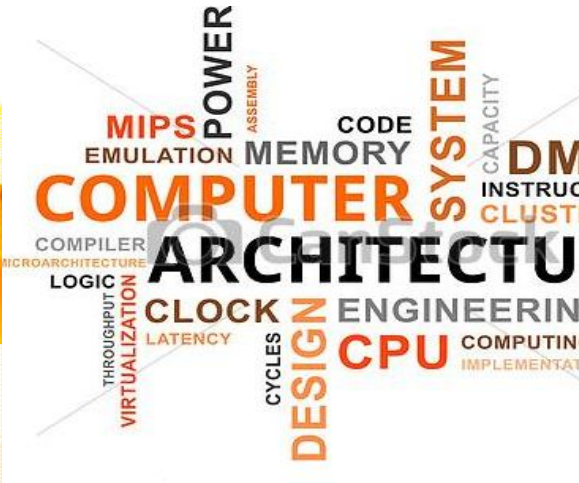
UNIT IV
MEMORY SYSTEM

Basic concepts of Semiconductor RAMs - ROMs – Speed, Size and Cost – Cache memories – Performance consideration – Virtual memory – **Memory Management requirements – Secondary storage** - Case Study: Memory Organization in Multiprocessors



Recap the previous Class

Memory management

- Operating system is concerned with transferring programs and data between secondary storage and main memory.
- Operating system **needs memory routines** in addition to the other routines.
- Operating system routines are assembled into a virtual address space called **system space**.
- System space is separate from the space in which user application programs reside. (This is user space.)
- Virtual address space is divided into **one system space + several user spaces.**

Memory management (contd..)

- MMU uses the **contents of the page table base register** to determine the address of the page table to be used in the translation.
  - Changing the contents of the page table base register can enable us to use a different page table, and switch from one space to another.
- At any given time, the page table base register can point to one page table.
  - Thus, only one page table can be used in the translation process at a given time.
  - Pages belonging to only one space are accessible at any given time.

Memory management (contd..)

- When multiple, independent user programs coexist in the main memory, how to ensure that one program does not modify/destroy the contents of the other?
- Processor usually has two states of operation:
  - Supervisor state & User state.
- **Supervisor state:**
  - Operating system routines are executed.

Memory management (contd..)

- **User state:**
  - User programs are executed.
  - Certain privileged instructions cannot be executed in user state.
  - These privileged instructions include the ones which change page table base register.
  - Prevents one user from accessing the space of other users.

Magnetic Hard Disks

Magnetic disks constitute a traditional method for **non-volatile storage** of information using **magnetic technology**.

- Broadly three types of devices appeared:

a) Floppy disk : made of bendable plastic

b) Magnetic drum : made of solid metal

c) Hard disk : made of metal or glass

- All of these rely on a rotating platter (metal or glass or plastic) coated with a thin magnetic material, and use a moveable read/write head to read and write data from / to the disk.
  - Data stored as tiny magnets.

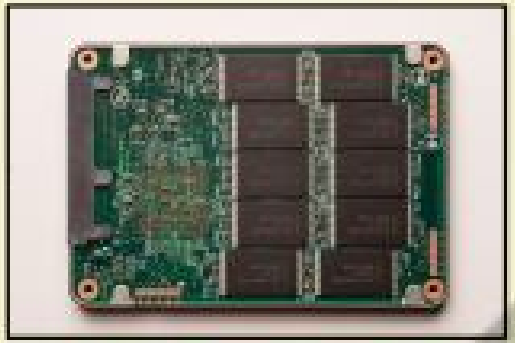
Magnetic Hard Disks

Magnetic drum
(62.5 Kbytes)

8" floppy disk
(360 Kbytes)

3.5" floppy disk
(1.2 Mbytes)

3.5" magnetic disk
(1 Tbytes)



1.8" solid-state disk
(512 Gbytes)

Magnetic Hard Disks

Since the platters in a hard disk are made of rigid metal or glass, they provide **several advantages** over floppy disks:

– They can be larger.

– Can have higher density since they can be controlled more precisely.

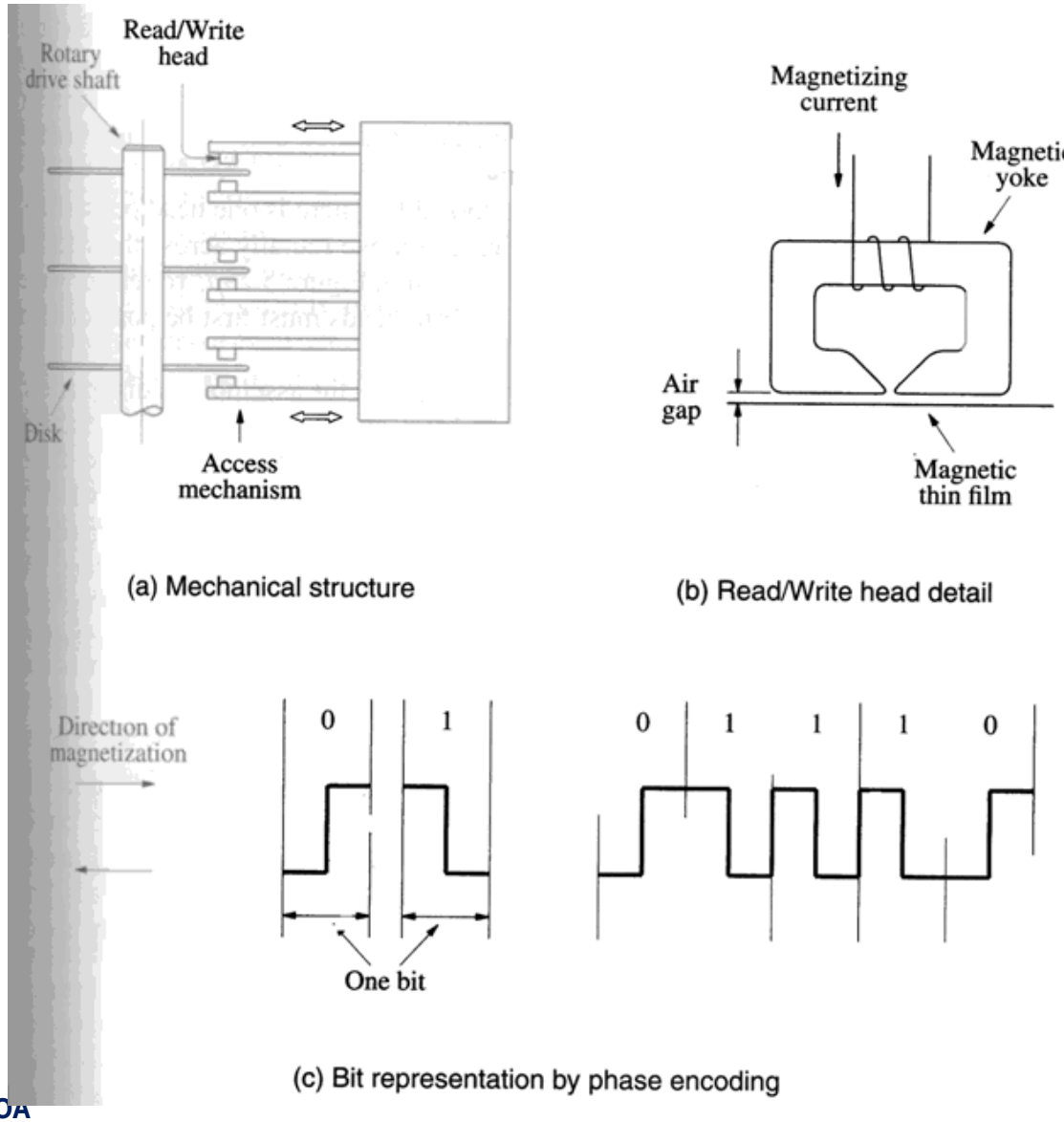
– Has a higher data rate because it spins faster

– No physical contact with read/write head as it spins faster.

- The read/write head floats on a cushion of air (few microns separation).
- Requires dustless environment.
- Results in higher reliability

– More than one platters can be incorporated in the same unit.

Magnetic Hard Disks



(a) Mechanical structure

(b) Read/Write head detail

(c) Bit representation by phase encoding

Organization of Data on a Disk

The hard disks consists of a **collection of platters** (typically, 1 to 5), which are connected together and can spin in unison.

– Each platter has two recording surfaces, and comes in various sizes (1 – 8 inches).

– The stack of platter typically rotates at a speed of 5400 to 7200 rpm.

– Each disk surface is divided into concentric circles called **tracks**.

- The number of tracks per surface can vary from 1000 to 5000.

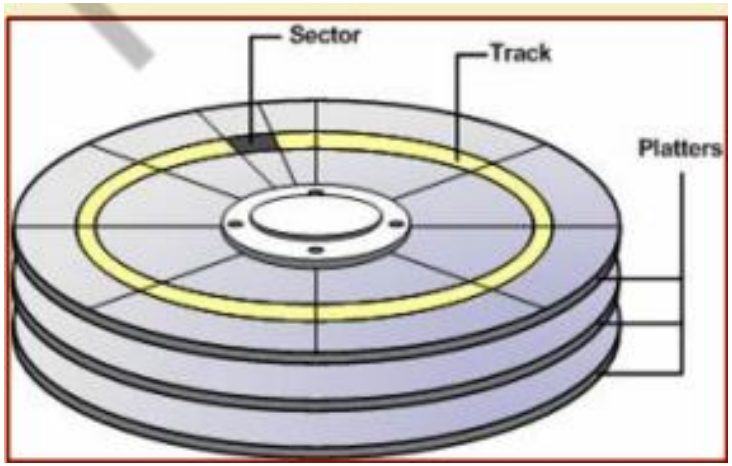
– Each track is divided into a **number of sectors (64 – 200 sectors/track).**

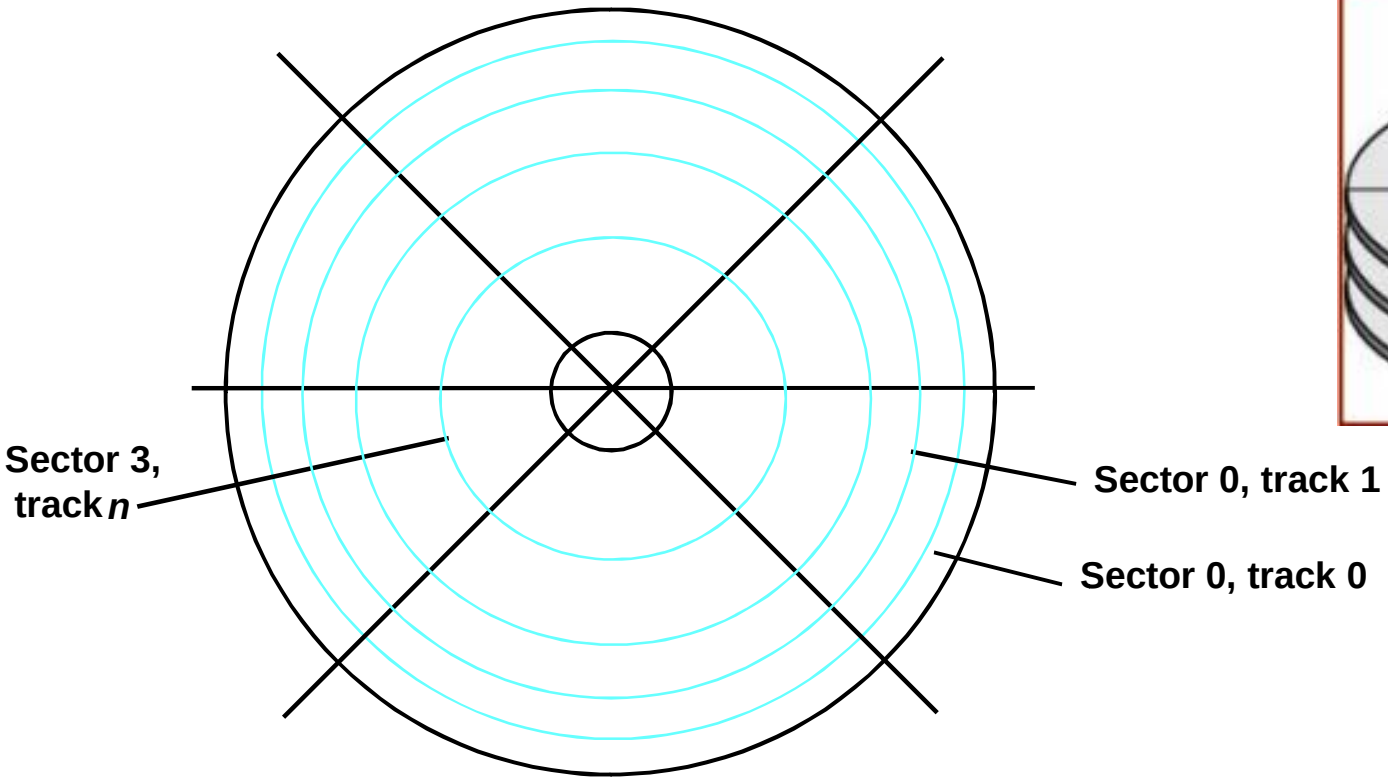
- Typical sector size: 512 – 2048 bytes.
- Sector is the smallest unit that can be read or written.

– The disk heads for all the surfaces are connected and move together.

– All the tracks under the heads at a given time on all surfaces is called a **cylinder.**

Organization of Data on a Disk





Disk Access Time

There are three components to the access time in hard disk:

a) Seek time:

- The time required to move the head to the desired track.
- Average seek times are in the range 8 – 20 msec.
- Actual average can be 25 – 30% less than this number, since accesses to disks are often localized.

Disk Access Time

b) Rotational delay:

• Once the head is on the correct track, we must wait for the desired sector to rotate under the head.

• The average delay or latency is the time for half the rotation.

Examples:

For 3600 rpm, average rotational delay = 0.5 rotation / 3600 rpm = **8.30 msec**

For 5400 rpm, average rotational delay = 0.5 rotation / 5400 rpm = **5.53 msec**

For 7200 rpm, average rotational delay = 0.5 rotation / 7200 rpm = **4.15 msec**

Disk Access Time

c) Transfer time:

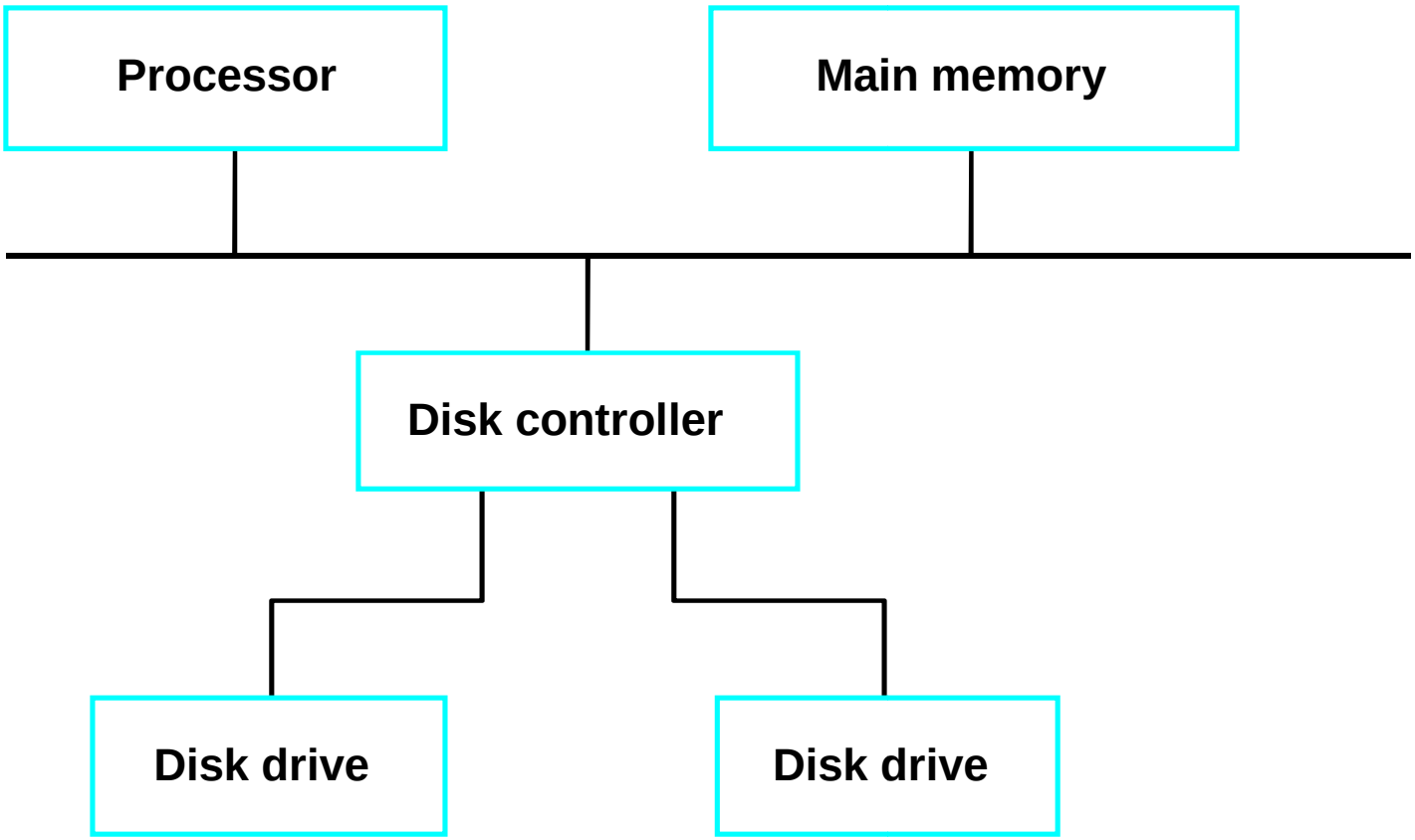
- The total time to transfer a block of data (typically, a sector).
- Transfer rates are typically 15 MB/sec or more.
- Transfer time depends on:
  - Sector size
  - Rotation speed of the disk
  - Recording density on the tracks

Example 1

- Consider a disk with sector size 512 bytes, 2000 tracks per surface, 64 sectors per track, three double-sided platters, and average seek time of 10 msec.
  a) What is the capacity of the disk?
  b) If the disk platters rotate at 7200 rpm, and one track of data can be transferred per revolution, what is the transfer rate?

  - Bytes/track = 512 x 64 = 32K
    Bytes/surface = 32K x 2000 = 64,000K
    Bytes/disk = 64,000K x 3 x 2 = 384,000K
  - Transfer rate = Capacity of a track / average rotational delay
    = 32K / 4.15 msec = 7,711 Kbytes/sec

Disk Controller



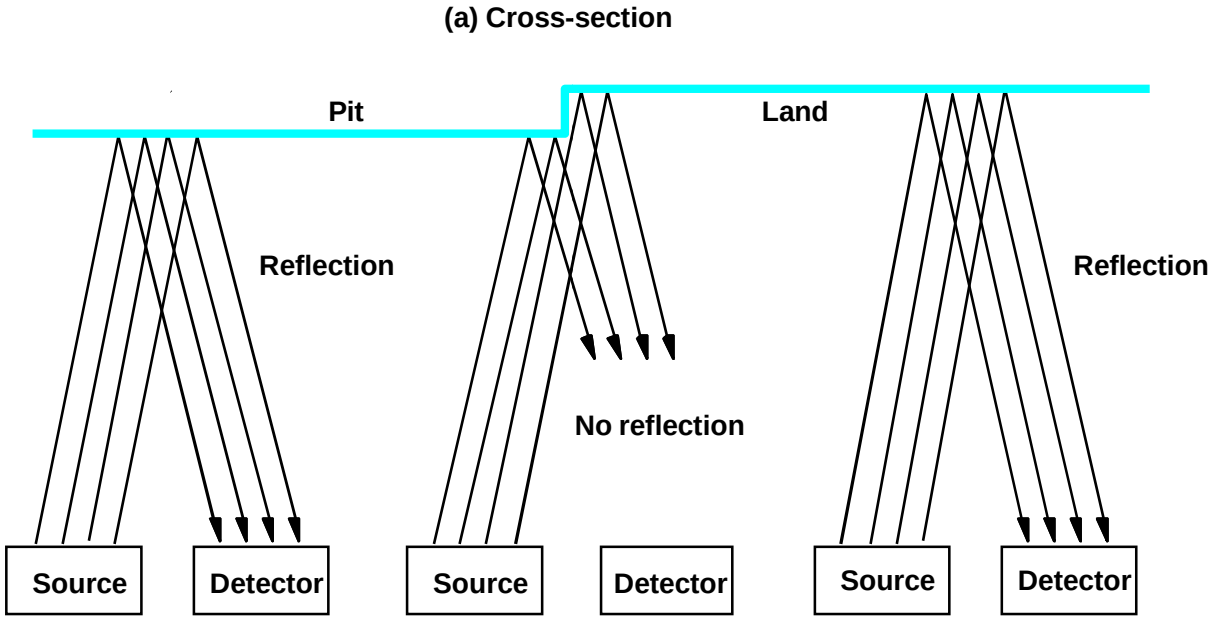
Disk Controller

- Seek
- Read
- Write
- Error checking

RAID Disk Arrays

- Redundant Array of Inexpensive Disks
- Using multiple disks makes it cheaper for huge storage, and also possible to improve the reliability of the overall system.
- RAID0 – data striping
- RAID1 – identical copies of data on two disks
- RAID2, 3, 4 – increased reliability
- RAID5 – parity-based error-recovery

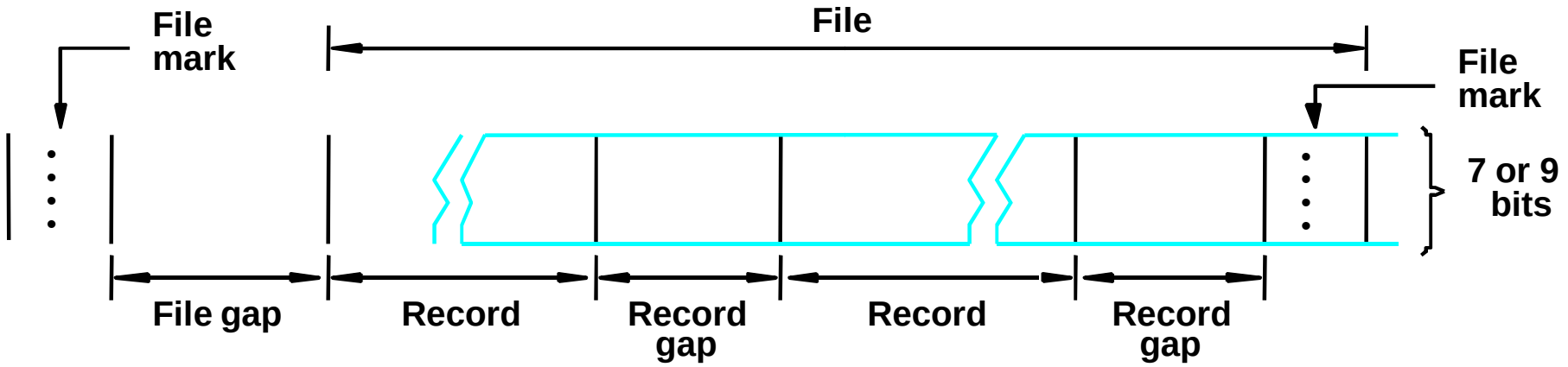
Optical Disks



Optical Disks

- CD-ROM
- CD-Recordable (CD-R)
- CD-ReWritable (CD-RW)
- DVD
- DVD-RAM

Magnetic Tape Systems



Organization of data on magnetic tape.

TEXT BOOK

Carl Hamacher, Zvonko Vranesic and Safwat Zaky, “Computer Organization”, McGraw-Hill, 6th Edition 2012.

REFERENCES

1. David A. Patterson and John L. Hennessey, “Computer organization and design”, MorganKauffman ,Elsevier, 5th edition, 2014.
2. William Stallings, “Computer Organization and Architecture designing for Performance”, Pearson Education 8th Edition, 2010
3. John P.Hayes, “Computer Architecture and Organization”, McGraw Hill, 3rd Edition, 2002
4. M. Morris R. Mano “Computer System Architecture” 3rd Edition 2007
5. David A. Patterson “Computer Architecture: A Quantitative Approach”, Morgan Kaufmann; 5th edition 2011

THANK YOU