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1) MAX =

process	A	B	C
P0	4	1	0
P1	1	4	1
P2	0	0	2
P3	2	2	4

AVAILABLE = [5 5 5]

ALLOCATION =

process	A	B	C
P0	0	0	0
P1	0	0	0
P2	0	0	0
P3	0	0	0

a) P0 requisita [2 1 0]

NEED =

process	A	B	C
P0	4	1	0
P1	1	4	1
P2	0	0	2

process	A	B	C
P3	2	2	4

$$REQ_0 = [2 \ 1 \ 0]$$

$$REQ_0 \leq NEED_0 \Rightarrow \text{OK: GOTO 2}$$

$$REQ_0 \leq AVAILABLE \Rightarrow \text{OK: GOTO 3}$$

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	0	0
P2	0	0	0
P3	0	0	0

NEED =

process	A	B	C
P0	2	0	0
P1	1	4	1
P2	0	0	2
P3	2	2	4

$$AVAILABLE = [3 \ 4 \ 5]$$

Verificação de estado seguro

$$FINISH = [F \ F \ F \ F]$$

$$WORK = [3 \ 4 \ 5]$$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow OK: GOTO 3$

$WORK = [3 \ 4 \ 5] + [2 \ 1 \ 0] = [5 \ 5 \ 5]$

$FINISH = [T \ F \ F \ F]$

$NEED_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow OK: GOTO 3$

$WORK = [5 \ 5 \ 5] + [0 \ 0 \ 0] = [5 \ 5 \ 5]$

$FINISH = [T \ T \ F \ F]$

$NEED_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow OK: GOTO 3$

$WORK = [5 \ 5 \ 5] + [0 \ 0 \ 0] = [5 \ 5 \ 5]$

$FINISH = [T \ T \ T \ F]$

$NEED_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow OK: GOTO 3$

$WORK = [5 \ 5 \ 5] + [0 \ 0 \ 0] = [5 \ 5 \ 5]$

$FINISH = [T \ T \ T \ T]$

Sistema em estado seguro \Rightarrow requisição aceita

b) P3 requisita $[0 \ 0 \ 1]$ AVAILABLE = $[3 \ 4 \ 5]$

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	0	0
P2	0	0	0
P3	0	0	0

NEED =

process	A	B	C
P0	2	0	0
P1	1	4	1

process	A	B	C
P2	0	0	2
P3	2	2	4

$$REQ_3 = [0 \ 0 \ 1]$$

$$REQ_3 \leq NEED_3 \Rightarrow \text{OK: GOTO 2}$$

$$REQ_3 \leq AVAILABLE \Rightarrow \text{OK: GOTO 3}$$

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	0	0
P2	0	0	0
P3	0	0	1

NEED =

process	A	B	C
P0	2	0	0
P1	1	4	1
P2	0	0	2
P3	2	2	3

$$AVAILABLE = [3 \ 4 \ 4]$$

Verificação de estado seguro

$$FINISH = [F \ F \ F \ F]$$

$$WORK = [3 \ 4 \ 4]$$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow OK: GOTO 3$

$WORK = [344] + [210] = [554]$

$FINISH = [TFFF]$

$NEED_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow OK: GOTO 3$

$WORK = [554] + [000] = [554]$

$FINISH = [TTFF]$

$NEED_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow OK: GOTO 3$

$WORK = [554] + [000] = [554]$

$FINISH = [TTTF]$

$NEED_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow OK: GOTO 3$

$WORK = [554] + [001] = [555]$

$FINISH = [TTTT]$

Sistema em estado seguro \Rightarrow requisição aceita

c) P2 requisita [0 0 2]

AVAILABLE = [3 4 4]

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	0	0
P2	0	0	0
P3	0	0	1

NEED =

process	A	B	C
P0	2	0	0

process	A	B	C
P1	1	4	1
P2	0	0	2
P3	2	2	3

$$REQ_2 = [0 \ 0 \ 2]$$

$$REQ_2 \leq NEED_2 \Rightarrow \text{OK: GOTO 2}$$

$$REQ_2 \leq AVAILABLE \Rightarrow \text{OK: GOTO 3}$$

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	0	0
P2	0	0	2
P3	0	0	1

NEED =

process	A	B	C
P0	2	0	0
P1	1	4	1
P2	0	0	0
P3	2	2	3

$$AVAILABLE = [3 \ 4 \ 2]$$

Verificação de estado seguro

FINISH = [F F F F]

WORK = [3 4 2]

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow OK: GOTO 3$

$WORK = [342] + [210] = [552]$

$FINISH = [TFFF]$

$NEED_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow OK: GOTO 3$

$WORK = [552] + [000] = [552]$

$FINISH = [TTFF]$

$NEED_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow OK: GOTO 3$

$WORK = [552] + [002] = [554]$

$FINISH = [TTTF]$

$NEED_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow OK: GOTO 3$

$WORK = [554] + [001] = [555]$

$FINISH = [TTTT]$

Sistema em estado seguro => requisição aceita

d) P3 requisita [2 0 1]

AVAILABLE = [3 4 2]

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	0	0
P2	0	0	2
P3	0	0	1

NEED =

process	A	B	C
P0	2	0	0
P1	1	4	1
P2	0	0	0
P3	2	2	3

$$REQ_3 = [2 \ 0 \ 1]$$

$$REQ_3 \leq NEED_3 \Rightarrow \text{OK: GOTO 2}$$

$$REQ_3 \leq AVAILABLE \Rightarrow \text{OK: GOTO 3}$$

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	0	0
P2	0	0	2
P3	2	0	2

NEED =

process	A	B	C
P0	2	0	0
P1	1	4	1
P2	0	0	0
P3	0	2	2

$$AVAILABLE = [1 \ 4 \ 1]$$

Verificação de estado seguro

FINISH = [F F F F]

WORK = [1 4 1]

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [141] + [000] = [141]$

$FINISH = [FTFF]$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [141] + [002] = [143]$

$FINISH = [FTTF]$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [143] + [202] = [345]$

$FINISH = [FTTT]$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [345] + [210] = [555]$

$FINISH = [TTTT]$

Sistema em estado seguro \Rightarrow requisição aceita

e) P1 requisita [0 4 1]

AVAILABLE = [1 4 1]

ALLOCATION =

process	A	B	C
P0	2	1	0

process	A	B	C
P1	0	0	0
P2	0	0	2
P3	2	0	2

NEED =

process	A	B	C
P0	2	0	0
P1	1	4	1
P2	0	0	0
P3	0	2	2

$$REQ_1 = [0 \ 4 \ 1]$$

$$REQ_1 \leq NEED_1 \Rightarrow \text{OK: GOTO 2}$$

$$REQ_1 \leq AVAILABLE \Rightarrow \text{OK: GOTO 3}$$

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	4	1
P2	0	0	2
P3	2	0	2

NEED =

process	A	B	C
P0	2	0	0
P1	1	0	0
P2	0	0	0
P3	0	2	2

AVAILABLE = [1 0 0]

Verificação de estado seguro

FINISH = [F F F F]

WORK = [1 0 0]

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow \text{Ok: GOTO 3}$

$WORK = [100] + [041] = [141]$

$FINISH = [FTFF]$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [141] + [002] = [143]$

$FINISH = [FTTF]$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [143] + [202] = [345]$

$FINISH = [FTTT]$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [345] + [210] = [555]$

$FINISH = [TTTT]$

Sistema em estado seguro => requisição aceita

f) P1 requisita [1 0 0]

AVAILABLE = [1 0 0]

ALLOCATION =

process	A	B	C
P0	2	1	0
P1	0	4	1
P2	0	0	2
P3	2	0	2

NEED =

process	A	B	C
P0	2	0	0
P1	1	0	0
P2	0	0	0
P3	0	2	2

$REQ_1 = [1\ 0\ 0]$

$REQ_1 \leq NEED_1 \Rightarrow$ OK: GOTO 2

$REQ_1 \leq AVAILABLE \Rightarrow$ OK: GOTO 3

ALLOCATION =

process	A	B	C
P0	3	1	0

process	A	B	C
P1	0	4	1
P2	0	0	2
P3	2	0	2

NEED =

process	A	B	C
P0	1	0	0
P1	1	0	0
P2	0	0	0
P3	0	2	2

AVAILABLE = [0 0 0]

Verificação de estado seguro

FINISH = [F F F F]

WORK = [0 0 0]

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow \text{FALSE}$

$NEED_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow \text{OK: GOTO 3}$

$WORK = [000] + [002] = [002]$

$FINISH = [FFTF]$

$NEED_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$NEED_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow \text{FALSE}$

$NEED_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow \text{FALSE}$

Sistema em estado inseguro => requisição recusada devido a risco de gerar deadlock

2)

AVAILABLE = [0 0 0]

ALLOCATION =

process	A	B	C
P0	3	0	1
P1	0	1	0
P2	5	2	0
P3	0	0	1
P4	0	0	1

REQUEST =

process	A	B	C
P0	0	0	1
P1	0	0	0
P2	0	1	1
P3	0	0	1
P4	0	0	0

a)

FINISH = [F F F F F]

WORK = [0 0 0]

$REQUEST_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow FALSE$

$REQUEST_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow OK: GOTO 3$

$FINISH = [FTFFF]$

$WORK = [000] + [010] = [010]$

$REQUEST_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow FALSE$

$REQUEST_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow FALSE$

$REQUEST_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow FALSE$

$REQUEST_4 \leq WORK \ \&\& \ FINISH[4] == F \Rightarrow OK: GOTO 3$

$FINISH = [FTFFT]$

$WORK = [010] + [001] = [011]$

$REQUEST_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow OK: GOTO 3$

$FINISH = [TTFFT]$

$WORK = [011] + [301] = [312]$

$REQUEST_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow OK: GOTO 3$

$FINISH = [TTTFT]$

$WORK = [312] + [520] = [832]$

$REQUEST_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow OK: GOTO 3$

$FINISH = [TTTTT]$

$WORK = [832] + [001] = [833]$

Sistema não está em deadlock

b)

AVAILABLE = [0 0 0]

ALLOCATION =

process	A	B	C
P0	3	0	1
P1	0	1	0

process	A	B	C
P2	5	2	0
P3	0	0	1
P4	0	0	1

REQUEST =

process	A	B	C
P0	0	0	1
P1	0	0	0
P2	0	1	1
P3	0	0	1
P4	1	0	0

FINISH = [F F F F F]

WORK = [0 0 0]

$REQUEST_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$REQUEST_1 \leq WORK \ \&\& \ FINISH[1] == F \Rightarrow \text{OK: GOTO 3}$

$FINISH = [FTFFF]$

$WORK = [000] + [010] = [010]$

$REQUEST_0 \leq WORK \ \&\& \ FINISH[0] == F \Rightarrow \text{FALSE}$

$REQUEST_2 \leq WORK \ \&\& \ FINISH[2] == F \Rightarrow \text{FALSE}$

$REQUEST_3 \leq WORK \ \&\& \ FINISH[3] == F \Rightarrow \text{FALSE}$

$REQUEST_4 \leq WORK \ \&\& \ FINISH[4] == F \Rightarrow \text{FALSE}$

Os processos P0, P2, P3 e P4 estão em deadlock