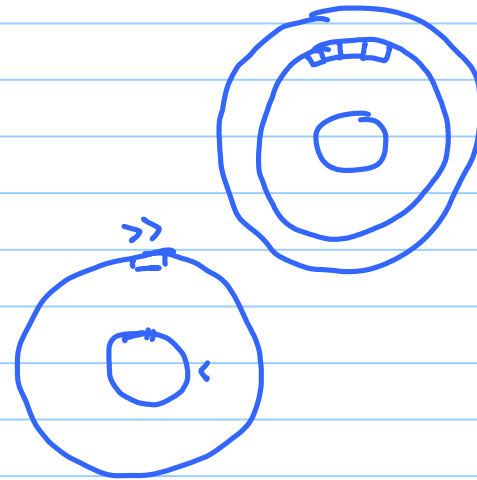
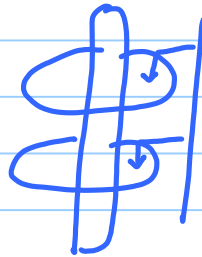
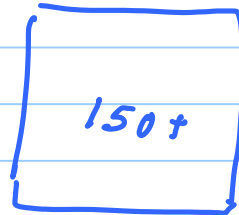
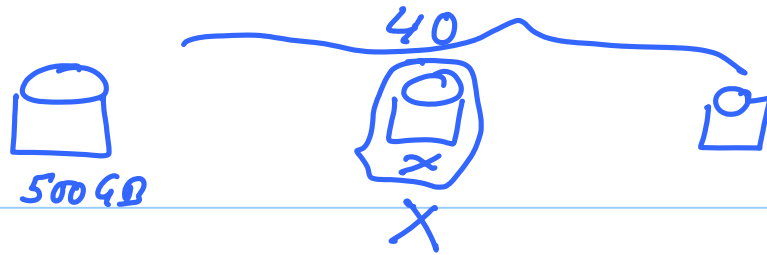


Nov 2nd



Large Storage:

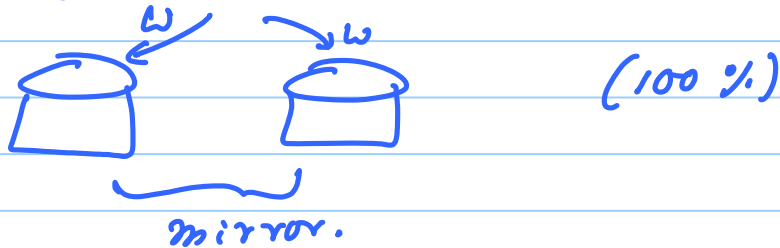




RAID : Redundent Array of Inexpensive Disks

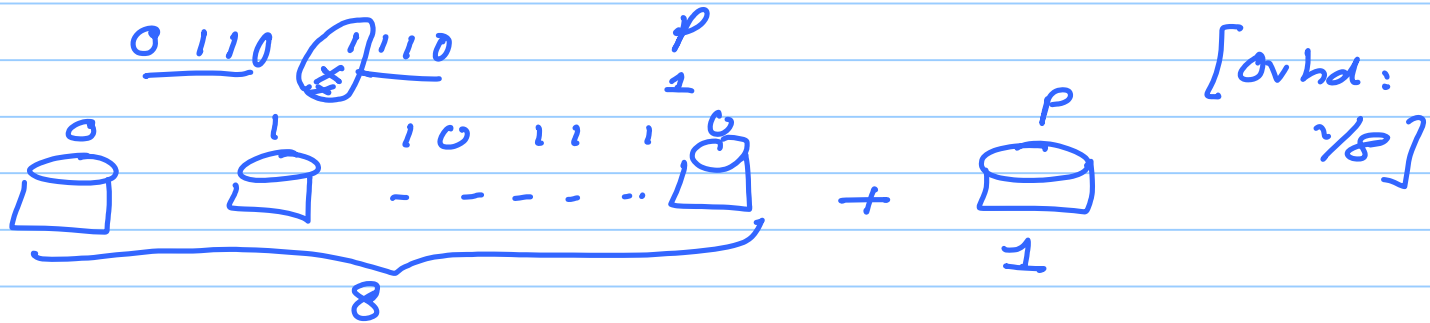
RAID-0 : NO fault tolerance

RAID 1:

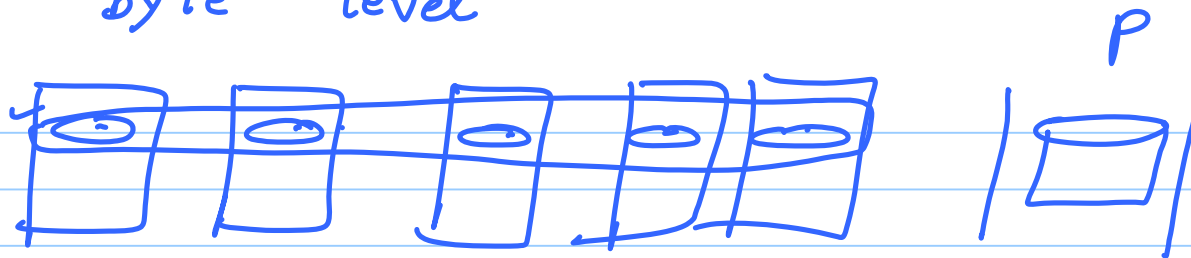


RAID 2:

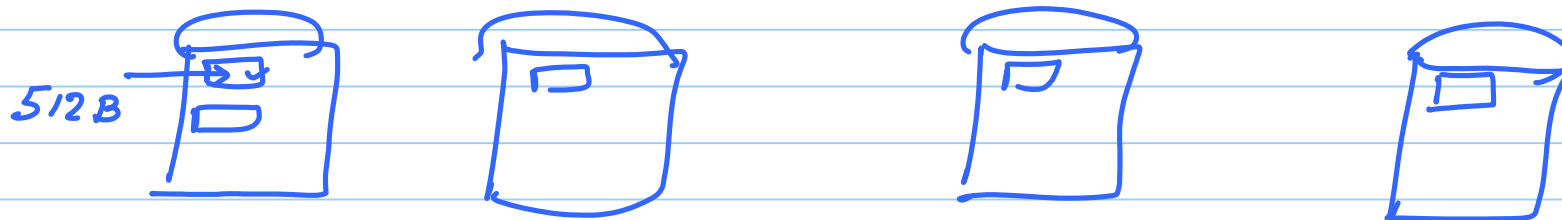
(bit level)



RAID 3: byte level



RAID 4: block level (512B)

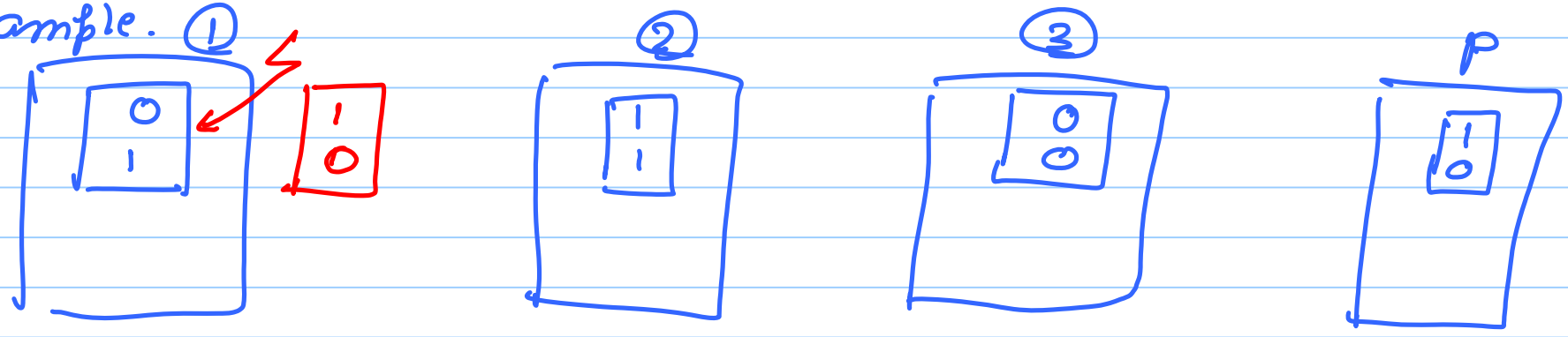


Write:

- 1) Read the old value of the block  $V_{blk}^{old}$
- 2) Write the block into the designated disk
- 3) Read the old parity block  $P_{old}$

4) Compute: 
$$P_{new} = P_{old} \oplus V_{blk} \oplus V_{blk}^{old} \quad \dots (1)$$

Example. ①



$$P_{new} = \begin{matrix} P_{old} \\ 1 \\ 0 \end{matrix} \oplus \begin{matrix} V_{blk}^{old} \\ 0 \\ 1 \end{matrix} + \begin{matrix} V_{blk}^{new} \\ 1 \\ 0 \end{matrix} = \begin{matrix} 0 \\ 1 \end{matrix}$$

$$P_{new} = \underbrace{\begin{bmatrix} 1 \\ 0 \end{bmatrix} \oplus \begin{bmatrix} 1 \\ 1 \end{bmatrix} \oplus \begin{bmatrix} 0 \\ 0 \end{bmatrix}}_{\text{Disks}} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad (N+1)$$

RAID 4:  $1W \Rightarrow 2R+2W$

Read

fail-stop: failure (system stops) (1)

fail-silent: data will get corrupted. (N+1)

RAID 4:

+ fault tolerance

+ higher bandwidth

—



RAID 5:

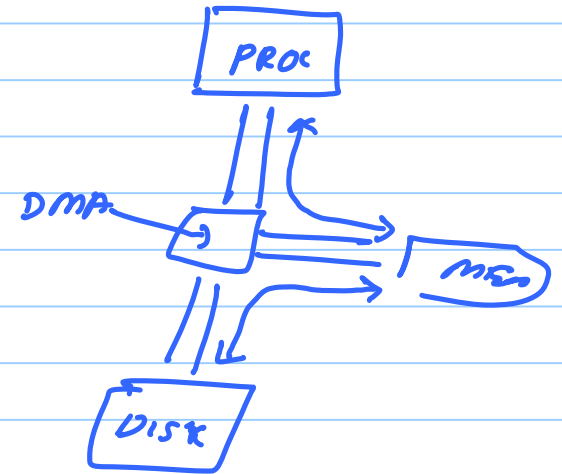
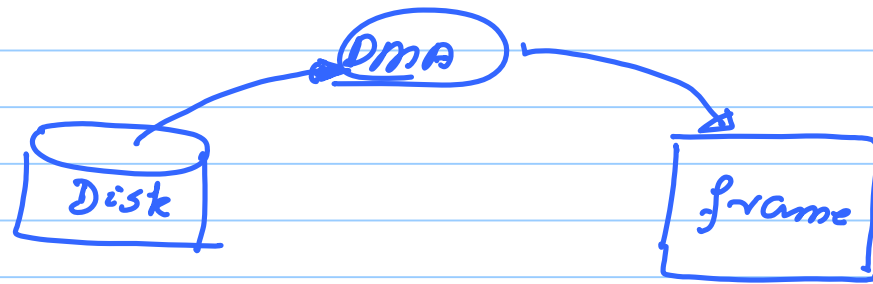
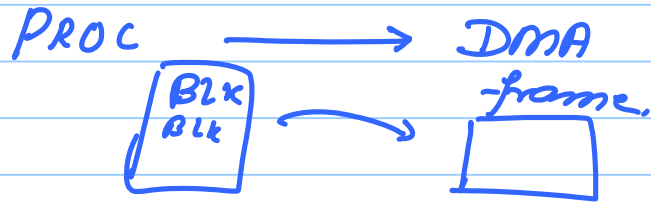
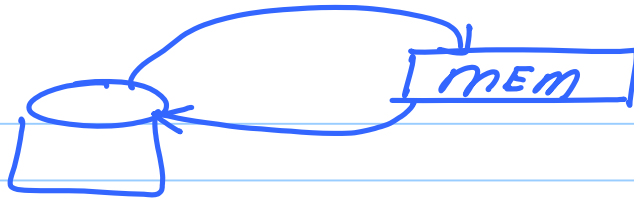


Tolerates 1  
disk failure

RAID 6. Tolerates two disk failures,



# DMA (Direct Memory Access)



1) Cycle stealing mode (low)  
(do its work in free cycles)

2) Burst mode. (high)