State of NVMe: Perceptions and Misconceptions

SURVEY REPORT

IN PARTNERSHIP WITH

ActualTech Media

Western Digital®

Key Findings and an NVMe Primer

In our first-ever study around knowledge and perceptions of Non-Volatile Memory express (NVMe), ActualTech Media and Western Digital sought to assess people's thoughts, opinions, and understanding of this evolving protocol. This survey and report are not intended to gauge market share and interest, but rather to better understand how much people know about NVMe. To this end, we received completed responses from 399 IT professionals and decision makers and analyzed the results in several ways. For more information about our overall methodology, please see "Appendix: Methodology" at the end of this report.

KEY FINDINGS

There are three key findings we want to highlight:

Finding 1: NVMe Hype Appears Well Deserved

It's clear from this survey that NVMe benefits are probably not being overhyped. With many new technologies, there is a lot written about how they will transform entire industries. Unfortunately, many of those technologies fail to live up to sky-high expectations. In some cases, people that are just considering new technology have great expectations compared with those that have deployed it, only to find out that it doesn't live up to the hype.

With NVMe, our results show just the opposite. Those who have yet to deploy NVMe are cautious, while those with direct experience are reporting even more positive outcomes.

Finding 2: Respondents Understand NVMe's Prime Workloads

In general, respondents seem to understand that not all workloads need or will benefit from NVMe, at least from a performance perspective. Respondents identified real-time workloads as the biggest beneficiaries of an NVMe performance boost. Given how NVMe impacts workload performance, this assessment is spot on. In other words, people are grasping the outcomes achieved from NVMe deployment and correctly applying those outcomes to potential workload benefits.

Finding 3: For Large Businesses, Current Flash Storage Solutions Are Poised to Become Too Slow

Flash is fast, but it's only as fast as all the components that sit between it and applications. NVMe aims to eliminate interconnect bottlenecks and unleash the full power of flash. For larger organizations, this transformation cannot come soon enough. Just 26% of enterprise respondents say that flash is exceeding their expectations. Sixteen percent of the respondents from large enterprise companies say that flash meets their needs today, but are concerned that this may not be the case in the future. Nearly 3% of respondents say that flash has failed to meet their ongoing performance needs.

There are some caveats to keep in mind. Most importantly, flash usage may be as part of a hybrid-flash system, not an all-flash system, a factor that could impact results. Regardless, it's clear that larger companies are ahead of smaller ones in terms of potentially exhausting the performance limits of their flash-based storage systems.

AN NVME PRIMER

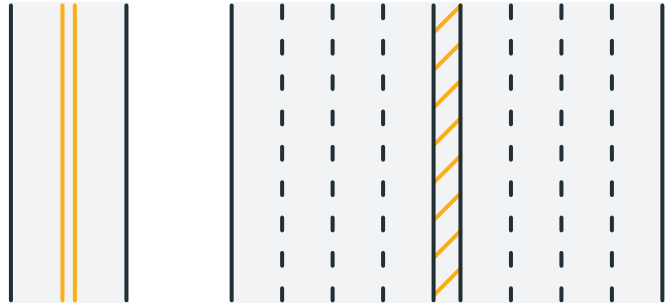
NVMe is quickly emerging as a replacement for legacy interconnect protocols between compute and storage. It promises to shatter performance barriers that have become limiting since the mainstream adoption of flash. As flash became a more viable option for organizations, storage vendors moved quickly to add this fast interface to their products. In some cases, entire new companies were born, focusing on flash-first approaches to storage.

However, a number of entrants into the flash market provided products that were originally architected in a disk-based world, which operates under far different physics than flash, and performs orders of magnitude slower. The architectural design decisions that go into a system built around spinning disks are vastly different than the ones that go into a flash system.

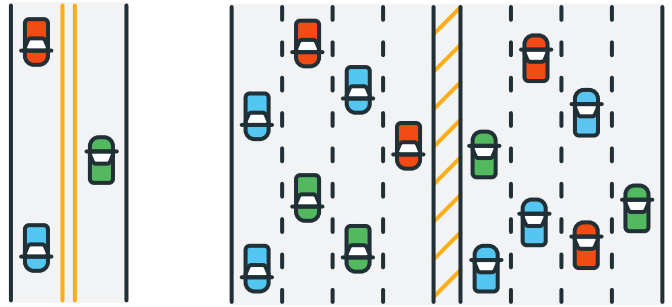
Disk-based protocols such as SAS (Serial Attached SCSI) and SATA (Serial ATA) work well for spinning disks, but develop serious constraints when deployed in flash systems. As an example, these disk-based protocols were developed to handle seek time induced latency issues, which do not exist in flash systems. The NVMe protocol is highly optimized for simultaneous reads and writes.

For all storage controllers, there are two physical constraints to understand:

- **Number of queues.** A queue is exactly what it sounds like. It's the lineup of commands that can be sent to storage. SAS and SATA storage controllers each have just a single queue. Think of it like a road. You have a single lane of traffic and vehicles are not allowed to pass each other. When you consider how spinning storage works, this limitation makes sense. When a read or write request is sent to a disk drive, the drive head needs to move to the correct disk platter location and then spin the disk to access the data. Due to this mechanical limitation, it's impossible to read from or write to multiple locations simultaneously. Therefore, a single queue is adequate.



Number of queues can be compared with the number of lanes on a road. SAS and SATA have just a single queue, like a road where vehicles aren't allowed to pass each other. NVMe dramatically increases the number of queues available, like a multi-lane super highway.



Queue depth equates to the total number of cars on the road at the same time. SAS and SATA have queue depths of 32 and 256, respectively, while NVMe is capable of supporting up to 64K commands.

- **Queue depth.** The queue depth indicates how many storage operations can be lined up for action by the controller. Going back to the road analogy, queue depth equates to the total number of cars on the road at the same time. In general, they can't pass one another, although some storage systems do have mechanisms for reordering operations to make them more efficient. In SATA systems, the queue depth is 32, while in SAS systems it's 256.

When flash storage systems first emerged in the market, storage vendors used SAS- and SATA-based storage controllers combined with flash media. Although this was still much faster than spinning disk, the true potential wasn't realized. In flash systems, you can read from and write to many locations at the same time. But if the controller can only handle a single command at a time, there is a bottleneck.

> An NVMe controller has 64K queues available, with each queue capable of supporting up to 64K commands.

Enter NVMe.

NVMe storage controllers dramatically increase both the number of queues available and the depth of each queue. An NVMe controller has 64K queues available, with each queue capable of supporting up to 64K commands. With a large enough system, this would mean that you could in theory line up more than 4 billion commands for action. Compare that to the total number of commands available with a spinning disk controller – 32 or 256 – and it becomes clear why there is so much excitement about NVMe.

The increase in queues and queue depth is just the beginning. The NVMe specification, coordinated by the NVM Express Organization, also includes a drastically reduced command set compared with SCSI. This simplification has the effect of reducing overall controller and CPU usage in NVMe host systems, leaving more processing capacity for both more and different operations. It also reduces IO latency even further.

Moreover, since NVMe leverages the PCIe bus with wider data lanes than older technologies, the IO transfer between the processor, memory (RAM) and persistent storage media (flash) is faster.

And that's just the beginning. The NVMe specification has been able to include some other critical needs in the NVMe architecture that have real-world impact, including:

- **End-to-end encryption**, which is a must in today's security-sensitive world
- **Reduced power consumption**, thanks to improved storage management
- **Improved scalability** when compared with traditional systems
- **Far lower latency** than traditional systems
- **Far higher IOPS** than traditional systems

This is just a brief overview of NVMe, but it's important to understand this context in order to maximize the insight gained from the results of the data we're presenting.

The Results

NVMe has been in development since early 2010. However, like many new technologies, there is a gestation period, especially as standards bodies and vendors figure out use cases and implementation details. As the industry tries to get a better handle on the technology and its implications, deployment can often be slow.

Furthermore, not every technology is readily embraced by the market. NVMe is not in this category. Today, interest in NVMe is growing at an explosive rate, due to a number of factors:

- **Application demand.** Applications today need to provide real-time interactions and experiences to end users. This means that applications need faster storage that can read and write a tsunami of data very quickly. Legacy storage technology simply cannot keep up with the performance demands imposed by new application environments.
- **Continued innovation in solid-state storage.** Flash has been around since the 80s in one form or another. However, over the past decade, its use has expanded as form factors have improved and capacities have increased. In addition to NAND-based flash storage, newer types of solid state storage, such as storage class memory, is emerging. These new types of persistent storage media can't unleash their full potential unless certain system bottlenecks are eliminated.
- **Security concerns.** Although storage vendors have used products such as self-encrypting drives and created custom security constructs to help protect data, the fact is that data security needs to be a native capability, not a bolt-on addition.

With all the benefits NVMe can bring to storage, we wanted to gain insight into what people really think about this technology and how well they understand it. It was striking to find just 15% of our survey respondents have actual experience with NVMe.

(Remember, this 15% figure indicates that 15% of respondents to this survey have direct experience with NVMe. We do not make the assertion that 15% of the world's IT pros have direct experience with NVMe.)

Almost one-third (31%) of respondents have never even heard the term NVMe, and 54% say that they've heard of it but do not have experience with it. In other words, there are incredible opportunities for vendors with an NVMe story to shape the narrative.

If we consider just the 1-to-100 employee segment of the survey, it becomes clear that company size plays a significant role in NVMe knowledge. In this segment, 55% of respondents have never heard of NVMe, and just 8% actually have experience with the technology (Figure 1).

Figure 1

Self-identified Knowledge of NVMe

(companies with fewer than 100 employees; N=66)

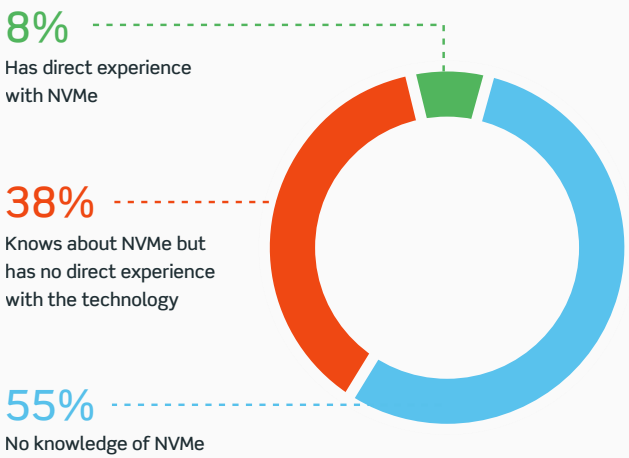
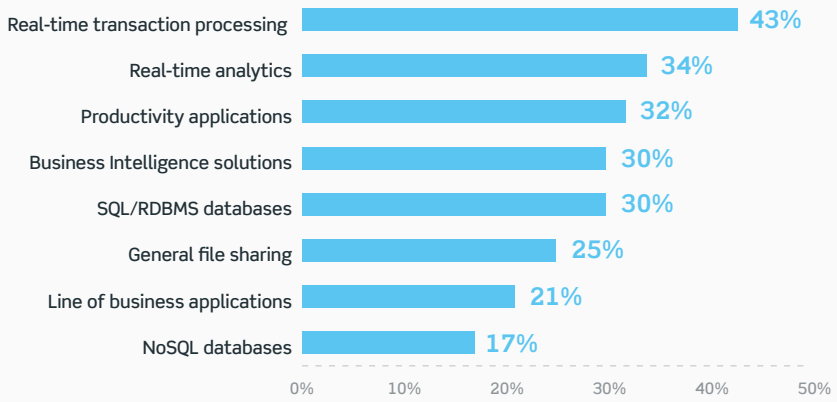


Figure 2

What types of applications do you feel get the most benefit from an NVMe-based architecture?

(top 3 options; N=273; filtered by knowledge of NVMe)



NVMe has the potential for incredible performance gains, but not all workloads will benefit equally, nor is NVMe necessary for all workloads. In general, real-time workloads that are sensitive to latency or applications that require a lot of throughput or IOPS will benefit from an NVMe solution.

Consider the user experience when they visit an e-commerce or other information-gathering sites. What is the one thing that will drive them away? Application response times, which is usually caused by system latency. Anything that can be done to reduce application response times and enhance user interactions will translate into increased revenue.

> There are incredible opportunities for vendors with an NVMe story to shape the narrative.

Figure 2 reveals that respondents understand that real-time applications benefit the most from NVMe, followed by productivity and business intelligence solutions. We were surprised to see general file sharing rank above line of business applications. File sharing doesn't typically require much in the way of performance, unless there is post production and concurrent editing of high-quality videos. This finding may indicate that the benefits of NVMe still aren't as fully-grasped as they could be, and more education is necessary.

Figure 3

What types of storage are you currently running?

(multiple responses allowed; N=399)

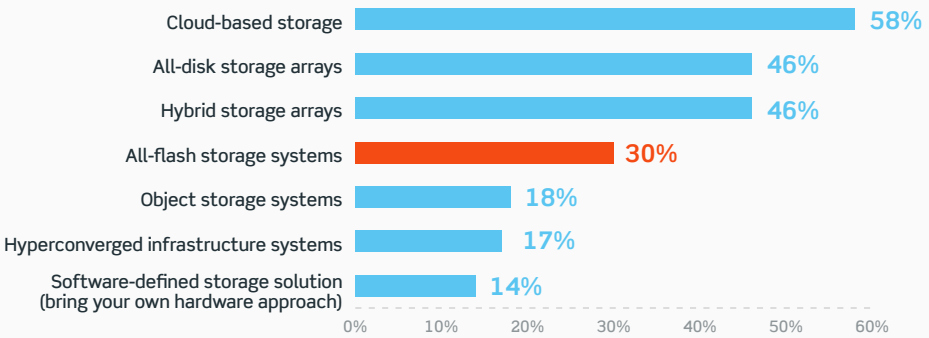


Figure 4

What storage protocols/interfaces are you using with your hybrid or flash storage solution?

(multiple responses allowed; N=399)

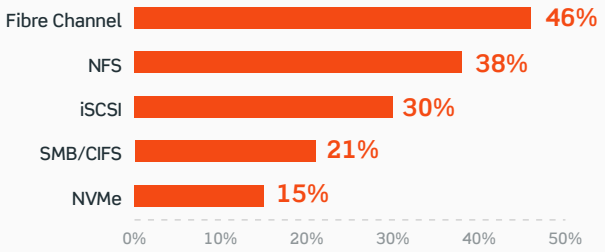
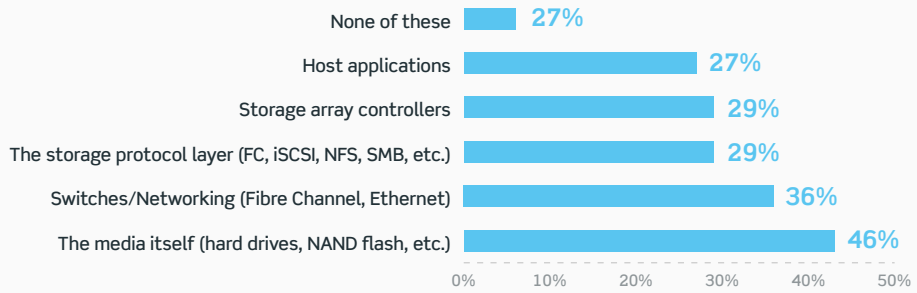


Figure 5

Where do you see the most actual or potential for storage performance bottlenecks?

(N=362)



NVMe doesn't support spinning disk. It's designed for flash and other solid-state media storage. Thirty percent of respondents are running some type of all-flash storage system (Figure 3), making them candidates for NVMe. *(It should be noted that NVMe can be used in conjunction with spinning disk. In such systems, the spinning disks will still be managed by their traditional controllers, while NVMe storage will be managed with NVMe controllers. In these scenarios, NVMe storage may be used as a tier in a hybrid-flash storage system.)*

Shared storage protocol wars have come and gone over the years, but NVMe adds a new entrant into the mix. At 15%, NVMe currently sits at the bottom of the protocol leaderboard, which is topped by perennial favorites Fibre Channel (46%) and NFS (38%) (Figure 4).

Don't take this to mean that NVMe is a failure; it's simply newer and not as widely available yet. Other limiting factors include the reality that not every workload needs NVMe. Since administrators often need to stretch their budgets, this might be a restriction, too.

Performance problems can pop up in any part of the infrastructure stack. We asked respondents to tell us where they typically see performance problems arise (Figure 5). (Bear in mind that respondents may not have deep familiarity with every part of their IT stack, and may not have monitoring tools that fully expose actionable metrics.)

Almost half of respondents blame underlying media for performance issues. Given that many of them continue to run disk-based storage systems, this result isn't surprising. In disk-based systems, the media may be a bottleneck for many.

More than one-third of respondents indicate that the storage fabric – Ethernet, Fibre Channel or some other fabric – is the primary contributor to their storage woes. NVMe can help here as well, with what is known as NVMe over Fabrics (NVMe-oF). NVMe-oF can enhance your current interconnect, which also dramatically improves performance and security.

We don't expect to see NVMe-oF replace existing technologies in a wholesale way. These interconnects, particularly as they get faster, will enjoy new life as NVMe-oF is further developed to take advantage of them.

Figure 6

What impact do you think NVMe has on overall flash storage performance?

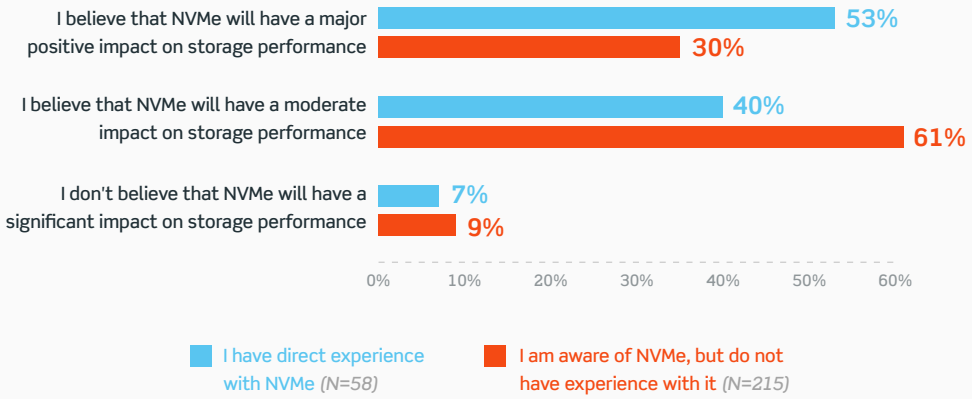
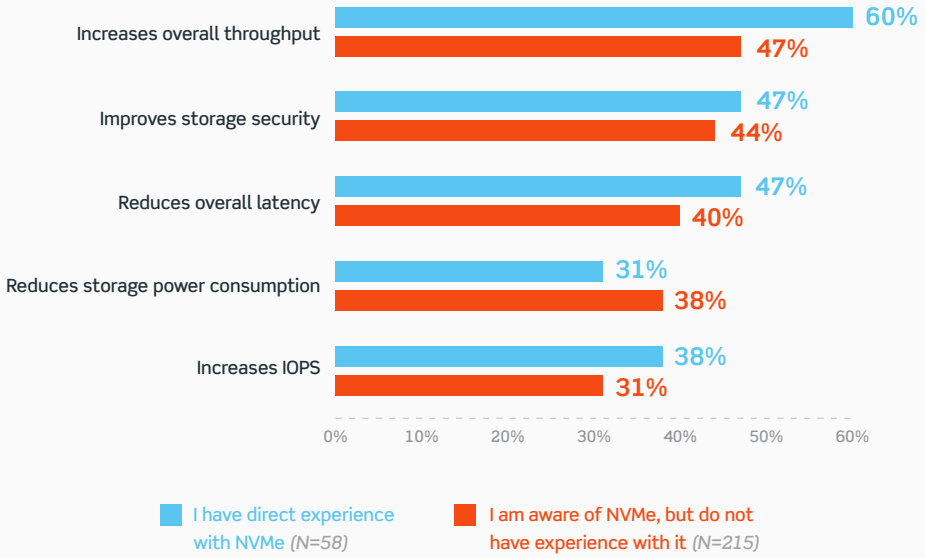


Figure 7

In what ways do you believe that NVMe adoption improves the overall storage environment?

(N=273)



Experience with NVMe makes all the difference in how performance outcomes are perceived. For respondents that have actual experience with NVMe, 53% say that it has or will have a major positive impact on flash storage performance (Figure 6). Forty percent say it will have a moderate impact, and 7% indicate that they don't believe it will have a major impact on storage performance. For those that know about NVMe but haven't worked with it, 30% believe it will have major performance benefits, while 61% say benefits will be moderate.

These responses suggest that NVMe performance outcomes are even better than what's being promised. People who have actual experience with the technology are reporting an experience that far outweighs the expectations of people who have yet to do so.

Given the overhaul that NVMe provides to the data path, we sought to gauge whether or not people truly understand what NVMe brings to the table; the results are shown in Figure 7. As was the case with other survey questions, those who have direct experience with NVMe reported (for the most part) more benefits for the technology. In terms of overall throughput, 60% of experienced NVMe practitioners said they believe that NVMe increases throughput. Only 47% of those without NVMe experience say the same.

All those who have direct experience with NVMe reported benefits far greater than those who didn't. This indicates that NVMe is exceeding the hype and delivering real benefits. One thing to note is that when it comes to power consumption, experienced NVMe respondents are not as likely to identify reduced power consumption as a benefit compared to non-practitioners. This is one area in which NVMe doesn't live up to some of the stated flash benefits, although it's a relatively minor issue.

Figure 8

What are your thoughts on the performance of your flash storage solution?

(by company size based on revenue; users of flash and hybrid systems only; N=218)

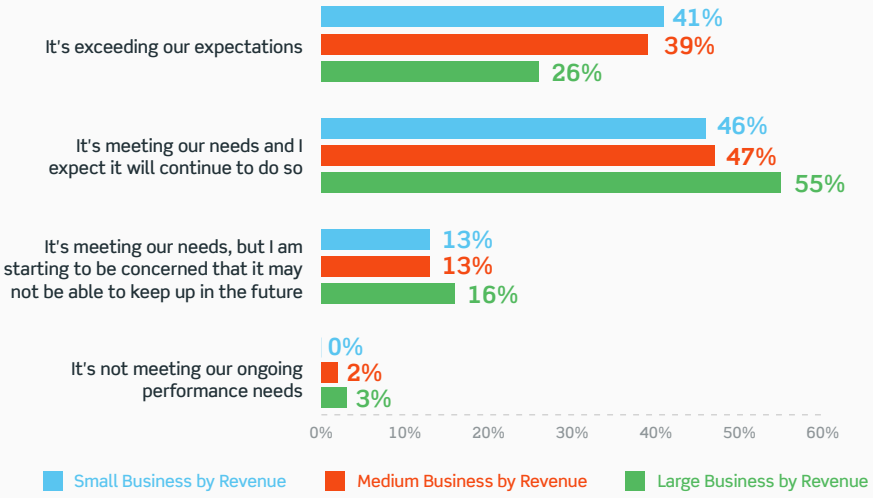
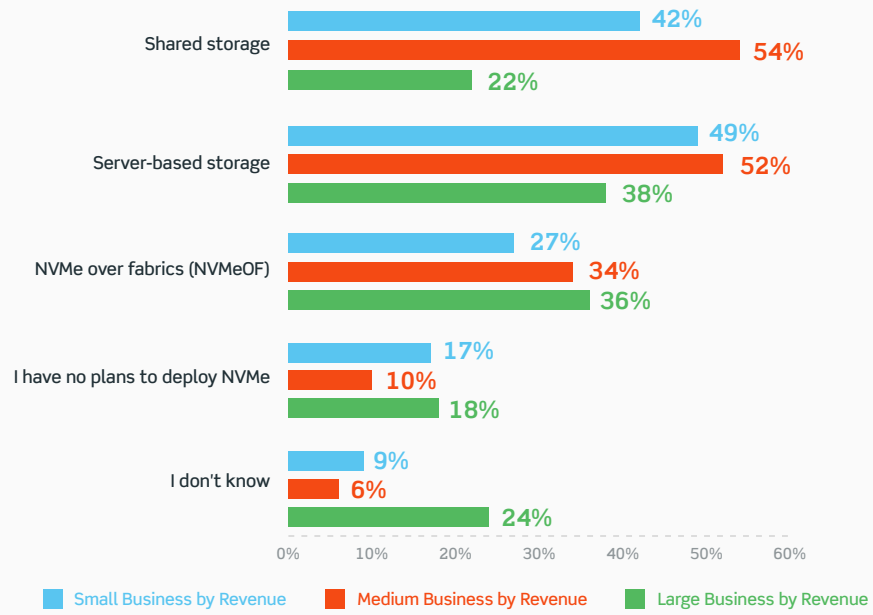


Figure 9

How have you deployed or how do you intend to deploy NVMe?

(by company size based on revenue; multiple selections allowed; N=360)



Flash is supposed to solve storage performance woes; but that may not be the case, leading to a need for either a successor to flash, or for technology that augments and supplements it, such as NVMe. In fact, only 26% of large company respondents say that their flash systems are exceeding their expectations, compared with 41% and 39% of small and medium companies, respectively (Figure 8).

Further, 16% of large company respondents report that they're becoming concerned about the ability of their flash systems to maintain performance needs for their workloads, while 13% of small and medium business say the same. It's likely that larger organizations simply push their storage systems closer to the limit than smaller organizations, hence the concerns around the ability for storage performance to keep pace.

We believed that NVMe would initially gain traction in large organizations, before smaller and medium-sized organizations adopt it. The concerns that large companies are expressing about flash may indicate a willingness to consider NVMe as one solution to get more life from flash storage.

> 16% of large company respondents report that they're becoming concerned about the ability of their flash systems to maintain performance needs for their workloads.

However, upon further reviewing the results, we found that 42% of respondents in large companies either don't know where they're going to deploy NVMe, or they have no plans to deploy NVMe (Figure 9). The only place in which large companies beat smaller ones in terms of expected NVMe deployments is around NVMe-oF, where large companies squeak a bit ahead of medium companies, with 36% of respondents from large companies saying that they'll make an investment in NVMe-oF.

Summary: A Hunger for NVMe Knowledge

One of the most revealing statistics about the future of NVMe came from the question *Do you want to learn more about NVME?* Seventy-nine percent of respondents replied in the affirmative.

Although much of the discussion today revolves around performance of NVMe media, we fully expect people to discover other benefits over time. Although we believe NVMe is an incredible leap forward, we are under no illusion that it will enjoy overnight adoption. People will make NVMe decisions based on cost and need, just as they do with other technology purchases.

Appendix: Methodology

HOW WE GOT OUR NUMBERS

We ran a comprehensive survey in early 2018, seeking respondents that work directly in IT with demonstrated knowledge of IT operations. We gathered a total of 399 valid responses to our survey. The information presented in this report includes various cross-sections of the gathered data, along with ActualTech Media's thoughts and analysis of the data.

There are a number of items to consider as you're reviewing this information:

- The presented information is a point-in-time look at a subsection of the broader IT marketplace, and is just one audience. Different audiences may have different thoughts, so the information included in this report may vary from findings in other industry reports.
- A number of questions included "I don't know" as a response. We included this option to avoid gathering poor-quality data. We exclude "I don't know" responses from our analysis, so the response counts to some of the questions will total fewer than 399 responses.

We broke down survey responses in different ways, including by company size and knowledge of NVMe.

COMPANY SIZE

For the purposes of this report, company size information is calculated in two different ways: by revenue, and by number of employees. For all data points presented, we include the sizing metric used for that particular point. Remember that there is no such thing as a one-size-fits-all definition for company size. What may be considered a large business in one industry may be considered a small business in another.

Figure 10

Company Size by Revenue

(N=360)

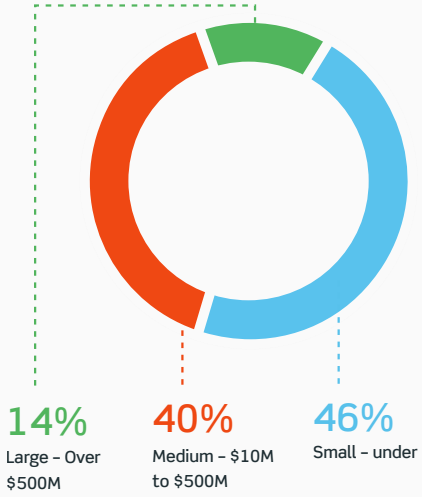


Figure 11

Company Size by Employee Count

(N=399)

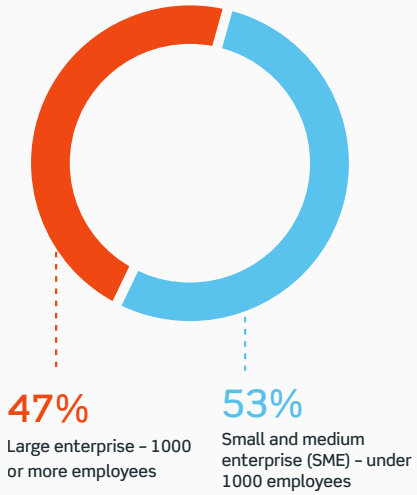
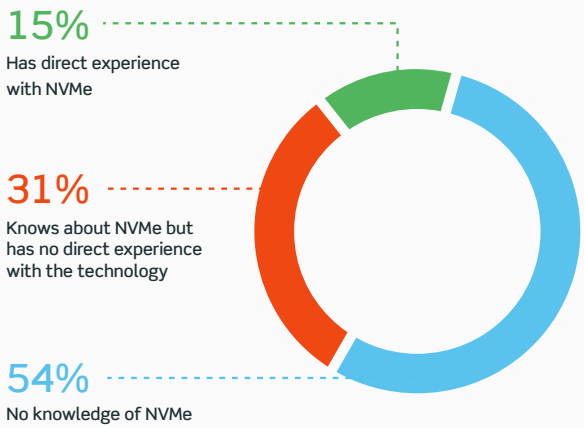


Figure 12

Self-identified Knowledge of NVMe

(N=399)



Our surveys ask respondents for company size in very narrow bands, allowing for analysis across more than just broader market segments. However, for the purposes of our general analysis, most of the statistics in this report use two or three company size categories:

Method 1. Breakdown by Organization Revenue (Figure 10)

- Small – less than $10M; 167 respondents in this category
- Medium – $10M to $500M; 143 respondents in this category
- Large – More than $500M; 50 respondents in this category

Method 2. Breakdown by Company Size (Figure 11)

- Small and medium enterprise (SME) = fewer than 1000 employees; 210 respondents in this category
- Large Enterprise = 1000 or more employees; 189 respondents in this category

KNOWLEDGE OF NVME

Given the topic of this survey and report, we sought to discover what perceptions and potential misconceptions respondents may have around NVMe and its potential. To that end, we asked respondents to self-identify their knowledge of NVMe, and provided three options, as shown in Figure 12.

- No knowledge of NVMe; 123 respondents in this category
- Knows about NVMe but has no direct experience with the technology; 216 respondents in this category
- Has direct experience with NVMe; 60 respondents in this category

For respondents who indicated no knowledge of NVMe, we did not ask any NVMe-related follow up questions.