Database System Concept (CSE 3103)

Lecture 09-Day 01

Nazmus Sakib, Assistant Professor, Dept. of CSE, AUST

Classification of Physical Storage Media

- Speed with which data can be accessed
- Cost per unit of data
- Reliability
  - data loss on power failure or system crash
  - physical failure of the storage device
- Can differentiate storage into:
  - **volatile storage:** loses contents when power is switched off
  - **non-volatile storage:**
    - Contents persist even when power is switched off.
    - Includes secondary and tertiary storage, as well as batter-backed up main-memory.

Physical Storage Media

- **Cache** – fastest and most costly form of storage; volatile; managed by the computer system hardware.

- **Main memory**:
  - fast access (10s to 100s of nanoseconds; 1 nanosecond = 10^{-9} seconds)
  - generally too small (or too expensive) to store the entire database
    - capacities of up to a few Gigabytes widely used currently
    - Capacities have gone up and per-byte costs have decreased steadily and rapidly (roughly factor of 2 every 2 to 3 years)
  - **Volatile** — contents of main memory are usually lost if a power failure or system crash occurs.

Physical Storage Media (Cont.)

- **Flash memory**
  - Data survives power failure
  - Data can be written at a location only once, but location can be erased and written to again
    - Can support only a limited number (10K – 1M) of write/erase cycles.
    - Erasing of memory has to be done to an entire bank of memory
  - Reads are roughly as fast as main memory
  - But writes are slow (few microseconds), erase is slower
 - Widely used in embedded devices such as digital cameras, phones, and USB keys

Storage Hierarchy
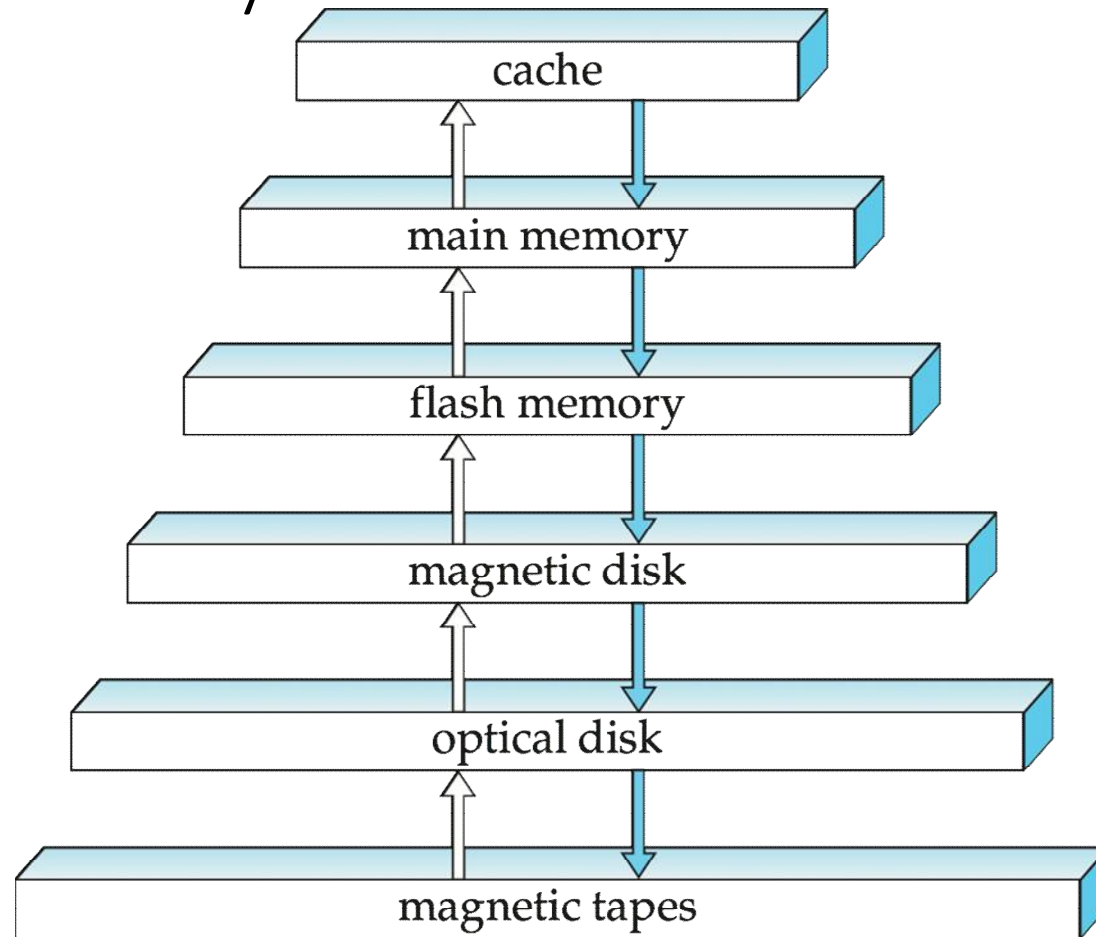
Storage Hierarchy (Cont.)

- **primary storage:** Fastest media but volatile (cache, main memory).
- **secondary storage:** next level in hierarchy, non-volatile, moderately fast access time
  - also called **on-line storage**
  - E.g. flash memory, magnetic disks
- **tertiary storage:** lowest level in hierarchy, non-volatile, slow access time
  - also called **off-line storage**
  - E.g. magnetic tape, optical storage

Magnetic Hard Disk Mechanism
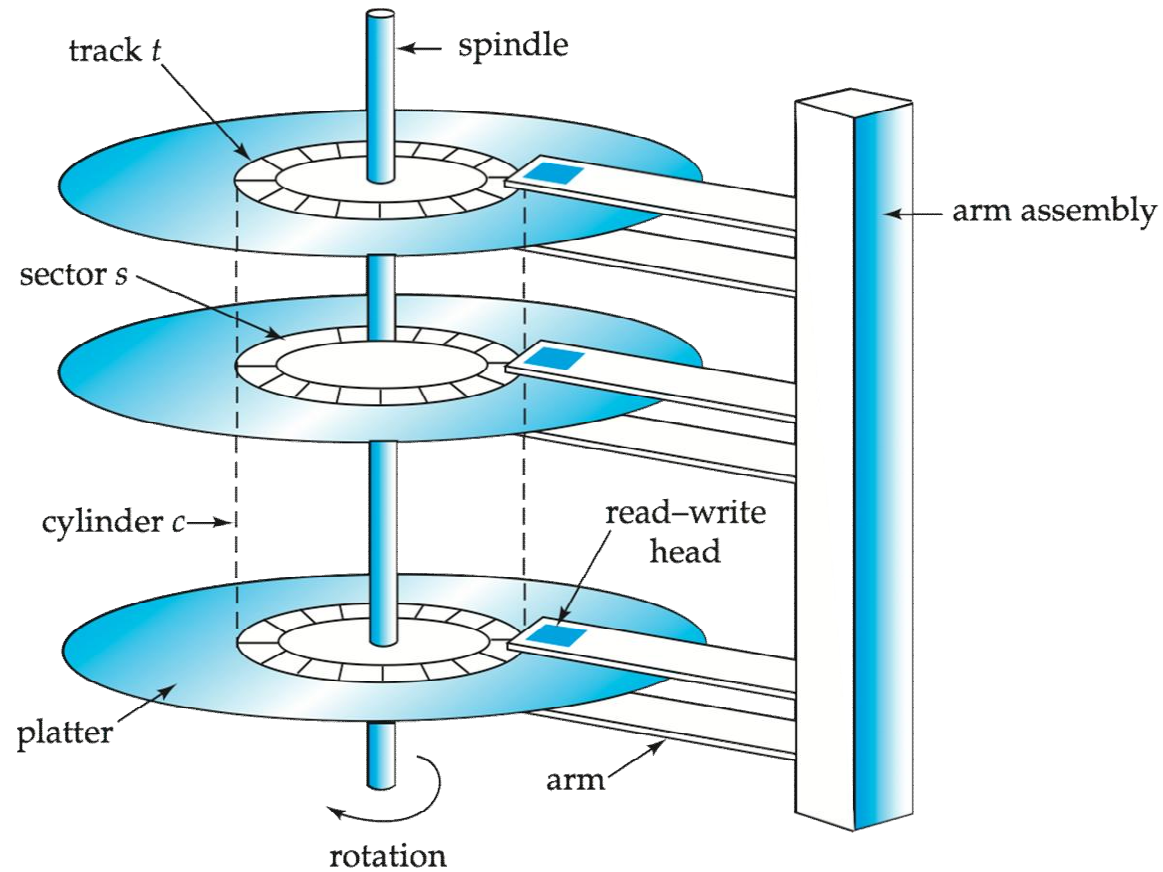
NOTE: Diagram is schematic, and simplifies the structure of actual disk drives

Magnetic Disks

- **Read-write head**
  - Positioned very close to the platter surface (almost touching it)
  - Reads or writes magnetically encoded information.
- Surface of platter divided into circular **tracks**
  - Over 50K-100K tracks per platter on typical hard disks
- Each track is divided into **sectors.**
  - A sector is the smallest unit of data that can be read or written.
  - Sector size typically 512 bytes
  - Typical sectors per track: 500 to 1000 (on inner tracks) to 1000 to 2000 (on outer tracks)
- To read/write a sector
  - disk arm swings to position head on right track
  - platter spins continually; data is read/written as sector passes under head
- Head-disk assemblies
  - multiple disk platters on a single spindle (1 to 5 usually)
  - one head per platter, mounted on a common arm.
- **Cylinder** i consists of ith track of all the platters

Magnetic Disks (Cont.)

- Earlier generation disks were susceptible to head-crashes
    - Surface of earlier generation disks had metal-oxide coatings which would disintegrate on head crash and damage all data on disk
    - Current generation disks are less susceptible to such disastrous failures, although individual sectors may get corrupted

- **Disk controller** – interfaces between the computer system and the disk drive hardware.
    - accepts high-level commands to read or write a sector
    - initiates actions such as moving the disk arm to the right track and actually reading or writing the data
    - Computes and attaches **checksums** to each sector to verify that data is read back correctly
        - If data is corrupted, with very high probability stored checksum won't match recomputed checksum
    - Ensures successful writing by reading back sector after writing it
    - Performs remapping of bad sectors

Disk Subsystem

- Disks usually connected directly to computer system

- In **Storage Area Networks (SAN)**, a large number of disks are connected by a high-speed network to a number of servers

- In **Network Attached Storage (NAS)** networked storage provides a file system interface using networked file system protocol, instead of providing a disk system interface

Flash Storage

- NOR flash vs NAND flash
- NAND flash
  - used widely for storage, since it is much cheaper than NOR flash
  - requires page-at-a-time read (page: 512 bytes to 4 KB)
  - transfer rate around 20 MB/sec
  - **solid state disks**: use multiple flash storage devices to provide higher transfer rate of 100 to 200 MB/sec
  - erase is very slow (1 to 2 millisecs)
    - erase block contains multiple pages
    - **remapp**ing of logical page addresses to physical page addresses avoids waiting for erase
      - **translation table** tracks mapping
        - also stored in a label field of flash page
      - remapping carried out by **flash translation layer**
    - after 100,000 to 1,000,000 erases, erase block becomes unreliable and cannot be used
      - **wear leveling**