CS & IT ENGINEERING

Operating System

Process Synchronization

Lecture - 06

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Recap of Previous Lecture

- **Topic** Two-Process Solution for Critical Section
- **Topic** Synchronization Hardware
- **Topic** Test-And-Set(), Swap()
- **Topic** Semaphore

Topics to be Covered

Topic Semaphore

Topic Questions on Semaphore

[NAT]

#Q. Consider a scenario where 2 processes are available: P1 and P2. The processes must be executed in order P1 and P2 only. Write a piece of code to control the sequence of execution with minimum number of semaphores?

P1

signal(S2)

P2

wait(S2)

Binary Semaphore

S2 = 0

Ans = 1

Sequence:-

P1 → P2 → P1 → P2 → P1 → P2 ---------

P1	P2
wait(S1)	wait(S2)
≡	
signal(S2)	Signal(S1)

Initialization:-

S2 = 0

S1 = 1

[NAT]

Ans = 2

#Q. Consider a scenario where 3 processes are available: P0, P1 and P2. The processes must be executed in order P1, P0 and P2 only. Write a piece of code to control the sequence of execution with minimum number of semaphores?

binary semaphores

P0
wait(S0)
signal(S2)

P1
signal(S0)

P2
wait(S2)

S0 = 0
S2 = 0

[MCQ]

#Q. Consider the following threads, T_1, T_2, and T_3 executing on a single processor, synchronized using three binary semaphore variables, S_1, S_2, and S_3, operated upon using standard wait() and signal(). The threads can be context switched in any order and at any time
Which initialization of the semaphores would print the sequence BCABCABCA...?

[2022]

T1	T2	T3

while(true){
wait (S_3);
print("C");
signal(S_2);
}
	while(true){
	wait(S_1);
	print("B");
	signal(S_3);}
		while(true) {
		wait(S_2);
		print("A");
		signal(S_1); }

T2 ⟶ T1 ⟶ T3

S1 = 1, S2 = 0, S3 = 0

A $S_1 = 1; S_2 = 1; S_3 = 1$

B $S_1 = 1; S_2 = 1; S_3 = 0$

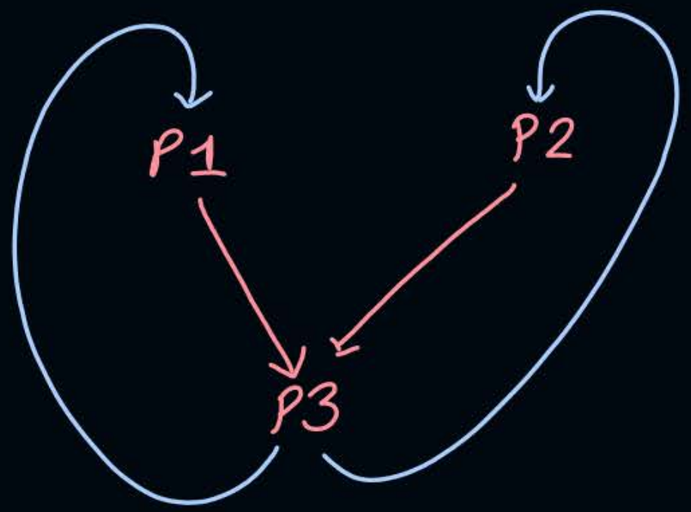
C ✓ $S_1 = 1; S_2 = 0; S_3 = 0$

D $S_1 = 0; S_2 = 1; S_3 = 1$

Ques) P1, P2, P3 3 processes

P3 can run only after complete execution of P1, P2 :
And then again P1, P2 can execute only after P3 completes

write code of P1, P2, P3 ?



S1=+0

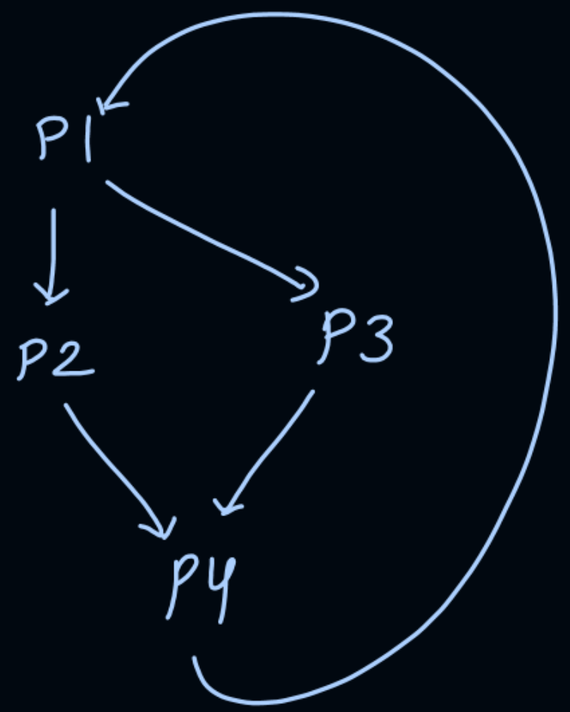
S-

P1	P2	P3
wait(S1)	wait(S2)	wait(S31) wait(S32)
signal(S31)	signal(S32)	signal(S1) signal(S2)

S1 = 1 S31 = 0

S2 = 1 S32 = 0

Ques) P1, P2, P3, P4



$S1 = 1, S2 = 0, S3 = 0, S41 = 0, S42 = 0$

P1

wait (S1)

Signal (S2)

signal (S3)

P2

wait (S2)

Signal (S41)

P3

wait (S3)

Signal (S42)

P4

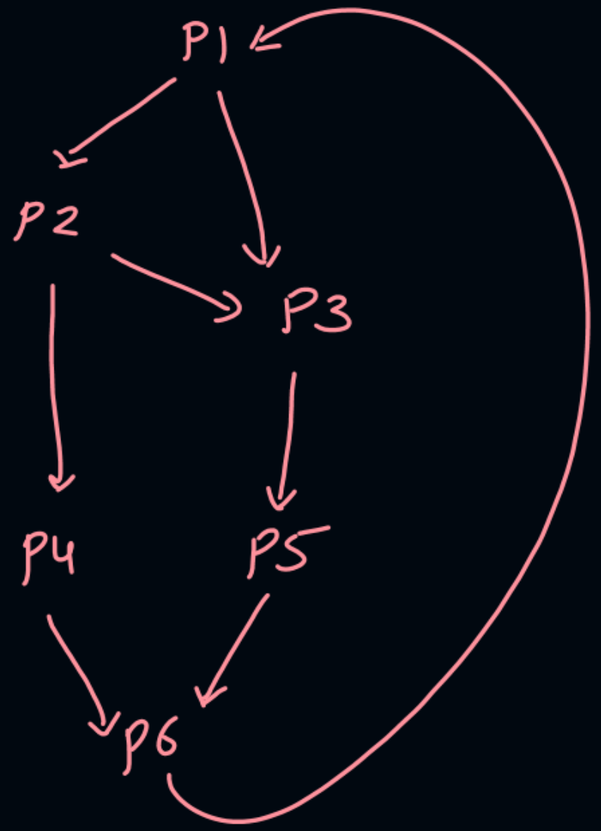
wait (S41)

wait (S42)

signal (S1)

Homework :-

Code ? with min. no. of binary semaphores ?



If $S = 1$

P1, P2, P3

wait(S)

How many processes will not be able to run wait() successfully

⇓

2

Ques) Counting semaphore

$S = 2$

2 times signal() & 4 times wait() } final value of $S = 0$

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any wait() can run after that ? ⇒ no because $S = 0$

[NAT]

Ans = 7

#Q. Consider a non-negative counting semaphore S. The operation P(S) decrements S, and V(S) increments S. During an execution, 20 P(S) operations and 12 V(S) operations are issued in some order. The largest initial value of S for which at least one P(S) operation will remain blocked is _____.?

[2016]

20 P(S) → 19 successful
→ 1 block

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19 P(S)
12 V(S)

$S - 19 + 12 = 0$

$S = 7$

[NAT]

Ans = 2

#Q. A shared variable x, initialized to zero, is operated on by four concurrent processes W, X, Y, Z as follows. Each of the process W and X reads x from memory , increments by one, stores it to memory and then terminates. Each of the processes Y and Z reads x from memory , decrements by two, stores it to memory and then terminates. Each processes before reading x invokes the P operation (i.e., wait) on a counting semaphore S and invokes the V operation (i.e., signal) on the semaphore S after storing x to memory. Semaphore S is initialized to two. What is the maximum possible value of x after all processes complete execution? **[2013]**

$x = 0$ $S = 2$

W	X	Y	Z
P(s)	P(s)	P(s)	P(s)
$x_1 = x + 1$	$x = x + 1$	$x = x - 2$	$x = x - 2$
V(s)	V(s)	V(s)	V(s)

$S = 2 \; 0 \; 2 \; 0 \; 2$

W ⇒ P(s) Read x $x = 0 \Rightarrow x = 1$ | W writes last | V(s)

Y ⇒ P(s) Read x $x = 0 \Rightarrow x = -2$ | | V(s)

$x = 1$

X ⇒ P(s) Read x $x = 1 \Rightarrow x = 2$ | X writes last | V(s)

Z ⇒ P(s) Read x $x = 1 \Rightarrow x = -1$ | | V(s)

$X = 2$

if $s = 1$ initialised

only 1 ans. possible $\Rightarrow$ $0 + 1 + 1 - 2 - 2$

$\Rightarrow$ $\underline{\underline{-2}}$ Ans.

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min. possible value of x, for $s = 2$

Ans = -4

All possible values of x ? $\rightarrow$ $1, -2, 2, -4, -1, 0, -3$

$0 + 1 + 1 - 2 - 2$

[NAT]

Homework.

#Q. A shared variable x, initialized to zero, is operated on by four concurrent processes W, X, Y, Z as follows. Each of the process W and X reads x from memory, increments by 2, stores it to memory and then terminates. Each of the processes Y and Z reads x from memory , decrements by 3, stores it to memory and then terminates. Each processes before reading x invokes the P operation (i.e., wait) on a counting semaphore S and invokes the V operation (i.e., signal) on the semaphore S after storing x to memory. Semaphore S is initialized to two. What are the total distinct possible values of x after all processes complete execution ?

2 mins Summary

Topic Semaphore

Topic Questions on Semaphore

Happy Learning

THANK - YOU