Computer Organization and Architecture (EET 2211)

Lecture 25

RAID

- 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.
- Redundant disk capacity is used to store parity information, which guarantees data recoverability in case of a disk failure.

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.
- 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.

(a) RAID 0 (Nonredundant)

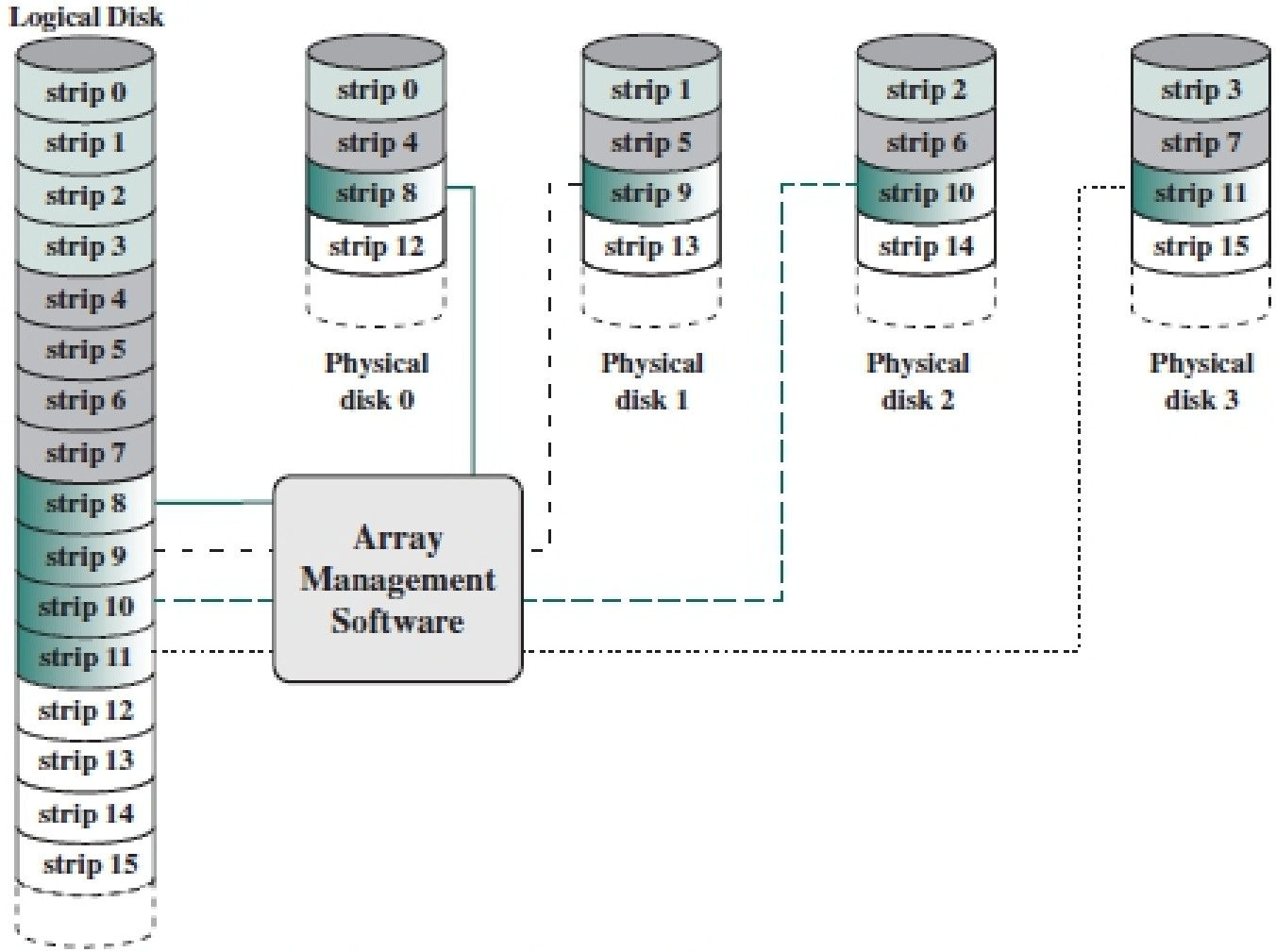
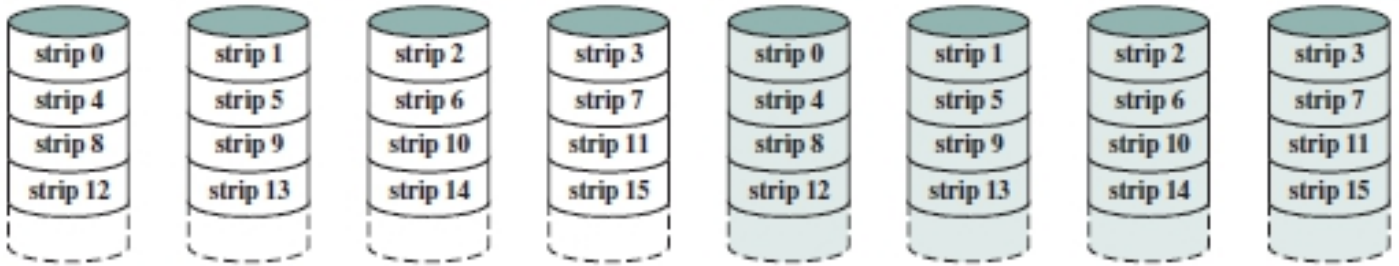


Figure 6.7 Data Mapping for a RAID Level 0 Array

RAID level 1:

- RAID 1 differs from RAID levels 2 through 6 in the way in which redundancy is achieved.
- In RAID 1, redundancy is achieved by the simple expedient of duplicating all the data.
- Data striping is used, as in RAID 0, but in this case, each logical strip is mapped to two separate physical disks so that every disk in the array has a mirror disk that contains the same data.
- RAID 1 can also be implemented without data striping, though this is less common.



(b) RAID 1 (Mirrored)

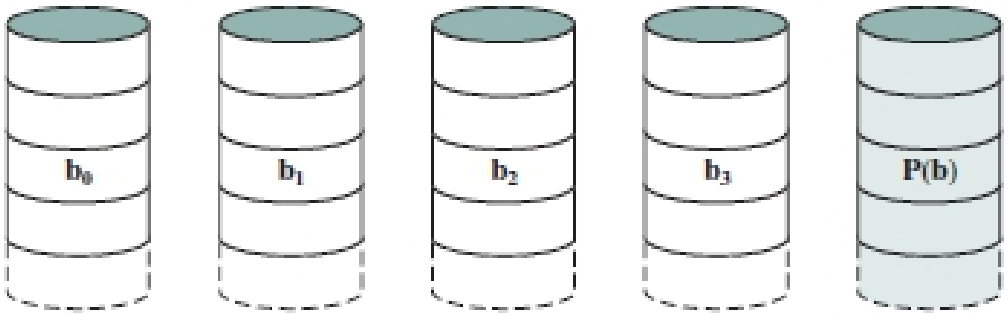
RAID level 2:

- RAID levels 2 and 3 make use of a parallel access technique.
- As in other RAID schemes, data striping is used.
- With RAID 2, an error-correcting code is calculated across corresponding bits on each data disk, and the bits of the code are stored in the corresponding bit position on multiple parity disks.

(c) RAID 2 (Redundancy through Hamming code)

RAID level 3:

- RAID 3 is organized in a similar fashion to RAID 2.
- The difference is that RAID 3 requires only a single redundant disk, no matter how large the disk array.
- RAID 3 employs parallel access, with data distributed in small strips.

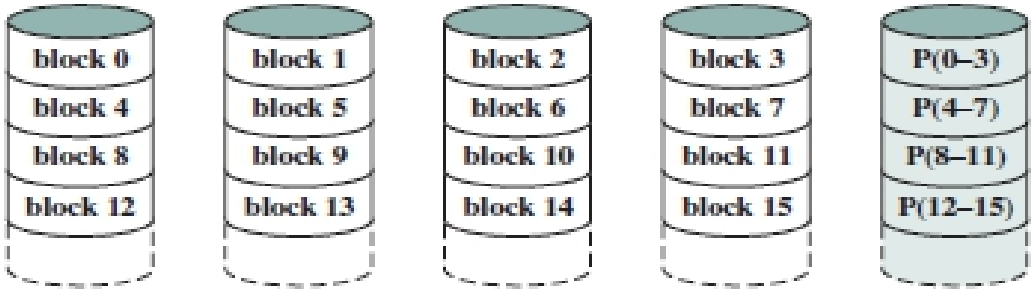


(d) RAID 3 (Bit-interleaved parity)

- In the event of a drive failure, the parity drive is accessed and data is reconstructed from the remaining devices.

RAID level 4:

- RAID levels 4 through 6 make use of an independent access technique.
- As in other RAID schemes, data striping is used.

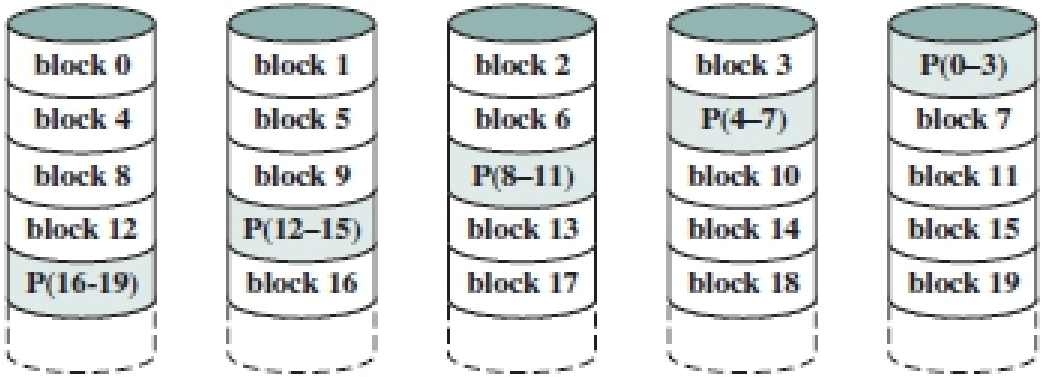


(e) RAID 4 (Block-level parity)

- In the case of RAID 4 through 6, the strips are relatively large.
- RAID 4 involves a write penalty when an I/O write request of small size is performed.

RAID level 5:

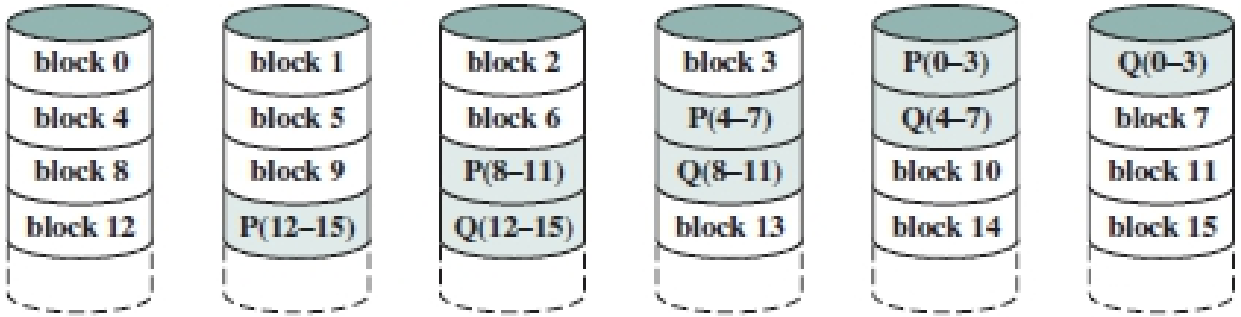
- RAID 5 is organized in a similar fashion to RAID 4.
- The difference is that RAID 5 distributes the parity strips across all disks.
- A typical allocation is a round-robin scheme.
- For an n-disk array, the parity strip is on a different disk for the first n stripes and the pattern then repeats.



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

RAID level 6:

- In RAID 6 scheme, two different parity calculations are carried out and stored in separate blocks on different disks. Thus, a RAID 6 array whose user data require N disks consists of N+2 disks.



(g) RAID 6 (Dual redundancy)

- The advantage of RAID 6 is that it provides extremely high data availability.
- Three disks would have to fail within the MTTR (mean time to repair) interval to cause data to be lost.

OPTICAL MEMORY

CD-ROM

- Both the audio CD and the CD-ROM (compact disk read-only memory) share a similar technology.
- The main difference is that CD-ROM players are more rugged and have error correction devices to ensure the data are properly transferred from disk to computer.
- Digitally recorded information (either music or computer data) is imprinted as a series of microscopic pits on the surface of the polycarbonate.
- The data capacity for a CD-ROM is about 680 MB.

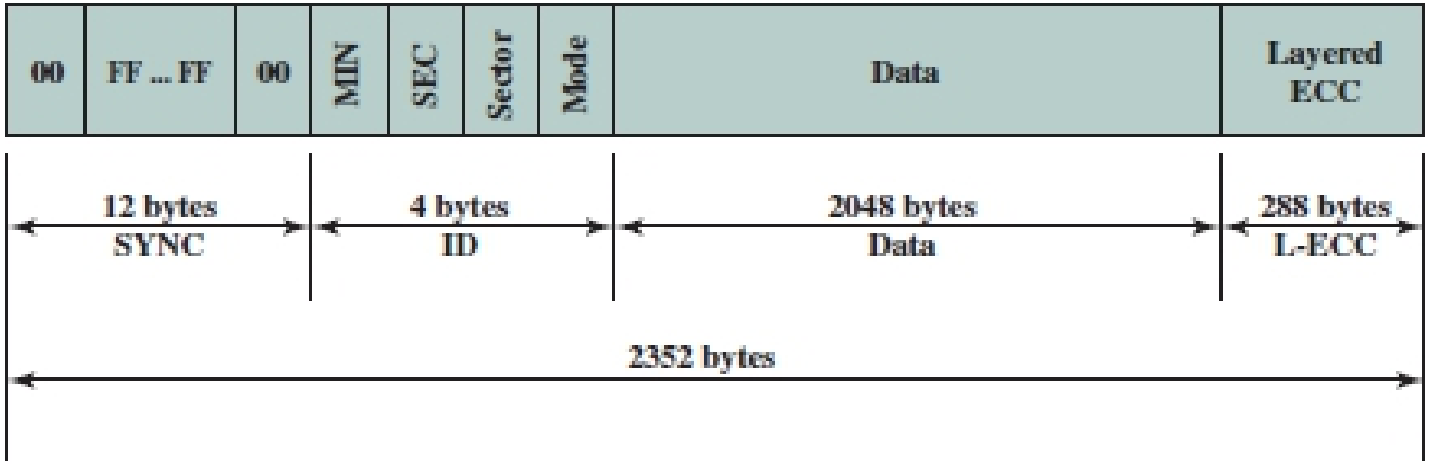


Figure 6.10 CD-ROM Block Format

CD RECORDABLE:

- To accommodate applications in which only one or a small number of copies of a set of data is needed, the write-once read-many CD, known as **CD recordable (CD-R)**, has been developed.
- For CD-R, a disk is prepared in such a way that it can be subsequently written once with a laser beam of modest-intensity.
- The CD-R medium is similar to but not identical to that of a CD or CD-ROM.
- For a CD-R, the medium includes a dye layer.
- The CD-R optical disk is attractive for archival storage of documents and files.

CD REWRITABLE:

- The **CD-RW** optical disk can be repeatedly written and overwritten, as with a magnetic disk.
- The **phase change** disk uses a material that has two significantly different reflectivities in two different phase states.
- There is an amorphous state, in which the molecules exhibit a random orientation that reflects light poorly; and a crystalline state, which has a smooth surface that reflects light well.
- A beam of laser light can change the material from one phase to the other.

Digital Versatile Disk:

- With the capacious **Digital Versatile Disk (DVD),** the electronics industry has at last found an acceptable replacement for the analog VHS video tape.

- The DVD takes video into the digital age.

- Vast volumes of data can be crammed onto the disk, currently seven times as much as a CD-ROM.

High-Definition Optical Disk:

- High-definition optical disks are designed to store high-definition videos and to provide significantly greater storage capacity compared to DVDs.
- The higher bit density is achieved by using a laser with a shorter wavelength, in the blue-violet range.
- Two competing disk formats and technologies initially competed for market acceptance: HD DVD and Blu-ray DVD.
- The HD DVD scheme can store 15 GB on a single layer on a single side.
- Blu-ray positions the data layer on the disk closer to the laser. This enables a tighter focus and less distortion and thus smaller pits and tracks.
- Blu-ray can store 25GB on a single layer.
- [redacted]re available: read only (BD-ROM), record[redacted]D-R), and rerecordable (BD-RE).

Review Questions

1. What common characteristics are shared by all RAID levels?
2. Explain the term *striped data.*
3. In the context of RAID, what is the distinction between parallel access and independent access?
4. What differences between a CD and a DVD account for the larger capacity of the latter?
5. Briefly define the seven RAID levels.
6. How is redundancy achieved in a RAID system?
7. Explain the CD-ROM block format.
8. How the information is retrieved from a CD or CD-ROM?
9. Discuss the advantages and disadvantages of CD-ROM.
10. Consider a 4-drive, 200GB-per-drive RAID array. What is [redacted] storage capacity for each of the RAID levels[redacted] and 6.