Computer Organization and Architecture (EET 2211)

Lecture 22

EXTERNAL MEMORY

TOPICS TO BE COVERED

1. RAID (RAID LEVEL 0 – RAID LEVEL 6)

2. Optical Memory (CD, DVD, High-Definition Optical Disks)

LERNING OBJECTIVES

- After studying this chapter you should be able to :

1. Explain the concept of RAID and describe the various levels.
2. Understand the differences among the different optical disk storage media.

CONTENTS

- We will examine the use of disk arrays to achieve greater performance ,looking specifically at the family of systems known as RAID (Redundant Array of Independent Disks).
- Then optical memory is examined.

INTRODUCTION

- Magnetic disks are the foundation of external memory on virtually all computer systems.
- A disk is a circular platter constructed of non-magnetic material, called the substrate, coated with a magnetizable material.
- Earlier the substrate was made of aluminum or aluminum alloy material.
- Recently glass substrates are used.
- Benefits of using glass substrate are:

1. Improvement in the uniformity of the magnetic film surface to increase disk reli

Contd.

- Benefits of using glass substrate are:

1. Improvement in the uniformity of the magnetic film surface to increase disk reliability.
2. A significant reduction in overall surface defects to help reduce read-write errors.
3. Better stiffness to reduce disk dynamics.
4. Greater ability to withstand shock and damage.

Contd.

- Typical Hard Disk Drive Parameters are:

1. Application (Enterprise / Desktop / laptop)
2. Capacity (in TB)
3. Average seek time
4. Spindle speed
5. Average latency
6. Maximum sustained transfer rate
7. Bytes per sector
8. Tracks per cylinder (number of platter surfaces)
9.

RAID

- 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.
- With the use of multiple disks, there is a wide variety of ways in which the data can be organized and in which redundancy can be added to improve reliability.
- RAID (Redundant Array of Independent Disks) is standardized scheme for multiple-disk database design.
- The RAID scheme consists of seven levels, zero through six.

These levels share three common characteristics:

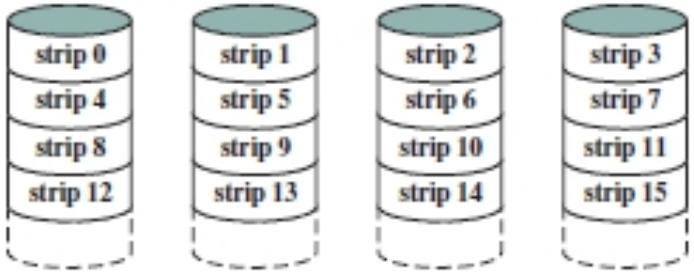
- RAID is a set of physical disk drives viewed by the operating system as a single logical drive.
- Data are distributed across the physical drives of an array in a scheme known as striping, described subsequently.
- Redundant disk capacity is used to store parity information, which guarantees data recoverability in case of a disk failure.

- The term *RAID* was originally coined in a paper by a group of researchers at the University of California at Berkeley.
- The paper outlined various RAID configurations and applications and introduced the definitions of the RAID levels that are still used.
- The RAID strategy employs multiple disk drives and distributions data in such a way as to enable simultaneous access to data from multiple drives, thereby improving I/O performance and allowing easier incremental increases in capacity.
- The unique contribution of the RAID proposal is to [redacted]ely the need for redundancy.

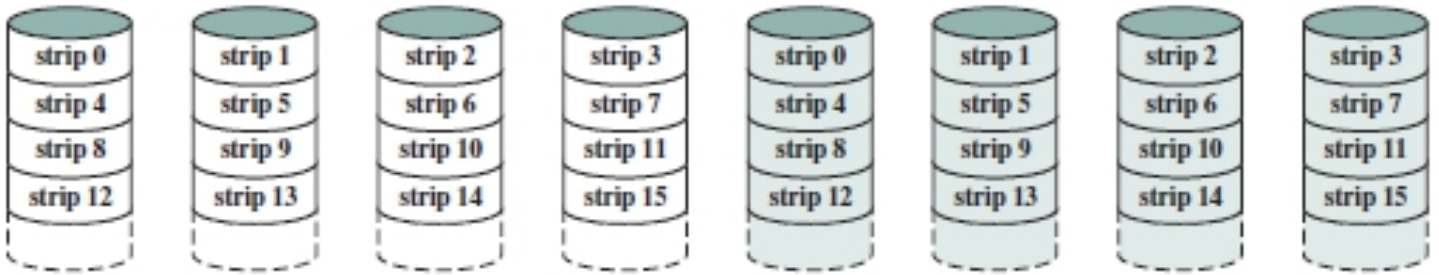
RAID LEVELS

Category	Level	Description	Disks Required	Data Availability	Large I/O Data Transfer Capacity	Small I/O Request Rate
Striping	0	Nonredundant	N	Lower than single disk	Very high	Very high for both read and write
Mirroring	1	Mirrored	$2N$	Higher than RAID 2, 3, 4, or 5; lower than RAID 6	Higher than single disk for read; similar to single disk for write	Up to twice that of a single disk for read; similar to single disk for write
Parallel access	2	Redundant via Hamming code	$N + m$	Much higher than single disk; comparable to RAID 3, 4, or 5	Highest of all listed alternatives	Approximately twice that of a single disk
	3	Bit-interleaved parity	$N + 1$	Much higher than single disk; comparable to RAID 2, 4, or 5	Highest of all listed alternatives	Approximately twice that of a single disk
Independent access	4	Block-interleaved parity	$N + 1$	Much higher than single disk; comparable to RAID 2, 3, or 5	Similar to RAID 0 for read; significantly lower than single disk for write	Similar to RAID 0 for read; significantly lower than single disk for write
	5	Block-interleaved distributed parity	$N + 1$	Much higher than single disk; comparable to RAID 2, 3, or 4	Similar to RAID 0 for read; lower than single disk for write	Similar to RAID 0 for read; generally lower than single disk for write
	6	Block-interleaved dual distributed parity	$N + 2$	Highest of all listed alternatives	Similar to RAID 0 for read; lower than RAID 5 for write	Similar to RAID 0 for read; significantly lower than RAID 5 for write

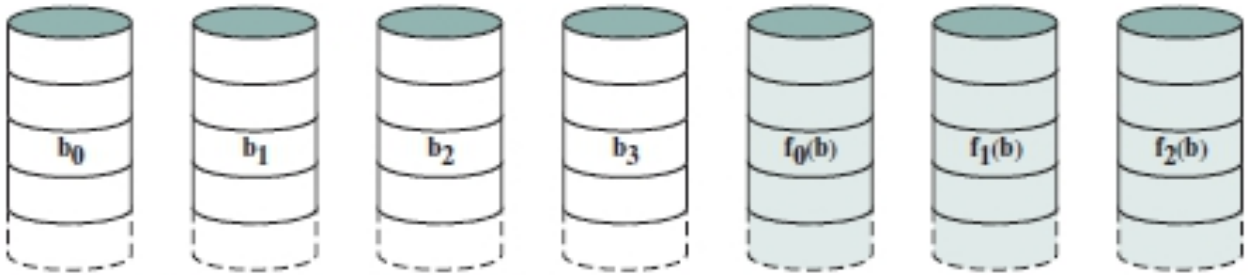
Note: N = number of data disks; m proportional to $\log N$



(a) RAID 0 (Nonredundant)

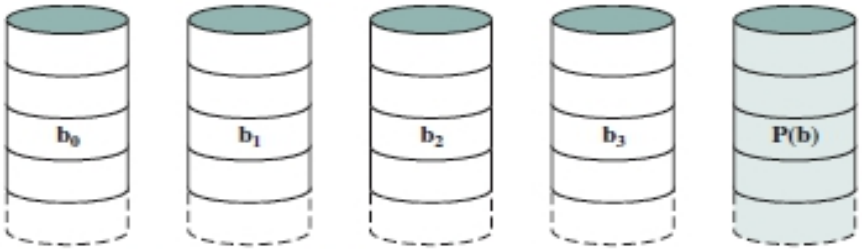


(b) RAID 1 (Mirrored)

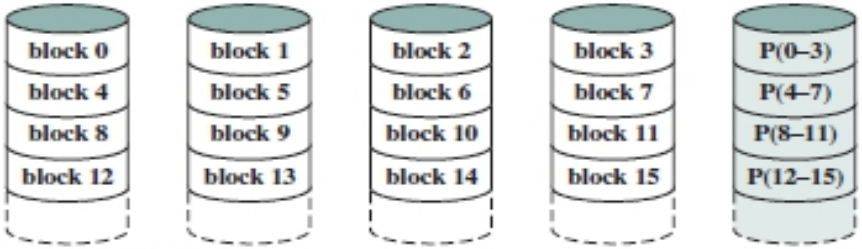


(c) RAID 2 (Redundancy through Hamming code)

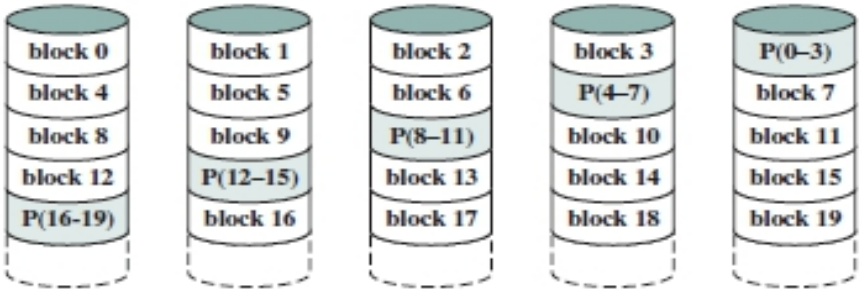
Figure 6.6 RAID Levels (*Continued*)



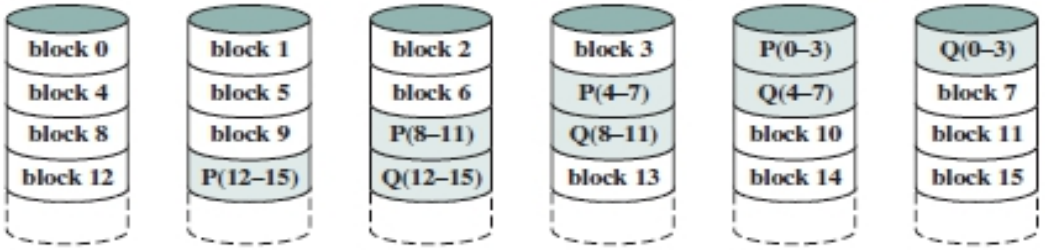
(d) RAID 3 (Bit-interleaved parity)



(e) RAID 4 (Block-level parity)



(f) RAID 5 (Block-level distributed parity)



(g) RAID 6 (Dual redundancy)

Figure 6.6 RAID Levels (*Continued*)

RAID Level 0:

- RAID level 0 is not a true member of the RAID family because it does not include redundancy to improve performance.
- For RAID, the user and system data are distributed across all of the disks in the array.
- **ADVANTAGE** : Two requests can be issued in parallel, reducing the I/O queuing time (if two different I/O requests are pending for two different blocks of data , then there is a good chance that the requested blocks are on different disks)
- But RAID 0, as with all of the RAID levels, goes further than simply distributing the data across a disk array.
- The data are *striped* across the available disks.

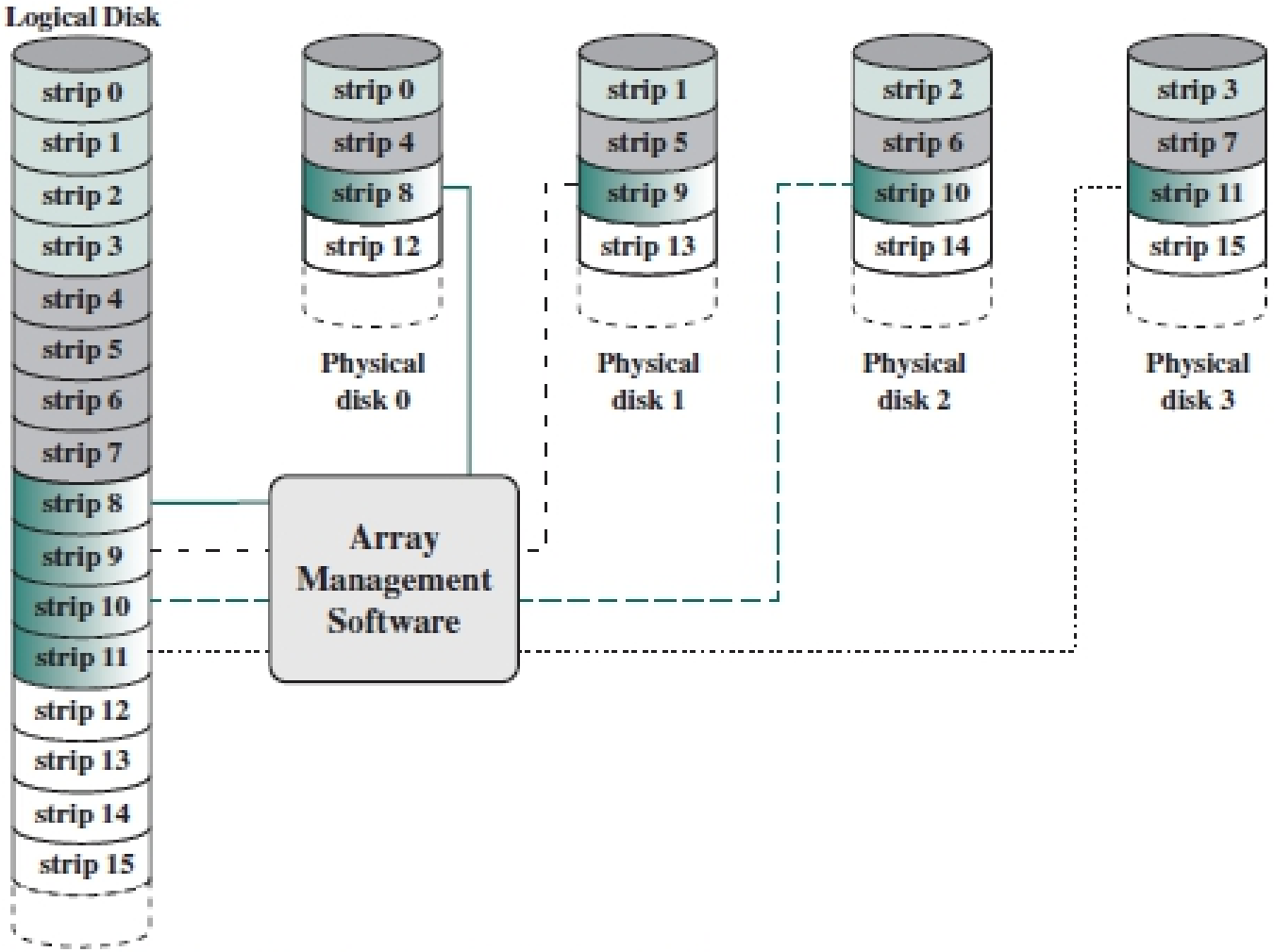


Figure 6.7 Data Mapping for a RAID Level 0 Array

RAID 0 for high data transfer capacity:

- The performance of any of the RAID levels depends critically on the request patterns of the host system and on the layout of the data.
- These issues can be most clearly addressed in RAID 0, where the impact of redundancy does not interfere with the analysis.
- For applications to experience a high transfer rate, two requirements must be met.
- First, a high transfer capacity must exist along the entire path between host memory and the individual disk drives.
- The second requirement is that the application must take I/O requests that drive the disk array efficiently.

RAID 0 for high I/O request rate:

- In a transaction-oriented environment, the user is typically more concerned with response time than with transfer rate.
- For an individual I/O request for a small amount of data, the I/O time is dominated by the motion of the disk heads (seek time) and the movement of the disk (rotational latency).
- A disk array can provide high I/O execution rates by balancing the I/O load across multiple disks.
- The performance will also be influenced by the strip size.

THANK YOU