-efficiency features.

The Nutanix hardware platform is available in six different model series of increased capacity and performance, including the new all-flash NX-9000. Nutanix recently partnered with Dell to **distribute the Nutanix software on Dell hardware**.

**SimpliVity (appliance).** SimpliVity Inc. was also founded in 2009, launching its first products in April 2013. The company **sells OmniCube**, a scale-out, node-based appliance. SimpliVity offloads some of OmniCube’s data optimization tasks to a dedicated PCI Express card that manages data deduplication and compression in real time. This data reduction is globally federated, allowing OmniCube deployments to be geographically dispersed for data protection, as only new data needs to be replicated between locations (after initial VM images have been seeded).

**Scale Computing (appliance).** Scale Computing has taken a different approach to delivering hyper-convergence, including using the **open source KVM hypervisor**. This has required the company to build its own clustered block-based **storage layer** known as Scale Computing Reliable Independent Block Engine (Scribe). Scribe abstracts the physical storage and implements I/O caching across all available resources. The company also created a state engine to manage the status of all physical hardware components.

Scale Computing is focused at the SMB/SME end of the market, and is looking to capitalize on the use of open source software to **remove the “VMware tax”** of other solutions.

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**Triple towers of IT are merging**

**HYPER-CONVERGENT** solutions collapse the traditional towers of storage, networking and compute into the single form-factor of the server. The watchword of these products is simplification; they remove the need to have specialist skills like storage management and therefore have been enthusiastically adopted by large and small enterprises alike. For many, hyper-converged will follow server virtualization as the de facto standard for deploying new workloads.
Nimboxx (appliance). Nimboxx Inc. is another hyper-convergence vendor that built its product using open source software, KVM in particular. The company claims its systems can be deployed in less than 10 minutes and deliver up to 10 times greater storage performance than its competitors.

Gridstore (appliance). Gridstore Inc. has recently re-positioned its Hyper-V-based scale-out storage solution as a hyper-converged offering called the Gridstore Hyper-Converged Appliance. The product line includes systems with all-flash or hybrid storage. Storage capacity can also be increased by adding dedicated hybrid or capacity storage nodes.

VMware EVO:RAIL (Software, reference model). The EVO:RAIL platform was announced by VMware Inc. at VMworld 2014 and is a collaboration between VMware (providing the software) and a range of hardware partners that currently includes Dell, EMC, Fujitsu, Hewlett-Packard, Hitachi, NetApp and Super Micro Computer. The solution delivers on VMware’s vision for the software-defined data center and includes components such as VMware Virtual SAN to provide the distributed storage layer and quick-start custom software for rapid deployment. The major negative to using EVO:RAIL is the tie-in to VMware as this is the only supported hypervisor; however, that may not be an issue for many customers.

In the software-only category, solutions are available from VMware (using VSAN as a software package only), Maxta Inc., Atlantis Computing, DataCore Symphony, EMC ScaleIO and StarWind. These products aren’t as fully packaged and feature-rich as the appliance offerings, so they require some degree of customer expertise to handle the required integration.

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Snapshot 1
Storage for VMs has improved, but it’s often still an issue

How many virtual servers does your company have?

- 7% None
- 16% One to nine
- 28% 10 to 99
- 22% 100 to 499
- 11% 500 to 999
- 11% 1,000 to 4,999
- 5% 5,000 or more

What’s the main type of storage you’re currently using for virtual servers, and what kinds of storage are you evaluating for purchase?*

<table>
<thead>
<tr>
<th>USING NOW</th>
<th>EVALUATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre Channel SAN</td>
<td>67%</td>
</tr>
<tr>
<td>iSCSI SAN</td>
<td>25%</td>
</tr>
<tr>
<td>Network-attached storage (NAS)</td>
<td>22%</td>
</tr>
<tr>
<td>Other</td>
<td>12%</td>
</tr>
<tr>
<td>Direct-attached storage (DAS)</td>
<td>10%</td>
</tr>
<tr>
<td>Unified storage system</td>
<td>9%</td>
</tr>
</tbody>
</table>

What storage-related challenges have you encountered since virtualizing your servers?*

- 43% Increased capacity requirements
- 32% None
- 17% Poor performance
- 17% VM backup/restore issues
- 17% Increased CPU and memory demands

* MULTIPLE SELECTIONS PERMITTED

*MULTIPLE SELECTIONS FOR “EVALUATING” ALLOWED*
Historically, backup and archive data has represented the most comprehensive data set in many organizations. But this data is rarely used for anything other than restoring deleted, corrupted or otherwise lost primary data. This is a noble duty in and of itself, but the excitement about big data analytics is leading some users to believe that there’s value in this aggregated data collection. While some of this attention may be unfounded, there’s an opportunity to turn some of the cost of backup into a resource. But to achieve that, it’s necessary to rethink the backup process.

In this article, when we talk about mining a company’s existing data for potential value, we’re talking about searching and accessing stored data, not about complex big data comparisons that require source data sets to be normalized or converted into different formats. One example could be finding customer data that fits specific criteria, such as purchasing behavior or demographics. Another example may be searching existing digital assets, such as stored videos or images, for data that may pertain to a current project.

Index and Search
To search and access stored backups, the backup application must provide an index for data objects (files) that fit certain parameters, since these backup applications...
typically store data in a proprietary format. Most of these applications were designed to provide fast backups while minimizing the amount of storage consumed. But some backup software providers, such as CommVault and Hewlett-Packard, include more advanced search and archive capabilities.

**SCALE-OUT NAS THAT LEVERAGES HIGH-CAPACITY DISK DRIVES OR TAPE CAN BE AN EFFECTIVE WAY TO STORE DIGITAL CONTENT BUT STILL KEEP IT ACCESSIBLE.**

CommVault collects backup and archive data using a single-pass process, storing data in a repository. Backup and archive data are cataloged in one index, and users can search across all data from a single screen. While this capability is most often deployed for compliance reasons, it can also facilitate data access for business analysis.

Snapshots are a common technology used to provide faster backups and increased efficiency. But they also make data retrieval more complex, especially when potentially hundreds of snapshots are created. Today, some legacy backup vendors have added snapshot index-and-search capabilities to backup software platforms to improve data access for shops that rely heavily on snapshots as part of their data protection strategy.

Another way to search proprietary data sets is to create an external index. Companies like Index Engines have built a business supporting the legal industry with products that crawl the network and catalog unstructured data, including data stored on backup systems. The primary use case for these products is in response to e-discovery requests, where all data objects pertinent to a given legal event can be culled and made available to the court. These indexes can also enable the search and access required to support business analysis.

**ARCHIVING UNSTRUCTURED DATA**

Most of the data growth in recent years has come from unstructured data, especially digital content, relatively large files created and seldom modified, such as images, video and audio. These data objects can represent a significant investment, so they’re saved for long periods of time, often indefinitely. But they need to be accessible at the file level to support immediate use cases, such as applications driven by current events or market conditions. These characteristics—large size, long retention time and static nature—make these objects ideal for moving out of traditional backup systems and storing in an archive. Moving data from backup into an archive improves search and helps to support the goal of pulling additional value out of stored data.

Scale-out NAS systems that leverage high-capacity disk drives (near-line SAS) or tape can be an effective way to store digital content but still keep it accessible. Solutions like StrongBox by Crossroads Systems Inc. can incorporate archive functions within a NAS architecture to...
significantly lower the overall cost per gigabyte compared to traditional disk arrays. While these storage systems don’t provide search functions themselves, data is still accessible via standard file formats to applications that do.

For data sets that can get exceedingly large, but must remain on disk, object storage platforms with an integrated file system or NAS gateway offer viable alternatives to traditional file storage. These are the architectures deployed by most public cloud storage providers and many enterprise private clouds. While object storage systems are used as unstructured data repositories, object-based architectures also represent a technology that can enhance the value-added processes this article focuses on.

**COPY DATA MANAGEMENT**

Companies face an accumulation of data copies used to support disparate applications, such as data protection, disaster recovery, test and development, business analysis and so on. Copy data systems essentially provide a single-instance repository by replacing these redundant data stores with a common storage area. There are several methods these products use, but one process is to create a golden copy of every file under management and keep it updated with incremental change tracking. This copy is then used to create virtual copies as needed for applications such as data protection and business analysis.

Copy data systems are available that can store both unstructured data and databases, replacing backup altogether for the data objects they store. Since they store files in their native formats, copy data management systems can be ideal for supporting data mining and business analysis.

**FUTURES**

In near the future, new technologies that provide capabilities not available today will come online. For example, object-based storage architectures have the flexibility to support much larger and more sophisticated metadata

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**Take a dip in a data lake**

**THE DATA LAKE** is a single instancing concept focused on “real” big data analytics, not the simpler search and access processes identified in this article. There are many definitions for data lakes, but most agree that they’re enterprise-wide data repositories designed to store data objects (using object-based architectures) in their native formats, as opposed to the format used by each particular application.

The objective is to make a company’s data more useful for analysis, without requiring format conversion or normalizing. Most data lake discussions involve Hadoop-based applications for running the analytics the data lake is supposed to espouse, and often the engine for management of the data lake itself.
stores than traditional file systems. This enables more data about each object to be retained within that object to support more content-specific searching and more detailed analysis.

Enhanced metadata is a capability object storage vendors are aware of and could add to their products’ feature sets, but most haven’t yet.

Object storage systems can support this enhanced metadata processing at scale, while maintaining storage performance. This ability is fundamental to the success object-based architectures have enjoyed to date in the cloud storage space.

**CONCLUSION**

Data mining is a concept that seems to resonate with companies across the board. The idea of reusing data that’s been stored for another purpose (like backup) is popular indeed. Backup, as an application, touches most of the data a company creates or uses, making it an ideal data set for supporting business analysis. If the deployed backup application provides adequate search capabilities, a company may be able to extract significant value from its stored backup.

However, many organizations store large data sets outside of the backup system to enhance search capabilities and save money, especially when data objects are large or saved for long periods of time. These data sets are also stored in native file formats, making them available for search and analysis by tools or applications designed for this purpose.

*ERIC SLACK* is an analyst at Storage Switzerland, an IT analyst firm focused on storage and virtualization.
Virtual server storage buyers need capacity, but also want to get advanced features.

**What are your key considerations when purchasing storage for virtual servers?***

- **Capacity**: 67%
- **Price**: 66%
- **High availability**: 63%
- **Computing speed**: 55%
- **Compatible with existing storage**: 45%
- **Technical support/consulting**: 37%
- **Vendor we've bought from before**: 19%

**How much storage capacity will your organization be purchasing?**

- 1 TB to 10 TB: 14%
- 10 TB to 49 TB: 31%
- 50 TB to 99 TB: 16%
- 500 TB to 999 TB: 8%
- 100 TB to 249 TB: 14%
- 250 TB to 499 TB: 9%
- 500 TB to 999 TB: 8%
- More than 1 petabyte (PB): 14%

**Which storage management features are you evaluating for purchase?***

- Automated storage tiering: 57%
- Thin provisioning: 51%
- Primary storage data compression: 42%
- Primary storage data deduplication: 40%
- Data archiving: 38%

*MULTIPLE SELECTIONS PERMITTED*
THERE HAS BEEN plenty of talk about all-flash arrays and hybrid flash/hard disk arrays, but deploying solid-state storage in a server is a popular alternative and one of the easiest ways to implement flash storage. There are a number of ways to deploy server-side flash, including SAS/ SATA disk form factors, PCI Express card-based flash, non-volatile memory express-compliant flash and dual in-line memory module-slot implementations. In addition, server-side flash technology can now be used as persistent storage, cache and even shared among other servers in the cluster. And new form factors, such as NVDIMM, and functions are on the way.

DISK DRIVE FORM-FACTOR SSDs

Disk drive form factors remain popular, and come in three sizes: 3.5 inch, 2.5 inch and 1.8 inch. They fit into the same drive bays as hard disk drives (HDDs) and are typically hot-swappable. Some solid-state drives (SSDs) are the same thickness as HDDs, while others are thinner. The 2.5-inch SSDs are the most common size of drive form factor for servers.

Dell recently announced a rack server model that
supports 1.8-inch SSDs. Nine 1.8-inch SSDs will fit into the same physical space as two 3.5-inch SSDs. If you need lots of IOPS in a small space, the 1.8-inch SSDs could be the solution for you. Capacities are also on the rise. For example, Samsung offers an enterprise-class, 2.5-inch SSD with 3.8 TB of capacity. We can expect more SSDs that exceed 2 TB in capacity to become available during 2015. Enterprise-class SSDs now exceed the capacities available in enterprise-class 10K rpm and 15K rpm disk drives.

**PCIe FLASH**
Another common form factor for servers is the PCI Express (PCIe) card. These cards install into a PCIe slot and provide very fast access to storage. In addition to their capacity, they are frequently described by their physical size—an important consideration for some smaller servers—with terms such as full-height full-length (FHFL) and half-height half-length (HHHL). These cards offer tremendous performance because connecting directly to the PCI bus offers very low latency. A drawback is that they are limited to a single server and require a power cycle of the server to install or remove them. Many PCIe SSDs require a PCIe 2.0 x8 slot in the server, but some of the newer products connect via a PCIe 3.0 x4 slot.

**BOOT DRIVES**
An increasing number of enterprise servers are being configured with solid-state storage as boot drives. At Demartek, we’ve been doing this in our lab since 2010, and we like how the operating system starts quicker and applications just seem to be snappier when loaded from SSDs. Boot drives typically don’t require the same performance levels as mission-critical application volumes, so more reasonably priced SSDs can be used for server boot drives. Because of the performance boost, using an SSD as a boot drive is another way to extend the life of a server.

**THERE ARE CURRENTLY TWO MEMORY CHANNEL FLASH FORM FACTORS: NON-VOLATILE DUAL INLINE MEMORY MODULE (NVDIMM) AND MEMORY CHANNEL STORAGE.**

**M.2** is a newer form factor designed for several different types of internally mounted devices, including SSDs. This card is 22 mm wide and has various lengths, ranging from 30 mm to 110 mm. These mount into a special M.2 PCIe slot and provide up to 480 GB of capacity, which is more than enough for a boot drive. This form factor is already available for laptop and desktop computers and will be available for some servers, possibly by the time you read this article.

A form factor similar to M.2 but slightly older is mSATA. These SSDs are mounted on a card approximately the size of a business card that is installed internally in a system. This form factor also started in laptop computers.
and may be used in servers, but the M.2 form factor will probably replace mSATA over time.

Server vendors are adopting another form factor from the consumer market known as microSD cards. This storage technology is used in some mobile phones and other small computing devices, and is expected to appear in some servers as boot drives. A server implementation will most likely use two microSD cards for redundancy.

The Supermicro SATA DOM (Disk on Module), also called SuperDOM, form factor is a proprietary form factor available on Supermicro servers. This is a very small flash drive that fits into a special SATA slot (we discuss SATA in the “Interfaces” section) in the vendor’s latest generation of server motherboards. This drive has enough capacity, up to 64 GB today, for a boot drive.

**MEMORY CHANNEL CONNECTED FLASH**

There are currently two memory channel flash form factors: non-volatile dual inline memory module (NVDIMM) and memory channel storage. Both form factors use the memory channel for the read and write operations to the device. They also connect into standard DIMM slots and provide storage, but do so in different ways.

NVDIMM incorporates DRAM, flash, control logic and an independent power source, typically supercapacitors. It operates as DRAM and, in the event of an unexpected power loss or system crash, saves the data in the DRAM onto the flash. When power is restored to the system, the DRAM data is restored from flash. NVDIMMs are available today in capacities from 4 GB
to 16 GB. Because of the relatively small capacities available, it is difficult to think of this as a large capacity storage device. But it is good for write caching, metadata storage, in-memory databases, memory queuing and similar operations that need full DRAM performance but with persistence.

Memory channel storage uses flash memory on a DIMM as a storage device. These devices are available in capacities up to 400 GB, but have single-digit microsecond latencies. There are a number of applications that require extremely low storage latencies that can take advantage of this technology. However, to make use of memory channel storage, the server motherboard BIOS/Unified Extensible Firmware Interface needs to know that memory and storage may be present in DIMM slots and be able to distinguish them. Some server makers are building motherboards with this capability today. There is currently a litigation action taking place between the two main companies that make these products, Diablo Technologies and Netlist, so supplies of the products may be constrained until the matter is resolved.

INTERFACES

Some of the solid-state storage device form factors, such as the drive form factor, use a variety of interfaces, including SATA, SAS and PCIe/Non-volatile memory express (NVMe). Others use a single interface such as SATA or PCIe.

SATA has been used as a single-device storage interface for several years. Traditional SATA, as we know it today, has reached the end of the line with the 6 Gbps (0.6 GBps) interface. There will not be a faster version of traditional SATA. Instead, SATA is moving to SATA Express, which uses up to two lanes of a PCIe interface to achieve 2 GBps with PCIe 3.0 and 1 GBps with PCIe 2.0. SATA can be used for drive form factors, M.2, mSATA and SuperDOM.

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Serial-attached SCSI (SAS) has been used for storage devices for several years and is moving forward with new
versions. The current version of SAS supports 12 Gbps, can connect multiple devices and has a roadmap for doubling its speed to 24 Gbps in the future. SAS refers to both the SCSI protocol and the underlying physical interface. SAS is also planning to take advantage of the PCIe physical interface with SCSI Express that will carry the same SCSI protocol, but over up to four lanes of the PCIe interface. SAS is used primarily for the drive form factor, and both SSDs and HDDs are available with the 12 Gbps SAS interface.

NVMe is a software interface designed for solid-state storage that uses PCIe as the physical interface, so it can be applied to the drive form factor, PCIe SSD cards and any of the newer PCIe form factors such as M.2. NVMe replaces the traditional SATA or SAS command protocols with a streamlined protocol that runs over PCIe. This allows for much greater performance and much lower latency. In our real-world testing of these devices in our lab, we have seen multiple GBps of performance from individual drive form factor and PCIe card SSDs.

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EVERYWHERE YOU TURN, there’s a speed-related analogy for solid-state: “It’s a turbo booster for your IT ecosystem” and “Solid-state storage is the Ferrari of the storage world.” This makes sense because solid-state storage technology provides an obvious performance benefit over spinning media technology, resulting in improved application response times and reduced latencies.

But sometimes focusing on the obvious can cause us to miss the bigger picture. Reduced latencies are just one of solid-state’s potential benefits, and overemphasizing this benefit may prevent some organizations from reaping larger rewards.

So why do so many miss the big picture? A cursory glance of the technology reveals the obvious: it’s really fast and a little pricy when compared to spinning media. In my conversations with IT leaders, I often hear that they want solid-state technology … but for a lower dollar-per-gigabyte price. That’s fine, but storage performance has never been purchased that way. For years, short stroking—trying to squeeze a few more I/Os out of each platter by throwing away capacity—was the rage. If price per capacity didn’t make sense for spinning media, why do organizations rely on it to compare performance-centric solutions today? It’s easier to do it that way. However, price per capacity is the wrong way to evaluate emerging solid-state storage technology, and it causes many individuals to overlook much of the disruptive power of solid-state.

BENEFITS OF SOLID-STATE STORAGE TECHNOLOGY
I often hear IT professionals say their solid-state is fast, but that their current storage performance is good enough. That’s a common response, as storage admins usually size their storage deployment to meet the needs of their applications.

That’s the challenge of focusing on storage performance alone. Some organizations don’t realize that by eliminating the storage bottleneck, solid-state technology can enhance the performance of the entire ecosystem and reduce costs across the IT environment. Here are a few examples of how solid-state storage technology can provide benefits outside of the storage system:
- **Fewer servers.** Eliminating the storage bottleneck enables each server to achieve higher utilization, allowing each system and processing core to deliver more capability. In turn, the same amount of work can be completed with fewer systems.

- **Fewer application licenses.** Many applications’ prices are determined by the number of processing cores, so fewer server cores mean lower application costs. Licensing can be a big part of an IT budget; I’ve spoken with some firms that have easily paid for their solid-state storage with money saved by reducing their application licenses.

- **Reduced support and warranty costs.** Fewer servers and applications translate into fewer licenses and warranties to manage. Fewer components to manage results in lower support costs and risk across the infrastructure.

- **Power and cooling efficiency.** Power and cooling concerns are a binary issue; either it’s a problem or it isn’t. If your data center is in a location where power and cooling is a challenge, you should already be evaluating or using solid-state storage technologies.

- **Lower network and infrastructure costs.** There are solid-state storage providers that can offer more than 100 TB of capacity with hundreds of thousands of IOPS in a 1U form factor. That level of storage efficiency can open up new and interesting possibilities. Advanced, high-performance workloads no longer need to be tethered to brick and mortar data centers. For example, seismic analysis for oil and gas exploration can be done on-site, even if that site is in the middle of the ocean. This freedom can speed data analysis and save the network and infrastructure costs of transmitting the data back and forth from the on-site location, which improves ROI.

- **Freed up manpower for more value-added opportunities.** Storage and server hardware, application licenses, warranties and maintenance contracts all require management. IT personnel resources are some of the most valuable in the data center. As organizations look for ways to better utilize their data, freeing up IT personnel from maintenance duties to provide value-added services can offer organizations a significant ROI boost.

Back within the storage system, reducing latencies may not be as important as providing predictability for more traditional IT applications. As application demands fluctuate or organizations add more workloads to the existing infrastructure, the extra performance headroom provided by solid-state (especially if the system offers quality of service capabilities), can ensure that increased organization demands won’t impact existing application performance.

The key takeaway is that the performance provided by solid-state storage technology is not limited to the storage system. If you were waiting for the ROI to improve before making an investment in solid-state storage, you may want to check your math. The value may already be there.

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All-flash arrays, hybrid arrays and a new breed

Oracle and HP prove that it’s just not a case of all-flash or hybrid when selecting a solid-state-enhanced array.

It’s easy to miss some of the subtle developments in flash-based storage systems while the market is raging and customers are deploying them across a wide array of applications and use cases. I’m specifically referring to a new approach to an all-flash array, exemplified by Oracle’s recently announced FS1-2 model. On the surface, Oracle’s storage system looks like an all-flash array but on closer inspection it looks like a hybrid with a large amount of hard disk drive storage. So which is it? Does it compete with the likes of EMC’s XtremIO all-flash array or does it go head to head with the likes of Nimble? To better understand this product, let’s reflect on the various ways flash is used in storage.

Flash background

Flash was first introduced in the form of a few solid-state drives (SSDs) replacing hard disk drives (HDDs) in an otherwise pure HDD-based array. That allowed for the creation of a small SSD tier that could be used for critical applications. Then came software that allowed the SSDs to be used as cache in front of all the HDDs to improve the performance of not just one or two but all applications running on the array. While this was taking place on the array side, companies like Fusion-io were making high-performance flash with a PCI Express interface that could serve any application running on the host server. Soon after, genuine hybrids arrived, arrays that were designed from the ground up to recognize that flash shouldn’t just be considered a replacement for HDDs. Hybrids from vendors like Nimble, Tintri and others used the full power of flash and made sure the interaction between flash and HDDs was such that performance approached that of all-flash arrays. Almost. The all-flash arrays were marketed with the premise that for the most mission-critical, I/O-starved applications nothing but an all-flash array would suffice. They were expensive, but cost was less important than performance.

Then several all-flash array vendors, notably Pure Storage, incorporated inline deduplication and claimed price parity for an all-flash array with a 15K rpm-based, high-end, HDD-based array. It’s debatable if 2014 was the
year the flash storage market matured, but it would be fair to say that there were more choices than ever with many superlative claims and a lot of overlap.

WHY ORACLE’S ARRAY IS SO INTERESTING

This all brings us back to Oracle’s new system. While the all-flash array market is expected to continue to grow at a CAGR of 50% or more for the next few years, most of the storage sold will be hybrid storage. It’s in this market that I see some subtle differences in architectures that I believe are important to understand.

Let’s look at Nimble as an example of a classic hybrid storage system. The product was designed from the ground up to recognize the availability of flash media. Each array would include a minimum amount of flash capacity to be used as cache. All writes go to flash and are then migrated to HDDs. Nimble, like several other vendors, calls this a flash-first philosophy. By all measures, the product delivers excellent performance improvements for most applications. But it is a hybrid, and compared to an all-flash array it will perform well; but in certain situations its “hybridness” will show and an all-flash array will win. Nimble even offers an all-flash version of its product that might come close to competing against other all-flash arrays. But its design center isn’t that of an all-flash array; it uses flash as an enhancer of the performance one would expect from HDDs.

But not the Oracle FS1-2. It’s an all-flash array, first and foremost. It doesn’t compromise on anything in that mode, and Oracle says it can compete head-to-head with the likes of EMC XtremIO, Pure, Violin and others. And yet it allows several petabytes of HDD storage behind flash.

What makes the product work is auto-tiering, storage domains and an extremely sophisticated quality of service (QoS) functionality. An application can be provided with an all-flash domain and get the same as an all-flash array. Yet other applications can get “hybrid” performance. It’s not easy to make something like this work. It requires a QoS the likes of which we have rarely seen. And the storage domain functionality allows it to be used in service provider environments where fine-grain controls are needed to satisfy a variety of disparate customers.

This is an unusual product in that its design center is an all-flash array that is extended to be hybrid. Contrast that to a flash-first hybrid whose design center is a hybrid that can also serve as an all-flash array when needed. The difference might appear trivial at first, but it’s not. All-flash array vendors are unlikely to add HDDs to their products anytime soon. Their battle cry is “all-flash” and why you should consider all-flash as a complete...
replacement for HDD-based arrays. That’s what makes the Oracle FS1-2 unique. But there are always exceptions that prove the rule. In this case, that would be the Hewlett-Packard (HP) 3PAR product line. Its all-flash incarnation is not simply SSDs sitting in HDD slots. It acts and performs like an all-flash array, but it can be configured as a hybrid as well. Unlike most other major vendors that added a brand new architecture for an all-flash array offering (e.g., EMC XtremIO and IBM FlashSystem) because it wasn’t feasible to extend their existing architectures to deliver an all-flash performance, HP was able to successfully extend the 3PAR architecture into the all-flash zone.

Cleary, flash has been a boon for IT. But given the wide variety of offerings in the market, finding the right product has become difficult at best. Hopefully, this discussion will help guide you in your selection.

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