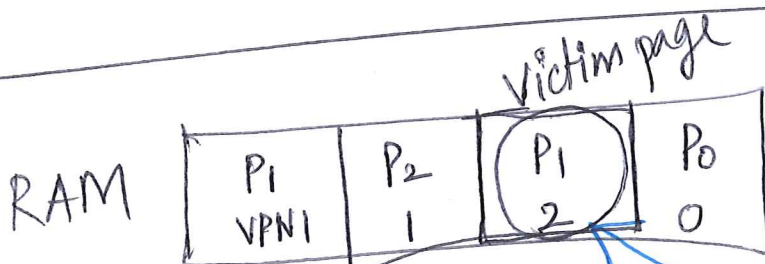
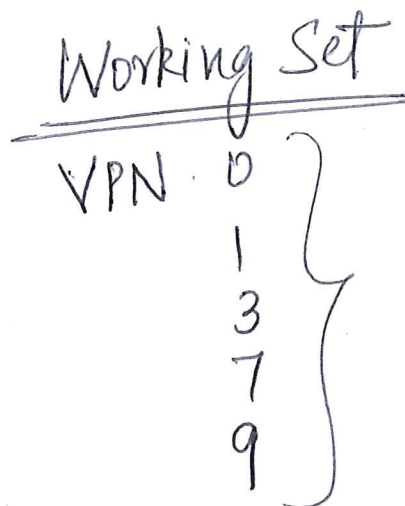
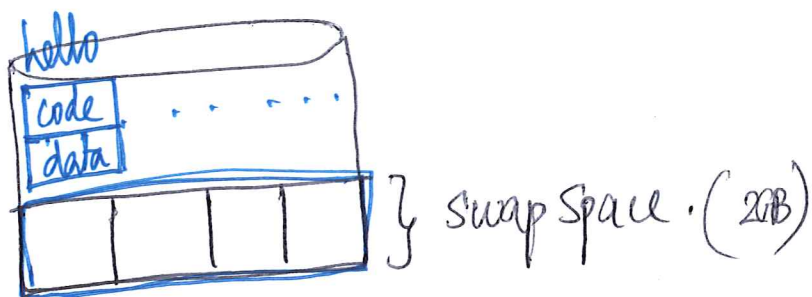
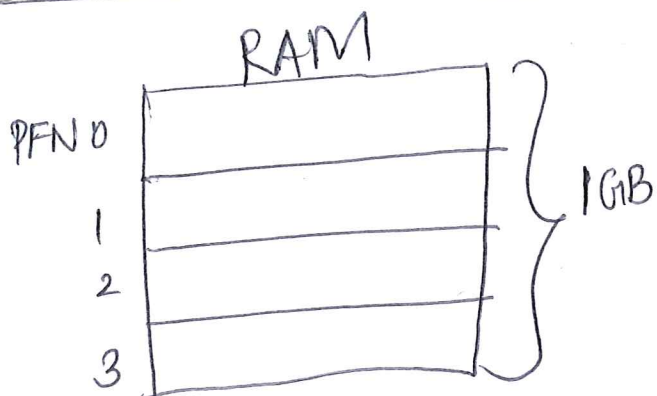


July 13th 2017

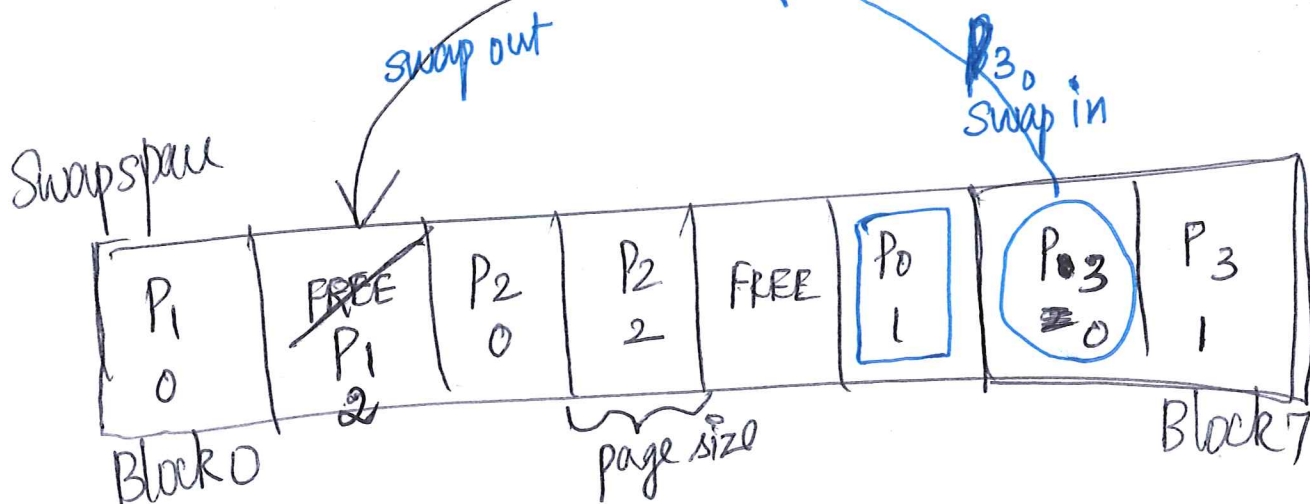
Swapping

Mechanisms

Policies



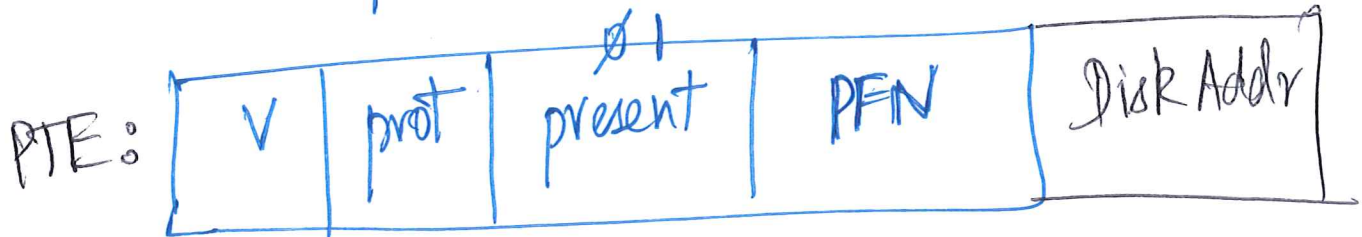
Which page should we evict?
⇒ Policy



Present Bit

PTE

V prot PFN



present = 1 $\Rightarrow$ page is in memory

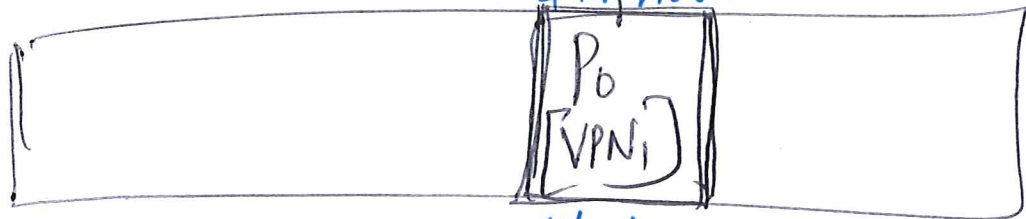
0 $\Rightarrow$ " NOT in "

Page Fault

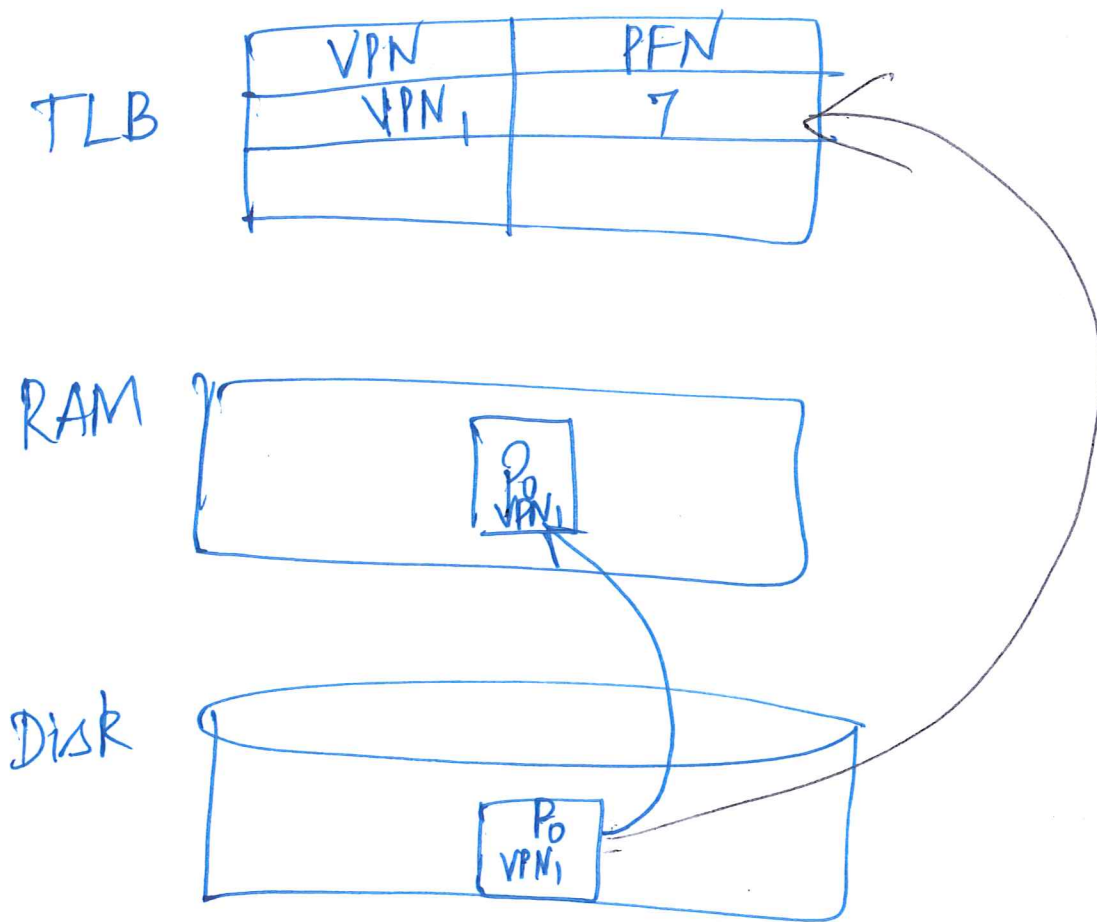
$P_0[VPN_i]$



Disk Addr

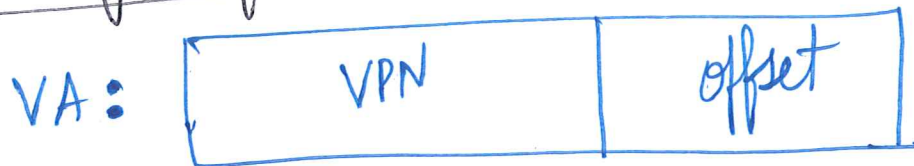


Block 6



1. instr. $\Rightarrow$ Page Fault
OS
2. ~~HW~~ HW- retries instr. $\rightarrow$ TLB Miss
OS $\Rightarrow$ TLB Miss Exception
3. HW- retry instr. $\Rightarrow$ Success
Access Memory

Memory Reference - New Control Flow



Assumptions:

1. simple linear PT
2. HW managed TLB.

1. Extracts VPN from VA.
2. check if the ~~ent~~ VPN is in TLB.

2.a) TLB Hit: Get the PFN + offset

Access

PA
PA

2.b) TLB Miss:

$$\Rightarrow \underline{PA_{PTE}} = PTBR + VPN \times \text{size}(PTE)$$

$\Rightarrow$ Access Memory (PA PTE)



$\Rightarrow$ ~~if~~

$\Rightarrow$ if (present == 1) // in phy. mem.
 $\rightarrow$ extract the PFN from the PTE
 $\rightarrow$ PFN | offset = PA_{data}
 $\rightarrow$ ~~Access Memory (PA_{data})~~ X
 $\rightarrow$ Update TLB for this VPN.
 $\rightarrow$ retry instr.
 else : // present == 0
 $\rightarrow$ raise (Page Fault Exception)

Page Fault Handler

OS:

PFN = Find Free Physical Page ();

if (PFN == -1) // no free page/frame on phy. mem.

$\leftarrow$ PFN = Evict Page ();

$\nwarrow$ DiskRead (PTE.DiskAddr, PFN) $\nearrow$ Page Replacement Policy

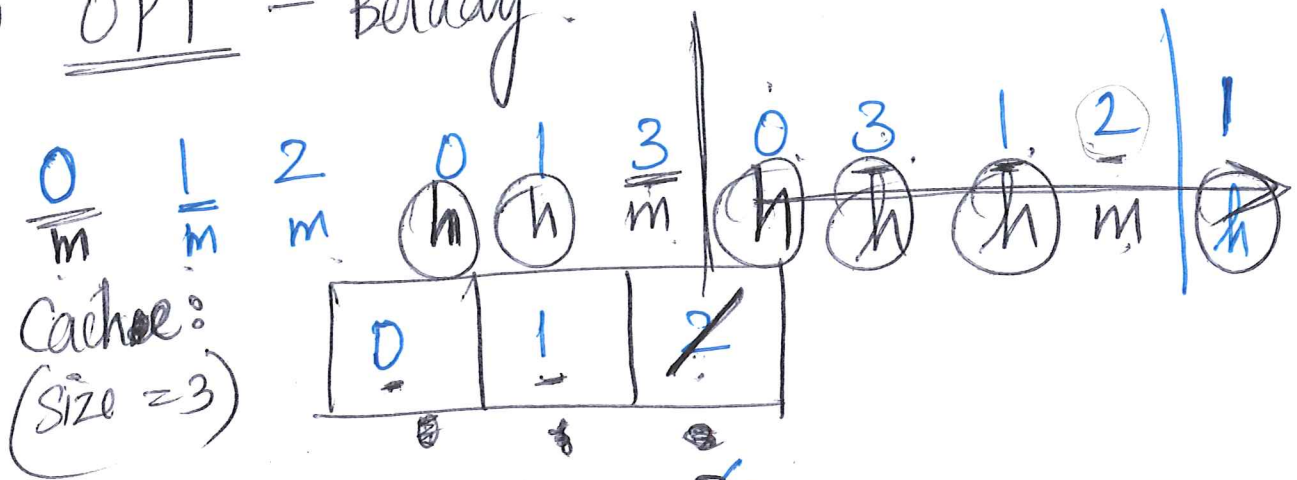
PTE. ~~Present~~ = 1; PTE.PFN = PFN;

Return From Trap (iret)

HW: retry ~~swt~~ instr.

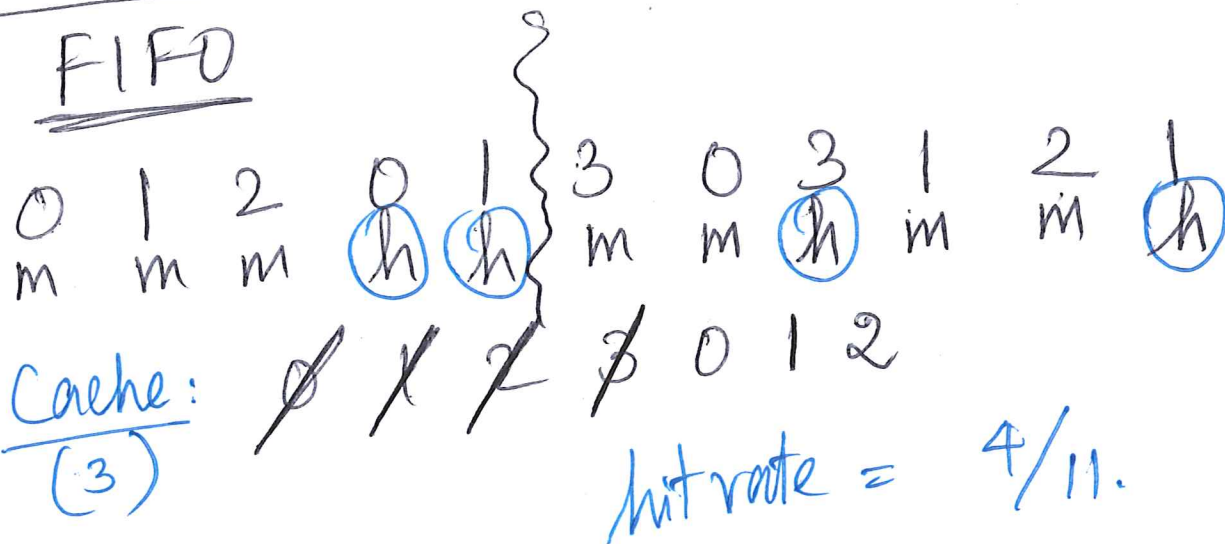
Policies

1) OPT - Belady.



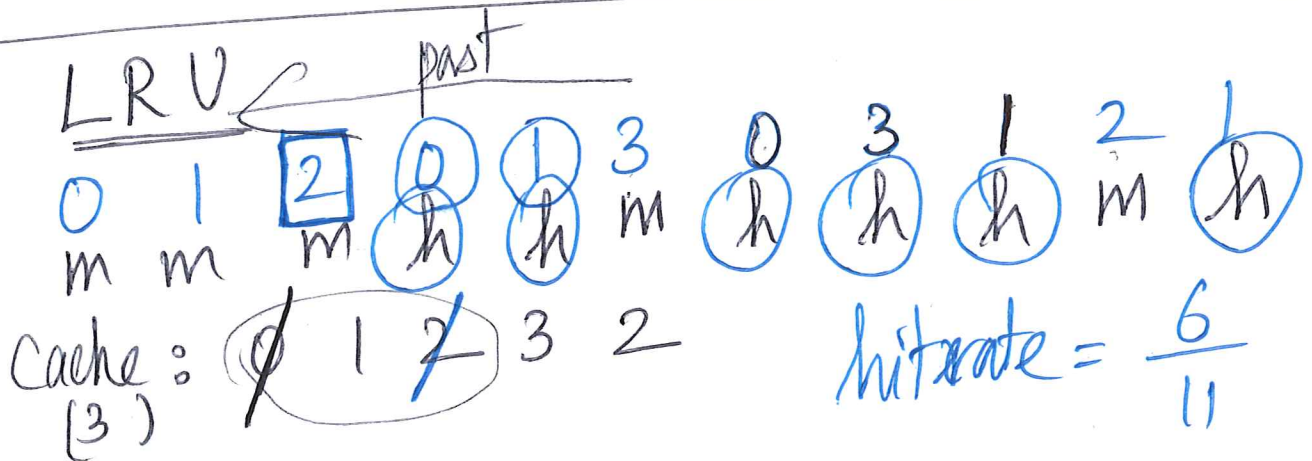
$$\text{hit rate} = \frac{6}{6+5} = \left(\frac{6}{11}\right)$$

2) FIFO



$$\text{hit rate} = 4/11.$$

3) LRU



$$\text{hit rate} = \frac{6}{11}$$

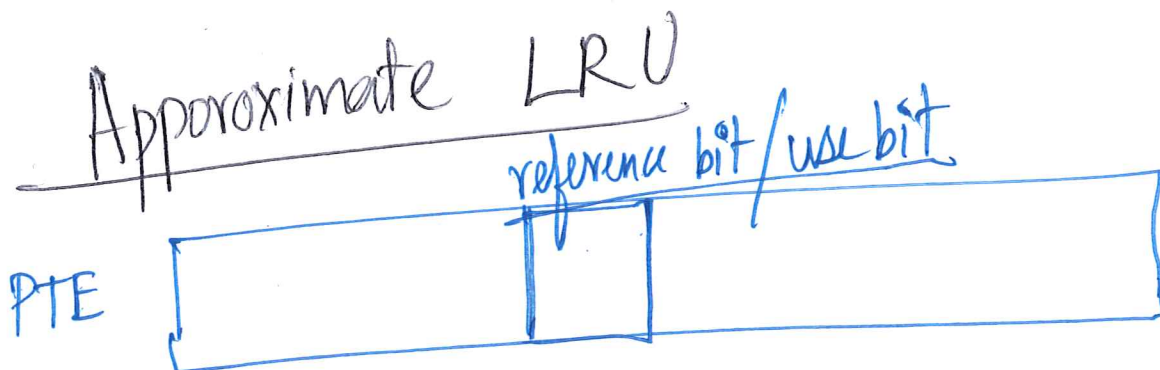
Page # PFN	Time Stamp
0	7
1	3
2	9
3	4

LRU

↓

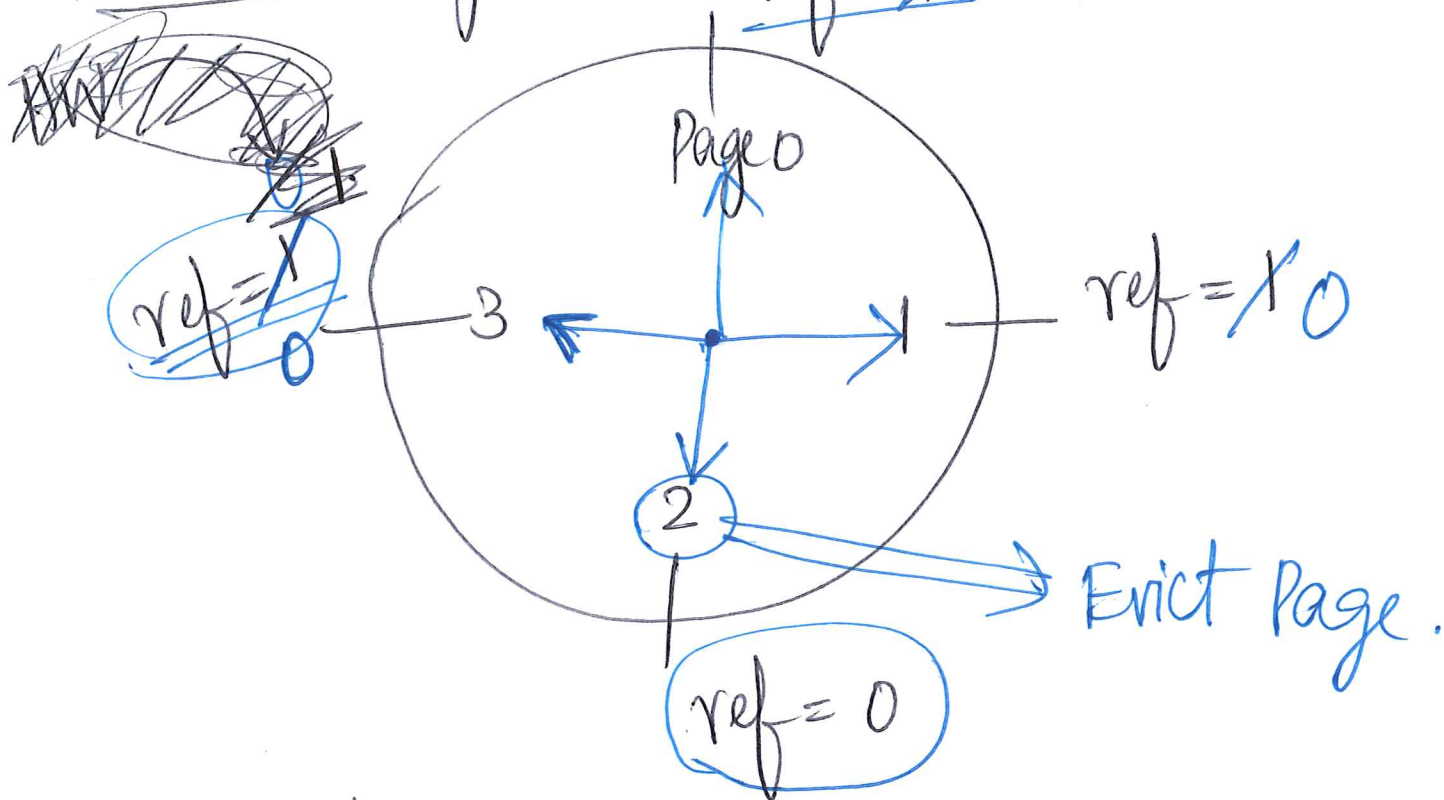
$$\frac{4GB}{4KB} = 2^{20} \text{ phy. frames}$$

≈ 1 million



Clock Algorithm

~~ref = 1~~ 0



ref. bit

HW → sets this bit when the page is referenced.

OS → checks if this bit == 1 ;
⇒ ref = 0 ⇒ done by OS
else if bit == 0 :
⇒ evicts page.