

# COSC 511: Computer Architecture

## Data Storage (Part 3)

Week 12



Last Week

A dark, atmospheric illustration of a large, gothic-style house surrounded by bare trees and mist. The house has multiple towers and spires, appearing dimly lit or obscured by fog. Bare trees stand in the foreground and background, their branches silhouetted against a hazy sky. The overall mood is mysterious and eerie.

No Class

# Two Weeks Ago

- Hard Drives vs Solid State Drives
- Types of SSDs
  - SATA, PCIe, NVMe
- Why SSDs are faster than HDDs
- Components of an SSD
  - Controller, DRAM, NAND
- Why is paging to a hard drive worse than paging to an SSD?
- Why shouldn't you defragment an SSD?
  - SSDs deliberately introduce fragmentation for wear leveling.
- Bit Rot

# Optical Storage

- Optical Storage
  - A storage medium that is written and read with a laser.



# Optical Storage – Timeline

- 1978 – LaserDisc is Introduced
  - LaserDisc is the first generally-available optical storage format
  - Throughout the 60s and 70s, other formats existed but were never widely used
    - LaserDiscs's popularity was mostly limited to Japan and some regions of Southeast Asia
- 1982 – Compact Discs are Introduced
  - You know them by their acronym: CD
  - CDs became the first optical storage format to become popular globally
- 1996 – Digital Video Disc/Digital Versatile Discs are introduced
  - You know them as DVDs
- 2006 – Blu-ray is Introduced



# Optical Storage

- In modern contexts, optical storage is usually a read-only medium.
  - Music CDs
  - Movies on DVD
  - Movies on Blu-ray
  - Video game discs
- Rewritable optical storage does exist though!
- LaserDisc: Interesting, but sadly, irrelevant.
  - So we won't talk about them. Not for now, anyway.



# Optical Storage

- Types of Compact Discs (CDs)
  - Initially, CDs were only intended for digital audio storage (1982)
    - These were manufactured in a factory and sold for read-only playback of the stored audio
  - Compact Disc Read-Only Memory/CD-ROM (1983)
    - Used for read-only storage of anything
    - The underlying hardware of CD-ROMs is the same as CDs
    - These were manufactured in a factory and sold for read-only usage

# Optical Storage

- Types of Compact Discs (CDs)
  - Compact Disc-Recordable/CD-R (1988)
    - CD-R discs come blank from the factory and are written using a CD burner
    - After data is burned on the CD, it cannot be rewritten
      - Moving forward, the disc is for read-only use
  - Compact Disc-Rewritable/CD-RW (1997)
    - CD-RW discs come blank from the factory and are written using a CD burner
    - Data can be written, read, erased, and rewritten
    - There is no limit on read operations
    - A single location on the disc was limited to approximately 1,000 write cycles
  - Other, more obscure formats: VCD, SVCD, Photo CD, Picture CD, CD-i



# Optical Storage

- Types of Digital Versatile Discs (DVDs)
  - Initially, DVDs were only intended for storing video (1996)
    - From the start, DVDs could be used for storing anything. It just wasn't the intention.
    - This is why the full version of the name changed from "Video" to "Versatile"
    - These were manufactured at a factory and sold for read-only use.
  - Digital Versatile Disc Recordable/DVD-R (1997)
    - DVD-R discs come blank from the factory and are written using a DVD burner
    - After data is burned on the DVD, it cannot be rewritten
      - Moving forward, the disc is for read-only use



# Optical Storage

- Types of Digital Versatile Discs (DVDs)
  - Digital Versatile Disc Recordable/DVD-RW
    - DVD-RW discs come blank from the factory and are written using a DVD burner
    - Data can be written, read, erased, and rewritten
    - There is no limit on read operations
    - There is no limit on write operations
    - A single location on the disc was limited to approximately 1,000 write cycles
  - There are three different versions of the DVD-RW standard
    - Version 1 – 1999
    - Version 2 – 2000
    - Version 1.2 – 2003
      - » Version 1.2 is not backwards compatible with earlier versions



# Optical Storage

- Types of Digital Versatile Discs (DVDs)
  - DVD+R
    - From a user perspective, it is the same as DVD-R
    - DVD+R is not compatible with the DVD-R format though!
  - DVD+RW
    - From a user perspective, it is the same as DVD-RW
    - DVD+RW is not compatible with the DVD-RW format!
  - DVD readers have to support the “dash” and “plus” formats separately.
    - Players that support both will usually be labelled as supporting DVD±R and/or DVD±RW.
  - Many other obscure formats.



# Optical Storage

- Types of Blu-rays
  - Blu-ray Disc Recordable (BD-R)
  - Blu-ray Disc Recordable Erasable (BD-RE)
  - Ultra HD Blu-Ray (released 2016)
  - Archival Disc (released 2016)
    - Not intended for consumer-grade usage.



# Optical Storage

- How are optical discs written?
  - Factory Stamping
    1. A master copy of the data is etched on to a glass plate using a complicated process.
    2. The glass plate is installed in a stamping machine.
    3. A flat piece of polycarbonate plastic is placed in the stamping machine.
    4. Liquid polycarbonate is injected into the stamping machine mold and hardens on the surface of the flat piece of plastic.
    5. Metal layers are added to the plastic to allow for reflection and protection of the disc surface.

# Optical Storage

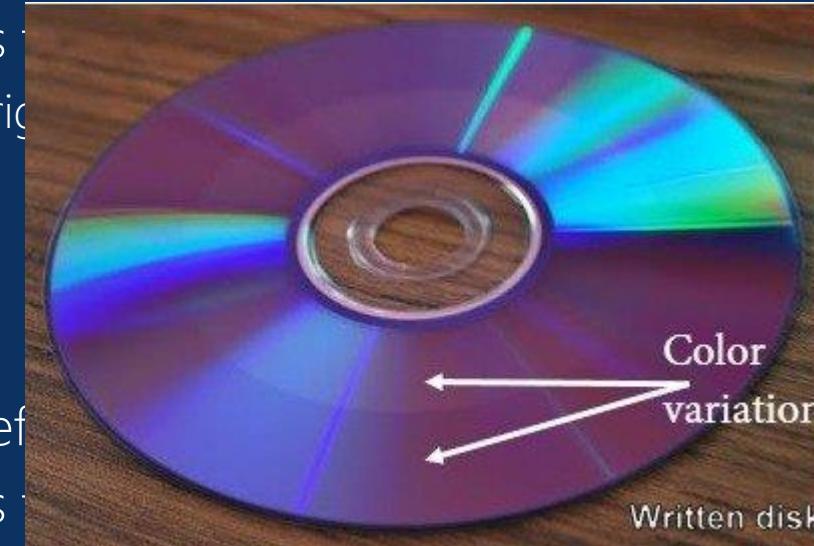
- How are optical discs written?

- Write-Once Discs

1. Write-once discs are manufactured with a reflective dye that covers the disc's surface.



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surface.

- properties.

- This process can be repeated again to revert the change to the paint's reflective properties.

# Optical Storage

- Physically, there are differences in the makeup of the disc surface
  - When reading data back, the difference is irrelevant.
    - Ex: CD, CD-R, and CR-RW are all interpreted the same way when reading.
    - CDs, DVDs, and Blu-rays are not interpreted the same way!
      - One more exception: DVD-R/DVD-RW and DVD+R/DVD+RW



# Optical Storage

- How are optical discs read?
  1. A laser is projected on to the surface of the disc.
  2. The variations in the disc surface cause variation in how the laser is reflected.
  3. The variation in reflection is analyzed by the reader and translated to a 0 or 1.
- The exact implementation of this varies across CDs, DVDs, and Blu-rays, but the fundamental concept remains the same.
  - For example, optical disk readers that support DVD and Blu-ray have to separate lasers. The one that is used varies depending on what type of disc is inserted.



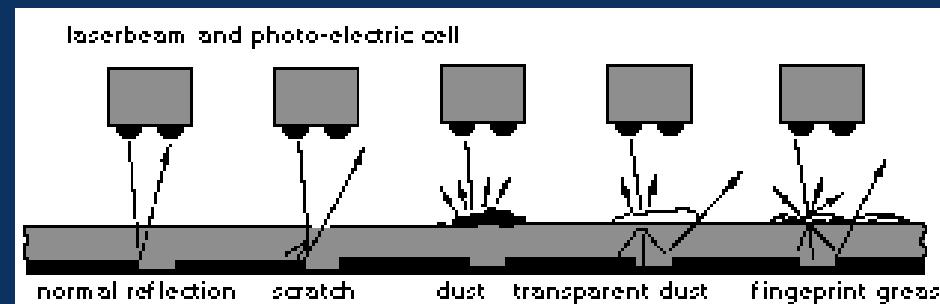
# Optical Storage

- Pros
  - Cost: Optical discs are very cheap.
  - Portability
    - At least, this used to be a pro.
  - Physical Media > Streaming Services
    - Physical media means ownership.
    - Streaming services mean continuously paying for the right to watch/listen.



# Optical Storage

- Cons
  - Storage Capacity: By modern standards, optical discs don't provide much storage space.
    - Currently, the format with the most storage space is the Archival Disc format: 300 GB
    - Supposedly, support for 1TB is coming.
  - Portability: Optical storage is becoming less common.
  - Durability: Optical storage is very easy to damage. Scratches can cause problems.



# Next Week

- Optical Storage
  - Differences in how different formats work.
- Other Stuff



# We're almost done. 😊

Date	Topics
November 8	Memory Hierarchy and Cache Design (part 1)
November 15	Memory Hierarchy and Cache Design (part 2)
November 22	Thanksgiving Break – No Class
November 29	Multiprocessing and Multithreading
December 6	Power and Energy Management

# We're almost done. 😊

Date	Topics
November 8	Data Storage (Part 3)
November 15	Data Storage (Part 4)
November 22	Thanksgiving Break – No Class
November 29	To Be Determined
December 6	Final?