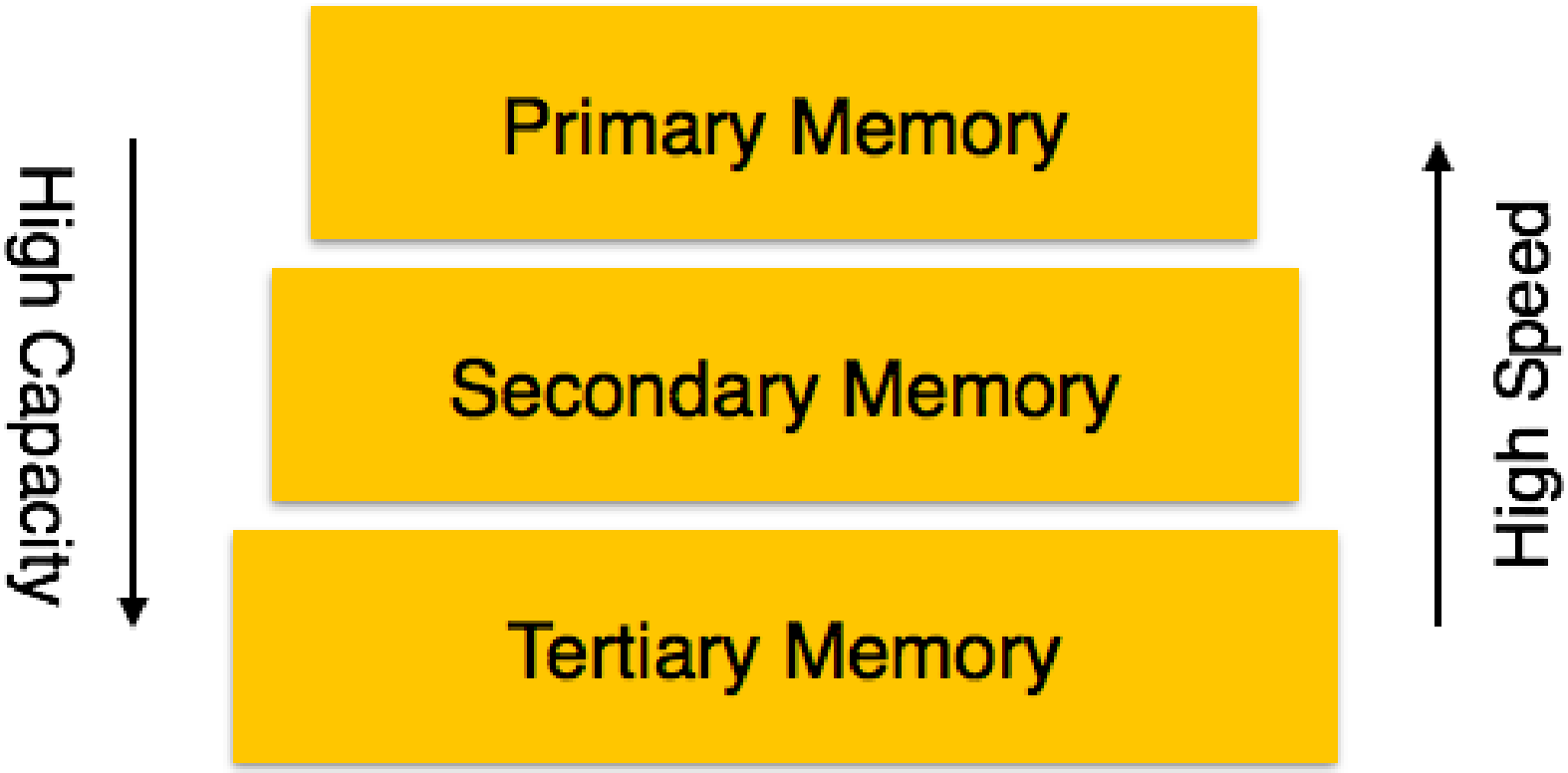
University of Central Florida
CGS 2545
Database Concepts

DEPARTMENT OF ELECTRICAL ENGINEERING & COMPUTER SCIENCE
COMPUTER SCIENCE DIVISION

Storage System

- Databases are stored in file formats, which contain records.
- At physical level, the actual data is stored in electromagnetic format on some device.
- These storage devices can be broadly categorized into three types
  - Primary memory
  - Secondary memory
  - Tertiary memory

Storage System



Storage System

- **Primary Storage**
  - The memory storage that is directly accessible to the CPU comes under this category.
  - CPU's internal memory (registers), fast memory (cache), and main memory (RAM) are directly accessible to the CPU, as they are all placed on the motherboard or CPU chipset.
  - This storage is typically very small, ultra-fast, and volatile.
  - Primary storage requires continuous power supply in order to maintain its state.
  - In case of a power failure, all its data is lost.

Storage System

- **Secondary Storage**
  - Secondary storage devices are used to store data for future use or as backup.
  - Secondary storage includes memory devices that are not a part of the CPU chipset or motherboard
  - For example
    - magnetic disks
    - optical disks (DVD, CD, etc.)
    - hard disks
    - flash drives
    - magnetic tapes

Storage System

- **Tertiary Storage**
  - Tertiary storage is used to store huge volumes of data.
  - Since such storage devices are external to the computer system, they are the slowest in speed.
  - These storage devices are mostly used to take the back up of an entire system.
  - Optical disks and magnetic tapes are widely used as tertiary storage.

Storage System

- Memory Hierarchy
  - A computer system has a well-defined hierarchy of memory.
  - A CPU has direct access to it main memory as well as its inbuilt registers.
  - The access time of the main memory is obviously less than the CPU speed.
  - To minimize this speed mismatch, cache memory is introduced.

Storage System

- Memory Hierarchy
  - Cache memory provides the fastest access time and it contains data that is most frequently accessed by the CPU.
  - The memory with the fastest access is the costliest one.
  - Larger storage devices offer slow speed and they are less expensive, however they can store huge volumes of data as compared to CPU registers or cache memory.

Storage System

- Magnetic Disks
  - Hard disk drives are the most common secondary storage devices in present computer systems.
  - These are called magnetic disks because they use the concept of magnetization to store information.
  - Hard disks consist of metal disks coated with magnetizable material.
  - These disks are placed vertically on a spindle.
  - A read/write head moves in between the disks and is used to magnetize or de-magnetize the spot under it.
  - A magnetized spot can be recognized as 0 (zero) or 1 (one).

Storage System

- Magnetic Disks
  - Hard disks are formatted in a well-defined order to store data efficiently.
  - A hard disk plate has many concentric circles on it, called **tracks**.
  - Every track is further divided into **sectors**.
  - A sector on a hard disk typically stores 512 bytes of data.

Storage System

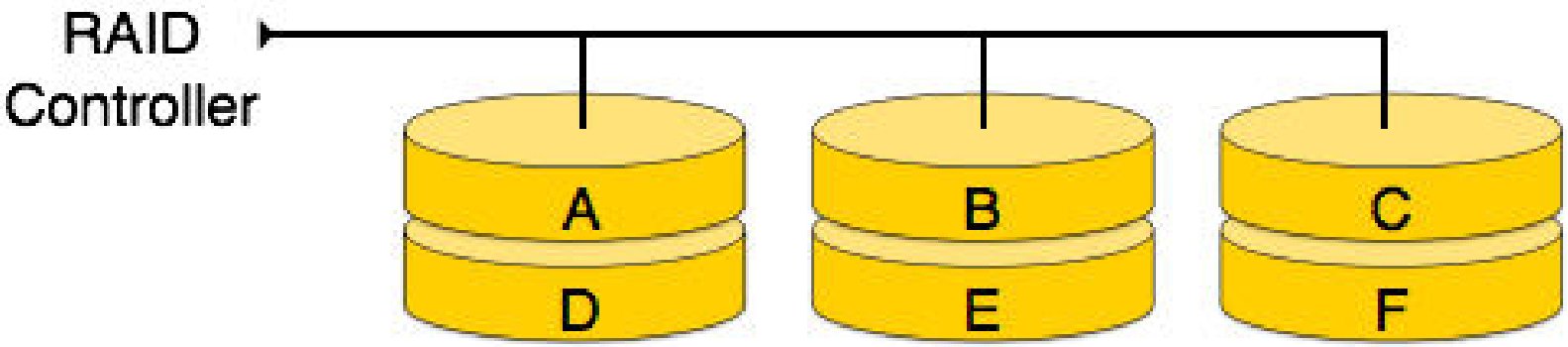
- Redundant Array of Independent Disks
  - RAID or **R**edundant **A**rray of **I**ndependent **D**isks, is a technology to connect multiple secondary storage devices and use them as a single storage media.
  - RAID consists of an array of disks in which multiple disks are connected together to achieve different goals.
  - RAID levels define the use of disk arrays.

Storage System

- RAID 0
  - In this level, a striped array of disks is implemented.
  - The data is broken down into blocks and the blocks are distributed among disks.
  - Each disk receives a block of data to write/read in parallel.
  - It enhances the speed and performance of the storage device.
  - There is no parity and backup in Level 0.

Storage System

- RAID 0

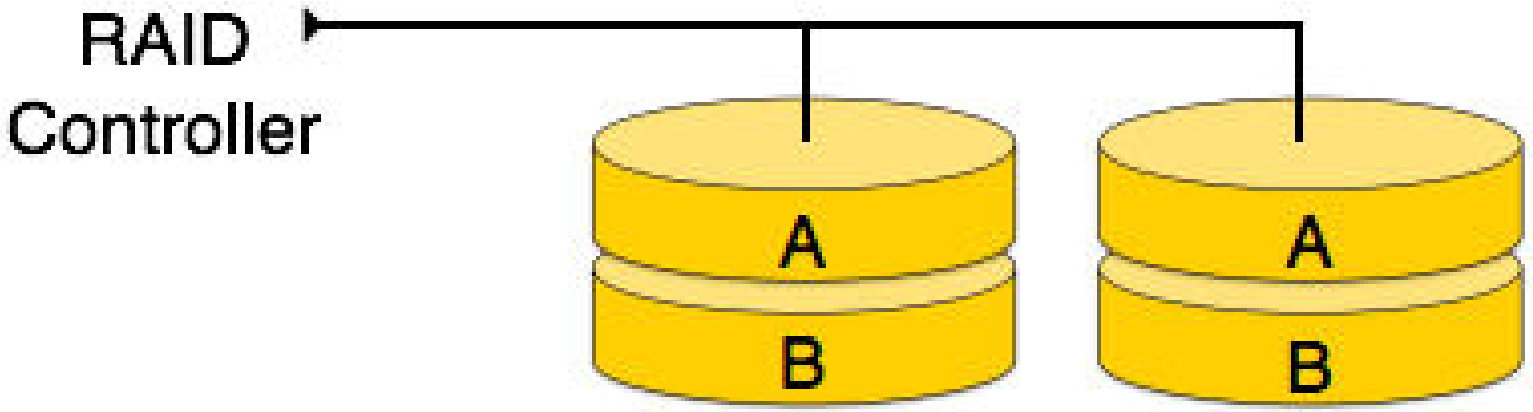


Storage System

- RAID 1
  - RAID 1 uses mirroring techniques.
  - When data is sent to a RAID controller, it sends a copy of data to all the disks in the array.
  - RAID level 1 is also called **mirroring** and provides 100% redundancy in case of a failure.

Storage System

- RAID 1

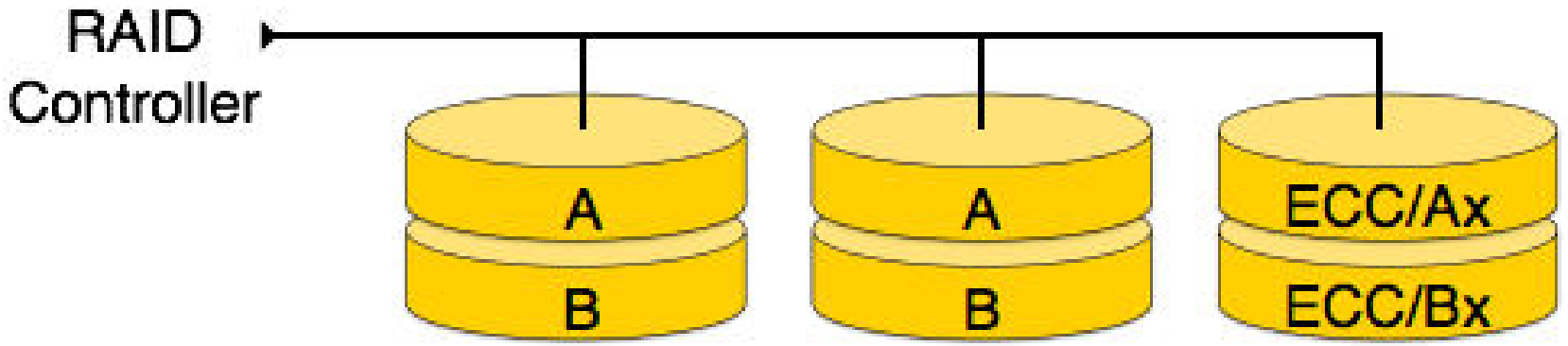


Storage System

- RAID 2
  - RAID 2 records Error Correction Code using Hamming distance for its data, striped on different disks.
  - Like level 0, each data bit in a word is recorded on a separate disk and ECC codes of the data words are stored on a different set disks.
  - Due to its complex structure and high cost, RAID 2 is not commercially available.

Storage System

- RAID 2

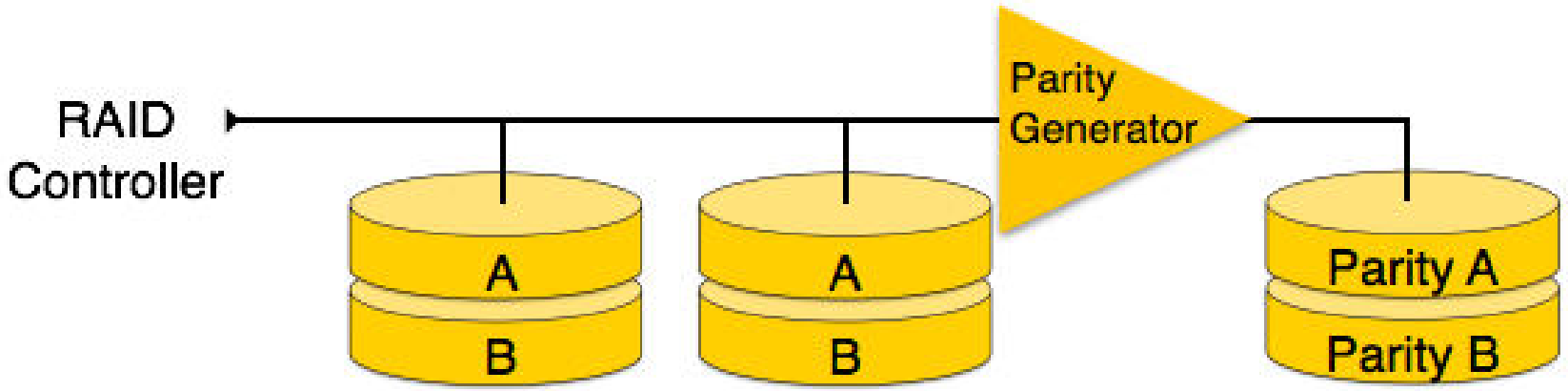


Storage System

- RAID 3
  - RAID 3 stripes the data onto multiple disks.
  - The parity bit generated for data word is stored on a different disk.
  - This technique makes it to overcome single disk failures.

Storage System

- RAID 3

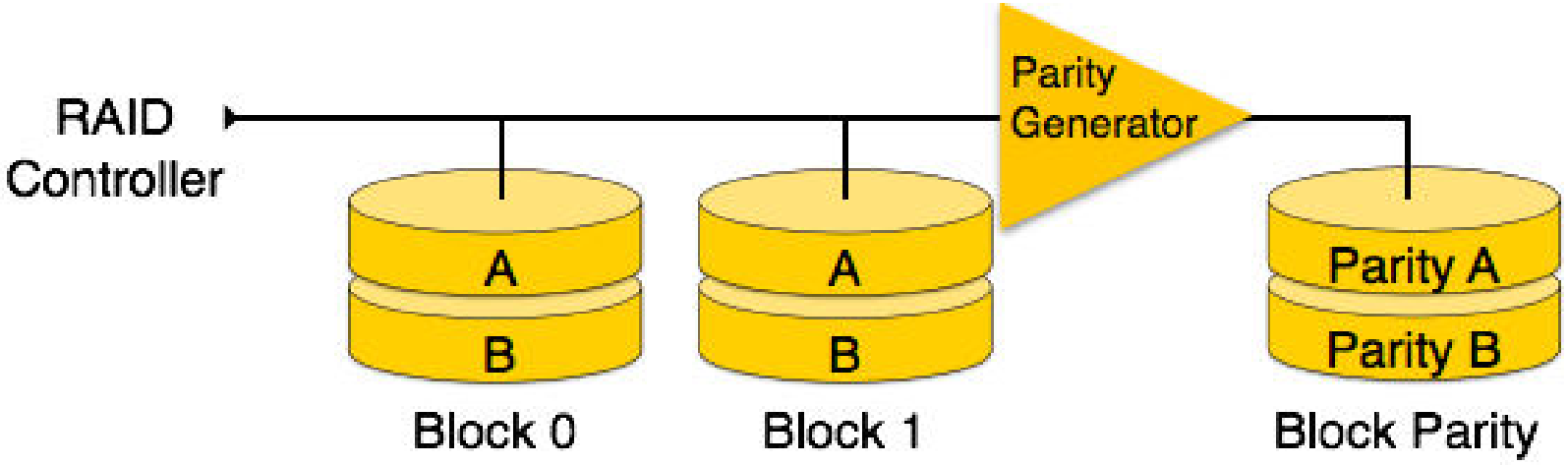


Storage System

- RAID 4
  - In this level, an entire block of data is written onto data disks and then the parity is generated and stored on a different disk.
  - Note that level 3 uses byte-level striping, whereas level 4 uses block-level striping.
  - Both level 3 and level 4 require at least three disks to implement RAID.

Storage System

- RAID 4

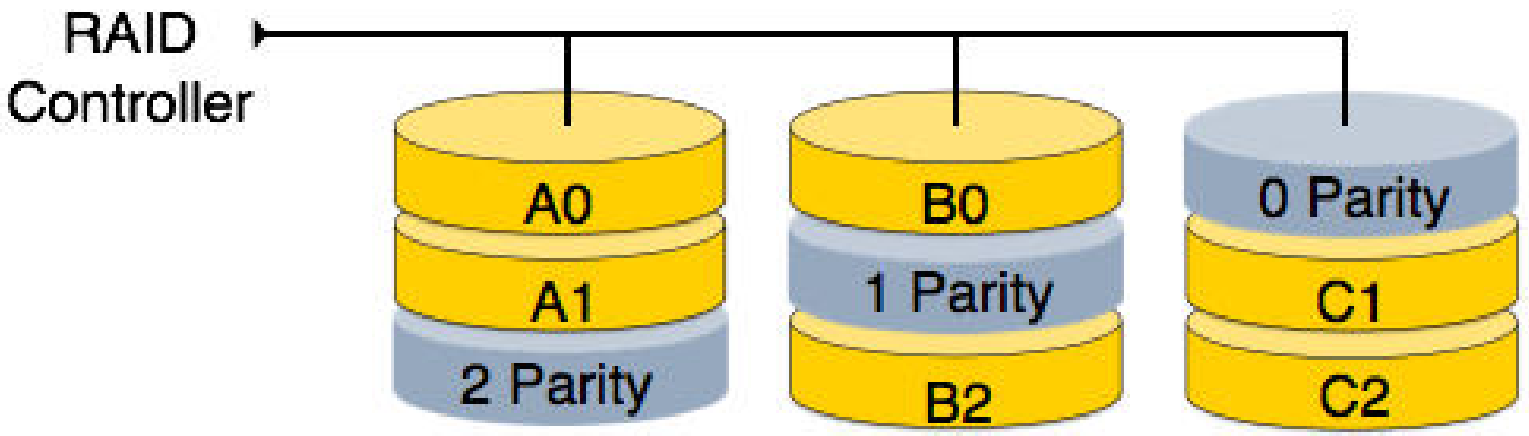


Storage System

- RAID 5
  - RAID 5 writes whole data blocks onto different disks, but the parity bits generated for data block stripe are distributed among all the data disks rather than storing them on a different dedicated disk.

Storage System

- RAID 5



Storage System

- RAID 6
  - RAID 6 is an extension of level 5.
  - In this level, two independent parities are generated and stored in distributed fashion among multiple disks.
  - Two parities provide additional fault tolerance.
  - This level requires at least four disk drives to implement RAID.

Storage System

- RAID 6