MODULE - II

Storage System Environment

MODULE 2

Storage System Environment

Module Description

This module caters the storage system environment and has its prime focus on storage. Students will get an insight on the key components of storage system environment and the various kinds of physical components of a disk drive, such as platter, spindle, controller, actuator arm and read/write head. Students will also get to know about zoned bit recording and why it should be used as well as get an insight on logical block addressing.

This module also explains the connectivity between the host and storage, which is facilitated by interface protocols and bus technology. Students will also read about different logical components of hosts, such as file system, operating system and volume managers and their individual role in the storage system environment. They will also be able to identify the factors affecting the disk performance.

Chapter 2.1
Storage System and Disk Drive

Chapter 2.2
Logical Components of the Host

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Chapter 2.1

Storage System and Disk Drive

Aim

To equip the students with the fundamentals of storage system and disk drive

Instructional Objectives

After completing this chapter, you should be able to:

- Explain the components of the storage system
- Describe the components of the disk drive
- Describe the various factors that affect the performance of disk drives
- Explain zoned bit recording

Learning Outcomes

At the end of this chapter, you are expected to:

- Discuss the three components of the storage system environment
- Elaborate each component of the disk drive components
- Identify the significance of zoned bit recording
- Explain how physical data is structured

2.1.1 Introduction

Storage is one of the core and important elements of a data centre and is identified as a distinct resource. A **storage system** can be understood as a group of components that aim at providing storage facilities to one or numerous computers. This system is responsible for the request or command to read or write the data as well as for the actual transmission of data.

As the time has evolved, storage has also evolved from single internal disks to huge and complex storage systems. And to keep up with that, storage system environment has also evolved along with the fast and varying changes in the computing models. In order to implement and manage storage, it requires a good amount of specialisation and focus. The flow of data occurs from an application to storage via numerous components, which are collectively referred to as a **storage system environment**.

This chapter details the storage system environment and primarily, focuses on storage. In the coming topics, we will discuss and understand various components present in the storage system and discuss the physical and logical components of each. We will also understand the components in a disk drive and their working.

Let us begin with understanding the different components present in a storage system environment.

2.1.2 Components of a Storage System Environment

In a storage system environment, at a very high level, there are three main components:

- Host
- Connectivity
- Storage

These three entities help to facilitate the access of data using their physical and logical components

The host system is used for the interaction between the OS and application that has requested the data. Connectivity, as the name suggests, provides the connection and helps in carrying out the data and the read or write commands between the storage mediums and the host. Finally, the data gets stored into the storage mediums or devices.

Now, let us discuss each of these three components in detail.

(i) Host

We have read in Module 1 that data is stored and retrieved via applications. A **host** can simply be understood as a computer or any other deice on which such applications run. Hence, host supports the running of applications. A host can be a desktop computer, a laptop, or even a complex bunch of servers. It can range from a simple device to a web of clustered devices. A host comprises of the hardware devices, which are the physical components. These physical components communicate with each other with the help of logical components.

The performance of the storage system environment and the feasibility in accessing the data depends upon both the physical and logical components of the host.

The process of storing the data is spread across various parts of the storage system. From the perspective of host, the storage or the read or write access happens through the physical and logical components.

The physical components of a host are:

- Central Processing Unit (CPU)
- Storage, such as disk devices or internal memory
- Input/Output (I/O) devices

Communication between the physical components takes place with the help of a communication pathway, which is known as a **bus**. A bus is used to connect the CPU to other physical components, such as memory and I/O devices.

The logical components of a host are:

- Software applications
- Operating system
- File systems
- Databases
- Disk drives

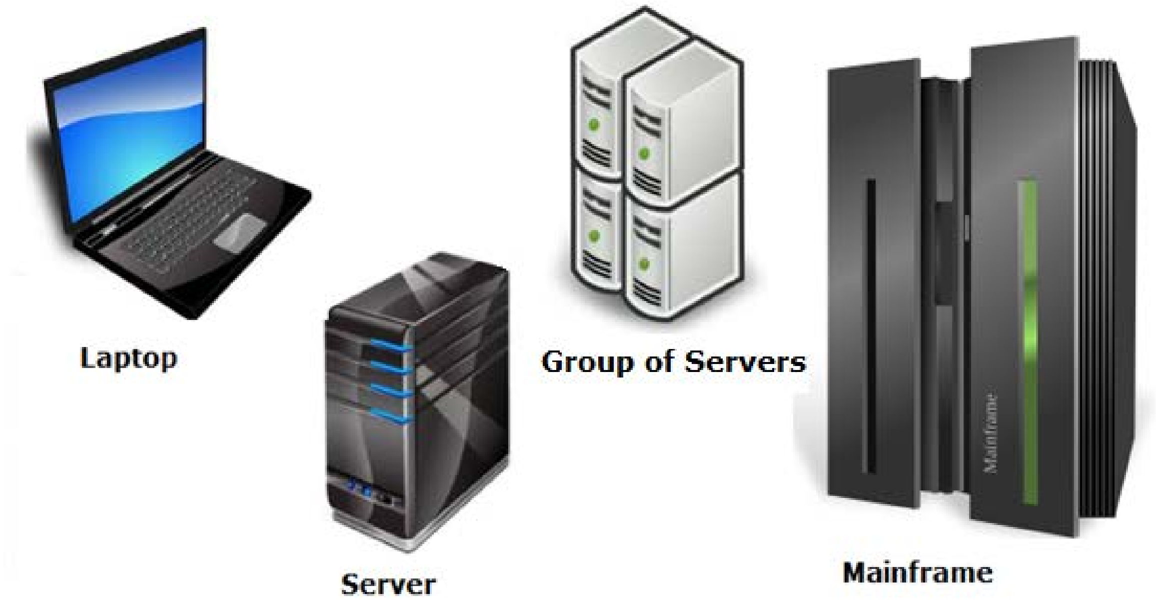

Figure 2.1.1: Different Types of Hosts

Did you Know?

In a computer network, host is the end point of communication.

(ii) Connectivity

The interconnections between two or more hosts or between host any other peripheral devices, such as printer or any storage devices, can be understood as connectivity. Or we can also say that a network connectivity encompasses everything between the host and the storage system.

In this chapter, we are focusing on the interconnections between a host and the connecting storage devices. Similar to hosts, the components of connectivity can also be classified as physical components and logical components.

To understand, the physical components of connectivity are the hardware elements that are used for connecting the host to the storage system. The logical components of connectivity are basically a set of protocols that are required for having a communication between the host and the storage system.

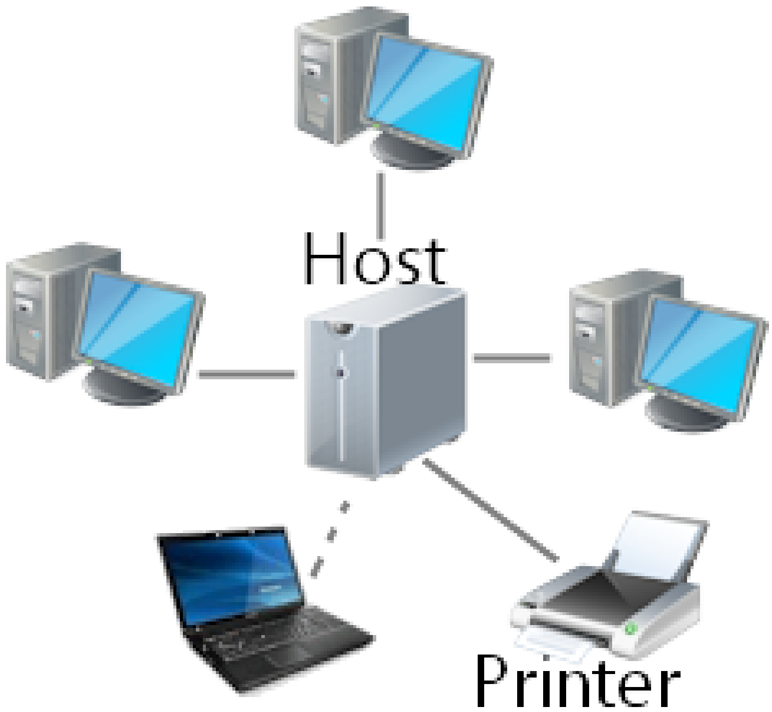

Figure 2.1.2: Connectivity between Host and Printer

Physical Components of Connectivity

The physical components of connectivity are:

- Port
- Cable
- Bus

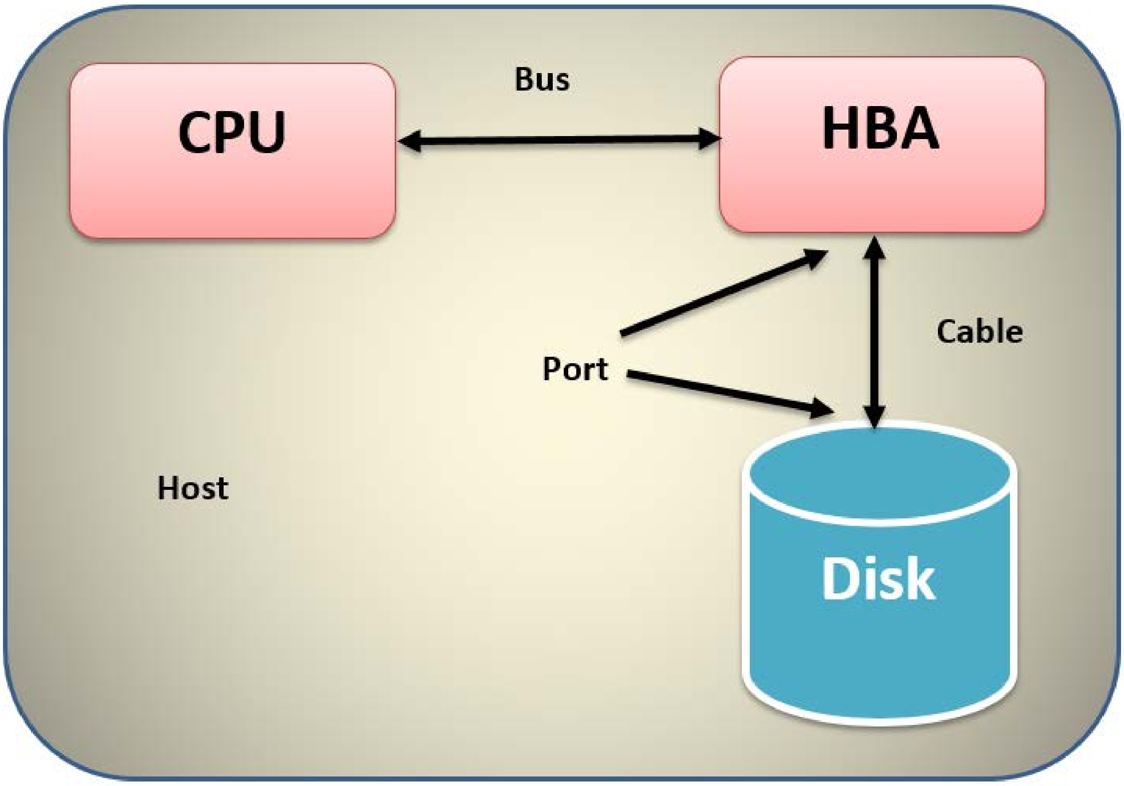

Figure 2.1.3: Physical Components of Connectivity

Refer to the Table 2.1.1 for a summarised description of all the three physical components.

Component	Description
Port	• Kind of outlet • Facilitates connectivity between host and other external devices
Cable	• Connects the host to the internal or external devices • Connection is made via copper wires or optical fiber mediums
Bus	• Collection of path • Enables data transmission from one place of computer to another

Table 2.1.1: Physical Components of Connectivity

Apart from these three prime components, we can also include the following as the subsidiary part of the physical component of connectivity.

- **Adapters**
  - Host Bus Adapter (HBA) – This enables the connection between the devices and a host's internal bus system.
  - Network Interface Cards – This enables simple network attachments to a host.
- **Switches/hubs**
  - This is used to manage traffic within a network.

The bus helps the physical components communicate with each other by sending bits of data, such as control, data and address, between the devices. The transmission of these bits through the bus takes place either serially or in parallel.

- **Serially:** In this type of transmission, the transmission of bits take place in a sequential manner along a single path. This type of transmission can both be unidirectional or bidirectional.

- **In Parallel:** In this type of transmission, the transmission of bits takes place along multiple paths, simultaneously. Parallel transmission can also be bidirectional.

The amount of data that can be transmitted through the bus at a time depends on the size or width of the bus. You can understand the width of a bus as the number of lanes in a highway. The wider the bus is; the more amount of data can be transmitted in a go. So, a 32-bit bus is able to transmit 32 bits of data and, similarly, a 64-bit bus has the potential to transmit 64 bits of data. The speed of the bus is measured in MHz (megahertz). These represent the rate of transfer of the data between the end points of the bus. Hence, a fast bus enables the applications to run faster by allowing faster rate of transfer of data.

Classification of Buses

Buses can be classified as the following:

- **System Bus:** These kind of buses takes care of the data flow from the processor to the memory.

- **Local Bus:** It is also known as I/O bus. It is a high-speed pathway connecting to the processor. It enables the transmission of data amongst the peripheral devices and the processor.

Logical Components of Connectivity

The logical components of connectivity are:

- PCI
- IDE/ATA
- SCSI

Let us discuss each of these logical components in detail.

- **PCI:** It stands for Peripheral Component Interconnect. It is a popular interface protocol which is used by the local bus in order to connect to a peripheral device. It is a synchronous bus architecture where all data transmission takes place relative to a system clock (CLK). It standardizes the information exchange between PCI expansion cards, such as modems or network cards and the CPU and provides an interconnection between the CPU and the attached devices.

In the terminology of PCI, the transfer of data takes place between an initiator, which is the bus master and a target, which is the bus slave. A PCI transfer comprises of one answer phase and any number of data phases.

PCI possess the plug-and-play functionality that enables the host to easily recognize as well as configure new devices and cards. A PCI bus can be of both 32-bit and 64-bit width. A throughput of 133 MB/s can be provided by a 32-bit PCI. An enhanced version of PCI bus is the PCI Express that provides considerably high throughput and clock speed.

- **IDE/ATA:** It stands for Integrated Device Electronics/Advanced Technology Attachment. It is one of the most popular protocol used on the modern disks. The ID/ATA protocol provides excellent performance at a relatively low cost.

  The IDE component in IDE/ATA offers the specifications for the controller that are connected to the computer's motherboard in order to communicate with the attached device. The ATA component provides an interface for connecting storage devices, such as floppy disk drives, hard disks, CDs, to the motherboard.

  An ATA interface supports two storages per connector in a master-slave configuration. Although, it is recommended that you do not share a port between multiple devices, in order to meet the performance of the drive.

- **SCSI:** It stands for Small Computer System Interface. SCSI has gradually emerged as one of the preferred protocols in high-end computers. SCSI, which was first developed for hard disks, is frequently compared with IDE/ATA. SCSI offers an improved performance and expandability and compatibility options, which makes it suitable for the high-end users. Although, on personal computers, IDE/ATA is more preferred than this interface. The higher cost associated with SCSI restricts its popularity amongst personal computer users.

  SCSI was developed to provide a device-independent methodology for attaching to a host computer and accessing it. It was initially used as a parallel interface, which was used to enable the connection of devices to a host. It also provided an efficient peer-to-peer I/O bus which supported multiple devices.

Nowadays, SCSI is majorly used as a hard disk interface and it can also be used to add devices, such as optical media drives and tape drives, to the host computer without performing any modification into the system's hardware or software. Over the years, SCSI has undergone radical changes and has been enhanced a lot and now includes a wide range of related standards and technologies.

(iii) Storage

In the storage system environment, a storage device is the most important component. A storage device uses the magnetic, optical, or solid state media.

Magnetic media

The data in a computer system needs to be stored in a digital manner and to do so, one of the most widely used data storage is the magnetic storage. Any sort of storage medium which utilizes the magnetic patterns for the representation of information can be considered as magnetic media. That means a magnetic storage is the storage of data in any kind of magnetized medium.

Digital data constitutes of binary information, which means data is represented in the form of zero and one. There are two types of magnetic polarities and each one of them represents either zero or one. Magnetic storage is an example of a non-volatile memory, which means when the storage device is not powered, then the data does not gets lost and is retained. Magnetic storages use various patterns of magnetization in magnetisable material to store the data and the information is accessed with the help of one or more read/write heads.

Magnetic storages are relatively cheap and are, hence, widely used for data storage. It is a read/write storage device and provides the feature of reusing the storage capacity over and over again by removing the old data. It is also beneficial when you need to store large amount of data, as it offers very large storage capacity.

Examples of devices that use the magnetic media are tapes, disks and diskettes.

Figure 2.1.4: A Magnetic Tape

Optical Media

Optical media are the kind of storage media that contain the content in a digital format and the read/write feature can be performed on them using a laser.

The examples of optical media include CD-ROMs, DVD-ROMs and all the variations of the two formats, as well as optical jukeboxes and autochangers.

In the computer, there is a dedicated drive known as the optical drive that can read CD-ROMs and other optical discs.

Optical media have a number of advantages over the magnetic media.

In terms of storage, optical disk capacity ranges up to 6 GB (gigabytes) as compared to the 1.44 MB (megabytes) of a floppy disk, which is an example of the magnetic disk. That is approx. 6 billion bytes compared to the 1,440,000 bytes of the floppy disk. That means, one optical disk can hold an equivalent of 500 floppy disk worth of data.

In terms of durability, optical media can last up to seven times as long as any traditional storage media.

Figure 2.1.5: CD-ROMs

Optical media is more popular with single-user computing environments and is used frequently to store media files or as a backup medium on personal computers or laptops. It is also a preferable distribution medium for movies, single application, such as games, or for transferring small amount of data from one self-contained system to another. Optical disks have limited storage and speed, which restricts its use as a business data storage solution.

Solid State Media

It is a kind of storage media which is made up of silicon microchips. It is a non-volatile storage and stores data electronically instead if storing it magnetically.

The solid state media stores and retrieves the digital data using only the electronic circuits. It contains no mechanical parts, which allows the transfer of data, to and from the storage medium, to take place at a very higher speed. Hence, it provides a more predictable lifespan for the storage media. As there are no moving mechanical parts involved in the solid state media, as a result, it produces far less heat than the hard disk drives (HDD).

The solid state media not only offers a faster and more consistent I/O times, but it also offers the same level of data integrity and endurance as any other electronic device. It requires less power and cooling than its electromechanical equivalents and also, generally, weighs less.

An example of a device that uses the solid state media is a removable flash memory.

Figure 2.1.6: A Flash Solid State Drive

Did You Know?

One advantage of optical media is the capability to write once and read many (WORM). A CD-ROM is an example of a WORM device.

Self-assessment Questions

1) Which of the following are the components of a storage system environment? Choose all that apply.
   a) Host
   b) Port
   c) Connectivity
   d) Storage

2) Which of the following acts as a communication pathway and helps CPU to connect to other physical components?
   a) Router
   b) Bus
   c) Host
   d) I/O devices

3) A set of protocols required for having a communication between the host and the storage system categorises as which type of component in connectivity?
   a) Physical component
   b) Hardware component
   c) I/O component
   d) Logical component

4) Which of the following is used to enable the connection between the devices and a host's internal bus system?
   a) Network Interface Card
   b) Host Bus Adapter
   c) Switches
   d) Hubs

5) Which of the following is the correct expansion for PCI?
   a) Peripheral Component Interconnect
   b) Peripheral Computer Interconnect
   c) Personal Computer Interconnect
   d) Personal Component Interconnect

6) Which of the following is an example of a solid state media?
   a) Floppy disks
   b) CD-ROMs
   c) Removable flash memory
   d) Autochangers

2.1.3 Disk Drive Components

A disk drive is one of the most popular, randomly accessible and rewritable storage medium used in the modern computers. It is a physical drive in a computer which is capable of holding and retrieving information. The disk drives are used for storing and accessing the data for performance-intensive, online application. They support quick access to random data locations, which means that the data can be written or retrieved in a quick manner for a higher number of simultaneous users or applications.

Disk drives can either be found internally within a computer or it can be an external device attached to the computer. They are found in personal computers, laptops and storage arrays. They offer a large storage capacity. The storage arrays of disks are configured with various disks in order to provide increased capacity and enhanced performance.

A disk drive uses a rapidly moving arm to perform the read and write functions on a data across a flat platter which is coated with magnetic particles. The transmission of data takes place from the magnetic platter to through the read/write head to the computer. Multiple platters are assembled together with the read/write head and the controller. The controller is popularly known as a HDD. The recording and deletion of data on a magnetic disk can happen any number of times.

Following are the key components of a disk drive:

- Platter
- Spindle
- Read/write head
- Actuator arm assembly
- Controller

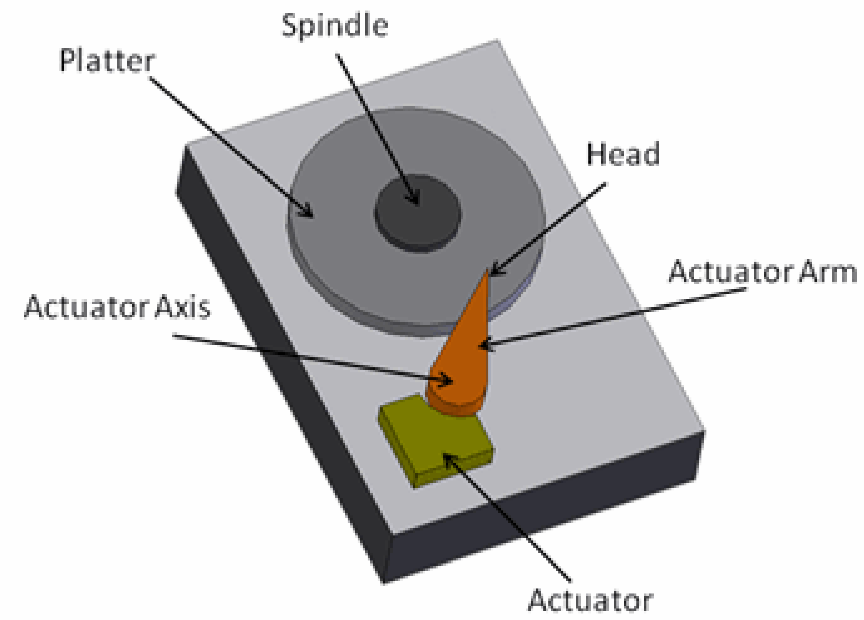

Figure 2.1.7: Components of a Disk Drive

Let us discuss each of the components in detail.

(i) Platter

One of the key components of a disk drive are platters. The hard drives are composed of multiple flat, circular disk like structures known as platters. The platters are stacked on each other and can be aluminium, glass, or ceramic disks placed within a hard drive to permanently store the computer's data.

They consist of a substrate coated with magnetic media which acts as a rigid support for the magnetic media. The magnetic layer is provided protection by a thin coating of carbon and lubricant so that it can prevent any damage in case the head comes in contact with the surface of the platter. Both sides of the platter contain magnetic media where the data can be stored. Tens of thousands of tracks per inch can be laid down on these platters.

When the computer is turned on, these platters begin to rotate at multiple revolutions per minute (RPM). The rate of rotation of platters depends upon the model of the hard drive. As the platters rotate, the read/write head of the drive accesses information present on the platters.

Data is recorded on these platters in binary codes, which is zero and one. Within a platter, the data is stored in tracks, sectors and cylinders. The set of rotating platters are sealed in a case known as a Head Disk Assembly (HDA). The data is encoded by polarising the magnetic area of the surface of the disk.

The storage and read/write of data can happen from both the top and bottom surfaces of the platter. The actual storage capacity of a drive is determined by the number of platters in a drive and the storage capacity of each platter.

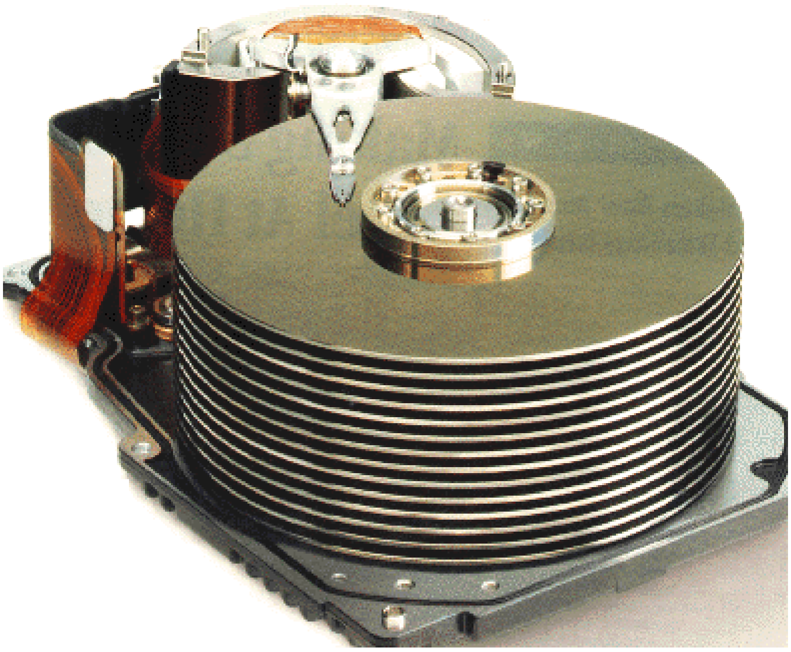

Figure 2.1.8: Platter

(ii) Spindle

A spindle is a shaft that rotates in the middle of the disk drives and holds together the rotating platters. Spindle is what holds the hard drive platters in place. The spindle holds these platters in a fixed position and provides enough space for the read/write arms to get in contact with the data on the disks.

A spindle connects all the platters and is also connected to a motor, which rotates with a constant speed. The speed of the spindle is measured in RPM and it can be several thousands of RPM. The performance of the disk drive can be gauged by the spindle speed.

Disk drives have spindle speeds of 7,200 RPM, 10,000 RPM, or 15,000 RPM. The speed of the spindle can affect the seeking time as well as the sustained rate at which the read/write functions can be performed on a data. Seek time is the speed at which a drive can locate a single bit of an information

The disk drive platters which are used on the current storage systems have a diameter of 3.5" or 90 mm. When the platter rotated at 15,000 RPM, the outer edge of the platter moves at around 25 percent of the speed of sound. With the improvement in technology, the speed of the revolution of platter is also increasing; however, extent of the improvement is limited.

Figure 2.1.9: Spindle

Did You Know?

In a removable disk, the spindle remains attached to the drive, such as in a CD-ROM. In a fixed disk, the spindle remains attached to the platter.

(iii) Read/Write Head

A read/write head is a part of the hard disk that is responsible for reading data from and writing data to the platter. The disk drives have two read/write heads per platter, one for each surface, top and bottom, of the platter. The read/write heads are made up of a thin, horizontal magnetic blade which is attached to an actual arm. Unlike the disk platter, the actual read/write head is made small. In modern disks, these parts are designed down to the nanoscale.

The read/write arm effectively records data to a disk drive by changing the electrical polarity of bits on a magnetic disk. While writing the data on the platter, the magnetic polarisation on the surface of the platter is changed by the read/write head. The head detects the magnetic polarisation on the surface of the platter while reading the data. The read/write head senses the magnetic polarisation and never touches the surface of the platter during the read and write functionality.

There is a microscopic air gap between the read/write heads and the platter when the spindle is rotating. This microscopic air gap is known as the **head flying height**. When the spindle stops rotating, this air gap is removed and the read/write head rests on a particular area on the platter near the spindle known as the **landing zone**. The landing zone is layered with lubricant to avoid friction between the head and the platter.

The disk drive logic ensures that the read/write heads are moved towards the landing zone before they touch the surface. Accidently, due to a malfunction, if the read/write head comes in contact with the surface of the platter outside the landing zone, the magnetic coating on the platter can be scratched and it may cause damage to the read/write head as well. Such situation is called a **head crash**. A head crash generally results in the loss of data.

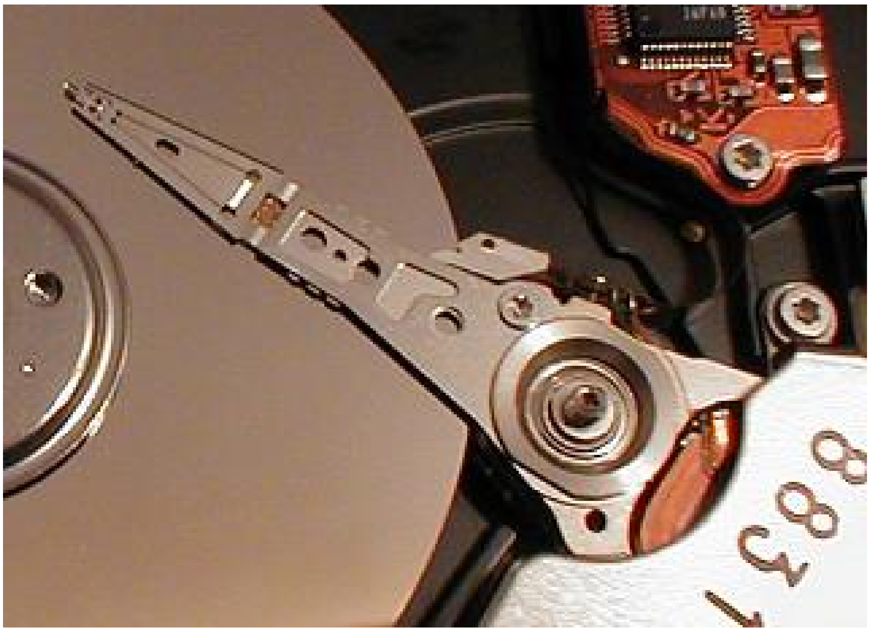

Figure 2.1.10: Read/Write Head

(iv) Actuator Arm Assembly

The read/write head accesses the platters for performing the read/write functionality. To do so, they must be held in an exact position which should be relative to the surfaces where the read/write operation is going on. Also, they must be moved from one track to the other to allow access to the entire surface of the disk. The read/write heads are mounted on a structure that facilitates and enables this process. That structure is known as the actuator arm assembly and it consists of various parts.

The read/write heads are mounted on head sliders and these head sliders are suspended over the surface of the disk at the ends of head arms. These head arms are mechanically fused into a single structure which moves around the surface of the disk with the help of an actuator.

An actuator is an electronic device that is controlled with a motor and is used to move the head arms. In older computers, the actuator arm was controlled by a stepper motor, which is an actuator motor that operates in small, consistent increments. However, today, the stepper motor has been replaced by the servo motor.

The read/write heads are mounted on the actuator arm assembly which positions the read/write head at the location where the data needs to read from or written to. The read/write heads for all the platters are attached to one actuator arm and move across the platters in a simultaneous manner.

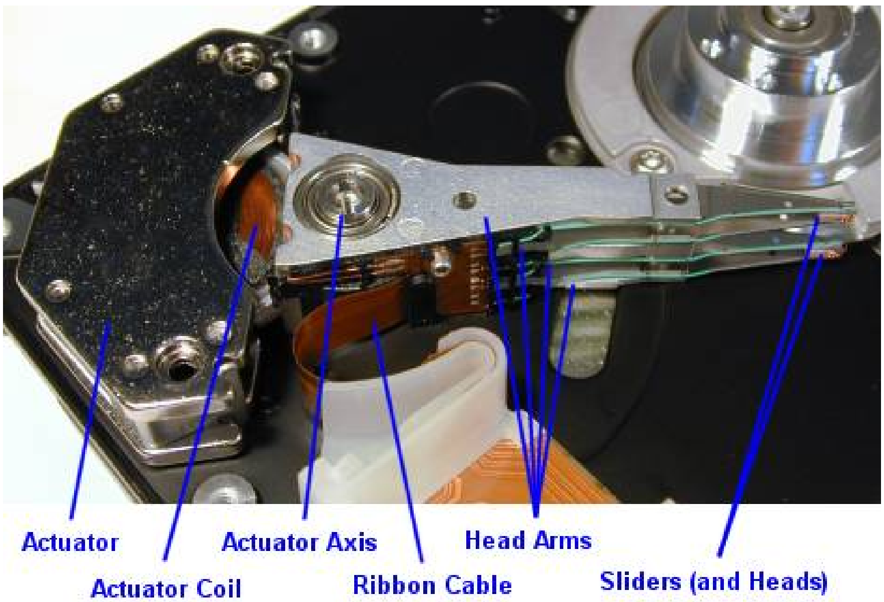

Figure 2.1.11: Actuator Arm Assembly

(v) Controller

The controller is a printed circuit board, which is mounted at the bottom of a disk drive. It is a circuit that enables the computer to read and write the information to a hard drive.

The controller consists of a microprocessor, circuitry, internal memory and firmware. The power to the spindle motor and the speed of the motor is controlled by the firmware. The controller also manages the drive and the host communications and controls the read/write operations by moving the actuator arm and making it switch between different read/write heads. It also performs the optimisation of data access.

It also acts as a bus and connects the hard disk to the rest of the components of the computer. Today, the controllers are built-in into the hard disk; they usually are the circuit boards covering the bottom part or are present on the back portion of the disk drive.

Now, let us understand the physical structure of the disk.

(vi) Physical Disk Structure

The physical structuring of the disk is as follows:

- **Tracks:** Around the spindle, tracks are concentric rings on the platter where the data gets stored. From the outer edge of the platter, the tracks are numbered starting from zero. The density of the tracks is measured as number of tracks per inch (TPI) and it measures how closely the tracks are packed on a platter.

- **Sectors:** Tracks are further broken down into sectors. A sector is the smallest unit of storage which can be individually addressed. The driver manufacturer mentions the track and the sector structure on the platter using a formatting operation. The number of sector per tracks depend on the model of the drive. There can be thousands of tracks on a platter, based on the physical dimensions and the recording density of the platter. Although some disks may be formatted with larger sector sizes, typically, a sector holds 512 bytes of user data. It also holds other information, such as platter or head number and track number. This information is required to easily locate the data on the drive, but storing this kind of information also consumes some space on the disk. And, hence there is a difference between the storage capacity of an unformatted and a formatted disk. ***For example***, a disk advertised as capable of 500 GB storage will only be able to hold approx. 456.7 GB of data, since, the remaining 34.3 GB is being utilised for metadata.

- **Cylinders:** On drives that have multiple platters, all the tracks present on all the platters that are equidistant from the centre can be referred to as cylinders. It is a set of identical tracks present on both the top and bottom surfaces of each platter.

- **Clusters:** The grouping of sectors are known as clusters. For an operating system, all the sectors in a cluster is considered to be single unit.

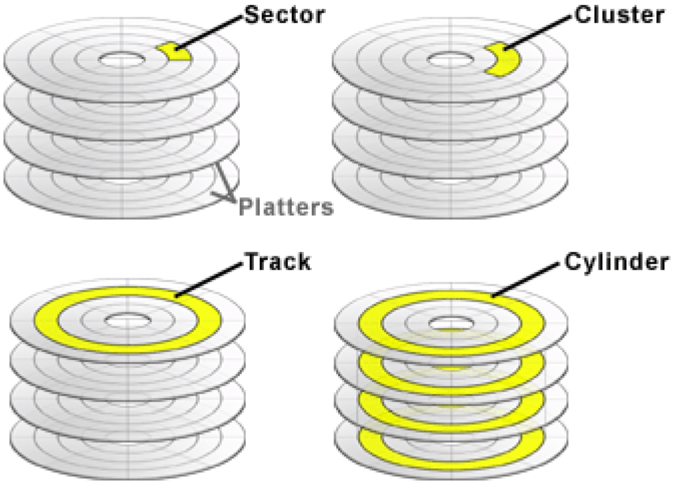

Figure 2.1.12: Physical Disk Structure

Did You Know?

The first personal computer disks had 17 sectors per track.

(vii) Zoned Bit Recording

The platters are made up of concentric tracks. Hence, the outer tracks being physically longer than the inner ones, can store more amount of data. In older times, the number of sectors in both the outer and inner tracks were the same. Due to this, the data density was low on the outer tracks, which was an inefficient use of the available space and a lot of space was getting wasted.

With zone bit recording, the disk can be utilised efficiently. This mechanism does the grouping of tracks into zones, on the basis of their distance from the disk centre. The numbering of the zones is made and the outermost zone is numbered as zone zero. Each zone is assigned an appropriate number of sectors per track. Based on this, the zone near the disk centre has fewer tracks as compared to the zone on the outer edge. However, the number of sectors are same for the tracks that fall into a particular zone.

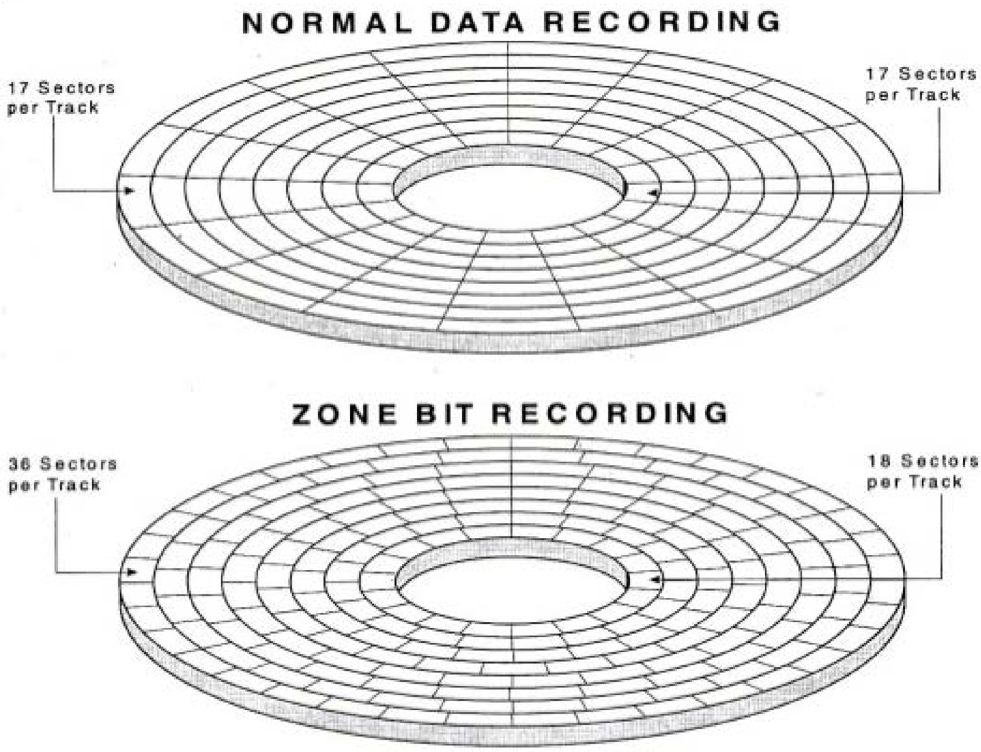

Figure 2.1.13: Zone Bit Recording

(viii) Logical Block Addressing (LBA)

Earlier, the physical address consisting of the cylinder, head and sector (CHS) numbers were used by the drives to refer to a specific location on the disk. In such cases, the host operating system had to be aware of the geometry of each disk which was in use.

LBA, simplifies this problem of addressing by using a linear address to access the physical blocks of the stored data. LBA is translated to a CHS address by the disk controller and the host only needs to be aware of the size of the disk drive in terms of the number of blocks. The mapping of the logical blocks to the physical sectors is done on a 1:1 basis. Each block has its own unique address.

Let us consider an example where the drive has eight sectors per track, eight heads and four cylinder. So, if we need to calculate the number of blocks, we need to multiply them together, which is 8 x 8 x 4 = 256 blocks.

So, the block number ranges from 0 to 255.

Considering that the sector contains 512 bytes of data, a 500 GB drive that has a formatted capacity of 465.7 GB will have more than 976,000,000 blocks.

Self-assessment Questions

7) Which of the following are the key components of a disk drive? Choose all that apply.
   a) Platter
   b) Spindle
   c) Controller
   d) Read/write head

8) Within a platter, the data gets stored in which of the following. Choose all that apply.
   a) Tracks
   b) Sectors
   c) Spindle
   d) Cylinders

9) Which of the following spindle speeds can a disk drive possess? Choose all that apply.
   a) 7,200 RPM
   b) 10,000 RPM
   c) 15,000 RPM
   d) 20,000 RPM

10) When the spindle is moving, what is the microscopic air gap between the read/write head and the platter known as?
    a) Landing zone
    b) Head flying height
    c) Head resting zone
    d) Head crash

11) Which of the following when occurs, generally, results in the loss of data?
    a) Head crash
    b) Read/write head on landing zone
    c) Spindle rotation
    d) Actuator arm movement

12) Which of the following mechanism does the grouping of tracks into zones, based on their distance from the centre?
    a) Logical block addressing
    b) Physical disk structuring
    c) Track grouping
    d) Zoned bit recording

Summary

- The main components of storage system environments are host, connectivity and storage.
- A host is a computer or any other device on which applications run.
- Communication between the physical components takes place with the help of a communication pathway, which is known as a bus.
- The interconnections between two or more hosts or between host any other peripheral devices, such as printer or any storage devices, can be understood as connectivity.
- Buses can be classified as system bus and local bus.
- The logical components of connectivity are PCI, IDE/ATA and SCSI.
- In the storage system environment, a storage device is the most important component. A storage device uses the magnetic, optical, or solid state media.
- A disk drive is a physical drive in a computer which is capable of holding and retrieving information and are used for storing and accessing the data for performance-intensive, online application.
- The key components of a disk drive are platter, spindle, read/write head, actuator arm assembly and controller.
- Data is recorded on these platters in binary codes, which is zero and one. Within a platter, the data is stored in tracks, sectors and cylinders.
- A spindle connects all the platters and is also connected to a motor, which rotates with a constant speed. Disk drives have spindle speeds of 7,200 RPM, 10,000 RPM, or 15,000 RPM.
- There is a microscopic air gap between the read/write heads and the platter when the spindle is rotating. This microscopic air gap is known as the head flying height.
- When the spindle stops rotating, this air gap is removed and the read/write head rests on a particular area on the platter near the spindle known as the landing zone.

- The physical structuring of the disk is done as tracks, sectors, cylinders and clusters.
- Zone bit recording groups tracks into zones based on their distance from the centre of the disk.
- Local block addressing (LBA) simplifies the problem of addressing by using a linear address to access the physical blocks of the stored data.

Terminal Questions

1. What is zone bit recording and why is it required?
2. Explain the structuring of a physical data.
3. Explain the reason behind less storage capacity in a formatted disk than an unformatted disk with an example.

Answer Keys

Self-assessment Questions	
Question No.	**Answer**
1	a, c, d
2	b
3	d
4	b
5	a
6	c
7	a, b, c, d
8	a, b, d
9	a, b
10	b
11	a
12	d

Activity

Activity Type: Offline **Duration:** 45 Minutes

Description:

Do a thorough study for each components of the storage system environment and disk drive and write a brief description for each component.

Case Study

Your company has decided to back up all the historical data scattered at places and keep it safe for future references. The volume of the data is quite high and the management has called for a meeting to ask for suggestions. One of your colleagues suggests using DVDs for taking and storing the backups.

- Do you agree with the suggestion of your colleague? State reasons for your choice.
- What, according to you, can be the best medium for backing up and storing the large volume of data?

Bibliography

e-References

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- *Optical media.* (2005). *SearchStorage*. Retrieved 23 June 2016, from http://searchstorage.techtarget.com/definition/optical-media

- *How to understand disk performance.* (n.d.). *Pcp.io*. Retrieved 23 June 2016, from http://www.pcp.io/pcp.git/man/html/howto.diskperf.html

- *Section 2 – Storage Systems Architecture.* (2006). Retrieved from http://read.pudn.com/downloads168/ebook/772307/STF2-0SectionIntroduction.pdf

Image Credits

- Figure 2.1.1: http://www.xeonbd.com/images/icons/computer-multiple.png, http://www.iconshock.com/img_jpg/REALVISTA/development/jpg/256/server_icon.jpg, https://pixabay.com/static/uploads/photo/2012/04/13/20/24/laptop-33521_960_720.png, http://www.clker.com/cliparts/2/0/1/d/1231686170190013628kattekrab_Mainframe.svg.med.png

- Figure 2.1.2 : http://www.jegsworks.com/lessons/ComputerBasics/lesson7/network-star.png

- Figure 2.1.3 : https://upload.wikimedia.org/wikipedia/commons/8/83/Magtape1.jpg

- Figure 2.1.5: http://www.computersupplies.us/compact-discs-582.jpg

- Figure 2.1.6: https://regmedia.co.uk/2007/03/27/sams_64gb_ssd_1.jpg
- Figure 2.1.7: http://www.ni.com/cms/images/devzone/tut/harddrive.gif
- Figure 2.1.8: http://www.hdd-tool.com/pic/hard-drive-PLATTER.GIF
- Figure 2.1.9: http://badmin.org/archangel/wp-content/uploads/2014/12/hdd-spindle.png
- Figure 2.1.10: http://www.fonerbooks.com/laptop/hard_2.jpg
- Figure 2.1.11: http://www.pcguide.com/ref/hdd/op/z_000873actassy.jpg
- Figure 2.1.12: http://www.sweetscape.com/010editor/images/010edsector.png
- Figure 2.1.13: http://image.slidesharecdn.com/chap2hdd2-120302094246-phpapp02/95/chap2-hdd2-28-728.jpg?cb=1330681666

External Resources

- Somasundaram, G. & Shrivastava, A. (2009) *Information storage and management* - Storing, managing and protecting digital information. *Indianapolis, Ind.: Wiley Pub.*

- Arpaci-Dusseau, R. & Arpaci-Dusseau, A. (2015). Hard Disk Drives. In R. Arpaci-Dusseau & A. Arpaci-Dusseau, *Operating Systems: Three Easy Pieces* (1st ed.). Arpaci-Dusseau Books.

- Dufrasne, B., Eriksson, R., Martinez, L., & Kalabza, W. (2014). *IBM XIV Storage System Architecture and Implementation* (9th ed.). International Business Machines Corporation.

Video Links

Topic	Link
Hard disks, sectors, zone bit recording, sectors vs blocks, CHS, LBA	https://www.youtube.com/watch?v=Cj8-WNjaGuM
Logical block addressing	https://www.youtube.com/watch?v=G0JL1rlJ7pk
Storage Media	https://www.youtube.com/watch?v=kOsqBdtV0Xc
Hard disk working	https://www.youtube.com/watch?v=4iaxOUYalJU

Notes: