SOLUTION BRIEF: The Renaissance of RAID

Why Pliops XDP is a Game Changer for NVMe SSD Workloads

Problem Statement

Data protection without performance penalty is highly critical for the design and deployment of modern business applications. This approach enables organizations to effectively manage service level agreements (SLAs) of both application performance and availability. Traditional data protection technologies such as RAID (A redundant array of inexpensive disks) have not evolved fast enough to meet customer needs for application performance, scalability, and reliability. While modern NVMe SSDs improved its performance to process millions of IOPS (IO operations per second), traditional RAID technologies that are managing these SSDs are bottlenecking performance capabilities. This has led to enterprises moving away from traditional server RAID deployments and adopting erasure coding and replication technologies as the optimized data protection for software-defined storage systems. While these technologies enable enterprises to protect data and tolerate server and SSD storage failures, even a single SSD failure causes a major Quality of Service (QoS) impact. The process of rebuilding SSD data while continuing to serve customer workloads introduces significant network traffic overhead. This situation has created a huge void and needs for new technologies that can provide server-level data protection to tolerate SSD failures while complementing erasure coding or replication for server failures.

Renaissance of RAID with Pliops XDP

Figure 1: Pliops Extreme Data Processor (XDP)

Traditional RAID technology was designed for mechanical hard disk drives. When used with SSDs, they introduce storage inefficiencies for driving performance as well as IO amplification effects effectively reducing the useful life of SSDs.

Introducing Pliops Extreme Data processor (XDP) that has been designed from the ground up to provide extremely reliable RAID data protection but without any associated performance penalty. XDP unlocks the full performance potential of SSDs by eliminating inefficient storage operations and offloading compute-intensive data processing activities from the CPU. By abstracting the data flow between the application and SSDs, XDP optimizes it by compressing, indexing, and sorting, and then writing data to SSDs in sequential patterns with parity for data protection. XDP fundamentally improves how data is processed, managed, and stored leading to accelerated application performance, higher reliability, and greater scalability at a reduced TCO(Total cost of ownership). Pliops XDP is delivered on a half-height, half-length PCI Express (PCIe) card as shown in figure 1.

Key Highlights

Pliops XDP ushers in a new era of RAID protection for SSDs by eliminating the inherent tradeoffs of traditional RAID solutions

Up to **12X** higher random read/write mixed workload performance benefit

Up to **7Min/TB** rebuild rate. **5X** faster than hardware-based RAID5

Up to **23X** higher performance during SSD rebuilds

Up to **6X** SSD capacity expansion

Up to **7X** enhanced SSD endurance for longer useful drive life

Full Performance for NVMe SSDs

NVMe SSD deployments are increasingly being adopted into cloud and enterprise data centers for data-intensive applications such as relational databases and NoSQL environments. Traditional hardware RAID 5 with parity-based RAID algorithms use small random writes which significantly impact performance. Updating a stripe requires reading existing data and parity blocks, computing new parity, and finally writing new data and parity. This process is called a read-modify-write operation. As SSD capacity reaches 70 to 80%, most writes will overwrite existing data blocks and since empty space on the SSDs becomes harder to find, it forces more stripe updates to occur which further impacts performance. Garbage collection of the SSDs adds to the I/O and computational overhead as it manages stale data to reclaim space, leading to significant performance impact.

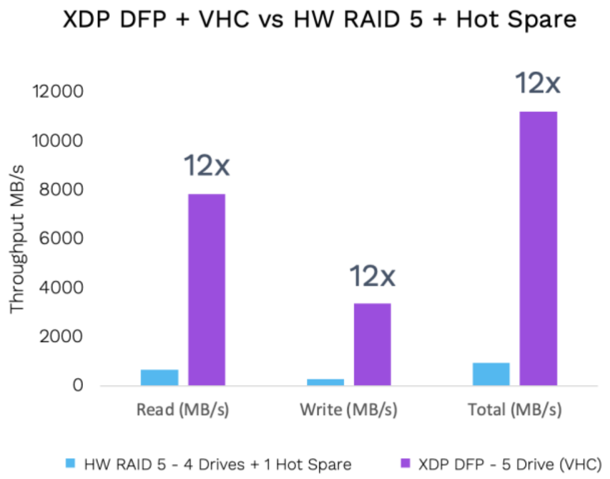


Figure 2: XDP Performance benefits for TLC SSDs in a five-drive configuration

Pliops XDP accelerates random writes by transforming them into compressed sequential writes. This improves storage performance, utilization, and SSD longevity compared with traditional RAID 5/6 solutions. Compression also shrinks the amount of data to be read, enabling better read throughput and latency while reducing IO amplification impacts. Unlike traditional RAID which uses a dedicated hot spare disk, Pliops XDP Drive Failure Protection (DFP) makes use of all SSDs with a virtual hot capacity (VHC) to drive performance and capacity benefits. Figure 2 compares Pliops XDP with DFP which provides 12X sustained performance benefits compared with hardware RAID 5 using similar SSD configurations for a 70/30 random read/write mixed workload at a 16K block size.

5X Ultra-Fast Rebuilds with 23X Performance Gain

Application performance and quality of service are equally critical as reliability and data protection during SSD failures. Quality of service plays a vital role in customer experience and satisfaction during storage outages.

When a drive fails using traditional HW RAID 5, system performance is degraded, which can significantly impact application quality of service and customer satisfaction. Secondly, when an SSD rebuild is initiated by HW RAID 5, the entire SSD capacity of the failed drive is rebuilt on a hot spare using the data and parity blocks from the remaining drives, leading to slow rebuild times and continued performance impact. This can put the organization's data at risk as the probability of another drive failure is increased during the rebuild process.

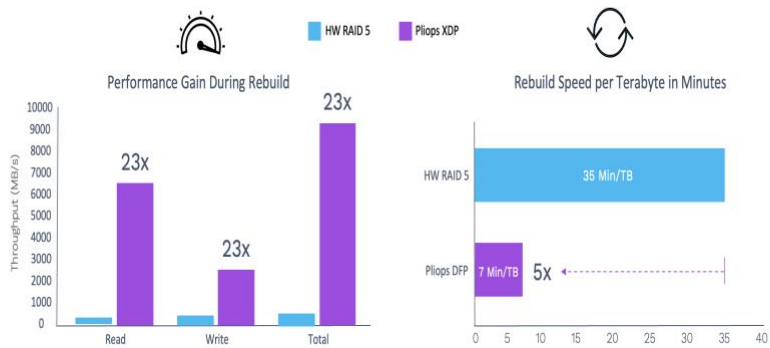


Figure 3: XDP Performance During Rebuild and Rebuild Speed

To address the long rebuild times, organizations are forced to use lower-capacity SSDs to shorten the rebuild times, this approach limits storage density and raises the effective cost per terabyte value. XDP accelerates rebuilds by only rebuilding user data impacted in the drive failure and not the entire SSD capacity of the drive, resulting in ultra-fast rebuilds with minimal impact on performance and quality of service (QoS). As shown in Figure 3, XDP provides a 23X performance boost over hardware RAID5 during an SSD failure scenario. It also shows that XDP can rebuild at a rate of 7 min/TB, which is 5x faster than hardware RAID 5. The net result is that user application impact is minimized, enabling organizations for improved customer satisfaction. The speed of XDP during a rebuild also removes the risks and anxiety of using high-capacity SSDs, making it easier to keep up with ongoing data growth and lowering the cost/terabyte of data storage

Reduced IO Amplification Increases Useful SSD Lifespan

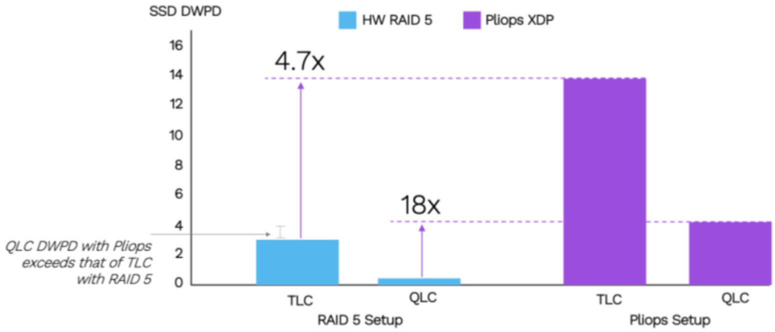
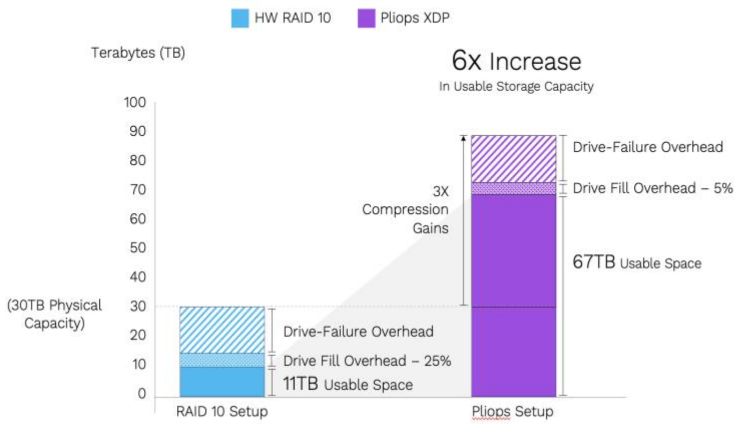


Figure 4: XDP TLC & QLC Endurance Benefits

In modern data centers with high data ingress and egress volumes, NAND flash can be the costliest storage component, with Total Cost of Ownership (TCO) directly linked to SSD costs. As a result, organizations have a vested interest in maximizing SSD lifespan. SSD endurance is typically stated in drive writes per day (DWPD) and represents the total amount of data an SSD can write over its lifetime. As the industry transitions from Triple Level Cell (TLC) SSDs to denser Quad Level Cell (QLC) SSDs and beyond, the level of endurance dramatically decreases. This is especially important for data-intensive, write-heavy application workloads. As previously discussed, traditional RAID 5 processes trigger read-modify-write processes, and garbage collection operations significantly contribute to IO amplification which itself contributes to driving wear and can lead to overprovisioning and the further shortening of SSD lifespans.

Pliops XDP with Drive Failure Protection (DFP) adds important value to both TLC and QLC SSDs by dramatically reducing write amplification by shaping data for optimal placement on SSDs. Random writes are transformed into sequential ones. Data is compressed into variable-sized objects merged, packed, and written to the SSD in large chunks. Figure 4 shows how XDP improves SSD endurance by 4.7x for TLC SSD and up to 18x for QLC SSDs. Pliops XDP practically increases the endurance of QLC beyond traditional TLC. It also extends the useful life of TLC SSDs and enables the mainstream use of high-capacity QLC SSDs for write-intensive workloads at a much lower cost/TB.

Expand Capacity and Lower Cost/TB



The data protection benefits of RAID 5 and RAID 10 come with unavoidable storage capacity losses due to parity and mirroring overhead, respectively. For RAID 5, parity consumes the capacity of an entire drive and typically another for a hot spare. RAID 10 uses 50% of the total capacity for mirroring. Data reduction methods such as compression improve capacity utilization by storing fewer bits but consume significant CPU resources overshadowing the benefits. XDP implements multiple parallel compression engines in hardware to prevent bottlenecks, freeing the CPU from this burden. Figure 4 shows how XDP's compression, efficient Drive Failure Protection overhead, and near-full drive utilization (95%) expand usable capacity by up to 6x vs. RAID 10. Starting with the same raw 30TB of storage, usable capacity goes from 11TB with RAID 10 to 67TB with Pliops XDP. The 6x increase in usable capacity is a substantial reduction in the cost/terabyte. With multiple petabytes deployed at the data center level; the increased capacity can translate to millions of dollars in savings.

Conclusion

Pliops XDP is an industry game-changer with technology that massively accelerates diverse and dynamic workload performance with enterprise data protection and reliability benefits. It eliminates the problems created by the inherent limitations of traditional hardware and software RAID data protection and bridges the performance gap between compute and data storage resources. As a simple server add-in card, Pliops XDP helps customers to meet today's business demands of supporting increased data volumes and overcoming data center constraints. The adoption of Pliops XDP dramatically reduces architecture complexity while also providing significant infrastructure cost savings for cloud and enterprise data centers.