IS NVME STORAGE RIGHT FOR TELEMETRY APPLICATIONS

Chris Budd
SMART High Reliability Solutions
Gilbert, AZ 85233
Chris.Budd@smartH.com

ABSTRACT

Generally, telemetry applications are not on the cutting edge of storage technology for several reasons: they do not need the high performance, cannot provide the power for high performance, and cannot afford the instability of new technologies. While Non-Volatile Memory Express (NVMe) might initially seem to be the opposite of those goals, it does in fact have the ability to meet them; power and performance can be matched to an application's needs, and NVMe is gaining stability as it gains overall market share. With the overall data storage industry moving to NVMe, other storage interfaces will begin to decline and future improvements will occur only on NVMe. With the right ruggedization and customization options, NVMe can be a good fit for telemetry applications.

KEYWORDS

NVMe, PCIe, SATA, SCSI, SSD

INTRODUCTION

For many decades, almost all storage interfaces were based on either SCSI or ATA; originally, they used parallel interfaces, and in the early 2000s, they upgraded to faster serial interfaces, Serial Attached SCSI (SAS) and Serial ATA (SATA), respectively. Even with this interface upgrade, they continued to use many legacy commands and data transfer mechanisms for backwards compatibility with existing infrastructure, and they still focused on rotating magnetic hard-disk drives (HDD). Around the same time, solid-state drives (SSD) entered the mass market and became more efficient, but using these existing legacy-focused interfaces restricted some of the potential performance gains of the new storage media technology. The NAND flash storage media inside the SSD provides near zero seek time since there are no moving mechanical parts; in addition, with enough NAND operating in parallel, the read/write performance of the SSD could far exceed the existing serial storage interfaces.

In 2007, several large companies including Intel, who makes SSDs and the NAND inside SSDs, aimed to create a new storage interface to improve the performance of nonvolatile memory-based SSDs. [1] After more than ten years, this interface, Non-Volatile Memory Express (NVMe), has become one of the hottest topics in data storage with many seminars and entire conferences devoted to it. However, is this new storage interface a good fit for telemetry applications? Like any industry, telemetry system designers would like to take advantage of commercial off-the-shelf (COTS) products for cost savings, but telemetry applications can have unique requirements that are not readily found in COTS products let alone found in products based on the latest technologies like NVMe. Before making a decision, a designer needs to know more about NVMe, the unique storage requirements of telemetry applications, and then compare the two.

1. NVME OVERVIEW

NVMe is designed specifically for non-volatile memory; consequently, the authors of NVMe were able to shed support for legacy storage devices, commands, and interfaces allowing them to focus on taking advantage of the high performance of the NAND flash found on SSDs, and the high performance PCIe slots on modern PC motherboards. Even though it is a new standard, it still has many adopters and is becoming more common.

1.1 NVME GAINS MOMENTUM

The first NVMe specification was released in 2011, and then the NVMe organization was incorporated in 2014. From 2014 to 2016, the organization nearly doubled in size as it grew from 61 to 115 members. [2] The member companies include several very large consumer storage companies such as Intel, Micron, Samsung, Seagate, Toshiba, and Western Digital. [3] All of these storage companies, and others, offer many different NVMe storage products. In 2017, the organization released the third revision to the specification, 1.3. [3] The fact that the organization is growing shows that the interface is gaining momentum, and will not fade away anytime soon.

1.2 HIGH PERFORMANCE

One of the main benefits of the new storage standard is higher read/write performance over traditional storage interfaces such as SAS or SATA. The NAND flash in SSDs has a memory-style interface with address and data lines; the SSD simply places the desired address on the address lines, and then reads the data almost instantly. Contrast this SSD data retrieval mechanism to the HDD mechanism that includes moving a mechanical arm to position a read/write head over the correct track of a magnetic platter, and spinning the platter to locate the desired data. In addition, an SSD generally has several channels of these NAND flash packages with independent address and data lines allowing for parallel access. NVMe takes advantage of this memory-style, parallel interface by creating a method for a host to issue multiple commands in multiple queues allowing the storage device to determine the best order to complete the commands to minimize the latency and time waiting for data. On top of the parallel command queues, NVMe uses up to 4 PCIe lanes of 8 Gigabits per second (Gb/s) each providing nearly 4 GigaBytes per second (GB/s) of potential bandwidth, rather than one 6 Gb/s interface like SATA providing about 0.5 GB/s.

1.3 HIGH POWER

All this performance comes at a cost of higher power consumption. Even low-power NVMe drives consume over 6W, while others consume more than 12W! [4] This higher power also implies more heat, and heat is not good for the SSD components, especially the NAND flash since NAND memory cells lose data retention as the temperature increases. Therefore, many NVMe SSD vendors are adding fins or ridges to their enclosures in an attempt to help dissipate this extra heat.

2. TELEMETRY STORAGE REQUIREMENTS

Designers of telemetry applications, on the other hand, generally do not need to be on the cutting edge of storage technology, and do not want to deal with the problems associated with it. Telemetry applications also have specific requirements not found on cutting-edge, commercial, off-the-shelf components such as rugged enclosure, industrial temperature range, write protection, erase triggers, etc. In addition, telemetry applications have certain demands such as a long-term supply and low performance to reduce power, allowing operation in low-power environments.

2.1 LONG-TERM SUPPLY

One potential cause for problems in telemetry applications comes from the components used in the system. If a supplier frequently changes a component or, worse yet, stops selling the component entirely, then the overall system must requalify the new component. If this requalification happens too often, it would cause the cost of the program to increase, and possibly increase beyond the point of profitability.

2.2 RELATIVELY LOW PERFORMANCE REQUIREMENTS

NVMe's high performance was designed for high-end enterprise applications with racks and racks of servers similar to Facebook or Google. Telemetry applications are not nearly that large, and need only keep up with the bandwidth of their data collection. Many telemetry applications still cannot saturate the 6 Gb/s on SATA, and if they can, they usually stripe the data across multiple 6 Gb/s SATA devices.

2.3 LOW POWER

One reason for the low performance is that telemetry applications frequently have limited power budgets. For example, if it is in an aircraft, it may be restricted by SWaP – size, weight and power. Even ground-based applications might be limited if they exist on portable systems relying on limited battery power.

3. PREDICTIONS

Even with these requirements and restrictions, can telemetry applications benefit from this new storage interface? The problem of power consumption is not an impossible obstacle and can be managed by reducing performance. In addition, since the storage market is moving to NVMe, there may be limited options for other interfaces in the near future.

3.1 LOWER THE POWER CONSUMPTION

One solution to control power consumption is to limit the performance; higher performance demands higher power consumption, and lower performance can provide power savings. If the telemetry application does not need the full performance benefit of NVMe, special firmware can limit the performance to keep the power consumption to a reasonable level. In addition, the modern storage products, including NVMe, have implemented low-power “sleep” modes such that when the storage device is idle, the power can be reduced dramatically down to a few milliwatts making the average power consumption less than 100 mW and much smaller than the active power consumption. [5]

3.2 STORAGE INDUSTRY IS MOVING

As the NVMe organization is gaining member companies, the NVMe interface becomes more ubiquitous, and more compatible. Also more consumers and enterprise customers are seeing the tremendous performance benefits and switching to the NVMe interface; experts predict that in two more years, NVMe revenues will be 20% of the enterprise storage market, and an even higher percentage in the overall storage market. [6] While it may take several years for NVMe to be the dominant storage interfaces, the shift is happening, and eventually it will be more difficult to find vendors for the other storage interfaces such as SATA and SAS; a similar scenario happened when ATA and SCSI switched from parallel interfaces to serial interfaces. Those vendors still supplying products will not be making major improvements to the interface, as they will be mainly concerned about maintaining compatibility with their existing customers’ legacy systems; they will most likely want to do as little work as possible due to the decreasing market size. Any technological storage changes will be focused on the newer NVMe interface.

CONCLUSION

NVMe is only a few years old, but it has already gained a stronghold and is clearly positioned to be the storage interface of the future. Several large storage companies are backing it and supply several products today. NVMe offers superior performance over the traditional storage interfaces which were designed around HDDs, and which must continue to support legacy devices. Additionally, NVMe will become the beneficiary of future improvements while lowering costs as adoption increases.

As market share increases, so do the number of vendors offering products which will alleviate supply concerns of telemetry applications. While NVMe vendors today are mainly focused on enterprise or consumer products; soon these vendors or new vendors will provide additional features to the NVMe products such as the ability to decrease power consumption by decreasing performance.

While any technological change brings challenges, NVMe has proven itself to be a worthwhile and stable technology. With the right ruggedization and customization, NVMe can be a good fit for telemetry applications.

REFERENCES

[1] Intel, "Dell, Intel And Microsoft Join Forces To Increase Adoption Of NAND-Based Flash Memory In PC Platforms," 30 May 2007. [Online]. Available: https://www.intel.com /pressroom/archive/releases/2007/20070530corp.htm. [Accessed 25 May 2018].

[2] A. Huffman, "NVM Express Past, Present, and Future," 9 Aug 2016. [Online]. Available: https://www.flashmemorysummit.com/English/Collaterals/Proceedings/2016/ 20160809_FA11_Huffman.pdf. [Accessed 25 May 2018].

[3] NVM Express, Inc., "About," [Online]. Available: https://nvmexpress.org/about/. [Accessed 25 May 2018].

[4] A. Malventano, "PCIe SSD Roundup - Samsung SM951 NVMe vs. AHCI, XP941, SSD 750 and More!," 17 Apr 2015. [Online]. Available: https://www.pcper.com /reviews/Storage/PCIe-SSD-Roundup-Samsung-SM951-NVMe-vs-AHCI-XP941-SSD-750-and-More/Power-Consumption. [Accessed 25 May 2018].

[5] R. Huang, "Making the Right Power/Performance Tradeoffs for PCIe/NVMe SSDs," 10 Aug 2017. [Online]. Available: https://www.flashmemorysummit.com/English/Collaterals /Proceedings/2017/20170810_FA31_Huang.pdf. [Accessed 25 May 2018].

[6] T. Coughlin, "Digital Storage Projections for 2018, Part 2," 2 Jan 2018. [Online]. Available: https://www.forbes.com/sites/tomcoughlin/2018/01/02/digital-storage-projections-for-2018-part-2/2/. [Accessed 25 May 2018].

NOMENCLATURE

ATA or Advanced Technology Attachment: An interface standard from T13 (http://www.t13.org/) for storage devices using a parallel bus (PATA), or serial bus (SATA).

Flash: A non-volatile memory device using an array of transistors each with a floating gate to store a charge.

GB or Gigabyte: 10^9 bytes.

HDD or Hard-disk drive: Traditional mass storage device using a rotating, magnetic platter.

MB or Megabyte: 10^6 bytes.

NAND: A high-density flash device usually with defect blocks marked by the factory; read and write operations must be done at a page level (several kilobytes), and erases must be done at an erase block level consisting of several hundred pages.

NVMe or Non-Volatile Memory Express: A high-speed storage interface commonly using PCIe.

PCIe or Peripheral Component Interconnect Express: A high-speed bus for computer peripherals.

SATA or Serial ATA: A storage bus interface where the data is transferred serially rather than through parallel data wires as in previous ATA devices.

SCSI or Small Computer System Interface: An interface standard from T10 (http://www.t10.org/) for storage devices typically using a parallel bus, or serial bus (SAS).

SSD or Solid-State Drive: A mass storage device typically using the same form factors as traditional hard-disk drives, but without the moving parts. An SSD typically stores data in SLC or MLC NAND flash.