Request matrix

Allocation matrix

$$Q = \begin{bmatrix}1&1&0\\0&1&0\\1&0&1\\1&1&1\\1&0&0\end{bmatrix} \qquad A = \begin{array}{ccc|l} 0&1&0&P1\\1&0&0&P2\\0&0&1&P3\\1&1&1&P4\\0&1&0&P5\\ \hline 2&3&2&\text{Total (A)}\end{array}$$

Add columns

Available vector

$V = [1\ 1\ 0]$

$R = V + A$

$V = R - A$

P1: ✓

P2: ✓

P3: ✗

P4: ✗

P5: ✓

Deadlock Detection:

✓ = Safe

✗ = DL

5. $R = [3\ 4\ 2]$

$R = [2\ 3\ 2] + [1\ 1\ 0] = [3\ 4\ 2]$

- Steps:

- $Q(R1) = [1\ 1\ 0]$, $V = [1\ 1\ 0]$

$Q(R1) < V$

1 1 0
1 1 0

So $\underbrace{[1\ 1\ 0]}_{V} + \underbrace{[0\ 1\ 0]}_{A(R1)} = [1\ 2\ 0] = \text{New V}$ ✓

- $Q(R2) = [0\ 1\ 0]$, $V = [1\ 2\ 0]$

$Q(R2) < V$

0 1 0
1 2 0

$\underbrace{[1\ 2\ 0]}_{V} + \underbrace{[1\ 0\ 0]}_{A(R2)} = [2\ 2\ 0] = \text{New V}$ ✓

- $Q(R3) = [1\ 0\ 1]$, $V = [2\ 2\ 0]$

$\begin{matrix}1&0&\boxed{1}\\2&2&\boxed{0}\end{matrix}$ ✗ $Q(R3) > V$

- $Q(R4) = [1\ 1\ 1]$, $V = [2\ 2\ 0]$

$\begin{matrix}1&1&\boxed{1}\\2&2&\boxed{0}\end{matrix}$ ✗ $Q(R4) > V$

- $Q(R5) = [1\ 0\ 0]$, $V = [2\ 2\ 0]$

$V + A(R5) = [2\ 2\ 0] + [0\ 1\ 0] = [2\ 3\ 0] = \text{New V}$ ✓

- Q(R3, 2nd try with [2 3 0] as V)

$Q(R3) = [1\ 0\ 1]$, $V = [2\ 3\ 0]$

$\begin{matrix}1&0&\boxed{1}\\2&3&\boxed{0}\end{matrix}$ $Q(R3) > V$ ✗

- Q(R4, 2nd try with [2 3 0] as V)

$Q(R4) = [1\ 1\ 1]$, $V = [2\ 3\ 0]$

$\begin{matrix}1&1&\boxed{1}\\2&3&\boxed{0}\end{matrix}$ ✗

$W = [2\ 3\ 0]$, our newest V.

$W = [2\ 3\ 0]$

$R = [3\ 4\ 2]$

DLs: P3 and P4

Banker's Algorithm

C = Claim matrix

$V = R - A$

$$C = \begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 4 \\ 2 & 0 & 2 \\ 3 & 3 & 4 \end{bmatrix} \quad A = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 2 \\ 0 & 3 & 1 \end{bmatrix} \quad R = [3 \ 5 \ 6]$$

$$\begin{matrix} 3 & 4 & 4 \end{matrix} \qquad V = [0 \ 1 \ 2]$$

$V = [0 \ 1 \ 2]$

$$C-A/Q = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 4 \\ 2 & 0 & 0 \\ 3 & 0 & 3 \end{bmatrix}$$

Deadlocks: None

W: $[3 \ 5 \ 6]$

- $V = R - A = [3 \ 4 \ 6] - [3 \ 4 \ 4] = [0 \ 1 \ 2]$
- $Q = C - A = \begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 4 \\ 2 & 0 & 2 \\ 3 & 3 & 4 \end{bmatrix} - \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 2 \\ 0 & 3 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 4 \\ 2 & 0 & 0 \\ 3 & 0 & 3 \end{bmatrix} \begin{matrix} ✓ \\ ✗ \\ ✓ \\ ✗ \end{matrix}$ ← Q or C-A

$\boxed{\begin{matrix} ✓ \\ ✓ \\ ✓ \\ ✓ \end{matrix}}$ ← were able to save all

Steps:

- $Q(P1) = [0 \ 1 \ 0], V = [0 \ 1 \ 2]$

$\begin{matrix} 0 & 1 & 0 \\ 0 & 1 & 2 \end{matrix}$, $Q(P1) < V$

$V + A(P1) = [0 \ 1 \ 2] + [1 \ 0 \ 1] = [1 \ 1 \ 3]$ = New V

✓

- $Q(P2) = [1 \ 1 \ 4], V = [1 \ 1 \ 3]$

$\begin{matrix} 1 & 1 & \boxed{\begin{matrix} 4 \\ 3 \end{matrix}} \\ 1 & 1 & \end{matrix}$ $Q(P2) > V$ ✗

- $Q(P3) = [1 \ 0 \ 0], V = [1 \ 1 \ 3]$

$\begin{matrix} 1 & 0 & 0 \\ 1 & 1 & 3 \end{matrix}$ $Q(P3) < V$

$V + A(P3) = [1 \ 1 \ 3] + [1 \ 0 \ 2] = [2 \ 1 \ 5]$ = New V

✓

- $Q(P4) = [3 \ 0 \ 3], V = [2 \ 1 \ 5]$

$\begin{matrix} \boxed{\begin{matrix} 3 \\ 2 \end{matrix}} & \begin{matrix} 0 & 3 \\ 1 & 5 \end{matrix} \end{matrix}$ ✗

- Q(P2, 2nd try w/ $[2 \ 1 \ 5]$ as V)

$Q(P2) = [1 \ 1 \ 4], V = [2 \ 1 \ 5]$

$\begin{matrix} 1 & 1 & 4 \\ 2 & 1 & 5 \end{matrix}$

$V + A(P2) = [2 \ 1 \ 5] + [1 \ 1 \ 0] = [3 \ 2 \ 5]$

✓ New V

- Q(P4, 2nd try w $[3 \ 2 \ 5]$ as V)

$\begin{matrix} 3 & 0 & 3 \\ 3 & 2 & 5 \end{matrix}$ $Q(P4) < V$

$V + A(P4) = [3 \ 2 \ 5] + [0 \ 3 \ 1] = [3 \ 5 \ 6]$ = New V, which is W

✓

Q(P2 and P4) were saved with new V

Banker's 2

$$C = \begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 4 \\ 2 & 0 & 2 \\ 3 & 3 & 4 \end{bmatrix}$$

$$A = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 2 \\ 0 & 3 & 1 \end{bmatrix}$$

$R = [3\ 5\ 6]$

- $V = R - A$

$= [3\ 5\ 6] - [3\ 4\ 4] = [0\ 1\ 2]$

- $Q = C - A$

$$= \begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 4 \\ 2 & 0 & 2 \\ 3 & 3 & 4 \end{bmatrix} - \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 2 \\ 0 & 3 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 4 \\ 1 & 0 & 0 \\ 3 & 0 & 3 \end{bmatrix}$$

Q(R1): ✓

Q(R2): ✗

Q(R3): ✓

- $Q(P1) = [0\ 1\ 0]$, $V = [0\ 1\ 2]$

0 1 0
0 1 2

$Q(P1) < V$

$V + A(P1) = [0\ 1\ 2] + [1\ 0\ 1] = [1\ 1\ 3]$

✓

$= \text{New } V$

- $Q(P2) = [1\ 1\ 4]$, $V = [1\ 1\ 3]$

1 1 4
1 1 3

$Q(P2) > V$ ✗

- $Q(P3) = [1\ 0\ 0]$, $V = [1\ 1\ 3]$

1 0 0
1 1 3

$Q(P3) < V$

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

✓

$= \text{New } V$

- $Q(P4) = [3\ 0\ 3]$, $V = [2\ 1\ 5]$

3 0 3
2 1 5

✗

Attempting to make P2 and P4 safe.

- $Q(P2) = [1\ 1\ 4]$, New $V = [2\ 1\ 5]$

1 1 4
2 1 5

$A(P2) + V = [1\ 1\ 0] + [2\ 1\ 5] =$
$[3\ 2\ 5]$

- $Q(P4) = [3\ 0\ 3]$, $V = [3\ 2\ 5]$

3 0 3
3 2 5

$A(P4) + V = [0\ 3\ 1] + [3\ 2\ 5]$
$= [3\ 5\ 6]$

Q(R1): ✓
Q(R2): ✓
Q(R3): ✓
Q(R4): ✓
New $V = W = R = [3\ 5\ 6]$
Safe state!