Hard Disk Drives

CS333
Spring 2020

Logistics

- Lab 1: Unix utilities, system calls, & C
  - Due Thursday
  - Anyone stuck?
  - Questions about C/system calls?
    - `` `man 2 read` ``

Last Class

- I/O Devices
    - Physical Interfaces
    - Device Drivers vs. Firmware
    - Polling vs. Interrupts
- Big Picture: Memory Hierarchy / Layers

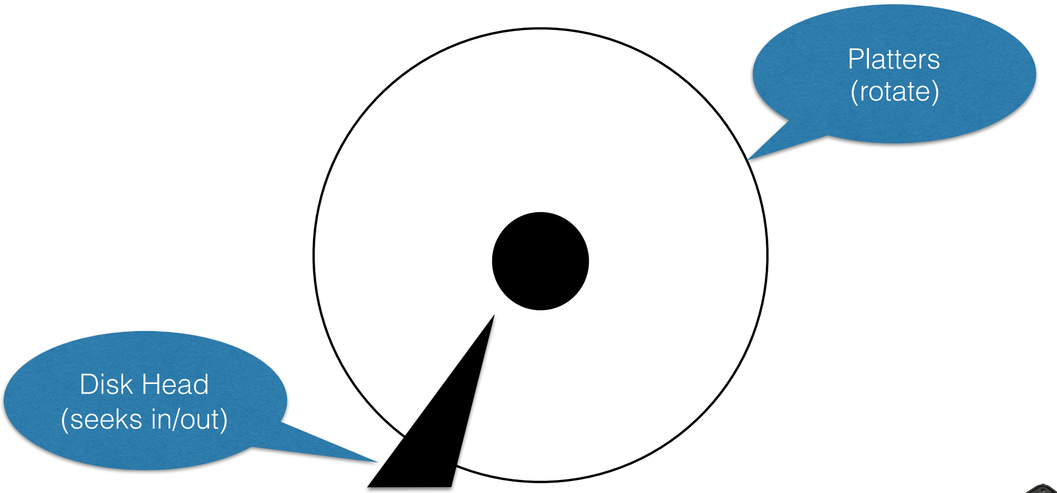
This Class

- HDD Guarantees
    - Performance & correctness
- Physical components and Geometry
    - Breaking down an I/O
- The role of caching
- Scheduling requests

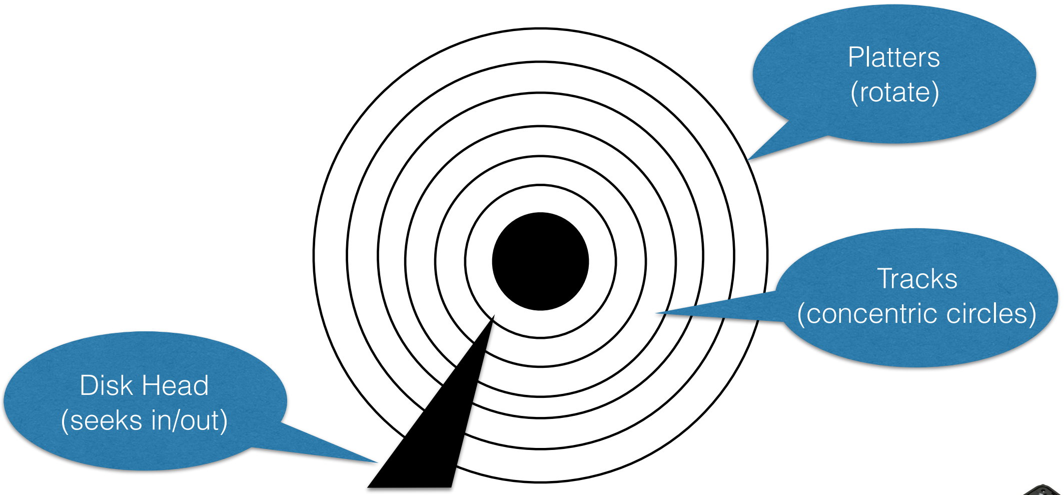
Hard Disk Drives (HDDs)

- High capacity, low cost
- Predictable performance
  - “Unwritten contract”: Tracks (LBAs) near each other are more efficient to access than tracks (LBAs) that are far away

HDDs



HDDs

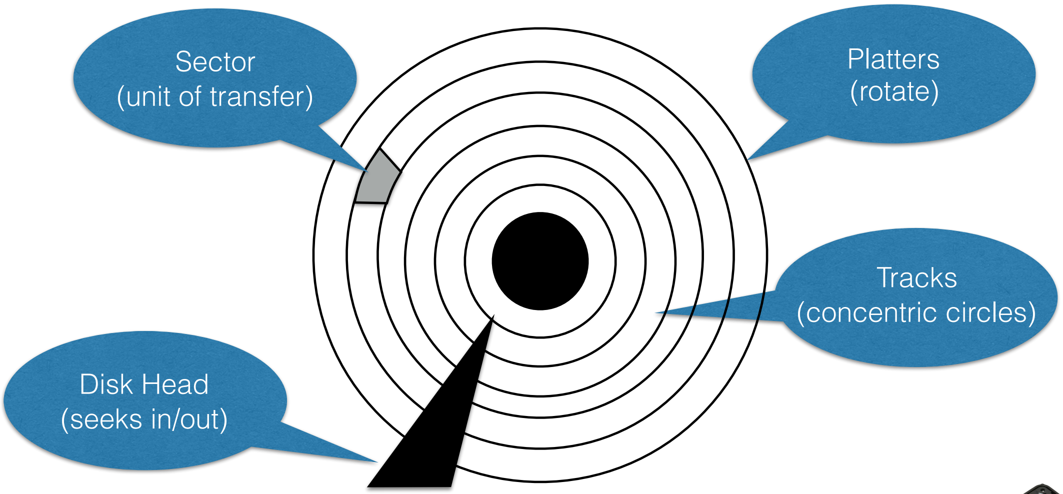


Platters
(rotate)

Tracks
(concentric circles)

Disk Head
(seeks in/out)

HDDs



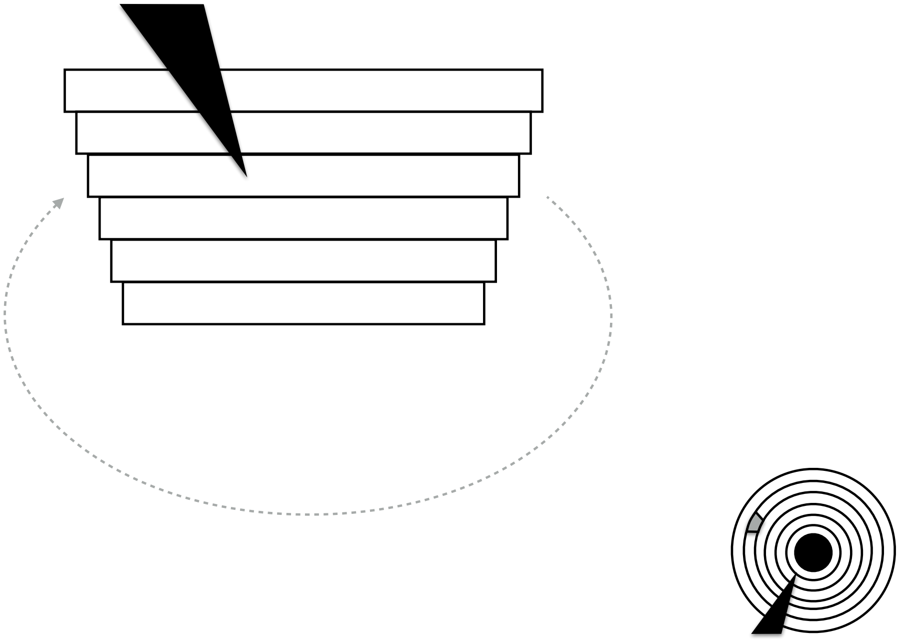
Sector
(unit of transfer)

Platters
(rotate)

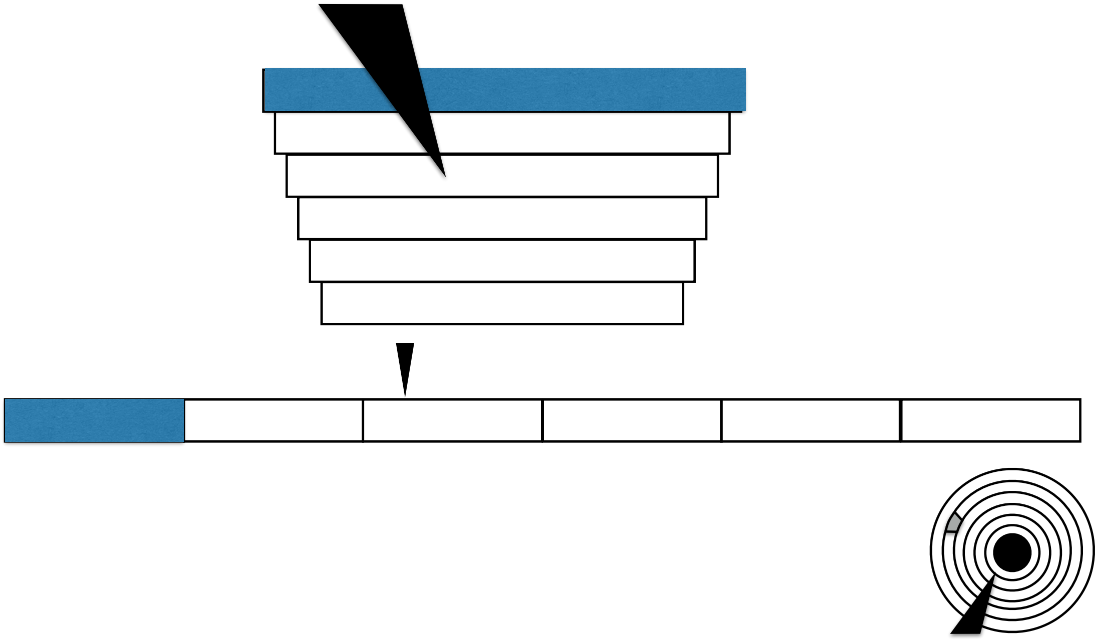
Tracks
(concentric circles)

Disk Head
(seeks in/out)

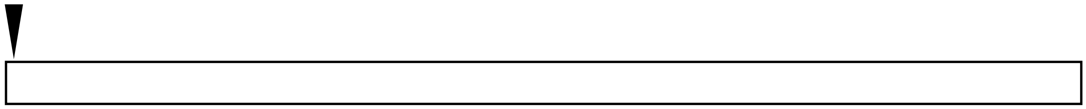
“Unwind” The Tracks



Seeking through the Linear Address Space

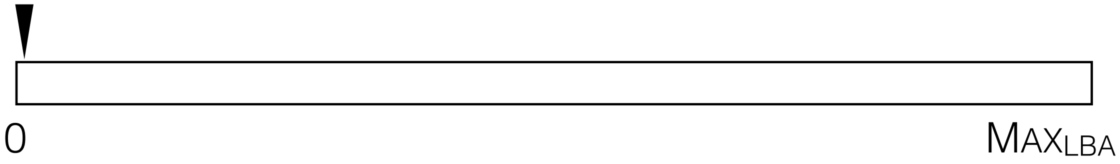


HDDs



HDDs

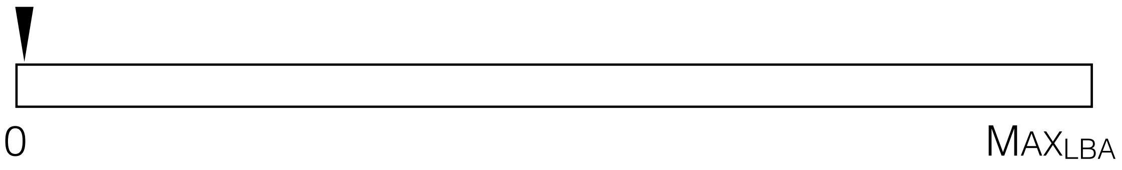
- Disks are addressed by **LBA**: [**0-MAX$_{LBA}$**)
- Transfer data in fixed-size units: “disk block”
  - “block interface” used for both reads and writes



Breaking Down an I/O

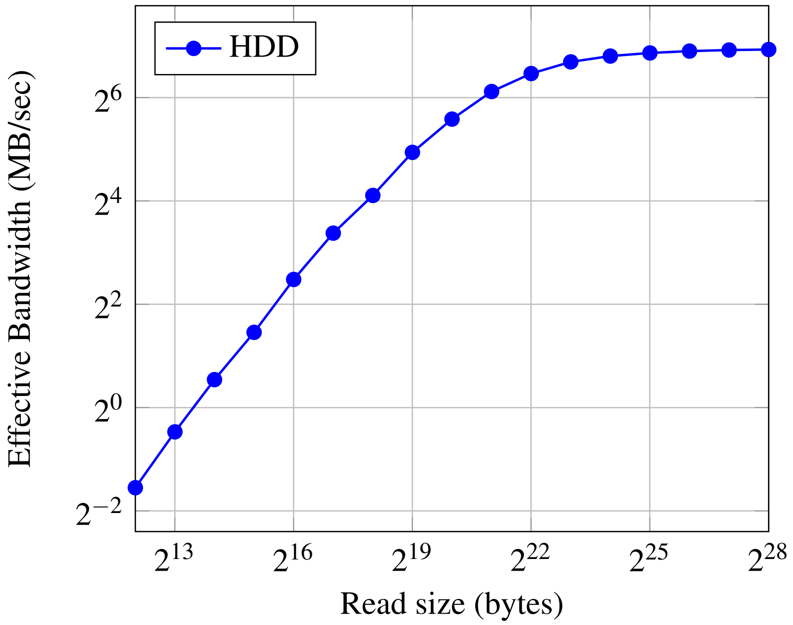
- Two costs to every operation:
  - **Setup:** Moving the disk head, rotating the platters
  - **Transfer:** Reading/writing while the disk rotates

Ex: `data <- read(10024, 10048)`



Performance Observations

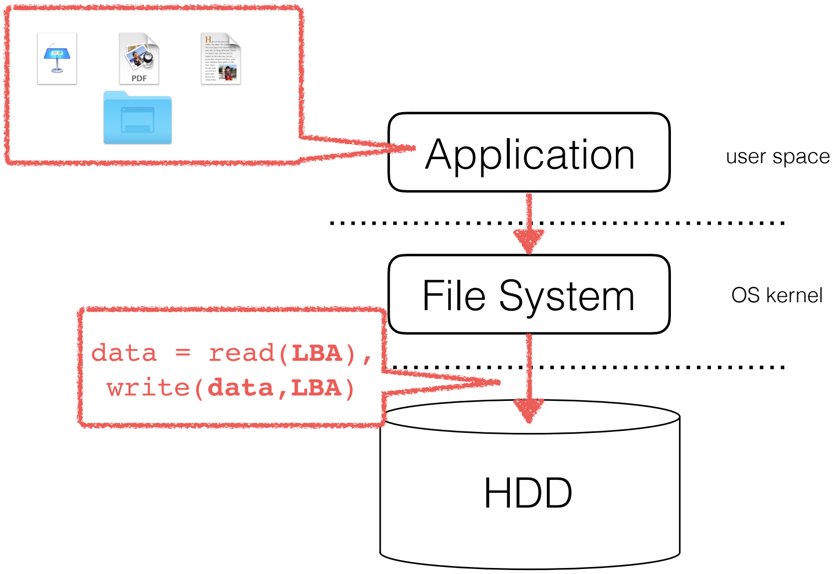
- **Setup** (placing the disk head) is expensive O(10 ms)
  - seeking to target track
  - Up to a full rotational delay to locate sector
- Once the disk head is in place, data **transfer** is quite fast O(100 MiB/s)



To maximize performance, minimize seeks and maximize the ratio of time spent transferring.

Why Does This Matter?

Simplified Storage Stack

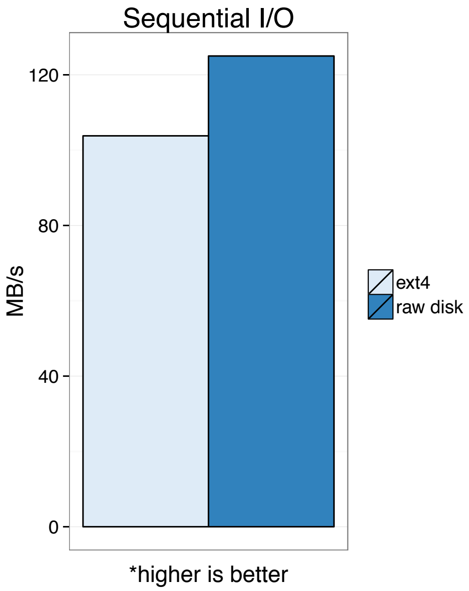


```
data = read(LBA),
 write(data,LBA)
```

Good Cases

Sequential I/O

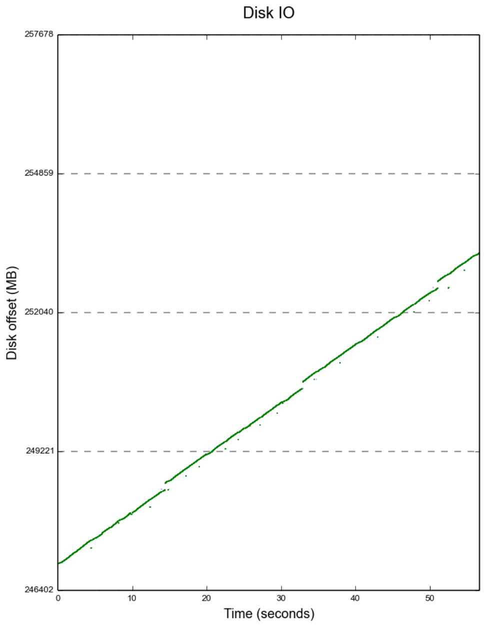
- Write a large file to an empty file system.
- Read an existing file in order



*higher is better

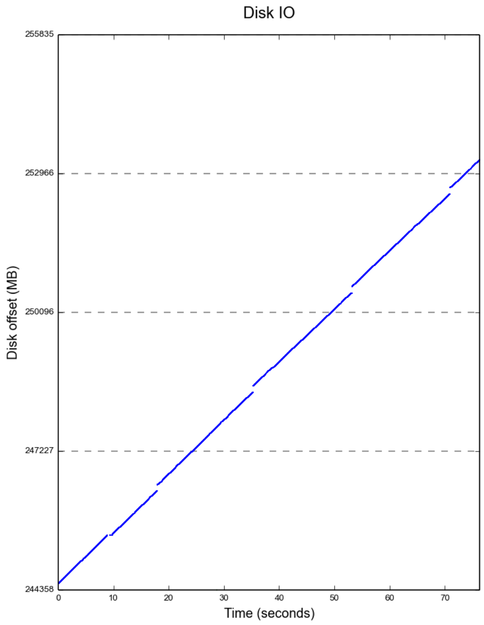
Good Cases

- Write a large file to an empty file system.



Good Cases

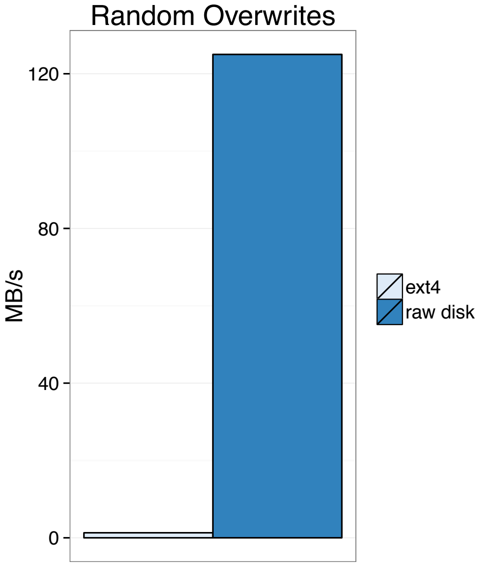
- Read an existing file in order



Bad Cases

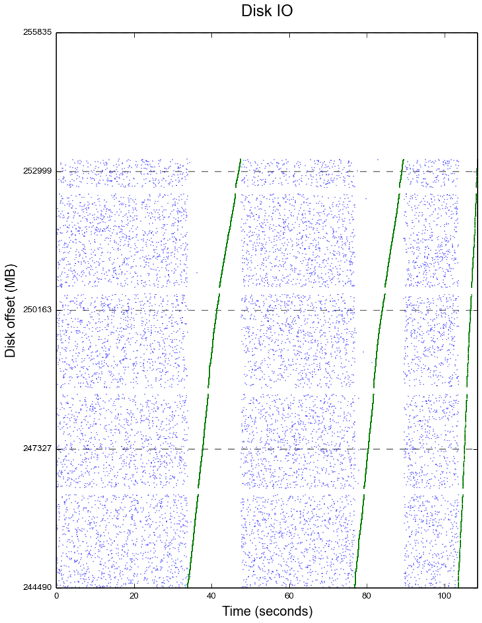
Random I/O

- Randomly update an existing file
- Randomly reading an existing file
- Reading data from many independent files



*higher is better

Bad Cases



- Randomly update an existing file

Takeaway:
Locality Matters

Disk Geometry

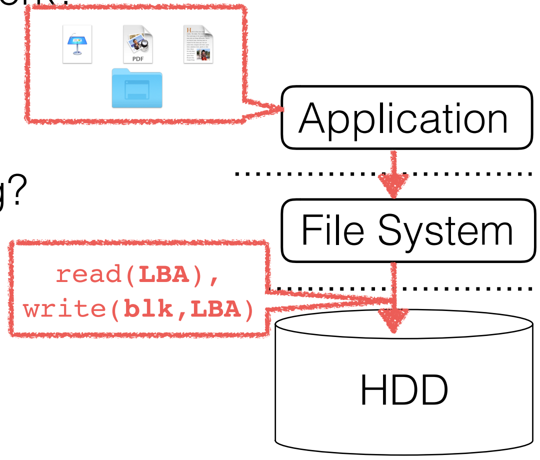
- High level idea gets us most of the way, but disk geometry adds complications (opportunities?)
  - Multi-zoned disks
  - Track Skew

Takeaway:

Sometimes it pays to "open the black box". Abstractions are important, but they hide important details.

Scheduling

- High Level Question: You are given a series of requests that must be completed (LBAs), what order do you perform the work?
    - Obstacles?
    - Who does the scheduling?



Scheduling

- Greedy: **Shortest job first**
  - Shortest-seek-time-first (SSTF)
  - Nearest-block-first (NBF)
- Problems?
  - **Starvation**: one (or more) requests never receive access to the resources they need to complete

Scheduling

- Elevator!

Any Questions?

HDD Handout

(15-20 minutes)

Activity: HDD Modeling

https://github.com/williams-cs/cs333-class