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RAID capabilities on HP Workstation platforms

What is RAID?

Redundant array of independent disks (RAID) provides a method of combining multiple disks into a single logical volume to increase performance or create data redundancy. There are many forms of RAID, see the differences section for more details on specific RAID configurations.

What are the benefits of RAID?

The benefits of RAID vary based on the type of RAID implemented but can include some combination of the following:

- Improved performance
- Data redundancy
- Improved resiliency (avoiding downtime)
- Larger storage volumes

What terminology do I need to know?

Controller Spanning is the ability to support RAID configurations across multiple controllers, including AHCI and NVMe controllers. Controller Spanning can consist of RAID arrays configured from SATA or SAS devices on disparate controllers. Newer PCIe storage devices that have storage controllers built into the device only support RAID configurations that span multiple controllers.

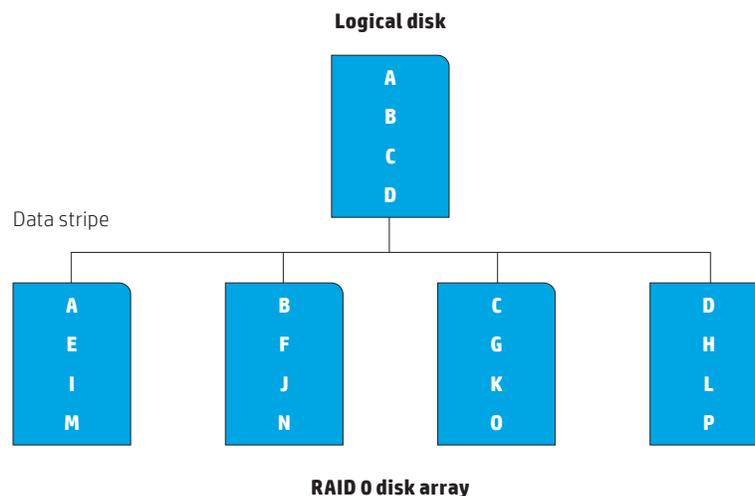
Data redundancy is the existence of additional data beyond the original data written that allows for the recovery of data in the event of errors or loss of original data. The amount of data redundancy and the ability to correct for errors varies based on the type of RAID array.

Parity is one mechanism to provide data redundancy and allows for the recovery of data if a drive fails. Generation of the parity data can take time and is most efficient when done in hardware.

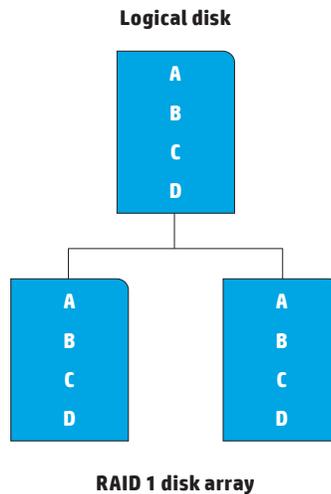
Hot spares are supported on some storage controllers. If a hot spare is supported, the designated drives will automatically replace a failed disk in a mirror. The hot spare must be the same capacity or greater than the largest disk in the array. Two hot spares can be designated for one array, or two different arrays can each be designated one hot spare.

What RAID configurations are available?

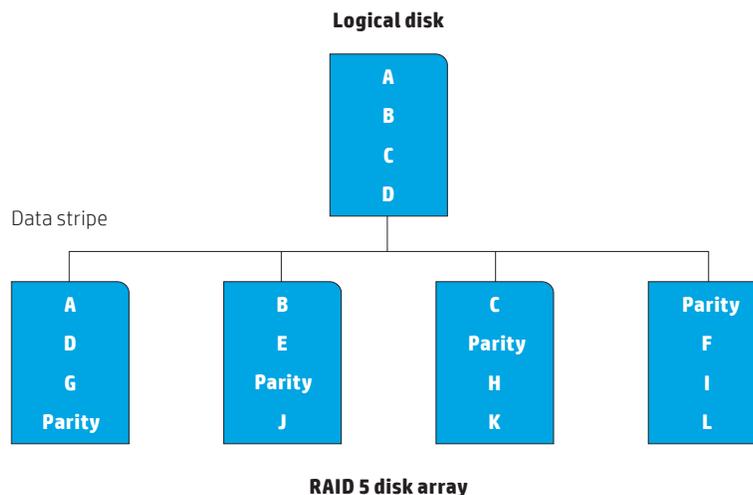
RAID 0 – Creates a single volume that has data striped across two or more drives. These drives are typically on one controller unless Controller Spanning is supported. The size of the volume is based on the size of the smallest capacity drive times the number of drives in the RAID 0 configuration. RAID 0 is used to either improve performance since data can be sent to multiple drives in parallel or to create a larger volume as each drive in the volume adds additional capacity. There is no data redundancy or parity in a RAID 0 configuration. If any hard drive member in a RAID 0 configuration fails, all data is lost for the entire array. The main advantage of RAID 0 is performance and an increased volume size.



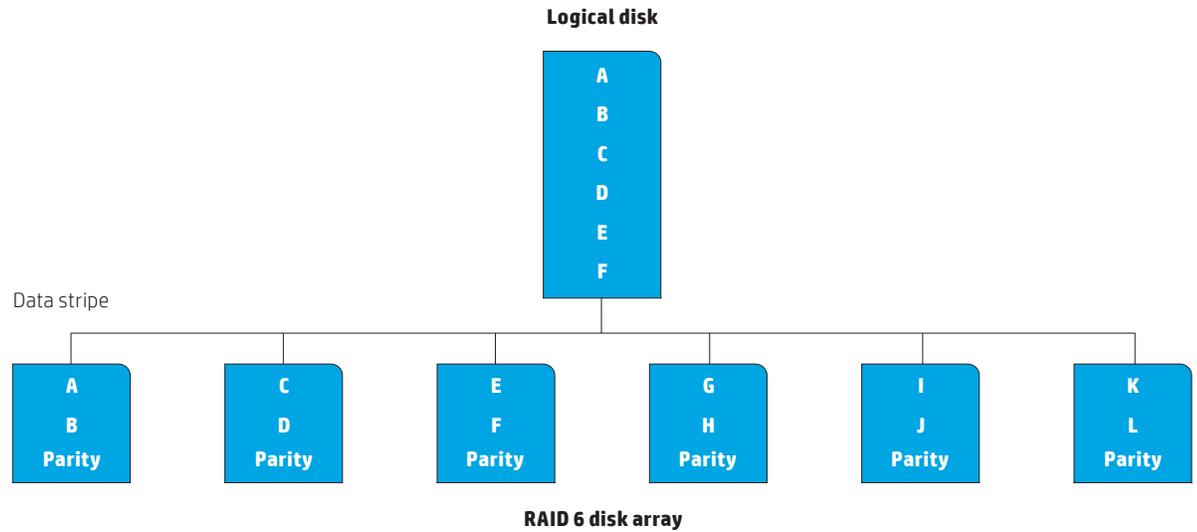
RAID 1 – Creates a single volume out of two drives. The drives are typically on one controller unless Controller Spanning is supported. The data on the two drives are mirror images of each other. The size of the mirror is limited by the smallest drive used in the RAID 1 configuration. This configuration provides data redundancy protection against a single drive failure, does not use parity, and does not improve performance. If a drive fails, the drive can be replaced by a drive of the same capacity or larger to rebuild the RAID array. If one drive fails, data is not lost. The main advantage of RAID 1 is data integrity.



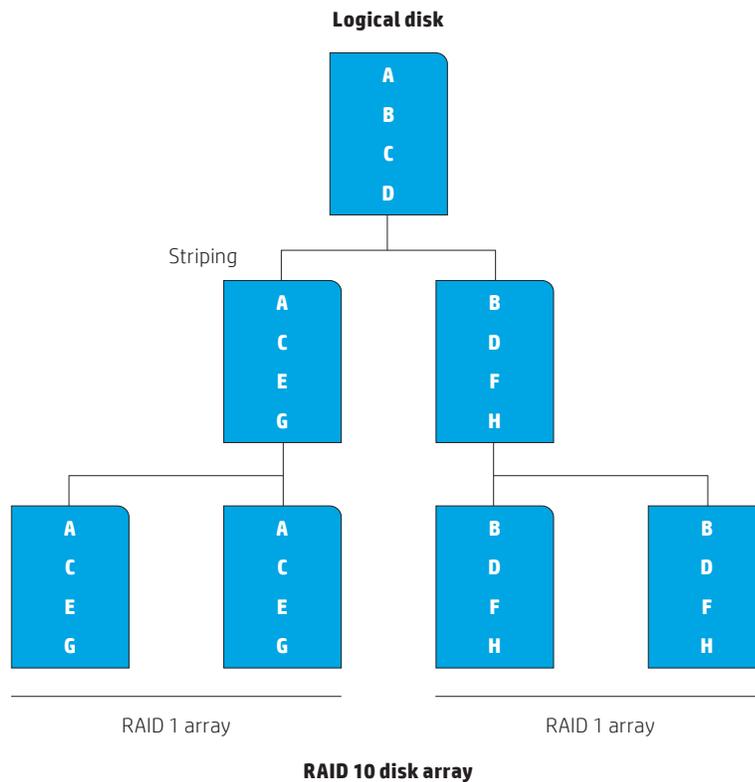
RAID 5 – Creates a single volume from three or more physical drives, typically on one controller, although it is possible to support multiple controllers if Controller Spanning is supported. RAID 5 uses striping with parity data in distributed blocks across all member disks. A RAID 5 volume is tolerant of a single disk failure. RAID 5 has performance attributes similar to a RAID 0 configuration and the reliability of RAID 1, however, parity calculations can reduce the performance relative to a RAID 0 configuration. RAID 5 adds distributed parity to block-level striping. So, RAID 5 has good read performance as well as excellent redundancy. Data integrity can be maintained after a single drive failure. RAID 5 also supports hot spare capability on certain controllers (see below). The main advantage of RAID 5 is speed/performance and data integrity.



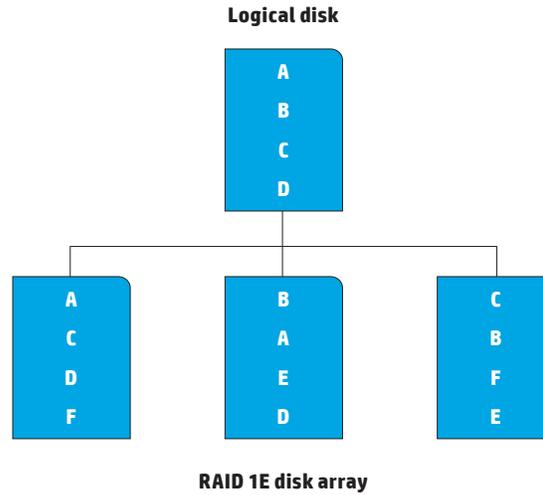
RAID 6 – Creates a single volume from three or more physical drives on a single controller. RAID 6 uses striping with parity data in distributed blocks across all member disks. Whereas RAID 5 uses a single parity stripe, RAID 6 uses two parity stripes. A RAID 6 volume is tolerant of two disk failures. RAID 6 performance depends highly on the number of disks used in the volume. As more disks are used in the volume, performance will increase. Because the capacity of two disks is lost to parity stripes, performance also suffers in small RAID 6 volumes. Writes require two parity updates (on different drives) to survive two disk failures. Data can be read from each disk independently. The main advantage of RAID 6 is data integrity.



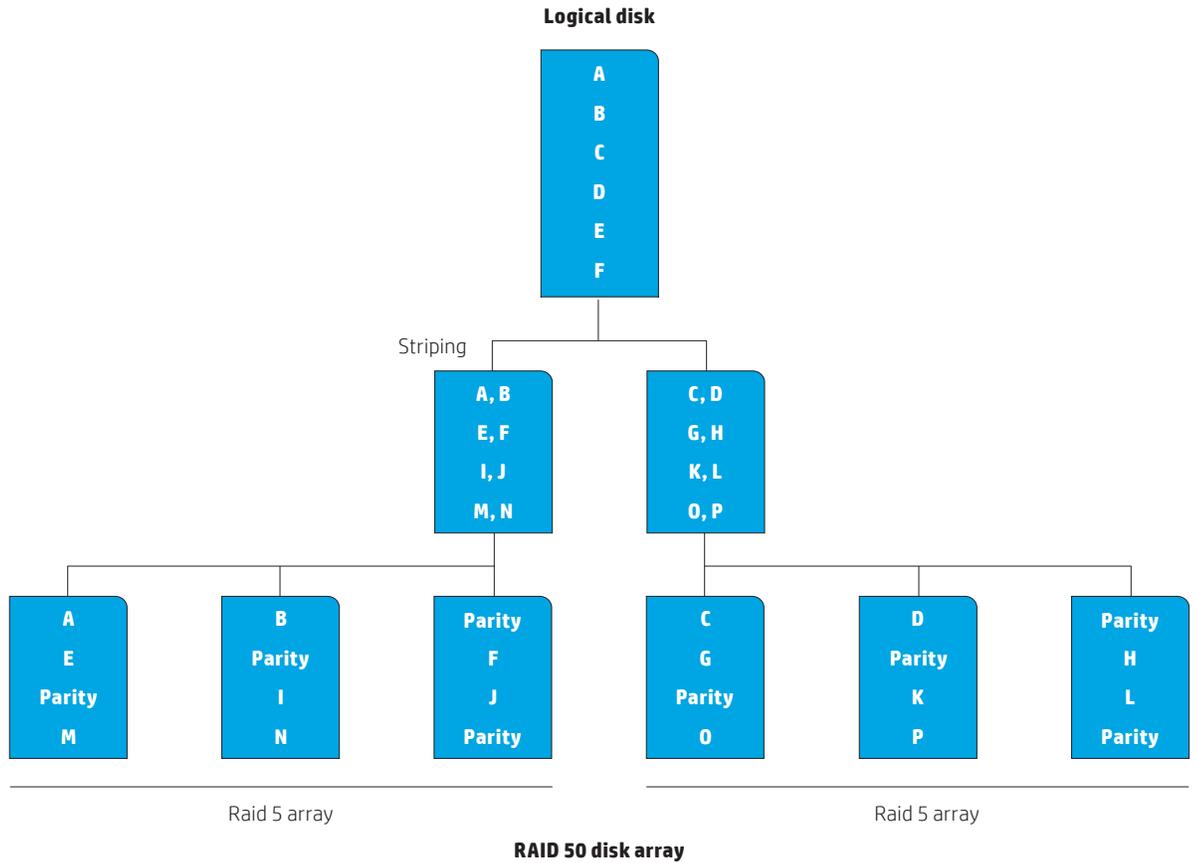
RAID 10 – Creates a mirror of drive pairs, and then stripes the data on the mirrored pairs. A RAID 10 must contain two or more drive pairs, with a four drive minimum. A RAID 10 is fault tolerant to one drive per mirrored pair. RAID 10, also known as RAID 1 + 0, combines the excellent performance of RAID 0 and the redundancy of RAID 1. The main advantage of RAID 10 is data integrity with the capability to tolerate up to 2 disk failures as long as they are not part of the same mirrored set.



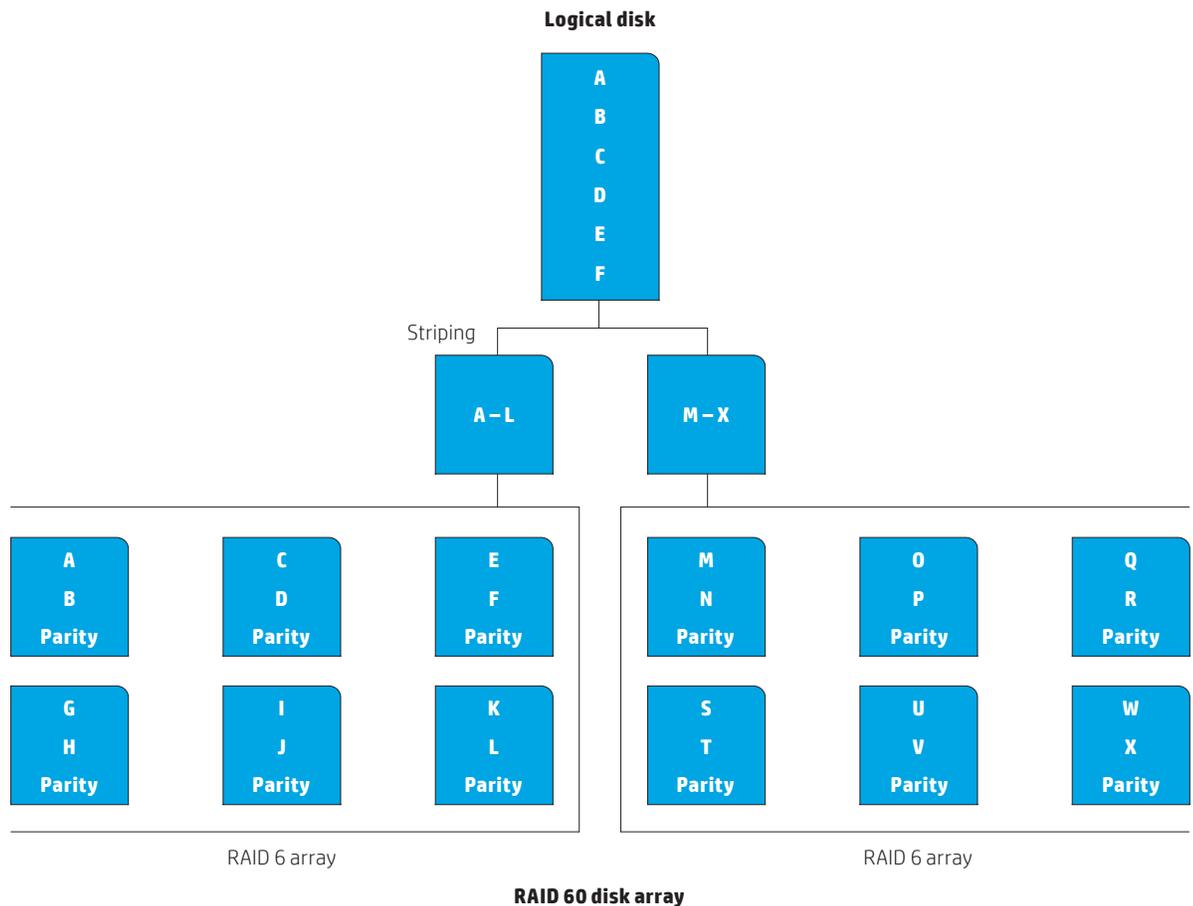
RAID 1E – Creates a mirror of a stripe on an adjacent drive such that if any one drive fails, there is a copy of its stripes on one of the other drives. A RAID 1E requires an odd number of physical drives with a three drive minimum. RAID 1E is similar to RAID 10. It is slightly faster than a RAID 1 (mirrored) array and provides excellent redundancy. RAID 1E will tolerate multiple disk failures as long as they are not adjacent. The main advantage of RAID 1E is data integrity.



RAID 50 – or RAID 5 + 0 creates a single striped volume across two RAID 5 arrays, essentially combining block-level striping of RAID 0 with the distributed parity of RAID 5. It requires a minimum of 6 disks. It provides better data redundancy, better data integrity and the capability to tolerate up to 2 disk failures as long as they are not part of the same mirrored set.



RAID 60 – or RAID 6 + 0 creates a single striped volume across two RAID 6 arrays, essentially combining block-level striping of RAID 0 with the double distributed parity of RAID 6. It requires a minimum of 6 disks. It provides better data redundancy, better data integrity and the capability to tolerate up to 2 disk failures per RAID 6 array before data is lost.



Raid configuration support varies by controller. See the controller section below for specific support details.

What is the value of a battery backed RAID controller?

Enabling the controller cache allows the controller to acknowledge receipt of the data before it is written to the RAID array to improve performance. This may put data at risk in the case of a sudden power loss. Some controllers, like the 9270-8i, support a battery backup unit (BBU) which protects the data in the controller cache in the case of a sudden power loss. If power loss is a concern, either the controller cache should be disabled or a BBU should be considered.

What are the differences between the 9217, 9270 & 2308 LSI controllers?

The **LSI 9217-4i4e** is a Host Bus Adapter (HBA). It has limited RAID capabilities and the primary purpose is to provide support for SAS drives but it also supports SATA drives. The 9217-4i4e supports the following RAID levels: 0, 1, 10, 1E.

The **LSI 2308** is an I/O controller (IOC). It has limited RAID capabilities and the primary purpose is to provide support for SAS drives but it also supports SATA drives. The LSI 2308 supports the following RAID levels: 0, 1, 10, 1E.

The **LSI 9270-8i** is an HBA that has a RAID-on-chip (ROC) processor on board. It has substantial RAID capabilities as compared to the 9217-4i4e and the LSI 2308. The primary purpose of this card is supporting SAS and SATA RAID arrays. The LSI 9270-8i supports the following RAID levels: 0, 1, 5, 6, 10, 50, 60. It also supports a battery backup for the data cache on the controller.

What is the difference between hardware RAID & software RAID?

Hardware RAID is implemented using dedicated RAID hardware associated with a RAID storage controller that the disk drives are connected to in the system. Typically, a single data transaction is sent to the RAID storage controller. Then, the storage controller is responsible for managing and sending data to the individual drives in the RAID. RAID provides better performance because of this hardware and is typically more reliable than software RAID. In software RAID, the drive sends multiple transactions to the storage controller and to each individual drive in the RAID. Hardware RAID has more configuration options but can be a more expensive solution because of the added hardware cost.

Software RAID can be implemented by the operating system (OS) or by a third party software/driver running on the system. Software RAID adds more latency in the software stack but is typically available at a lower price point. The performance of software RAID is dependent on system load and the bandwidth available to the storage controller and each drive.

Controller Usage Specifics

What should I know about the built-in controller options?

The table below provides detailed information on the available support for the built-in controllers on each HP platform. Software RAID using OS RAID capability is also available for HP Z Turbo Drives.

System	Controller options	# ports	Connector color	RAID capability	Max # of arrays
HP Z440	SATA (6 Gb/s)	2	Black	0, 1	1
HP Z640	sSATA (6 Gb/s)	4	Dark grey	0,1,5,10	2
HP Z840	SATA (6 Gb/s)	2	Black	0, 1	1
	sSATA (6 Gb/s)	4	Dark grey	0,1,5,10	2
HP Z230	LSI SAS (6 Gb/s)	8	White	0,1,10,1E	2
	SATA (6 Gb/s)	5	Black	0,1,5	2
HP Z1	SATA (6 Gb/s)	2	Black	0,1	2

Note: sSATA is sometimes called secondary SATA or server SATA.

Why is it recommended to use an add-in controller card (ROC) for RAID 5?

HP recommends using an add-in controller card RAID-On-Chip (ROC) for RAID 5 due to the processing power it takes to generate the parity stripes used in RAID 5 arrays. If a separate processor (the ROC in this case) is not used to generate the parity, the host CPU must generate the parity. Using the host CPU may lead to lower performance than offloading the parity generation to dedicated hardware.

Is TRIM supported when using RAID with SSDs?

Yes, TRIM is supported on various SSDs when using RAID. The table below demonstrates the platforms and RAID configurations that support the TRIM operation.

Controller	Platform	TRIM supported RAID levels	TRIM not supported RAID levels
SATA	HP Z440, HP Z640, HP Z840	0, 1	
sSATA	HP Z440, HP Z640, HP Z840	0, 1, 10	5
SAS	HP Z840		0, 1, 1E, 10
SATA	HP Z1	0,1	
SATA	HP Z230	0,1	5
Microsoft Software RAID*	Any platform	Spanned, striped, mirrored, RAID-5	
LSI 9217	HP Z440, HP Z640, HP Z840		0, 1, 1E, 10
LSI 9270	HP Z440, HP Z640, HP Z840		0, 1, 5, 6, 10, 50, 60

***Note:** Microsoft software RAID can span controllers (SATA, SAS, PCIe) and mixed device types (HDDs, SSDs, PCIe Storage, HP Z-Turbo).

What is the difference between 6 Gb/s SAS controllers and 12 Gb/s SAS controllers?

The difference is that 12 Gb/s controllers have the ability to transfer more data, or greater bandwidth. The maximum bandwidth of a 6 Gb/s port is 600 MB/s, whereas the maximum bandwidth of a 12 Gb/s port is 1200 MB/s. A standard workstation with 3-4 SAS HDDs connected to the controller will see very little performance difference between 6 Gb/s and 12 Gb/s controllers. The limiting factor is the rate at which the hard drives can read and write data. At this time, hard drives do not saturate a 6 Gb/s bus, therefore limiting the value of a 12 Gb/s controller. The most probable use case for a 12 Gb/s controller is in conjunction with an external drive enclosure that contains enough disks to saturate the 12 Gb/s links of the controller. If this configuration is desired, a 12 Gb/s SAS card with external connections should be considered.

How does performance scale with drives and RAID level?

- RAID 0 – Performance scales with the number of drives used. e.g. for 2 drives, the performance is roughly 2x that of the one drive.
- RAID 1 – Performance is equal to the slowest drive in the mirror.
- RAID 5 – Performance scales with the number of drives used, minus 1.
- RAID 10 – Performance scales with the number of drives used, divided by 2.
- RAID 1E – Performance scales with the number of drives used, minus 1.

What is the ideal combination of drives used in RAID volumes?

Ideally, all drives included in a RAID array should be the same in:

- Capacity
- Technology (SAS/SATA/PCIe)
- Drive vendor

How long does it take to initialize an array with high capacity disks?

Initialization times/rates are as follows:

Intel RAID 1	160 MB/s	(1 TB of RAID 1 HDDs takes about 1.6 hours)
LSI RAID 1	30 MB/s	(1 TB of RAID 1 HDDs takes about 8 hours)

While the system can be used during initialization, doing so may increase initialization time. The system should not be powered down during initialization. Powering down during initialization may cause initialization to restart and prevent completion of initialization on large arrays.

Why is the LSI RAID 1 initialization slower than the Intel RAID 1 initialization?

Initialization of RAID in the LSI controller is handled by the controller in background mode at a slow rate to minimize impact on system operation.

Set up

What documents do I need in order to understand the RAID process?

The Maintenance and Service Guide for HP Workstation platforms includes a RAID appendix that details how to set up RAID arrays on the controllers supported by the platforms.

To find the Maintenance and Service Guide for your platform, visit the HP Support Center at hp.com/go/workstationsupport

How do I use RAID with cache devices?

The HP Z1 G2 and the HP Z230 Workstations that are built on Intel's client chipset architecture and use Intel's RST driver can support a caching mechanism called Smart Response Technology (SRT). SRT caching uses a small solid-state drive (SSD) as a cache to a larger but slower hard disk drive (HDD). In order to use SRT, the BIOS must be in RAID mode. SRT can be enabled and used with any volume on the embedded AHCI controller, including RAID volumes.

How do I RAID HP Z Turbo Drives in Windows?

At this time, the only RAID available for use on the HP Z Turbo Drive is software RAID. For software RAID in a Windows environment, the RAID setup is performed in the Disk Management snap-in on the Microsoft Management Console. For Client Windows OS, RAID 0 (called a "striped volume") and RAID 1 (called a "mirrored volume") are supported.

HP only supports Windows RAID volumes as data volumes.

Below are the steps for creating both types of RAID volumes:

RAID 0 (striped volume):

- Ensure you are logged into the system with administrative rights.
- Right-click on **My Computer** and select **Manage**.
- Select the **Disk Management** module in the left hand column.
- Remove partitions from the disks you would like to include in your RAID 0 array.
 - Ensure that any data you need on the drives is backed up.
 - Right-click on any volumes present on the disks and select **Delete Volume**.
- Right-click on one of the disks you wish to include in your array and select **New Striped Volume**.
- Select the disks you would like to include in your RAID 0 array, and click the **Add** button to move them to the **Selected** column.
- Click **Next**.
- Change the driver letter or mount point if desired.
- Click **Next**.
- Set the desired formatting options.
- Click **Next**.
- Verify the information in the dialog box, and click **Finish** to complete the process.

RAID 1 (mirrored volume):

- Ensure you are logged in to the system with administrative rights.
- Right-click on **My Computer** and select **Manage**.
- Select the **Disk Management** module in the left hand column.
- Remove partitions from the disks you would like to include in your RAID 0 array.
 - Ensure that any data you need on the drives is backed up.
 - Right-click on any volumes present on the disks and select **Delete Volume**.
- Right-click on one of the disks you wish to include in your array and select **New Mirrored Volume**.
- Select the disks you would like to include in your RAID 1 array, and click the **Add** button to move them to the **Selected** column.
- Click **Next**.
- Change the driver letter or mount point if desired.
- Click **Next**.
- Set the desired formatting options.
- Click **Next**.
- Verify the information in the dialog box, and click **Finish** to complete the process.

How do I RAID HP Z Turbo drives in Linux®?

For software RAID on Linux® systems, please see the RAID appendix in the Maintenance and Service Guide for the platform you're working on.

To find the Maintenance and Service Guide for your platform, visit the HP Support Center at hp.com/go/workstationsupport

Can I RAID across SATA and sSATA controllers?

No. Controller Spanning is not supported across SATA and sSATA controllers. Controllers can only manage drives that are connected directly to that controller. For example, if you have 6 drives in an HP Z440, four of which are on the sSATA ports and two of which are on the AHCI/SATA ports, you can only create a four drive array on the sSATA ports and a two drive array on the AHCI/SATA ports.

Configuring RAID when ordering systems

What is the difference between “factory available” and “supported” configurations?

Factory available means the customer is able to configure and buy directly from HP.

Supported means HP has tested and supports the configuration but it cannot be directly ordered from HP. HP does offer configuration services. Talk to your HP sales representative for more information.

What are the constraints for supporting RAID configurations?

HP offers and tests a broad range of RAID configurations to meet a breadth of customer needs but it is not possible to test all configurations. Because of this, non-support of a specific configuration does not mean it will not work.

Why are certain combinations of drives not supported for factory integrated RAID?

There are many reasons that specific combinations of drives are not supported by factory integration. To manage the complex matrix of possible combinations, HP recommends always using the same vendor, model, and capacity of drives used in each RAID configuration.

Can I use storage devices that have different capacities or performance in a RAID configuration, e.g. SSD + HDD?

This is not recommended. Factory integration and support is only for devices of the same capacity.

Will the new HP Z Turbo Drive PCIe SSDs be allowed in factory integrated RAID?

Yes. Customers will be able to configure and order factory integrated RAID for the HP Z Turbo Drive. HP will start by supporting OS data RAID. Other configurations may follow, depending on platform and factory enablement.

Can I use SED (self-encrypting drive) components in RAID?

No. The TCG Opal specification, to which all HP SED devices are compliant, does not allow usage in RAID arrays. The drives can be used in a RAID array, but it is not possible to manage the hardware encryption key when the drives are members of a RAID array.

Why can't I get factory integrated RAID with Linux®?

Many RAID configurations are supported with Linux®, just not available from the factory. It has been found that many customers install their own Linux® image and thus set up their own RAID configuration as part of the installation process. Therefore, it is not fully supported as a factory option, although it is supported by HP.

Can I configure a system with battery backup RAID?

Specific controllers, like the 9270-8i, support a battery backup option which protects the data in the controller RAM before it is written to the data array.

Recovery

Is there a notification when a drive fails?

For a Linux® software RAID created using mdadm(8), there are options under the **–monitor** function that allow a program to be run when there is a RAID event, and/or for a notification to be sent by email if that is enabled on the system.

MegaRAID Storage Manager is provided by LSI/Avago for Linux® operating systems as well as Windows.

All of the information that follows is for a Windows based OS.

In order to get notifications for failed drives, the user must have already installed the management tools for the controller they are using.

In the case of the Intel controllers, the customer should install the Intel® Rapid Storage Technology application. This application will not provide pop-ups when a drive fails, but will show information within the notification tray of the drive and array status.

In the case of LSI controllers, the customer should install the MegaRAID Storage Manager application. MegaRAID Storage Manager can be configured to alert the customer in several different ways, including pop-ups and email notifications. This application will function on all LSI controllers supported on HP workstation platforms.

When a drive fails, do I need to recover before continuing to work?

No. But be aware that the RAID is no longer healthy and you risk reduced performance and/or data loss.

How do I determine which HDD/SSD failed in the RAID array?

If the RAID array was created using the SW RAID stack associated with a storage controller, enter the Option ROM of the RAID controller while the system is booting. During POST (Power on Self Test), look for and press one of the following key combinations (Ctrl – C for LSI, Ctrl – I for Intel, or Ctrl – H for LSI MegaRAID Cards).

Write down all the serial numbers presented to you in the Option ROM and make note of any drives marked failed. Power off the system.

Read this step carefully or else you could lose your data. Start pulling each drive one by one. Plug each HDD back into the same SATA/SAS connector before removing the next HDD to check the serial number.

It is important to follow this step or else you could lose your data. Compare the serial numbers on the HDDs to the list you had presented to you in the Option ROM screen. If you find the serial number of a drive that was marked as failed in the Option ROM list, replace that drive with a new drive of the same model. If you don't have the same model replacement, make sure the replacement drive is equal to or greater capacity than the drive you are replacing. If you find an HDD/SSD that is NOT on the list presented by the Option ROM utility, you have found the failed drive. This is the drive to replace.

If the RAID was created as a data RAID using the RAID capability built into the OS, use the OS disk manager to determine the failing drive. For Microsoft Software RAID failures, open the disk manager applet, click "help," and type "Troubleshooting Disk Management" or "failed" and select the Troubleshooting Disk Management item from the search results. Choose the topic or topics that best match your symptoms and follow Microsoft's guidelines for resolving the issue.

What is the recovery process when a drive is lost in RAID 0?

RAID 0 provides no data redundancy and therefore recovery of the array from the data remaining in the array is not possible. Recovery from backup is required either to a single drive or a newly created RAID array.

What is the recovery process when using RAID 1, RAID 10, and RAID 5?

Determine which drive has failed, power down the system, replace the failed drive with a drive of the same capacity or larger (same performance drive not required), and power the system back up. The rebuild will initialize on power up. Expect reduced performance while rebuild occurs and be aware that a second failure during rebuild could be catastrophic.

What is the recovery process for software data RAID 1?

Linux® software RAID management is done with the md(4) device files and mdadm(8) command. The system administrator should be familiar with this software set.

Mdadm with the **--monitor** option gives information about RAID status.

If a drive in RAID 1 has failed, it can be removed from the RAID set using **--manage --remove** followed by an unmount of the raw device. A new drive can be added with **--manage --add**. Then, the rebuilding status can be viewed with the **--monitor** mode.

To recover from a software RAID 1 using Windows, you must first determine which drive has failed. The drive should be replaced with the same type of drive that has failed. Next, enter into the Disk Management snap-in for the Microsoft Management Console. The Disk Management snap-in will recognize that there is a failed array. Follow the on-screen steps to recover the RAID 1 array.

How am I notified that a drive might fail so that I can replace it before it fails?

In some cases, pre-failure will show up as a SMART event notification at boot time. These notifications will appear when the option ROM posts status. The system will not stop on an event, so the user must be observant at boot time. Once in the OS, The Intel GUI (balloon status messages), LSI MegaRAID Storage Manager (pop-up), or MS Windows (pop-up) may alert the user that errors are occurring or that SMART events have occurred on the drive. Other subtle indicators include a reduction in system performance, HDD LED remaining on constantly (do not confuse with Windows defrag activity or RAID initialization/rebuild activity which will also result in the HDD LED being on constantly), and clicking sounds coming from a mechanical drive.

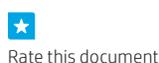
How long should it take to recover?

Recovery time varies greatly depending on the size and type of RAID but may take several hours. The user should expect reduced performance during a rebuild.

Can HP Support help with the recovery process?

During the warranty period, an HP Support agent can assist you in restoring the original OS back to your system—including to a factory configured RAID array. Note that many advanced RAID configurations may be outside the scope of warranty support. In these cases, you will be responsible for rebuilding your configuration to meet your specific RAID requirements.

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