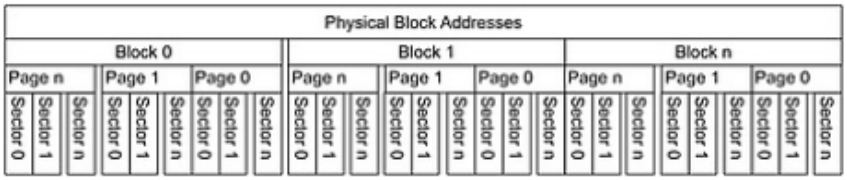
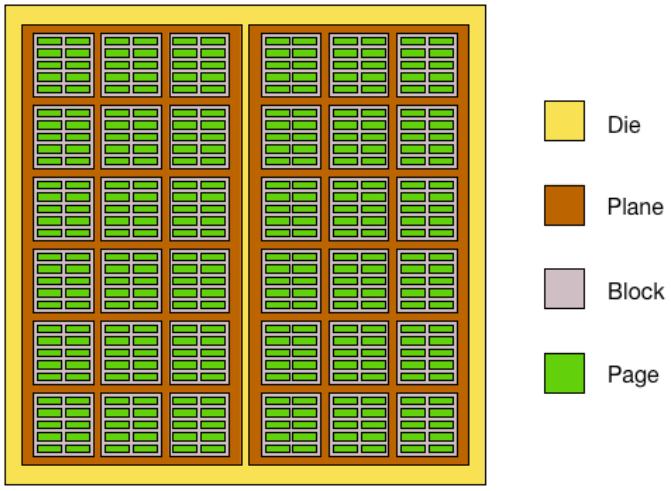
1 Flash-Based SSDs

Vocabularies

1. **Flash Solid-State Storage**
   - Is a type of non-volatile computer storage that stores and retrieves digital information using only electronic circuits, without any involvement of moving mechanical parts
2. **NAND-Based Flash**
   - Is an electronic non-volatile computer memory storage medium using NAND-gate that can be electrically erased and reprogrammed.
3. **Flash Page**
   - Is the smallest unit that can be programmed into flash
4. **Flash Block**
   - Is a group of pages and the smallest unit that can be erased.

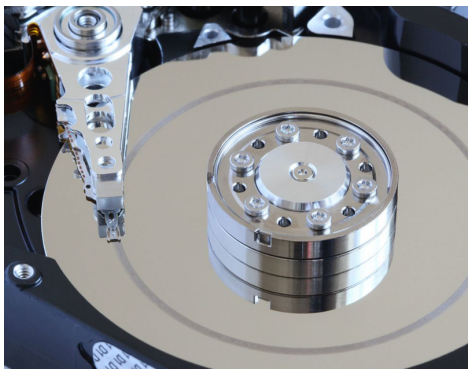




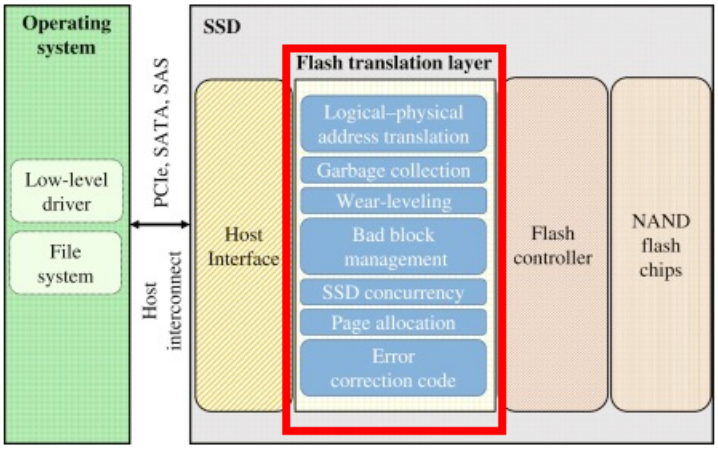
5. **Wear Out**

- Is similar to going past **expiration date**
- Means it has exceeded their endurance rating

6. **Single-Level Cell**
   - Is a type of cell in solid-state storage that stores one bit of data per transister (0 or 1)
7. **Multi-Level Cell**
   - Is a type of cell in solid-state storage that stores two bits of data (i.e 00, 01, 10, 11) per cell using two different levels of charge
8. **Triple-Level Cell**
   - Is a type of cell in solid-state storage that stores three bits of data per cell (i.e 000, 001, 010, 011, 100, 101, 110, 111)
9. **Bank / Plane**
   - Is a group of large number of cells
10. **Head Crash**
    - Is a condition where the drive head makes contact with the recording surface



11. **Disturbance**
    - Is also known as **read disturbance** or **program disturbance**
    - Is a condition where accesing a bit in a page causes some bits to get flipped in neighboring pages
12. **Flash Transition Layer**
    - Is an intermediate system made up software and hardware that manages SSD operations



13. **Wear Leveling**

    - Is a technique for prolonging the service life of some kinds of erasable computer storage media, such as flash memory, which is used in solid-state drives (SSDs)

14. **Direct Mapped**

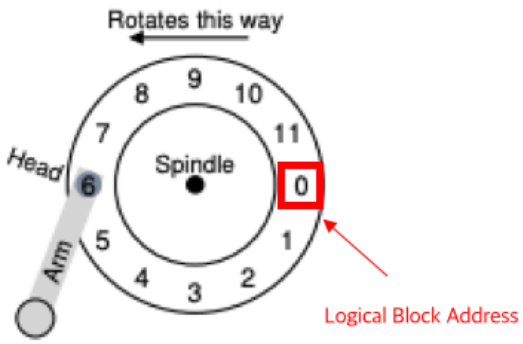
    - Is a simplest organization of an **Flash Transition Layer** that maps read of logical page N directly to read of playsical page N.

15. **Logging**

    - Is a concept in **log-structured file system** that buffer all writes (data + metadata) using an in-memory segment; once the segment is full, write the segment to a log

16. **Logical Block Address**

    - Is a common scheme used for specifying the location of blocks of data stored on computer storage devices, generally in secondary storage system



17. **In-Memory Mapping Table**

    - Is a table inside the memory of the secondary storage device (is persistent in some form) that stores the physical address of each logical block in the system

18. **Garbage Block**

    - Is also called **Dead Block**
    - Is old version of block in secondary storage, such as solid state drive

19. **Garbage Collection**

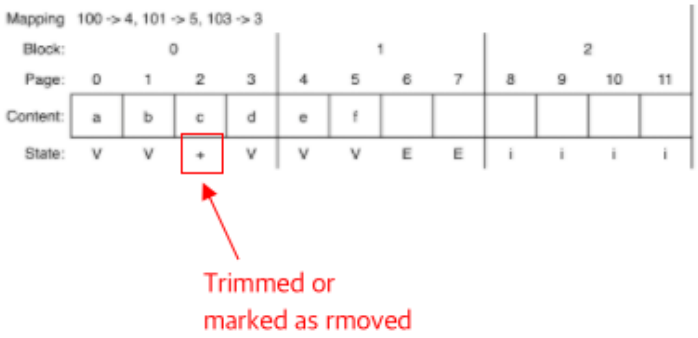
    - Is the process of finding garbage blocks and reclaiming them for future use

20. **Cache Flush**

    - Is the process of clearing out sections of memory to ensure writes have actually been persisted in solid state drive

21. **Trim**

    - Is an operation that takes an address (and possibly a length) and informs the device that the block(s) specified by the address (and length) have been deleted



22. **Overprovision**

- Is an extra amount of flash space used to reduce the cost of **garbage collection**, increase the logitivity of flash drive, and prevents the device from slowing down

23. **Page-Level FTL**

- Is an intermediate system made of software and hardware that manages SSD operations at page-level.
  - It does not write a full block
  - Only writes the necessary page(s) of data along with the FTL metadata that must be written to track of the new position of the data

24. **Hybrid Mapping**

- Is a mapping technique used in **Flash Transition Layer** that utilizes both block-based mapping and page-based mapping to enable flexible writing but also reduce mapping costs

25. **Log Blocks**
    - Are blocks in solid state storage where contents are erased and all writes are directed
26. **Switch Merge**
    - This will be revisited when reading related section
27. **Partial Merge**
    - This will be revisited when reading related section
28. **Full Merge**
    - This will be revisited when reading related section

1.1 Flash-Based SSDs

- Has two interesting problems to overcome
  1. To write a small chunk (called **flash page**), a bigger chunk (**flash block**) must be erased first
  2. Writing too often would cause a page to **wear out**

1.2 Storing a Single Bit

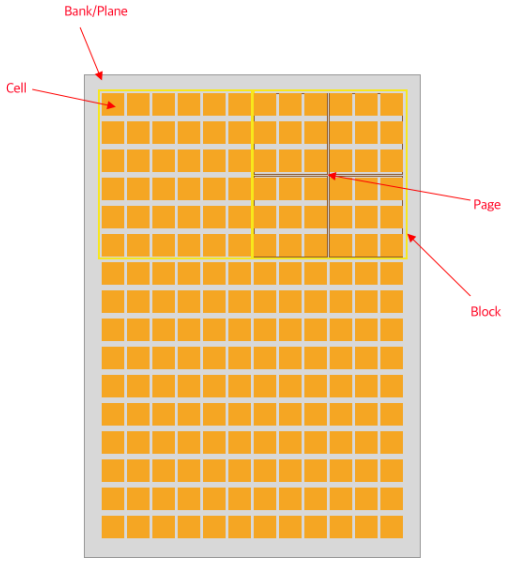
- **Single-level cell** → 1 bit per cell
- **Multi-level cell** → 2 bits per cell
- **Triple-level cell** → 3 bits per cell
- **Single-level cell** has higher performance and are more expensive
  - More 촘촘하다
- How SLC, MLC, TLC works → Physics!!

1.3 From Bits to Banks / Planes

Question Is conent in a flash chip a cell? How many bits can be stored per content?

Question I should ask clarification from professor about why Samsung and other tech giants are producing higher level cells if SLC is better in performance

- In each plane/bank, there are large number of blocks
- In each block, there are a large number of pages



1.4 Basic Flash Operations

- **Read (a page):**
  - Is fast (10 μs)
  - Can access any location uniformly
    - flash-based SSD is a **random access device**
- **Erase (a block):**
  - Is most expensive
  - **block** must be erased before erasing a **page**

- **Program (a page):**
  - Is used to change some of the 1's within a page to 0's and vice versa
  - Is less expensive then erasing a block
  - Is more costly than reading a page

1.5 From Raw Flash to Flash-Based SSDs

1.6 FTL Organization: A Bad Approach

1.7 A Log Structured FTL

1.8 Garbage Collection

1.9 Mapping Table Size

1.10 Hybrid Mapping

1.11 Wear Leveling

1.12 SSD Performance And Cost