Disks

frank

Outline

- Interfaces
- Geometry
- Add new disks
  - Installation procedure
  - Filesystem check
  - Add a disk using sysinstall
- RAID
  - GEOM
  - ZFS

Disk Interfaces

- 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

Expensive!
SCSI Card ~ 10k

Low Price!

Enhancement

Speeds up!

Disk Interfaces – ATA & SATA

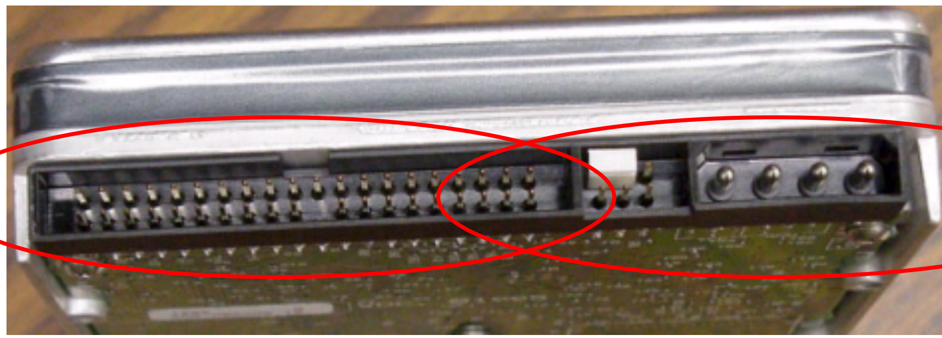
- ATA (AT Attachment)
  - ATA2
    - PIO, DMA
    - LBA (Logical Block Addressing)
  - ATA3, Ultra DMA/33/66/100/133
  - ATAPI (ATA Packet Interface)
    - CDROM, TAPE
  - Only one device can be active at a time
    - **SCSI support overlapping commands, command queuing, scatter-gather I/O**
  - Master-Slave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

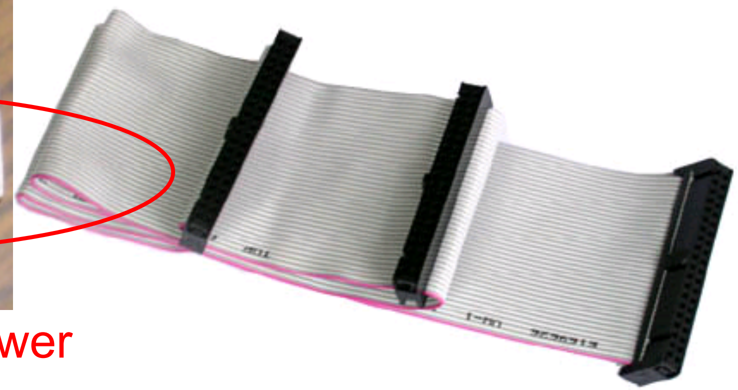
Primary Master (0)/Slave(1)
Secondary Master(2)/Slave(3)

- SATA
  - Serial ATA
  - SATA-1 1.5Gbit/s, SATA-2 3Gbit/s, SATA-3 6GBit/s

Disk Interfaces – ATA & SATA Interfaces

- ATA interface and it's cable

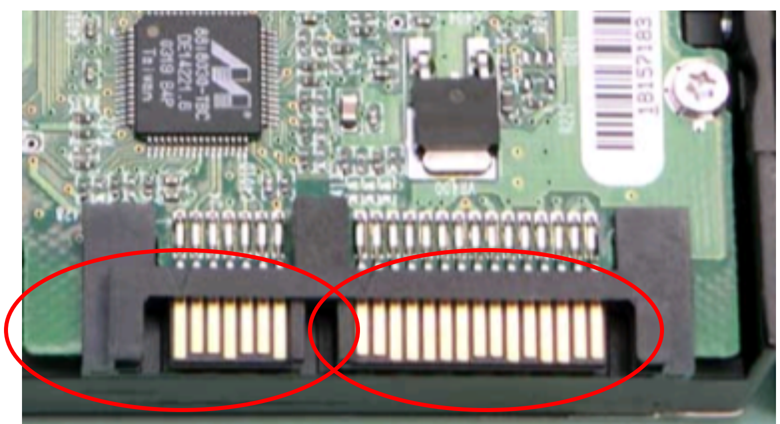




Data

Power

- SATA interface and it's cable



Data

Power

Disk Interfaces – USB

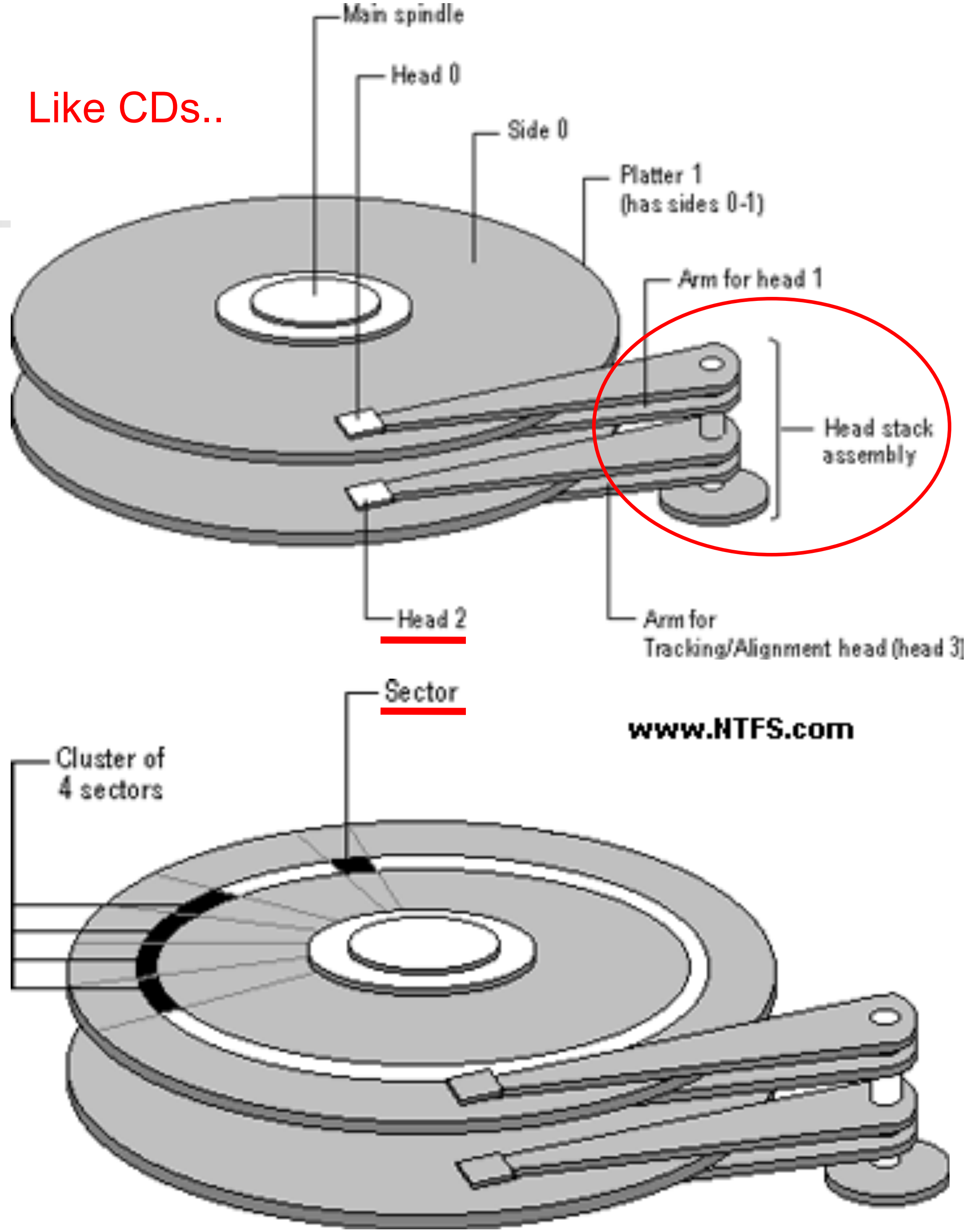
- IDE/SATA to USB Converters

Disk Geometry (1)

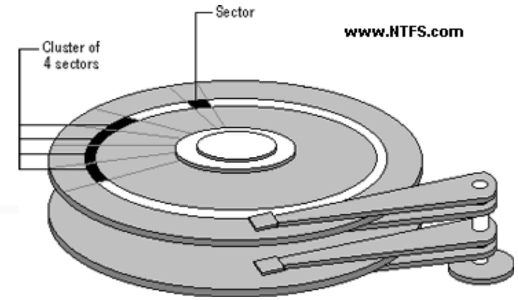
Like CDs..

- ❑ sector
  - Individual data block
- ❑ track
  - circle
- ❑ cylinder
  - circle on all platters

- ❑ Position
  - CHS:
    Cylinder,
    Head (0, 1, …),
    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

G M K

  - 1KB = 1024 bytes
  - 1MB = 1024 KB = 1,048,576 bytes
  - 1GB = 1024 MB = 1,073,741,824 bytes

Why?

  - 40,024,212,480 / 1,073,741,824 ≒ 37.275 GB

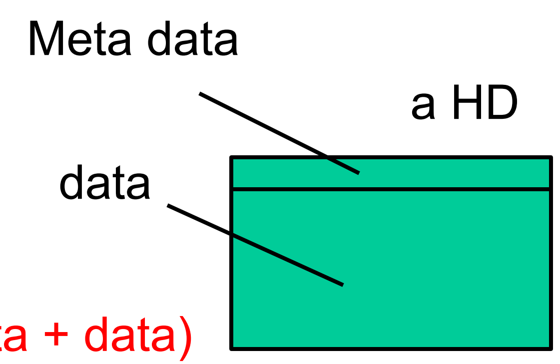
10^3 vs. 2^10…

Disk Installation Procedure (in BSD…)

Disk Installation Procedure (1)

- The procedure involves the following steps:
  - Connecting the disk to the computer
    - IDE: master/slave
    - SATA
    - SCSI: ID, terminator
    - power
  - Creating device files
    - Auto created by devfs
  - Formatting the disk
    - Low-level format
      - Manufacturer diagnostic utility
      - **Kill all** address information and timing marks on platters
      - Repair bad sectors → mark the bad sectors and don't use them!

Please do it offline…



Format (meta data + data) vs. fast format (data only)

Disk Installation Procedure (2)

- **Partitioning and Labeling the disk**
  - **Allow the disk to be treated as a group of <u>independent data area</u>**
  - **e.g. root, home, swap partitions**
  - **Former Suggestions:**
    - **/var, /tmp ➔ separate partition (for backup issue)**
    - Make a copy of root filesystem for emergency
- **Establishing logical <u>volumes</u>**
  - **<u>Combine multiple partitions into a logical volume</u>**
  - **Related to RAID**
  - **Software RAID technology**
    - **GEOM: geom(4)、geom(8)**
    - **ZFS: zpool(8)、zfs(8)、zdb(8)**

Disk Installation Procedure (3)

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

  Software info.

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

- sync

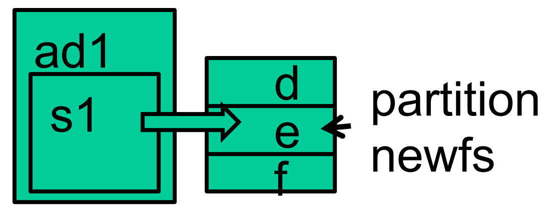
  SoftUpdate

  - 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).

  done automatically nowadays~ ☺

Disk Installation Procedure (5)

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



Mount CD
Also for ISO img. file

Usually: 2, 1 for root;
No write = 0

liuyh@NASA:/etc> cat 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/acd0	/cdrom	cd9660	ro,noauto	0	0
/dev/ad2s1a	/backup	ufs	rw,noauto	2	2
csduty:/bsdhome	/bsdhome	nfs	rw,noauto	0	0

Mount from the network; talk about it in "NFS"…

Disk Installation Procedure (6)

- **Setting up swapping on swap partitions**
  - swapon, swapoff, swapctl
  - swapinfo, pstat

e.g. swapon –a // mount all partitions for swap usage

```
17:05 pmli@bsd5 [~] >swapinfo
Device              1K-blocks     Used    Avail Capacity
/dev/label/swap-0     1048572    60372   988200      6%
/dev/label/swap-1     1048572    59808   988764      6%
Total                 2097144   120180  1976964      6%
17:05 pmli@bsd5 [~] >
```

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. (fsck -p)
  - 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)
    - ffsinfo(8): dump metadata

auto. Do it at boot time

check if filesys. is clean…
0 dirty (rw) 1 clean (ro)

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, …

No guarantee on fully recover you HD…

Adding a disk to FreeBSD (1)

1. Check disk connection
   - Look system boot message

```
ad3: 238475MB <Hitachi HDS722525VLAT80 V36OA6MA> at ata1-slave UDMA100
```

Line, speed

2. Use /usr/sbin/sysinstall to install the new HD
   - Configure → Fdisk → Label
     - Don't forget to "W" the actions
     - Easiest approach, but has some problems.
   - fdisk(8), bsdlabel(8), newfs(8)
3. Make mount point and mount it
   - # mkdir /home2
   - # mount –t ufs /dev/ad3s1e /home2
   - # df
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/ad3s1e
  - % mount –t ufs /dev/ad3s1e /home2
  - % mount

```
/dev/ad0s1a on / (ufs, local, soft-updates)
/dev/ad1s1e on /home (ufs, local, soft-updates)
procfs on /proc (procfs, local)
/dev/ad3s1e on /home2 (ufs, local, soft-updates)
```

RAID

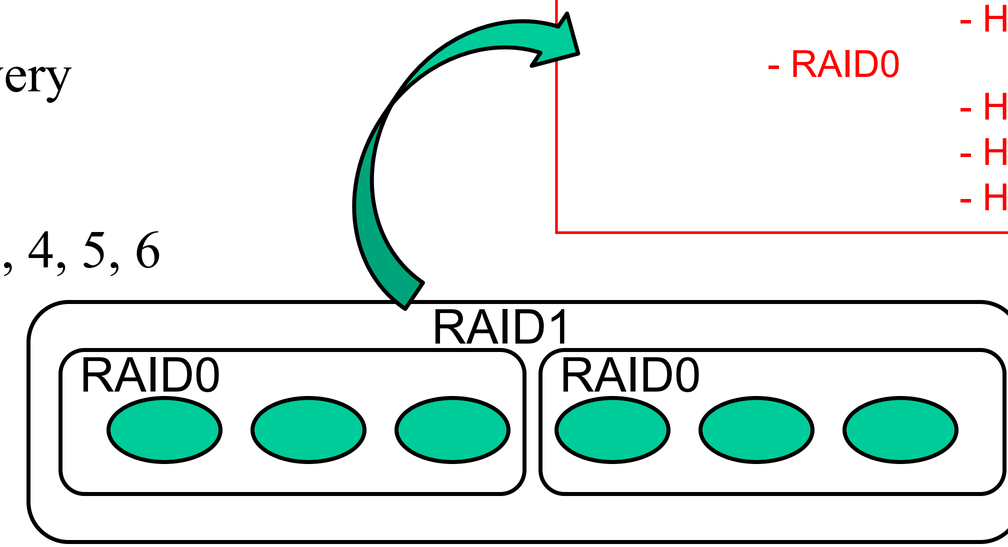
RAID – (1)

- Redundant Array of Inexpensive Disks
  - A method to combine several physical hard drives into one logical unit

e.g. HD1, HD2 → D:\ in windows

- 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

RAID1
- RAID0
  - HD
  - HD
  - HD
- RAID0
  - HD
  - HD
  - HD

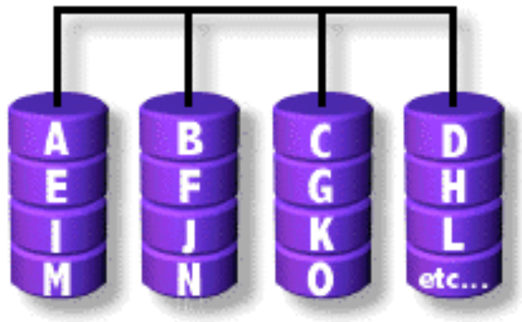


RAID – (2)

- 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
    - **GEOM**
      - **CACHE、CONCAT、ELI、JOURNAL、LABEL、MIRROR、MULTIPATH、NOP、PART、RAID3、SHSEC、STRIPE、VIRSTOR**
    - **ZFS**
      - **STRIPE**
      - **MIRROR**
      - **RAID-Z、RAID-Z2、RAID-Z3**

RAID 0 (normally used)

(500GB+500GB=1TB)



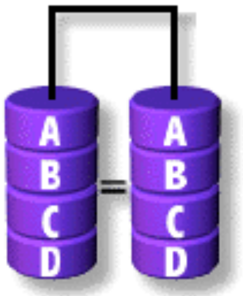
- ❑ Stripped data intro several disks
- ❑ Minimum number of drives: 2
- ❑ Advantage
  - Performance increase in proportional to n **theoretically**
  - Simple to implement
- ❑ Disadvantage
  - No fault tolerance
- ❑ Recommended applications
  - Non-critical data storage
  - Application requiring high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

e.g. HD1 (500GB), HD2 (500GB)
→ D:\ in windows (1TB)

parallel file io from/to different HDs

RAID 1 (normally used)

(500GB+500GB=500GB)

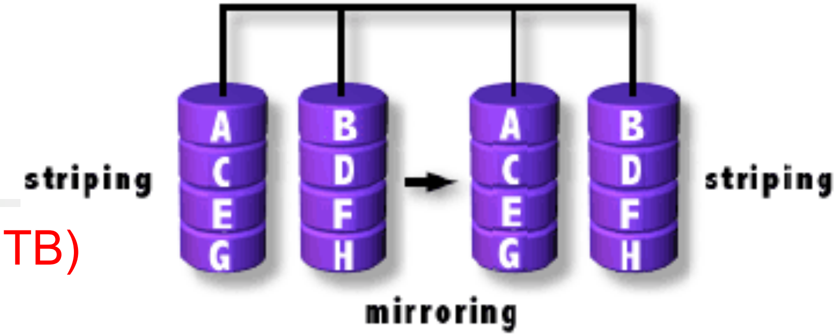


- Mirror data into several disks
- Minimum number of drives: 2
- Advantage
  - 100% redundancy of data
- Disadvantage
  - 100% storage overage
  - Moderately slower write performance
- Recommended application
  - Application requiring very high availability (such as home)

Cause by double check mechanisms on data…

RAID 0+1 (normally used)

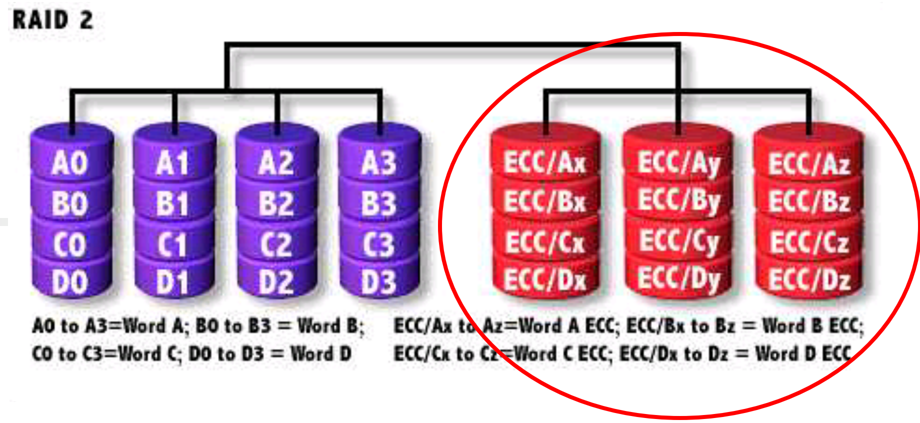
[(500GB+500GB)+(500GB+500GB)]=1TB)



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

RAID1, RAID1
Them RAID0 above it

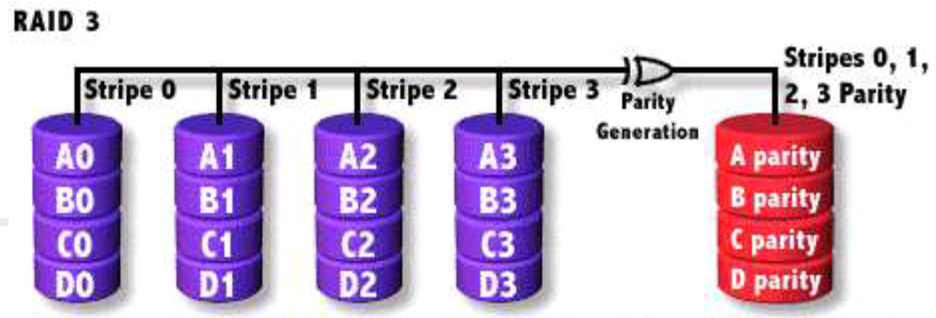
RAID 2



- 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

Read, check if correct, then read

RAID 3

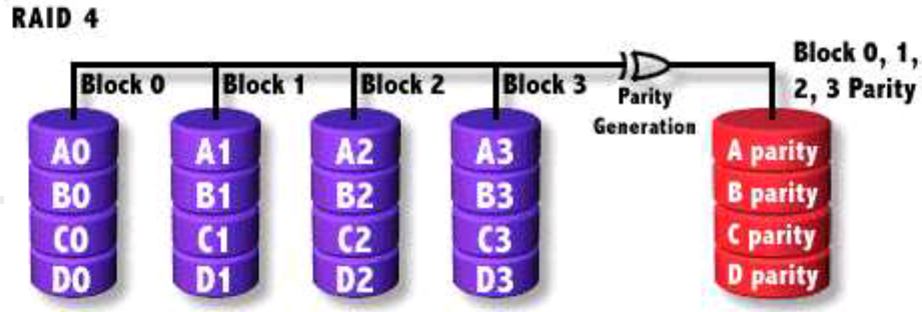


RAID1 if two HDs

Save parity

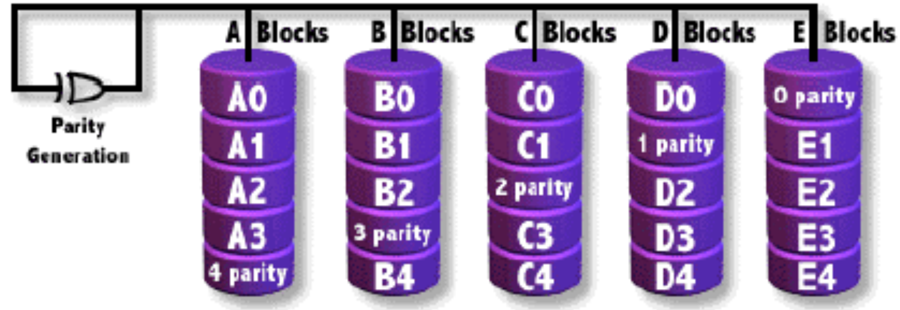
- Parallel transfer with Parity
- Minimum number of drives: 3
- Advantages:
  - Very high data transfer rate
- Disadvantages:
  - Transaction rate equal to that of a single disk drive at best
- Recommended Application
  - Any application requiring high throughput

RAID 4



- Similar to RAID3
- RAID 3 V.S RAID 4
  - Byte Level V.S Block Level
  - Block interleaving
    - Small files (e.g. 4k)

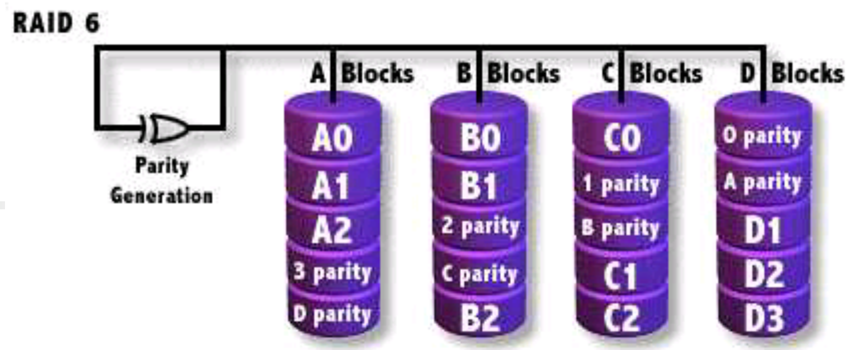
RAID 5 (normally used)



- ❑ Independent Disk with distributed parity blocks
- ❑ Minimum number of drives: 3 — Origin from RAID3
- ❑ Advantage — Parallel file I/O
  - 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

Can tolerate only 1 HD failure

RAID 6 (normally used)



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

Slower than RAID5 because of storing 2 parities…

GEOM

Modular Disk Transformation Framework

GEOM – (1)

- Support
  - ELI – geli(8): cryptographic GEOM class
  - JOURNAL – gjournal(8): journaled devices
  - LABEL – glabel(8): disk labelization
  - MIRROR – gmirror(8): mirrored devices
  - STRIPE – gstripe(8): striped devices
  - …

Journalize (logs) before write

Software RAID1

Software RAID0

- http://www.freebsd.org/doc/handbook/geom.html

GEOM – (2)

- GEOM framework in FreeBSD
  - Major RAID control utilities
  - Kernel modules (/boot/kernel/geom_*)
  - Name and Prodivers ← devices
    - "manual" or "automatic"
    - Metadata in the last sector of the providers

Logical volumes

- Kernel support
  - {glabel,gmirror,gstripe,g*} load/unload
    - device GEOM_* in kernel config
    - geom_*_enable="YES" in /boot/loader.conf

(1) On demand load/unload kernel modules..

(2) Build-in kernel and recompile

(3) load automatically at booting

GEOM – (3)

- LABEL
  Why use it? → bundle by name instead of bundle by provider
  - Used for GEOM provider labelization.
  - Kernel
    - device GEOM_LABEL
    - geom_label_load="YES"

    e.g. ad0s1d → usr
  - glabel (for new storage)
    - # glabel label -v usr da2
    - # newfs /dev/label/usr
    - # mount /dev/label/usr /usr
    - # glabel stop usr
    - # glabel clear da2

    Label → auto. at boot
    >> Create → only this time

    /dev/label/usr

    Stop using the name

    Clear metadata on provider
  - UFS label (for an using storage)
    - # tunefs -L data /dev/da4s1a
    - # mount /dev/ufs/data /mnt/data

    "data" is a name

GEOM – (4)

❑ MIRROR

- Used for GEOM provider labelization.
- Kernel
  - device GEOM_MIRROR
  - geom_mirror_load="YES"
- gmirror ※ Using gmirror for building up RAID1
  - # gmirror label -v -b round-robin data da0
  - # newfs /dev/mirror/data
  - # mount /dev/mirror/data /mnt
  - # gmirror insert data da1
  - # gmirror forget data
  - # gmirror insert data da1
  - # gmirror stop data
  - # gmirror clear da0

logical volume called "data", using HD: da0, …

Add in HD

Kill inexist HDs

GEOM – (5)

❑ STRIPE

- Used for GEOM provider labelization.
- Kernel
  - ➢ device GEOM_STRIPE
  - ➢ geom_stripe_load="YES"
- gstripe
  - ➢ # gstripe label -v -s 131072 data da0 da1 da2 da3
  - ➢ # newfs /dev/stripe/data
  - ➢ # mount /dev/stripe/data /mnt
  - ➢ # gstripe stop data
  - ➢ # gstripe clear da0

Create logical volume "data", which stripe da0~da3 HDs