

(1) Bacon, sect 16.2-2.

resources  $R = \begin{pmatrix} R_1 & R_2 & R_3 & R_4 & R_5 \\ 2 & 1 & 1 & 2 & 1 \end{pmatrix}$

allocation matrix  $A = \begin{matrix} & P_1 & P_2 & P_3 & P_4 & P_5 \\ \begin{matrix} R_1 \\ R_2 \\ R_3 \\ R_4 \\ R_5 \end{matrix} & \begin{pmatrix} 1 & 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix} \end{matrix}, \text{Req} = \begin{pmatrix} 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 \end{pmatrix}$

free objects  $F = (0 \ 0 \ 0 \ 0 \ 1)$

(note:  $R - F = \sum_j A_{ij}$ )

Sim  $F = (0 \ 0 \ 0 \ 0 \ 1), \text{Comp} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$

$i = 3: = (0 \ 0 \ 0 \ 1 \ 1), \text{Comp} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$

note: process  $i = 4$  can't be deadlocked  
(holds no resources)

processes 1 & 2 are deadlocked

(Fig 16.9)



**Figure 16.9** Graphs for the example in Section 16.6.2. (a) The graph at the start of the algorithm. (b) The graph when the algorithm terminates. (c) The cycle.

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$$R = \begin{matrix} & R_1 & R_2 & R_3 \\ \begin{matrix} R_1 \\ R_2 \\ R_3 \end{matrix} & \begin{pmatrix} 1 & 2 & 1 \end{pmatrix} \end{matrix}$$

$$A = \begin{matrix} & P_1 & P_2 & P_3 \\ \begin{matrix} R_1 \\ R_2 \\ R_3 \end{matrix} & \begin{pmatrix} 0 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \end{matrix}$$

$$Req = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

$$Free = (0 \ 0 \ 0)$$

all deadlocked

if remove  $P_3$ 's request  $R_2$ :

$$Req = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix}$$

$$SimF = (0 \ 0 \ 0)$$

$$Comp = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$i=3 \quad = (0 \ 0 \ 1)$$

$$Comp = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$i=2 \quad = (1 \ 1 \ 1)$$

$$Comp = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

$$i=1 \quad = (1 \ 2 \ 1)$$

$$Comp = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$

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$$R = \begin{matrix} & R_1 & R_2 & R_3 \\ \begin{pmatrix} 1 & 2 & 1 \end{pmatrix} \end{matrix}$$

$$A = \begin{matrix} P_1 \\ P_2 \\ P_3 \end{matrix} \begin{pmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 0 \end{pmatrix}$$

$$Req = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 1 \end{pmatrix}$$

$$Sim F = (0 \ 0 \ 0) \quad C_{imp} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$i = 2: \quad (1 \ 1 \ 1) \quad C_{imp} = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

$$i = 1: \quad (1 \ 2 \ 1) \quad C_{imp} = \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}$$

$$i = 3: \quad (1, 2 \ 1) \quad = C_{imp} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$