BACHELOR OF COMPUTER APPLICATIONS

SEMESTER 3

DCA2103

COMPUTER ORGANIZATION

Unit 8

Secondary Memory

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1. INTRODUCTION

In the previous unit, you studied high-speed memories. You also studied Cache Memory, External Memory, Virtual memory, and Memory Management in operating systems. In this unit you will be introduced to the secondary memory and its types. Secondary memory is a non-volatile form of memory that is connected to the motherboard but is not part of it. Secondary memory is slower than primary memory because it is located further away from the CPU. There are many forms of secondary memory that can be used for long-term storage, backup, or transfer of data including - Hard Drives (direct access). Hard Drives are the most common form of secondary memory and are used to locally store and copy data. Tapes (sequential access) are used in the industry to backup very large amounts of data, and CDs (direct access) are used to transfer music files, and data and are used sometimes for the backup of files. USB Sticks (direct access) are used often as a portable form for data storage and are used to transfer data from one place to another. Flash Memories (direct access) which include Cards and USB Sticks are used to transfer data from one computer to another or store files on Cameras or MP3 Players.

1.1 OBJECTIVES:

After studying this unit, students should be able to:

- *Explain Magnetic Disk and Tape*
- *Describe Digital Audio Tape (DAT)*
- *Define RAID and list its levels*
- *Discuss optical memories*

2. MAGNETIC DISK AND TAPE

Magnetic tape is a medium for magnetic recording, made of a thin magnetizable coating on a long, narrow strip of plastic film. It was developed in Germany, based on magnetic wire recording. Devices that record and playback audio and video using magnetic tape are tape recorders and videotape recorders. A device that stores computer data on magnetic tape is a drive. Magnetic tape revolutionized broadcast and recording. When all radio was live, it allowed programming to be pre-recorded. At a time when gramophone records were recorded in one take, it allowed recordings to be made in multiple parts, which were then mixed and edited with tolerable loss in quality. It is a key technology in early computer development, allowing unparalleled amounts of data to be mechanically created, stored for long periods, and to be rapidly accessed. Figure 8.1 shows Compact Cassette.

Fig 8.1: Compact Cassette

Magnetic tape was invented for recording sound by Fritz Pfleumer in 1928 in Germany, based on the invention of magnetic wire recording by Valdemar Poulsen in 1898. Pfleumer's invention used a ferric oxide (Fe_2O_3) powder coating on a long strip of paper. This invention was further developed by the German electronics company AEG, which manufactured the recording machines, and BASF, which manufactured the tape. In 1933, working for AEG, Eduard Schuller developed the ring-shaped tape head. Previous head designs were needle-shaped and tended to shred the tape. An important discovery made in this period was the technique of AC biasing which improved the fidelity of the recorded audio signal by increasing the effective linearity of the recording medium.

Magnetic tape

Magnetic tape revolutionized broadcast and recording. When all radio was live, it allowed programming to be pre-recorded. At a time when gramophone records were recorded in one take, it allowed recordings to be made in multiple parts, which were then mixed and edited with tolerable loss in quality. Figure 8.2 shows Magnetic tape.

Fig 8.2: Magnetic tape

The practice of recording and editing audio using magnetic tape rapidly established itself as an obvious improvement over previous methods. Many saw the potential of making the same improvements in recording television. Television ("video") signals are similar to audio signals. A major difference is that video signals use more bandwidth than audio signals. Existing audio tape recorders could not practically capture a video signal. Many set to work on resolving this problem.

Data storage

In all tape formats, a tape drive (or "transport" or "deck") uses motors to wind the tape from one reel to another, passing tape heads to read, write or erase as it moves. Magnetic tape was first used to record computer data in 1951 on the Eckert-Mauchly UNIVAC I. The recording medium was a thin strip of one-half inch (12.65 mm) wide metal, consisting of nickel-plated bronze. Recording density was 128 characters per inch (198 micrometer/ character) on eight tracks. Figure 8.3 shows a Small open reel of 9 track tape

Fig 8.3: Small open reel of 9 track tape

Most modern magnetic tape systems use reels that are much smaller than the 10.5 inch open reels and are fixed inside a cartridge to protect the tape and facilitate handling. Many late 1970s and early 1980s home computers used Compact Cassettes, encoded with the Kansas City standard, or several other "standards" such as the Tarbell Cassette Interface. Modern cartridge formats include LTO, DLT, and DAT/DDC.

Tape remains a viable alternative to disk in some situations due to its lower cost per bit. This is a large advantage when dealing with large amounts of data. Though the areal density of tape is lower than for disk drives, the available surface area on a tape is far greater. The highest capacity tape media are generally in the same order as the largest available disk drives (about 5 TB in 2011). The tape has historically offered enough advantage in cost over disk storage to make it a viable product, particularly for backup, where media removability is necessary.

SELF ASSESSMENT QUESTIONS – 1

1. A device that stores computer data on magnetic tape is a_____________ .
2. Magnetic tape was first used to record computer data in_____________ .

3. DIGITAL AUDIO TAPE (DAT)

Digital Audio Tape (DAT) is a signal recording and playback medium developed by Sony and introduced in 1987. In appearance it is similar to a compact audio cassette, using 4 mm magnetic tape enclosed in a protective shell, but is roughly half the size at 73 mm × 54 mm × 10.5 mm. As the name suggests, the recording is digital rather than analog. DAT can record at higher, equal, or lower sampling rates than a CD (48, 44.1, or 32 kHz sampling rate respectively) at 16 bits quantization. If a digital source is copied then the DAT will produce an exact clone, unlike other digital media such as Digital Compact Cassette or non-Hi-MD Minidisc, both of which use a loss data reduction system.

For example:

Although intended as a replacement for audio cassettes, the format was never widely adopted by consumers because of issues of expense and concerns from the music industry about unauthorized digital quality copies. The format saw moderate success in professional markets and as a computer storage medium. As Sony has ceased production of new recorders, it will become more difficult to play archived recordings in this format unless they are copied to other formats or hard drives. Below Figure **8.4** shows Digital Audio Tape (DAT).

Fig 8.4: Digital Audio Tape (DAT)

Use of DAT

Professional recording industry

DAT was used professionally in the 1990s by the professional audio recording industry as part of an emerging all-digital production chain also including digital multi-track recorders and digital mixing consoles that were used to create a fully digital recording.

Amateur and home use

DAT was envisaged by proponents as the successor format to analog audio cassettes in the way that the compact disc was the successor to vinyl- based recordings; however, the technology was never as commercially popular as CD or cassette. DAT recorders remained relatively expensive, and commercial recordings were generally not made available on the format. However, DAT was, for a time, popular for making and trading recordings of live music (see bootleg recording), since available DAT recorders predated affordable CD recorders.

Computer data storage medium

The format was designed for audio use, but the ISO Digital Data Storage standard was adopted for general data storage, storing from 1.3 to 80 GB on a 60 to 180-meter tape depending on the standard and compression. It is a sequential-access medium and is commonly used for backups. Due to the higher requirements for capacity and integrity in data backups, a computer-grade DAT was introduced, called DDS (Digital Data Storage). Although functionally similar to audio DATs, only a few DDS and DAT drives (in particular, those manufactured by Archive for SGI workstations)[6] are capable of reading the audio data from a DAT cassette. SGI DDS4 drives no longer have audio support; SGI removed the feature due to "lack of demand"

SELF ASSESSMENT QUESTIONS – 2

3. First Digital Audio Tape (DAT) introduced in____________Year.
4. DDS stand for_________________.

4. RAID

RAID (redundant array of independent disks, originally redundant array of inexpensive disks) is a storage technology that combines multiple disk drive components into a logical unit. Data is distributed across the drives in one of several ways called "RAID levels", depending on what level of redundancy and performance (via parallel communication) is required.

RAID is an example of storage virtualization and was first defined by David Patterson, Garth A. Gibson, and Randy Katz at the University of California, Berkeley in 1987. Marketers representing industry RAID manufacturers later attempted to reinvent the term to describe a redundant array of independent disks as a means of dissociating a low-cost expectation from RAID technology.

RAID is now used as an umbrella term for computer data storage schemes that can divide and replicate data among multiple physical drives. The physical drives are said to be in a RAID array, which is accessed by the operating system as one single drive. The different schemes or architectures are named by the word RAID followed by a number (e.g., RAID 0, RAID 1). Each scheme provides a different balance between three key goals: resiliency, performance, and capacity.

Standard RAID levels

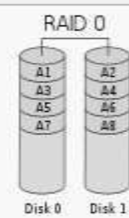
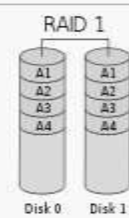
A number of standard schemes have evolved which are referred to as levels. There were five RAID levels originally conceived, but many more variations have evolved, notably several nested levels and many non-standard levels (mostly proprietary). RAID levels and their associated data formats are standardized by the Storage Networking Industry Association (SNIA) in the Common RAID Disk Drive Format (DDF) standard.

The most commonly used RAID levels are:

- **RAID 0** (block-level striping without parity or mirroring) has no (or zero) redundancy. It provides improved performance and additional storage but no fault tolerance. Hence simple stripe sets are normally referred to as RAID 0. Any drive failure destroys the array, and the likelihood of failure increases with more drives in the array (at a minimum, catastrophic data loss is almost twice as likely compared to single drives without RAID). A single drive failure destroys the entire array because when data is written to a RAID 0 volume, the data is broken into fragments called blocks. The number of blocks is dictated by the stripe size, which is a configuration parameter of the array. The blocks are written to their respective drives simultaneously on the same sector. This allows smaller sections of the entire chunk of data to be read off each drive in parallel, increasing bandwidth. RAID 0 does not implement error checking, so any error is uncorrectable. More drives in the array mean higher bandwidth, but a greater risk of data loss.

- **RAID 1** (mirroring without parity or striping), data is written identically to two drives, thereby producing a "mirrored set"; at least two drives are required to constitute such an array. While more constituent drives may be employed, many implementations deal with a maximum of only two; of course, it might be possible to use such a limited level 1 RAID itself as a constituent of a level 1 RAID, effectively masking the limitation. The array continues to operate as long as at least one drive is functioning. With appropriate operating system support, there can be increased read performance, and only a minimal write performance reduction; implementing RAID 1 with a separate controller for each drive in order to perform simultaneous reads (and writes) is sometimes called multiplexing (or duplexing when there are only two drives).
- **RAID 2** (bit-level striping with dedicated Hamming-code parity), all disk spindle rotation is synchronized, and data is striped such that each sequential bit is on a different drive. Hamming-code parity is calculated across corresponding bits and stored on at least one parity drive.
- **RAID 3** (byte-level striping with dedicated parity), all disk spindle rotation is synchronized, and data is striped so each sequential byte is on a different drive. Parity is calculated across corresponding bytes and stored on a dedicated parity drive.
- **RAID 4** (block-level striping with dedicated parity) is identical to RAID 5 (see below), but confines all parity data to a single drive. In this setup, files may be distributed between multiple drives. Each drive operates independently, allowing I/O requests to be performed in parallel. However, the use of a dedicated parity drive could create a performance bottleneck; because the parity data must be written to a single, dedicated parity drive for each block of non-parity data, the overall write performance may depend a great deal on the performance of this parity drive.

- **RAID 5** (block-level striping with distributed parity) distributes parity along with the data and requires all drives but one to be present to operate; the array is not destroyed by a single drive failure. Upon drive failure, any subsequent reads can be calculated from the distributed parity such that the drive failure is masked from the end-user. However, a single drive failure results in reduced performance of the entire array until the failed drive has been replaced and the associated data rebuilt. Additionally, there is the potentially disastrous RAID 5 write hole. RAID 5 requires at least three disks.
- **RAID 6** (block-level striping with double distributed parity) provides fault tolerance of two drive failures; the array continues to operate with up to two failed drives. This makes larger RAID groups more practical, especially for high-availability systems. This becomes increasingly important as large-capacity drives lengthen the time needed to recover from the failure of a single drive the following table provides an overview of the most important parameters of standard RAID levels. Below figure **8.5** shows RAID Levels.

Level	Description	Minimum # of drives**	Space Efficiency	Fault Tolerance	Array Failure Rate***	Read Benefit	Write Benefit	Image
RAID 0	Block-level striping without parity or mirroring.	2	1	0 (none)	$1-(1-r)^n$	nX	nX	
RAID 1	Mirroring without parity or striping.	2	1/n	n−1 drives	r^n	nX	1X	

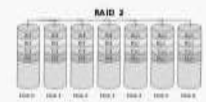
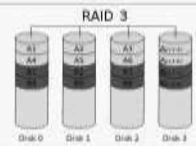
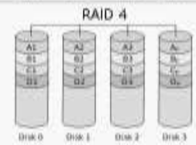
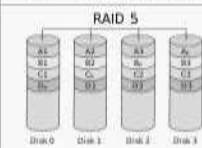
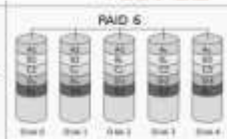
RAID 2	Bit-level striping with dedicated Hamming-code parity.	3	$1 - 1/n \cdot \log_2(n-1)$	RAID 2 can recover from 1 drive failure or repair corrupt data or parity when a corrupted bit's corresponding data and parity are good.	variable	variable	variable	
RAID 3	Byte-level striping with dedicated parity.	3	$1 - 1/n$	1 drive	$n(n-1)r^2$	$(n-1)X$	$(n-1)X^*$	
RAID 4	Block-level striping with dedicated parity.	3	$1 - 1/n$	1 drive	$n(n-1)r^2$	$(n-1)X$	$(n-1)X^*$	
RAID 5	Block-level striping with distributed parity.	3	$1 - 1/n$	1 drive	$n(n-1)r^2$	$(n-1)X^*$	$(n-1)X^*$	
RAID 6	Block-level striping with double distributed parity.	4	$1 - 2/n$	2 drives	$n(n-1)(n-2)r^3$	$(n-2)X^*$	$(n-2)X^*$	

Fig 8.5: RAID Levels

In any case, Array space efficiency is given as an expression in terms of the number of drives, this expression designates a value between 0 and 1, representing the fraction of the sum of the drives' capacities that are available for use. For example, if three drives are arranged in RAID 3, this gives an array space efficiency of (approximately 66%); thus, if each drive in this example has a capacity of 250 GB, then the array has a total capacity of 750 GB but the capacity that is used for data storage is only 500 GB.

The array failure rate is given as an expression in terms of the number of drives, and the drive failure rate, (which is assumed to be identical and independent for each drive). For example, if each of three drives has a failure rate of 5% over the next 3 years, and these drives are arranged in RAID 3, then this gives an array failure rate of over the next 3 years.

SELF ASSESSMENT QUESTIONS – 3

5. RAID stand for________________
6. SNIA stands for________________
7. Block-level striping with dedicated parity______________
8. Block-level striping with double distributed parity________________

5. OPTICAL MEMORY

Optical memory was an early form of computer memory invented at the Mellon Institute in the 1950s. The device used a combination of photoemissive and phosphorescent materials to produce a "light loop" between two surfaces. The presence or lack of light, detected by a photocell, represented a one or zero. Although promising, the system was rendered obsolete with the introduction of core memory in the early 1950s. It appears that the system was never used in production, but it represents one of the typically odd earlier attempts to produce a useful high-speed memory system.

Writing

Writing to the cell was accomplished by an external cathode ray tube (CRT) arranged in front of the photoemissive side of the grid. Cells were selected by using the deflection coils in the CRT to pull the beam into position in front of the cell, lighting up the front of the tube in that location. This initial pulse of light, focussed through a lens, would set the cell to the "on" state. Due to the way the photoemissive layer worked, focusing light on it again when it was already "lit up" would overload the material, stopping electrons from flowing out the other side into the interior of the cell. When the external light was then removed, the cell was dark, turning it "off".

Reading

Reading the cells was accomplished by a grid of photocells arranged behind the phosphorescent layer, which emitted photons non-directionally. This allowed the cells to be read from the back of the device, as long as the phosphorescent layer was thin enough. To form a complete memory the system was arranged to be regenerative, with the output of the photocells being amplified and sent back into the CRT to refresh the cells periodically.

The storage capacity of most CD-ROMs is about 650Mb of data. Originally CD-ROMS were read-only devices, but now read/write technology has been developed.

CD-ROMs

Many CD-ROMs are the interface to the computer using the ATAPI (Attachment Packet Interface) interface. This is ATA Packet Interface which is an IDE interface. This is designed for extra drives like CD-ROMs and tape drives that connect to an ATA(AT Attachment) connector. The ATAPI interface is the standard interface for IDE-controlled CD-ROMS. If your CD-ROM uses an ATAPI interface, it should be supported by all available software. If you are using a SCSI controller, you should probably use a SCSI CD-ROM. There are two primary types of CD-ROMs today.

1. Read-only
2. Read and Write CD-ROM

These are primarily available as an internally mounted drive, but can also be purchased as an external device. There are some CD-ROM drives that interface through the parallel printer port.

Speed

The primary performance concern of CD-ROM drives is their speed. Speeds are expressed in terms of 1X, 2X, and 4X, which is the number of times the drive is then the standard CD-ROM reader. Of the read-only type, speeds have exceeded 50X. CD-ROMS of up to 52X speeds and beyond can be purchased today for a reasonably low price.

The read/write types of CD-ROM speeds are expressed with three values. They are **read, write, and rewrite**. Therefore we recommend you do not rely upon your read/write CD-ROM drive for reading normal CDs, especially where playing games is concerned. You could wear out your expensive CD- ROM performing read operations which cost a great deal more than a read-only CD-ROM!

Other Storage Devices

- **DVD Drive –** DVD stands for Digital Video Disk. Most DVD drives use the ATAPI interface. They are available as internal or external devices. They can operate at up to 16X speeds but 8X is more common. They are primarily used for video storage but they can be used to hold audio and computer data. DVD is categorized into DVD-Video and DVD-ROM devices. The DVD-ROM device is for computer data storage.

- **Zip drives** – A removable cartridge storage device that may be used to store compressed data as a data backup method. A zip drive has between a 100Mb to 2G storage capacity. Some zip drives can also be used to read standard 3.5 inch floppy diskettes.
- **Tape drives backup kits –** Their capacity is 3G to 40G. The cost range is from $200 to $1000.

CD – Compact Disk

- Non-erasable
- Stores digitized audio
- 12 cm disk
- 60 minute uninterrupted playing time

CD-ROM – Compact Disk Read-Only Memory

- Non-erasable
- 12 cm
- 650 Byte capacity
- Disk made of polycarbonate resin
- Stores computer data as a series of microscopic pits on the surface of a Polycarbonate resin using a highly focused laser
- Polycarbonate coated with a highly reflective material such as aluminum
- Acrylic coating added for protection – label printed on acrylic coating
- Data read using reflecting laser – reflection intensity determines the value
- Disk contains a single spiral track – starts at the center and ends at the edge
- Constant linear velocity – disk rotates slower towards the edge CD-ROM Block Format Data organized as a sequence of blocks
- Sync: beginning of a block – byte of 0s, 10 bytes of 1s, byte of 0s
- Header: block address and mode byte
  - ✓ 0 – blank data
  - ✓ 1 – ECC and 2048 bytes of data

    - ✓ 2 – No ECC and 2336 bytes of data
- Data: user data
- Auxiliary:
    - ✓ Mode 1 – 288 byte ECC
    - ✓ Mode 2 – additional user data

CD-R – CD-Recordable

- Similar to CD-ROM
- Can be written to once
- Medium includes a dye layer – high-intensity laser used to change reflectivity
- Provides a permanent record of large volumes of user data

CD-RW – CD Rewritable

- Similar to CD-ROM
- Can be written to and erased multiple times
- Phase change – two different reflections in two different phase states – laser

DVD – Digital Versatile Disk

DVD is an optical disc storage format, invented and developed by Philips, Sony, Toshiba, and Panasonic in 1995. DVDs offer higher storage capacity than Compact Discs while having the same dimensions. Pre-recorded DVDs are mass-produced using molding machines that physically stamp data onto the DVD. Such discs are known as DVD-ROMs because data can only be read and not written nor erased. Blank recordable DVDs (DVD-R and DVD+R) can be recorded once using a DVD recorder and then function as a DVD-ROM. Rewritable DVDs (DVD-RW, DVD+RW, and DVD-RAM) can be recorded and erased multiple times. DVDs are used in DVD-Video consumer digital video format and in DVD-Audio consumer digital audio format, as well as for authoring AVCHD discs. DVDs containing other types of information may be referred to as DVD data discs. Figure 8.6 shows the DVD.

Fig 8.6: DVD

- Originally for producing digitized, compressed representations of video Information
- Also used for storing large volumes of other digital data
- 8 and 12 cm disks
- 17 G byte capacity
- Basic DVD is read-only (DVD-ROM)

CD-ROM and DVD-ROM

Bits packed more closely on a DVD

- Spiral spacing on a CD is 1.6 um – distance between pits is 0.834 um
- Spiral spacing on a DVD is 0.74 um – distance between pits is 0.4 um
- Shorter wavelength laser
- Seven-fold increase in capacity over CD-ROM – 4.7 Gbyte

DVD uses two layers of lands and pits

- Semi-reflective top layer - reflective underlayer
- Laser can adjust focus to read each layer separately
- Double the capacity – 8.5 Gbyte

DVD-Rom can be two-sided

- Double the capacity again – 17 Gbyte

DVD-R – DVD Recordable

- Similar to DVD-ROM

- Can be written once
- One-sided disks only

DVD-RW – DVD Rewritable

- Similar to DVD-ROM
- Can be written to and erased multiple times
- One-sided disks only

SELF ASSESSMENT QUESTIONS – 4

9. Cd – Rom stands for________________
10. DVD stands for________________
11. Can be written to and erased multiple times with ________________
12. Spiral spacing on a DVD______________ distance between pits________________ .

6. SUMMARY

In this unit, we discussed secondary memory. We explained the various units of a Basic Magnetic Disk, how it works, and the working of magnetic Tape, DAT, RAID, and RAID algorithms & levels. Magnetic tape is a medium for magnetic recording, made of a thin magnetizable coating on a long, narrow strip of plastic film. Digital Audio Tape (DAT) is a signal recording and playback medium developed by Sony and introduced in 1987. DVD is an optical disc storage format, invented and developed by Philips, Sony, Toshiba, and Panasonic in 1995. RAID is now used as an umbrella term for computer data storage schemes that can divide and replicate data among multiple physical drives.

7. TERMINAL QUESTIONS

1. What is the use of RAID ALGORITHM?
2. What is meant by Magnetic tape and Magnetic disk?
3. Explain in detail Optical memory?
4. Write a note on DVD.

8. ANSWERS

Self Assessment Questions:

1. Drive
2. 1951
3. 1987
4. Digital Data Storage
5. redundant array of independent disks
6. Storage Networking Industry Association
7. RAID 4
8. RAID 6
9. Compact Disk Read-Only Memory
10. Digital Versatile Disk
11. Having CD Rewritable
12. 0.74 um & 0.4 um

Terminal Questions:

1. RAID algorithm is having 6 basic process for more details go through Refer section 8.3.
2. Magnetic tape is a medium for magnetic recording, made of a thin magnet sable coating on a long, narrow strip of plastic film. And Magnetic disk revolutionized broadcast and recording. When all radio was live, it allowed programming to be pre-recorded. for more details go through Refer section 2.
3. Optical memory was an early form of computer memory invented at the Mellon Institute in the 1950s. The device used a combination of photo emissive and phosphorescent materials for more details go through Refer section 5.
4. DVD is an optical disc storage format, invented and developed by Philips, Sony, Toshiba, and Panasonic in 1995. DVDs offer higher storage capacity than Compact Discs for more details go through Refer sub section 5.2.