10 Facts about Solid State Disks

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Solid State Storage Initiative

Like a phoenix from the ashes, solid state disks (SSDs) have re-appeared on the stage a mere 20 years after their initial rise and fall. If the enthusiasm of the storage community is any indicator, it seems they are here to stay this time. Those who are deciding whether or not to buy should be familiar with these ten essential facts about SSDs.

1. **SSDs help reduce energy costs and support the green data centre.**
   Because SSDs do not have any moving parts, they use less energy than hard disk drives (HDDs), which produce less heat and therefore require less cooling. Based on that, SSDs make a valuable contribution to energy-saving and green IT practices, although today the price per capacity is still higher than other alternatives. However, there are variations in energy consumption among SSDs, depending on how the interface technology was implemented and what other components, such as DRAM cache, they are using.

2. **When it comes to price/capacity, HDDs are still first choice.**
   Though capacities go up and prices go down, SATA drives are still cheaper in terms of £/GB. And as hard disk drive prices are also falling and capacities still rising, the point in time where SSDs will also score well on price per capacity is still not in sight.

3. **When it comes to price/IOPS, SSDs could be the best choice.**
   With no moving parts, latency of SSDs is very small. In an environment with random access to large data packages SSDs perform very well. They can also deliver amazing read throughput. However, writing to an SSD can be pretty slow because of the way it operates; it has to erase the content of a cell before it can write new content. And depending on how it does that, this takes time. Enterprise-class SSDs take specific actions to speed up write operations, e.g. by using DRAM as a cache, and typically perform factors faster than HDDs. Though they are still very expensive, their £/IOPS ratio can easily be better than that of hard HDDs.

4. **For SSDs, form factor loses importance.**
   Today, flash chips are built into disk frames to support the same form factor as hard disks, so they can be used in current server and RAID array designs. Like HDDs, they are available in either 2.5” or 3.5” form factor. Unlike HDDs, where these form factors have an immediate effect on price and available capacity, for SSDs this is not a very important criterion.

5. **The write operation of SSDs is complex and therefore slower.**
   While the read performance of a flash chip is typically faster than that of most disks, write performance is often slower. This is because on a flash chip you do not just write one block; the block first has to be erased, and you cannot erase single blocks, only a number of blocks at the same time. This group of blocks is called the “erase block”; it
can be quite large, and it may contain data that you still need, which makes the write operation quite complex.

Enterprise-class SSDs overcome this limitation in a number of ways, e.g. they use a cache to aggregate write operations and transform many small ones into one big one. As changing all blocks in an erase block is almost as fast as changing one, it is great if a cache can help; however, if the blocks are spread throughout different erase blocks, caching doesn’t really solve the problem. Another way to improve write performance is to address a number of flash chips in parallel, which also means writing to different erase blocks at the same time and by that converting sequential write operations into parallel ones.

When it comes to performance, the write operation is the Achilles heel of flash and is where the difference between consumer-class and enterprise-class SSDs is most apparent.

6. **There are limits to the durability of SSDs.**
   A block can be written on a flash chip typically no more than 10,000 to 100,000 times, depending on the type of chip. This is not much for a storage system that must deliver high IO loads, especially as failing blocks impact the lifetime of the entire flash chip. So the SSD has to make sure that all blocks are used in a balanced way through a process called ‘wear levelling’ where the idea is to write to the block that has been used least. Another strategy to increase the life of the chip is to provide overhead capacity sufficient to replace defective blocks; this requires an intelligent way of detecting and managing defective blocks.

7. **There are important differences when choosing between MLC and SLC.**
   MLC stands for Multi-Level Cell, SLC for Single-Level Cell. SLCs store one bit per cell, MLCs store more, typically three. The negative aspects of MLC are that if one bit fails in a three-bit MLC combination, all three stop working. MLCs are also slower than SLCs in both read and write operations, and they use more power. However, MLCs offer more capacity at almost the same manufacturing cost as SLCs and these chips have factor ten fewer write cycles, and a better £/capacity ratio. So when you find particularly price aggressive SSD offerings, these could be MLC-based. If the priority is capacity then this is fine, but beware if IOPS are the key factor.

8. **SSDs reduce the demand for physical storage extensions, but won’t replace external arrays.**
   To achieve high IOPS with HDDs, you need many: more spindles equals more speed. As servers cannot physically house numerous spindles, the use of an external RAID array makes sense. Now that two SSDs running in RAID 1 can replace several spindles, and because two drives fit easily into any server, it may appear as though RAID systems for high performance will become obsolete because of SSDs. But they will not because externalised storage arrays still offer the benefits of consolidation; many servers can access them and consolidation dramatically decreases unused spare capacity. Also, many applications require RAID-controller protected storage, and they can’t be run with internal or JBOD storage. Though SSDs will reduce the demand for simple physical storage extensions, i.e. JBODs, their weakness is still in price per capacity. If you are using applications that don’t require great speed, the whole picture changes.
9. **SSDs enable storage systems with much higher density.**
   A flash chip is small. Though today it is typically built into a disk frame, this needs not be the case for future storage devices. And because flash chips use little power, they don’t get hot and therefore need less cooling than HDDs. So it is possible to imagine storage devices with new form factors with a tremendous increase in density. Capacity has been roughly doubling each year while the price per GB has declined. Flash technology is good for enabling small storage devices with high capacity and tremendous performance that in future will look completely different from today’s RAID systems.

10. **The choice between SSDs and other storage media is usage-dependent**
    As usual in storage environments, the ideal infrastructure depends on the specific scenario. If the main aim is to store huge amounts of data that is rarely accessed, like a file server, SSDs are not the best choice and will not be in the near future. If speed is the priority, SSDs could be the right option, but as discussed, write performance is a critical factor. So where the application primarily demands fast reads, choose SSDs. If there is a high share of writes, SSDs could be too slow. That said, enterprise-class SSDs address these weaknesses very effectively, so it is possible to achieve good performance even when they are not ideal.