What is RAID and How Does it Work?

What is RAID?

RAID is the acronym for either 'redundant array of inexpensive disks' or 'redundant array of independent disks'. When first conceived at UC Berkley the former was the actual term that was coined but the latter is more commonly used today intentionally to disassociate the technology from the word inexpensive and the perception that RAID somehow implies a low cost solution.

Why Use RAID?

RAID is a storage technology that provides increased data reliability through data redundancy. This is achieved primarily by duplicating data across several storage drives in a configuration referred to as an array of disks.

How Many Different Types of RAID are There?

There are several different types of RAID array configurations each type being denoted by a single digit numeral, 0 through 6 (and various combinations thereof). These types are commonly referred to as RAID 'levels'.

What Distinguishes one RAID Level From Another?

The makeup of the different RAID levels is varying combinations of redundancy, spanning, mirroring and striping.

What is Redundancy?

Redundancy is the duplication of data onto more than one physical drive to increase fault tolerance. If one physical drive in a redundant array fails no data is lost and there is an opportunity to replace the failed device. As long an one drive is functional, data is secure. However, in the case of a failure, the failed device must be replaced and the array rebuilt onto the new device. In very large data structures this can sometimes take a great deal of time. If there were to be a failure during the process of rebuilding the array all data would be lost.

What is Spanning?

Spanning is the configuration of two or more physical drives into one 'logical' drive. The logical drive is treated exactly the same as a physical drive and will appear as just one device. Spanning is used to increase the amount of storage capacity of an array. As an example: if three 100 gigabyte hard drives are configured as one spanned array, the result would be one logical drive 300 gigabytes in size.

Spanning alone provides no redundancy or fault tolerance and it is commonly combined with mirroring.

What is Mirroring?

Mirroring is the duplication of data onto two or more drives simultaneously to create data redundancy and increase fault tolerance. A mirrored array sacrifices half of its storage capacity to achieve a redundant status. If two 100 gigabyte drives are mirrored the result is a single 100 gigabyte mirrored array.

What is Striping?

Striping is a bit more complex. Striping is used to increase performance. This increase in performance is achieved by splitting the read and write data down into 'blocks' and then writing or reading that data simultaneously onto two or more physical drives on the same sector of each respective drive.

In a simplified example imagine that you are writing 100 megabytes of data out to a striped array. If you were to take that data and split it into two 50 megabyte chunks and then write both of those chunks simultaneously, one 50 megabyte chunk to drive (a) and the other 50 megabyte chunk to drive (b), you would theoretically half the time required to perform the process. That, in essence, is the theory behind striping.

Striping provides a significant increase in performance but it is also the most dangerous of all the RAID levels when used alone. Not only is there no redundancy but if either or any of the drives in a striped array fails, all of the data from the entire array is completely lost.

RAID Level 0

RAID Level 0 – (2 Drive Minimum – no Fault Tolerance) Block Level Striping without Parity or Mirroring: Because this type of RAID offers no fault tolerance or redundancy it is technically not actually RAID. Raid 0 offers the best performance of all the RAID levels. Data is broken down into fragments called blocks and is then written to all drives in the 'array' simultaneously across what is called a 'stripe' (on the corresponding disks in the same sector). When data is read it is broken down into smaller pieces which can be read in parallel thereby increasing bandwidth. With RAID 0 if any drive fails all data is lost across the entire 'array'. Even at minimum the likelihood of a catastrophic loss is double that of a single drive without any RAID at all. RAID 0 should never be used alone for critical data.

RAID Level 1

RAID Level 1 – (2 Drive Minimum – Data Redundancy) Mirroring: In its simplest form RAID 1 simply duplicates data onto two different hard drives simultaneously, thereby providing data redundancy. Data redundancy means that if either of the two hard drives fails for any reason no data will be lost as there is an exact duplicate or 'mirrored set' of the data on the other drive. Data integrity is maintained as long as either of the two hard drives in the array is functioning. In the event that one of the drives does fail it is simply swapped out for a new working drive. The 'array' then 'rebuilds' itself by duplicating all of the data onto the new drive and recreating the 'mirrored set'. Data is, however, vulnerable while a rebuild is in progress.

RAID Level 5

RAID Level 5 – (3 Drive Minimum - Redundancy Through Parity) Block-Level Striping with Distributed Parity: RAID 5 combines the increased speed of striping with redundancy through distributed parity. In RAID 5 one drive out of the array will always be sacrificed to achieve redundancy. In other words, when there are three 100 gigabyte drives present in a RAID five, the array will be 200 gigabytes in size. However, by using distributed parity, the redundancy is spread across the entire array. Therefore, if any one drive in a RAID 5 fails, data integrity is maintained and an opportunity exists to replace the failed device and rebuild the array.

RAID Level 6

RAID Level 6 - (4 Drive Minimum - Redundancy Through Parity) Block-Level Striping with Double Distributed Parity: Very similar to RAID 5, RAID 6 builds on the security of RAID 5 by adding an additional level of redundancy. In a RAID 6 up to two drives can fail and no data will be lost. RAID 6 makes very large arrays possible, where the time it takes to rebuild the array after a drive failure can be quite lengthy. In a RAID 5 scenario data would be vulnerable for far too long while the rebuild is in progress. RAID 6 addresses this concern by adding an additional redundancy drive. RAID 6 is the solution that should be used where data is extremely critical or high system availability is important.

RAID Level 1+0

RAID Level 1+0 - (2 Drive Minimum (though 4 are more commonly used) - Redundancy Through Mirroring) Mirrored Sets in a Striped Set: Fault tolerance and increased performance. This RAID level is a combination of RAID 1 (mirroring) and RAID 0 (striping). RAID 1+0 can sustain multiple drive failures as long as no mirror loses all of its drives.

RAID Level 0+1

RAID Level 0+1 - (4 Disk Minimum; must be even number of drives - Redundancy Through Mirroring) Striped Sets Mirrored: Here, a second striped set is created to mirror the first striped set. In contrast to the 1+0, in RAID 0+1, all the drives in one mirror can fail without a data loss but if drives fail on both sides of the mirror everything on the entire array is lost.

There are also more combinations possible but I will stop here.

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