Chapter 9: Peripheral Devices: Magnetic Disks

- Basic Disk Operation
- Performance Parameters and History of Improvement
- Example disks
- RAID (Redundant Arrays of Inexpensive Disks)
  - Improving Reliability
  - Improving Performance
Magnetic Disk Drives

- High density and non-volatile
  - Densities similar to semiconductor RAM on an inexpensive medium
  - No power required to retain stored information
- Motion of medium supplies power for sensing
- More random access than tape: direct access
  - Different platters selected electronically
  - Track on platter selected by head movement
  - Cyclic sequential access to data on a track
- Structured address of data on disk
  - Drive: Platter: Track: Sector: Byte
Multi-Platter Hard Disk Drive
Simplified View of Disk Track and Sector Organization

- An integral number of sectors are recorded around a track.
- A sector is the unit of data transfer to or from the disk.
Simplified View of Individual Bits Encoded on a Disk Track

- Inside tracks are shorter & thus have higher densities or fewer words
- All sectors contain the same number of bytes
  - Inner portions of a platter may have fewer sectors per track
- Small areas of the disk are magnetized in different directions
  - Change in magnetization direction is what is detected on read
Typical Hard Disk Sector Organization

- Serial bit stream has header, data, & error code
- Header synchronizes sector read and records sector address
- Data length is usually power of 2 bytes
- Error detection/correction code needed at end
Disk Formatting

- Disks are pre-formatted with track and sector address written in headers
- Disk surface defects may cause some sectors to be marked unusable for the software
The PC AT Block Address for Disk Access

- Head number determines platter surface
- Cylinder is track number for all heads
- Count sectors, up to a full track, can be accessed in one operation
The Disk Access Process

1. OS Communicates LBA to the disk interface, and issues a READ command.
2. Drive seeks to the correct track by moving heads to correct position, and enabling the appropriate head.
3. Sector data and ECC stream into buffer. ECC is done "on the fly."
4. When correct sector is found data is streamed into a buffer.
5. Drive communicates "data ready" to the OS
6. OS reads data byte by byte or by using DMA.
Static Disk Characteristics

- Areal density of bits on surface
  
  \[ \text{density} = \frac{1}{(\text{bit spacing} \times \text{track spacing})} \]

- Maximum density: density on innermost track

- Unformatted capacity: includes header and error control bits

- Formatted capacity:

\[
\text{capacity} = \frac{\text{bytes}}{\text{sector}} \times \frac{\text{sectors}}{\text{track}} \times \frac{\text{tracks}}{\text{surface}} \times \# \text{ of surfaces}
\]
Dynamic Disk Characteristics

- **Seek time**: time to move heads to cylinder
- **Track-to-track access**: time to adjacent track
- **Rotational latency**: time for correct sector to come under read/write head
- **Average access time**: seek time + rotational latency
- **Burst rate** (maximum transfer bandwidth)

burst rate = \( \frac{\text{revs}}{\text{sec}} \times \frac{\text{sectors}}{\text{rev}} \times \frac{\text{bytes}}{\text{sector}} \)
Improving Disk Reliability & Performance: RAID, Redundant Array of Inexpensive Disks

- Raid LEVEL 0: Speed improvement only, by "striping" data across several disks so they can be accessed in parallel.

- RAID Level 1: "Mirroring," writing the exact same data to two different disk drives. If one drive fails, the other can be used.

- RAID Level 2: Data is striped at the bit level across several disks with additional ECC bits to recover data if one drive fails.
Improving Disk Reliability & Performance: RAID, Redundant Array of Inexpensive Disks

- RAID Level 3: Striped as in level 0, but at the byte level, and ECC data is written to a separate drive.

- RAID Level 4: Same as level 3, but blocks are used instead of bytes, and data are written asynchronously. Often used in transaction-based systems, such as in airline reservation systems.

- RAID Level 5: Similar to level 4, but both data and ECC bits are both striped across 3 or more drives.

- RAID Level 6: Similar to level 5, but extra correction bits are present to permit recovery from multiple errors.