CSE360-Computer Interfacing
BRAC University
Magnetic Disk

Magnetic Disk

- A magnetic disk is the primary storage disk in a computer.
- A magnetic disk is a used to read from and write data to the disk.
- The data on a magnetic disk are read and written using a magnetization process.
- It is covered with a magnetic coating and stores data in the form of tracks and sectors.
- Physically a magnetic disk is a thin, circular plate or platter made of metal or plastic that is usually coated on both sides with a magnetizable recording material such as Iron Oxide. It is called substrate.

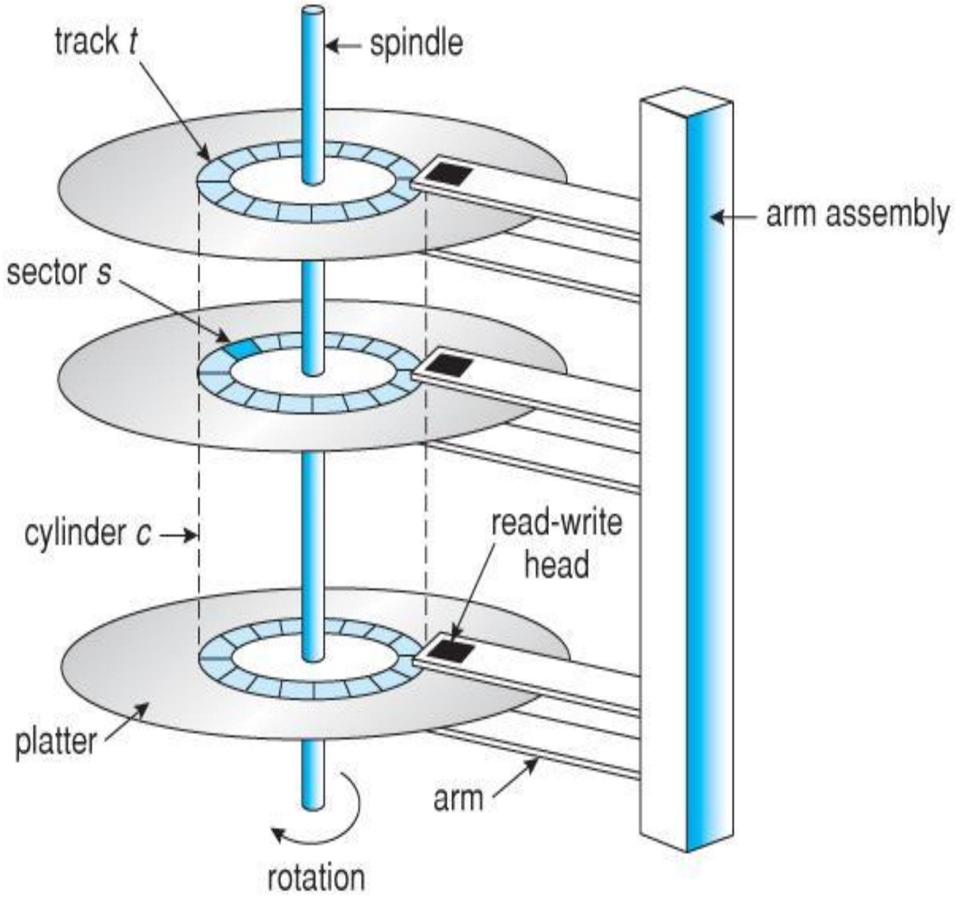
Magnetic Disk

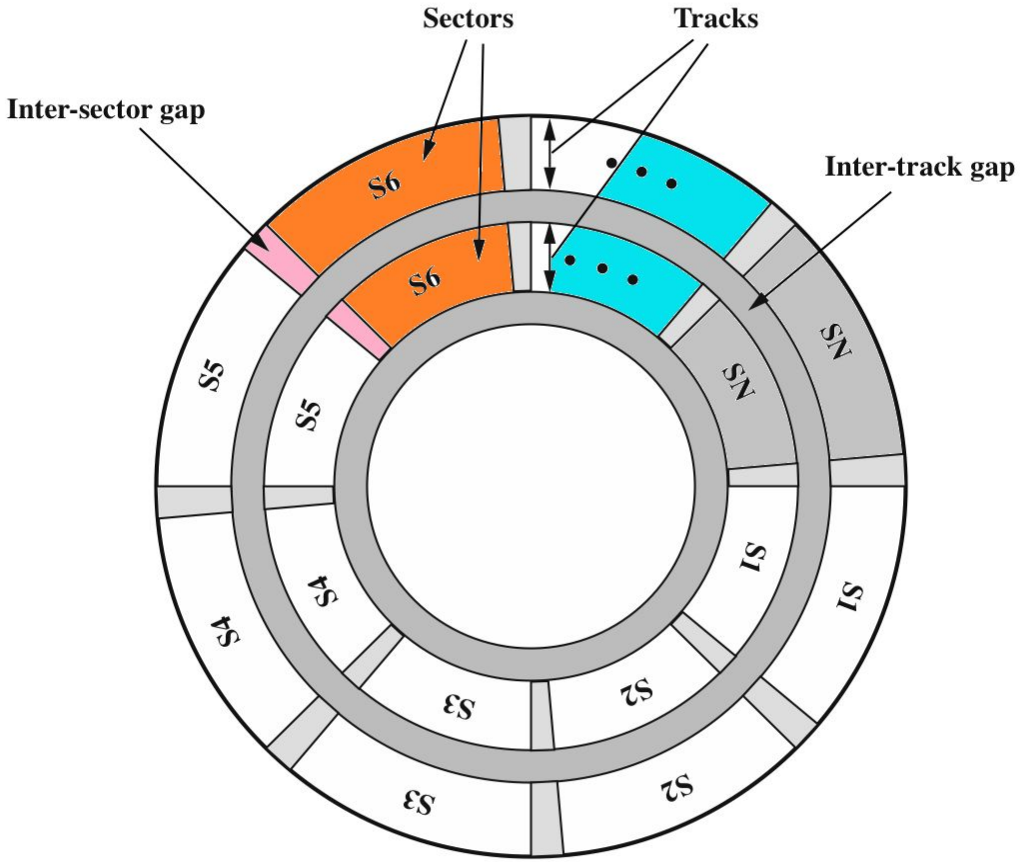
- The disk is stored in a specially designed protective envelop or cartridge, or several of them are stacked together in a sealed, contamination-free container.
- Hard disks, zip disks and floppy disks are common examples of magnetic disks.

Read -> Magnetic field of the oriented magnetic particle -> Electric Field -> Micro Electricity

Write -> Electrical current through Arm -> Electric Field -> Magnetic field -> orients the magnetic particle in north –south / south-north

Magnetic Disk





Magnetic Disk

- **TRACK:-**
  - The disk surface is divided into concentric tracks (circles within circles).
  - The thinner the tracks, the more storage.
  - The data bits are recorded as tiny magnetic spots on the tracks. The smaller the spot, the more bits per inch and the greater the storage.
- **SECTOR:-**
  - Tracks are further divided into sectors, which hold a block of data that is read or written at one time.
  - In order to update the disk, one or more sectors are read into the computer, changed and written back to disk. The operating system figures out how to fit data into these fixed spaces.

Magnetic Read and Write Memory

- The write mechanism the electricity flowing through a coil produces a magnetic field.
- Electric pulses are send to the write head and the resulting magnetic patterns are recorded on the surface below, with different patterns for positive and negative currents.
- The read mechanism exploits the fact that a magnetic field moving relative to a coil produces an electrical current in the coil.
- When the surface of the disk passes under the head, it generates a current of the same polarity as the one already recorded.
- The read head consists of a partially shielded magneto resistive (MR) sensor.
- The MR material has an electrical resistance that depends on the direction of the magnetization of the medium moving under it.

Magnetic Disk

Some key Concept:

- Outcome:
  1. Total
  2. Partial
  3. Total Failure

- Storage Unit:
  1. Allocation Unit

Timings in Operation

- **Disk Access Time:** It is the interval between a computer makes a request for transfer of data from a disk system to the primary storage and the instant the operation is completed. Disk Access Time depends on the following three parameters: Seek time + Latency + Transfer Rate
- **Seek Time:** It is the time required to position the read/write head over the desired track, as soon as a read/ write command is received by disk unit. 1. Track Select
- **Latency:** It is the time required to spin the desired sector under the read/write head, once the read/write is positioned on the desired track. 2. Sector Select
- **Transfer rate:** It is the rate at which data are read/written to the disk, once the read/write head is positioned over the desired track.

3. Read/ Write

Disk Partition

- **Logical Partition:** A disk can be partitioned into multiple drives. We can partition our disk space into multiple drives and this is called as logical partition.

- **Physical Partition:** When we will have multiple disks operating in a same system then it will be called as physical partition.

Bad Sector

- If for some reason magnetic particles of the disk lost their magnetic property, when we will write or read data from there, they will not be affected by magnetic fields. IF the magnetic particle of disk surface lost its magnetic property, then we can not affect its alignment north- south or south – north. Then it will form bad-sector.
- Reason of bad-sector:
  - Spark is taken place on room
  - Dropping the hard-disk from your hand on the floor
  - hammering on the disk
- - in all these cases, the disk can get hurt can be affected and for the reason magnetic property can be lost.

Advantages

- Very fast access to data.
- Data can be read directly from any part of the hard disc.
- In most of the magnetic storage devices the acces speed is about 1000kb/s
- Some of the magnetic storage devices are very cheap for example floppy disks.
- Most of the magnetic storage devices store very large amounts of data.

Disadvantages

- Data can be altered by magnetic fields, dust, mechanical problems
- Gradually lose their charge over time - data lost
- Hard disks eventually fail which stops the computer from working.
- Regular crashes can damage the surface of the disk, leading to loss of data in that sector.

Thank You

For Your Attention

Magnetic Disk

A magnetic disk is a storage device that uses a magnetization process to write, rewrite and access data. It is covered with a magnetic coating and stores data in the form of tracks, and sectors. **Magnetic disk**s are flat circular plates of metal or plastic, coated on both sides with iron oxide. Input signals, which may be audio, video, or data, are recorded on the surface of a disk as magnetic patterns or spots in circular or spiral tracks. The data on a magnetic disk is read and written using a magnetization process. There's just a large shiny, circular "plate" of magnetic material called a **platter**, divided into billions of tiny areas. Each one of those areas can be independently magnetized (to store a 1) or demagnetized (to store a 0). Magnetism is used in computer storage because it goes on storing information even when the power is switched off.

Hard disks, zip disks and floppy disks are common examples of magnetic disks. Magnetic disks have traditionally been used as primary storage in computers. With the advent of solid-state drives (SSDs), magnetic disks are no longer considered the only option, but are still commonly used.

On a disk we can perform two operations. **One is a read another one is write**. These plates look thing is knows as platter. Separata disks are there, they are known as platters. All these platters are rigidly fixed on the central rod known as spindle rod. Spindle rod is the central rod where disk platters are rigidly connected/ That means all the disks will rotate when the spindle rod will rotate. This is call read-write arms. At the tip of the arms, there are read-write heads on there. On the disks, we can perform read- write operation on both sides. We know there are two sides on a disk, up side and down side and we can perform read- write on both the sides. That’s why read-write arms have read- write heads on both sides of the disks. These read- write heads can move front and back direction. And slightly right and left so that the disk surface can be accessed. In combination of spindle rod rotation, and movement of read-write head, full disk data can be accessed. Data is organized on the disk in the form of tracks and sectors, where tracks are the circular divisions of the disk. Tracks are further divided into sectors that contain blocks of data. All read and write operations on the magnetic disk are performed on the sectors.

On a disk, we are having some concentric circles, and they are known as **tracks**. The thinner the tracks, the more storage. The data bits are recorded as tiny magnetic spots on the tracks.

And the disk will be divided radially into multiple zones. Each zone is known as **sector**. So, we can say, the disk is having co-ordinate system. This co-ordinate system will consist tracks and sectors. All the tracks available on the all the surfaces having the same radius is called a cylinder. There will be tracks of different radius on each disk, so there will be tracks of same radius on each disk. And they will form cylinder. Form the count of cylinder. We can understand how many tracks are there in total disk.

Allocation unit: The portion of the track, enclosed within a sector, is known as allocation unit. A hard disk can have 2Kb of allocation unit size. Remember one thing, allocation unit cannot be partially allocated. Example: when we open a text file , and write hello world there, we will see, the size of the file is only 10 Bytes, and we save that file, you will notice that your total hard disk will be reduced by size not by the size of the file of 10Bytes rather by the size of the allocation unit. That means 2KB. So, either it will be allocated totally or not all.

Read – Write Mechanism:

We have magnetic bubbles in the disk, and this magnetic bubbles or magnetic particles, these bubbles will be on the up direction or in the down direction which will indicate either 0 or 1. There magnetic particles are used in disk surface to hold data. In case or write operation, through this particular read-write arms, and to e specific through this read-write head, **electric current** will flow and due to the flow of the current, **magnetic field** will be generated. Due to the presence of magnetic field, the **magnetic particles will align accordingly, north-south or south north** orientation, that will indicate whether it is holding the value 0 or 1. In case of read operation, these aligned magnetic particles will produce a **magnetic particles** in the read-write head and that read-write head, **due to presence of magnetic field, will have some micro – current** and the current direction will indicate whether it has read 0 or whether it has read 1.

Outcomes:

There are three outcomes are possible from these read and write operations. One is successful, another one is partial and the last one is total failure. Successful read-write means we have done the operation fruitfully. Partial means some of the disk data are falling on the bad sector. Bad sector means it cannot contain data. Or if you write data there, you cannot restore that one. In this case, we have a partial failure. These are the total outcomes.

Disk Partition:

Logical partition: A disk can be partitioned into multiple drives. In our pc, we usually partition out total hard disk into multiple drives. There are also, some softwares and by using them, we can partition our disk space into multiple drives and this is called as logical partition.
Physical Partition: When we will have multiple disks operating in a same system then it will be called as physical partition.

Bad Sector:

We have magnetic bubbles in the disk, and this magnetic bubbles or magnetic particles, these bubbles will be on the up direction or in the down direction which will indicate either 0 or 1. There magnetic particles are used in disk surface to hold data, but for some reason they might have lost their magnetic property. Then what will happen, when we will write or read data from there, they will not be affected by magnetic fields. IF the magnetic particle of disk surface lost its magnetic property, then we cannot affect its alignment north-south or south – north. Then it will form bad- sector.

Reasons of Bad-Sector:

If you do the hammering on the disk, if some spark can be taken place on room if you drop the hard-disk from your hand on the floor, then the disk can be hurt can be affected so what magnetic property can be lost.

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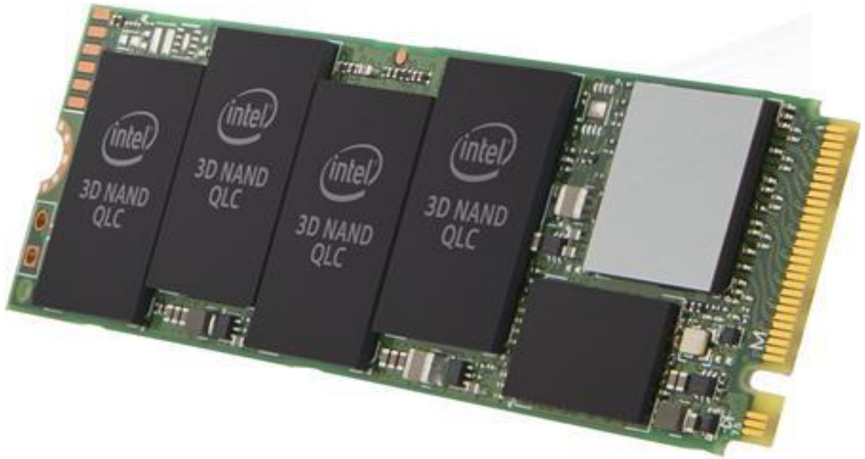
Solid State Drive (SSD)



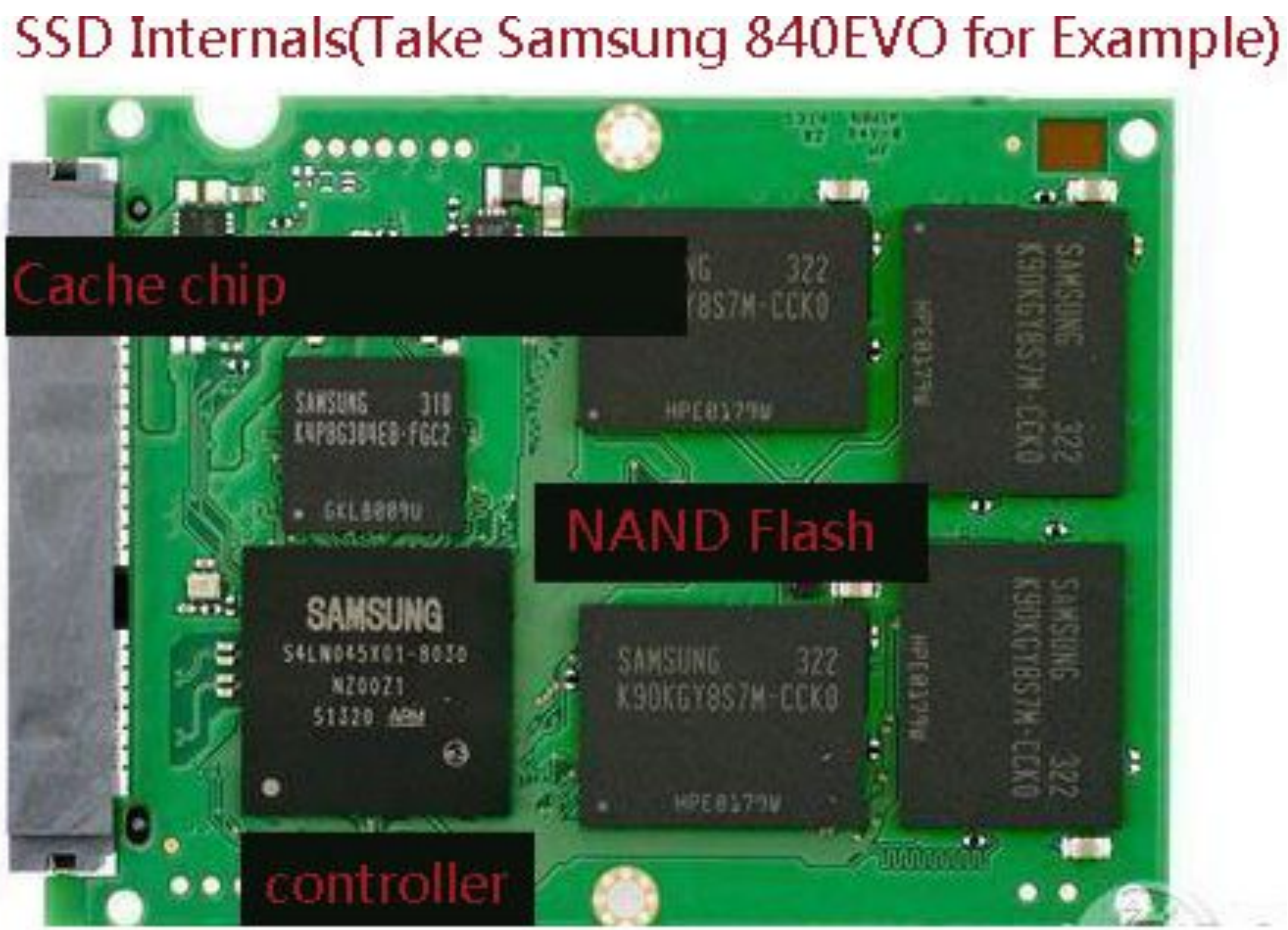
Solid State Drive

- An SSD is a Solid State Drive that is used to store data, files and applications, as well as to run computing devices.
- Solid state drives offer significant performance advantages over conventional hard disk drives (HDDs).
- SSDs do not have any moving mechanical components, which distinguishes them from traditional magnetic disks such as hard disk drives(HDDs).
- SSDs use microchips that retain data in non-volatile memory chips.
- SSD uses non volatile NAND Flash Memory , which enables it to retain data when the power is removed.

Internal Components and Design

Major Components:

1. Outer Shell
2. NAND Flash
3. Controller
4. Firmware
5. DRAM Buffer



Outer Shell

- The outer shell could be of metal or plastic and it helps in absorbing most of the heat from inside the flash memory.
- Although, SSDs don't contain any moving parts, they give off very little heat and emit no noise. This particular feature is vital in increased durability of an SSD.
- An SSD can withstand 10X more vibration than an HDD and up to 1500G of shock (compared to less than 70Gs for a typical HDD).
- SSDs exceed expectations in handling shock, vibration, and temperature extremes as well.

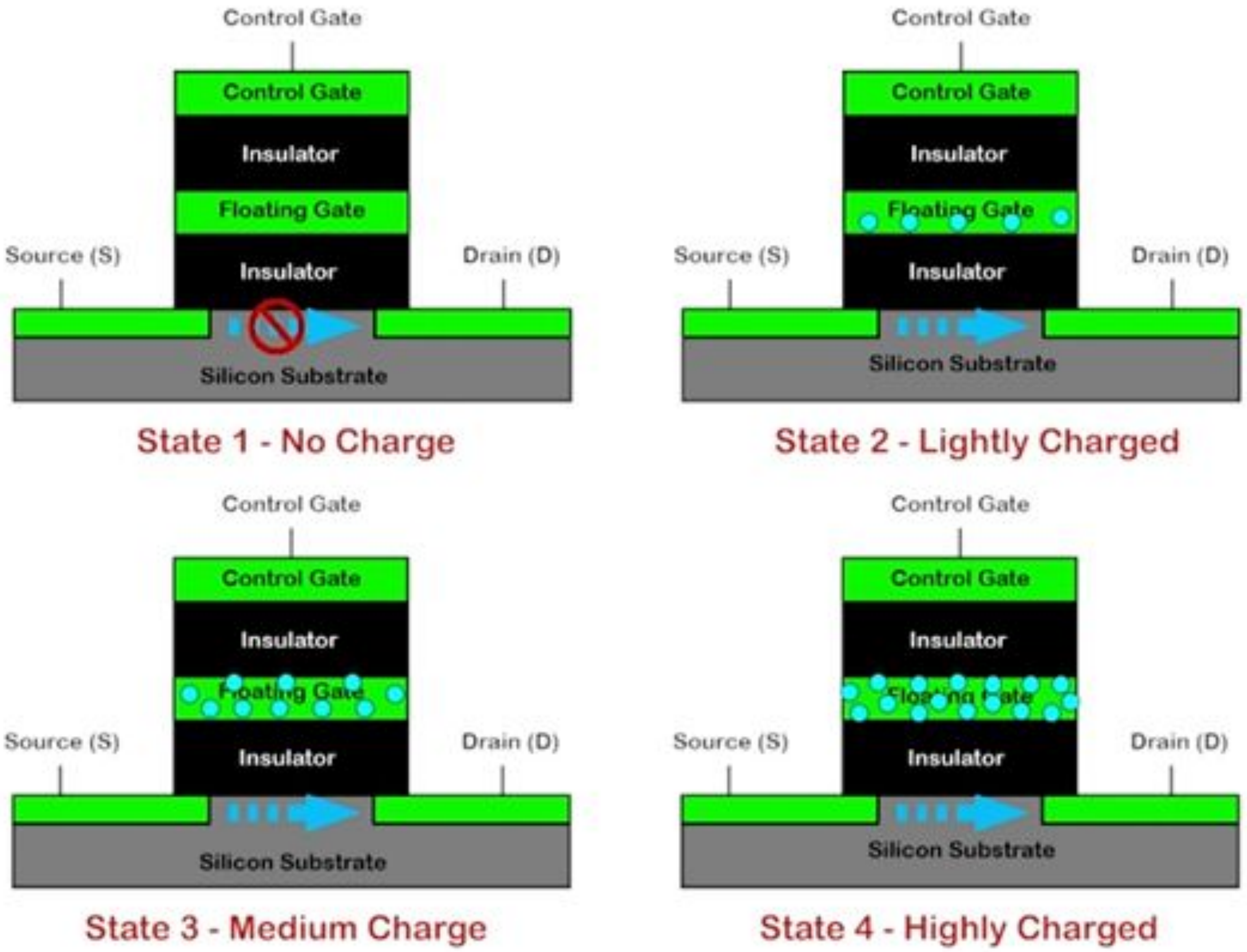
NAND Flash

- NAND Flash Memory is the key component of SSD.
- It is a specific type of EEPROM chip.
- It has a grid of columns and rows with a cell that has two transistors at each intersection as Control gate and Floating gate transistor.
- The principle of operation is based on MOSFETs.
- NAND flash memory is non-volatile that means it has ability to retain the data without a constant power supply.
- Lower cost compared to DRAM.
- Flash memory SSDs are slower than DRAM solution.
- NAND Flash components have structures called pages and blocks.

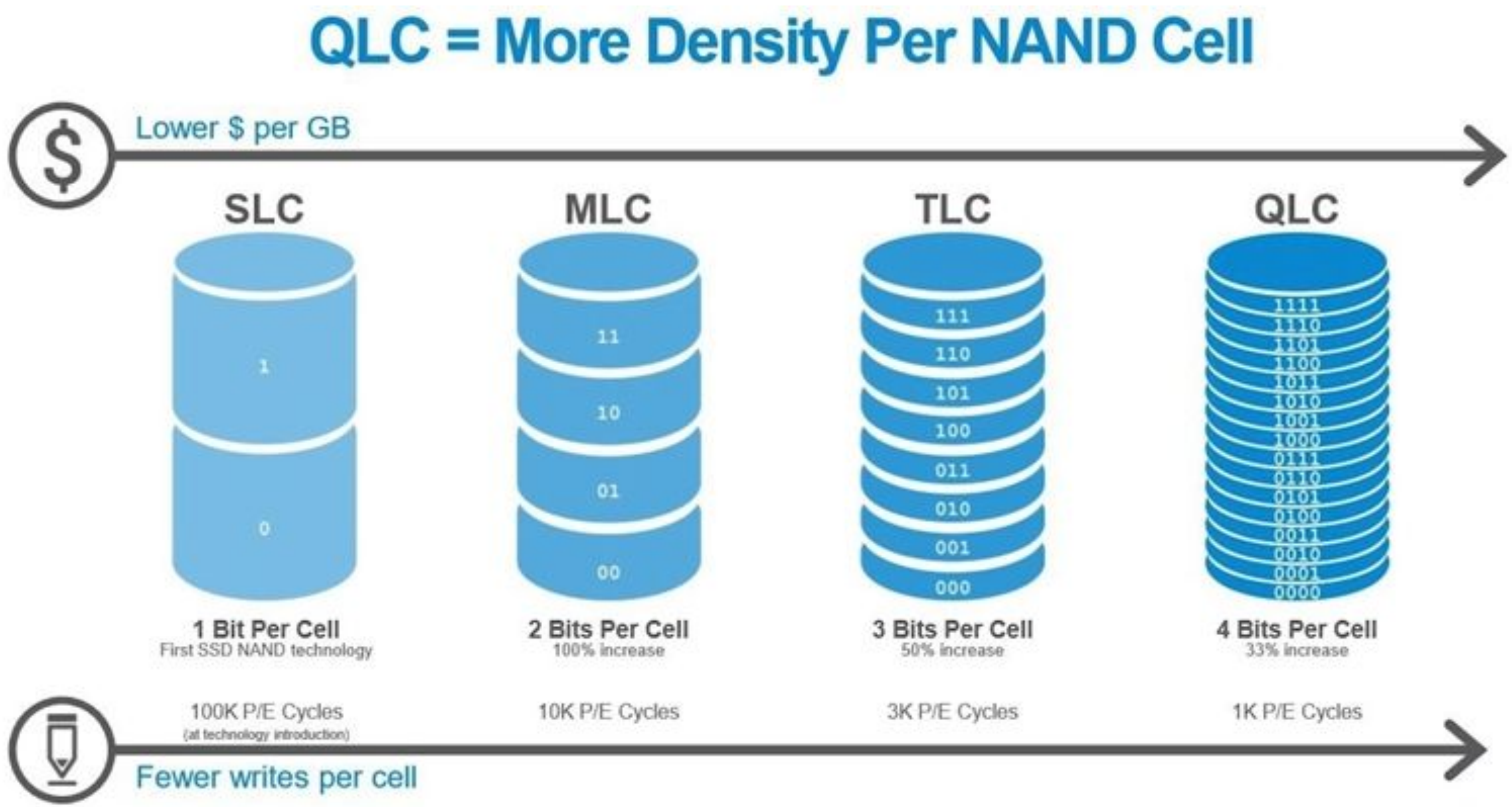
NAND Flash

- Groups of NAND flash cells are organized into pages and these pages are organized into blocks.
- Read and write operations can be performed on pages, but erase operations can only be performed at the block level.
- This means that when rewriting a page, the entire block must be erased first. This is because the act of erasing NAND flash requires a high amount of voltage.
- The SSD controller manages this process.

Charge States



NAND Cell Storage



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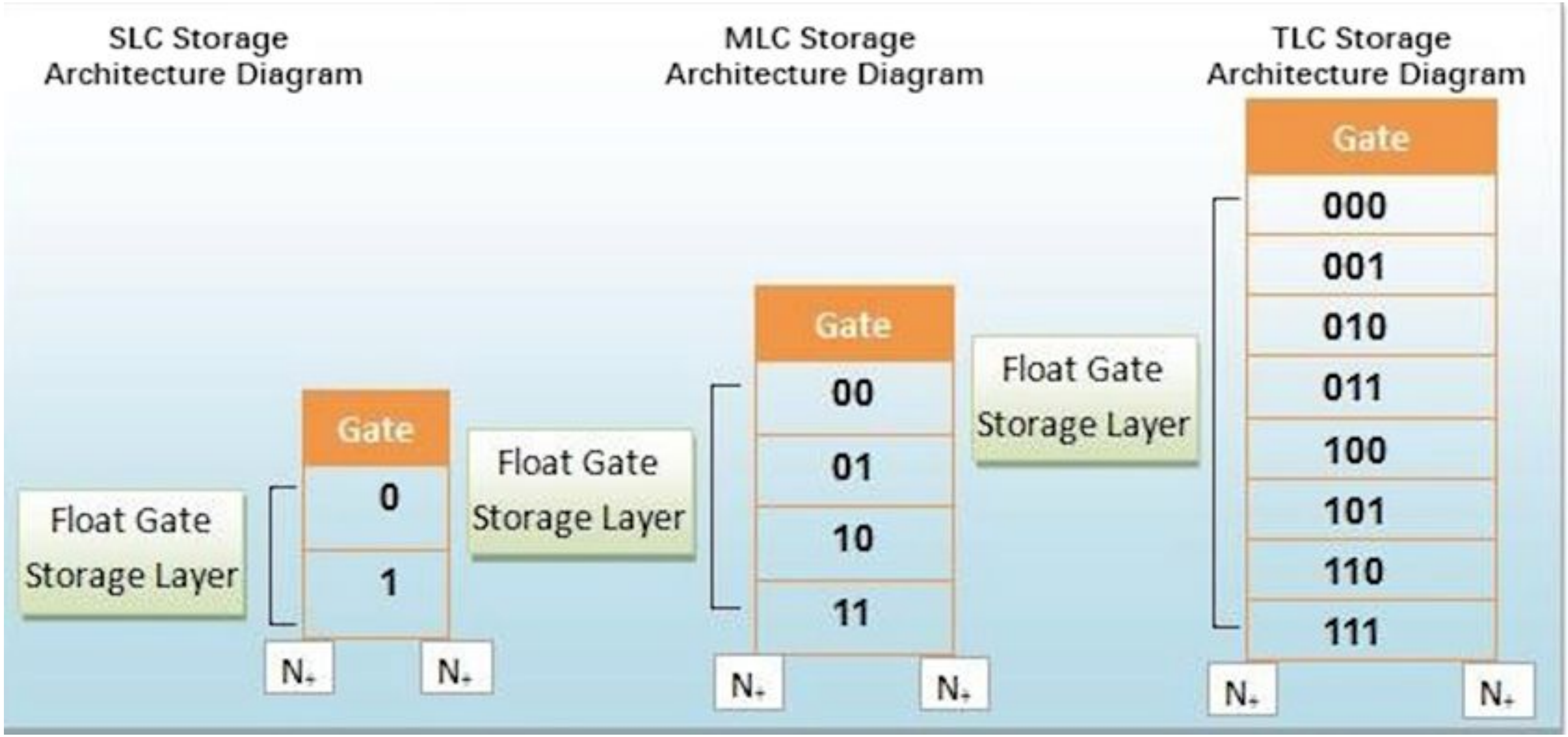
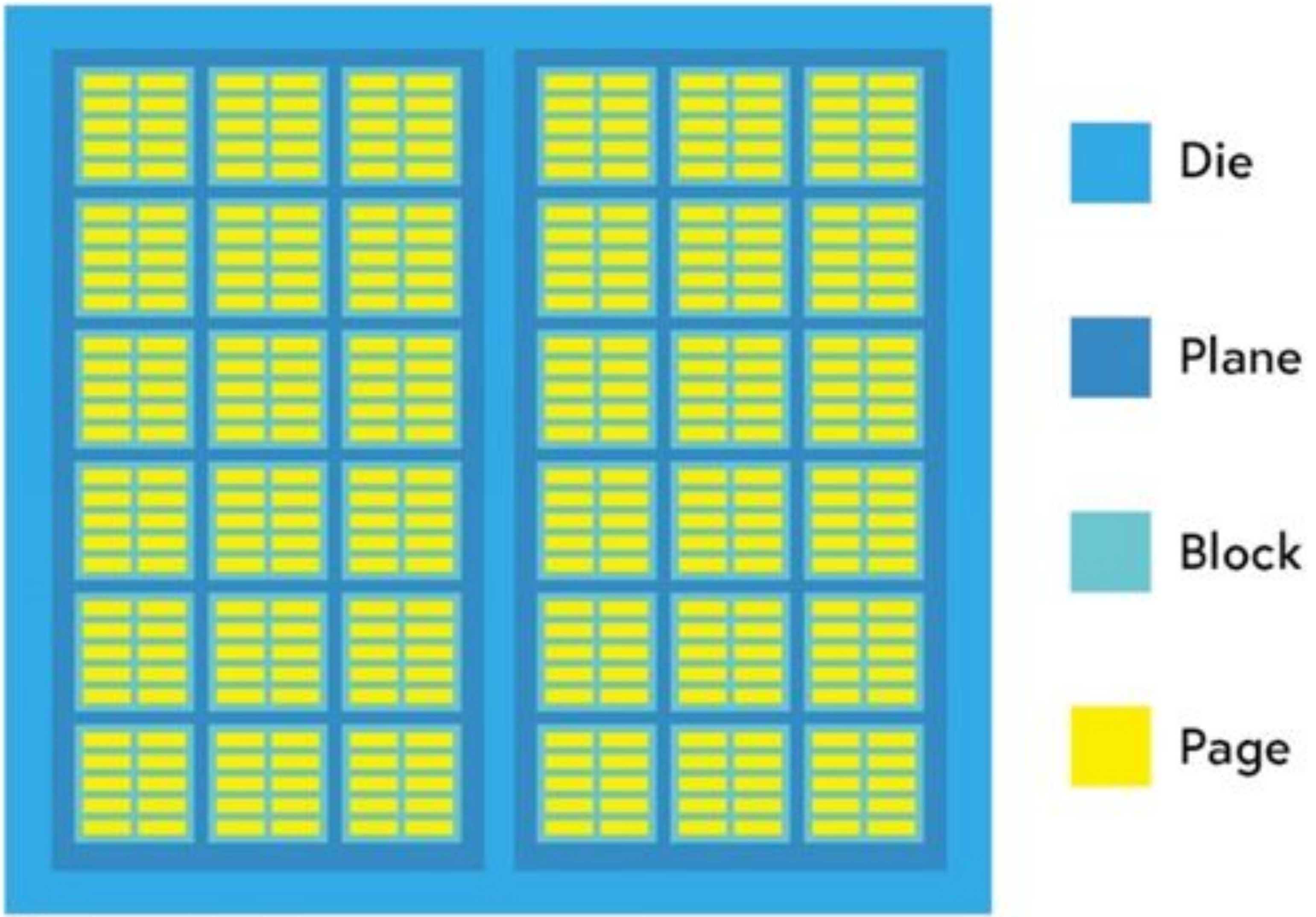
NAND Cell Storage



Performance Comparison

	SLC	MLC	TLC	HDD	RAM
P/E cycles	100k	10k	5k	*	*
Bits per cell	1	2	3	*	*
Seek latency (μs)	*	*	*	9000	*
Read latency (μs)	25	50	100	2000-7000	0.04-0.1
Write latency (μs)	250	900	1500	2000-7000	0.04-0.1
Erase latency (μs)	1500	3000	5000	*	*
Notes	* metric is not applicable for that type of memory				
Sources	P/E cycles [20] SLC/MLC latencies [1] TLC latencies [23] Hard disk drive latencies [18, 19, 25] RAM latencies [30, 52] L1 and L2 cache latencies [52]				

NAND Flash Die Layout



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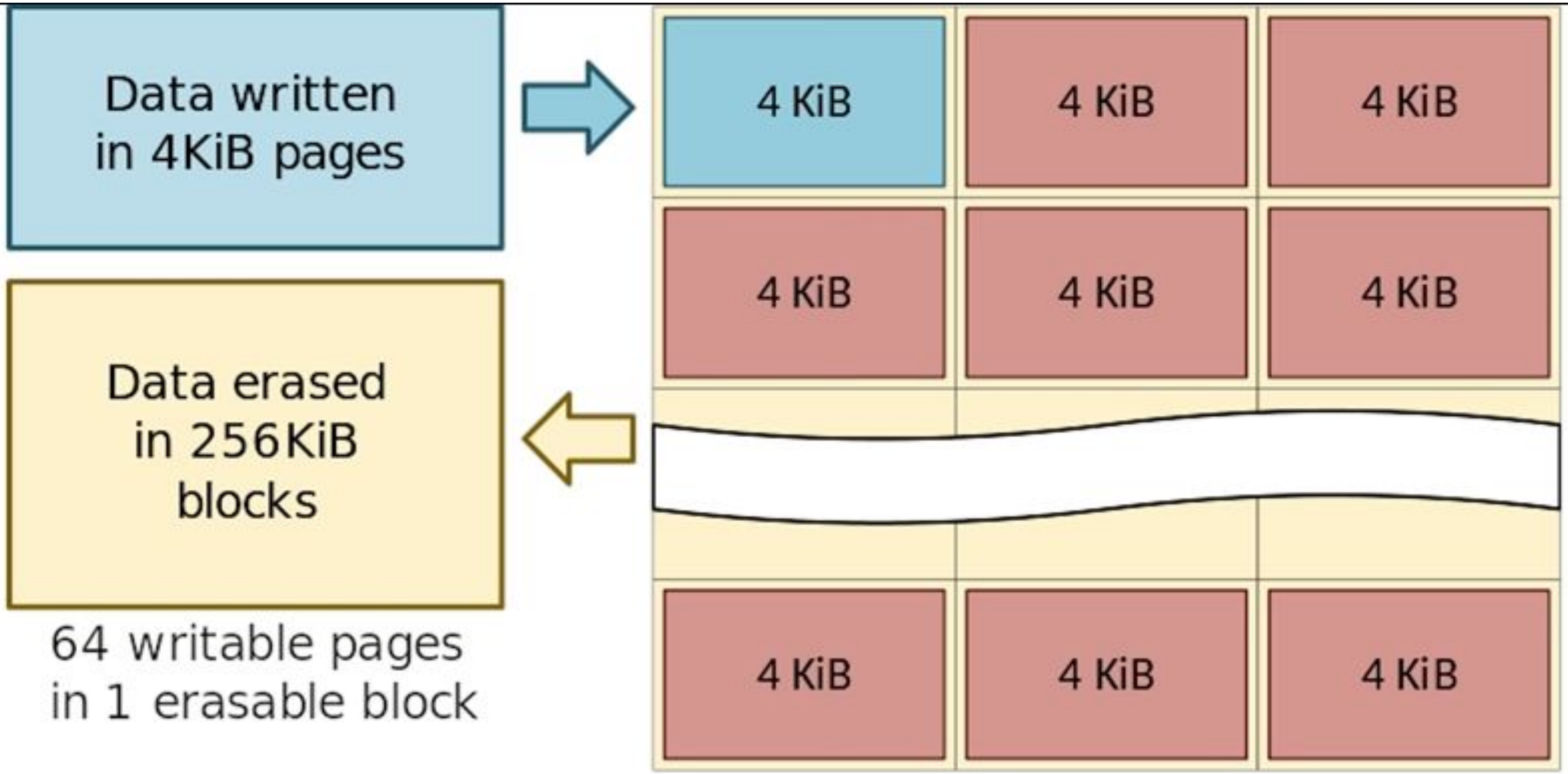
NAND Flash

- The only way for an SSD to update an existing page is to copy the contents of the entire block into memory, erase the block, and then write the contents of the old block + the updated page.
- If the drive is full and there are no empty pages available, the SSD must first scan for blocks that are marked for deletion but that haven't been deleted yet, erase them, and then write the data to the now-erased page.
- Garbage collection is a background process that allows a drive to mitigate the performance impact of the program/erase cycle by performing certain tasks in the background.

Data Read, Write and Erase

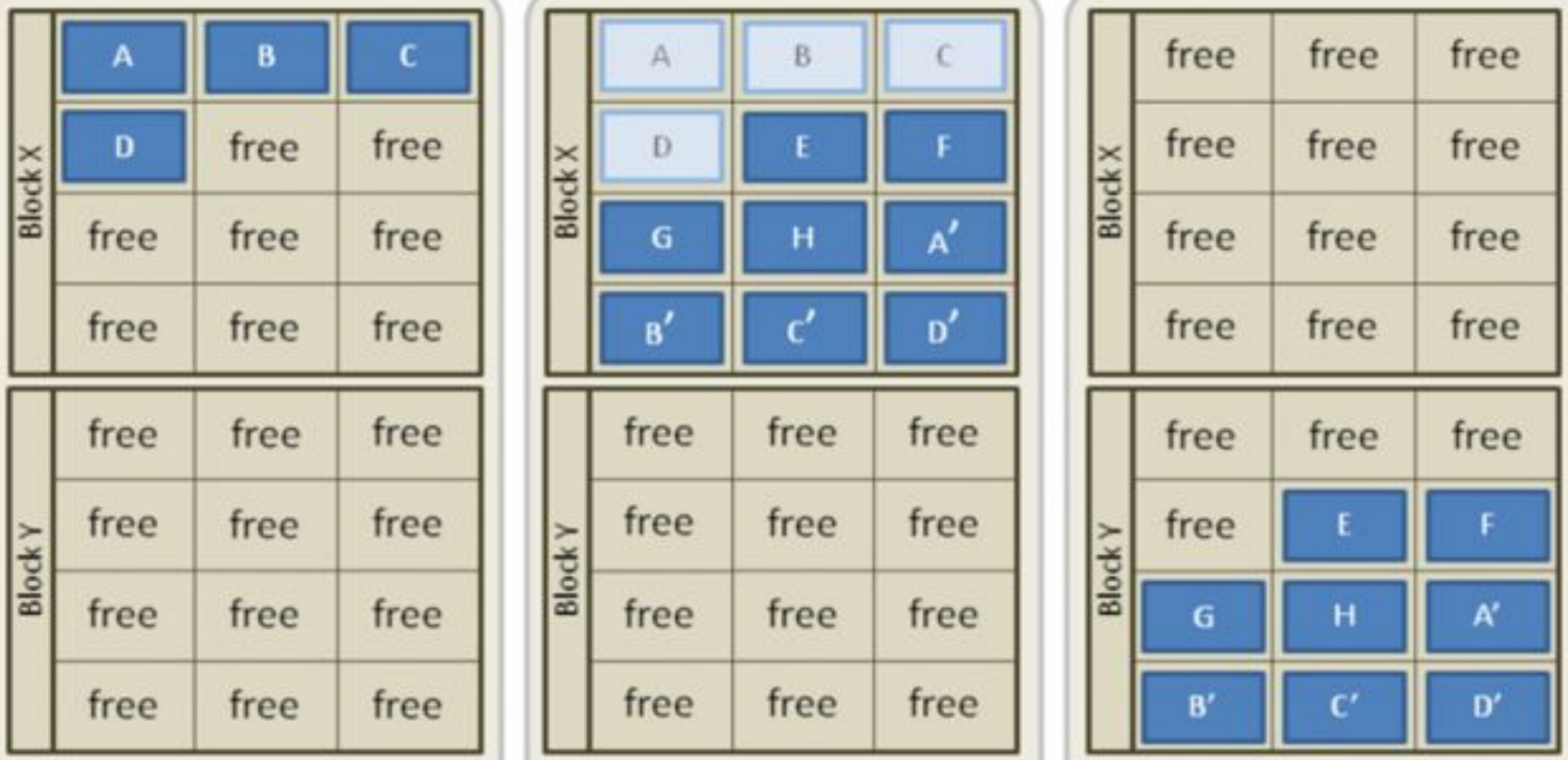


Typical NAND flash pages and blocks

Some Important Concepts

1. Garbage Collection
2. TRIM Command
3. Wear Leveling
4. Write Amplification
5. Over-Provisioning

Garbage Collection

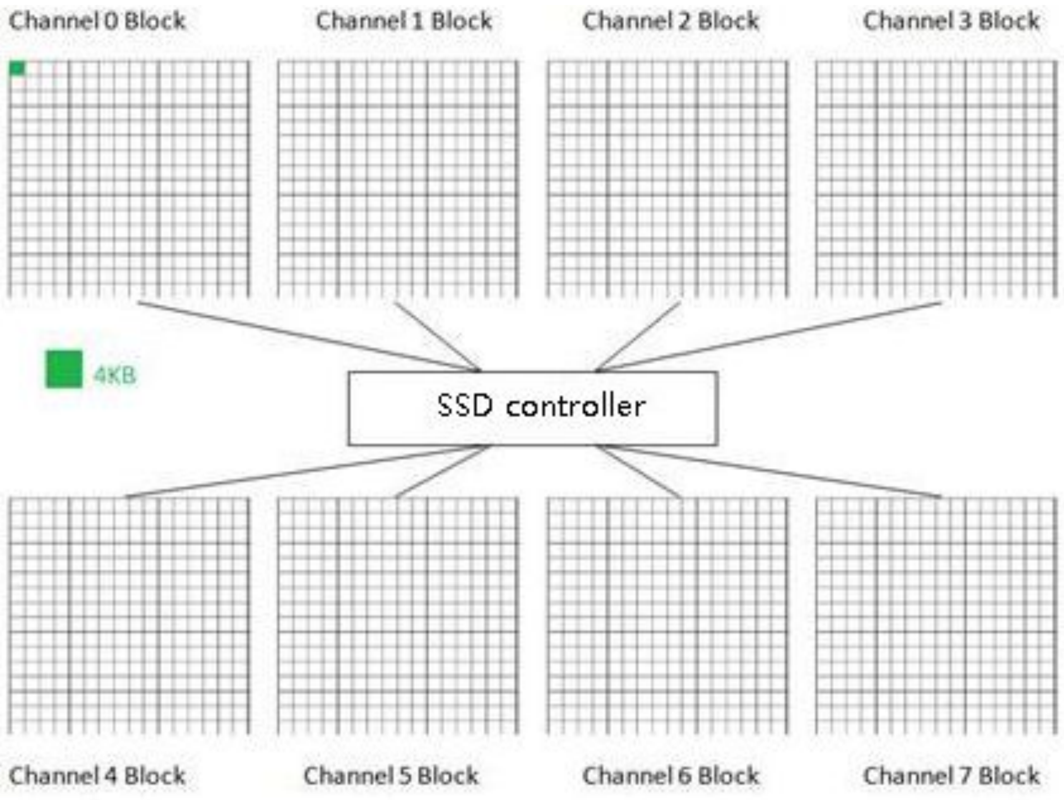


1. Four pages (A-D) are written to a block (X). Individual pages can be written at any time if they are currently free (erased).

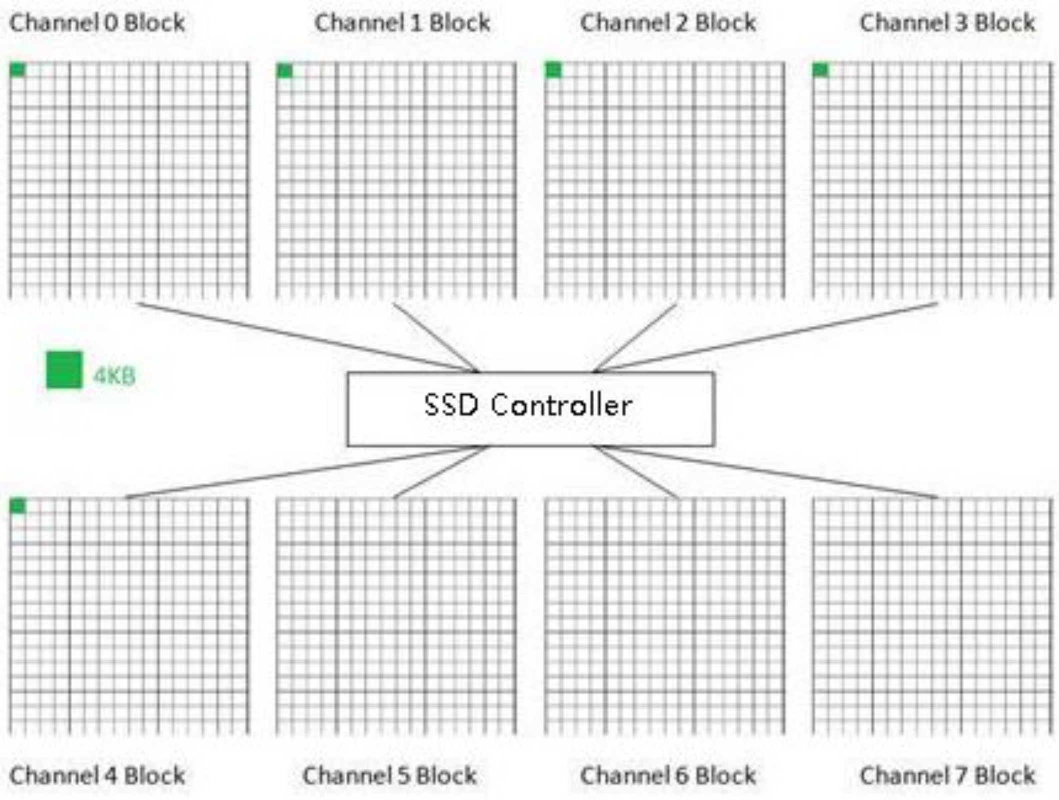
2. Four new pages (E-H) and four replacement pages (A′-D′) are written to the block (X). The original A-D pages are now invalid (stale) data, but cannot be overwritten until the whole block is erased.

3. In order to write to the pages with stale data (A-D) all good pages (E-H & A′-D′) are read and written to a new block (Y) then the old block (X) is erased. This last step is *garbage collection*.

Wear Leveling



When HOST write 4KB of data:



HOST continues to write 16KB of data

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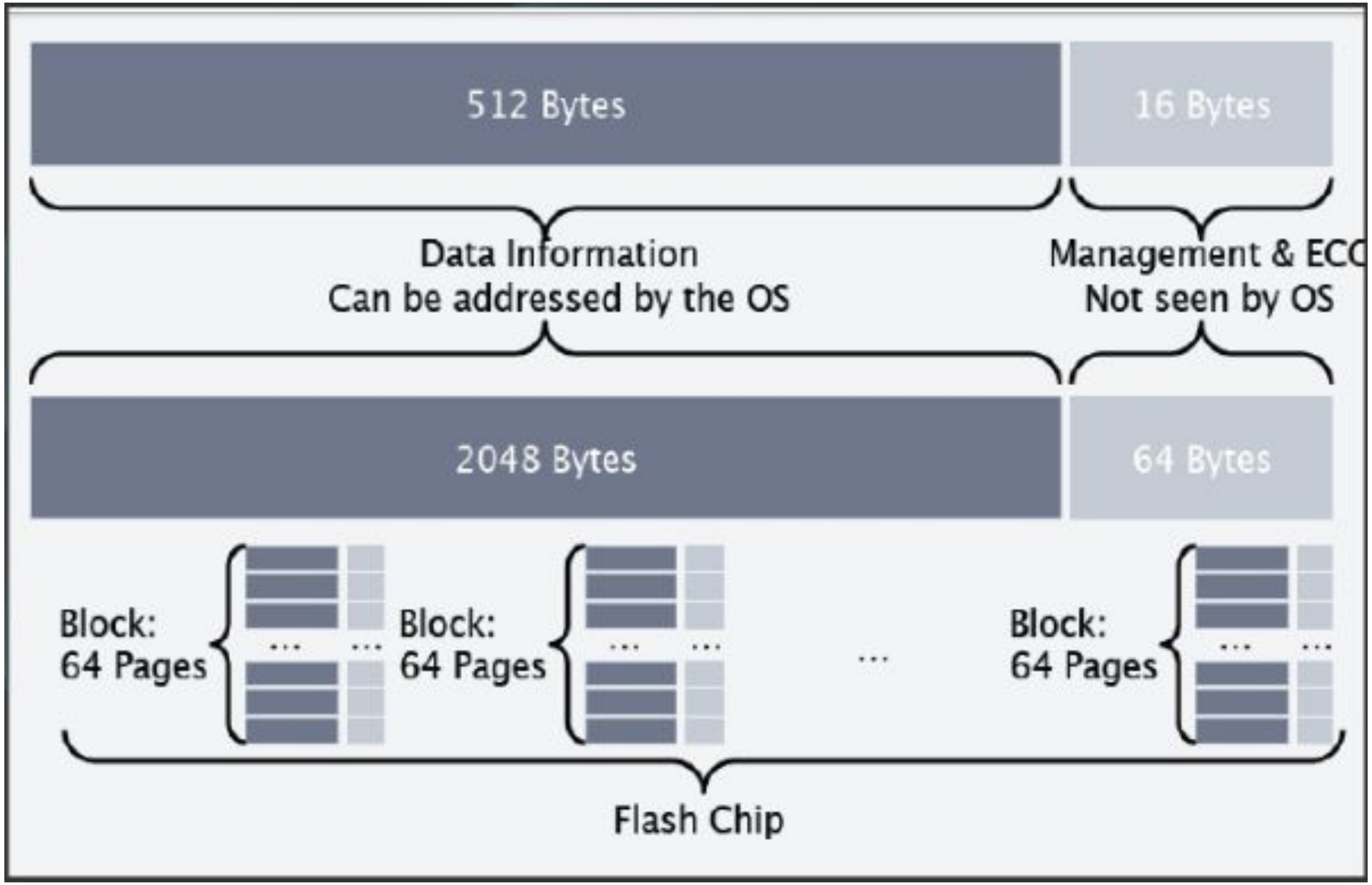
Over-Provisioning



SSD Controller

- Flash controller includes the electronics that bridge the Flash memory components to the SSD input/output interfaces.
- The controller is an embedded processor that executes firmware-level software.
- Every SSD includes a controller i.e. an embedded processor that executes firmware-level code and is one of the most important factors of SSD performance.
- Functions:
  1. Error Correction(ECC).
  2. Bad block mapping.
  3. Read disturb management.
  4. Read and write caching.
  5. Encryption.

DRAM

- A bit of DRAM is included in every SSD for the process of buffering.
- Similar to hard drive's cache, data is stored on it for some time temporarily before it is being written to the device.
- It increases SSD performance to some level.

Advantages

- High performance-Significantly faster than a standard HDD.
- Faster seek time-Up to 60x faster than HDD.
- Higher reliability-No moving parts.
- Lower power-Lesser power consumption, cooler operation.
- Silent Operation-Ideal for post production environments.
- Light weight-Perfect for portable devices.
- Wider Operating Temp.

Disadvantage

- They are more expansive than traditional hard drives.
- They currently offer less storage space then traditional hard drives.
- Flash memory SSDs are slower than DRAM solution.

Applications

- Desktop Computers
- Laptops
- Ultra books
- HD Camcorder, CCTV Digital Video Recorder (DVR)
- Smart TV
- Set Top Boxes
- Mobile Phones
- Servers - SSD are used as cache at server side of Enterprises.

SSD vs HDD

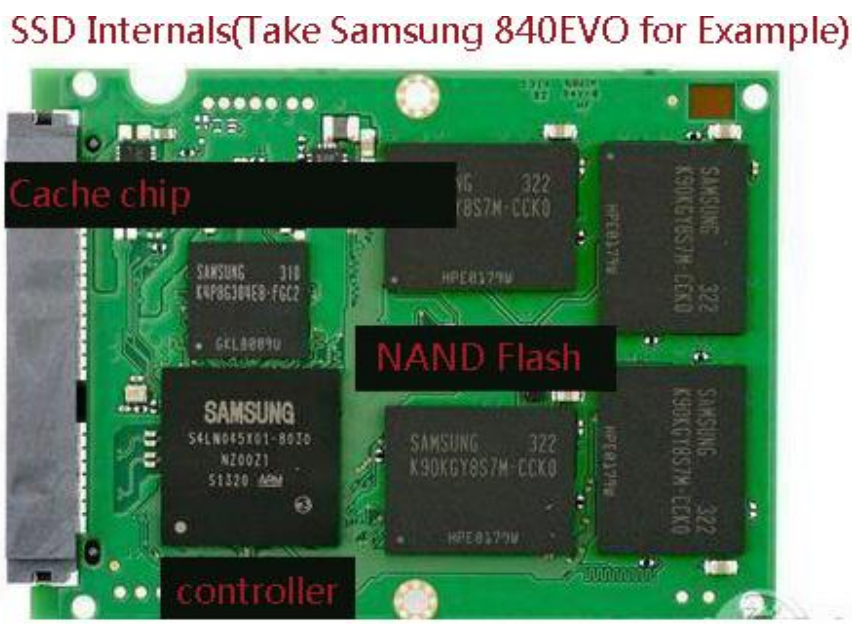
2.5" SATA 3.3 Gbps SSD		2.5" SATA 3.8 Gbps HDD
Solid NAND Flash based	**Mechanism Type**	Magnetic Rotating platters
64GB	**Density**	80 GB
75gm	**Weight**	365gm
Read: 100MB/s Write: 80MB/s	**Performance**	Read: 59MB/s Write: 60MB/s
1W	**Active Power Consumption**	3.86W
10-2000Hz	**Operating Vibration**	22-350Hz
1500G/0.5ms	**Shock Resistance**	170G/).5ms
0 °C– 70°C	**Operating Temperature**	5°C– 55°C
None	**Acoustic Noise**	0.3 dB
MTBF > 2M hours	**Endurance**	MTBF < 0.7M hours

Thank You

For Your Attention

Solid State Drive

An SSD is a Solid-State Drive that is used to store data, files and applications, as well as to run computing devices. Solid state drives offer significant performance advantages over conventional hard disk drives (HDDs). HDD’s work by way of a mechanical drive head that must physically move to access locations on a rapidly-spinning magnetic disk. That has rotating magnetic parts, read- write heads etc. When the computer sends a request to retrieve data, the disk and arm must each move to the appropriate location for the data to be collected and sent to the CPU for processing. SSD’s, on the other hand, have no moving parts. An SSD is actually just a thin wedge of NAND flash memory - exactly same as the one that is there in your USB drive, but rather than being encased in a thin stick, SSD is put inside a shell or enclosure of 2.5 inches along with a SATA interface for enhanced performance levels.



The major components inside an SSD are:

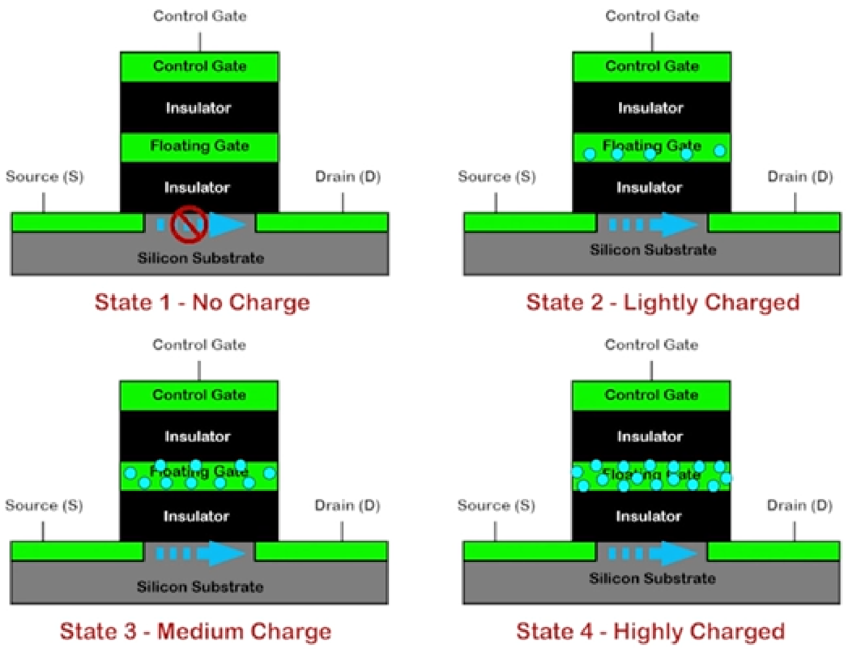
Outer Shell:

- The outer shell could be of metal or plastic and it helps in absorbing most of the heat from inside the flash memory.

- Although, SSDs don't contain any moving parts, they give off very little heat and emit no noise. This particular feature is vital in increased durability of an SSD.
- An SSD can withstand 10X more vibration than an HDD and up to 1500G of shock (compared to less than 70Gs for a typical HDD).
- SSDs exceed expectations in handling shock, vibration, and temperature extremes as well.

NAND FLASH:

Solid-state drives are called that specifically because they don't rely on moving parts or spinning disks. Instead, data is saved to a pool of NAND flash. NAND itself is made up of what are called floating gate transistors. Unlike the transistor designs used in DRAM, which must be refreshed multiple times per second, NAND flash is designed to retain its charge state even when not powered up. This makes NAND a type of non-volatile memory.



The diagram above shows a simple flash cell design. In NAND cell, the data are stored as charged state, Electrons are stored in the floating gate, which then reads as charged "0" or not-charged "1." Yes, in NAND flash, a 0 means data is stored in a cell — it's the opposite of how we typically think of a zero or one. NAND flash is organized in a grid. The entire grid layout is referred to as a block, while the individual rows that make up the grid are called a page. Common page sizes are 2K, 4K, 8K, or 16K, with 128 to 256 pages per block. Block size therefore typically varies between 256KB and 4MB.

One advantage of this system should be immediately obvious. Because SSDs have no moving parts, they can operate at speeds far above those of a typical HDD. The following chart shows the access latency for typical storage mediums given in microseconds.

	SLC	MLC	TLC	HDD	RAM
P/E cycles	100k	10k	5k	*	*
Bits per cell	1	2	3	*	*
Seek latency (μs)	*	*	*	9000	*
Read latency (μs)	25	50	100	2000-7000	0.04-0.1
Write latency (μs)	250	900	1500	2000-7000	0.04-0.1
Erase latency (μs)	1500	3000	5000	*	*
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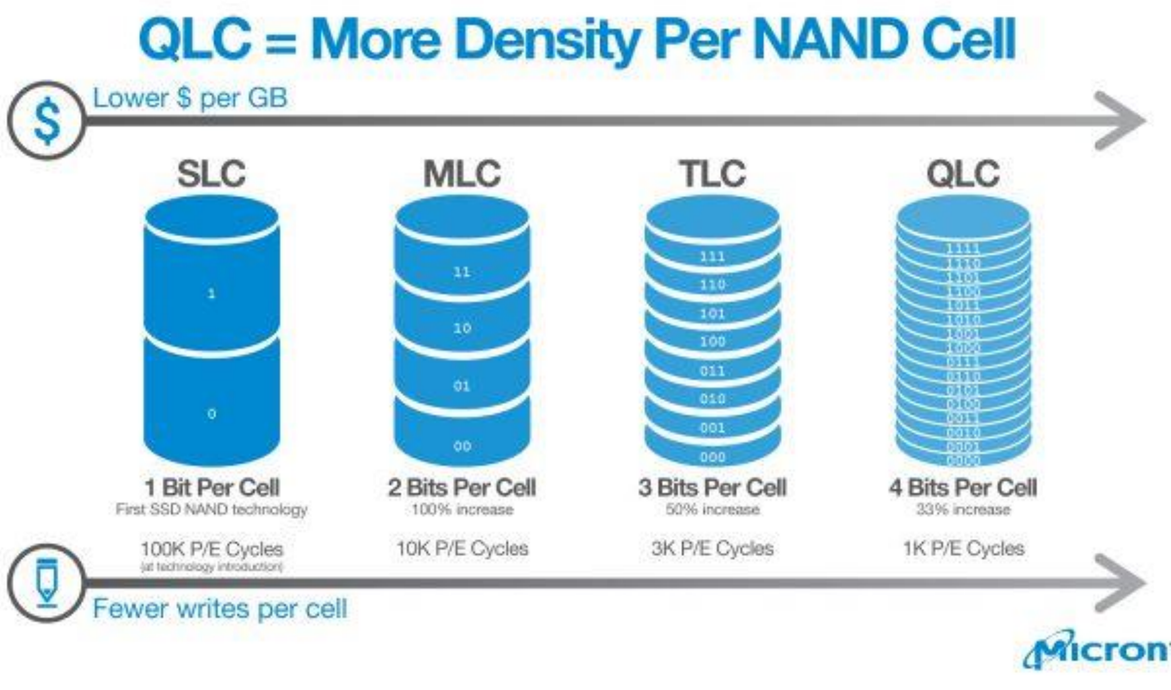
Image by CodeCapsule

NAND is nowhere near as fast as main memory, but it's multiple orders of magnitude faster than a hard drive. While write latencies are significantly slower for NAND flash than read latencies, they still outstrip traditional spinning media. How to understand SLC, MLC and TLC flash? To be Simple, the data in NAND flash is stored in each storage cell. SLC, MLC, and TLC are different bits of storage.

The difference between single-tier and multi-tier storage is the number of "bits" each NAND storage cell can store at a time. SLC (single-level Cell) stores only 1bit of data per Cell, while MLC (multi-level Cell) stores 2 bits and TLC (Trinary-Level) stores 3 bits. A storage cell stored the more bits at a time and will has more capacity, which can save the cost of flash memory and increase NAND production. However, the state is difficult to discern when adding more data to each cell. In the same time, reliability, durability and performance will reduce.

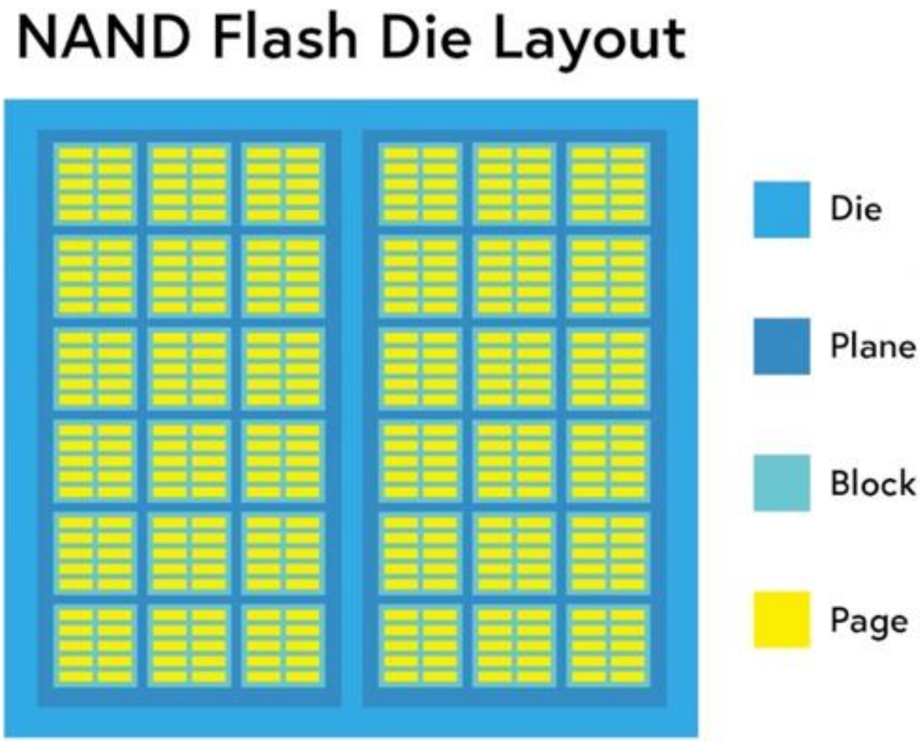
There are two things to notice in the above chart. First, note how adding more bits per cell of NAND has a significant impact on the memory's performance. It's worse for writes as opposed to reads — typical triple-level-cell (TLC) latency is 4x worse compared with single-level cell (SLC) NAND for reads, but 6x worse for writes. Erase latencies are also significantly impacted. The impact isn't proportional, either — TLC NAND is nearly twice as slow as MLC NAND, despite holding just 50% more data (three bits per cell, instead of two). This is also true for QLC drives, which store even more bits at varying voltage levels within the same cell.



The reason TLC NAND is slower than MLC or SLC has to do with how data moves in and out of the NAND cell. With SLC NAND, the controller only needs to know if the bit is a 0 or a 1. With MLC NAND, the cell may have four values — 00, 01, 10, or 11. With TLC NAND, the cell can have eight values, and QLC has 16. Reading the proper value out of the cell requires the memory controller to use a precise voltage to ascertain whether any particular cell is charged. But the think I like to mention that, in most of the SSD, there are some SLC cells that manufacturer provide with, embedded on the chip to perform faster processing to some level.

Internal Structure of NAND Flash

This is a figure of single die.



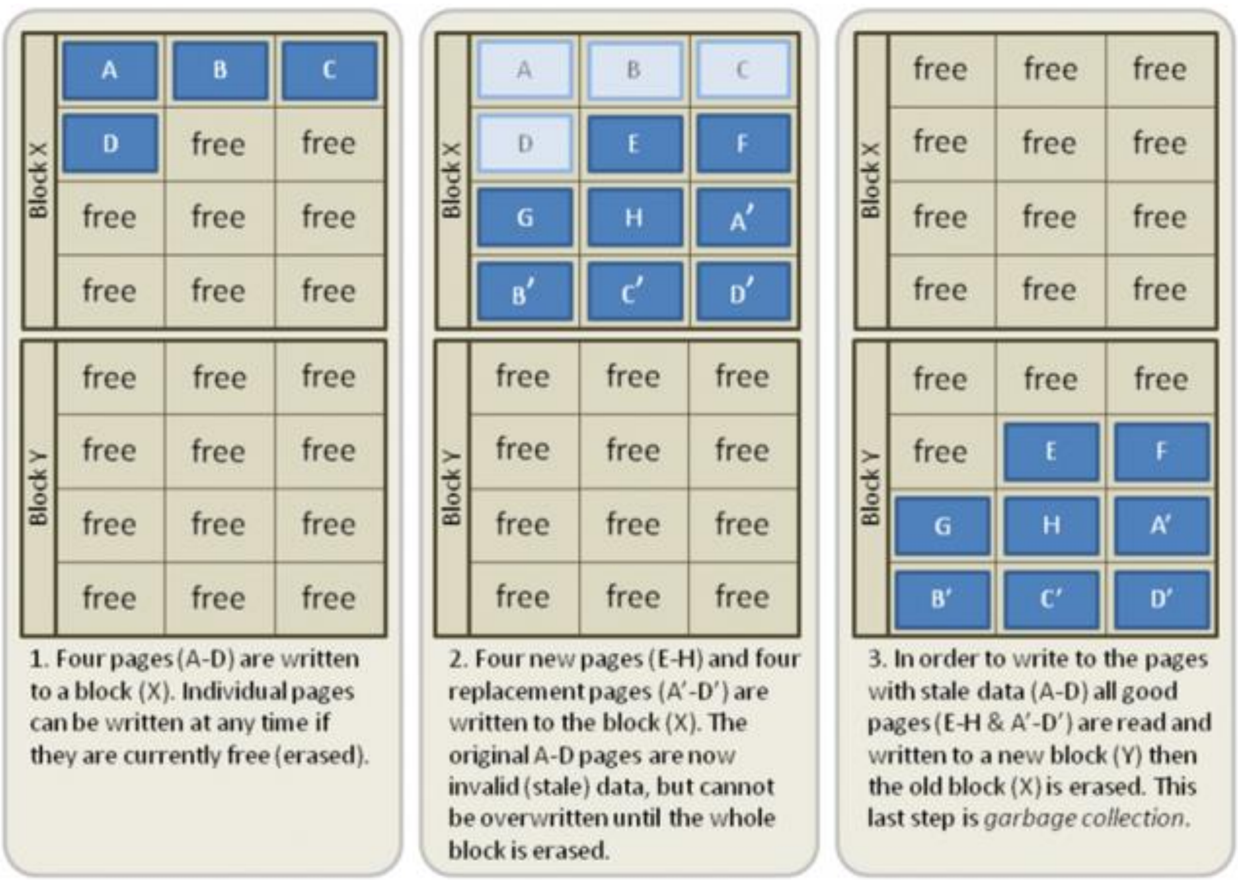
The die is marked as blue color here. There are multiple dies in a single NAND flash chip. Die is the smallest stage where a single command or instruction can be executed independently. In a single die, there may be one or two planes. The planes are colored as deep blue In this figure. The planes can run a single process concurrently or you can say run a single process into multiple planes at a time. In planes, there are multiple blocks, here blocks are colored as paste. In this block level, data erase operation is performed. In each single block, there are multiple pages there, in this figure, they are colored as yellow. Data write operation is performed at page level. Remember one thing, data erase operation is done at block level.

Reads, Writes, and Erasure

One of the functional limitations of SSDs is while they can read and write data very quickly *to an empty drive*, overwriting data is much slower. This is because while SSDs read data at the page level (meaning from individual rows within the NAND memory grid) and can write at the page level, assuming surrounding cells are empty, they can only erase data at the block level. This is because the act of erasing NAND flash requires a high amount of voltage. While you can theoretically erase NAND at the page level, the amount of voltage required stresses the individual cells around the cells that are being re-written. Erasing data at the block level helps mitigate this problem.

The only way for an SSD to update an existing page is to copy the contents of the entire block into memory, erase the block, and then write the contents of the old block + the updated page. If the drive is full and there are no empty pages available, the SSD must first scan for blocks that are marked for deletion but that haven't been deleted yet, erase them, and then write the data to the now-erased page. This is why SSDs can become slower as they age — a mostly-empty drive is full of blocks that can be written immediately, a mostly-full drive is more likely to be forced through the entire program/erase sequence.

If you've used SSDs, you've likely heard of something called **"garbage collection."** Garbage collection is a background process that allows a drive to mitigate the performance impact of the program/erase cycle by performing certain tasks in the background. The following image steps through the garbage collection process.



1. Four pages (A-D) are written to a block (X). Individual pages can be written at any time if they are currently free (erased).

2. Four new pages (E-H) and four replacement pages (A′-D′) are written to the block (X). The original A-D pages are now invalid (stale) data, but cannot be overwritten until the whole block is erased.

3. In order to write to the pages with stale data (A-D) all good pages (E-H & A′-D′) are read and written to a new block (Y) then the old block (X) is erased. This last step is *garbage collection*.

Image courtesy of Wikipedia

The next concept I want to discuss is TRIM. When you delete a file from Windows on a typical hard drive, the file isn't deleted immediately. Instead, the operating system tells the hard drive it can overwrite the physical area of the disk where that data was stored the next time it needs to perform a write. This is why it's possible to undelete files (and why deleting files in Windows doesn't typically clear much physical disk space until you empty the recycling bin). With a traditional HDD, the OS doesn't need to pay attention to where data is being written or what the relative state of the blocks or pages is. With an SSD, this matter. So, what trim command actually does, when we give modify command, trim will mark some pages which are outdated for erased, and will perform the operation later.

The **TRIM command** allows the operating system to tell the SSD it can skip rewriting certain data the next time it performs a block erase. This lowers the total amount of data the drive writes and increases SSD longevity. Both reads and writes damage NAND flash, but writes do far more damage than reads. Fortunately, block-level longevity has not proven to be an issue in modern NAND flash. More data on SSD longevity, courtesy of the Tech Report, can be found here.

The last two concepts we want to talk about are **wear leveling and write amplification**. Because SSDs write data to pages but erase data in blocks, the amount of data being written to the drive is always larger than the actual update. If you make a change to a 4KB file, for example, the entire block that 4K file sits within must be updated and rewritten. Depending on the number of pages per block and the size of the pages, you might end up writing 4MB worth of data to update a 4KB file. Wear leveling is an algorithm that perform a special task that is to find out the pages where there is no such page that are marked for erase or outdated. So, they find out a fresh block of memory, where they don't need to do any erase, rather than they can write the data easily. When, there will be no such fresh storage, then it will again search the outdated pages or pages which were marked for erase, and update them. So, we can easily understand, an SSD performs well when it has been recently bought and almost fresh. But when it is going to be filled up, the blocks are wearing out day by day, then SSD takes more time than previous to perform necessary operation and gets slower to some comparatively. Here, wear leveling helps them to find out fresh blocks and pages.

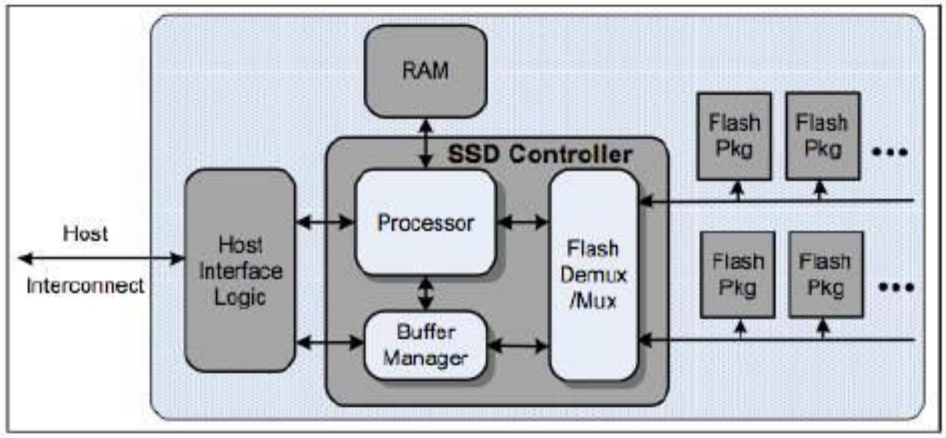
Wear- leveling

Wear-leveling data (Wear leveling is a process to distribute write/erase cycles evenly among all flash blocks of the SSD to prevent data from becoming unreliable and a particular block from wearing out) is also stored on the cache for some time during the running of the drive. **Wear leveling** refers to the practice of ensuring certain NAND blocks aren't written and erased more often than others. While wear leveling increases a drive's life expectancy and endurance by writing to the NAND equally, it can actually increase write amplification. In other to distribute writes evenly across the disk, it's sometimes necessary to program and erase blocks even though their contents haven't actually changed. A good wear leveling algorithm seeks to balance these impacts. This is a figure of wear leveling. In SSD, SSD controller operate multiple FLASH particles in parallel through several channels. In first figure it has written data on a single page of 4kb within a block. But when it wants to write data of 16kb, it does not write again pages of the same block, rather it distributes data to multiple pages of multiple blocks. That's why a single block is not weared out so quickly. This happens because of wear leveling process.

Garbage collection reduces the impact of write amplification, as does the TRIM command. Keeping a significant chunk of the drive free and/or manufacturer over-provisioning can also reduce the impact of write amplification. We know, while writing, to write a 4 KB file, an entire block of 4Mb has to written or replaced. So, all the blocks of NAND chip get weared out so quickly. To solve this case, In SSD, there are given some extra storage, which we cannot use physical for storage operation, rather it is used by the OS to reduce the overhead of write amplification. This method is called **over-provisioning.**

The SSD Controller

The controller of SSD is an embedded microchip (such as CPU in computer) with the function of issuing all operation requests ranging from reading and writing data to collecting garbage and depletion equalization algorithm to ensure the speed and cleanliness of SSD. So, the controller is the brain center of SSD. There are major controllers available today such as Marvell, SandForce, Samsung, Indilinx. For example, Marvell is powerful in all directions and the Marvell 88ss9187/89/90 controller is used on the SSD of the Plextone, SanDisk, Crucial and other brands.



SSD Logic Components

A typical SSD controller

NAND flash in an SSD is typically connected to the controller through a series of parallel memory channels, you can think of the drive controller as performing some of the same load-balancing work as a high-end storage array —all operations like wear leveling, garbage collection, and SLC cache management all have parallels in the big iron world.

Some drives also use data compression algorithms to reduce the total number of writes and improve the drive's lifespan. The SSD controller handles error correction, and the algorithms that control for single-bit errors have become increasingly complex as time has passed.

In Some SSD, there is DRAM

A bit of DRAM is included in every SSD for the process of buffering.

Similar to hard drive's cache, data is stored on it for some time temporarily before it is being written to the device.

It increases SSD performance to some level.

Advantages:

- SSDs are More Durable Solid-State Drives feature a non-mechanical design of NAND flash mounted on circuit boards, and are shock resistant up to 1500g/0.5ms. Hard Drives consist of various moving parts making them susceptible to shock and damage.

- SSDs are Faster SSDs can have 100 times greater performance, almost instantaneous data access, quicker boot ups, faster file transfers, and an overall snappier computing experience than hard drives. HDDs can only access the data faster the closer it is from the read write heads, while all parts of the SSD can be accessed at once. Features
- SSDs Consume Less Power SSDs use significantly less power at peak load than hard drives, less than 2W vs. 6W for an HDD. Their energy efficiency can deliver longer battery life in notebooks, less power strain on system, and a cooler computing environment. SSDs are Lighter Flash-based SSDs weigh considerably less than hard drives – only 77g vs. 752.5g for HDDs. SSDs won't weigh down your notebook when you're on the go or your desktop when rearranging your office!
- SSDs are Cooler As an energy-efficient storage upgrade for your desktop or laptop, SSDs require very little power to operate that translates into significantly less heat output by your system.
- SSDs are Quieter With no moving parts, SSDs run at near silent operation and never disturb your computing experience during gaming or movies, unlike loud, whirring hard disc drives.

Disadvantages:

The only single disadvantage of SSDs is that they are quite expensive. But there’s a silver lining
to it- prices of SSDs are decreasing rapidly. Moreover, with an increase in SSD adoption rates, prices are sure to fall further.