A guide to hybrid flash storage arrays
Hybrid flash storage arrays overview: SAN’s big six and the startups

In this special report we look at products that merge SSD and spinning disk, and key market trends. First up, Antony Adshead on the big six storage vendors, then Chris Evans considers the startups

All-flash arrays, and in particular those supplied by startup companies, have been the stars of the flash revolution. With architectures designed from the ground up for flash, they have pioneered rapid-access, solid-state storage for the era of the virtualised datacentre.

But three or four years on from the onset of flash, most customers still do not have all-flash arrays installed, and have opted to build hybrid flash arrays from existing systems instead.

There are some key reasons for this.

All-flash arrays often offer blistering performance – up to and exceeding 1,000,000 input/output operations per second (IOPS) – but this comes with a hefty price tag that means they are out of the range of all but the most performance-hungry, deep-pocketed organisations. A mission-critical, money-no-object application is needed to justify the spend.

In addition, most all-flash arrays are likely to end up as standalone subsystems, unable to work seamlessly with existing storage hardware.

They are also unlikely to have advanced storage features, such as replication and snapshots that can work with other suppliers’ arrays that are already in place.

And so, more often than not, customers have chosen to add flash to existing systems. This lets them build on their investment in incumbent arrays, while giving them the benefits of flash.

Sure, this approach doesn’t usually allow for hyper-fast performance, but it does offer the ability to direct low-latency storage to where it is needed for key applications. Often this will be carried out by the use of automated storage tiering that pushes the hottest data to a flash tier that comprises a small percentage of overall capacity.

Alternatively, volumes can be pinned to flash for performance-sensitive apps that always need flash’s low latency, whether data is hot or not.

So for the time being, flash in a hybrid array from an incumbent supplier is the way most people choose to implement solid-state storage.

First, we’ll cast a glance over the storage area network (SAN) products available from the biggest six storage suppliers and see what they offer.

Most of the big six rest content, for now at least, with the ability to offer flash drives as part – or sometimes all – of total capacity, without any to hardware that can speed processing or backplane traffic for solid-state storage.

But others, such as EMC, Hitachi Data Systems (HDS) and HP, have developed or inherited controller hardware more suited to the needs of flash.

All-flash arrays come with a hefty price tag that means they are out of the range of all but the most performance-hungry, deep-pocketed organisations.
EMC

EMC’s enterprise SAN VMAX family and mid-range to entry-level enterprise VNX arrays can all be configured with up to 100% flash drives.

VNX arrays benefitted from a controller software upgrade in late 2013 that allows them to take advantage of Intel multi-core Xeon 5600 central processing units (CPUs), as well as the optimisation of array hardware for flash storage, using the latest Gen 3 peripheral component interconnect express (PCIe) cards in the controller.

Flare, the previous VNX operating system (OS), wasn’t built for multi-core CPUs and suffered from processing bottlenecks when using flash drives. It was rebranded as MCx and rewritten to spread workload across up to 32 cores in the Xeon processors.

While all the VNX arrays are optimised for flash with the MCx upgrade and could be entirely populated with flash drives, EMC also sells a VNX array marketed as all-flash. It’s called VNX-F and scales to 400TB of capacity. EMC says that the VNX7600-F can handle 500,000 8K IOPS.

NetApp

NetApp has recently moved to phase out some of its fabric-attached storage (FAS) filer lines and replace them with products that can be hybrid flash or all-flash.

In particular, the company announced that it would phase out the FAS2000, FAS3000 and FAS6000 families and replace them with the FAS8000 and FAS2500 series.

All of these come with Flash Pool – a few terabytes of Data ONTAP-managed auto-tiered cache. The FAS2500s (launched in 2014) come with the option for more than 50% of drives to be flash.

The FAS8080EX and FAS2520 can be all-flash. But, the other arrays in the FAS2500 range are limited in the proportion of flash they can accommodate, with a maximum of 96 out of 144 drives able to be flash.

The older FAS8000s can take only a few terabytes of flash capacity on arrays that scale to the single-figure petabytes.

All EMC’s VNX arrays are optimised for flash with the MCx upgrade and could be entirely populated with flash drives.
NetApp’s E-Series arrays have one all-flash array – the EF550 – but lack any reference to flash drives in their spec sheets.

**Dell**

The Dell Compellent SC4020 combines Fibre Channel and internet-small-computer-system-interface (iSCSI) access, and can be hybrid or all-flash, with multi-level cell (MLC) or single-level cell (SLC) drives, as well as serial-attached SCSI (SAS) hard-disk drives (HDDs) up to 15,000 revolutions per minute (rpm). The base unit can hold 24 drives and the system can scale to 120 drives with added disk enclosures.

Capacity can reach around 500TB, while performance tops out at around 120,000 IOPS and latency of “less than a millisecond”.

Dell also makes the Dell Compellent SC220 Flash-Optimised Solution, which is a disk enclosure add-on to its SC8000 controller. It can accommodate 400GB or 1.6TB MLC or SLC flash drives, as well as an SAS spinning disk.

In its iSCSI-only EqualLogic range, Dell has the PS6210XS, which is a hybrid flash model that can house up to 26TB, comprising seven 2.5in 800GB flash drives and 17 10,000rpm SAS drives.

The PS6210 family was introduced in 2013 as successor to the EqualLogic PS6110 series and features upgraded CPUs, increased memory, a doubling of the 10Gbps ports and a new version of the controller OS.

**HDS**

HDS’s foray into flash so far comprises the Hitachi Accelerated Flash Storage (HAFS) module for its enterprise SAN virtual storage platform (VSP) and Hitachi Unified Storage (HUS) arrays. HAFS is a controller with a custom application-specific integrated circuit (ASIC) and firmware designed for MLC flash.

HAFS comes in 2U modules with 2.5in 400GB or 800GB MLC flash drives with a maximum capacity of 19.2TB, or a dense array with HDS’s proprietary Flash Module Drives (1.6TB or 3.2TB) that provide up to 38TB of MLC capacity.

Up to four flash enclosures can be housed in a VSP array. VSP can also treat HAFS as a distinct tier of storage using its Hitachi Dynamic Tiering.

**HP**

HP has hybrid flash options across nearly all its storage array product lines – 3Par, StoreVirtual, MSA and XP.

HP’s enterprise-class 3Par products are built for high-capacity and cloud operations, with features such as multi-tenancy and data tiering. The 3Par line is not a ground-up flash design, but the 3Par OS and controller ASIC have flash-friendly features that help reduce wear and provide the fine levels of granularity suited to flash cell block sizes.

3Par arrays include one all-flash array – the StoreServ 7450 – and two that can be configured as hybrid flash, the 7000 and 10000.

The StorServ’s 10000’s two variants scale to four and eight controller nodes. Capacities are 1.6PB and 3.2PB in 24 or 48 disk enclosures, with MLC and enterprise MLC (eMLC) drives mixed with Fibre Channel or SAS HDDs, as well as 8Gbps or 10Gbps Ethernet connectivity to hosts.
The StorServ 7200 and 7400 slot into the range below the 7450 all-flash array. They have either two (7200) or two to four (7400) controller nodes and scale to 240 or 480 2.5in drives and have Fibre Channel and Ethernet connectivity.

HP’s StoreVirtual family – built on internet protocol (IP) acquired from LeftHand Networks in 2008 – are iSCSI block-access products. One product in the range, the 4335, can accommodate a proportion of flash solid-state drives alongside SAS HDDs, and scales from 7.5TB to 240TB.

HP’s entry-level Fibre Channel and iSCSI MSA family includes one hybrid array, the 2040. It can house up to 199 2.5in flash drives or SAS HDDs – or 96 in 3.5in format. Maximum capacity supported is 384TB, which is accommodated in added disk enclosures.

HP’s XP high-end storage arrays – repackaged HDS hardware with HP software – scale into the hundreds of PB and have mainframe fibre connection (Ficon) connectivity alongside Fibre Channel and iSCSI. XP arrays allow for a proportion of total capacity to be flash SSD, alongside an SAS spinning disk.

IBM

IBM’s DS8000 series enterprise arrays are for high-end use cases and compete with EMC’s VMAX arrays. They offer all-flash and hybrid-flash options and scale to petabyte levels with Fibre Channel and Ficon access. Flash drives can be added alongside a spinning disk or in a separate flash enclosure, the DS8870.

XIV is an enterprise-class set of arrays acquired in 2008 by IBM from an Israeli startup. It was designed to support cloud environments and more recently has been targeted at analytics workloads.

XIV has a parallel hardware architecture with multiple controller nodes – while data is distributed for availability and data protection with rapid drive, rebuild speeds are claimed. XIV is connected to iSCSI and Fibre Channel, and offers a small portion of flash caching per XIV module.

IBM’s Storwize V7000 arrays are attached to Fibre Channel and iSCSI, with a unified model that also provides NAS functionality. They scale up to 1,056 drives in a clustered setup and can accommodate flash drives alongside SAS or a Nearline-SAS spinning disk.
What’s on offer from the startups

While all-flash arrays have gained a lot of attention in recent years, some of the smaller suppliers have developed products with flash that focus on performance and value, rather than purely the fastest hardware.

Hybrid flash arrays use a combination of flash and traditional hard-disk drives to deliver improvements in performance over traditional arrays without saddling the purchasing with a hefty all-flash price.

Hybrid flash arrays designed from the ground up differ from traditional storage arrays retrofitted with a tier of flash in existing disk slots by using flash storage in a way that targets I/O performance more effectively.

This means flash is used to accelerate all I/O, and not just the data sitting on the flash tier. This approach is more effective at using the benefits of flash as there is no need to constantly restructure data to ensure that active I/O is placed on and delivered from flash, which was the case with the first flash-enabled arrays.

The benefits of the hybrid approach are obvious in terms of cost savings compared with all-flash arrays. All-flash systems can cost up to $20 per raw GB of capacity, whereas hybrid suppliers can deliver products at a quarter of that price.

For many organisations, all-flash can’t be justified because implementing a separate all-flash system simply introduces complexity into the environment. This is especially true in mid-sized organisations that don’t have multiple storage systems and are often managed and operated by IT generalists.

Many applications don’t need the very low latency that all-flash solutions can provide, but do need a greater I/O density (IOPS/TB) than spinning disk can deliver. Hybrid solutions can be deployed with variable amounts of flash installed to match the user’s performance requirements, typically starting at about 10% of capacity.

Hybrid appliances are also typically more feature-rich than their all-flash counterparts, so for many organisations, hybrid solutions are a great stepping-stone towards a fully flash-enabled datacentre.

Hybrid flash systems are available from a range of startup companies, competing directly with products from the big six providers. As will become apparent, the way in which flash is implemented by these suppliers has been achieved in many innovative ways.

**Nimble Storage**

Nimble was founded in 2008 and the company was floated on the New York Stock Exchange in 2013. Its CASL or Cache Accelerated Sequential Layout uses flash purely as a read cache, placing all frequently accessed data into the cache layer either as data is written to the array or as a result of frequent read requests.

Write I/O requests are cached in NVRAM before being committed to hard disk as sequential I/O, which results in a much better use of the capabilities of spinning media and allows performance optimisation by absorbing burst and overwrite data (data written multiple times before being committed to disk).

Nimble offers four product categories, as follows.
The CS210 and CS215 devices are aimed at small/medium organisations and scale up to an effective capacity of 106TB (with 1.2TB of flash).

CS300 series arrays scale to a maximum of 606TB (effective capacity) with up to 3.2TB of flash.

CS500 arrays aim at high-performance requirements and also scale to 606TB, but cater for up to 6.4TB of flash (more than five times that of the CS300).

For extreme performance, the CS700 offers the same capacities and performance as the CS500, with the option to cluster up to four arrays in a single scale-out system.

**Tintri**

Tintri has focused on delivering storage to virtual environments. Initially it catered for VMware vSphere but now does Hyper-V and RHEL (Red Hat Enterprise Virtualisation) too. The appliances also provide virtual desktop infrastructure (VDI) storage for VMware Horizon View and Citrix XenDesktop.

Tintri's latest T800 series arrays use flash and spinning disk to offer VM-centric QoS (quality of service) capabilities that are only now being made available through technologies such as VMware's VVOLs.

However, these features are provided on NFS and SMB3 file-based protocols, which will not initially be supported by VMware with the first VVOLs release.

Tintri's current range of products scale from the entry-level T820, with 1.7TB of flash and 20TB of disk capacity, through to the T850, with 5.3TB of flash and 52TB of disk.

The largest appliance is the T880, which offers 8.8TB of flash and 78TB of raw disk capacity. In each case, flash is about 10% of disk capacity.

**Tegile**

Tegile Systems, founded in 2009, has based its storage appliances around ZFS, developed by Sun Microsystems and initially released into the Solaris operating system in 2005.

ZFS uses system DRAM and flash storage as a cache for read and write I/O to optimise the process of writing to slower hard drives, which are used as the permanent storage medium. Tegile storage optimisation and efficiency features (known as IntelliFlash) significantly extend ZFS and have introduced data deduplication, compression and media management capabilities.

Tegile offers a range of products that are designed for capacity or performance. The HA2100 and HA2130 platforms offer 96GB of DRAM and either 600GB or 1.2TB of flash storage, respectively. Disk capacity can scale up to 100TB or 150TB for the two models.

The HA2100EP and HA2130EP systems provide what is described as a “balanced” optimisation, favouring neither capacity nor performance. Both offer 192GB of DRAM and 1.2TB or 2.4TB of flash storage, respectively.

The HA2300 and HA2400 arrays are optimised for performance, with 192GB of DRAM and 1.2TB or 2.2TB of storage, respectively.

Finally, the T3400 delivers maximum performance and capacity based on 192GB of DRAM, 28.2TB of flash and up to 312TB of disk.
Coho Data

Coho Data has applied the principles of software-defined networking (SDN) to storage array design, offering a scale-out solution based on Arista SDN switches and storage nodes known as MicroArrays.

SDN is used as the switching mechanism to target I/O at the MicroArray serving data for a specific volume. Currently only the NFS protocol is supported.

Each DataStream 1000 MicroArray provides 48TB of disk storage, supplemented with four 1.4TB Micron PCIe SSD flash devices for a total of 54TB (raw). Currently the platform supports only RAID 1, providing a usable capacity of 26TB for each node.

X-IO Technologies

X-IO has been around for some time and originated as a spinout from hard-disk manufacturer Seagate.

The company sells products under the ISE brand name and focuses on selling “black-box” appliances that need zero maintenance.

At the same time, knowledge of drive firmware operations allows the company to extend the life of hard drives by selectively marking only the failed part of a hard drive as inoperative, rather than taking an entire HDD out of operation. This provides a more cost-effective use of hard drives and enables zero maintenance to be achieved.

X-IO’s recently released G3 platform includes the use of flash through a feature called Intelligent Adaptive Flash (IAF). This allows logical unit numbers (LUNs) to be pinned fully into flash or to target the use of flash more effectively than simply using it as a tier within the appliance. ISE now also supports thin provisioning and QoS.

ISE 700 Series hybrid arrays start with the entry-level ISE 710 G3 with 7.2TB of disk and 1.6TB of flash. This scales through the ISE 720G3 (14.4TB disk), ISE 730 G3 (21.6TB disk), ISE 740 G3 (28.8TB disk), all of which provide 1.6TB of flash. The ISE 780 G3 offers higher performance with 28.8TB of disk and 6.4TB of flash capacity.