INDUSTRY DEVELOPMENTS AND MODELS

Justifying Investment in All-Flash Arrays

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IDC OPINION

During the course of research efforts in the all-flash array (AFA) space, IDC is still encountering IT executives, particularly CIOs and CFOs, who have an outdated perspective on relevant cost metrics for comparing all-flash solutions with legacy hard disk drive (HDD)-based systems. In IDC's view, flash is an absolute requirement for performance reasons in any 3rd Platform computing environment. While most understand the need for flash performance, there is still a subset that does not view the broader use of flash in the enterprise as cost effective. AFA vendors have struggled to adequately explain what IDC refers to as the "secondary economic benefits of flash deployment at scale" to prospective customers that are often still using the storage metrics of a bygone era to evaluate flash cost-effectiveness. More than 10,000 AFAs are deployed in production. The AFA market is one of the fastest-growing subsegments of the overall enterprise storage space with a compound annual growth rate (CAGR) of 21.4% through 2020, and AFAs are already being used by a number of organizations — both enterprises and service providers — as general-purpose primary storage platforms hosting multiple mission-critical applications. In an effort to more clearly explain the economic benefits of an "all flash for primary storage" strategy, this IDC study provides a business-level discussion of the financial advantages AFAs can bring to the table when used as a general-purpose storage platform. These benefits span six areas, each of which contribute to a compelling total cost of ownership (TCO) story for AFAs. It is crucial to understand the impact of storage efficiency technologies to be able to fully evaluate the TCO of an AFA in any environment. With a good understanding of each of these contributions, it is much easier for executive management to see how the financial advantages of all-flash array deployment are compellingly better today than those offered by HDD-based alternatives. The six areas that lower the AFA TCO are:

- Far fewer devices to meet performance requirements
- Much lower energy and floor space consumption
- Fewer application servers
- Lower software licensing
- Lowered administration costs
- Much better device-level reliability

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IN THIS STUDY

This IDC study takes a business look at the secondary economic benefits of flash deployment at scale, focusing on the total cost of ownership impacts that this drives. Discussions with end users indicate that these areas are still not as well understood as they should be by business line management. The target audience is CIOs and CFOs. This vendor-neutral discussion explains how the secondary economic benefits of flash deployment at scale should be evaluated.

In this discussion, we will draw a distinction between primary storage (storage associated with very latency-sensitive applications like online transaction processing relational databases) and secondary storage (storage associated with less performance-sensitive but much more cost-sensitive [on a cost-per-gigabyte basis] applications like backup, archive, and other "cold storage" environments).

SITUATION OVERVIEW

Over the past decade, the information technology (IT) industry has transitioned from client/server computing based around dedicated application servers (2nd Platform computing) to what IDC calls "3rd Platform computing." The 3rd Platform computing infrastructure is built around virtualization technologies enabling mixed workload consolidation on physical servers that may be running many virtual servers, each with its own dedicated workload. IT organizations are tasked with supporting legacy applications, such as relational databases, messaging and collaboration platforms, and network file shares, while bringing on next-generation applications in the mobile computing, social media and business, big data/analytics, and cloud areas. This new consolidated workload mix demands a very different set of capabilities from the IT infrastructure, which legacy, hardware-defined architectures cannot cost effectively deliver. This is what is driving the massive 3rd Platform computing buildout – by 2017, over 50% of organizations' IT spending will be for 3rd Platform technologies, solutions, and services, rising to over 60% by 2020. During that same period, over 95% of growth in IT spending will be driven by these same factors.

While the 3rd Platform computing buildout challenges CIOs to rethink conventional wisdom in traditional IT planning, it also invalidates some of the key financial metrics CFOs have been using to justify and/or approve technology purchases. IT organizations tend to be conservative, and new technologies are often adopted slowly to maintain continuity, minimize risk, and leverage the most out of existing investments. But with market dynamics changing so rapidly, not adopting key new and proven technologies in a timely manner presents risks of its own. Today's environment demands the flexibility to enable rapid response to evolving business conditions, and the consequences of moving too slowly include missed incremental revenue opportunities, losing customers to more agile competitors, losing valued employees to more forward-looking IT organizations, and an inability to identify and take advantage of new business opportunities early.

The first AFAs shipped back in 2011. At the time, AFAs were relatively low-capacity arrays targeted for use with a single, extremely performance-sensitive application (like an OLTP database) or one where customers wanted a siloed storage solution because of the extreme swings in workload an application saw at different times of the day (such as virtual desktop infrastructure [VDI]). As IT management became familiar with these products, AFAs were pegged as very fast but very expensive storage solutions that weren't appropriate for most workloads. Things have changed significantly since then – flash costs have plummeted at unprecedented rates and AFAs have been fitted out with extensive enterprise-class functionality and higher capacities and have matured, and now many customers are using these systems not just for a single workload but for dense mixed workload consolidation (in other words, as highly flash-optimized general-purpose storage platforms).

Many of the performance benefits of flash (10x lower latencies and 100x higher throughput than HDDs, consistent sub-millisecond storage latencies under load) are well known, but far too many IT executives and business line managers continue to view all-flash configurations as too expensive to function as a replacement for their legacy general-purpose storage platforms. This is often because of past prejudices (when flash really was expensive) and because they are looking at the wrong comparison metrics (specifically, cost per gigabyte for raw storage capacity) to make a cost-justified business decision. In a word, IT management needs to make sure that it understands the true impact that the secondary economic benefits of flash deployment at scale (at least 80TB of raw capacity) have in a comparison with HDD-based systems (including hybrid flash arrays [HFAs]).

To properly discuss the secondary economic benefits of flash deployment at scale, we will define and discuss two areas in more detail:

- **Enterprise flash storage** is a storage technology that uses flash memory, instead of spinning disks, to meet storage requirements that offer 10x better latencies and 100x better throughput than HDDs and open up the use of real-time storage efficiency technologies with latency-sensitive primary storage applications.
- **Storage efficiency technologies** are a combination of different inline (as opposed to post process) capacity optimization technologies, including compression, deduplication, thin provisioning, space-efficient snapshots and clones, and delta differential-based replication, among others, that will decrease the raw cost of storage capacity anywhere from 2x to 10x with common workloads, resulting in a significantly lower effective cost per gigabyte.

Flash as Primary Enterprise Storage

Flash memory, initially developed as an extremely high-performance volatile data store for use, for example, as main memory, has evolved into a cost-effective, persistent primary storage medium and been adapted for enterprise use. The extremely random, volatile I/O profiles driven by virtualization cannot be cost effectively served by HDDs, and flash latencies, throughput, and reliability make it the best-qualified successor to spinning disk technology for primary storage environments. Traditionally thought of as "expensive," evolutions in NAND flash memory technology over the past five years, combined with plummeting flash costs, have made flash easily cost justifiable for a majority of primary storage workloads and driven the rapid adoption of flash in both server- and network-based enterprise storage solutions.

Most established enterprise storage vendors, as well as a number of start-ups, are now pushing an "all flash for primary storage" strategy. As of January 2016, EMC, HDS, HPE, IBM, NetApp, Oracle, and a number of other vendors were actively competing in the AFA space, some with more than one entry. Once Dell's acquisition of EMC is complete, Dell and EMC will be able to field a number of AFAs. In late 2015, IDC surveys indicated that 80% of IT organizations have committed to this strategy over time, moving workloads from older storage platforms to all-flash configurations as they retire legacy equipment. Over 10,000 AFAs have been deployed in production since the first of these shipped in 2011, and many of these are being used for mixed enterprise workloads that include mission-critical applications.

The AFA market will be $4.20 billion in 2016 and will grow at a CAGR of 21.4% to crest $7.74 billion in 2020 (out of a total $26.3 billion in 2020 for all external storage), making AFA one of the fastest-growing market segments in enterprise storage. In contrast, the HFA market (i.e., systems built from a mix of flash and spinning disk in the same system) will only be growing at a CAGR of 1.9% over that same period and will in fact exhibit negative growth from 2019 to 2020. IDC expects that by 2020, over 70% of all primary storage spend will be driven by AFAs.

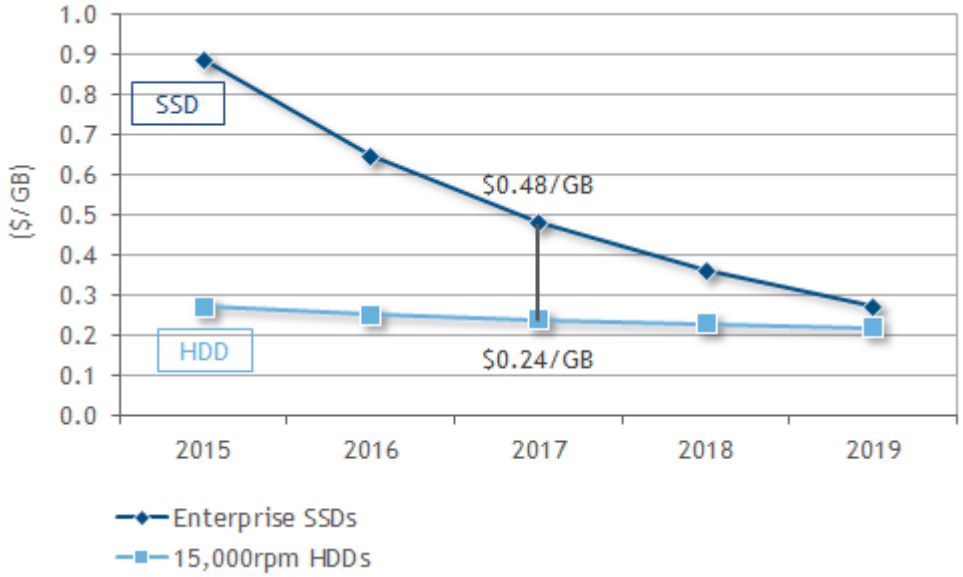
While flash is known for performance, all-flash storage exhibits many other benefits over HDD-based systems, which IDC refers to as the "secondary economic benefits of flash deployment at scale." There are six major areas that lower the AFA TCO: far fewer devices needed to meet performance requirements, much lower energy and floor space consumption, need for fewer application servers to meet performance requirements, lower software licensing (due to needing fewer servers), lowered administration costs, and much better device-level reliability. The sections that follow discuss each area that lowers AFA TCO.

Need for Far Fewer Devices

While a single "performance optimized" HDD (15K RPM) may be able to do as much as 200 I/O operations per second (IOPS) with random, 3rd Platform workloads, a single flash-based device (solid state disk, or SSD) can easily handle 10,000-20,000+ IOPS. If an IT organization needs to buy a 200,000 IOPS system, it will need 1,000 15K RPM HDDs, or 10 SSDs. While it is true that the capacity requirements will likely require that some more SSDs are added, it is important to understand the difference storage efficiency technologies will make in the environment (as discussed further in the document) when calculating how many SSDs will be needed. So even if this comparison results in 1,000 15K RPM HDDs and 40 SSDs, the better cost per gigabyte that HDDs offer will not offset this huge difference. *This is why IT should not be using raw price per gigabyte as a relevant metric when evaluating all-flash options for primary storage – they should be using effective price per gigabyte.* Figure 1 shows the anticipated raw price per gigabyte for 15K RPM HDDs and enterprise-class flash over the next five years – it should be clear that plummeting flash costs over the next five years will only make this flash advantage that much greater.

FIGURE 1

Raw Price per Gigabyte for Flash and Performance-Optimized HDDs, 2015–2019



Source: IDC, 2016

Lower Energy and Floor Space Consumption

While it varies, on average, an SSD will consume roughly half the power of an HDD of similar capacity. And since the number of SSDs will generally be at least 60-90% lower (due to the "need for fewer devices" argument), they will draw significantly less power. They will also require less floor space and require less cooling. It is very common when people replace an HDD-based system with an all-flash system, they will move from a configuration that requires several full racks (and several floor tiles) to one that requires typically less than half a rack (and one floor tile). Power savings alone over a four to five-year life cycle can easily be in the $50,000-100,000+ range for systems that require at least 80TB of provisioned storage capacity. *This is enough of a savings that CFOs should always ensure that they look at the energy and facilities costs and make that a part of the TCO comparison.*

Need for Fewer Servers

With HDD-based systems, the storage latencies are so high compared with CPU latencies in today's x86-based servers that many servers are required to drive the desired storage performance. Relatively slow HDD latencies have the very fast CPUs spending most of their time waiting for the storage to respond. These application server-rich configurations are effectively leveraging the parallelism of multiple server nodes across hundreds or thousands of relatively "slow" HDDs to generate the desired application performance. Flash latencies are on the order of 10x lower than HDDs, which means that 1TB of flash-based storage will be able to "get" a lot more performance out of an application server than 1TB of HDD-based storage – this is because the server spends far less time "waiting" for the storage to respond. CPU utilization goes way up. IDC consistently sees IT organizations needing 5-30% fewer x86 servers to drive desired application performance when they move workloads from HDD-based storage to flash-based storage. Those freed-up servers can then be redeployed in other areas (or the organization can buy fewer servers to begin with in greenfield deployments).

Lower Software Licensing Costs

It's great to not have to buy as many x86 servers, but these servers are relatively inexpensive (often less than $10,000 each when configured for popular legacy applications like Oracle, SQL Server, Exchange, and SharePoint). The real savings are from not having to license expensive software like Oracle on those servers. If an organization has already paid for the software licenses, then those licenses can be redeployed on other projects, but if it is a greenfield deployment, then the project start-up costs will decrease accordingly. Note also that, unlike legacy arrays where array software is often sold separately, AFAs use a much more generous bundling approach, including a good amount of array software with the purchase price of the system.

Lower Administration Costs

For storage administrators running 3rd Platform computing workloads, generally at least 20% of their time is spent fielding customer complaints about performance and tuning storage systems to address these concerns. When IDC interviews organizations that have deployed AFAs, we consistently hear that storage performance complaints (and the time spent tuning systems to address them) drop to zero. Common administrative tasks, like storage provisioning, are largely automated with these new systems, another ease-of-use feature that differentiates AFAs from many legacy arrays. While it may be hard to quantify these soft costs, it is necessary to be aware of the impact they may have on administrative productivity, administrative span of control, response time to user requests, and more cost effectively handling future growth.

Better Reliability

SSDs are based on electronic (rather than mechanical) media and therefore have very different failure characteristics than HDDs. MTBF ratings vary, but typically an SSD will exhibit 3x to 6x higher reliability than a comparably sized HDD. In our example as mentioned previously, imagine how often an administrator will be replacing failed HDDs in a 1,000 HDD configuration versus how often he/she will be replacing failed SSDs in a 40 SSD configuration. This is not an availability issue (since RAID or other data protection mechanisms will ensure that failures are transparent and have minimal impact on performance), but it is more of an operational cost and risk issue. If failed devices are not replaced before a second device failure occurs, then data integrity may be put at risk (depending on the data protection method chosen), so the HDD-based configuration will clearly require more care and feeding than the SSD-based one. And this becomes a more important differentiator as provisioned capacity increases.

The Broad-Reaching Impact of Storage Efficiency Technologies

Storage efficiency technologies effectively allow 1TB of raw storage capacity to store more than, and in some cases much more than, 1TB of data and allow provisioned capacity to be used much more efficiently than it ever has been with HDD-based systems. Vendors do this by employing a number of "tricks," such as identifying and removing redundancies in data, among other things. 3rd Platform computing workloads tend to exhibit much higher degrees of data redundancy than 2nd Platform workloads did, making storage efficiency technologies very interesting in these environments.

Storage efficiency technologies are most efficient when used inline – that is, they identify and remove redundancies *before* data is written to persistent media. Data reduction methods like compression (which identifies redundant data within a file) and deduplication (which identifies redundancies across files) take time to execute, adding latency if they are performed inline. With HDD-based systems, the much higher latency of HDDs meant that technologies like this could not be used in line with latency-

sensitive primary storage environments — the latency impact on application response times was not acceptable. The much lower latency of flash, however, enables its use in latency-sensitive primary storage environments, and this is a game changer in a number of areas that impact performance, system longevity, and overall cost.

Effectively, storage efficiency technologies minimize the amount of data that has to be written to handle a given transaction. For example, a 64K block of data enters a system, is compressed, and the resulting smaller amount of data is what is written to persistent storage — *without losing any of the information content of the data.* The fact that less data has to be written increases write performance, but it also increases flash endurance. Unlike spinning disk, flash media gets "used up" when it is written to, and eventually it can no longer be used. Anything which reduces the amount of data that has to be written extends the longevity of flash media. Most reputable storage vendors have included a variety of write-minimization enhancements to their AFAs and provide endurance guarantees of five to seven years on their flash media, which is typically longer than the depreciation life cycle of enterprise-class arrays. Three to four years ago, flash endurance with write-intensive enterprise workloads was a concern, but this is no longer an issue.

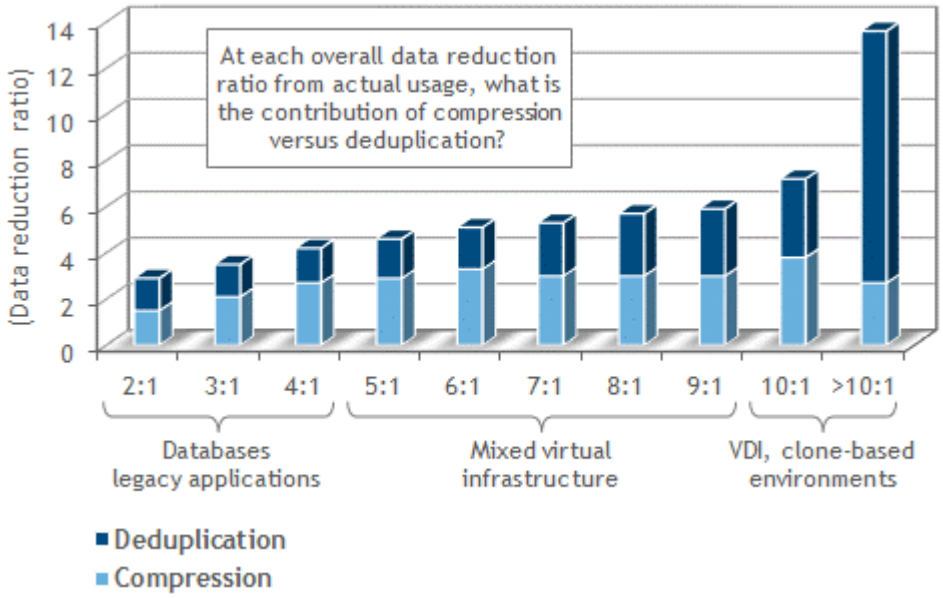
The ability to store more data in less space has a huge impact on the effective price per gigabyte of flash capacity. For the sake of simplicity, let's assume that HDD capacity costs $1 per gigabyte and enterprise flash capacity costs $4 per gigabyte, and we will use a 1TB drive of each type for comparison. If a data reduction ratio of 4:1 can be achieved on a given workload, then 4TB of data can be stored on that 1TB SSD, while only 1TB of data can be stored on the HDD (remember, high HDD latencies mean that inline storage efficiency technologies cannot be used with latency-sensitive primary applications). This cuts the cost of the SSD by a factor of 4, resulting in an effective cost per gigabyte of $1. In this case, the SSD then costs the same (in actual usage) as the HDD, yet provides all the benefits that were mentioned previously.

The key here is what the data reduction ratio actually is. Data reduction ratios vary by workload type. Some applications benefit more from compression (like relational databases), while some applications benefit more from deduplication (VDI), so it is important that an AFA offer both if it will be used for mixed workloads. Data reduction ratios can also vary over time as new workloads are added to the AFA, depending on whether that new workload is more or less reducible than the combination of workloads already running on the array. AFA vendors track their own data reduction performance across their installed bases, and a good number of them have an average ratio (across their entire installed base) higher than 4:1. A given AFA that is running more database workloads than mixed virtual or clone-intensive workloads will exhibit a lower average data reduction ratio.

IDC tracks data reduction ratios on AFAs by workload type based on data collected from AFA vendors over time. Figure 2 provides a summary of that data. Two things are clear from this data: for mixed workloads, average data reduction ratios in the 4:1 to 6:1 range are not unreasonable, and most workloads benefit from both compression and deduplication (but typically one is much more important). Think back to the declining cost of enterprise SSD capacity shown in Figure 1 — a data reduction ratio of even only 2:1 means that flash will be less expensive on an effective cost-per-gigabyte basis than 15K RPM HDDs by the end of 2016.

FIGURE 2

Data Reduction Ratios by Workload Type



Source: IDC, 2016

Understanding the data reduction ratio is clearly critical to understanding the TCO of an AFA. Vendors are aware of this, typically keep a close eye on the data reduction ratios they are achieving across their entire installed base, and many of the more reputable AFA vendors provide data reduction ratio guarantees on their systems. If an AFA is not achieving its promised data reduction ratio, the vendor will add flash storage to it at no charge to bring it back into line with the promise. Fortunately, most AFAs track the overall data reduction ratio being achieved on the entire array in real time, and some also allow the data reduction ratio to be viewed on an application-by-application basis. *Prospective AFA customers are strongly recommended to get promised data reduction ratios in writing prior to an AFA purchase and to track what they get in production usage closely, following up with their AFA vendor every six months or so to ensure the vendor makes good on its guarantee.*

The contributions to space efficiency that many of the other key storage efficiency technologies, such as thin provisioning, space-efficient snapshots and clones, and delta differential replication, make are very dependent on application workflows, and explaining them is beyond the scope of this document. CIOs and CFOs should make sure their technical people evaluate the contribution of these capabilities as well in their environment but should calculate the effective price per gigabyte of an AFA prior to purchase based just on the combination of compression and deduplication against their workload. These other contributions should be viewed as additive, making the promised data reduction ratio likely a conservative estimate.

Where Flash Should Not Be Used

The magnitude of the contribution that the secondary economic benefits of flash deployment at scale make is highly dependent on the performance intensivity of the workload. In general, the lower the latency and higher the throughput requirements for a particular application, the bigger the financial impact of all-flash deployments. Cold storage environments that might be "write once, read many" ("WORM") type of workloads, or where they are infrequently written to and there are no latency requirements when the data is accessed, will find it much harder to cost justify flash usage. Keep in mind that capacity-intensive 7,200 RPM HDDs, while they are much slower than 15K RPM HDDs, cost roughly $0.04 per gigabyte in 2016. Much of the financial justification provided previously is based on the fact that HDDs are very underpowered in terms of performance relative to the capacity they provide, whereas the flash cup "runneth over" when it comes to performance. Most HDD-based systems were way overprovisioned in terms of capacity just to provide the necessary performance, leading to a significant amount of wasted spinning disk capacity that still drew power and took up floor space. AFAs will tend to be overprovisioned in terms of performance to meet a certain capacity requirement, but remember that the cost-per-gigabyte paid for that capacity is at the data reduction ratio discount.

The overall capacity of the flash is also a factor, since most of the savings are based on percentages. For a workload that only requires 10TB of provisioned capacity, a savings of 30% will likely not reduce the flash device count (depending on the capacity of the SSDs chosen). SSDs on the market today are available in 1TB, 2TB, 4TB, and 15TB capacities (among others), so a single SSD could easily service the 10TB capacity requirement (assuming 4:1 data reduction). In that single device case, though, at least a second SSD will have to be configured to provide redundancy for data protection purposes. So the secondary economic benefits do not really kick in at very low capacities. But once a system gets to about 80TB of raw capacity, these start to have an appreciable effect. The maximum secondary economic benefits will be achieved as systems grow into the several hundred terabyte range.

FUTURE OUTLOOK

As flash becomes ubiquitous in primary storage environments, inline data reduction technologies will become a requirement. Already all the successful AFA vendors have a combination of storage efficiency technologies built into their all-flash systems. This is as it should be – for a flash-optimized system to get the most out of provisioned flash capacity in terms of performance, endurance, reliability, storage density, and cost, it must offer a range of these technologies, all of which do not impact its ability to consistently deliver sub-millisecond response times across varying 3rd Platform workloads. The move to using inline data reduction technologies should be viewed as a one-time shift onto a new effective price-per-gigabyte line that will not change much once the shift has occurred. IDC does not expect to see major improvements in storage efficiency technologies with flash-based storage that will provide anything other than incremental improvements to the achievable data reduction ratios over the next three to five years.

ESSENTIAL GUIDANCE

Clear direction for CIOs and CFOs falls out of this discussion:

- When legacy general-purpose storage platforms that are predominantly used for primary storage workloads come up for renewal, organizations should be considering AFAs as replacements.
- For applications where improved performance has a direct impact on revenue generation, the quality of customer responsiveness, or other bottom-line business benefits, an additive AFA purchase can be considered just for these more performance-sensitive workloads (this is more of the older model of AFA deployment); note that as workloads are moved off of an overloaded legacy array onto an AFA, the performance of both the applications on the AFA and those that stay on the legacy array will be improved.
- Do not use historical comparison metrics to evaluate the acquisition cost of an AFA; use more relevant metrics like the cost per effective gigabyte, cost per IOPS, or (best of all) the TCO adjusted for the discussed secondary economic benefits of flash deployment at scale — the relative all-flash TCO advantage will improve as the AFA hosts more workloads (infrastructure density is much higher on AFAs than it is on HDD-based arrays).
- Comprehensively evaluate the overall contribution of flash's secondary economic benefits to AFA TCO — while these include some soft costs like easier administration and lower support costs, they also include hard cost savings on array hardware and software, servers, and software licenses.
- Be open to realistically evaluating all the financial implications that flash brings to the table — flash is not just about performance, it is a game changer in a number of areas that result in immediate hard cost savings — push your technical decision makers to quantify these savings in your environment and explicitly plan to take advantage of them.
- Realize that flash will enable higher application and infrastructure densities, allowing small datacenters to appear much "larger" in terms of the workloads they can service. IDC has talked to more than one customer that has been able to delay or entirely forego an expansion of datacenter floor space by a timely move to the use of AFAs for all primary storage.

LEARN MORE

Related Research

- *Worldwide External Enterprise Storage Systems Forecast, 2016-2020: AFA Market Still Continues to Significantly Outpace Overall Enterprise Storage Growth* (IDC #US41581116, July 2016)
- *Worldwide All-Flash Array Market Shares, 1Q16: Established Storage Vendors Dominate* (IDC #US41556316, July 2016)
- *IDC's Worldwide Flash in the Datacenter Taxonomy, 2016* (IDC #US41302116, May 2016)
- *Why Enterprise Storage Managers Need to Understand the Net Promoter Score* (IDC #US41185416, April 2016)
- *Scale-Out Technology Permeates the AFA Market* (IDC #US41180616, April 2016)
- *Flash-Optimized Hybrid-Flash Array Vendor Nimble Storage Joins the All-Flash Array Fray* (IDC #US41049716, February 2016)

- *HDS Rounds Out Its All-Flash Portfolio with a True All-Flash Array* (IDC #US41013016, February 2016)
- *NetApp Expands Its All-Flash Offerings with the Acquisition of SolidFire* (IDC #US40909616, January 2016)
- *IDC MarketScape: Worldwide All-Flash Array 2015-2016 Vendor Assessment* (IDC #US40721815, December 2015)

Synopsis

This IDC study takes a business look at the secondary economic benefits of flash deployment at scale, focusing on the total cost of ownership impacts that this drives. During the course of research efforts in the all-flash array (AFA) space, IDC is still encountering IT executives (particularly CIOs and CFOs) who have an outdated perspective on relevant metrics for comparing all-flash solutions with legacy hard disk drive (HDD)-based systems. This IDC IT Buyer's Research document goes beyond the performance benefits of flash usage in 3rd Platform computing environments to discuss the secondary economic benefits of flash deployment at scale from a business and vendor-neutral perspective. The intended audience for this document is CIOs and CFOs as well as executive IT management.

"When all-flash arrays are deployed as general-purpose storage platforms for primary applications, the total cost of ownership advantage flash brings to the table relative to hard disk drive–based systems is overwhelming," said Eric Burgener, research director for Storage. "Because they may not fully understand the business-level impacts of flash deployment at scale, many C-level personnel erroneously still view flash as an expensive enterprise storage alternative."

About IDC

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