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

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

$+ \quad 3 \quad 4 \quad 4 \quad 4$

$R = [\ 3\ 6\ 5\ 7\ ]$

a.) Find V

$V = R - A$ (sum of columns)

$[\ 0\ 2\ 1\ 3\ ]$ //

b.) Safe State?

b1.) Find Q

$Q = C - A$

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

b2.) Use V to Satisfy Processes w/ Q

$$\begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{bmatrix} 0 & 1 & 0 & 1 \\ 1 & 2 & 3 & 2 \\ 3 & 0 & 3 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix} \begin{array}{l} \le\ 0\ 2\ 1\ 3 \ \checkmark \text{ All True} \\ \le\ 1\ 2\ 2\ 3 \ \text{X False} \\ \le\ 1\ 2\ 2\ 3 \ \text{X False} \\ \le\ 1\ 2\ 2\ 3 \ \checkmark \text{ True} \end{array}$$

New V = Old V + A_R

Updated V for P_1

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

$= [1\ 2\ 2\ 3]$

Drag V Down

New V =

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

$= [2\ 2\ 4\ 5]$

Reiterate to try to
to turn F's to T's

$$\begin{array}{c} P_2 \\ P_3 \end{array} \begin{bmatrix} 1 & 2 & 3 & 2 \\ 3 & 0 & 3 & 0 \end{bmatrix} \begin{array}{l} \le\ 2\ 2\ 4\ 5 \ \text{T} \\ \le\ 3\ 3\ 4\ 6 \ \text{T} \end{array}$$

New V = $[3\ 3\ 4\ 6] + [0\ 3\ 1\ 1]$

$= [3\ 6\ 5\ 7]$

Final $V = [3\ 6\ 5\ 7]$ //

New V =

$[2\ 2\ 4\ 5] + [1\ 1\ 0\ 1]$

$= [3\ 3\ 4\ 6]$

Example 2 :

$V = R - A$

$Q = C - A$

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

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

$+ \quad 4 \quad 4 \quad 6$

$V = [0\ 1\ 0]$

① Calculate R Vector

$V = R - A \rightarrow R = V + A$ (sum of col)

$R = [0\ 1\ 0] + [4\ 4\ 6] = [4\ 5\ 6]$ //

② V After Running Banker's Algo

$Q = C - A$

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

Run Algorithm:

$$\begin{array}{c} P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{bmatrix} 1 & 1 & 0 \\ 3 & 0 & 0 \\ 1 & 2 & 0 \\ 0 & 1 & 0 \end{bmatrix} \begin{array}{l} \leq 0\ 1\ 0 \quad F \\ \leq 0\ 1\ 0 \quad F \\ \leq 0\ 1\ 0 \quad F \\ \leq 0\ 1\ 0 \quad T \end{array}$$

$\longrightarrow$ New V

$[0\ 1\ 0] + [1\ 0\ 1]$

$= [1\ 1\ 1]$

Re-Run $\downarrow$

$$
\begin{array}{c}
P_1 \\ P_2 \\ P_3
\end{array}
\begin{bmatrix} 1 & 1 & 0 \\ 3 & 0 & 0 \\ 1 & 2 & 0 \end{bmatrix}
\begin{array}{l}
\le 1\ 1\ 1 \quad T \rightarrow \text{New } V \\
\le 3\ 1\ 3 \quad T \\
\le 3\ 4\ 5 \quad T
\end{array}
$$

$[1\ 1\ 1] + [2\ 0\ 2]$

$= [3\ 1\ 3]$

New V

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

$= [3\ 4\ 5]$

New V

$[3\ 4\ 5] + [1\ 1\ 1]$

$= [4\ 5\ 6]$

Final $V = [4\ 5\ 6]$ //

③ Safe State?

Yes, no deadlocks //