



Hardware RAID at Entry-Level Price Points with Adaptec Series 6E

Introduction

Introduced in 1990 as a server-side option, RAID has evolved into a standard data protection requirement. The first implementations were high-performance controller boards with price tags that limited their usage to expensive server environments. Today, RAID is found everywhere, including laptops, desktops, workstations, and external storage enclosures.

RAID comes in a variety of formats – hardware, software, and hardware-assisted software – each of which has its own sets of cost and performance benefits and drawbacks, as outlined in this Technology Brief.

Adaptec by PMC Series 6 Entry-Level (Series 6E) Unified Serial SATA/SAS hardware RAID controllers strike an ideal balance between performance and price by offering true hardware RAID at a reduced cost. Ideal for entry-level desktop and industrial motherboard solutions, they offer the same reliability as the 6Gb/s Adaptec Series 6 product line and share the same drivers and management tools as Series 6 controllers to help keep implementation and maintenance costs low.

Entry-Level RAID Comparison

	RAID 0	RAID 1	RAID 10	RAID 1E
Minimum # Drives	2	2	4	3
Data Protection	No Protection	Single-drive failure	Up to one disk failure in each sub-array	Single-drive failure
Read Performance	High	High	High	High
Write Performance	High	Medium	Medium	Medium
Read Performance (degraded)	N/A	Medium	High	High
Write Performance (degraded)	N/A	High	High	High
Capacity Utilization	100%	50%	50%	50%
Typical Applications	High end workstations, data logging, real-time rendering, very transitory data	Operating system, transaction databases	Operating system, transaction databases	Fast databases, application servers

What is RAID?

RAID (Redundant Array of Independent Disks) is a way to improve storage performance, capacity and reliability by virtualizing multiple, independent hard disk drives into one or more arrays. The total array capacity depends on the type of RAID array that is built and the number and size of the disk drives used, and is independent of whether software or hardware RAID is used.

Entry-level RAID solutions often face several limitations: RAID is usually implemented in software only (which limits its robustness), or comes without support for DRAM caching (which hinders RAID performance, especially with spinning media). Many integrated solutions do not offer full OS support, or else require closed source libraries on certain open source OS platforms. Also, management and troubleshooting capabilities are limited and not in line with full-blown RAID controller products, which requires additional training, qualification and support efforts.

Highlights

Hardware RAID

PCI-X or PCIe controller card, or a motherboard-integrated RAID-on-Chip

- **Primary benefit:** Isolated RAID tasking yields best performance
- **Primary drawback:** Hardware makes it an expensive RAID solution

Software RAID

Runs on the host system's CPU

- **Primary benefit:** Lowest cost due to lack of hardware
- **Primary drawback:** Lowest performance as CPU must power RAID tasks in addition to OS and applications

Hardware-Assisted RAID

Combines software RAID with a Host Bus Adapter RAID or motherboard-integrated RAID

- **Primary benefits:** Lower cost than hardware RAID/better performance than software RAID
- **Primary drawbacks:** Moderate performance as software places additional load on server

Adaptec Series 6E Benefits

Hardware RAID performance at an entry-level price point

- Built upon PMC-Sierra's proven PM8013 SRC 6Gb/s RAID-on-Chip
- Utilizes DRAM caching to outperform software RAID and hardware-assisted RAID in real-world settings
- Outperforms hardware RAID without DRAM caching

Proven compatibility with existing ecosystems

- Tested with more than 300 devices

Advanced features

- Intelligent Power Management
- Support for SSD/HDD Hybrid RAID

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Types of RAID Solutions

Hardware RAID

At the top end of the spectrum is hardware RAID – a small independent computer system with its own processor and memory that offloads the RAID tasks from the host system. Hardware RAID comes in two flavors: 1) as a separate RAID controller card, or 2) as integrated hardware based on RAID-on-Chip technology.

A RAID controller card is a plug-in expansion card that plugs into PCI-X or PCIe slots of the computer system's motherboard and has a built-in RAID processor and its own interfaces to the drives. Because the RAID functionality is completely independent of the host system, these cards usually offer the best performance and the most flexibility.

In integrated hardware RAID-on-Chip (ROC) solutions, the RAID processor, memory controller, host interface, I/O interfaces for hard disk drive connection, and sometimes even the memory, are all integrated into a single chip. This chip can replace the I/O interface chip found on many server motherboards or may be located on a controller card. Either way, ROC offers hardware RAID capabilities with reduced costs. While hardware RAID is the best-performing and the most flexible RAID solution, its price point usually makes it unattractive as an entry-level option.

Benefits of Hardware RAID:

- **Protected at boot:** No loss of data if boot drive has errors or fails.
- **RAID application independent of host:** No data integrity issues if system crashes.
- **Enhanced protection in case of power loss:** Hardware RAID implementations typically keep track of in-progress writes in non-volatile hardware.
- **Not vulnerable to viruses:** RAID arrays are completely independent of the host system and OS.
- **Offloads the RAID task from the host:** Best suited for complex RAID 5 or RAID 6 scenarios which usually offers best cost/performance ratio.
- **Dedicated GUI and software to build and maintain the RAID:** Supports easy setup and maintenance of the RAID array.
- **Supports advanced RAID features:** Typical examples include disk hot plug, array-level migration and online capacity expansion.
- **On-controller caching:** Accelerates access times by usage of cache memory.

- RAID controller cards offer additional benefits:
 - **Performance independent of workload on server:** No impact on the performance of the application(s) running on the host system.
 - **Easy to migrate and replace:** Card can be plugged into any system and easily replaced or upgraded. It is also easier to migrate from one operating system to another.

Drawbacks of Hardware RAID:

- RAID controller cards come with the highest cost due to the I/O processor and additional memory.
- ROC solutions are priced lower than RAID controller cards due to their lower chip count, but are still more expensive than other RAID solutions.
- Motherboard-based ROC solutions offer limited flexibility and can be migrated to other systems only if they are equipped with a similar motherboard-based ROC solution.

Targeted Applications:

Hardware RAID is best for applications that require complex RAID algorithms, such as:

- High-performance workstations with large data storage requirements.
- Entry-level to enterprise servers requiring performance and scalability from the storage subsystem.

Software RAID

Instead of running the RAID task on independent hardware, software RAID runs entirely on the CPU of the host computer system, which means that the CPU's computing power is split between the RAID tasks, the operating system, and all the associated applications. Software RAID uses hard disk drives which are attached to the computer system via a built-in I/O interface or a processor-less host bus adapter (HBA).

Software RAID offers the lowest cost of all the RAID solutions, making it well-suited for entry-level applications, but also comes with several limitations.

Benefits of Software RAID:

- **Low cost:** No extra charge for the RAID functionality, as it is built into the OS. The only cost is the additional disk drives.

Drawbacks of Software RAID:

- **Unprotected at boot:** RAID protection isn't active until the operating system has loaded the RAID driver software, which can lead to an inoperable system if a drive fails or data is corrupted before the driver is loaded.

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- **Additional performance load on server:** The more drives involved and the more complex the RAID system is (e.g. involving parity on a RAID 5), the greater the impact on overall performance.
- **Limited operating system migration:** RAID functionality might be limited to the current OS if drivers for other OSes are not available.
- **Vulnerable to viruses:** Because RAID is running as an application on the computer system, it could be impacted by viruses and other harmful software.
- **Data integrity issues due to system crashes:** Software or hardware problems on the server can impact data consistency and integrity.
- **No write-back cache:** Software RAID runs only in writethrough mode. Hardware RAID, on the other hand, can add another level of data protection by running in write-back mode if it has a battery.

Targeted Applications:

Software RAID is best suited for simple RAID 0, 1, and 10 scenarios where performance or data availability is crucial, such as:

- Workstations without large data storage requirements.
- Entry-level servers without boot protection requirements.

Hardware-Assisted RAID

Hardware-assisted RAID combines software RAID with additional hardware such as an HBA with a RAID BIOS or just a RAID BIOS integrated onto the motherboard, and helps to overcome some of the weaknesses of pure software RAID.

With a moderate price point and fewer limitations than software RAID, hardware-assisted RAID is commonly found in entry-level RAID solutions.

Benefits of Hardware-Assisted RAID:

- **Moderate cost:** Only an HBA plug-in card or an additional flash memory for the BIOS on the motherboard is needed.
- **Protected at boot:** The additional BIOS makes the RAID functionality available when the system is switched on, so there is no negative impact on data availability if the boot drive has medium errors or fails completely.
- **Dedicated GUI** and software to build and maintain the RAID: Supports easy setup and maintenance of the RAID array.

Drawbacks of Hardware-Assisted RAID:

- **Additional performance load on server:** The more drives involved and the more complex the RAID system is (e.g. involving parity on a RAID 5), the greater the impact on overall performance.
- **Limited operating system migration:** Although more OS-independent than pure software RAID, hardware-assisted RAID functionality might be limited to the current OS if drivers for other OSes are not available.
- **Vulnerable to viruses:** Because RAID is running as an application on the computer system, viruses and other harmful software could impact RAID functionality.
- **Data integrity issues due to system crashes:** Software or hardware problems on the server can impact data consistency and integrity.
- **No write-back cache:** Software RAID runs only in writethrough mode. Hardware RAID, on the other hand, can add another level of data protection by running in write-back mode if it has a battery.

Targeted Applications:

Hardware-assisted RAID is good for cost-sensitive solutions similar to pure software RAID, but with bootability requirements, including:

- Entry-level servers without large storage requirements.
- Compute engines connected to networked storage.

Adaptec Series 6E RAID Controllers

The Adaptec by PMC family of Series 6E RAID controllers are the industry's first true hardware 6Gb/s SATA/SAS RAID controllers with on-board DRAM cache designed for the entry-level market segment.

Based on PMC's proven PM8013 SRC 6Gb/s RAID-on-Chip (ROC), these entry-level Series 6E controllers utilize HBA and hardware RAID functionality with DRAM caching to significantly outperform comparably-priced software-only and hardware-assisted RAID options in real-world settings. They also outperform hardware RAID solutions without DRAM caching.

The four-port Adaptec RAID 6405E is optimized for maximum host connectivity with an LP/MD2 form factor and PCIe x1 host interface that fits into any workstation, industrial PC or entry-level server platform. The Adaptec RAID 6805E is an eight-port, LP/MD2 form factor with bandwidth-optimized PCIe x4 host connectivity for higher throughput. Both products feature SAS 2.0, PCIe Gen2 and 128 MB DDR2-800 MHz DRAM cache for device acceleration.

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It is important to note that the DRAM cache on Series 6 controllers works in conjunction with Adaptec Zero Maintenance Cache Protection (ZMCP) to protect cached data in the event of a power failure, making Series 6 controllers ideal for applications that require full data protection in addition to the performance acceleration benefits of DRAM write caching. Conversely, the DRAM cache on Series 6E controllers enhances performance by caching data and reading ahead what might be needed next, but does not protect data for write back caching if power is lost. ZMCP is not available with Series 6E, making these controllers best suited for applications that do not require advanced data protection.

Series 6E controllers run the same Adaptec RAID Code (ARC) as all other members of the Series 6 family, as well as the same drivers, BIOS and storage management tools, allowing them to be deployed with minimum additional effort for integration, training. ARC delivers maximum reliability with RAID levels 0, 1, 1E, 10 and JBOD, and also offers RAID Level Migration (the ability to easily migrate RAID levels), Online Capacity Expansion (expand capacity without powering down the server), and Copyback Hot Spare (when a failed drive has been replaced, data is automatically copied from the hot spare back to the restored drive).

Adaptec Series 6E controllers support SATA and SAS devices and have been qualified with the same systems, operating systems, motherboards, backplanes and drives as Series 6 RAID controllers. Additionally, they are also certified compatible with entry-level storage devices for desktop use and the entry-level server platforms, workstations and motherboards most typically used for basic servers, performance workstations or industrial PCs.

Adaptec Series 6E Target Applications

Series 6E controllers are optimized for applications where the robustness and/or performance of hardware RAID is required but an Adaptec Series 6 controller would not work from a price, form factor or host connectivity standpoint, including:

- Performance workstations, such as video imaging.
- Industrial PCs, such as those used for process control and/or data acquisition.
- Entry-level servers.



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Hybrid RAID

With Hybrid RAID 1 & 10, Series 6E controllers offer maximum performance and reliability by combining Solid State Drives (SSDs) and Hard Disk Drives (HDDs) in a single array. Performing read operations from the faster SSD and write operations on both the SSDs and HDDs offers tremendous performance gains over standard HDD RAID arrays. Hybrid RAID offers the benefits of both technologies and allows a better cost-per-GB ratio than comparable SSD-only RAID arrays.

The Case for Cache

The fastest way for a RAID controller to fulfill a read or write request is to serve data out of its cache. Enabling the RAID controller cache offers significant performance benefits, such as reduced latency in I/O requests, bandwidth and queue depths that surpass software application limits, and on-the-fly parity calculations on sequential writes.

Intelligent Power Management

Intelligent Power Management (IPM) slashes power and cooling costs by up to 70% using intelligent I/O caching combined with disk drive power savings via standby and power-off modes.

One-view Storage Management

Series 6E controllers operate under Adaptec Storage Manager™, a one-view tool that centralizes management of all Adaptec RAID products.

Broad Operating System Support

Series 6E controllers support all major operating systems, including Windows 7, Windows Server 2008/2008 R2, Windows Vista, VMware ESX Classic 4.x, Red Hat Enterprise Linux (RHEL), SUSE Linux Enterprise Server (SLES), Sun Solaris 10, FreeBSD, Debian Linux, Ubuntu Linux.

Compatibility, Reliability, and Support

Series 6E controllers have been extensively tested with third-party components to deliver the utmost in compatibility. The cards are backed by a 3-year warranty and the company's legendary technical support.