RAID

RAID

- RAID is an acronym for **Redundant Array of Inexpensive, or Independent Disks**
- There are **two types of RAID** that can be used on computer systems.
- These types are *hardware RAID and software RAID*

Types

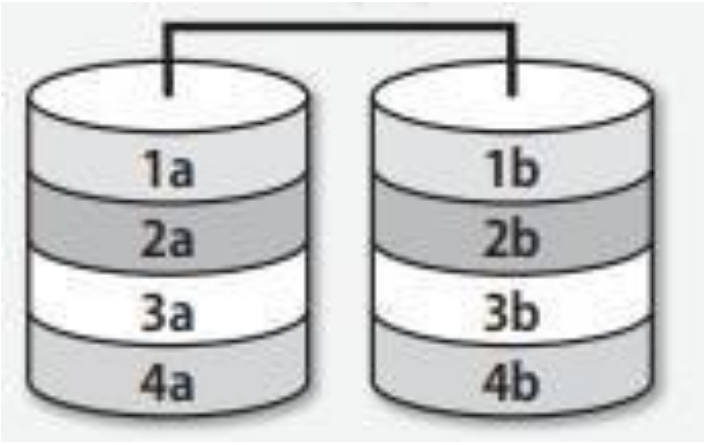
- **Hardware RAID** — In hardware RAID the disks have their own RAID controller with built-in software that handles the RAID disk setup, and I/O.
- **Software RAID** — In software RAID there is no RAID controller card. The operating system is used to set up a logical array, and the operating system controls the RAID level used by the system.

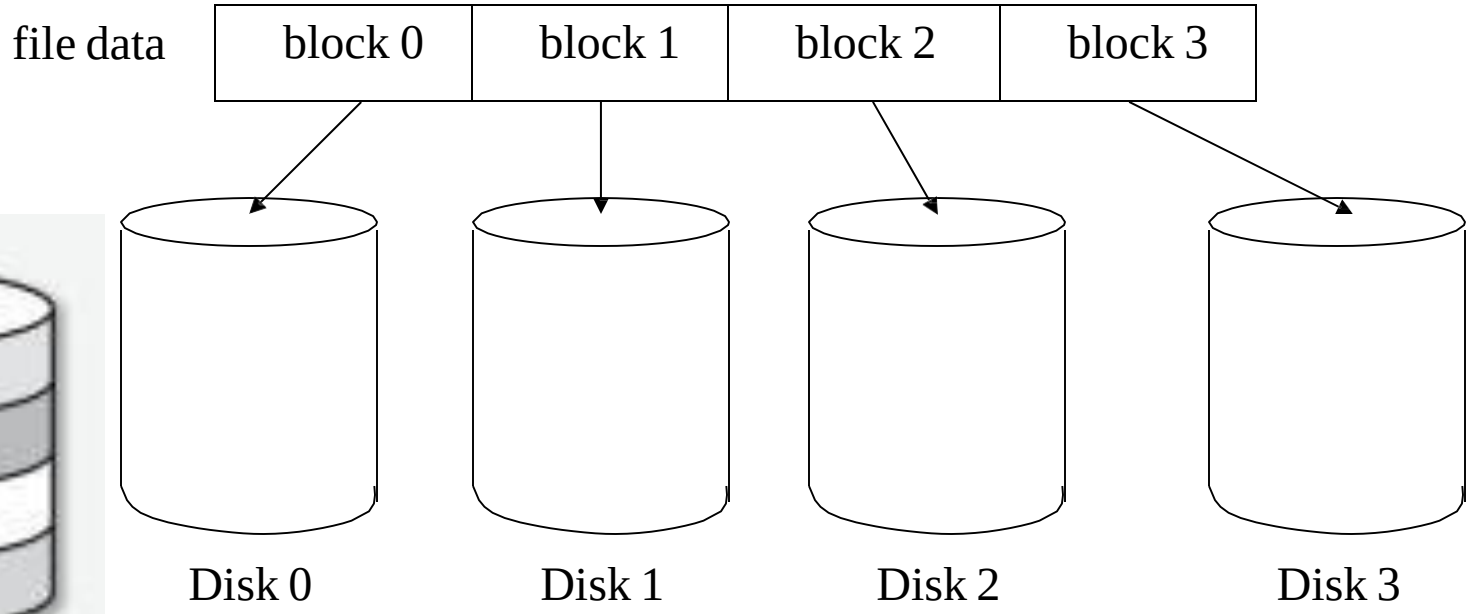
RAID

- Basic idea is to **connect multiple disks together** to provide
  - large storage capacity
  - faster access to reading data
  - redundant data
- Depending on how you set up the array, this configuration can **increase performance** (by reading or writing disks in parallel), **increase reliability** (by duplicating or parity-checking data across multiple disks), or both
- Many different levels of RAID systems
  - differing levels of redundancy, error checking, capacity, and cost

Striping

- Take file data and map it to different disks
- Allows for reading data in parallel





Parity

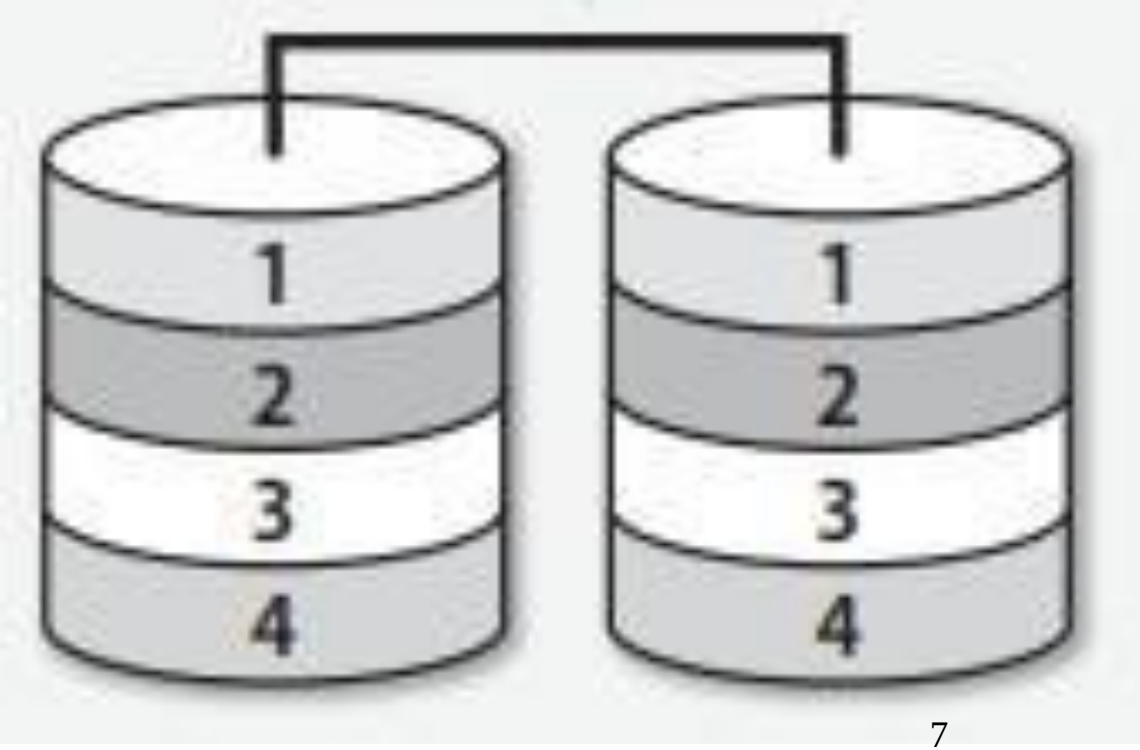
- Way to do error checking and correction
- Add up all the bits that are 1
  - if even number, set parity bit to 0
  - if odd number, set parity bit to 1
- To actually implement this, do an exclusive OR of all the bits being considered
- Consider the following 2 bytes

byte	parity
10110011	1
01101010	0

- If a single bit is bad, it is possible to correct it

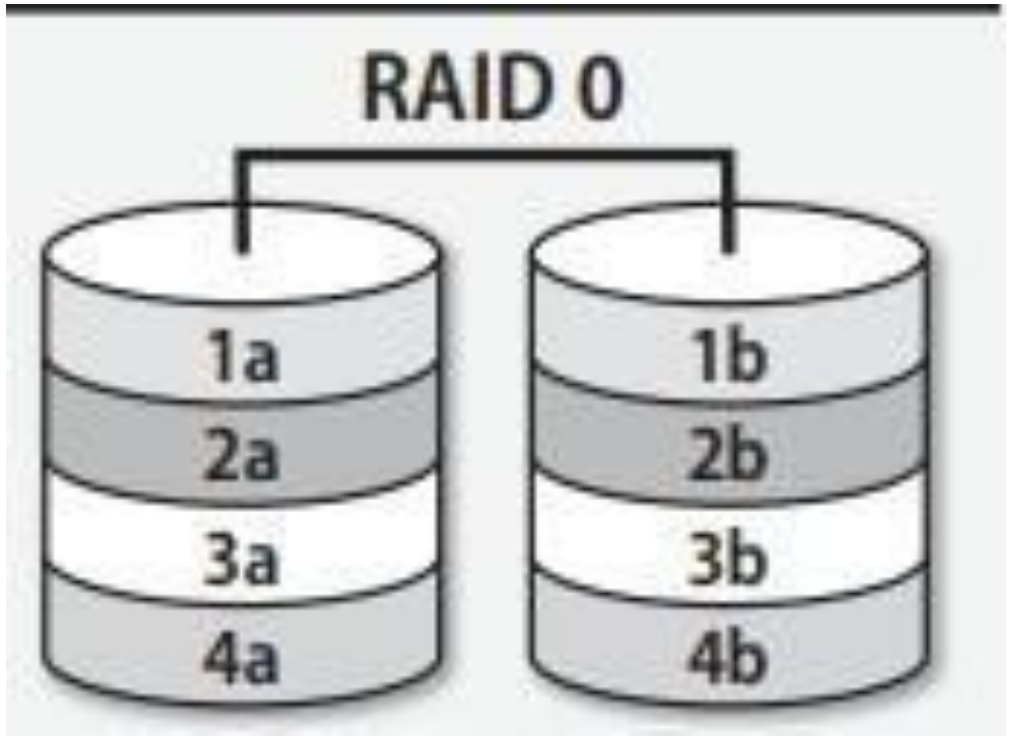
Mirroring

- Keep to copies of data on two separate disks
- Gives good error recovery
  - if some data is lost, get it from the other source
- Expensive
  - requires twice as many disks
- Write performance can be slow
  - have to write data to two different spots
- Read performance is enhanced
  - can read data from file in parallel

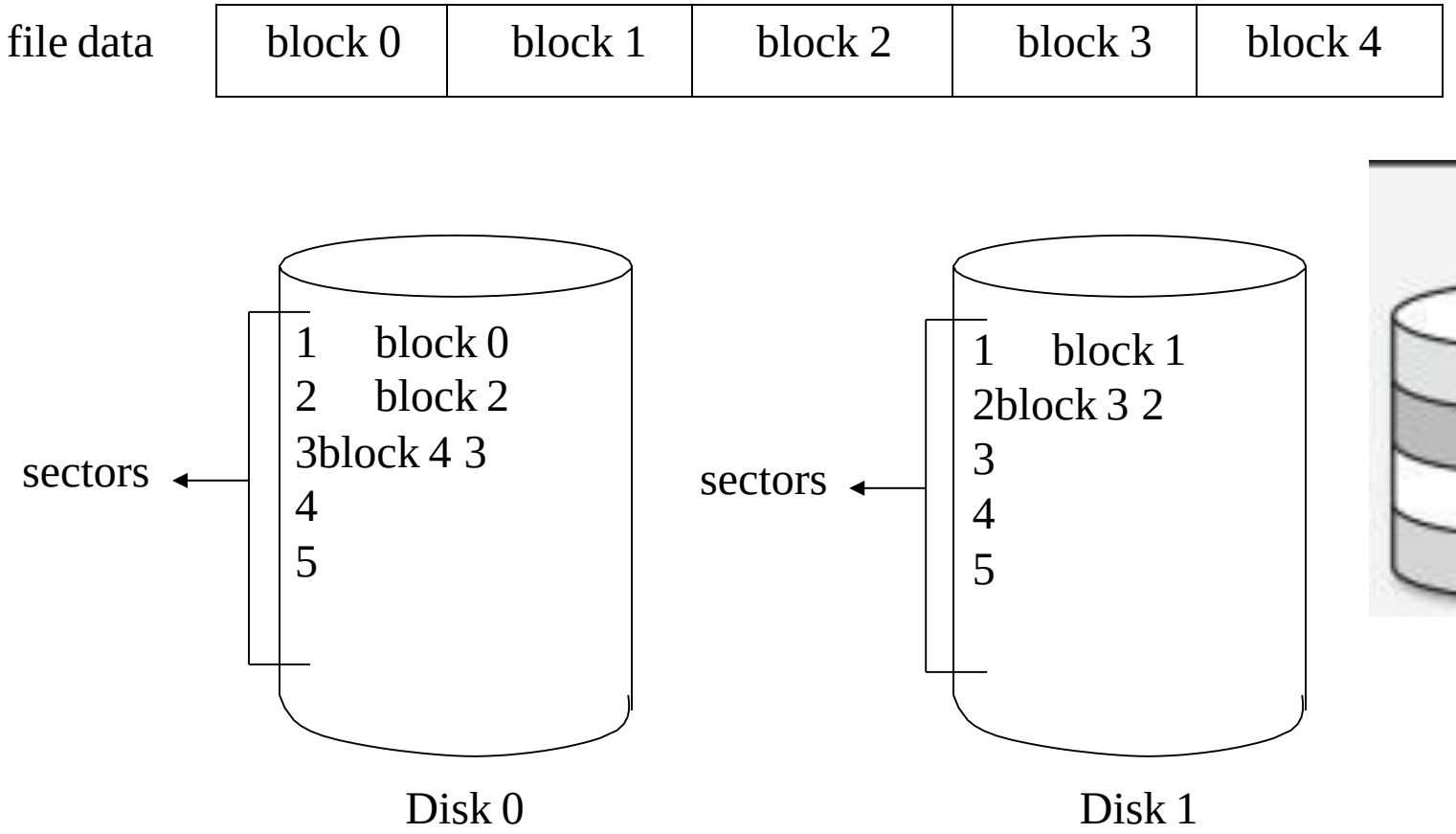


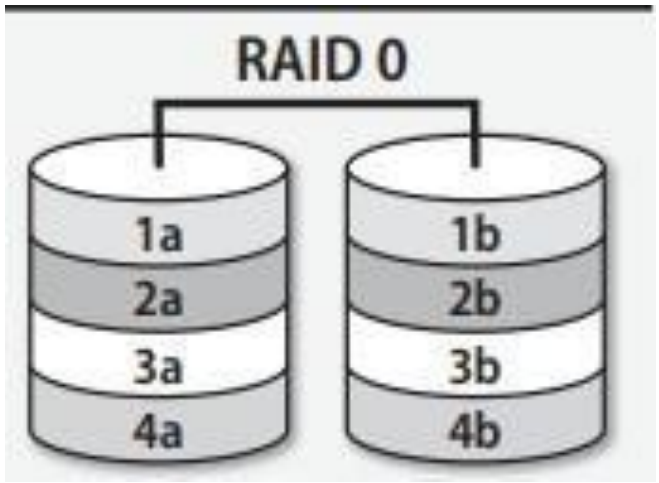
RAID Level-0 (Striping)

- Often called striping
- Break a file into blocks of data
- Stripe the blocks across disks in the system



RAID Level-0


file data
block 0
block 1
block 2
block 3
block 4
sectors
1 block 0
2 block 2
3block 4 3
4
5
Disk 0
sectors
1 block 1
2block 3 2
3
4
5
Disk 1

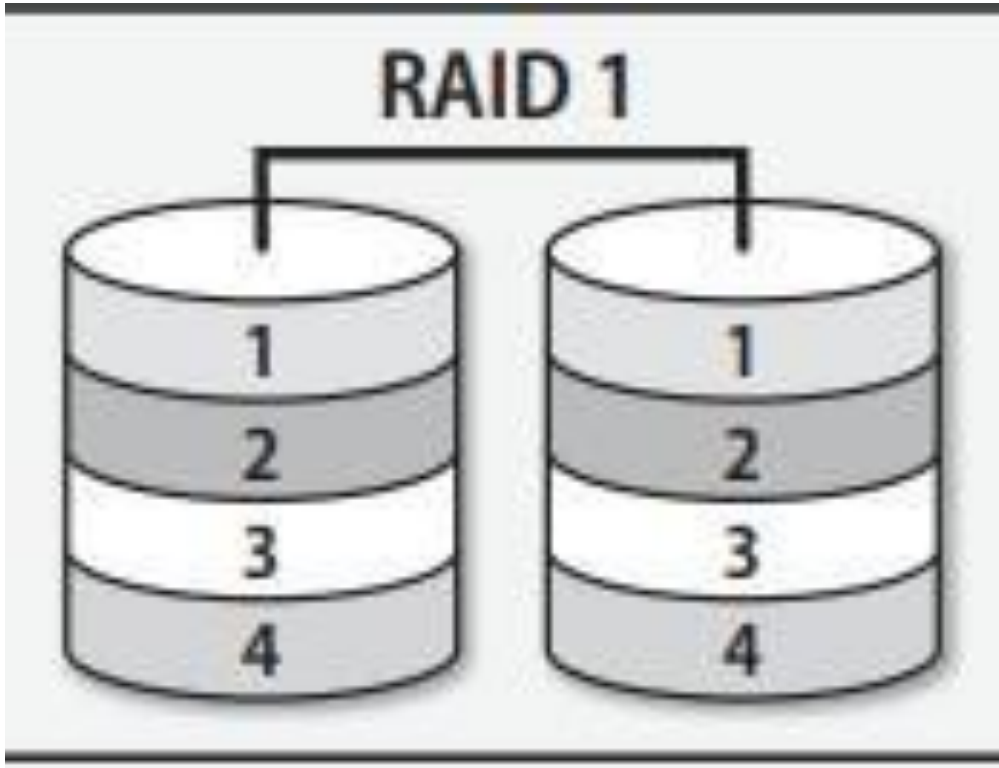

RAID 0
1a
2a
3a
4a
1b
2b
3b
4b

Advantages and Disadvantages

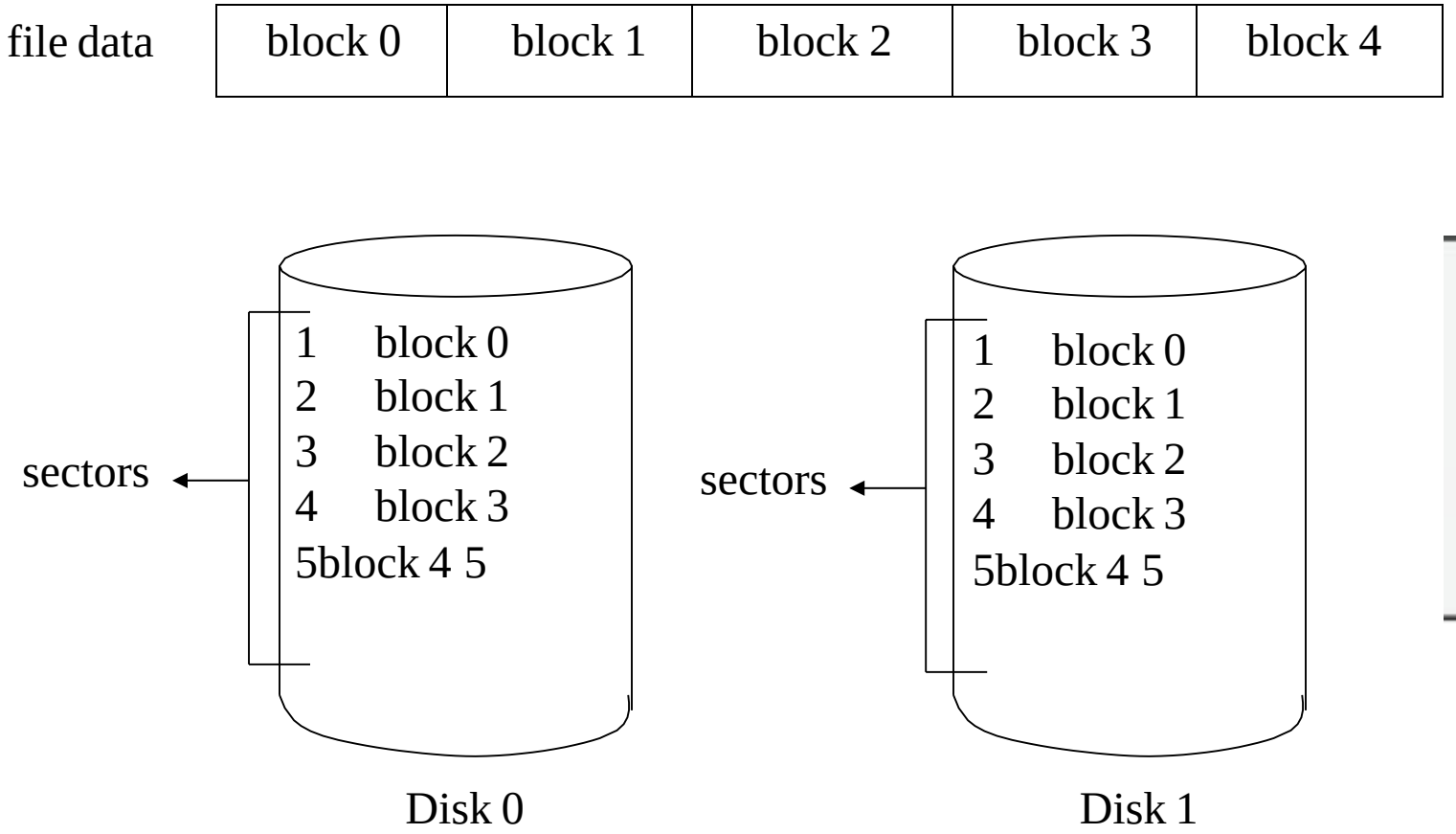
- Fast access
- If one disk fails, the entire system will no more be able to use the data on all the disks

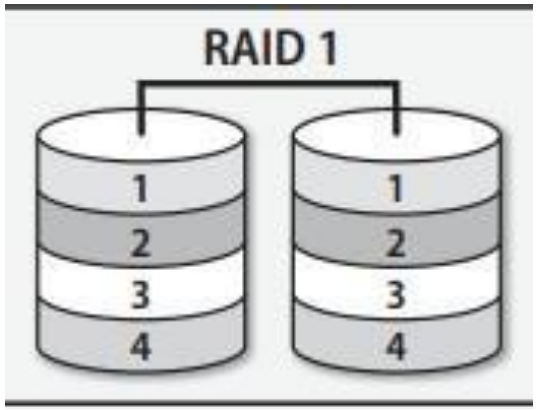
RAID Level-1 (Data Mirroring)

- A complete file is stored on a single disk
- A second disk contains an exact copy of the file
- Provides complete redundancy of data
- Read performance can be improved
  - file data can be read in parallel
- Write performance suffers
  - must write the data out twice
- Most expensive RAID implementation
  - requires twice as much storage space



RAID Level-1


file data
block 0
block 1
block 2
block 3
block 4
sectors
1 block 0
2 block 1
3 block 2
4 block 3
5block 4 5
Disk 0
sectors
1 block 0
2 block 1
3 block 2
4 block 3
5block 4 5
Disk 1


RAID 1
1
2
3
4
1
2
3
4

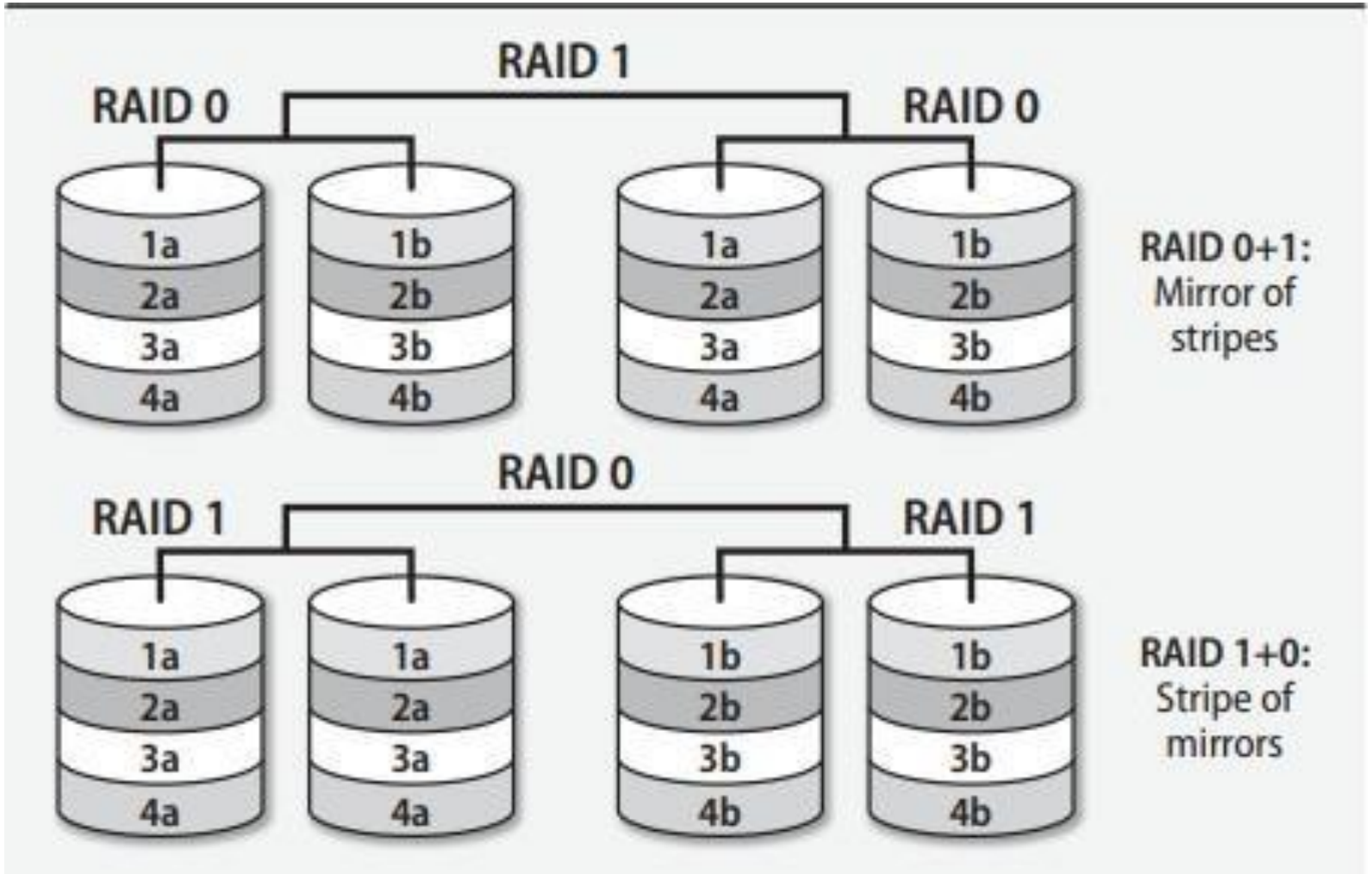
RAID 1 Performance

- Read performance is improved because both disks can be simultaneously read for different records
- Write performance remains unchanged as the same data need to be written to both disks

RAID Level-10

- Combine Level-0 and Level-1
- Stripe a files data across multiple disks
  - gives great read/write performance
- Mirror each strip onto a second disk
  - gives the best redundancy
- The most high performance system
- The most expensive system

RAID 10


RAID 1
RAID 0
RAID 0
1a
2a
3a
4a
1b
2b
3b
4b
1a
2a
3a
4a
1b
2b
3b
4b
RAID 0+1:
Mirror of
stripes
RAID 0
RAID 1
RAID 1
1a
2a
3a
4a
1a
2a
3a
4a
1b
2b
3b
4b
1b
2b
3b
4b
RAID 1+0:
Stripe of
mirrors

RAID 2 (Bit Level Striping with dedicated Hamming Code Parity) & RAID 3

- *RAID 2 and 3* are rarely used strategies that are similar enough to RAID 5.
- However, it should be noted that RAID 3 gives particularly good performance for sequential reads. Therefore, large graphics files, streaming media, and video applications often use RAID 3. If your organization is hosting such files, you may wish to consider a RAID 3 implementation for that particular storage server, especially if files tend to be archived and are not changed frequently.

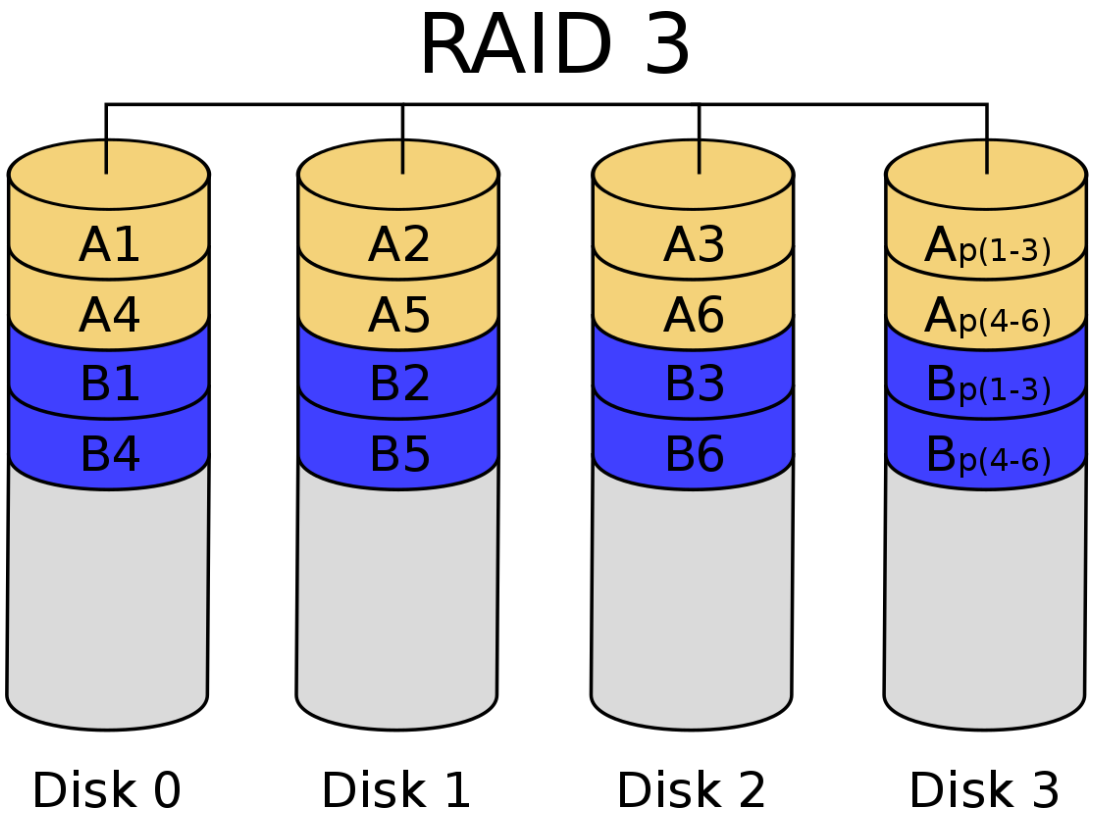
RAID 2,3 &4

- RAID levels 2, 3, and 4 are defined but are rarely deployed.

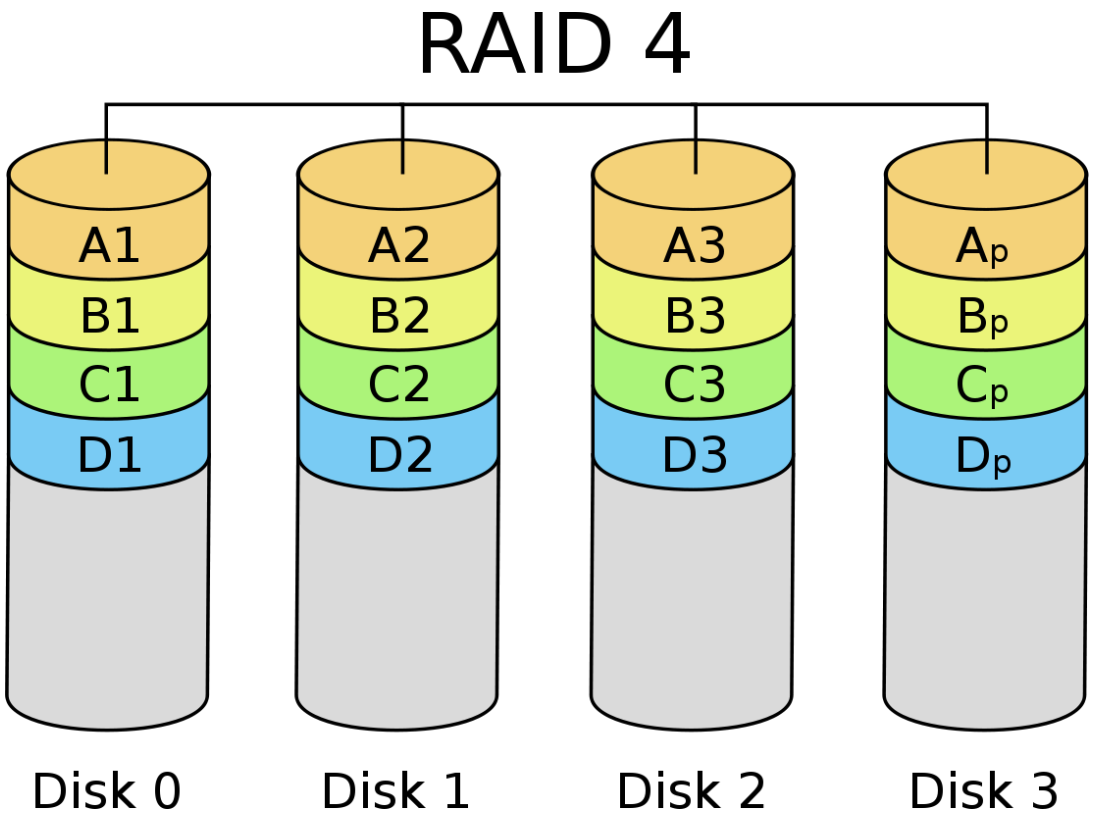
RAID 3 (Byte Level Striping with dedicated Parity)

- RAID 3 is a RAID configuration that uses a parity disk to store the information generated by a RAID controller instead of striping it with the data.
- Because the parity information is on a separate disk, RAID 3 does not perform well when tasked with numerous small data requests.

RAID 3


RAID 3
A1
A4
B1
B4
A2
A5
B2
B5
A3
A6
B3
B6
Ap(1-3)
Ap(4-6)
Bp(1-3)
Bp(4-6)
Disk 0
Disk 1
Disk 2
Disk 3

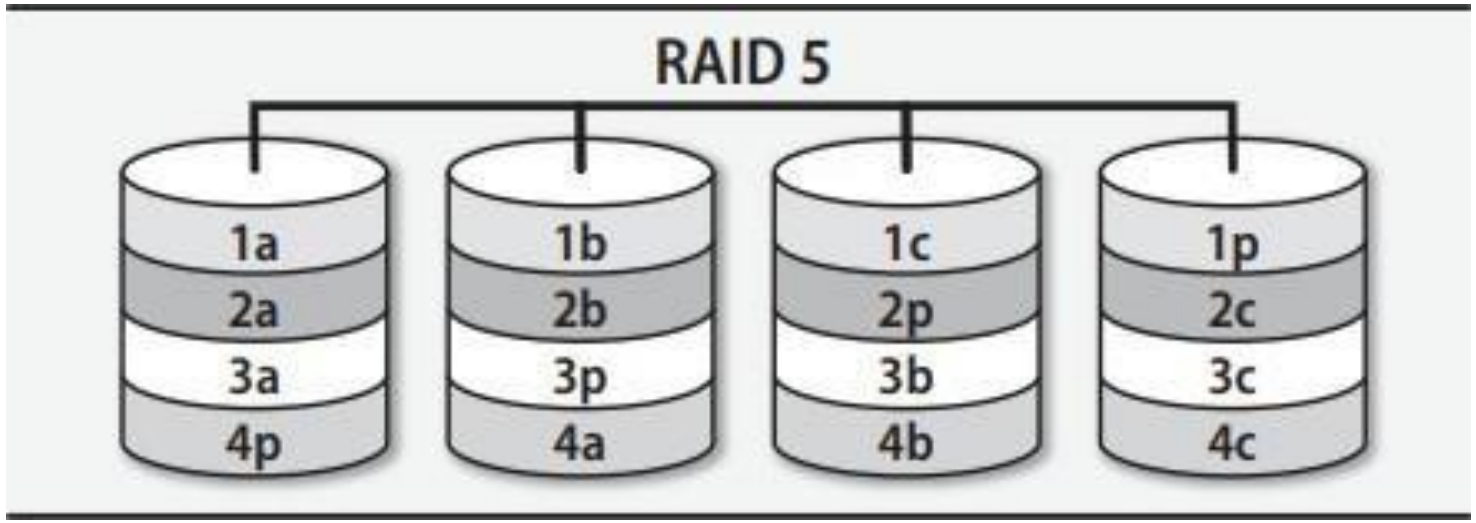
RAID 4(Block Level Striping with dedicated Parity)



RAID 5(Block Level Striping with distributed Parity)

- RAID level 5 stripes both data and parity information, adding redundancy while simultaneously improving read performance.
- In addition, RAID 5 is more efficient in its use of disk space than is RAID 1.
- If there are N drives in an array (at least three are required), N–1 of them can store data.
- The space-efficiency of RAID 5 is therefore at least 67%, whereas that of mirroring cannot be higher than 50%.

RAID 5



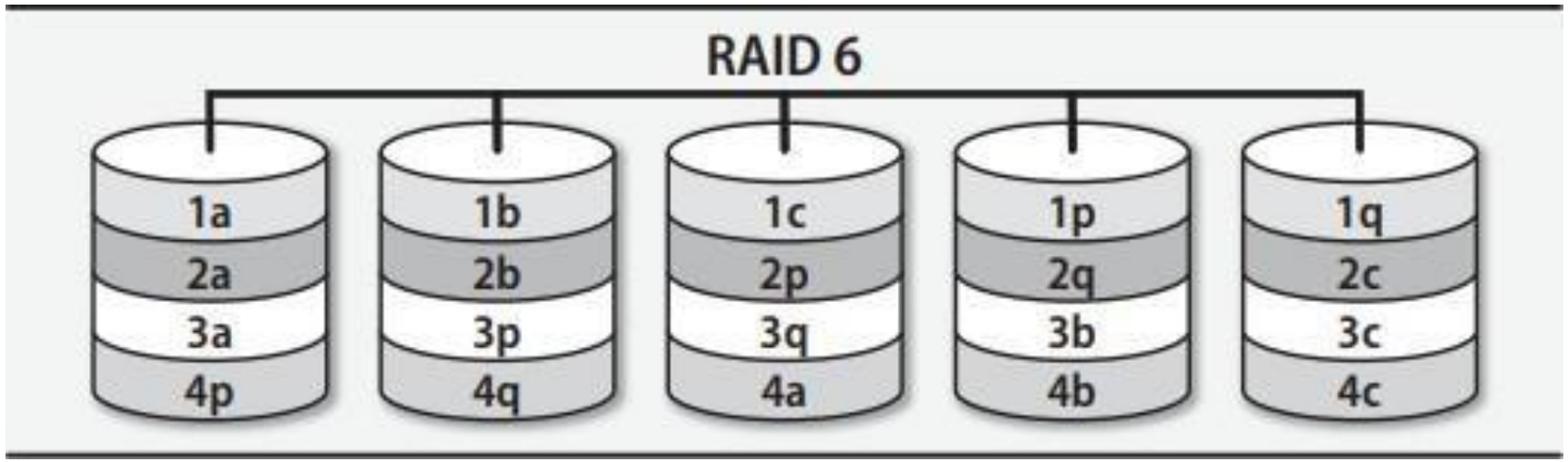
RAID Level-5

- Level-5 stripes file data and check data over all the disks
  - no longer a single check disk
  - no more write bottleneck
- Radically improves the performance of multiple writes
  - they can now be done in parallel
- Slightly improves reads
  - one more disk to use for reading
- Provides fault tolerance using Parity
- Data and parity information is distributed over all the disks

RAID 6 (Block Level Striping with double distributed Parity)

- RAID level 6 is similar to RAID 5 with two parity disks.
- A RAID 6 array can withstand the complete failure of two drives without losing data

RAID 6



Summary

- RAID is not a substitution for backing up
- Redundancy is not the same thing as a backup.

Level	Description	Minimum number of drives[b]	Space efficiency	Fault tolerance	Fault isolation	Read performance	Write performance
						as factor of single disk	
RAID 0	Block-level striping without parity or mirroring	2	1	None	Drive Firmware Only	n	n
RAID 1	Mirroring without parity or striping	2	$\frac{1}{n}$	$n-1$ drive failures	Drive Firmware or voting if $n > 2$	n[a][15]	1[c][15]
RAID 2	Bit-level striping with Hamming code for error correction	3	$1 - \frac{1}{n}\log_2(n+1)$	One drive failure[d]	Drive Firmware and Parity	Depends	Depends
RAID 3	Byte-level striping with dedicated parity	3	$1 - \frac{1}{n}$	One drive failure	Drive Firmware and Parity	$n-1$	$n-1$[e]
RAID 4	Block-level striping with dedicated parity	3	$1 - \frac{1}{n}$	One drive failure	Drive Firmware and Parity	$n-1$	$n-1$[e][*citation needed*]
RAID 5	Block-level striping with distributed parity	3	$1 - \frac{1}{n}$	One drive failure	Drive Firmware and Parity	n[e]	single sector: $\frac{1}{4}$ full stripe: $n-1$[e] [*citation needed*]
RAID 6	Block-level striping with double distributed parity	4	$1 - \frac{2}{n}$	Two drive failures	Drive Firmware and Parity	n[e]	single sector: $\frac{1}{6}$ full stripe: $n-2$[e] [*citation needed*]