ESG Lab Review

Datrium DVX: Server-powered Storage Unlocks VM Performance

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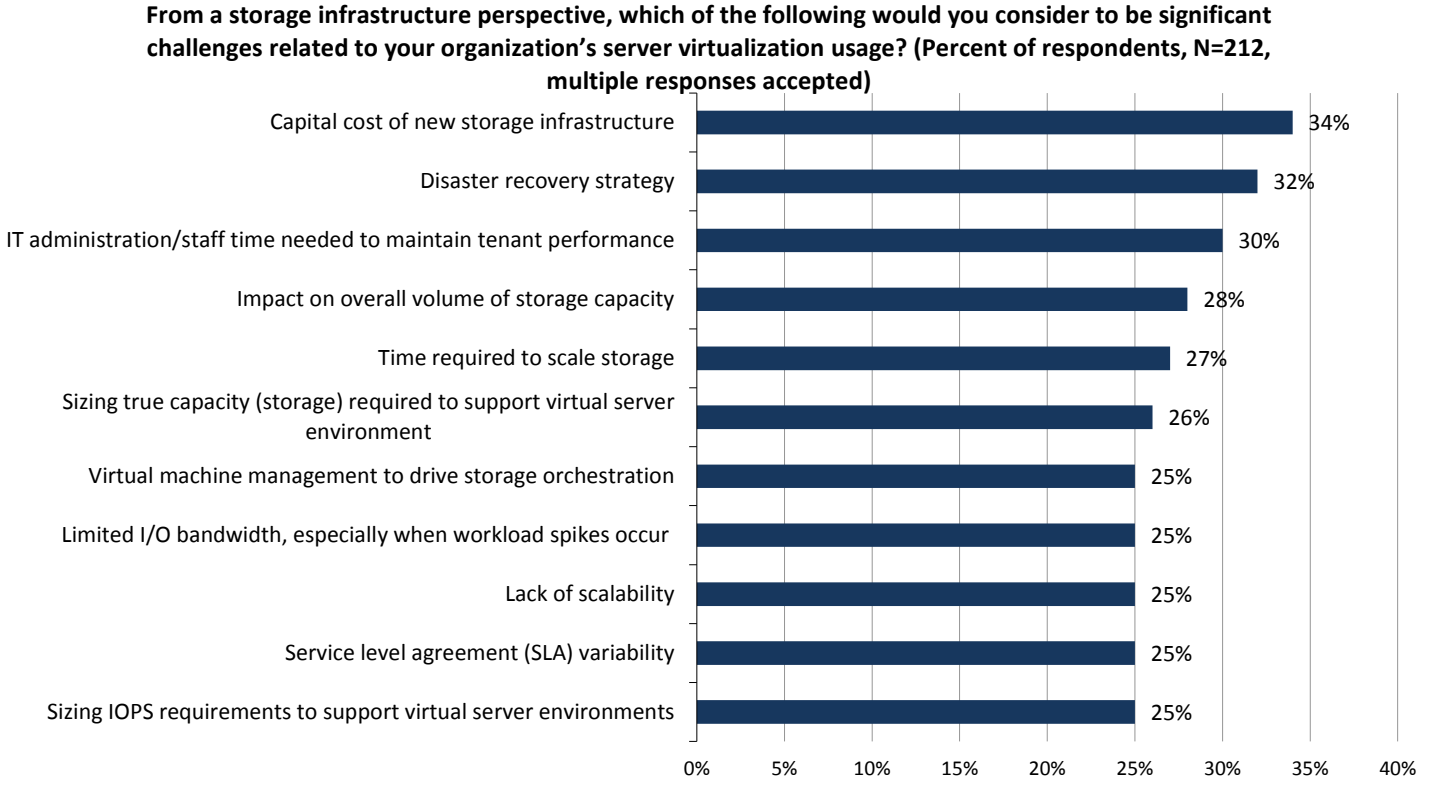
Abstract

This ESG Lab review documents hands-on testing of Datrium DVX, a server-powered storage solution leveraging host-based flash and CPU, software, and a durable capacity storage appliance to improve virtual machine (VM) performance and manageability.

The Challenges

Server virtualization has permanently altered the IT landscape by making workloads portable, enabling better utilization of resources, and reducing TCO. But challenges remain, particularly in delivering the right performance to all VMs. Contention between workloads impacts performance, leading IT to depend on expensive over-provisioning or array-based flash. For a recent investigation into server virtualization, ESG surveyed IT professionals familiar with their storage environments; as Figure 1 shows, the key VM storage challenges they cited were focused on storage cost and growth, staff time to maintain performance, sizing and managing the VM storage environment, limited I/O for workload spikes, and delivering the required I/O per second (IOPS). [1]

FIGURE 1. Top Ten Storage Challenges Related to Server Virtualization



Source: Enterprise Strategy Group, 2016

[1] Source: ESG Custom Research, *Storage Infrastructure Considerations for Virtualized Environments*, July 2015. All ESG research references and charts in this Lab Review have been taken from this study.

VMs can easily move between hosts, but it's not that simple to migrate storage. As a result, VM environments often use centralized, shared storage that distributes capacity to multiple servers. However, when high-priority workloads compete equally with low-priority workloads, the result can be insufficient resources and performance where they are needed most. As more workloads are added, the storage performance must be divvied up among more applications, resulting in SLA decay. Adding flash to the storage can help, but array-based flash is expensive, and trying to configure flash for specific VMs is an administrative nightmare—further driving up costs. In the same survey, when asked about the difficulty of aligning storage capabilities with VM requirements, more than one-third (39%) of respondents classified that task as either difficult or extremely difficult.

The Solution: Datrium DVX

Datrium DVX is a server-powered storage solution that leverages host-local flash and CPU plus a shared, durable storage capacity appliance. The Datrium DVX DiESL controller software is installed on multi-core VMware ESX servers that include 800 GB to 8 TB of any direct-attached flash supported by the server vendor. The software creates a read cache using host-local flash; data is deduplicated and compressed before being stored on flash, with typical data reduction rates of 2-6x. The combination of large amounts of flash and data reduction make it possible to configure a massive local read cache, resulting in virtually all reads for any VM on a host coming from the local flash. Compressed writes are sent to a Datrium NetShelf appliance (populated with near-line disk) where they are deduplicated post-process. Since no data persists on the host flash drives, server flash can be used, enabling much lower costs than storage array-based flash.

The Datrium solution eliminates the need for storage-oriented performance management, instead enabling administrators to manage VM performance through the allocation of server-side CPU and flash. Datrium DVX supports VMware vSphere 5.5 U2 and above, and comes with no-cost licenses for the DVX software on vSphere hosts. The vCenter plug-in enables VM-centered management, and there are no storage artifacts such as LUNs, tiers, or zones to be managed. When VMs need more performance, administrators can simply move them via vMotion to servers with more available compute, memory, and storage performance resources. The ability to isolate or relocate a VM to an appropriate host is also effective in eliminating the "noisy neighbor" challenges that can occur when VMs share network-attached storage resources or depend on other hosts for their storage resources.

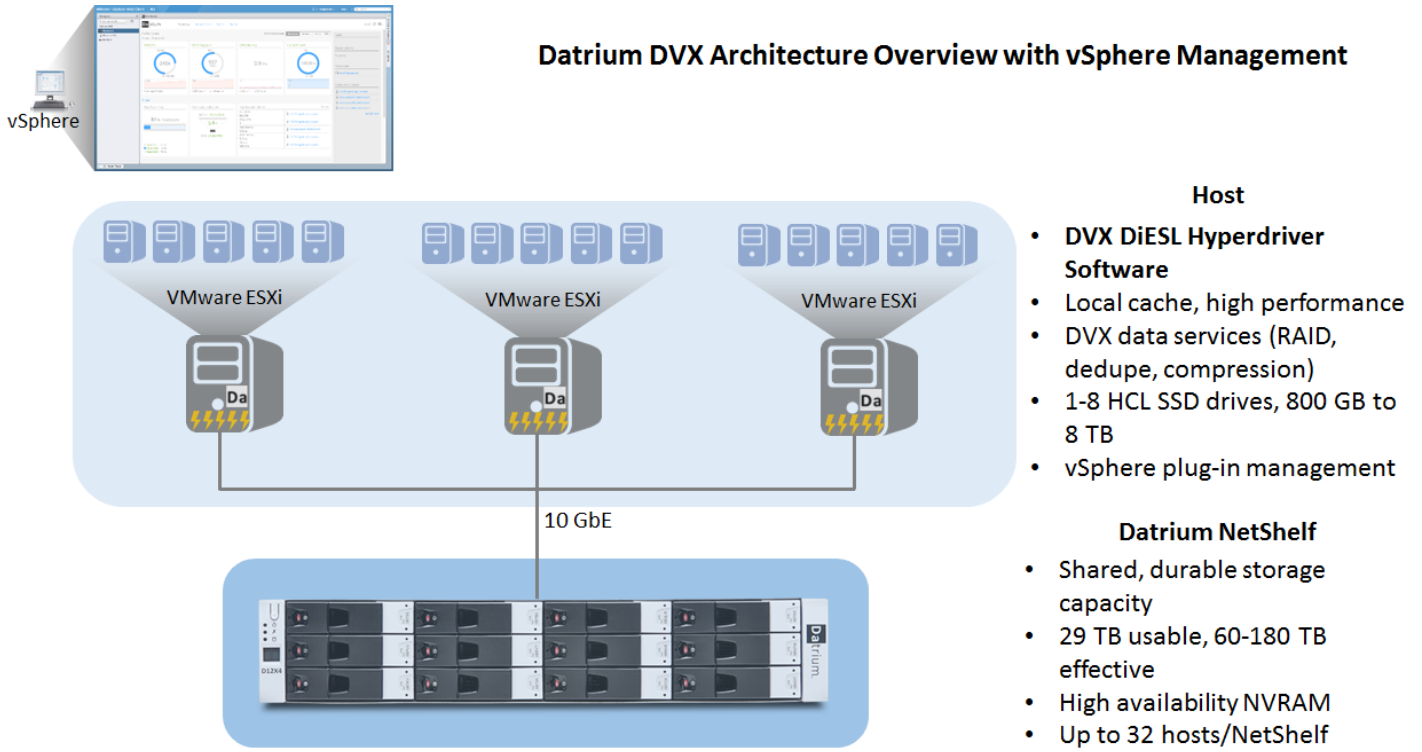
The solution consists of the two primary components: 1) Datrium DVX DiESL Hyperdriver software that is installed on VMware ESX hosts, and 2) Datrium NetShelf, a network-attached, durable-capacity storage appliance for data retention.

- Datrium DVX DiESL Hyperdriver Software. This software is installed on the host as a vSphere Installation Bundle (VIB). The DiESL Hyperdriver essentially makes the host flash a primary storage cache into the NetShelf data store, which is presented as a local NFS mount to the ESXi host. Typical storage services such as deduplication, compression, and RAID are handled by the Hyperdriver at the host. The default configuration (Fast Mode) consumes up to 20% of the available host CPU, while Insane Mode can be configured to consume up to 40% of CPU, though not exceeding @20 cores on a host. Administrators can toggle between Fast and Insane Modes on the fly.

- Datrium NetShelf. This durable capacity appliance provides 29 TB of usable capacity, which can effectively deliver 60-180 TB with the built-in data reduction; writes enter the NetShelf in a compressed format, and are deduplicated post-process. Each NetShelf appliance supports up to 32 hosts in a single ESX vCenter configuration. The appliance includes dual controllers (active/standby) for high availability and mirrored NVRAM for fast, persistent write acknowledgement. Each NetShelf includes redundant SFP+ and 10GbaseT 10GbE ports per controller, plus optional 1GbE management ports. Built-in resiliency includes automatic rebuilding for drive failures, plus alerts that trigger Datrium support services for proactive parts replacement.

Datrium DVX supports a wide variety of host-compatible flash modules, from low-cost, read-optimized SATA SSDs up to the fastest PCI-e cards, so organizations can select the optimal price/performance ratio for their existing or new servers. Customers can leverage their current server infrastructures, including blade servers, increasing ROI and reducing TCO; in addition, built-in capacity reduction enables more workloads to use the flash, reducing its TCO even further.

FIGURE 2. Datrium DVX Architecture Overview



Source: Enterprise Strategy Group, 2016

ESG Lab Testing

ESG Lab tested the Datrium DVX solution with a focus on simple management and performance scalability.

Ease of Management

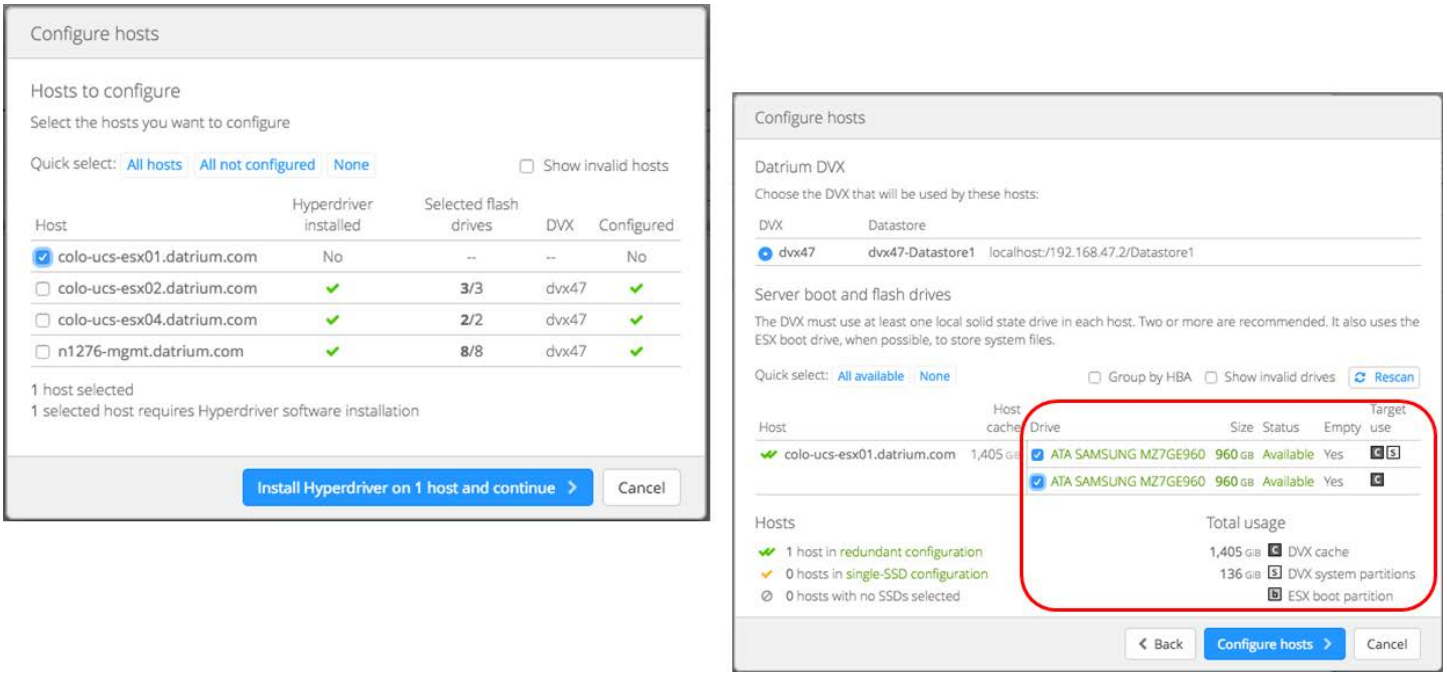
ESG Lab testing began with an exploration of the user interface, which included managing common tasks such as adding or configuring an ESXi host and migrating a VM to another host using vMotion. Administrators would undertake these tasks in order to change the performance profile for a VM.

We began with a Datrium DVX deployment using two ESXi hosts, four VMs, and a NetShelf that had already been assigned a network identity and registered with vCenter—two simple steps that complete the initial setup. After these steps, the Datrium solution was managed through an integrated vCenter Server Appliance (VCSA) plug-in. After clicking on the Datrium icon in vCenter and viewing the main dashboard, ESG Lab clicked ***Configure hosts*** from the drop-down settings icon. This launched a crawl through the vCenter inventory. A pop-up window displayed all the hosts connected to vCenter. ESG Lab selected the host (with two SSDs) that was not yet configured to Datrium (*colo-ucs-esx01.datrium.com*) and clicked ***Install Hyperdriver on 1 host and continue*** (see Figure 3, top). This initiated installation of the DiESL Hyperdriver software on the ESXi host, which took about two minutes to complete. Next, the Datrium DVX window opened (see Figure 3, bottom), and ESG Lab selected the *dvx47* implementation and two available SSDs on the host. This window also provides recommendations about server boot and flash drives, plus details of the SSD capacity, status, and DVX usage. Note that this

window shows how much flash is used for the actual DVX cache, as well as how much is used for DVX system and ESX boot partitions (red box). This provides administrators with a realistic view of the physical cache size, from which they can extrapolate potential cache size based on 2-6x capacity reduction in Datrium DVX.

ESG Lab clicked ***Configure hosts***, launching the configuration wizard to complete the installation, create partitions, and mount the data store, which took less than three minutes.

FIGURE 3. Adding a Host to Datrium DVX



Source: Enterprise Strategy Group, 2016

Once the configuration was complete, the dashboard displayed the updated configuration details.

Flexibility

Datrium DVX enables the flexibility to have a mixture of ESX hosts for different VMs based on performance characteristics. For example, for OLTP workloads that need high performance, IT might configure ESXi hosts with hefty processing and RAM resources and PCIe-based flash, while for test/dev clusters, they could use fewer cores, less RAM, and SATA-based flash. Also, as workloads change, organizations are not locked into storage arrays whose performance degrades over time as more hosts are attached, where the only way to increase performance is with a controller upgrade.

With Datrium DVX, adding hosts adds more server-powered storage capability to the current environment. The flexibility of configuring the right combination of ESX hosts with the best resource mix of CPU, memory, and host-based flash for storage performance allows organizations to leverage existing investments in virtualization components. The ability to mix and match host-side resources (existing or new) to meet the needs of application workloads provides a level of flexibility not typically found in array-based or hyperconverged infrastructure (HCI) solutions. In fact, when ESG asked IT managers in a recent survey about their concerns regarding HCI deployment, lack of configuration flexibility was the second most-cited concern, behind only the loss of pricing leverage.[2]

[2] For additional detail, please read the ESG Lab White Paper, *Datrium: Helping to Solve Server Virtualization Storage*.

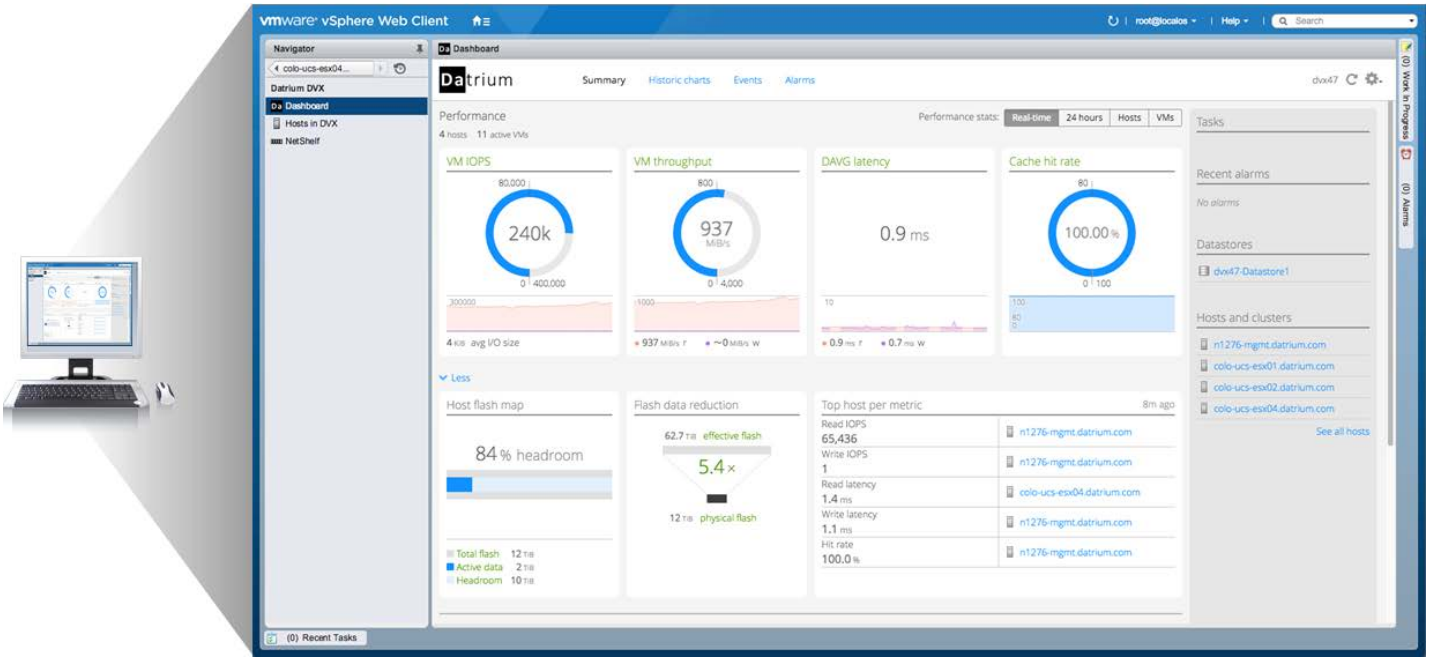
Monitoring

Next, ESG Lab explored several of the dashboards and charting options in the GUI. The main dashboard (see Figure 4) is focused on performance. Across the top are charts showing aggregate IOPS and throughput across all VMs using the Datrium storage, average latency experienced by the VMs, and cache hit rate. Notable features include:

- The DAVG latency shows end-to-end latency for all VMs in the context of the view; this is a much more useful metric than traditional storage solutions that display only storage latency, which is just a portion of what impacts the application.
- Cache hits are commonly 100% because the combination of inexpensive, commodity server flash and Datrium's data reduction makes it affordable to configure a cache size that will accommodate all in-use data, not just the latest active data.

The main dashboard can show real-time or 24-hour performance for VMs or hosts. In addition, this dashboard can display other host details including the amount of projected capacity headroom available for the host flash (an indicator of its ability to accept additional workloads); the capacity reduction rate, showing how much physical and effective flash is available; and which hosts are experiencing the highest IOPS or latency.

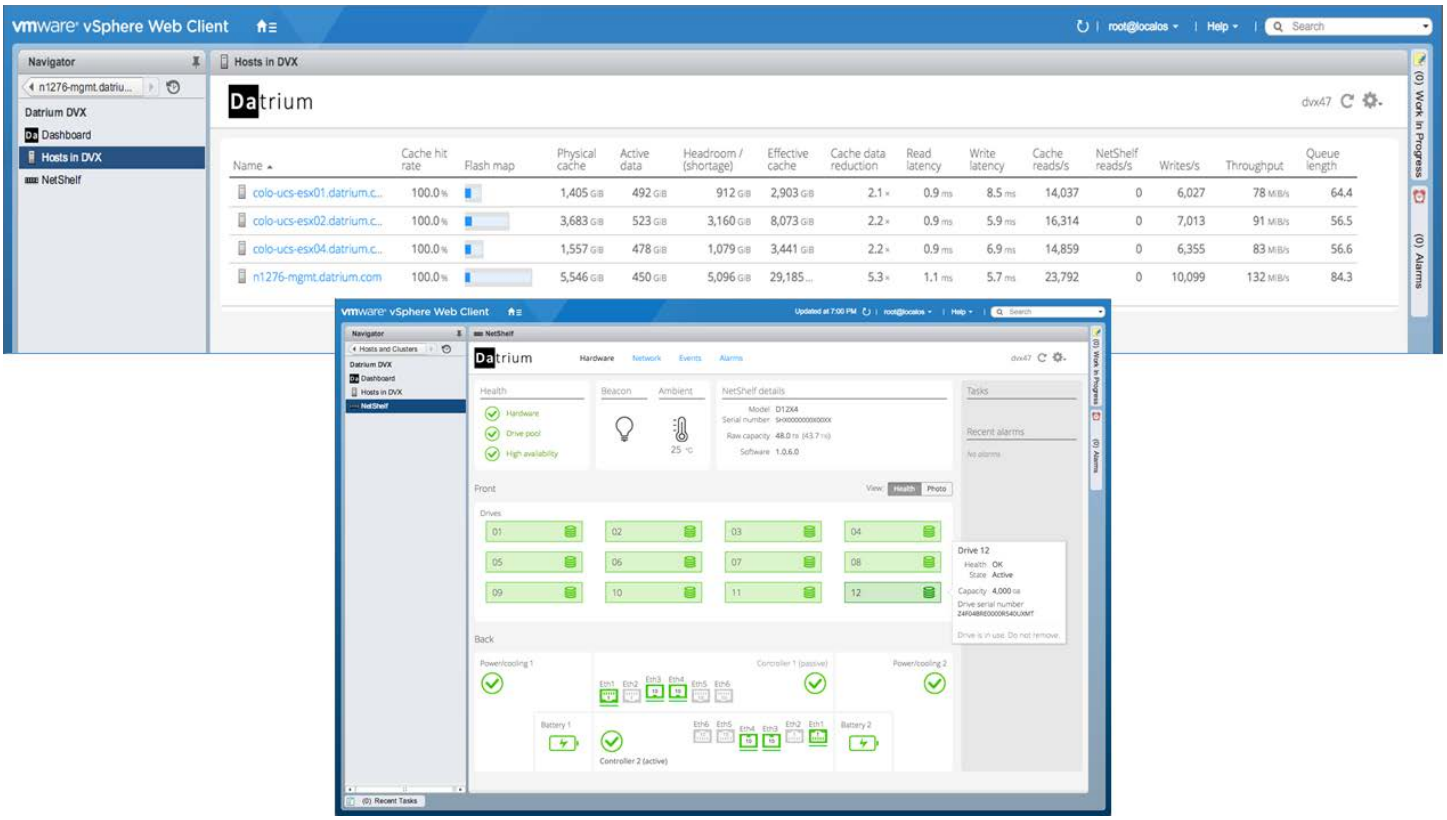
FIGURE 4. Main Dashboard



Source: Enterprise Strategy Group, 2016

In addition, there are specific dashboards for host and NetShelf details. The host dashboard monitors cache, flash headroom, data reduction, read and write latency, and more for all connected hosts (see Figure 5, top). The NetShelf dashboard provides a health and capacity overview; details for each disk drive; and power, port, and active/passive status details for the dual controllers. Green check marks indicate that all is well, and administrators can drill down into events and alarms (see Figure 5, bottom). Datrium automated support can monitor the health of ESX hosts and the NetShelf and proactively reach out to address customer problems.

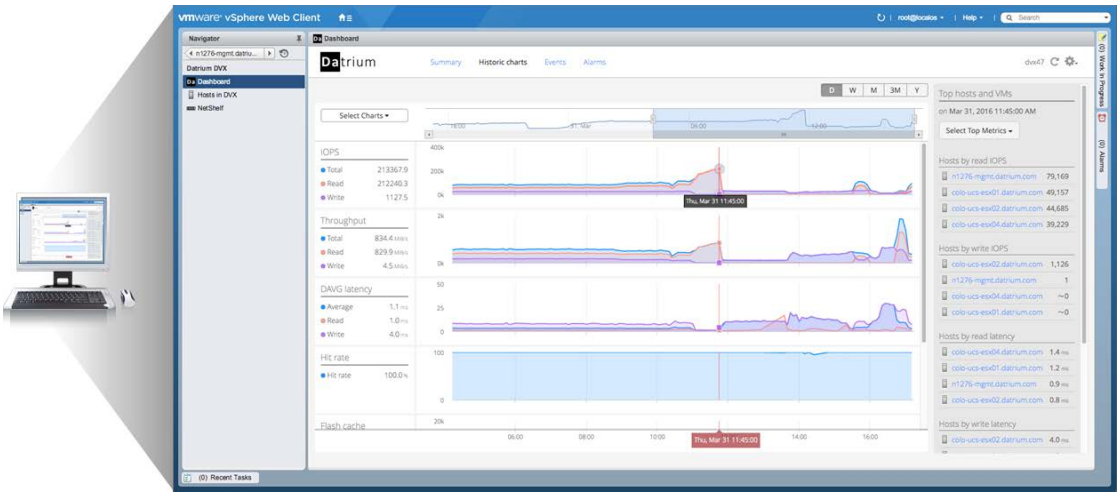
FIGURE 5. Host and NetShelf Dashboards



Source: Enterprise Strategy Group, 2016

Datrium DVX also shows dynamic key performance indicators (KPIs) and historic charts in the GUI, enabling administrators to identify host- and VM-level metrics by day, week, month, quarter, or year. On the VM dashboard, administrators can track KPIs such as the cached and active data, flash capacity reduction, latency, and throughput. Historic charts can be viewed for any metric (see Figure 6).

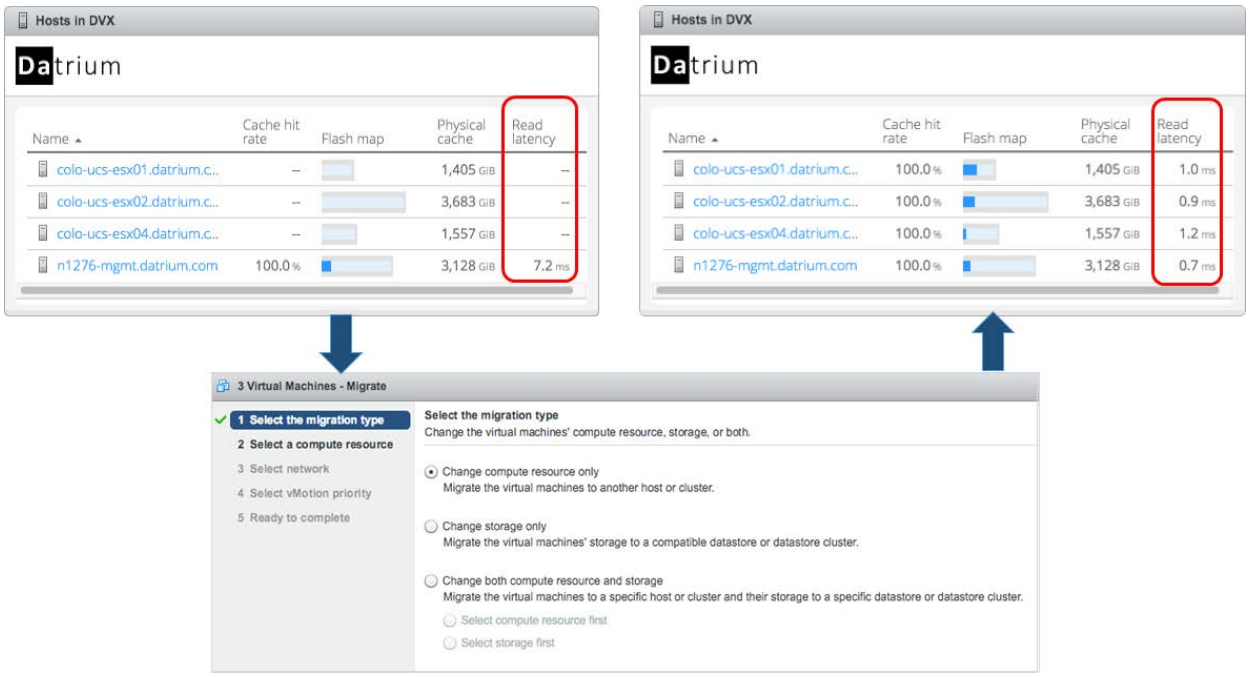
FIGURE 6. Historic Charts



Source: Enterprise Strategy Group, 2016

Finally, ESG Lab performed a vMotion migration to demonstrate the ease of managing VM performance. A single ESXi host (*n1276-mgmt.datrium.com*) in a four-host cluster housed 12 VMs with 7-8 ms read latency while running an FIO benchmark utility. The test VMs were designed to exert storage pressure on the containing host. We selected three VMs (*perfhost1, perfhost2,* and *perfhost3*); right-clicked; selected ***Migrate*** and ***Change compute resource only***; chose the new host we had previously added (*colo-ucs-esx01.datrium.com*); and watched as vMotion moved the VMs quickly. With two more iterations of this task, we had successfully distributed the load so that the 12 VMs were evenly distributed among the four ESXi hosts. Once this was completed, read latency dropped to 1-1.5 ms. Figure 7 shows the performance before and after the vMotion migration, with the latency highlighted in red. Overall performance of the 12 VMs increased nearly fourfold as the workload was shifted from a single ESX host and spread over four ESX hosts.

FIGURE 7. Improved Performance after vMotion Migration



Source: Enterprise Strategy Group, 2016

When a VM is migrated between hosts, the cache is read from the source host to the destination, enabling fast cache warm up on the destination host. It should be noted that when VMs are migrated between hosts, Datrium tries to read from the local flash to retain data locality. Because there is dedupe on block commonality across VMs on a given host, if a VM has already been on the destination host, the required blocks may already be on the local flash—if this is the case, no data is transferred. If not, data will be fetched from the source host, enabling flash reads and minimizing the need to fetch blocks from the NetShelf.

Why This Matters

Managing individual VM performance with traditional storage solutions is difficult and time consuming, and requires administrators to use multiple infrastructure tools to manipulate servers, storage, and networks in hopes of attaining performance objectives. Sharing network-attached storage makes it difficult to configure individual VMs with the performance they need, and "noisy neighbors" can interrupt high-priority SLAs. Similarly, supporting VMs with today's hyperconverged solutions can mean lower efficiency and higher TCO due to the lack of configuration flexibility.

ESG Lab validated the ease of deploying, managing, and monitoring the Datrium DVX solution. Administrators configure host-based CPU and flash to optimize VM price/performance using vCenter only, with no storage LUNs or zones complicating matters. Moving VMs with vMotion vastly simplifies performance optimization by taking the process out of the storage and network domains. Instead of suffering through a controller upgrade to improve storage performance, administrators manage end-to-end VM performance, taking advantage of the local flash and CPU and moving VMs to hosts with available resources as needed.

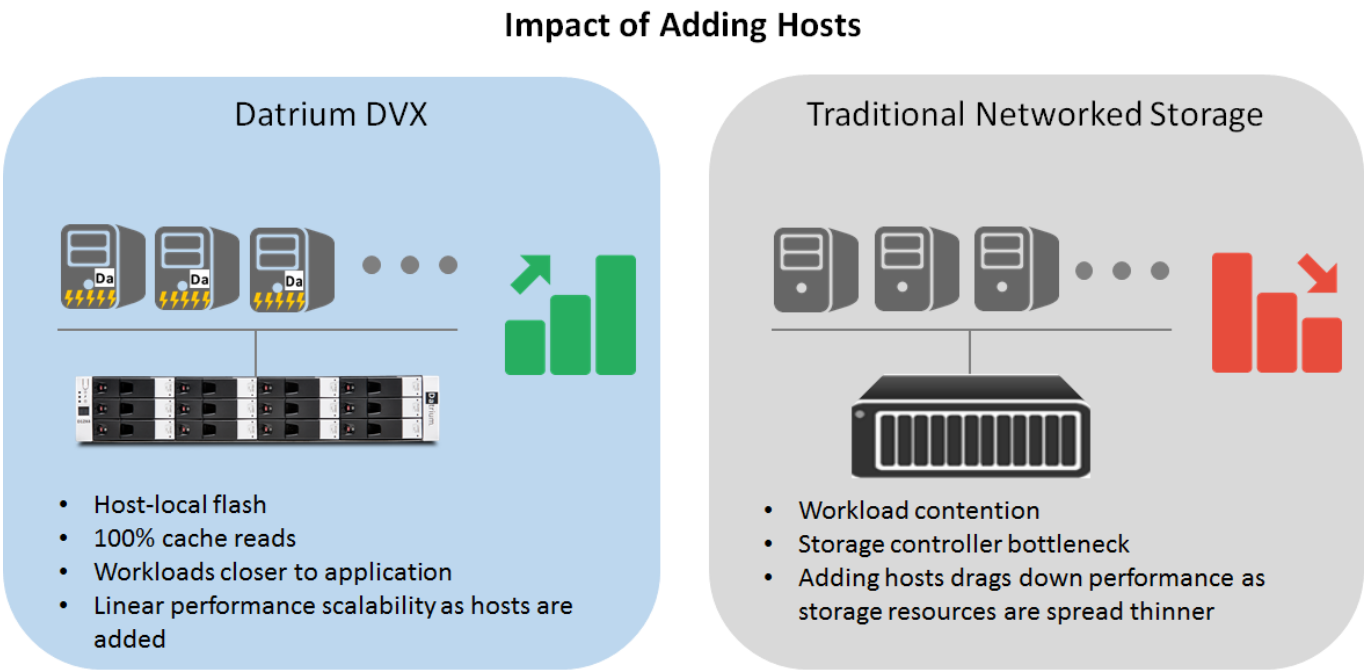
Performance Scalability

ESG Lab audited testing conducted by Datrium performance engineers with a goal of demonstrating performance scalability. The Datrium DVX architecture enables IT administrators to manage VM performance through vCenter, focusing on the application, rather than managing storage. It offers three methods of improving performance: 1) adding hosts; 2) choosing more powerful hosts; and 3) leveraging Datrium Insane Mode.

Add Hosts

A key differentiator of the Datrium architecture is that it enables performance to *increase* as you add hosts, since each host brings additional CPU and flash. This is in stark contrast to typical networked storage environments, in which adding hosts reduces the performance available to each host because resources are spread even thinner (see Figure 8).

FIGURE 8. Impact of Adding Hosts

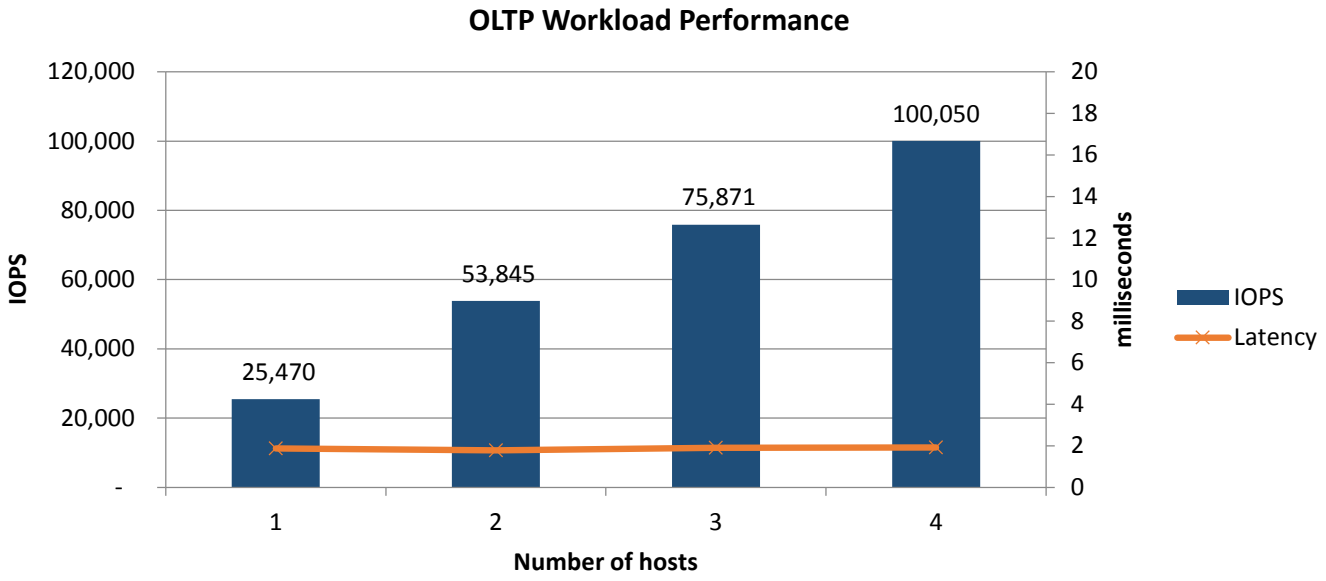


Source: Enterprise Strategy Group, 2016

ESG Lab validated the performance scalability of various simulated workloads as hosts were added. The test bed included a single Datrium DVX NetShelf appliance and four VMware ESXi hosts configured with 1-5 TB of flash. Each host contained three test VMs containing 200 GB of test data, for a total of 12 test VMs. The DVX was configured to run in Insane Mode.

Testing was conducted using the FIO benchmark utility to show IOPS, throughput, and latency for various workloads as the number of hosts was increased. ESG Lab audited results for a typical 4K block size OLTP workload, consisting of 100% random, mixed read/write I/Os. Figure 9 shows the performance scalability: As the number of hosts was increased from one to four, IOPS increased in a linear fashion from 25,470 to 100,050, while latency remained steady at just under two milliseconds.

Figure 9. OLTP Workload Performance



Source: Enterprise Strategy Group, 2016

ESG Lab validated similar IOPS results with simulated OLTP, VDI, and Exchange workloads, and throughput results for a simulated backup. All testing demonstrated linear performance scalability as hosts were added, while retaining low latency.

Choose More Powerful Hosts

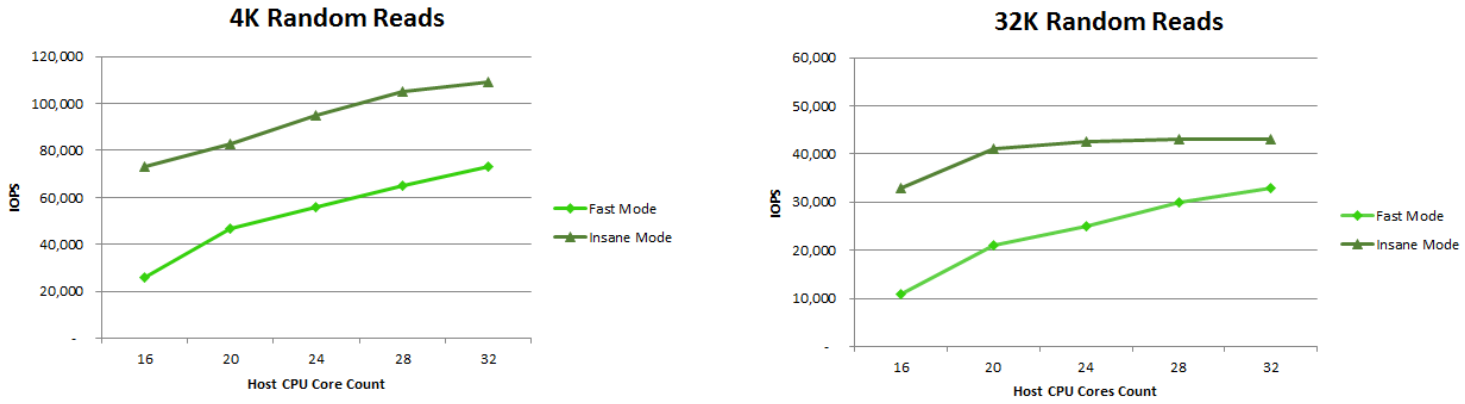
Hosts with more CPU resources offer another option for managing VM performance. Hosts with more and/or faster CPU cores provide more CPU for Datrium to leverage, whether in Fast or Insane Mode. Administrators can simply vMotion VMs to other hosts with available resources to improve IOPS and latency.

Leverage Fast Mode versus Insane Mode

Datrium DVX offers the ability to choose how much of the host CPU will be allocated to storage operations. The default configuration, Fast Mode, reserves up to 20% of the CPU resources. With a click of the mouse in the vCenter GUI, administrators can switch to Insane Mode and leverage up to 40% of CPU resources; this can be done on the fly, with no interruption to running workloads. Datrium DVX will add threads as long as VM utilization is less than 40% of the CPU so as not to disrupt other host processes. CPU reservation will be relinquished through normal host resource scheduling for other hypervisor activity if Datrium DVX is not using it.

ESG Lab audited results of Datrium testing with a robust host configuration of 32 cores @ 2.3 GHz. The testing used the FIO utility to run 100% random read workloads using both 4K and 32K block I/Os. Figure 10 demonstrates the dual performance benefits of adding CPU cores and leveraging Insane Mode.

Figure 10. Improve Performance with Additional CPU Cores and/or Insane Mode



Source: Enterprise Strategy Group, 2016

What the Numbers Mean

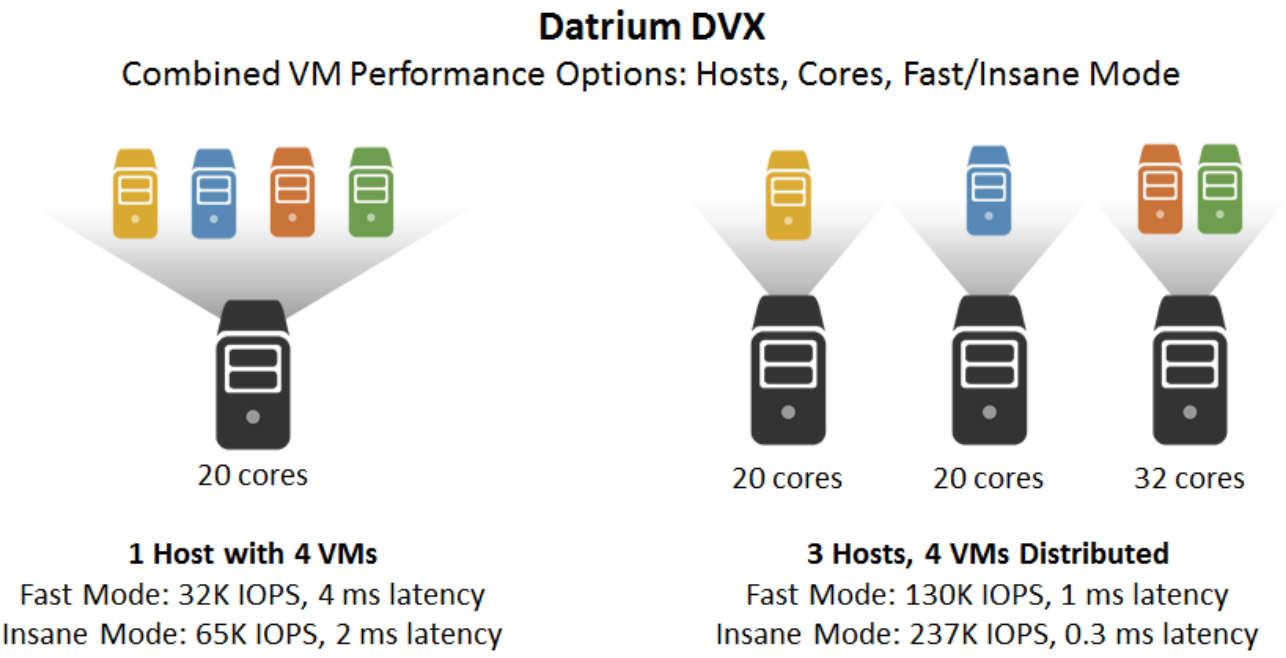
- As cores increased from 16 to 32, in Fast Mode, 4K random read performance improved from 26K IOPS to 73K IOPS, and 32K random read performance improved from 11K IOPS to 33K IOPS.
- As cores increased from 16 to 32, in Insane Mode, 4K random read performance improved from 73K IOPS to 109K IOPS, and 32K random read performance improved from 33K IOPS to 43K IOPS.
- Depending on the core count, Insane Mode delivered 49% to 180% more 4K IOPS than Fast Mode, and 30% to 200% more 32K IOPS.
- Core count and DVX mode can be used independently or together, enabling administrators to achieve performance objectives for each host with the optimum infrastructure configuration. For example, for 4K random reads, Fast Mode with 32 cores produced about the same results as Insane Mode with 16 cores, both achieving 73K IOPS.

Finally, ESG Lab validated Datrium testing that combined performance management options, including host count, core count, and Fast/Insane Modes. Testing was conducted using 2 x 20-core hosts, 1 x 32-core host, and 4 VMs, running 4K random reads with FIO.

- With a single 20-core host supporting the 4 VMs, changing from Fast Mode to Insane Mode doubled the IOPS (from 32K to 65K) and reduced latency by half (from 4 ms to 2 ms).
- By distributing the VMs among the hosts and running in Insane Mode, Datrium DVX was able to generate 237K IOPS and reduce VM latency to 0.3 ms (see Figure 11).

While this was tested in a non-production setting designed to maximize impact, it clearly indicates the power of the Datrium DVX performance management options.

Figure 11. Combining Performance Management Options



Source: Enterprise Strategy Group, 2016

Why This Matters

Maintaining optimal performance across VMs can be a constant challenge, as workloads compete for priority. In traditional networked storage environments, adding hosts and workloads spreads storage resources ever thinner, dragging down performance. A spike in one application workload will negatively impact other applications with unpredictable results.

With Datrium DVX, adding hosts increases performance since new hosts bring additional CPU and flash. ESG Lab validated linear performance scaling with low latency for several simulated workloads. ESG Lab also validated the performance benefits of leveraging host count, core count, and Fast/Insane Mode, separately and together. These options empower administrators to make infrastructure design decisions simply and easily based on available resources and VM activity, enabling them to move VMs or add resources as needed with assurance of delivering the right performance for every VM.

The Bigger Truth

A decade or so ago, the revolution of server virtualization began with the harnessing of unused horsepower on servers. Instead of having only a single operating system and application on each server, organizations could take available server resources and add multiple OS and application instances, encapsulated in files. VMware quickly became the *de facto* leader in server virtualization, a position it has yet to relinquish.

Several heavy hitters from VMware and Data Domain recently launched the Datrium DVX, an enterprise storage solution that stems from the same basic principle. Innovations in CPU speed and density mean that many VMware environments have a CPU surplus; Datrium DVX lets you take advantage of that CPU, along with host-based flash, to handle *on the server* tasks such as deduplication, compression, and RAID that are commonly performed by storage arrays. This enables VM performance to not only be freed from network and storage controller bottlenecks, but also managed on a per-VM basis through vCenter instead of through esoteric storage tasks.

Datrium DVX delivers data services using host-local flash, and persistent storage capacity using a network-attached storage appliance. A key benefit and real differentiator of this approach is that it eliminates the need to manage storage performance. After all, who cares about storage performance on its own? It is only relevant for its impact on application performance. In traditional environments, administrators must manage storage in hopes of balancing application performance needs with data services such as RAID protection and capacity reduction; it is difficult, at best, to match storage performance to individual VM performance, and requires network reconfiguration. Datrium turns that upside down. Storage and network administrators need no longer be involved in performance optimization—instead, VMware administrators manage *application* performance, adding server-side resources or moving VMs wherever additional host CPU and flash are available. Adding hosts actually *adds* performance capabilities, since they bring CPU and flash with them; this starkly contrasts with traditional environments, in which adding hosts means spreading networked storage resources thinner. Datrium DVX provides configuration flexibility that array-based or hyperconverged solutions cannot deliver, enabling greater efficiency and lower TCO.

ESG Lab validated the ease of deploying, managing, and monitoring Datrium DVX. We easily added a new ESXi host to the deployment, and moved a VM using vMotion to another host, witnessing the improved performance. We also validated the linear performance scalability for various workloads as hosts were added, and the ease of improving performance through adding hosts, choosing more powerful hosts, and leveraging Fast/Insane Modes.

ESG Lab was very impressed with the Datrium DVX. It is a new, V1 product, so it will be interesting to see how customers respond. A few features—such as native replication, support for other hypervisors, and the ability to expand appliance capacity—would round out the product and make it applicable to more customers.

Datrium DVX provides customers with the opportunity to manage what matters in a VMware environment—VM performance—with lower costs. Software-based, server-side caching is ideal for existing blade server environments, enabling organizations to leverage existing investments in compute, networking, and flash. The ability to provision large amounts of commodity flash to handle all in-use data means that Datrium enables in-memory computing without having to rewrite applications. In addition, IT organizations—in private data centers or service providers—can configure hosts with the right amounts of CPU and flash to accommodate workloads and cost requirements; isolate workloads as needed; and take advantage of future flash and CPU innovations.

The goal of ESG Lab reports is to educate IT professionals about data center technology products for companies of all types and sizes. ESG Lab reports are not meant to replace the evaluation process that should be conducted before making purchasing decisions, but rather to provide insight into these emerging technologies. Our objective is to go over some of the more valuable feature/functions of products, show how they can be used to solve real customer problems and identify any areas needing improvement. ESG Lab's expert third-party perspective is based on our own hands-on testing as well as on interviews with customers who use these products in production environments.