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

Date

From this if there is deadlock we can say that it is unsafe.

Safe sequence means no deadlock.

Check Need $\leq$ work

~~P_0~~

P_0, $743 \leq 332$ ✗

P_1 $122 \leq 332$ ✓ $w = w + alloc$

$= 332 + 200$ (alloc of P_1)

New work $= 532$

P_2 $600 \leq 532$ ✗

P_3 $011 \leq 532$ ✓ $w = w + alloc$

$532 + 211$ (allo of P_3)

$= 743$

P_4 $431 \leq \cancel{532}$ 743 ✓

$w = w + alloc$

$= 743 + 002$

$= 745$

~~P_5~~

P_0 $743 \leq 745$ ✓ $=$ $w = w + alloc$

$745 + 010$

755

P_2 $600 \leq 755$ ✓

$w = w + allo$

$755 + 302$

$= 10\ 5\ 7$

final work.

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

free ~~3~~ ~~5~~ 10.

Date

Here 9 tapes are allocated and 3 are free.

If P_0 is currently holding 5, then it can request 5 more in worst case, similarly P_1 can request 2 & P_2 can request 7.

When P_1 is over. ie it will release the ~~a~~ 2 tape drives & now free becomes 3+2 = 5 available

$\langle P_1$

ie with this 5, we can satisfy P_0, and once P_0 is over it will releases 5 tape drives and available becomes 10. and this will satisfy P_2's request

then $\langle P_0, P_1, P_2 \rangle$ will be a safe sequence

Example

Consider a system with 5 process P_0 through P_4 → A B C are 3 resource types.

~~Example~~

Resource type A has $\boxed{10}$ instances

B 5 "

C 7

allocation means already allocated

(Work) (Current)

at time T_0,

Total		Allocation (CPU m/y printer) ABC	Max need ABC	Available ABC
	P_0	0 1 0	7 5 3	~~3 3 2~~
10 5 7 −	P_1	2 0 0	3 2 2	~~5 3 2~~
7 2 5	P_2	3 0 2	9 0 2	~~7 4 3~~
3 3 2	P_3	2 1 1	2 2 2	~~7 4 5~~
	P_4	0 0 2	4 3 3	~~7 5 5~~
		Total allocated 7 2 5		10 5 7

The contents of need matrix is $\boxed{\text{Max need} - \text{Allocation}}$

	Need ABC	available ABC
P_0	7 4 3	3 3 2
P_1	1 2 2 ①	
P_2	6 0 0	
P_3	0 1 1 ②	
P_4	4 3 1	

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

3 ~~3~~ ~~2~~ 0
~~2~~ ~~1~~ 2
~~5~~ ~~4~~ 2

3 ~~3~~ 2
~~2~~ 2
~~2~~ ~~1~~ 0

work = available

P_0 request $\leq$ available $< P_0, P_2, P_3, P_4$

000 $\leq$ 000

w = w + allocation

= 000 + 010

= 0 1 0

P_1 2 0 2 $\leq$ 0 1 0 X

P_2 0 0 0 $\leq$ 0 1 0 ✓

W = 0 1 0 + 3 0 3

= 3 1 3

P_3 1 0 0 $\leq$ 3 1 3 ✓

W = 3 1 3 + 2 1 1

= 5 2 4

P_4 0 0 2 $\leq$ 5 2 4 ✓

W = 5 2 4 + 0 0 2

= 5 2 6

P_1 2 0 2 $\leq$ 5 2 6 ✓

W = 5 2 6 + 2 0 0

= 7 2 6

7 2 6 = equals, the actual available

So no deadlock.

Deadlock avoidance

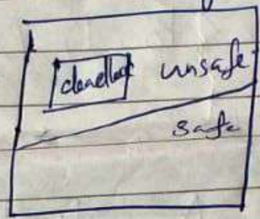
Construct An algorithms that ensures that the System will never enter a deadlock state. is the deadlock avoidance algorithms.

* A deadlock avoidance alg dynamically examines the resource allocation state to ensure that a circular wait condition can never exist.

Safe state

A state is safe if the system can allocate resources to each process in some order and still avoid a deadlock.

A system is in a safe state only if there exists a safe sequence.

fig 8.4 

Safe, unsafe & and deadlock state spaces

* A safe state is not a deadlock state

A deadlock state is an unsafe state.

Not all unsafe states are deadlocks.

An unsafe state may lead to a deadlock. — may or may not

Consider a system with 12 tape drives & 3 processes, P_0, P_1, P_2

P_0 requires 10 tapes drives
P_1 ,, 4 ,,
P_2 ,, 9 ,,

Suppose At time t_0, P_0 is holding 5 tape drives
P_1 ,, 2 ,,
& P_2 ,, 2 ,,

	Maximum needs	Current needs
P_0	10	5
P_1	4	2
P_2	9	2

Date

Deadlock Detection

Allocation

P0
P1
P2
P3
P4

Total resources A B C
7 2 6

Available A	B	C		Allocation A	B	C	Request A	B	C
0	0	0	P0 ✓	0	1	0	0	0	0
0	1	0	P1 ×	2	0	0	2	0	2
3	1	3	P2	3	0	3	0	0	0
5	2	4	P3	2	1	1	1	0	0
5	2	6	P4	0	0	2	0	0	2

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

We have allocation matrix, request ~~matrix~~ & available vector.

At the initial state any of the allocation values are all 0 0 0. So any of the finish variables to f true at this time..

Work = al~~location~~ Available
= 0 0 0

Check request ≤ available

Look at a process whose request is 0 0 0
mark P0 as done
P0
add 0 1 0 to available

P1

⟨P0, P2, P3, P4, P1⟩

No deadlock is detected

Date

deadlock detection

* Allow the system to enter deadlock state

detection

- Single Instance (wait for graph)
  - (Detect cycle)
- Multiple instances (Variant of Banker's alg)

* Detection of cycle is necessary & sufficient condition for deadlock

Safety alg

size of work m

" " Finish n

work → available

ith process

P_1	P_2	P_3
T	T	T

safe

one process false means unsafe