

# **CSE 120**

## **Principles of Operating Systems**

**Fall 2000**

**Lecture 12: Disk I/O**

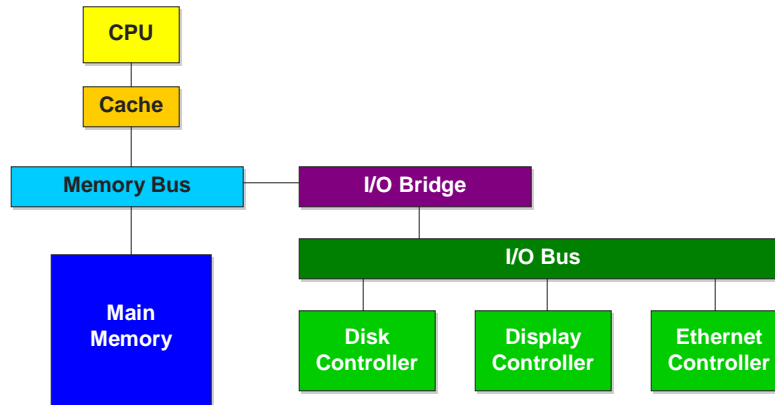
Geoffrey M. Voelker

## **Secondary Storage**

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- The next topic that we will cover is secondary storage
  - Disk I/O (today)
  - File systems (next time)

## I/O Diagram



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## Secondary Storage

- Secondary storage is usually:
  - Anything outside of "primary memory"
  - Anything that does not permit direct instruction execution or data fetch via machine load/store instructions
- Characteristics
  - It's large – hundreds of megabytes, gigabytes, terabytes
  - It's cheap – 70 GB disks cost \$1000
  - It's persistent – data survives loss of power
  - It's slow – milliseconds to access (why is a millisecond slow?)

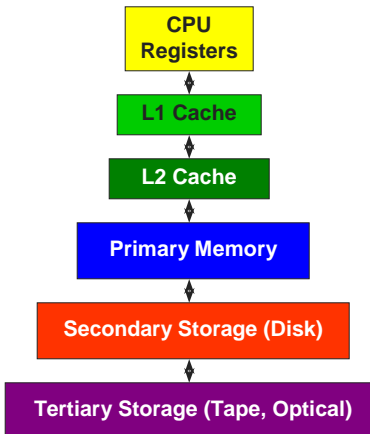
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# Memory Hierarchy

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- Each level acts as a cache of data for the level below

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# Secondary Storage Devices

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- Drums
  - ◆ Ancient history
- Magnetic disks
  - ◆ Fixed
  - ◆ Removable (floppy)
- Optical disks
  - ◆ Write-once, read-many (CDR)
  - ◆ Write-many, ready-many
  
- We're going to focus on the use of fixed (hard) magnetic disks for implementing secondary storage

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## Disks and the OS

- Disks are messy physical devices:
  - Errors, bad blocks, missed seeks, etc.
- The job of the OS is to hide this mess from higher level software
  - Low-level device control (initiate a disk read, etc.)
  - Higher-level abstractions (files, databases, etc.)
- The OS may provide different levels of disk access to different clients
  - Physical disk block (surface, cylinder, sector)
  - Disk logical block (disk block #)
  - File logical (file block, record, or byte #)

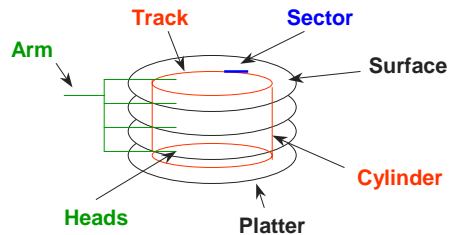
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## Physical Disk Structure

- Disk components
  - Platters
  - Surfaces
  - Tracks
  - Sectors
  - Cylinders
  - Arm
  - Heads



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## Disk Interaction

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- Specifying disk requests requires a lot of info:
  - ♦ Cylinder #, surface #, track #, sector #, transfer size...
- Older disks required the OS to specify all of this
  - ♦ The OS needed to know all disk parameters
- Modern disks are more complicated
  - ♦ Not all sectors are the same size, sectors are remapped, etc.
- The disk provides a higher-level interface (SCSI)
  - ♦ The disk exports its data as a logical array of blocks [0...N]
    - » It maps logical blocks to cylinder/surface/track/sector
  - ♦ Only need to specify the logical block # to read/write
  - ♦ But now the disk parameters are hidden from the OS

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## Disk Parameters (1999)

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- IBM Ultrastar 36XP drive
  - ♦ Form factor: 3.5"
  - ♦ Capacity: 36.4 GB
  - ♦ Rotation rate: 7,200 RPM
  - ♦ Platters: 10
  - ♦ Surfaces: 20
  - ♦ Sector size: 512-732 bytes
  - ♦ Cylinders: 11,494
  - ♦ Cache: 4MB
  - ♦ Transfer rate: 17.9 MB/s (inner) – 28.9 MB/s (outer)
  - ♦ Full seek: 14.5 ms
  - ♦ Head switch: 0.3 ms

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## Disk Performance

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- Disk request performance depends upon a number of steps
  - ♦ Seek – moving the disk arm to the correct cylinder
    - » Depends on how fast disk arm can move (changing very slowly)
  - ♦ Rotation – waiting for the sector to rotate under the head
    - » Depends on rotation rate of disk (increasing, but slowly)
  - ♦ Transfer – transferring data from surface into disk controller electronics, sending it back to the host
    - » Depends on density (increasing fast)
- When the OS uses the disk, it tries to minimize the cost of all of these steps
  - ♦ Particularly seeks and rotation

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## Disk Scheduling

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- Because seeks are so expensive (milliseconds!), the OS tries to schedule disk requests that are queued waiting for the disk
  - ♦ FCFS (do nothing)
    - » Reasonable when load is low
    - » Long waiting times for long request queues
  - ♦ SSTF (shortest seek time first)
    - » Minimize arm movement (seek time), maximize request rate
    - » Favors middle blocks
  - ♦ SCAN (elevator)
    - » Service requests in one direction until done, then reverse
  - ♦ C-SCAN
    - » Like SCAN, but only go in one direction (typewriter)

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## Disk Scheduling (2)

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- In general, unless there are request queues, disk scheduling does not have much impact
  - ◆ Important for servers, less so for PCs
- Modern disks often do the disk scheduling themselves
  - ◆ Disks know their layout better than OS, can optimize better
  - ◆ Ignores, undoes any scheduling done by OS

## Summary

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- I/O overview
- Memory hierarchy
- Secondary storage
  - ◆ Large, persistent, but **slow**
- Disks
  - ◆ Physical structure
  - ◆ Interface
  - ◆ Performance
  - ◆ Scheduling

## Next time...

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- Read Chapter 17 (skip 17.5, 17.8)