Paging/Segmentation — Exercises

Logical Address:
- 64 Pages of 1024 bytes

Physical Memory:
- 32 Frames

a) How many bits in the logical address

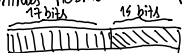
$2^6 \times 2^{10} = 2^{16}$ R:. 16 bits

b) How many bits in the physical address

5 bits to address the frames
10 bits to the frame offset
Total: 15 bits

Page and frame typically have the same size.

32 bit logical address 2^5
4KB page size 2^{12} bytes 2^{23}
512 MB physical memory 2^{32} bits
a) # entries normal 1 lvl page table



$\frac{2^{32}}{2^{12}} = 2^{20}$ 32 bits

b) $\frac{2^{23}}{2^{12}} = 2^{17}$

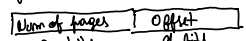
200 ns for memory reference
a) 400 ns → 1 to use the table + 1 for the needed instruction
b) How with TLB, 75% of all references are found in the TLB, what's the memory reference time?

$TT = (H_{TLB} \times TT_{TLB\,Hit}) + (Miss \times TT_{TLB\,miss})$
$= 0.75 \times (100ns) + 0.25 \times 400 = 175 + 100 = 250ns$ //

128kB = 2^{17} bits

Exercise 2

Physical Memory → 256 MBytes → $2^8 \times 2^{23} = 2^{31}$
Virtual Memory → 2 GBytes → $2 \times 2^{33} = 2^{34}$
Logical address:



- Max number of pages: 2^{20}
- Size of each page: $\frac{2^{34}}{2^{20}} = 2^{14} = 2 \times 2^{13} = 2$KB
- PTE occupies 8bytes
  ↳ Max size of table of pages: $2^{20} \times 2^6 = 2^{26} = 8$MB

If inverted ⇒ Capped to physical memory size

$\frac{2^{31}}{2^{14}} = 2^{17}$ $2^{17} \times 2^6 = 2^{23}$ bits

$\frac{2^{26}}{2^{14}} = 2^{12} = 4096$

32 bit logical addresses
1024 entries 128 frames
} LRU Page replacement algorith

Char A[2*1024*1024]

for(int i=0; i<sizeof(A); ++i) A[i]=0

$\log_2 1024 = 10$ → bits for addressing

$2^{22} = 2^2 \times 2^{10} \times 2^{10}$

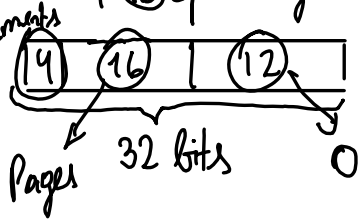
Size of the page

1 Page Fault

⑥ Segmentation + Paging → 4 bits to address them

Virtual Address: 32 bits | 16 equal segments | Each page has 4KB (2^{12} bytes)

PTE: 4 bytes



a) R:. $2^{32} = 4GB$

b) 4, 16, 12

c) $2^{16} \times 2^{2} = 2^{18}$ bytes = 256KB

d) $\frac{2^{18}}{2^{12}} = 2^{6}$ Pages

// Segmentation //

① a) 430 + 219 = 649 b) 2310 c) Illegal Reference ⇒ Trap to OS

d) 1327 + 400 = 1727

// Demanding Paging //

Page Fault → 8ms → Replaced page not modified MAT = 100ns

Page Fault → 20ms → Replaced page modified | Page to be replaced is modified 70% of the time

What's the maximum acceptable page fault rate for an effective access time of no more than 200ns?

$EAT = (1-p) \times MAT + p \times (0,3 \times 8000000ns + 0,7 \times 20000000 + 100)$

$\Leftrightarrow 200 = (1-p) \times 100 + p \times 16400100$

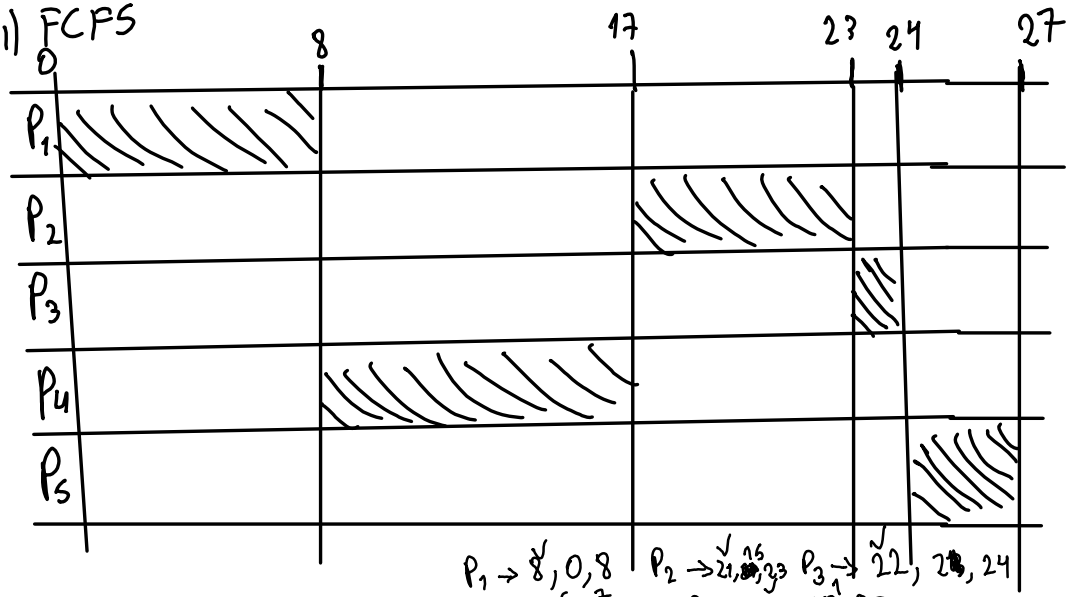
$\Leftrightarrow 200 = 100 - 100p + 16400100p$

$\Leftrightarrow 100 = 16400100p$

$\Leftrightarrow p = \frac{1}{164001}$

Scheduling Exercises

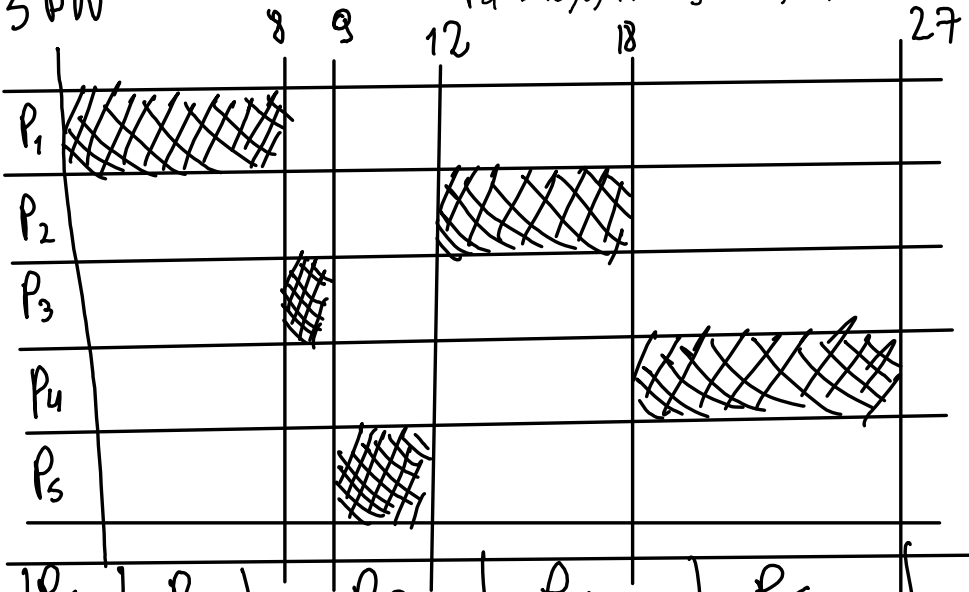
(1) FCFS



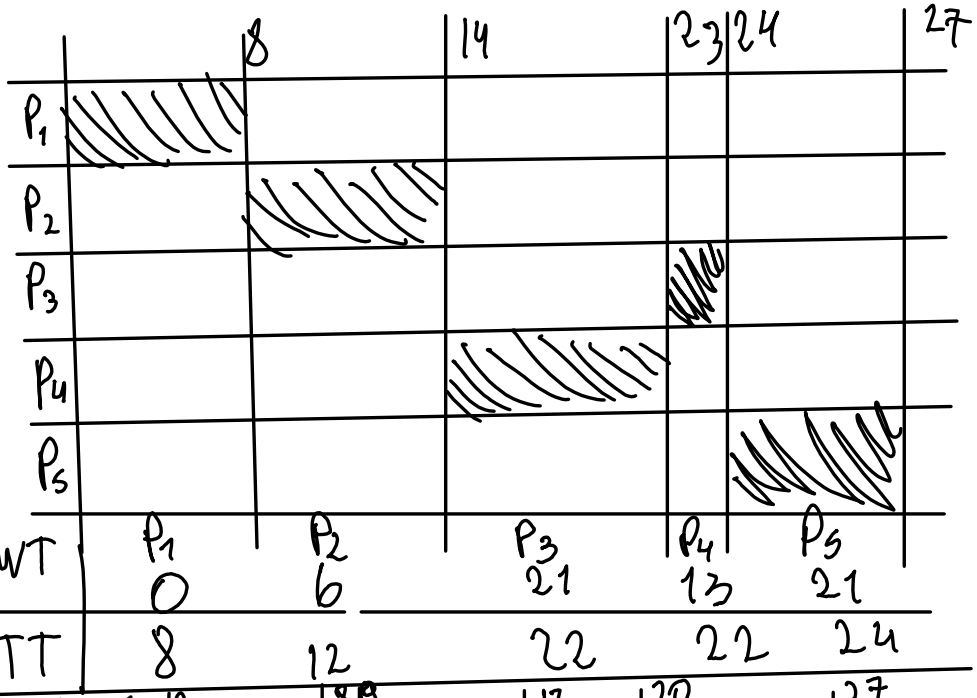
$P_1 \to 8, 0, 8$ $P_2 \to 21, 16, 23$ $P_3 \to 22, 23, 24$

$P_4 \to 16, 7, 17$ $P_5 \to 24, 27, 27$

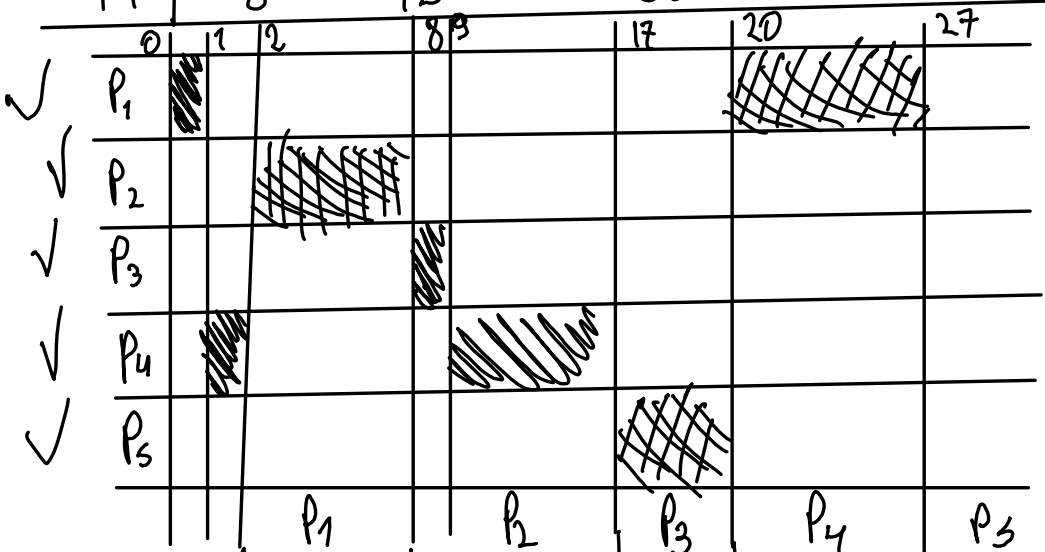
SPN



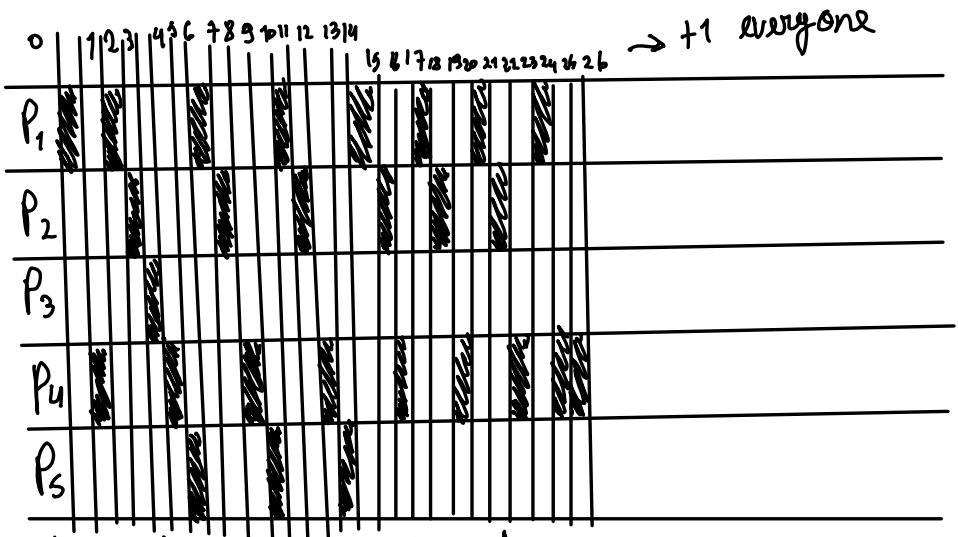
	P_1	P_2	P_3	P_4	P_5
WT	0	10	6	17	6
TT	8	16	7	26	9



	P_1	P_2	P_3	P_4	P_5
WT	0	6	21	13	21
TT	8	12	22	22	24



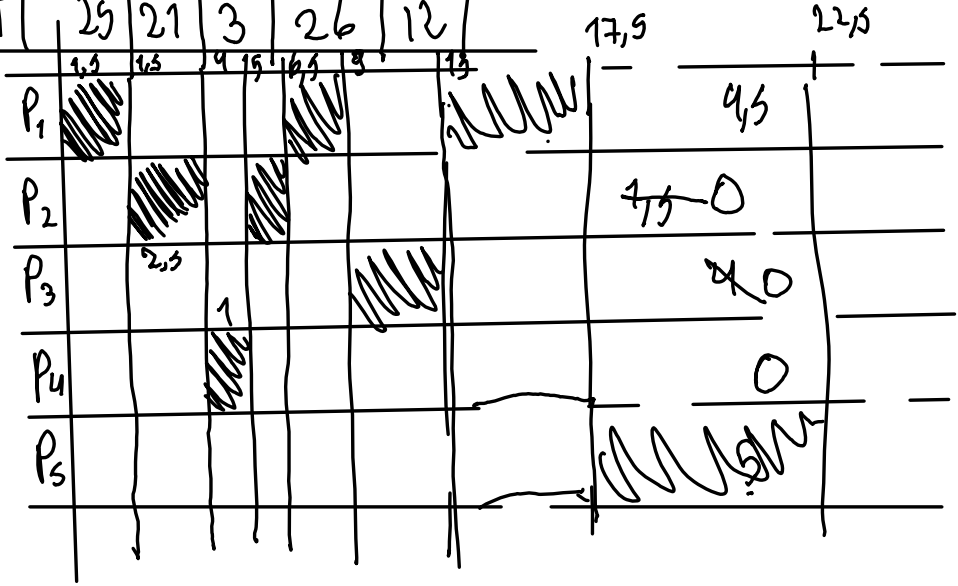
	P_1	P_2	P_3	P_4	P_5
WT	19	0	6	7	14
TT	27	6	7	16	17

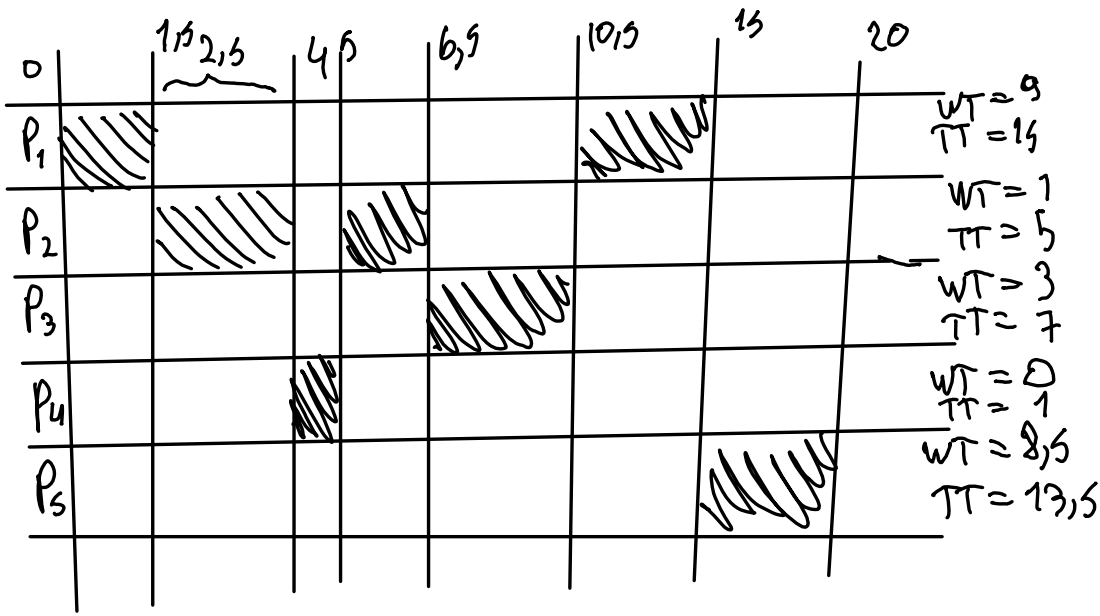


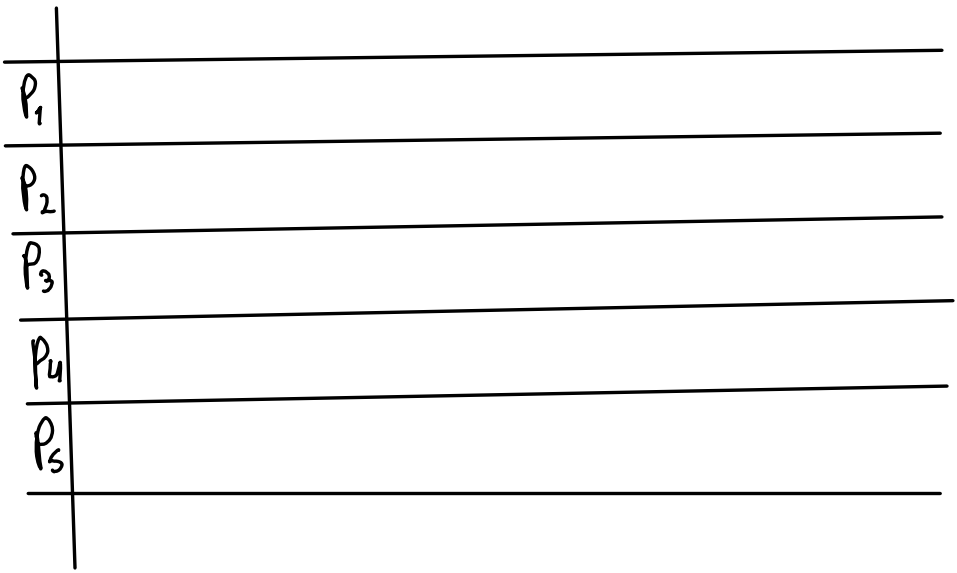
WT	17	13	2	17	9
TT	25	21	3	26	12

P4

SRTF




0
1,5
2,5
4
5
6,5
10,5
15
20
P1
P2
P3
P4
P5
WT = 9
TT = 14
WT = 1
TT = 5
WT = 3
TT = 7
WT = 0
TT = 1
WT = 8,5
TT = 13,5


P1
P2
P3
P4
P5

MAX - ALLOCATION ← What we will need

	A	B	C	D	
P_1	0	0	0	0	✓
P_2	0	7	5	0	✗
P_3	1	0	0	2	✓
P_4	0	0	2	0	✓
P_5	0	6	4	2	✓

Available: [1,5,2,0]

→ [1,5,3,2] → ✓

→ [2,8,8,6]

→ [2,14,11,8]

→ [2,14,12,12]

a) Safe State Sequence: P_1, P_3, P_4, P_5, P_2

b)

ALLOC

	A	B	C	D
P_1	0	0	1	2
P_2	1	4	2	0
P_3	1	3	5	4
P_4	0	6	3	2
P_5	0	0	1	4

NEED

	A	B	C	D
P_1	0	0	0	0
P_2	0	3	3	0
P_3	1	0	0	2
P_4	0	0	2	0
P_5	0	6	4	2

AVAILABLE: [1,5,2,0]

R: YES

Alloc	R_1	R_2	R_3	R_4
P_1	0	0	1	0
P_2	0	0	1	1
P_3	2	0	0	1
P_4	0	1	2	0

Vector Available

R_1	R_2	R_3	R_4
2	1	0	0

$\rightarrow [2,2,2,0]$

$\rightarrow [2,2,3,0]$

$\rightarrow$

Req	R_1	R_2	R_3	R_4
~~P_1~~	~~1~~	~~0~~	~~2~~	~~0~~
P_2	2	0	0	1
P_3	1	0	1	1
~~P_4~~	~~2~~	~~1~~	~~0~~	~~0~~
	-			

R: $\{P_2, P_3\}$

[~~2*~~, ~~1*~~, ~~3*~~]
~~4~~ ~~2*~~ ~~1*~~
~~3*~~ 4 2
1

Page faults: 1 1 1 1 1 1 1 1 1 1

Swap-Outs: 1 1 1 1 1