Chapter 8
Adding a Disk

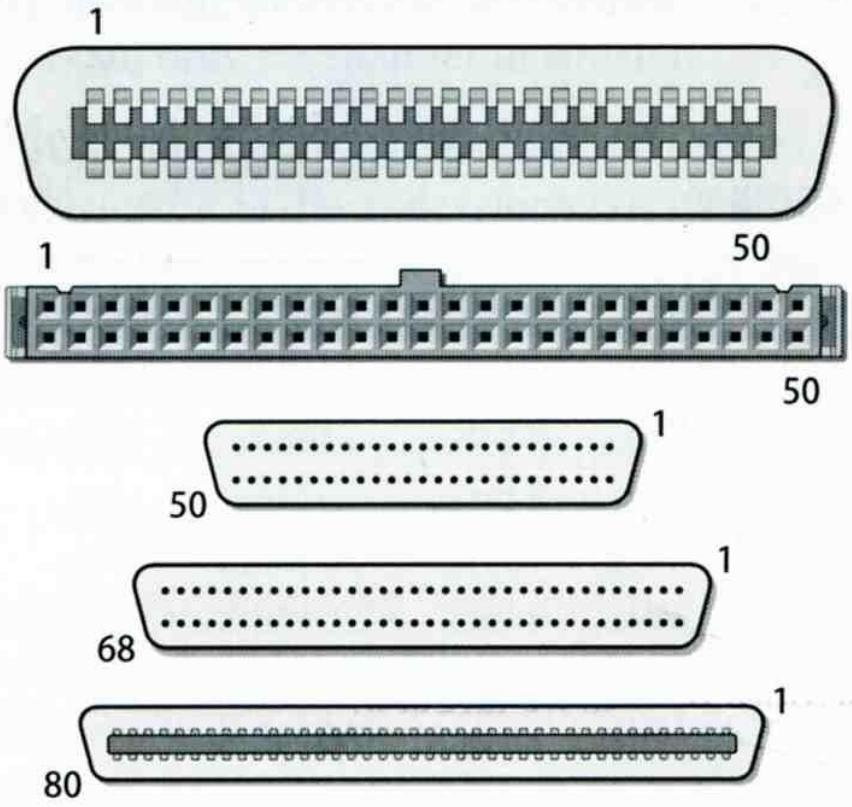
Disk Interface

- SCSI
  - Small Computer Systems Interface
  - High performance and reliability
- IDE (or ATA)
  - Integrated Device Electronics (or AT Attachment)
  - Low cost
  - Become acceptable for enterprise with the help of RAID technology
- SATA
  - Serial ATA
- SAS
  - Serial Attached SCSI
- USB
  - Universal Serial Bus
  - Convenient to use

Disk Interface – SCSI Interface Evolution

Version	Freq.	Width	Speed	Length	Diff.
SCSI-1	5MHz	8 bits	5MB/s	6m	25m
SCSI-2	5MHz	8 bits	5MB/s	6m	25m
SCSI-2 Fast	10MHz	8 bits	10MB/s	3m	25m
SCSI-2 Fast Wide	10MHz	16 bits	20MB/s	3m	25m
Ultra SCSI	20MHz	8 bits	20MB/s	1.5m	25m
Ultra Wide SCSI	20MHz	16 bits	40MB/s	1.5m	25m
Ultra2 SCSI	40MHz	16 bits	80MB/s	-	12m
Ultra160 SCSI	80MHz	16 bits	160MB/s	-	12m
Ultra320 SCSI	160MHz	16 bits	320MB/s	-	12m

Disk Interface – SCSI Interface Connector



Centronics
50 pins, SCSI-1/2, external

Ribbon connector (female)
50 pins, SCSI-1/2, internal

Mini-micro, aka HD50
50 pins, SCSI-2, external

Wide mini-micro, aka HD68
68 pins, SCSI-2/3, int/ext

SCA-2
80 pins, SCSI-3, internal

Disk Interface – SCSI Interface

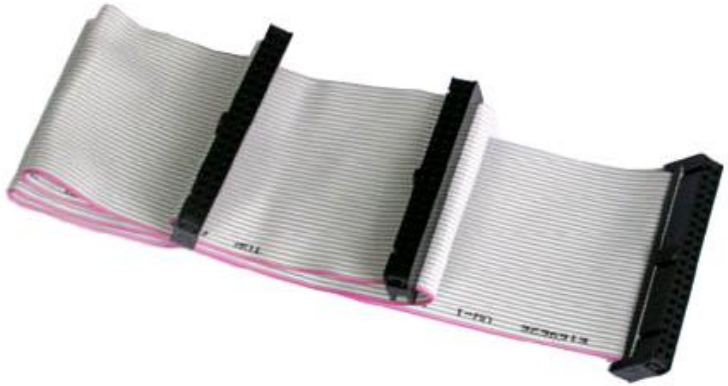
- Daisy chain on SCSI bus
  - Most external devices have two SCSI ports
  - Terminator
- Each SCSI device has a SCSI ID

Disk Interface – ATA & SATA

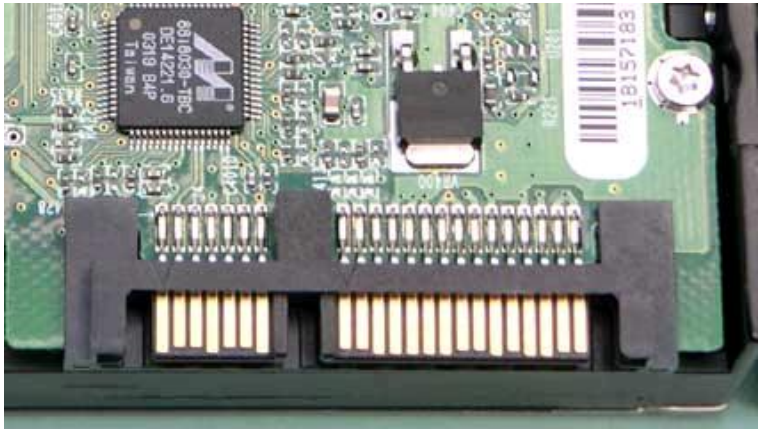
- ATA (AT Attachment)
  - ATA2
    - PIO, DMA
    - LBA (Logical Block Addressing)
  - ATA3, Ultra DMA/33/66/100/133
  - ATAPI (ATA Packet Interface)
    - CDROM, TAP
  - Only one device can be active at a time
    - SCSI support overlapping commands, command queuing, scatter-gather I/O
  - Master-Slave
  - 40-pin ribbon cable
- SATA
  - Serial ATA

Disk Interface – ATA & SATA Interface

- ATA interface and it's cable



- SATA interface and it's cable



Disk Interface – SAS

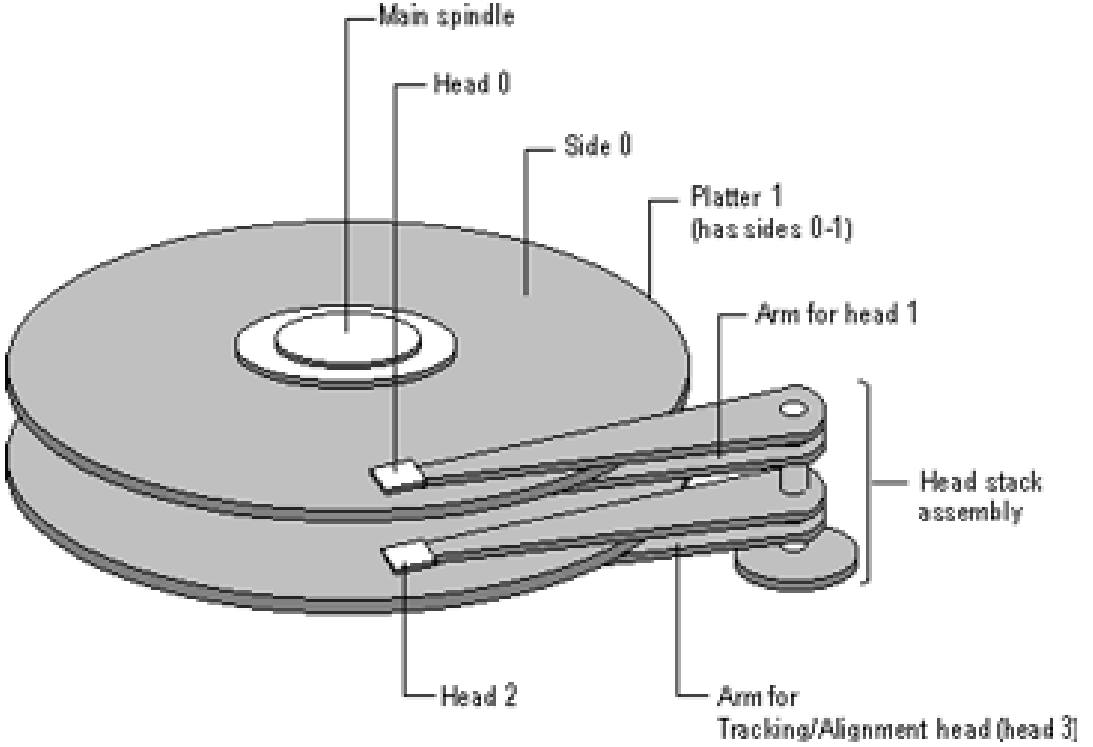
- SAS – Serial Attached SCSI
- SAS vs parallel SCSI
  - Serial transfer protocol to interface multiple devices
    - lesser signaling overhead
    - higher speed
  - Point-to-point
    - No bus contention
    - SCSI is multidrop
  - No termination
    - does not require terminator
  - Eliminates skew
  - Supports higher number of devices (> 16384)
    - SCSI limits it to 16 or 32
  - Supports higher transfer speed (1.5, 3.0 or 6.0 Gbps)
    - SCSI the speed is shared across the entire multidrop bus
  - Supports SATA devices
  - Uses SCSI commands to interface with SAS End devices

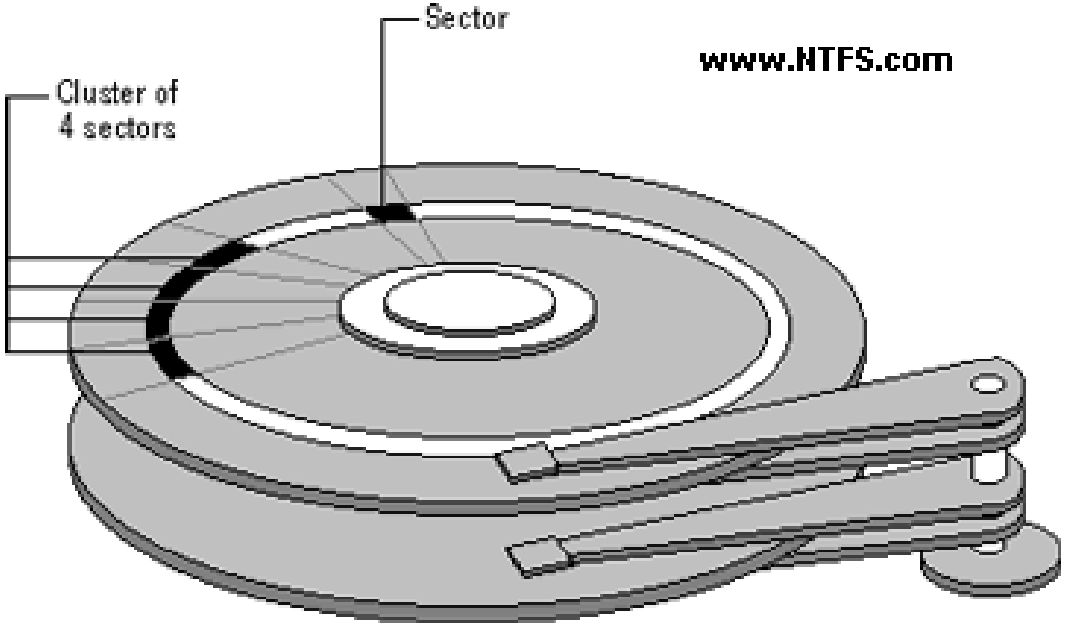
Disk Interface – USB

- USB to IDE/SATA Converter

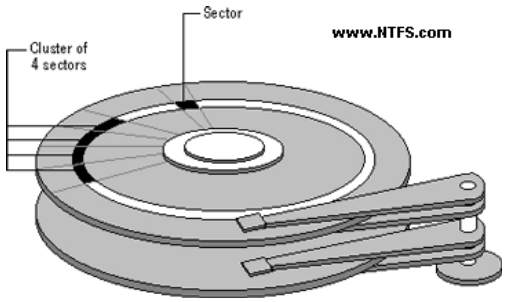
Disk Geometry (1)

- Sector
  - Individual data block
- Track
  - circle
- Cylinder
  - circle on all platters
- Position
  - CHS
  - Cylinder, Head, Sector





Disk Geometry (2)



- 40G HD
  - 4866 cylinders, 255 heads
  - 63 sectors per track, 512 bytes per sector
  - 512 * 63 * 4866 * 255 = 40,024,212,480 bytes
  - 1KB = 1024 bytes
  - 1MB = 1024 KB = 1,048,576 bytes
  - 1GB = 1024 MB = 1,073,741,824 bytes
  - 42,278,584,320 / 1,073,741,824 ≒ 39.375 GB

Disk Installation Procedure (1)

- The procedure involves the following steps:
  - Connecting the disk to the computer
    - IDE: master/slave
    - SCSI: ID, terminator
    - power
  - Creating device files
    - /dev
    - Now auto created by devfs devfs(5,8)
  - Formatting the disk
    - Low-level format
      - Address information and timing marks on platters
      - bad sectors
    - Manufacturer diagnostic utility

Disk Installation Procedure (2)

- Partitioning and Labeling the disk
  - Allow the disk to be treated as a group of independent data area
  - root, home, swap partitions
  - Suggestion:
    - /var, /tmp ➔ separate partition
    - Make a copy of root filesystem for emergency
- Establishing logical volumes
  - Combine multiple partitions into a logical volume
  - Software RAID technology
    - FreeBSD (GEOM)
    - Linux (Linux LVM)
    - Sun (Solstice Disk Suite, ZFS)

geom(4)

Disk Installation Procedure (3)

- Creating UNIX filesystems within disk partitions
  - Use "newfs" to install a filesystem for a partition

    newfs(8)

  - Filesystem components
    - A set of inode storage cells
    - A set of data blocks
    - A set of superblocks
    - A map of the disk blocks in the filesystem
    - A block usage summary

Disk Installation Procedure (4)

- Superblock contents
  - The length of a disk block
  - Inode table's size and location
  - Disk block map
  - Usage information
  - Other filesystem's parameters

※ sync
  - The sync() system call forces a write of dirty (modified) buffers in the block buffer cache out to disk.
  - The sync utility can be called to ensure that all disk writes have been completed before the processor is halted in a way not suitably done by reboot(8) or halt(8).

sync(2,8)

Disk Installation Procedure (5)

- mount
  - Bring the new partition to the filesystem tree
  - mount point can be any directory
  - `# mount /dev/ad1s1e /home2`
- Setting up automatic mounting
  - Automount at boot time
    - /etc/fstab
    - % mount –t ufs /dev/ad2s1a /backup
    - % mount –t cd9600 –o ro,noauto /dev/acd0c /cdrom

```
sabsd:~ -lwhsu- cat /etc/fstab
# Device            Mountpoint              FStype   Options          Dump     Pass#
/dev/ad0s1b         none                    swap     sw               0        0
/dev/ad2s1b         none                    swap     sw               0        0
/dev/ad0s1a         /                       ufs      rw               1        1
/dev/acd0c          /cdrom                  cd9660   ro,noauto        0        0
proc                /proc                   procfs   rw               0        0
/dev/ad2s1a         /backup                 ufs      rw,noauto        1        1
ccduty:/bsdhome  /bsdhome         nfs      rw,noauto         0        0
```

Disk Installation Procedure (6)

- Setting up swapping on swap partitions
  - swapon command
  - swapon, swapoff, swapctl

swapon(8)

fsck – check and repair filesystem (1)

- System crash will cause
  - Inconsistency between memory image and disk contents
- fsck
  - Examine all local filesystem listed in /etc/fstab at boot time
  - Automatically correct the following damages:
    - Unreferenced inodes
    - Inexplicably large link counts
    - Unused data blocks not recorded in block maps
    - Data blocks listed as free but used in file
    - Incorrect summary information in the superblock

fsck(8)
fsck_ffs(8)

fsck – check and repair filesystem (2)

- Run fsck in manual to fix serious damages
  - Blocks claimed by more than one file
  - Blocks claimed outside the range of the filesystem
  - Link counts that are too small
  - Blocks that are not accounted for
  - Directories that refer to unallocated inodes
  - Other errors
- fsck will suggest you the action to perform
  - Delete, repair, …

Adding a disk to FreeBSD (1)

1. Check disk connection
   - Look system boot message
   - /var/run/dmesg.boot

```
ad1: 238475MB <Hitachi HDT725025VLA380 IBM V5DOA7CA> at ata0-slave SATA150
```

2. Use /stand/sysinstall to install the new HD
   - Configure → Fdisk
     → Label
   - Don't forget to "W" the actions
   - (Easiest, but has some problems)
   - fdisk(8), bsdlabel(8), newfs(8)
3. Make mount point and mount it
   - `# mkdir /home2`
   - `# mount -t ufs /dev/ad1s1e /home2`
   - `# df (checking)`
4. Edit /etc/fstab

Adding a disk to FreeBSD (2)

- If you forget to enable soft-update when you add the disk
  - `# umount /home2`
  - `# tunefs –n enable /dev/ad1s1e`
  - `# mount –t ufs /dev/ad3s1e /home2`
  - `# mount`

```
/dev/ad0s1a on / (ufs, local, soft-updates)
devfs on /dev (devfs, local)
procfs on /proc (procfs, local)
/dev/ad1s1e on /home2 (ufs, local, soft-updates)
```

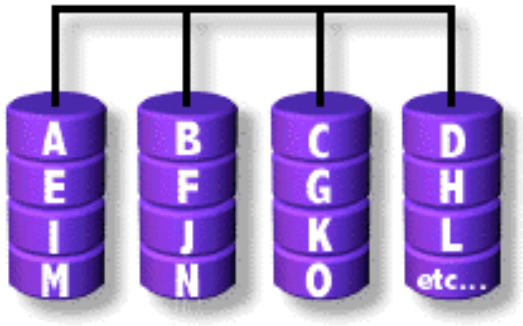
RAID (1/2)

- Redundant Array of Inexpensive Disks
  - A method to combine several physical hard drives into one logical unit
- Depending on the type of RAID, it has the following benefits:
  - Fault tolerance
  - Higher throughput
  - Real-time data recovery
- RAID Level
  - RAID 0, 1, 0+1, 2, 3, 4, 5, 6
  - Hierarchical RAID

RAID (2/2)

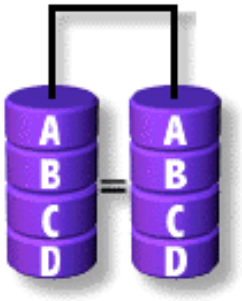
- Hardware RAID
  - There is a dedicate controller to take over the whole business
  - RAID Configuration Utility after BIOS
    - Create RAID array, build Array
- Software RAID
  - FreeBSD (GEOM)
  - Linux (Linux LVM)
  - Sun (Solstice Disk Suite)

RAID 0



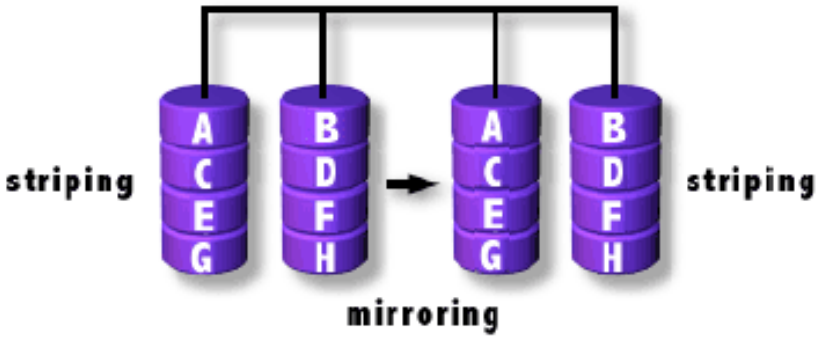
- Stripped data intro several disks
- Minimum number of drives: 2
- Advantage
  - Performance increase in proportional to n theoretically
  - Simple to implement
- Disadvantage
  - No fault tolerance
- Recommended applications
  - Non-critical data storage
  - Application requiring high bandwidth (such as video editing)

RAID 1



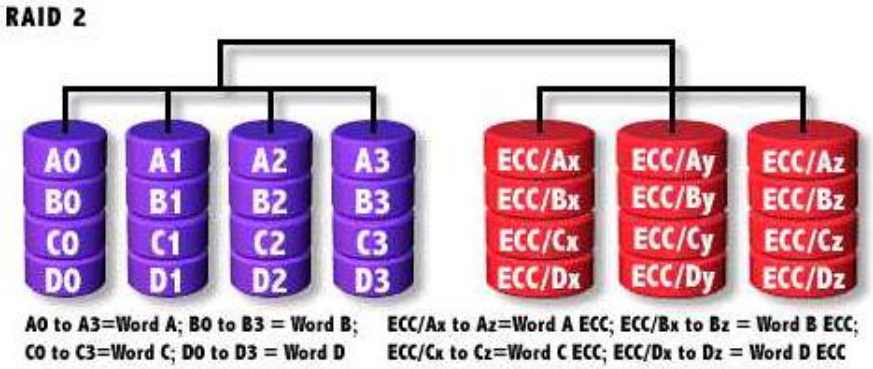
- Mirror data into several disks
- Minimum number of drives: 2
- Advantage
  - 100% redundancy of data
- Disadvantage
  - 100% storage overage
  - Moderately slower write performance
- Recommended application
  - Application requiring very high availability (such as home)

RAID 0+1



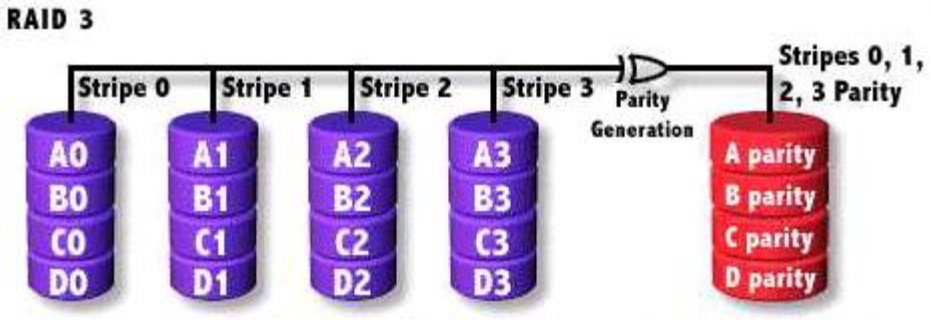
- Combine RAID 0 and RAID 1
- Minimum number of drives: 4

RAID 2



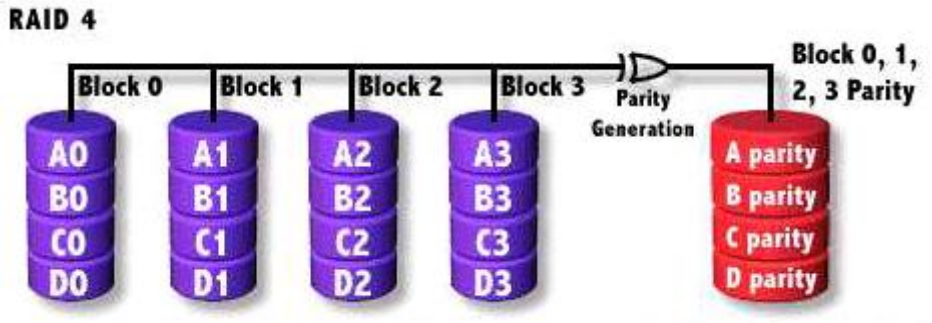
- Hamming Code ECC Each bit of data word
- Advantages:
  - "On the fly" data error correction
- Disadvantages:
  - Inefficient
  - Very high ratio of ECC disks to data disks
- Recommended Application
  - No commercial implementations exist / not commercially viable

RAID 3



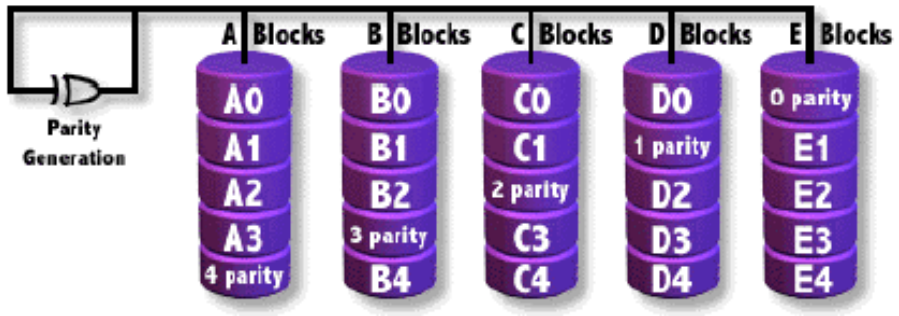
- Parallel transfer with Parity
- Minimum number of drives: 3
- Advantages:
  - Very high data transfer rate
- Disadvantages:
  - Transaction rate equal to that of a single disk drive at best
- Recommended Application
  - Any application requiring high throughput

RAID 4



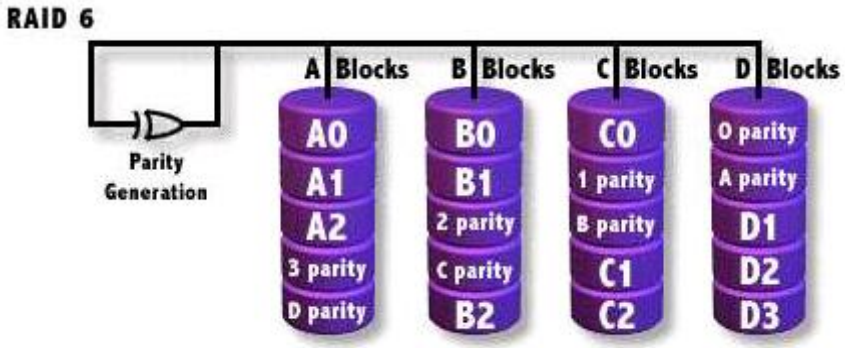
- Similar to RAID3
- RAID 3 V.S RAID 4
  - Byte Level V.S Block Level
  - Block interleaving

RAID 5



- Independent Disk with distributed parity blocks
- Minimum number of drives: 3
- Advantage
  - Highest read data rate
  - Medium write data rate
- Disadvantage
  - Disk failure has a medium impact on throughput
  - Complex controller design
  - When one disk failed, you have to rebuild the RAID array
  - “write hole”

RAID 6



- Similar to RAID5
- Minimum number of drives: 4
- 2 parity checks, 2 disk failures tolerable.