Synology RAID F1 White Paper

Synology®

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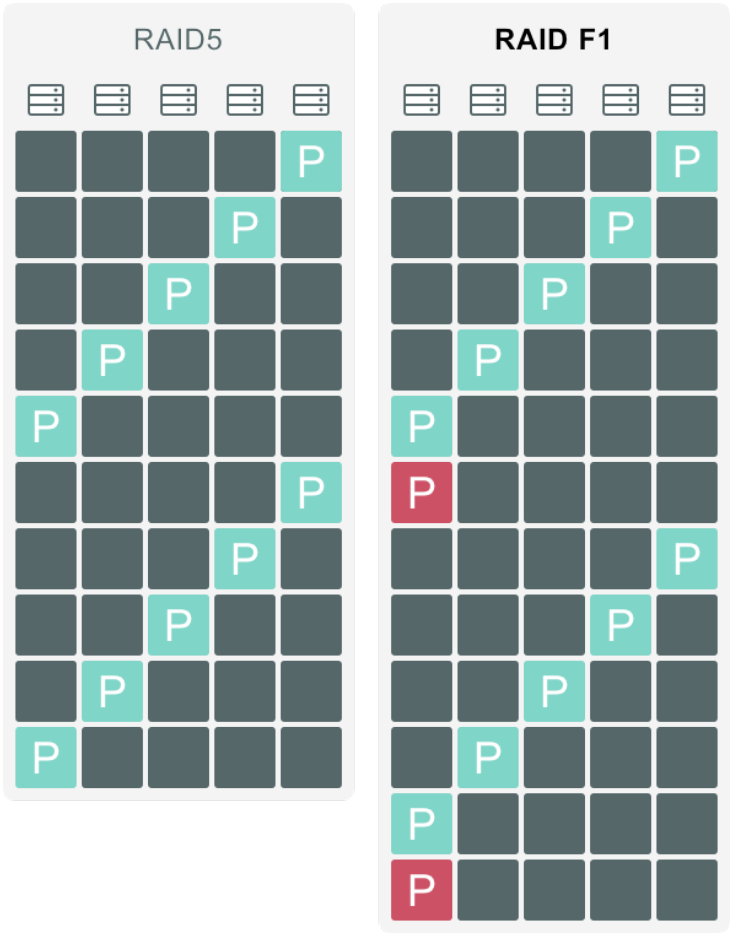
Executive Summary

RAID is widely used in enterprise storage products. It does not only prevent data loss in case of disk failure, but also increases performance by spreading data to multiple disks. In the past, RAID implementations always assume that spinning disks are used as the storage media, instead of SSDs or flash disks. However, SSDs have a finite number of program-erase (P/E) cycles. If traditional RAID is used for random write workloads, multiple SSDs will probably be worn out and fail at the same time, resulting in a crashed RAID and data loss. **Synology RAID F1** algorithm tackles the problem by writing more parity bits into a specific SSD to avoid all SSDs from being worn out at the same time, and making one system-assigned SSD to be worn out in the first place. With this approach, RAID F1 will be very unlikely to crash as data are unevenly written to SSDs. Thus, Synology RAID F1 enhances the endurance of RAID compared to other RAID algorithms, an important concern for enterprise flash storage products.

Introduction to Synology RAID F1

RAID F1 is the new RAID type for SSDs. **F** stands for flash, and **1** stands for 1-disk resiliency and 1-parity. The layout of RAID F1 is based on RAID 5. The difference between these two RAID types is that, for RAID F1, one additional parity blocks will be in each cycle. In the illustration below, block with “P” stands for parity block, and the rest are data blocks.



Since each write-operation involves writing to the parity block, it is expected that the parity block will be worn out in the first place. This uneven parity distribution approach will lead to that one SSD reaches its lifespan earlier than others, instead of making all SSDs reach the end of their lifespan at the same time. When one SSD fails, the customer can replace it with a new one.

The characteristics of RAID F1 is similar to RAID 5. Parity blocks are XOR’ed of all other data blocks. One block is used as parity block within each stripe, so the usable capacity of a RAID F1 array is N-1 times of smallest drive, where N is the stripe width or the number of disks.

RAID F1 Performance

In brief, RAID F1 provides the best balance between reliability and performance. The RAID F1 parity assignment, compared with RAID 4, provides more IOPS, as the single parity device in RAID 4 will be the bottleneck. The read and write performance of RAID F1 can be close to that of RAID 5. There will be small performance differences because of the extra parity block on RAID F1 volumes. There is no notable effect on the CPU utilization between RAID F1 and RAID 5.

RAID Rebuild

The goal of RAID F1 is to minimize the possibility of data loss. To achieve this goal, the system will find out the most aged SSD, rebuild and reallocate the parity layout. For example, when disk **A** is removed, we will repair the array by installing disk **F**. The system finds out that disk **B** is the most aged, and it will thus be the new system-assigned SSD into which more parity blocks will be written. This approach ensures only **one** “most aged SSD” storing the most parity blocks.

Reliability compared with RAID 5

RAID 5 uses up all SSDs’ life at the same pace, as parity are evenly distributed to all disks in the array. In this case, the possibility of data loss on an SSD failure becomes very high along with RAID aging. In contrast, RAID F1 consistently minimizes data loss probability by making one of the most aged SSD reaches the end of its lifespan in the first place.

Conclusion

In summary, Synology RAID F1 benefits from the following:

- Performance is close to RAID 5
- Intelligent RAID Rebuild
- Flash endurance superior to traditional RAID algorithm
- High storage efficiency with low capacity overhead of 8% (RAID F1 with 12 SSDs)

Synology RAID for flash protection mechanism represents a giant leap forward in flash storage technology. By tailor-made for the unique characteristics of flash storage, RAID F1 enables Synology all-flash arrays to provide better data endurance and avoid data loss, giving IT administrators confidence to deploy Synology FS series products in their production and business critical environments.