

Banker's Algorithm

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Q. Solve the following using Banker's Algorithm.

Consider the system with 5 processes, P_0 to P_4 and resource type A, B, C.

Find need matrix and find out whether resultant system state is safe or not from given snapshot

Allocation	Max Allocation			Available		
	A	B	C	A	B	C
P_0	0	1	0	7	5	3
P_1	2	0	0	3	2	2
P_2	3	1	0	9	0	2
P_3	2	1	1	2	2	2
P_4	0	2	0	2	4	3

Need Matrix = $\text{Allocation} - \text{Allocation}$

$$\text{Need} = \text{max} - \text{Allocation}$$

S A B C

Process	A	B	C	\geq	S	A	B	C
P_0	7	4	3	\geq	1	8	9	1
P_1	1	2	2					
P_2	6	0	0	\geq	10	10	10	10
P_3	0	1	1	\geq	10	10	10	10
P_4	4	3	1	\geq	10	10	10	10

Resultant State $\geq S + P \geq S A T$

Need \leq Available

$$P_0 \quad 7 \ 4 \ 3 \leq 7 \ 3 \ 3 \rightarrow \text{False} \quad (\text{Not satisfied})$$

$$P_1 \quad 1 \ 2 \ 2 \leq 3 \ 3 \ 2 \rightarrow \text{True} \quad (\text{satisfied})$$

Available = Available + Allocation

$$= 13 \ 3 \ 2 + 2 \ 0 \ 0$$

$$= 15 \ 3 \ 2$$

$$P_2 \quad 6 \ 0 \ 0 \leq 5 \ 3 \ 2 \rightarrow \text{False} \quad (\text{Not satisfied})$$

$$P_3 \quad 0 \ 1 \ 1 \leq 5 \ 3 \ 2 \rightarrow \text{True} \quad (\text{satisfied})$$

Available = Available + Allocation

$$= 5 \ 3 \ 2 + 1 \ 2 - 1 \ 1 \ 0 = 6 \ 2 \ 1$$

$$= 7 \ 4 \ 3$$

$$P_4 \quad 4 \ 3 \ 1 \leq 7 \ 4 \ 3 \rightarrow \text{True} \quad (\text{satisfied})$$

Available = Available + Allocation

$$= 7 \ 4 \ 3 + 0 \ 0 \ 2$$

$$= 7 \ 4 \ 5$$

$$P_0 \quad 7 \ 4 \ 3 \leq 7 \ 4 \ 5 \rightarrow \text{True} \quad (\text{satisfied})$$

Available = Available + Allocation

$$= 7 \ 4 \ 5 + 0 \ 1 \ 0$$

$$= 7 \ 5 \ 5$$

$P_2 \rightarrow 6 \ 0 \ 0 \ 0 \ 5 \ 7 \ 5 \ 5 \rightarrow$ True → Safe

↳ If P_2 can be allocated then all processes are safe.

Available \Rightarrow Available for Allocation

• 7 5 5 + 2 0 2

Allocation 1 2 3 4 5 7

Available 1 2 3 4 5 6 8

Safe Sequence

$\langle P_1, P_3, P_4, P_0, P_2 \rangle$

- Q. Consider the following snapshot of a system
- What is the content of matrix need?
 - Is the system in safe state?

Process	Allocation				MAX				Available			
	A	B	C	D	A	B	C	D	A	B	C	D
P ₁	0	0	1	4	0	6	5	6	1	6	2	5
P ₂	0	6	3	2	0	6	5	2				
P ₃	0	0	1	2	0	0	1	2				
P ₄	1	0	0	0	1	7	5	0				

Need Matrix

$$\text{Need} = \text{Max} - \text{Allocation}$$

Process	A	B	C	D
P ₁	0	6	4	2
P ₂	0	0	2	0
P ₃	0	0	0	0
P ₄	0	7	5	0

Need \leq Available

$$P_1 \quad 0 \ 6 \ 4 \ 2 \quad \leq \quad 1 \ 6 \ 2 \ 0 \rightarrow \text{True Satisfy}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 1 \ 6 \ 2 \ 0 + 0 \ 0 \ 1 \ 4$$

$$= 1 \ 6 \ 3 \ 4$$

$$P_2 \quad 0 \ 0 \ 2 \ 0 \quad \leq \quad 1 \ 6 \ 3 \ 4 \rightarrow \text{True Satisfy}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 1 \ 6 \ 3 \ 4 + 0 \ 6 \ 3 \ 2$$

$$= 1 \ 12 \ 6 \ 6$$

P_3 $0 \ 6 \ 0 \ 0 \leq 1 \ 12 \ 6 \ 6 \rightarrow$ True satisfied

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 1 \ 12 \ 6 \ 6 + 1 \ 0 \ 0 \ 1 \ 2$$

$$= 1 \ 3 \ 12 \ 7 \ 8$$

P_4 $0 \ 7 \ 5 \ 0 \leq 1 \ 12 \ 7 \ 8 \rightarrow$ True satisfied

$$\text{Allocation} = 0 \ 0 \ 0 \ 0 \quad \text{Allocation}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 1 \ 12 \ 7 \ 8 + 1 \ 0 \ 0 \ 0 \ 0$$

$$= 0 \ 2 \ 12 \ 7 \ 8$$

$$A \ P \ R \ D \ E \ S \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1$$

Safe State $A \ P \ R \ D \ E \ S \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1$

$$E \ E \ A \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0$$

$\langle P_1, P_2, P_3, P_4 \rangle$

END

Q. Solve the following using Banker's Algorithm

Find out whether resultant system state is safe or not.

i) Find Need matrix.

ii) Find out system state is safe.

iii) If P_1 makes a request $R_1(1, 0, 2)$ is the resulting state safe?

Process	Allocation			Max			Available		
	A	B	C	A	B	C	A	B	C
P_0	0	1	0	7	15	3	3	3	2
P_1	2	0	8	3	2	2			
P_2	3	0	2	9	0	2			
P_3	2	1	1	2	2	2	10	12	13
P_4	0	0	1	4	3	3			

Need Matrix

$$\text{Need} = \text{Max} - \text{Allocation}$$

Process	A	B	C
P_0	7	4	3
P_1	1	2	2
P_2	6	0	0
P_3	0	1	1
P_4	4	3	2

Need \leq Available

$$P_0 \quad 743 \leq 332 \rightarrow \text{False, Not satisfied}$$

$$P_1 \quad 122 \leq 332 \rightarrow \text{True, Satisfied}$$

Available = Available + Allocation

$$= 332 + 200$$

$$= 532$$

$$P_2 \quad 600 \leq 532 \rightarrow \text{False, Not satisfied}$$

$$P_3 \quad 011 \leq 532 \rightarrow \text{True, Satisfied}$$

Available = Available + Allocation

$$= 532 + 211$$

$$= 743$$

$$P_4 \quad 432 \leq 743 \rightarrow \text{True, Satisfied}$$

Available = Available + Allocation

$$= 743 + 001$$

temp = 744 allocation = 001

$$801 - 744 =$$

$$P_0 \quad 743 \leq 744 \rightarrow \text{True, Satisfied}$$

Available = Available + Allocation

$$= 744 + 010$$

$$= 754$$

$$P_2 \quad 6 \ 0 \ 0 \leq 7 \ 5 \ 4 \rightarrow \text{True} \quad \text{satisfied}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 7 \ 5 \ 4 + 3 \ 0 \ 2$$

$$= 10 \ 5 \ 6$$

Safe Sequence

$$< P_1, P_3, P_4, P_0, P_2 >$$

Addition Request

$$P_1 = (21, 70, 8)$$

Request \leq Need

$$1 \ 1 \ 2 \leq 1 \ 1 \ 2$$

$$1 \ 0 \ 2 \leq 2 \ 1 \ 2$$

Request \leq Available

Allocation \leq Available

$$1 \ 0 \ 2 + 2 \ 1 \ 2 = 3 \ 1 \ 4$$

Available = Available - Request

$$= 3 \ 3 \ 2 - 1 \ 0 \ 2$$

$$= 2 \ 3 + 0 \geq 2 \ 1 \ 2$$

Allocation \leq Allocation + Request

$$0 \ 1 \ 0 + 2 \ 0 \ 0 + 1 \ 0 \ 2$$

$$= 3 \ 0 \ 2$$

$$\text{Need} = \text{Need} - \text{Request}$$

$$= 122 - 102$$

$$= 20$$

New Need Matrix

Process	A	B	C	Available
P ₀	0	7	4	3
P ₁	0	2	0	0
P ₂	6	0	0	0
P ₃	0	5	1	2
P ₄	4	3	1	0

Initial State → 122 20 0 20

Process	Allocation	Need	Available
P ₀	0 1 0	7 4 3	2 3 0
P ₁	3 0 2	0 2 0	0 0 0
P ₂	3 0 2	6 0 0	0 0 0
P ₃	2 1 1	0 1 1	0 0 0
P ₄	0 0 1	4 3 2	0 0 0

122 20 0 20

Need \leq Available

$$P_0 \quad 743 \leq 230 \rightarrow \text{False} \quad \text{Not satisfied}$$

$$P_1 \quad 020 \leq 230 \rightarrow \text{True} \quad \text{Satisfied}$$

Available = Available + Allocation

$$= 230 + 020$$

$$= 253$$

$$P_2 \quad 600 \leq 532 \rightarrow \text{False} \quad \text{Not satisfied}$$

$$P_3 \quad 011 \leq 532 \rightarrow \text{True} \quad \text{Satisfied}$$

Available = Available + Allocation

$$= 532 + 211$$

$$= 743$$

$$P_4 \quad 430 \leq 743 \rightarrow \text{True} \quad \text{Satisfied}$$

Available = Available + Allocation

$$= 743 + 001$$

$$= 744$$

$$P_0 \quad 743 \leq 744 \rightarrow \text{True} \quad \text{Satisfied}$$

Available = Available + Allocation

$$= 744 + 010$$

$$= 754$$

$$P_2 = 6.00 \leq 7.54 \rightarrow \text{True} \quad \text{Satisfied}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 7.54 + 3.02$$

$$= 10.56$$

Safe sequence

$$< P_1, P_3, P_4, P_0, P_2 >$$

Q. Solve the following using Banker's algorithm

Process	Allocation				Max				Available			
	A	B	C	D	A	B	C	D	A	B	C	D
P ₀	0	0	1	2	0	0	1	2	1	5	2	0
P ₁	1	0	0	0	1	7	5	0				
P ₂	1	3	5	4	2	3	5	6				
P ₃	0	6	3	2	0	6	5	2				
P ₄	0	0	1	4	0	6	5	6				

- I] What is the content of need matrix ?
- II] Is the system in safe state ?
- III] If the request from process p₁ arises for
0 4 2 0 can the request be granted
immediately ?

Need Matrix

$$\text{Need} = \text{Max} - \text{Allocation}$$

Process	A	B	C	D
P ₀	0	0	0	0
P ₁	0	7	5	0
P ₂	1	0	0	2
P ₃	0	0	2	0
P ₄	0	6	4	2

Need \leq Available

$$P_0 \quad 0000 \leq 1520 \rightarrow \text{True} \rightarrow \text{satisfied}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 1520 + 0012$$

$$= 1532$$

$$P_1 \quad 0750 \leq 1532 \rightarrow \text{False} \rightarrow \text{Not satisfied}$$

$$P_2 \quad 1002 \leq 1532 \rightarrow \text{True} \rightarrow \text{satisfied}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 1532 + 1354$$

$$= 2886$$

$$P_3 \quad 0020 \leq 2886 \rightarrow \text{True} \rightarrow \text{satisfied}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 2886 + 0632$$

$$= 2948$$

$$P_4 \quad 0642 \leq 2948 \rightarrow \text{True} \rightarrow \text{satisfied}$$

$$06 + 0 = 082112$$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 214118 + 0014$$

$$= 214112$$

$$06 + 0 + 0014 =$$

$$P_1 \quad 0 \quad 0 \quad 0 \quad 0 \quad \leq \quad 2 \quad 14 \quad 12 \quad 12 \rightarrow \text{Safe} \quad \text{satisfied}$$

$$\text{Available} = \text{Available} + \text{Allocation}$$
$$= 2 \quad 14 \quad 12 \quad 12 \quad 4 \quad 1 \quad 0 \quad 0 \quad 0$$

Safe sequence

$$< P_0, P_2, P_3, P_4, P_1 >$$

Addition Request

$$P_1 = (0 \quad 4 \quad 2 \quad 0)$$
$$+ 2 \quad 8 \quad 1 \quad + 0 \quad 2 \quad 1 \quad =$$

Request \leq Need

$$2 \quad 0 \quad 0 \quad 4 \quad 2 \quad 0 \quad \leq \quad 2 \quad 0 \quad 8 \quad 7 \quad 5 \quad 0 \quad 0 \quad - \quad 0 \quad 0 \quad 0 \quad 0$$

Request \leq Available

$$2 \quad 0 \quad 8 \quad 0 \quad + \quad 0 \quad 2 \quad 0 \quad =$$

$$0 \quad 4 \quad 2 \quad 0 \quad \leq \quad 1 \quad 5 \quad 2 \quad 0 \quad =$$

Available = Available - Request

$$= 1 \quad 5 \quad 2 \quad 0 \quad - \quad 0 \quad 4 \quad 2 \quad 0$$

Allocation = Allocation - Request

$$= 1 \quad 0 \quad 0 \quad 0 \quad + \quad 0 \quad 4 \quad 2 \quad 0$$

Allocation = Allocation + Request

$$= 1 \quad 0 \quad 0 \quad 0 \quad + \quad 0 \quad 4 \quad 2 \quad 0$$

$$0 \quad 4 \quad 2 \quad 0 \quad = 1 \quad 4 \quad 2 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0$$

$$\text{Need} = \text{Allocated} - \text{Request}$$

$$= 0750 - 0420$$

$$= 0330$$

New Need matrix after allocation

Process	A	B	C	D
P ₀	0	0	0	0
P ₁	0	3	3	0
P ₂	1	0	0	2
P ₃	0	0	2	0
P ₄	0	6	4	2

Allocation + Available = Allocation

0 1 4 2 0 0 3 3 0

Process	Allocation				Need				Available			
	A	B	C	D	P	B	C	D	A	B	C	D
P ₀	0	0	1	2	0	0	0	0	3	1	1	0
P ₁	1	4	2	0	0	3	3	0				
P ₂	3	5	4	1	0	0	0	2				
P ₃	0	6	3	2	0	0	2	0				
P ₄	0	6	4	2	0	6	4	2				

Need \leq Available \rightarrow True \rightarrow Satisfied

$$P_0 \quad 0 \ 0 \ 0 \ 0 \leq 1 \ 1 \ 0 \ 0 \rightarrow \text{True} \rightarrow \text{Satisfied}$$

Available = Available + Allocation

$$= 1 \ 1 \ 0 \ 0 + 0 \ 0 \ 1 \ 2$$

$$= \boxed{1 \ 1 \ 1 \ 2} \quad ?$$

$$\begin{array}{|c|c|c|c|c|c|} \hline & 0 & 0 & 0 & 0 & 0 \\ \hline \end{array}$$

$$P_1 \quad 0 \ 3 \ 3 \ 0 \leq 0 \ 1 \ 1 \ 1 \ 2 \rightarrow \text{False} \rightarrow \text{Satisfied}$$

$$\begin{array}{|c|c|c|c|c|c|} \hline & 0 & 0 & 1 & 0 & 0 & 0 \\ \hline \end{array}$$

$$P_2 \quad 1 \ 0 \ 0 \ 2 \leq 2 \ 1 \ 1 \ 1 \ 2 \rightarrow \text{True} \rightarrow \text{Satisfied}$$

$$\begin{array}{|c|c|c|c|c|c|} \hline & 1 & 1 & 1 & 2 & 0 & 0 \\ \hline \end{array}$$

Available \neq Available + Allocation

$$= 1 \ 1 \ 1 \ 2 + 1 \ 3 \ 5 \ 4$$

$$= \boxed{2 \ 4 \ 6 \ 6} \quad ?$$

$$\begin{array}{|c|c|c|c|c|c|} \hline & 0 & 0 & 8 & 4 & 0 & 0 \\ \hline \end{array}$$

$$P_3 \quad 1 \ 0 \ 0 \ 2 \ 0 \leq 2 \ 8 \ 4 \ 1 \ 6 \ 0 \ 6 \rightarrow \text{True} \rightarrow \text{Satisfied}$$

$$\begin{array}{|c|c|c|c|c|c|} \hline & 0 & 8 & 8 & 0 & 0 & 0 \\ \hline \end{array}$$

Available = Available + Allocation

$$0 \ 0 \ 0 \ 0 = 2 \ 4 \ 6 \ 6 + 0 \ 6 \ 3 \ 3$$

$$8 \ 6 \ 4 \ 3 = 2 \ 1 \ 0 \ 9 \ 8 \ 0 \quad ?$$

$$P_4 \quad 0 \ 6 \ 4 \ 2 \leq 2 \ 1 \ 0 \ 9 \ 8 \rightarrow \text{True} \rightarrow \text{Satisfied}$$

Available = Available + Allocation

$$= 2 \ 1 \ 0 \ 9 \ 8 + 0 \ 0 \ 1 \ 4$$

$$= 2 \ 1 \ 0 \ 1 \ 0 \ 1 \ 2$$

$P_1 \quad 0 \ 3 \ 3 \ 0 \leq 2 \ 10 \ 10 \ 10 \rightarrow \text{True satisfied}$

$$\text{Available} = \text{Available} + \text{Allocation}$$

$$= 2 \ 10 \ 10 \ 10 + 4 \ 1 \ 4 \ 2 \ 0 \\ = 3 \ 14 \ 12 \ 12$$

Safe Sequence

$\langle P_0, P_2, P_3, P_4, P_1 \rangle$