WHITE PAPER

DATA CENTERS EMBRACE ADVANCED STORAGE TECHNOLOGY

E1.S and E1.L Drives Deliver the Performance and Packaging Required for Next Generation Compute and Storage Systems

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SUPERMICRO

Supermicro (Nasdaq: SMCI), the leading innovator in high-performance, high-efficiency server and storage technology is a premier provider of advanced server Building Block Solutions® for Enterprise Data Center, Cloud Computing, Artificial Intelligence, and Edge Computing Systems worldwide. Supermicro is committed to protecting the environment through its “We Keep IT Green®” initiative and provides customers with the most energy-efficient, environmentally-friendly solutions available on the market.

Executive Summary

Storage has become a fundamental requirement of modern data centers as the amount of data generated continues to grow[1.] . An increasing amount of data is constantly being collected at the edge, and a percentage of that data may be moved to larger cloud or enterprise data centers. To effectively manage and store the data from the edge to the cloud, standards need to be developed that create a competitive eco-system that gives IT managers choices depending on their workloads and data access requirements. For example, the E1.S and E1.L form factors are designed so that airflow can easily reach the CPUs directly compared to a U.2 storage device where a backplane is needed. An overall design of systems should not be taken lightly, as innovative mechanical designs need to consider the cooling and packaging requirements. The realization the new storage devices can affect the overall physical design and cooling requirements of the CPUs has led to the creation of this form factor that delivers high capacities while minimizing air flow restrictions.

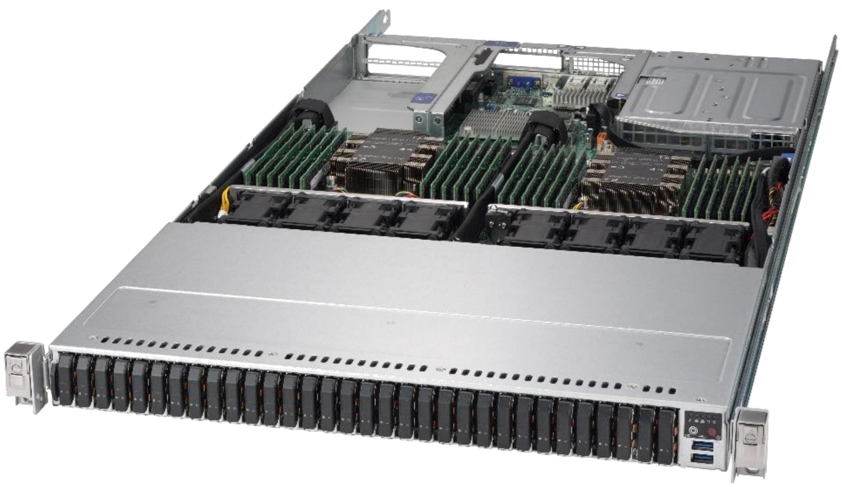
Basics

Storage for systems has moved from sizeable rotating disk drives (HDDs) to smaller and faster drives that fit into almost any form factor. Over the past 10-20 years, popular sizes have been the 2.5” and 3.5” HDDs, which fit into a wide array of servers and storage appliances. The Solid State Drive (SSD) has become the most popular storage device for high-powered data center servers down to workstations and laptops. With a current storage capacity in the Petabyte (PB) range per server, the SSD has become the device of choice due to data storage and retrieval speed and the lower power consumption of solid-state technology. However, a 2.5” or 3.5” device will not physically fit in a number of the new types of servers that are used today. SSD form factors were originally developed to replace HDDs within the server. This led to inefficient designs which were forced into a form factor that had detrimental effects on the critical airflow design within the server.

A storage device that is used within a server needs to fit within an “envelop,” which will be limited by the following constraints:

1. **Physical Size:** Since servers are designed for different environments requiring different physical sizes, the storage device needs to fit within the server dimensions allocated for this function. Various form factors have been used for storage over time. However, new generations of servers, which are smaller than before that may be installed at the edge, require smaller form factor storage. The most common shape is a “stick,” also referred to as a “ruler.” These devices are designed to connect via a PCI-E connector, utilizing the latest PCI-E technology and specifications.

2. **Thermal Limits:** The CPUs and GPUs in a server continue to produce more heat than the rest of the components. Therefore, the mechanical design of a system is critical in allowing cooling air to reach the CPUs and GPUs with no obstructions. Supermicro systems such as the SuperStorage product line are designed to operate at maximum performance, which will generate more heat than a lightly used system. For this reason, innovative designs are used for maximum airflow.



Supermicro 32-bay E1.S Server with Optimized Airflow Design in 30” depth System (model SSG-1029P-NES32R)

The EDSFF backplanes are installed in a system parallel to the airflow direction, allowing higher amounts of air to reach the CPUs than a U.2 backplane. As a result, more powerful CPUs and GPUs can be used with the EDSFF form factors, increasing performance while remaining within the thermal design envelopes.

In addition, the drive will heat up as SSDs receive data from the host CPU or deliver data back. Dissipating the heat is critical to maintaining the integrity of the drive within the specified operating performance. Likewise, the airflow over an SSD heatsink is essential to remove the heat. Thus, the SSD enclosure (containing the heat sink and air vents) must be sized to allow enough airflow to keep the SSD cool.

3. **Capacity:** Every organization will need different amounts of storage capacity, so flexibility in various capacities while retaining the form factor is essential for IT managers. As the amount of data generated and needs to be stored continues to grow, new SSD capacities must also increase. Keeping the data close to the CPU (within the same system) and in persistent memory requires increased storage density. New technologies enable higher density drives, which are now in the double-digit TB range but increasing rapidly. Another alternative is utilizing Intel Optane persistent memory modules for improved performance and data resilience.

4. **Connectivity:** Standard interfaces are necessary for the broad adoption of any technology. Standards have been shown to increase markets and encourage innovation and a range of suppliers. The key to wide adoption of this technology is using the same connectors and protocols in various form factors from multiple vendors. Therefore, connectors must be standardized, allowing for different vendors to supply these SSDs, keeping competition innovating.

Current Technologies

Most systems in use today utilize the PCI-E 3.0 bus for connecting storage devices to the CPUs. With the new PCI-E 5.0 specification, the performance will increase tremendously compared to PCI-E 3.0 standard (4X throughput), requiring new storage technologies to get maximum performance from the entire system. While current storage systems may have an unbalanced architecture, as one of the main sub-systems cannot deliver or analyze data as fast as other components can, future servers that incorporate PCI-E 5.0 and next generation CPUs will be fully able to take advantage of E1.S and E1.L storage technology. The challenge with the design of future high end systems is to cool the CPUs and GPUs (if installed). While liquid cooling remains an option, most racks of servers will still be utilizing air cooling. Thus, the density and placement of the storage hardware for easy serviceability will be essential for overall system operation. Since most servers today move air from the front to the back, serviceable storage components will reside at the system's front and must not block airflow.

Storage Networking Industry Association (SNIA)

SNIA, a non-profit organization made up of member companies spanning information technology, maintains the specifications for different form factors of storage devices. The latest one becoming widely adopted is the Enterprise and Data Center Standard Form Factor or EDSFF described below:

Form Factors – Why E1.S Will Prevail

The current form factor gaining popularity for data center storage is designated the E1.S, which has a technical specification defined by the SNIA, through the SNIA SFF Technology Affiliate (TA) Technical Work Group (TWG). The E1.S form factor is geared to replace the M.2 drive form factor in the data center due to a smaller form factor, reduced cooling requirements, and increased capacity.

The U.2 and M.2 form factors for data center server environments are summarized below.

Form Factor	Name	Dimensions (WxLxH, mm)	Main Use
M.2	22mm x 30mm	22.15 x 30.15 x 2.23	Server boot
M.2	22mm x 80mm	22.15 x 80.15 x 2.23	Hyperscale Data
M.2	22mm x 110mm	22.15 x 110.15 x 3.88	Hyperscale Data
U.2	2.5-inch (7 mm)	69.85 x 100 x 7	Hyperscale environments
U.2	2.5-inch (15 mm)	69.85 x 100 x 15	Server or Storage Enterprise environments

The E1.S form factors allow for an increased amount of air to be moved through the server, resulting in cooler CPUs, less likelihood of failure, and a reduction in fan speed and power needed.

While a longer (and higher capacity) form factor, called the E1.L, is available, many enterprises will realize that the E1.S will satisfy the needs for capacity, longevity, and performance. In addition, the E1.S allows for the popular 1U servers to accommodate up to 32 front-mounted drives, which are also easily serviceable. Finally, all of the E1.S models (currently five widths are available) reflect different heat sink sizes. As stated above, the more use and higher the SSD performance, the more heat is produced.

Image 1 - E1.S - With Cooling System

The available form factors for E1.[S, L] are as follows:

Product	Width of Enclosure	Recommended sustained power	Length
E1.S	5.9mm	12 watts	111.49mm
E1.S	9.5mm	20 watts	118.75mm
E1.S	15mm	20+ watts	118.75mm
E1.S	25mm	25+ watts	118.75mm
E1.L	9.5mm	25 watts	318.75mm
E1.L	18mm	40 watts	318.75mm

Table 1 - Form Factor Comparison

There are various reasons why a customer would want an E1.S or an E1.L SSD. The E1.S is obviously shorter, taking up less space in a compact server. The E1.L has a larger cooling surface, which will allow for higher operating temperatures. Within the E1.S options, there is a tradeoff between the different widths available (which reflects the cooling capacity) and the number of drives that can be installed and easily serviced within a server.

A 1U high server would contain up to 32 of the 5.9mm or 9.5 mm E1.S SSDs.

Image 2 - Server with 32 x 9.5mm E1.S

Similarly, 24 of the 15mm E1.S SSDs could be installed in a 1U server.

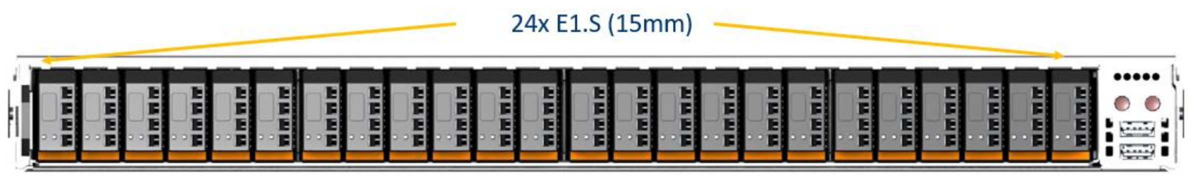


Image 3 - Server with 24 x 15mm E1.S

E1.L Description

The E1.L is a form factor that is optimized for data center storage systems, such as storage arrays. Longer than the E1.S at 318.75 length, the E1.L can store more data than an E1.S, but at a tradeoff of space in the server. In addition, the E1.L is specified at two different thicknesses, of 9.5mm and 18mm, which allow for more cooling (heat sinks) and thus an increase in storage capacity and activity.

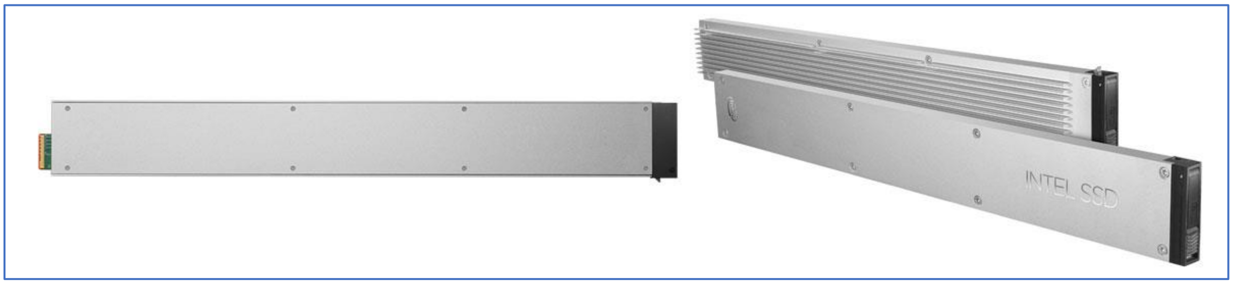


Image 4 - E1.L SSDs

Related to the E1.S and E3.L is the E3 specification. The E3 form factor is designed to replace, over time, the U.2 2.5” form factor SSD.

Looking Forward

A balanced system for a given workload will not have any bottlenecks that limit performance. Since the CPUs and GPUs are the highest valued item in many servers that are designed for simulations or data analytics, keeping a system busy means getting the CPUs / GPUs the required data with few stalls. Fast storage is critical, but the bus speed is vital as well. Future servers will need to incorporate the ability to communicate to other sub-systems with the latest bus technology (PCI-E). The new form factors, the E1.S and E1.L, will support new generations of PCI-E, which will move data center servers to the next level.

PCI-E has undergone tremendous improvements in performance since 2003. As a result, PCI-E 5.0 will be the ideal bus for E1.S SSDs to avoid bottlenecks.

Version of PCI-E	Introduced	Transfer Rate	X16 Throughput
1.0	2003	2.5 GT/s	4.000 GB/s
2.0	2007	5.0 GT/s	8.000 GB/s
3.0	2010	8.0 GT/s	15.754 GB/s
4.0	2017	16.0 GT/s	31.508 GB/s
5.0	2019	32.0 GT/s	63.015 GB/s
6.0 (planned)	2021	64 GT/s	126.031 GB/s

Table 2 - PCI-E Generational Comparison

The general requirements for future systems will include:

- CPUs need to be kept busy
- Memory needs to be fast enough to feed the CPUs
- Bus speed needs to be fast enough to feed data to the memory system
- Storage needs to be fast enough as not to be a bottleneck
- Mechanical designs that allow airflow throughout the entire system

References and Further Reading

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