

Problem 6.1: safe states

(2 points)

A system has $n = 5$ processes, $m = 5$ resource types, and the number of resources for each resource type is given by $t = (6, 17, 9, 9, 7)$. The system is in the following state:

$$M = \begin{bmatrix} 2 & 5 & 3 & 3 & 2 \\ 3 & 5 & 8 & 9 & 1 \\ 4 & 9 & 4 & 9 & 2 \\ 6 & 1 & 4 & 5 & 5 \\ 1 & 2 & 3 & 4 & 5 \end{bmatrix} \quad A = \begin{bmatrix} 1 & 5 & 3 & 1 & 1 \\ 0 & 2 & 1 & 1 & 1 \\ 0 & 7 & 1 & 2 & 1 \\ 3 & 1 & 1 & 1 & 0 \\ 1 & 2 & 3 & 2 & 1 \end{bmatrix}$$

Is the system in a safe state? Provide a calculation to justify your answer.

$$N = M - A = \begin{bmatrix} 1 & 0 & 0 & 2 & 1 \\ 3 & 3 & 7 & 8 & 0 \\ 4 & 2 & 3 & 7 & 1 \\ 3 & 0 & 3 & 4 & 5 \\ 0 & 0 & 0 & 2 & 4 \end{bmatrix}$$

$$avail = t - \text{colsum}(A)$$

$$avail = (1, 0, 0, 2, 3)$$

$$avail = (2, 5, 3, 3, 4)$$

$$avail = (2, 5, 3, 5, 8)$$

$$R = \{1\} \quad \text{Process 1 terminates}$$

$$R = \{5\} \quad \text{Process 5 terminates}$$

no other process can terminate

State is unsafe

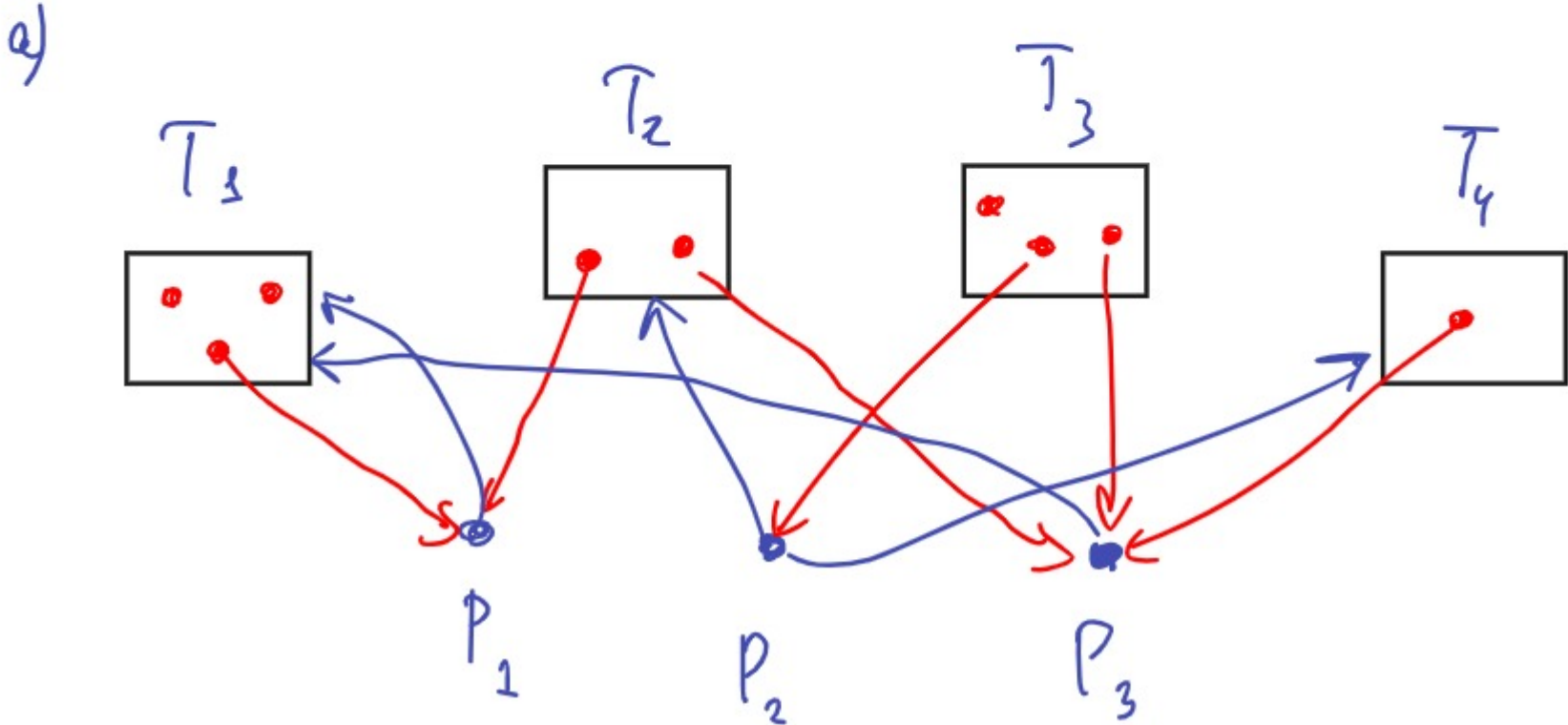
Problem 6.2: deadlock detection

(1+1 = 2 points)

A system has $n = 3$ processes, $m = 4$ resource types, and the number of resources for each resource type is given by $t = (3, 2, 3, 1)$. The system is in the following state:

$$A = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 \end{bmatrix} \quad N = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

- Draw the corresponding resource allocation graph.
- Is the system deadlocked? Provide a calculation to justify your answer.



b)

$$\text{avail} = (2, 0, 1, 0) \quad R = \{P_1, P_3\} \quad P_1, P_3 \text{ terminate}$$

$$\text{avail} = (3, 2, 2, 1) \quad R = \{P_2\} \quad P_2 \text{ terminates}$$

$$\text{avail} = (3, 2, 3, 1) \quad A = \emptyset \quad \text{no deadlock}$$

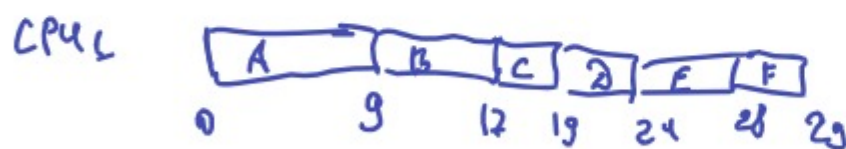
A computer system with a single CPU has to execute six processes A, \dots, F . The arrival times and the execution times of the processes are given by the following table.

process	arrival time	execution time
A	0	9
B	4	8
C	6	2
D	8	5
E	13	4
F	15	1

- a) Draw the schedule for the scheduling strategies first-come first-served (FCFS), shortest processing time first (SPTF), longest processing time first (LPTF), and round robin (RR) with a time slice of 1 time unit. Assume that arrivals happen before a scheduling point and that new processes are added at the end of the run queue.

- b) For each schedule, calculate the average turnaround time \bar{t} and the average waiting time \bar{w} .

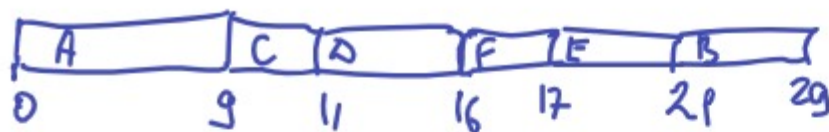
1) FCFS:



$$\bar{t} = \frac{1}{6} (9 + 13 + 13 + 16 + 15 + 14) = \frac{80}{6} = \frac{40}{3}$$

$$\bar{w} = \frac{1}{6} (0 + 5 + 11 + 11 + 11 + 13) = \frac{51}{6}$$

2) SPTF:



$$\bar{t} = \frac{1}{6} (9 + 25 + 5 + 8 + 8 + 2) = \frac{57}{6}$$

$$\bar{w} = \frac{1}{6} (0 + 17 + 3 + 3 + 4 + 1) = \frac{28}{6} = \frac{14}{3}$$

3) LPTF:



$$\bar{t} = \frac{1}{6} (9 + 13 + 22 + 14 + 13 + 14) = \frac{85}{6}$$

$$\bar{w} = \frac{1}{6} (0 + 5 + 20 + 9 + 9 + 13) = \frac{56}{6}$$

4) R R:

A		B	A	B	C	A	B		D	C	A	B	D	E	A	B	F	D	E	A	D	D	E	B	D	E	B	
4		5	6	7	8	9		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	

$$\bar{t} = \frac{1}{6} (22 + 25 + 6 + 19 + 15 + 4) = \frac{91}{6}$$

$$\bar{w} = \frac{1}{6} (13 + 17 + 4 + 14 + 11 + 3) = \frac{62}{6}$$