Computer Organization and Architecture

Memory System Design

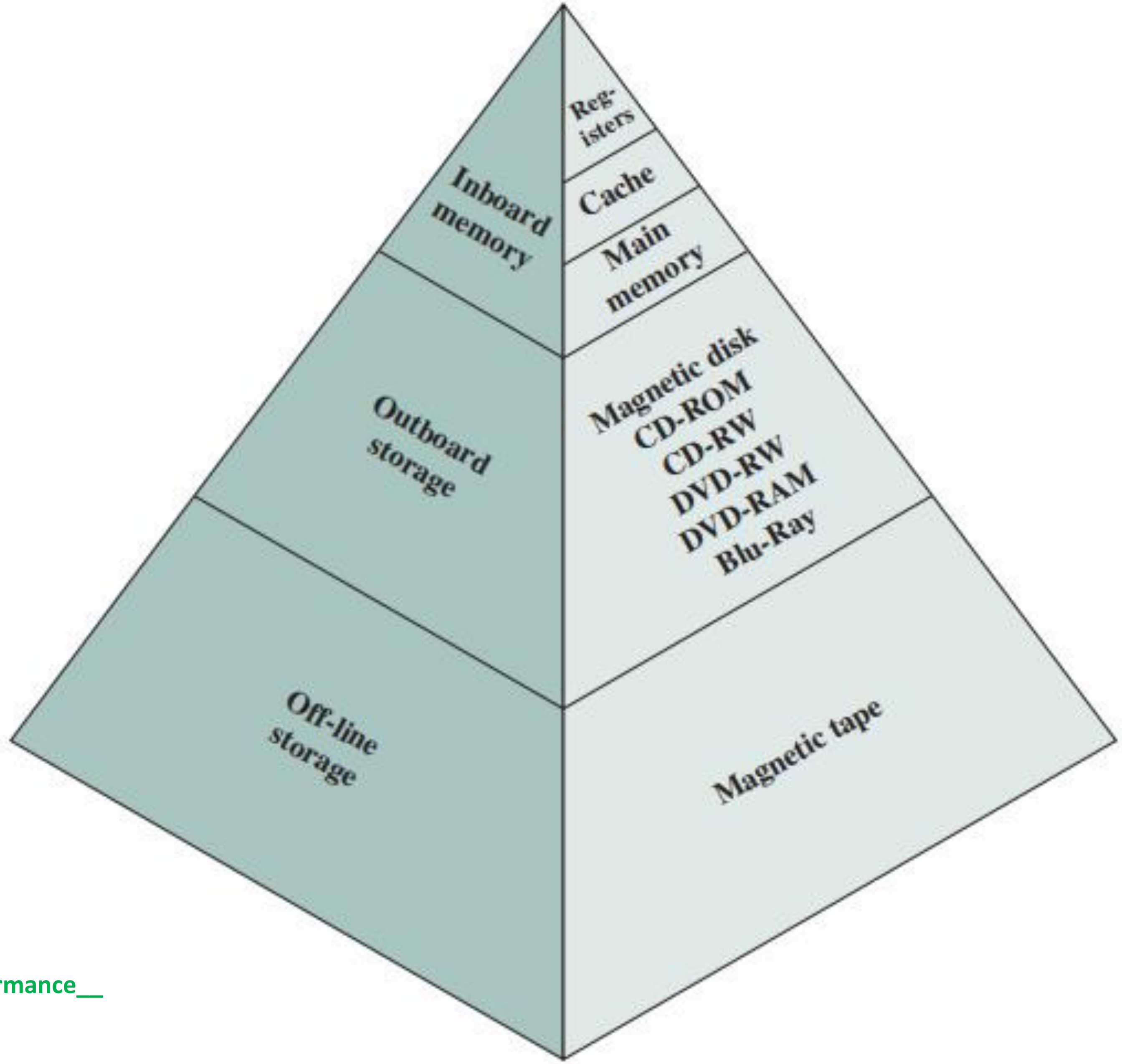
Introduction to Multicore Processors

(Date: 17/03/2023)

Faster access time → greater cost per bit

Greater capacity → smaller cost per bit

Greater capacity → slower access time



Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

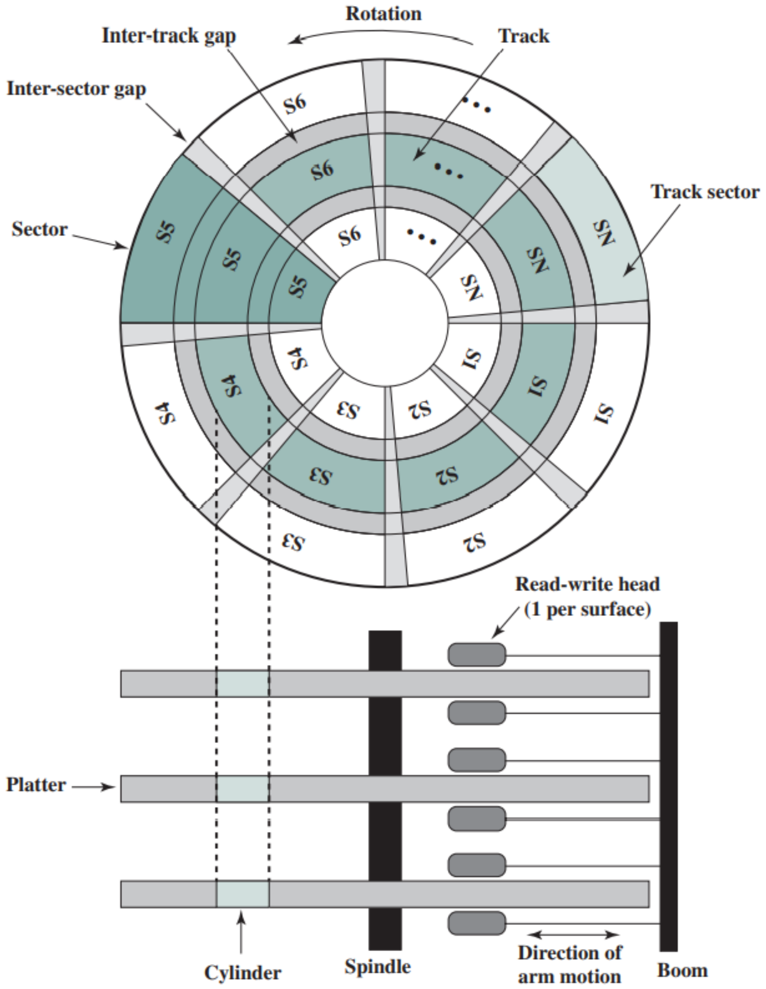
RAID (Redundant Array of Independent Disks)

- ➢ The rate in improvement in secondary storage performance has been considerably less than the rate for processors and main memory

- ➢ This mismatch has made the disk storage system perhaps the main focus of concern in improving overall computer system performance

- <u>Arrays of disks that operate independently and in parallel</u>

✓ With multiple disks, separate I/O requests can be handled in parallel, as long as the data required reside on separate disks



Disk Data Layout

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

➢ RAID Comparison

Level	Advantages	Disadvantages	Applications
0	I/O performance is greatly improved by spreading the I/O load across many channels and drives No parity calculation overhead is involved Very simple design Easy to implement	The failure of just one drive will result in all data in an array being lost	Video production and editing Image Editing Pre-press applications Any application requiring high bandwidth
1	100% redundancy of data means no rebuild is necessary in case of a disk failure, just a copy to the replacement disk Under certain circumstances, RAID 1 can sustain multiple simultaneous drive failures Simplest RAID storage subsystem design	Highest disk overhead of all RAID types (100%)—inefficient	Accounting Payroll Financial Any application requiring very high availability
2	Extremely high data transfer rates possible The higher the data transfer rate required, the better the ratio of data disks to ECC disks Relatively simple controller design compared to RAID levels 3, 4, & 5	Very high ratio of ECC disks to data disks with smaller word sizes—inefficient Entry level cost very high—requires very high transfer rate requirement to justify	No commercial implementations exist/not commercially viable
3	Very high read data transfer rate Very high write data transfer rate Disk failure has an insignificant impact on throughput Low ratio of ECC (parity) disks to data disks means high efficiency	Transaction rate equal to that of a single disk drive at best (if spindles are synchronized) Controller design is fairly complex	Video production and live streaming Image editing Video editing Prepress applications Any application requiring high throughput
4	Very high Read data transaction rate Low ratio of ECC (parity) disks to data disks means high efficiency	Quite complex controller design Worst write transaction rate and Write aggregate transfer rate Difficult and inefficient data rebuild in the event of disk failure	No commercial implementations exist/not commercially viable
5	Highest Read data transaction rate Low ratio of ECC (parity) disks to data disks means high efficiency Good aggregate transfer rate	Most complex controller design Difficult to rebuild in the event of a disk failure (as compared to RAID level 1)	File and application servers Database servers Web, e-mail, and news servers Intranet servers Most versatile RAID level
6	Provides for an extremely high data fault tolerance and can sustain multiple simultaneous drive failures	More complex controller design Controller overhead to compute parity addresses is extremely high	Perfect solution for mission critical applications

- ✓ Fault tolerance
- ✓ Performance
- ✓ Storage space

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

Magnetic Tape

- Tape systems use the same reading and recording techniques as disk systems
- The medium is flexible tape coated with magnetizable material
- The tape and the tape drive are analogous to a home tape recorder system
- Tape widths vary from 0.38 cm (0.15 inch) to 1.27 cm (0.5 inch)
- Data on the tape are structured as a number of parallel tracks running lengthwise
- Earlier tape systems typically used nine tracks
- This made it possible to store data one byte at a time, with an additional parity bit as the ninth track

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

Magnetic Tape

- This was followed by tape systems using 18 or 36 tracks, corresponding to a digital word or double word
- The recording of data in this form is referred to as parallel recording
- Most modern systems instead use serial recording, in which data are laid out as a sequence of bits along each track, as is done with magnetic disks
- As with the disk, data are read and written in contiguous blocks, called physical records, on a tape
- Blocks on the tape are separated by gaps referred to as inter record gaps
- As with the disk, the tape is formatted to assist in locating physical records
- The typical recording technique used in serial tapes is referred to as serpentine recording
- In this technique, when data are being recorded, the first set of bits is recorded along the whole length of the tape
- When the end of the tape is reached, the heads are repositioned to record a new track, and the tape is again recorded on its whole length, this time in the opposite direction
- That process continues, back and forth, until the tape is full (as shown in the Figure)

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

Magnetic Tape

Serpentine reading and writing

- Magnetic tape was the first kind of secondary memory
- It is still widely used as the lowest-cost memory
- Slowest-speed member of the memory hierarchy

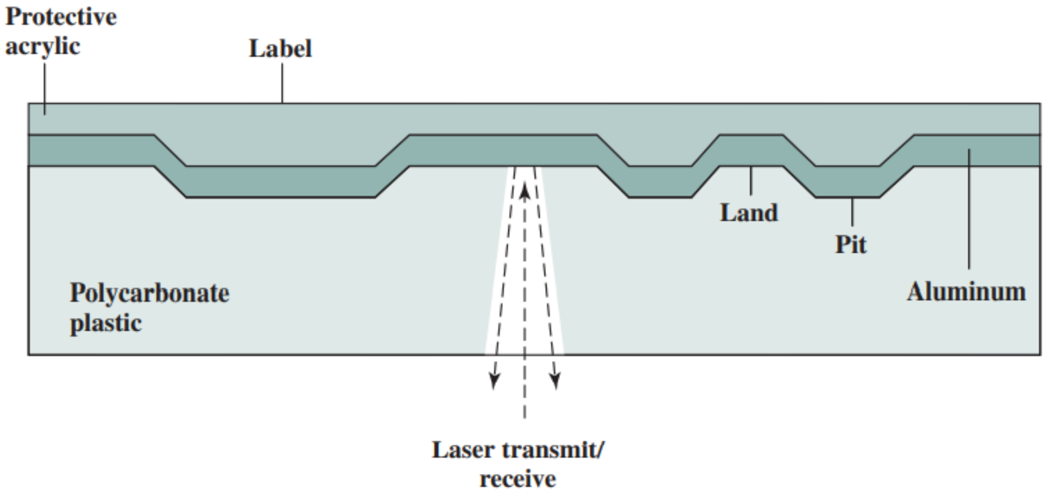
- ✓ A tape drive is a sequential- access device. If the tape head is positioned at record 1, then to read record N, it is necessary to read physical records 1 through N-1
- ✓ If the head is currently positioned beyond the desired record, it is necessary to rewind the tape a certain distance and begin reading forward

- In contrast to the tape, the disk drive is referred to as a direct-access device (a disk drive need not read all the sectors on a disk sequentially to get to the desired one / It will only wait for the intervening sectors within one track and can make successive accesses to any track)

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

Compact Disk

- The disk is formed from a resin, such as polycarbonate
- Digitally recorded information (either music or computer data) is imprinted as a series of microscopic pits on the surface
- This is done, with a finely focused, high-intensity laser
- This shiny surface is protected against dust and scratches by a top coat of clear acrylic
- Finally, a label can be silkscreened onto the acrylic



Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

- Information is retrieved from a CD or CD- ROM by a <u>low- powered laser</u> housed in an optical- disk player, or drive unit
- The laser shines through the clear polycarbonate while a motor spins the disk
- The intensity of the reflected light of the laser changes as it encounters a change from pit to land or, land to pit (the areas between pits are called lands)
- A land is a smooth surface, which reflects back at higher intensity
- If the laser beam falls on → pit-to-land (which has a somewhat rough surface) → the light scatters and a low intensity is reflected back to the source
- Reflected light is detected by a photo sensor and converted into a digital signal

- To achieve greater capacity, CDs and CD-ROMs do not organize information on concentric tracks
- Instead, the disk contains <u>a single spiral track, beginning near the center and spiraling out to the outer edge of the disk</u>

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

➢ Optical Disk Products

CD

Compact Disk. A nonerasable disk that stores digitized audio information. The standard system uses 12-cm disks and can record more than 60 minutes of uninterrupted playing time.

CD-ROM

Compact Disk Read-Only Memory. A nonerasable disk used for storing computer data. The standard system uses 12-cm disks and can hold more than 650 Mbytes.

CD-R

CD Recordable. Similar to a CD-ROM. The user can write to the disk only once.

CD-RW

CD Rewritable. Similar to a CD-ROM. The user can erase and rewrite to the disk multiple times.

DVD

Digital Versatile Disk. A technology for producing digitized, compressed representation of video information, as well as large volumes of other digital data. Both 8 and 12 cm diameters are used, with a double-sided capacity of up to 17 Gbytes. The basic DVD is read-only (DVD-ROM).

DVD-R

DVD Recordable. Similar to a DVD-ROM. The user can write to the disk only once. Only one-sided disks can be used.

DVD-RW

DVD Rewritable. Similar to a DVD-ROM. The user can erase and rewrite to the disk multiple times. Only one-sided disks can be used.

Blu-ray DVD

High-definition video disk. Provides considerably greater data storage density than DVD, using a 405-nm (blue-violet) laser. A single layer on a single side can store 25 Gbytes.

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings

Digital Versatile Disk

The DVD takes video into the digital age (it delivers movies with impressive picture quality)

Large volume of data can be crammed onto the disk (huge storage capacity)

The DVD’s greater capacity is due to three differences from CDs

1) Bits are packed more closely on a DVD

The spacing between loops of a spiral on a CD is 1.6 um and the minimum distance between pits along the spiral is 0.834 um

The DVD uses a laser with shorter wavelength and achieves a loop spacing of 0.74 um and a minimum distance between pits of 0.4 um

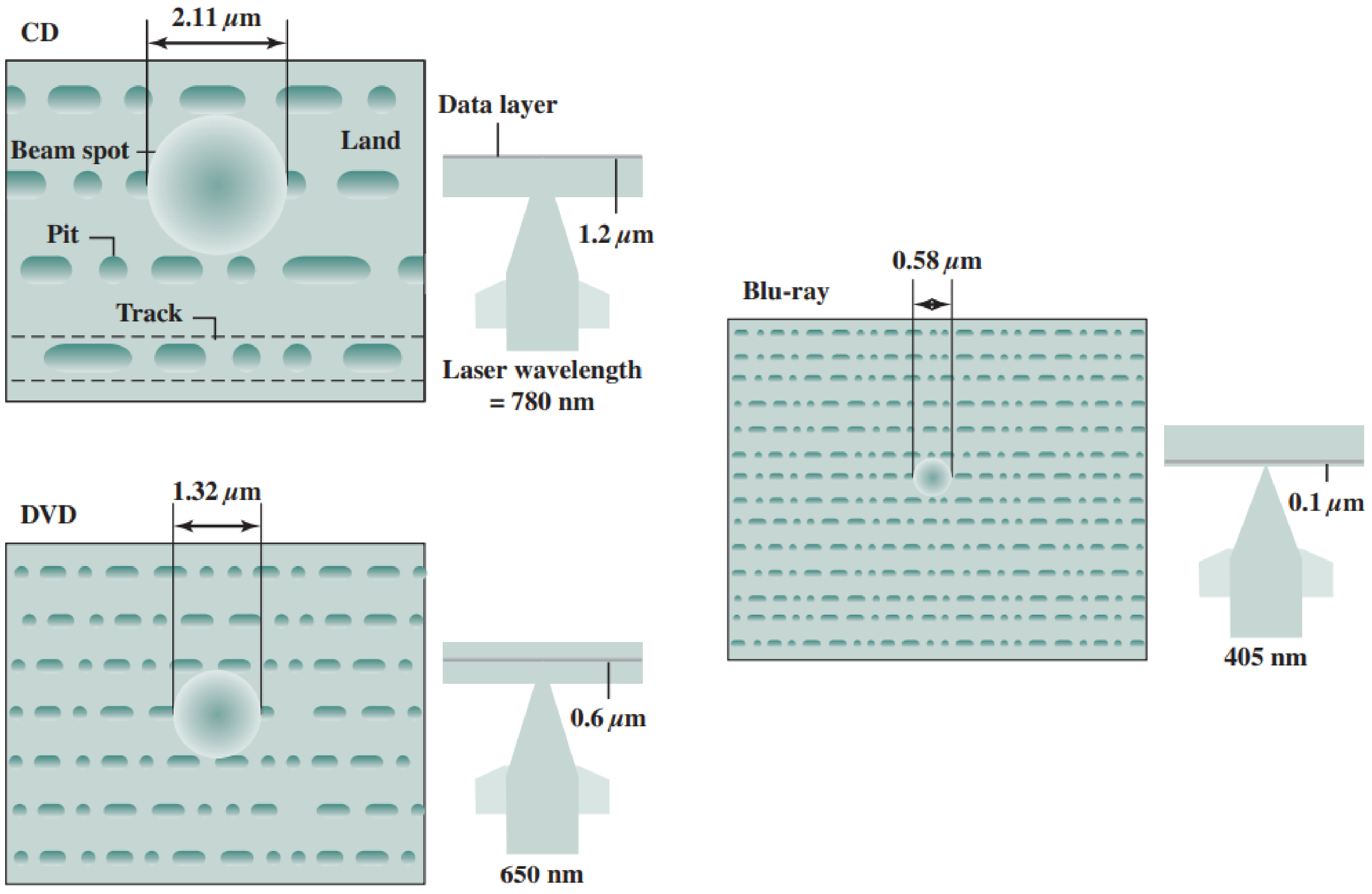
2) The DVD employs a second layer of pits and lands on top of the first layer

A dual-layer DVD has a semi-reflective layer on top of the reflective layer, and by adjusting focus, the lasers in DVD drives can read each layer separately

- This technique almost doubles the capacity of the disk (the lower reflectivity of the second layer limits its storage capacity so that a full doubling is not achieved)

3) The DVD-ROM can be two sided, whereas data are recorded on only one side of a CD

Ref: Computer Organization and Architecture Designing for Performance__ William Stallings



Ref: Computer Organization and Architecture Designing for Performance__ William Stallings