M.2 Form-factor SSD Future of the Data Center

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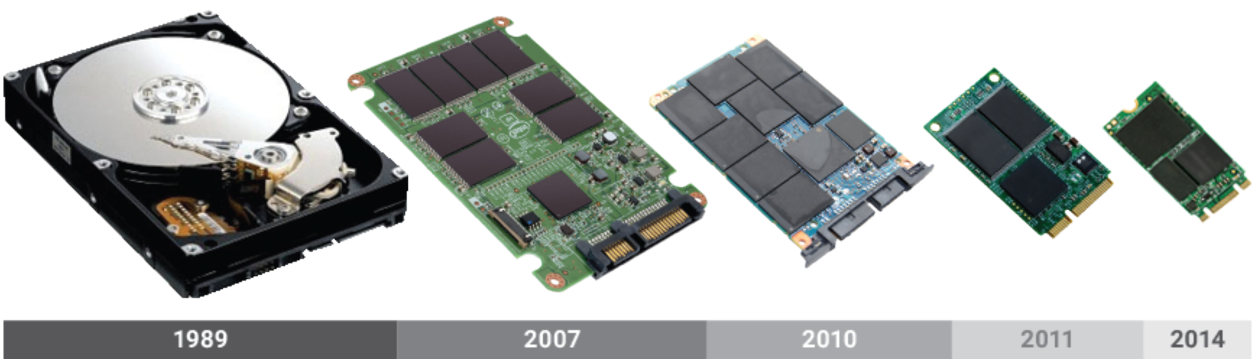
OVERVIEW

Form-factors for storage devices have been in constant change from the advent of digital storage. Storage form-factors have evolved over time, changing in size over four times (e.g., 5.25”, 3.5”, 2.5”, and 1.8”) and being driven by hard disk drive (HDD) requirements – each time reducing size and increasing capacity density. The same has held true for solid-state drives (SSD) since their introduction, always matching similar form-factors to the HDD (e.g., 2.5” and 1.8”). More recently, the industry has recognized that SSDs do not need to adhere to the shape and size restrictions of the HDD, therefore allowing for the introduction of new form-factors (e.g., PCIe, mSATA, and M.2) while further reducing size and increasing capacity density. A major driving force behind this form-factor evolution in enterprise storage has been the pursuit of reduced footprint and improved total cost of ownership (TCO). As such, the demand for smaller footprints has enabled higher deployment density in data center and enterprise applications; this trend will continue to drive the evolution of storage. Modern data centers can take advantage of the reduced footprints, higher storage densities, greater efficiency, and improved TCO benefits enabled by the deployment of smaller form-factor storage devices.

BACKGROUND

It is expected that the next trend in solid-state storage (SSD) form-factor devices will evolve to encompass the emerging M.2 SSD. The M.2 form-factor is already gaining significant traction in client PC applications, but it is expected that the next major adoption of M.2 SSDs will be in enterprise and data center environments. Many of today’s data center architects are currently using 2.5” and PCIe devices as a method of deploying SSD into their infrastructure, but the server industry is beginning to adopt more M.2 form-factor storage into server designs due to the overwhelming advantages of the M.2 form-factor. Data centers benefit greatly from the reduced footprint, lower cost, higher performance, and improved TCO provided by M.2 SSDs, particularly when comparing M.2s to other form-factor storage devices. However, one major issue with the deployment of these smaller devices is the limited availability of M.2 sockets: very few motherboards and backplanes currently support the M.2 form-factor. The storage industry has yet to solve how to deploy M.2 SSDs en masse into servers and data center environments.

Figure 1: Evolution of Storage Form-factors



FORM-FACTOR ANALYSIS

The primary goal of this white paper is to compare several different SSD form-factors. The main comparison is between the 2.5" and the M.2 form-factor due to the prevalence of the former and opportunity with the latter in traditional enterprise and data center environments.

Table 1: SATA 2.5" SSD vs. M.2 NVMe SSD

	2.5" SATA	2.5" SAS	M.2 SSD
Interface	6 Gb SATA	12 Gb SAS	Gen3 PCIe
Performance	600 MB/s	1200 MB/s	4000 MB/s
Form-factor	100 x 70 x 9.5	100 x 70 x 15	22 x 110 x 3.5
Volume	8x	12x	1x
Power	~5 W	~10 W	~5 W
Ecosystem	Mature	Mature	Emerging

Based on the analysis, several important findings surfaced:

1) M.2 has 8x to 12x smaller footprint compared to 2.5" form-factor

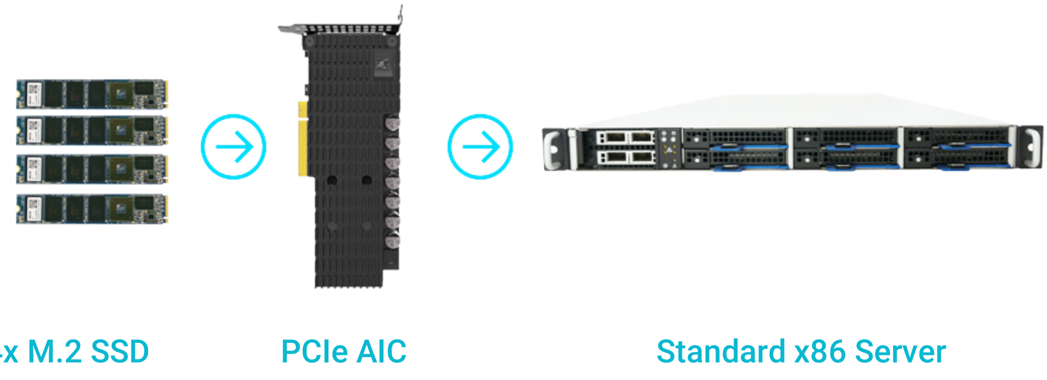
2) M.2 NVMe enables 4x to 8x higher performance compared to 2.5" form-factor

3) M.2 provides improved TCO by reducing power, reducing initial cost, and providing greater density and efficiency

DEPLOYMENT METHODS

The distinctions of M.2- and PCIe-based storage are significant. In order to realize the benefits, including reduced footprint, greater efficiency, improved TCO, and increased performance, the parallel deployment of many M.2 storage devices is essential. To achieve these results, PCIe switching technology must be utilized to enable many M.2s to be connected into a single system. Standard PCIe sockets are available in all modern servers, but there is no sophisticated method to connect the M.2 form-factor to standard PCIe sockets. One new deployment method is a PCIe add-in-card (AIC) that supports connecting multiple M.2 SSDs to a single PCIe device. This PCIe AIC provides the ability to connect many M.2 devices directly into any standard server that supports a PCIe socket.

Figure 2: M.2 PCIe Add-In-Card (AIC) Overview



PCIE AGGREGATION

M.2-based solid-state storage provides measurable benefits, ranging from higher performance to lower TCO by reducing floor space and providing greater efficiency. When combined with a method of deployment that allows numerous M.2s to be connected inside a system via PCIe switching technology, M.2 SSDs can provide tangible benefits, including higher sequential and random read performance, higher capacity/density per server, and increased efficiency of each unit. Table 2 illustrates the net result when multiple M.2 SSDs are deployed into a single server.

Table 2: M.2 SSD Results Per Add-In-Card vs. Server

	4x M.2 Per Add-In-Card	6x Add-In-Card Per Server
# of M.2	4x M.2 per card	24x M.2 per server
Throughput	6 GB/s	36 GB/s
IOPS	1.25 M	7.5 M
Capacity	8 TB of SSD	48 TB of SSD

SUMMARY

The storage industry will continue to evolve and deliver more innovative solutions for deploying solid-state devices over time. The M.2 form-factor is the future of the data center and enables benefits not offered through legacy interfaces and legacy form-factors. Currently, 90% or more of any given NAND Flash producer's worldwide output is tailored to client-grade solutions, such as M.2 SSDs. As a result, there is a significant cost advantage by leveraging economies of scale enabled by M.2 SSDs. It may take time for the server industry to begin deploying these new devices natively, as they require new motherboards and new backplane technologies not currently available. However, solutions such as PCIe AICs will enable data centers to deploy these new M.2 devices today, in their current infrastructures, and realize higher performance and improved efficiency at lower operating costs.

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