I D C M A R K E T S P O T L I G H T

Application-Aware Storage for Virtual Environments

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Adapted from *Storage for Virtual Environments Survey* by Eric Burgener, Gary Chen, and Eric Sheppard, IDC #248298

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As the IT industry struggles with explosive data growth while managing an infrastructure buildout to handle the dynamic demands of mobile, social media, big data and analytics, and cloud, major storage challenges have arisen. It is clear that legacy storage architectures are not able to cost-effectively meet the demands for performant, scalable, efficient, and agile storage. The ability to provision, tune, and manage storage in an easy, intuitive manner is becoming more important. The need for "application-aware storage" is emerging, and IDC believes that this will become a central tenet in the next-generation storage platform that is designed specifically to deal with the needs of virtual infrastructures.

IT Management Focus Is Shifting

When virtual infrastructure is deployed, a single virtual machine (VM) is often dedicated to a single application. The agility that virtual infrastructure offers opens up a number of administrative options that were not easily or cost-effectively available before in managing applications. Hypervisor-driven operations like failover, live migration, and workload balancing that can be applied at the VM level make it very easy to perform those same operations atomically for applications. And typically when administrators think about management, they think in terms of applications.

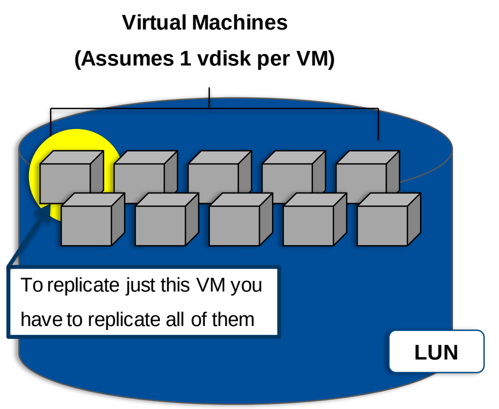
IDC is seeing quantitative evidence of this application focus in its current survey work. In IDC's July 2013 *Storage Purchasing Trends Among U.S. Firms QuickPoll Survey,* respondents identified application workload requirements as the most important factor in selecting storage products.

An Application Focus Will Drive Storage Changes

Being able to manage all operations at the VM level, including storage, would be very intuitive for administrators already comfortable with managing applications or VMs. Administrators looking to perform storage operations like snapshots, clones, or replication for a particular application would need to effectively perform those operations at the VM level (see Figure 1). But today's legacy storage architectures are built around a LUN or volume-level management paradigm that introduces several challenges to enterprises using virtual infrastructure.

Figure 1

Shifting the Storage Management Model to a More Application-Aware Approach



- LUN-centric storage management
- Multiple virtual disks per LUN
- Storage operations like snapshot performed at the LUN level
- Lack of management granularity leads to inefficiencies

- VM-centric storage management
- **LUN layout irrelevant to management**
- Storage operations like snapshot performed at the VM level
- More efficient — perform storage operations on selected VMs only

Source: IDC, 2014

With legacy storage architectures, physical disk devices tend to be logically combined into virtual devices called LUNs, which are then presented as storage to servers. Disk arrays understand what a LUN is and can apply storage operations like snapshots, clones, and replication at that level. To ease storage management, storage administrators often make LUNs large relative to the size of individual VMs. As a result, each LUN generally supports 10–30 or more VMs. When a storage operation is applied at the LUN level, it affects all VMs on that LUN.

Because LUN or volume-level storage operations have no visibility of a VM, they have no ability to operate at the VM level. If an administrator could configure a storage system with only one VM per LUN, he/she could achieve sufficient management granularity. But storage arrays support limited numbers of LUNs, and all except the smallest virtual environments require administrators to configure multiple VMs per LUN. If an administrator wanted to replicate a single VM on a LUN, he/she would have to replicate all VMs on that LUN. This takes up not only additional storage capacity on the target but also additional network bandwidth — all to replicate a number of VMs that the administrator may not even care about. The same concept holds true when performing any storage operation at the LUN or volume level, such as snapshots or cloning, and results in an inefficient use of available resources, adding extra cost.

LUN or volume-level management also introduces management complexities. In the typical virtual environment with a shared storage array that is providing the snapshots, cloning, and replication, and possibly other storage efficiency technologies of interest like deduplication, some operations are managed from the hypervisor user interface (UI), like VM provisioning, and other operations are managed from the array's UI, like snapshots. The need for a second UI introduces additional training requirements and is more complex than an environment where everything could be managed from a single UI.

The management issues and complexities imposed by LUN or volume-level management are not the only challenge legacy storage architectures have in virtual environments. They also suffer from the I/O blender effect, an issue that impacts both performance and costs in a major way.

The I/O Blender Effect

Legacy storage architectures were designed with spinning disks in mind. Spinning disks deliver better performance (i.e., higher input/output operations per second [IOPS]) with sequential rather than random workloads — as much as 10x more. When there was a 1:1 relationship between a dedicated server and its application and storage, and that server wrote directly to the physical disk, there were opportunities to manage an application's I/O stream to allow the underlying disk to operate in sequential mode a good percentage of the time, delivering better performance. Operating systems like Windows Server do exactly that.

With virtualization, each server (i.e., VM) no longer writes directly to the disk — it writes to the hypervisor, which then writes to the disk. As the I/O streams from each of the VMs on a host are written to the hypervisor, it multiplexes the I/O streams, creating an extremely random I/O pattern that is then written to disk. As this extremely random I/O pattern is written to spinning disk, the increases in seek times and rotational latencies for each I/O produce much lower overall IOPS and more importantly increase the latencies experienced by the applications. This lower performance can be very noticeable to end users, whose perception is that virtual applications run more slowly.

The I/O blender effect generally gets worse as VM density per host increases. VM density on the average host today hovers around 10, and as physical servers get more powerful, that density is expected to increase to over 12 by 2017, so the I/O blender effect is only expected to get worse. Certain environments, such as virtual desktop infrastructure (VDI), tend to host significantly more VMs per host, and densities of 100–140 VMs per host are not uncommon in these environments. Because of this, the I/O blender effect is much worse with VDI.

The I/O blender effect results in virtual environments requiring significantly more IOPS than legacy storage systems are able to cost-effectively provide to deliver acceptable application performance. To build the storage configuration up to deliver more performance, more spinning disk is generally added. Each additional disk adds not only IOPS but also more capacity and cost. By the time sufficient IOPS have been added to the storage to meet end-user performance requirements, there is also generally way more provisioned capacity than is actually needed. It is not uncommon for this over-provisioning to drive storage costs, both capex and opex, up to as much as 40–60% higher than in comparable physical environments.

Economics Demand a Different Storage Management Paradigm

Virtualization is clearly the future. Already, an average of 44% of installed x86 servers are virtualized, and 56% of enterprises have a "virtual first" strategy for new server deployment going forward. According to IDC forecasts, the IT infrastructure buildout over the next five years, largely driven by the needs of mobile, social media, big data and analytics, and cloud, will almost exclusively leverage virtualization technology. The market need is there for a new approach to storage in virtual environments that does not suffer from the lower performance, complexities, inefficiencies, and higher costs of legacy storage architectures.

Increasingly, administrators want to tune their storage to meet specific application requirements, but the LUN or volume-level management model of legacy storage architectures means that multiple applications (i.e., VMs) are hosted on each LUN, effectively precluding the ability to optimize the storage to meet the requirements of any particular application. The legacy storage management model also means that the desired feature/function merits of any given storage solution cannot be applied to individual applications; they can only be applied to groups of applications that may or may not require the same storage functionality.

What is needed is a VM-aware storage management model that allows storage to be allocated to VMs, not LUNs, and that allows storage operations including tuning, snapshots, cloning, and replication to be performed on VMs, not LUNs. This would effectively allow storage to be managed at an application level. What is needed is application-aware storage.

End-User Perceptions

Most customers are not aware of the I/O blender effect directly, but they are clearly aware of its impacts. IDC's July 2013 *Storage Purchasing Trends Among U.S. Firms QuickPoll Survey* reveals several pertinent data points. Along with storage performance, storage efficiency is ranked as a must-have, on par with resiliency and failure survival in terms of importance, by enterprise customers (see Figure 2, where 1 = most important and 10 = least important). Storage features directly related to storage efficiency include deduplication and compression (for both primary and secondary storage), thin provisioning, thin import and thin replication, efficient utilization of flash, and an ability to perform storage operations at the VM rather than the LUN or volume level. Together, these features all make more efficient use of existing capacity and lower storage costs (both capex and opex).

In IDC's May 2014 *Storage for Virtual Environments Survey,* only 35% of respondents were familiar with the term I/O blender effect, but of those, 67% had quantitatively characterized its impact on their virtual application performance. This indicates that of those administrators who understand the problem, a high percentage are taking specific steps to address it.

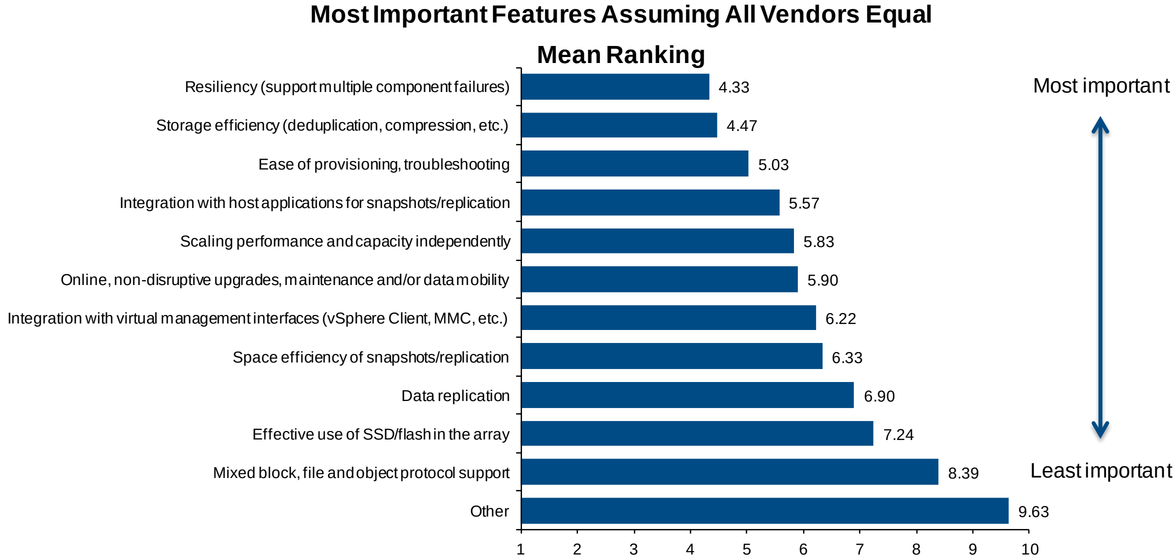
Flash is particularly interesting in that it provides a medium that not only delivers as much as 100x the IOPS of spinning disk at the systems level but consumes far less power and floor space. Use of flash has been growing, and we have now passed the point where over half (51%) of enterprise customers are using flash in some form (caching/tiering, either in the host, in appliances, or in hybrid or all-flash arrays) in their storage environments today. For the next 12 months, flash purchase intent continues to be strong, with the remaining 49% of those planning to buy storage looking to add flash to their environments. The higher price per terabyte of enterprise flash relative to spinning disk is being offset by software features such as deduplication, compression, and thin provisioning to bring the effective price per terabyte more in line with that of spinning disk.

When flash is combined with application-aware storage, the two technologies effectively address the performance, cost, and efficiency issues with legacy storage in virtual environments.

Figure 2

Resiliency, Efficiency, and Ease of Use Are Cost of Business

Q. *All vendors being equal, what features would be most important in your decision to replace your current external disk storage system with a new supplier's product? (No tie rank.)(Must rank features from 1, most important, to 10, least important.)*



Source: IDC's *Storage Purchasing Trends Among US Firms QuickPoll Survey,* July 2013

Defining Application-Aware Storage

Storage for the virtual world must solve two fundamental problems with legacy storage architectures — a lack of application-aware storage management functionality and the performance impact of the I/O blender effect.

First, application-aware storage must understand the concept of a VM (and thereby an application) and allow storage operations like provisioning, snapshots, cloning, and replication to be performed at the application rather than the LUN or volume level. By providing this management granularity, and the flexibility to select an individual or a dynamically defined group of VMs on which to perform storage operations, existing storage resources will be used much more efficiently. The ability to select groups of VMs is important in providing the needed storage support for multitier applications, such as SAP, that run across multiple VMs simultaneously. When, for example, replicating an application in this type of environment, it is critical to be able to do it in such a way that preserves write ordering to ensure data integrity at the target site.

The application awareness of the storage should extend to any and all workflows that would potentially leverage storage operations such as snapshots or replication. The availability of an application-aware storage API would support this, enabling more efficient operations to be easily integrated into automated workflows. This is important because as the administrative span of control increases, more automated operations are required to maintain the level of reliability enterprise environments require.

Second, application-aware storage must differentiate between the type of underlying storage media (i.e., flash or spinning disk) in use and take that into account as it actively manages I/Os for optimum efficiency. Hybrid storage arrays — those that allow customers to mix both flash and spinning disk in any combination to cost-effectively meet the needs for both performance and capacity — are becoming popular as storage systems in virtual environments. The best offerings of this breed use caching and/or tiering approaches to keep frequently used data on the fastest tier (i.e., flash) to maximize read performance and leverage technologies like log-structured file systems to remove the randomness from write I/O patterns to maximize write performance, thereby addressing the I/O blender effect. Flash optimizations designed to further improve performance and reliability of flash media include write minimization and wear-leveling algorithms, and storage efficiency technologies such as thin provisioning, data reduction (e.g., deduplication), and application awareness (discussed previously) work together to get the most out of limited flash capacities.

Although the use of flash is not necessarily required to implement application-aware storage, the overall storage solution will be better suited to address the overall storage requirements of virtual environments when flash is included as part of the solution with a storage architecture that understands how to use it most effectively.

Benefits of Application-Aware Storage

The main benefit of an application-aware storage model is that it allows the storage for each individual application to be managed and optimized independently, regardless of what other workloads and applications are present. Storage system features like high performance, balanced scalability, data reduction, and an application-aware management paradigm are critical to the efficient use of storage resources. One or more pools of shared storage resources could be flexibly allocated to deliver optimal performance for each application workload running in that environment. Application-aware storage requires the right mix of hardware resources with the right software-defined storage layer.

But application-aware storage goes beyond just meeting application-specific performance requirements. There are a variety of storage features, in addition to performance and capacity, that can be "provisioned" in this manner, including provisioning definitions (i.e., thick, thin); snapshot, cloning and replication policies; and the use of data reduction technologies such as deduplication and data protection. The beauty of this model is that a single storage solution that offers all the storage features to meet the requirements of a mixed workload can dole out the type of storage that is required for each application individually. The definition of storage features that each application gets would determine the effective cost of that storage.

Application-aware storage also provides monitoring and troubleshooting benefits. When the storage is aware of the logical construct of a VM, it can associate a particular virtual storage object (a virtual disk) with a particular application. The end-to-end visualization of the data path that this provides allows administrators to track a variety of statistics, such as IOPS, latency, capacity consumption, and other storage metrics, at the application level. This can assist in chargeback and make it easier to identify and remediate storage-related problems.

IDC believes that this application-aware storage concept is the model best suited to meet the new storage requirements of virtual computing. It implies that a set of shared storage resources that encompass a variety of different hardware- and software-based storage technologies can be optimized to simultaneously meet a variety of different application performance requirements, ensuring that the available storage resources will be used most efficiently. With this approach, each application gets the desired levels of performance, availability, recoverability, and so forth without imposing those same levels on any other application.

Conclusions and Recommendations

As virtual computing becomes ever more mainstream, storage architectures will inevitably evolve to better deliver the type of storage performance and data management services these environments demand. New storage architectures that are better optimized for the performance and efficient data management requirements of virtual computing are already starting to emerge. Customers looking to deploy enterprise storage solutions that can meet the requirements of these environments more cost-effectively than legacy architectures should look for the following features:

- A more flexible application-aware management model that allows storage to be provisioned, optimized, and managed at the level of individual applications
- Software functionality, such as log-structured file systems and write coalescing, specifically targeted to resolve the performance impacts of the I/O blender effect
- Enterprise-class data services, such as provisioning, snapshots, clones, caching and/or tiering, deduplication, and replication, that support the administrative needs and workflows of production applications
- Storage architectures that differentiate between the type of media in use (flash or spinning disk) and are optimized to maximize the performance, endurance, and reliability of each based on its characteristics
- Quality-of-service capabilities that allow end users to dial in the specific performance they require on an application basis and can ensure that applications get the specified performance regardless of what else is going on in the array

The continued explosive growth of data, combined with budgetary issues, is driving the industry toward storage architectures that provide application awareness and are specifically designed to address the unique storage challenges in virtual environments. These are the characteristics of the enterprise storage workhorse of the future, and enterprises can't afford not to consider them as they look to refresh their enterprise storage solutions.

A B O U T T H I S P U B L I C A T I O N

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