

Course: Operating System (CS570)

Assignment 2: Game of Turns

Instructor: Prof. Kartik Gopalan

Submitted by

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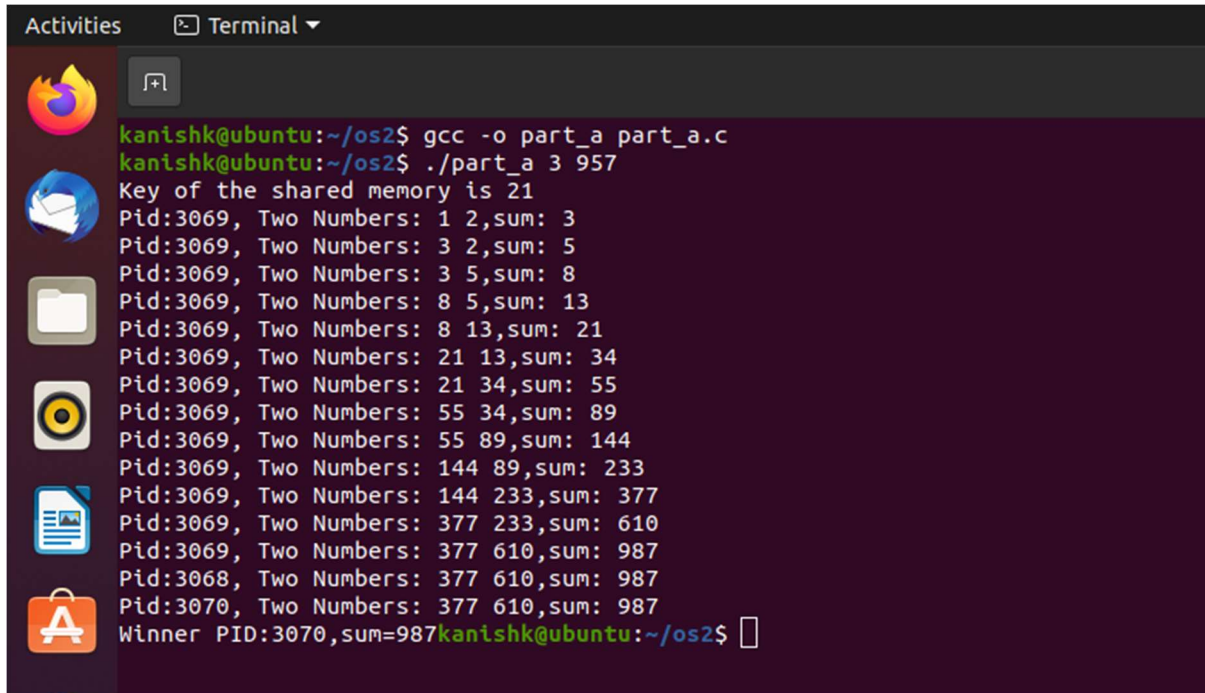
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Part-A: Multi-Process Addition Game Without Locking

- Output Screenshot

A terminal window titled 'Terminal' showing the execution of a C program. The user 'kanishk@ubuntu' is in the directory '~/os2'. They compile 'part_a.c' with 'gcc -o part_a part_a.c' and then run './part_a 3 957'. The program outputs a key for shared memory (21) and then a series of lines showing two numbers and their sum for different PIDs. The PIDs are mostly 3069, but there are also 3068 and 3070. The sums range from 3 to 987. The final line indicates a winner with PID 3070 and a sum of 987.

```
kanishk@ubuntu:~/os2$ gcc -o part_a part_a.c
kanishk@ubuntu:~/os2$ ./part_a 3 957
Key of the shared memory is 21
Pid:3069, Two Numbers: 1 2,sum: 3
Pid:3069, Two Numbers: 3 2,sum: 5
Pid:3069, Two Numbers: 3 5,sum: 8
Pid:3069, Two Numbers: 8 5,sum: 13
Pid:3069, Two Numbers: 8 13,sum: 21
Pid:3069, Two Numbers: 21 13,sum: 34
Pid:3069, Two Numbers: 21 34,sum: 55
Pid:3069, Two Numbers: 55 34,sum: 89
Pid:3069, Two Numbers: 55 89,sum: 144
Pid:3069, Two Numbers: 144 89,sum: 233
Pid:3069, Two Numbers: 144 233,sum: 377
Pid:3069, Two Numbers: 377 233,sum: 610
Pid:3069, Two Numbers: 377 610,sum: 987
Pid:3068, Two Numbers: 377 610,sum: 987
Pid:3070, Two Numbers: 377 610,sum: 987
Winner PID:3070,sum=987kanishk@ubuntu:~/os2$
```

Figure 1: Output screenshot for Multi-Process Addition Game without Locking.

- Major Insights

- ➔ The locking mechanism is not introduced due to which the different PID try to access shared memory region arbitrarily (Figure 1).
- ➔ In some iterations, one or more winner PID (wpid) are observed.
- ➔ One child try to overwrite the sum of another child.

Part B: Addition Game with Locking

1. Busy-wait locking with "sem_trywait()" and "continue"

- Output

```
kbarhan1@remote02:~$ ipcrm -a
ipcrm: permission denied for id (196641)
kbarhan1@remote02:~$ ./sem 3 555
Key of the shared memory is 196647
Pid:194431, Two Numbers: 1 2,sum: 3
Pid:194431, Two Numbers: 3 2,sum: 5
Pid:194431, Two Numbers: 3 5,sum: 8
Pid:194431, Two Numbers: 8 5,sum: 13
Pid:194431, Two Numbers: 8 13,sum: 21
Pid:194431, Two Numbers: 21 13,sum: 34
Pid:194431, Two Numbers: 21 34,sum: 55
Pid:194431, Two Numbers: 55 34,sum: 89
Pid:194431, Two Numbers: 55 89,sum: 144
Pid:194431, Two Numbers: 144 89,sum: 233
Pid:194431, Two Numbers: 144 233,sum: 377
Pid:194431, Two Numbers: 377 233,sum: 610

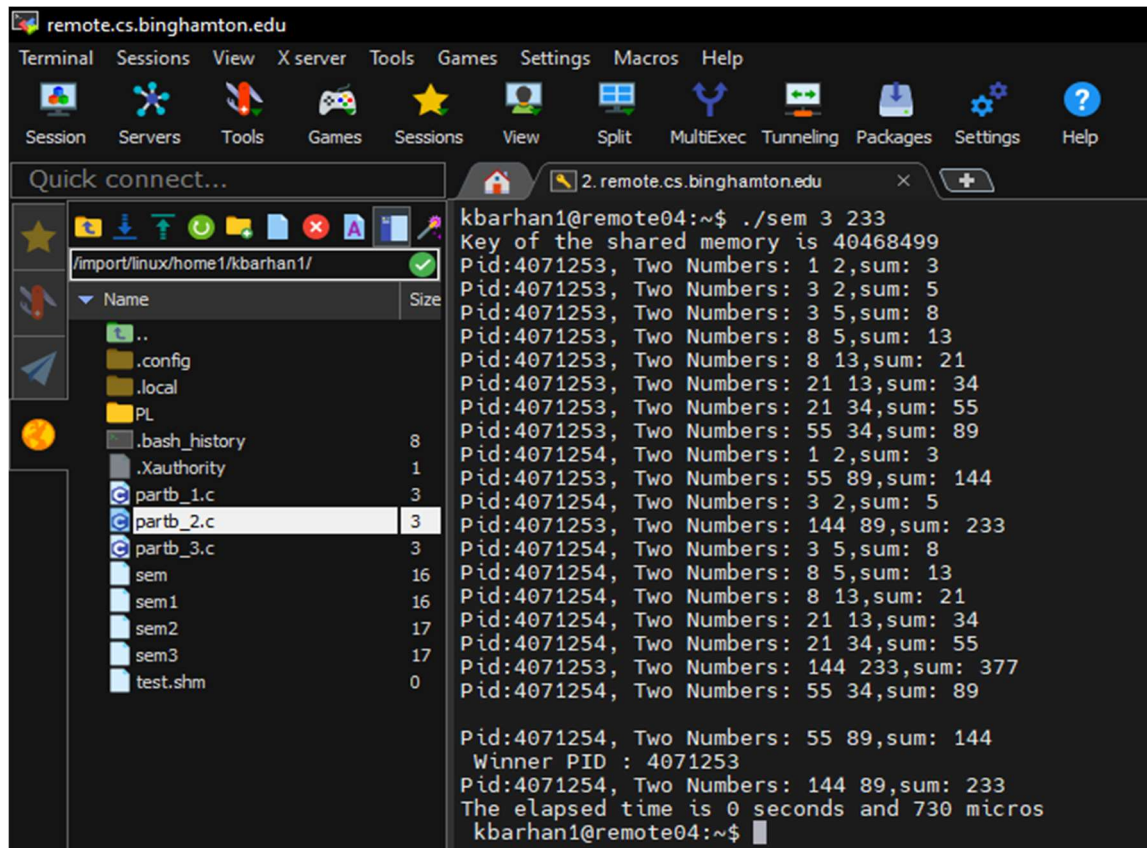
Winner PID : 194431
Pid:194432, Two Numbers: 1 2,sum: 3
Pid:194432, Two Numbers: 3 2,sum: 5
Pid:194432, Two Numbers: 3 5,sum: 8
Pid:194432, Two Numbers: 8 5,sum: 13
Pid:194432, Two Numbers: 8 13,sum: 21
Pid:194432, Two Numbers: 21 13,sum: 34
Pid:194432, Two Numbers: 21 34,sum: 55
Pid:194432, Two Numbers: 55 34,sum: 89
Pid:194432, Two Numbers: 55 89,sum: 144
Pid:194432, Two Numbers: 144 89,sum: 233
Pid:194432, Two Numbers: 144 233,sum: 377
Pid:194432, Two Numbers: 377 233,sum: 610

Winner PID : 194432
The elapsed time is 0 seconds and 381 micros
Pid:194433, Two Numbers: 1 2,sum: 3
Pid:194433, Two Numbers: 3 2,sum: 5
Pid:194433, Two Numbers: 3 5,sum: 8
Pid:194433, Two Numbers: 8 5,sum: 13
Pid:194433, Two Numbers: 8 13,sum: 21
Pid:194433, Two Numbers: 21 13,sum: 34
Pid:194433, Two Numbers: 21 34,sum: 55
Pid:194433, Two Numbers: 55 34,sum: 89
Pid:194433, Two Numbers: 55 89,sum: 144
Pid:194433, Two Numbers: 144 89,sum: 233
Pid:194433, Two Numbers: 144 233,sum: 377
Pid:194433, Two Numbers: 377 233,sum: 610

Winner PID : 194433
kbarhan1@remote02:~$ █
```

Figure 2: Output for "sem_trywait()" and "continue".

2. Busy-wait locking with `sem_trywait()` and `sched_yield()`



```
kbarhan1@remote04:~$ ./sem 3 233
Key of the shared memory is 40468499
Pid:4071253, Two Numbers: 1 2,sum: 3
Pid:4071253, Two Numbers: 3 2,sum: 5
Pid:4071253, Two Numbers: 3 5,sum: 8
Pid:4071253, Two Numbers: 8 5,sum: 13
Pid:4071253, Two Numbers: 8 13,sum: 21
Pid:4071253, Two Numbers: 21 13,sum: 34
Pid:4071253, Two Numbers: 21 34,sum: 55
Pid:4071253, Two Numbers: 55 34,sum: 89
Pid:4071254, Two Numbers: 1 2,sum: 3
Pid:4071253, Two Numbers: 55 89,sum: 144
Pid:4071254, Two Numbers: 3 2,sum: 5
Pid:4071253, Two Numbers: 144 89,sum: 233
Pid:4071254, Two Numbers: 3 5,sum: 8
Pid:4071254, Two Numbers: 8 5,sum: 13
Pid:4071254, Two Numbers: 8 13,sum: 21
Pid:4071254, Two Numbers: 21 13,sum: 34
Pid:4071254, Two Numbers: 21 34,sum: 55
Pid:4071254, Two Numbers: 144 233,sum: 377
Pid:4071254, Two Numbers: 55 34,sum: 89

Pid:4071254, Two Numbers: 55 89,sum: 144
Winner PID : 4071253
Pid:4071254, Two Numbers: 144 89,sum: 233
The elapsed time is 0 seconds and 730 micros
kbarhan1@remote04:~$
```

Figure 3: Output for `sem_trywait()` and `sched_yield()`

3. Busy-wait locking with sem_wait()

```
kbarhan1@remote04:~$ ipcrm -a
ipcrm: permission denied for id (40271900)
ipcrm: permission denied for id (40468527)
kbarhan1@remote04:~$ ./sem3 3 555
Key of the shared memory is 40501258
Pid:4086324, Two Numbers: 1 2,sum: 3
Pid:4086324, Two Numbers: 3 2,sum: 5
Pid:4086324, Two Numbers: 3 5,sum: 8
Pid:4086324, Two Numbers: 8 5,sum: 13
Pid:4086324, Two Numbers: 8 13,sum: 21
Pid:4086324, Two Numbers: 21 13,sum: 34
Pid:4086324, Two Numbers: 21 34,sum: 55
Pid:4086325, Two Numbers: 1 2,sum: 3
Pid:4086324, Two Numbers: 55 34,sum: 89
Pid:4086324, Two Numbers: 55 89,sum: 144
Pid:4086325, Two Numbers: 3 2,sum: 5
Pid:4086324, Two Numbers: 144 89,sum: 233
Pid:4086324, Two Numbers: 144 233,sum: 377
Pid:4086324, Two Numbers: 377 233,sum: 610

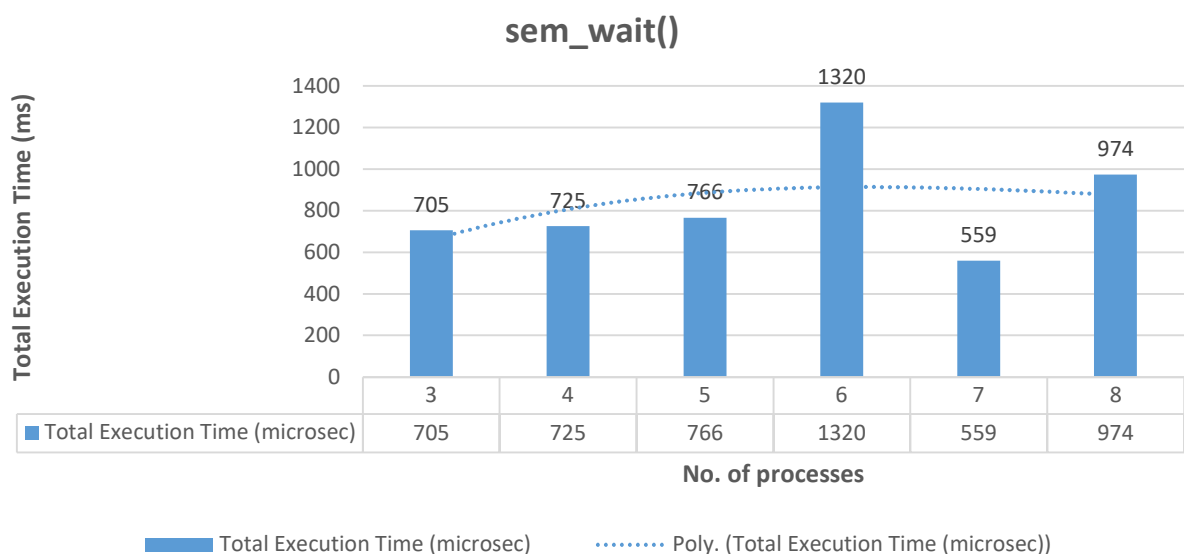
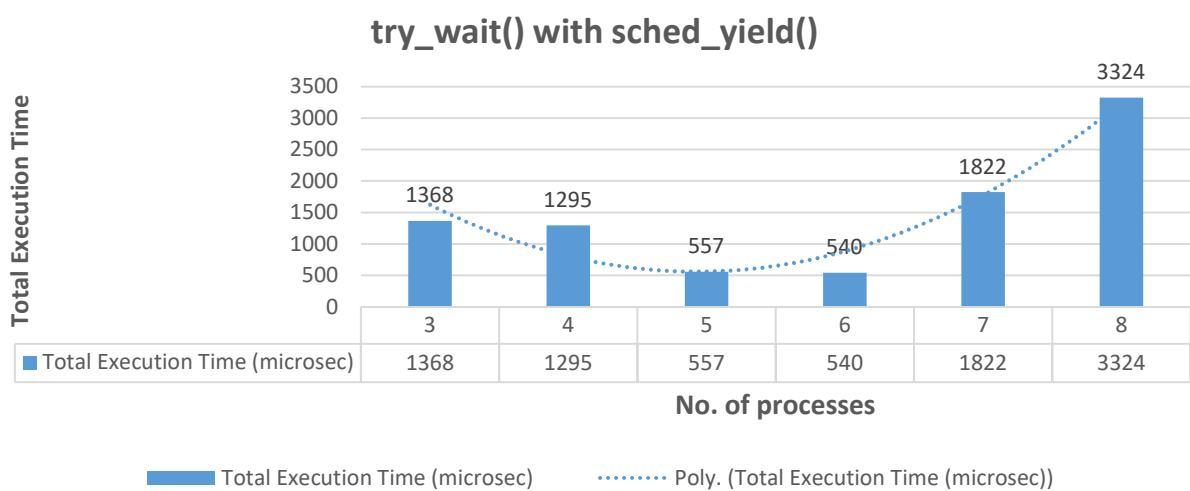
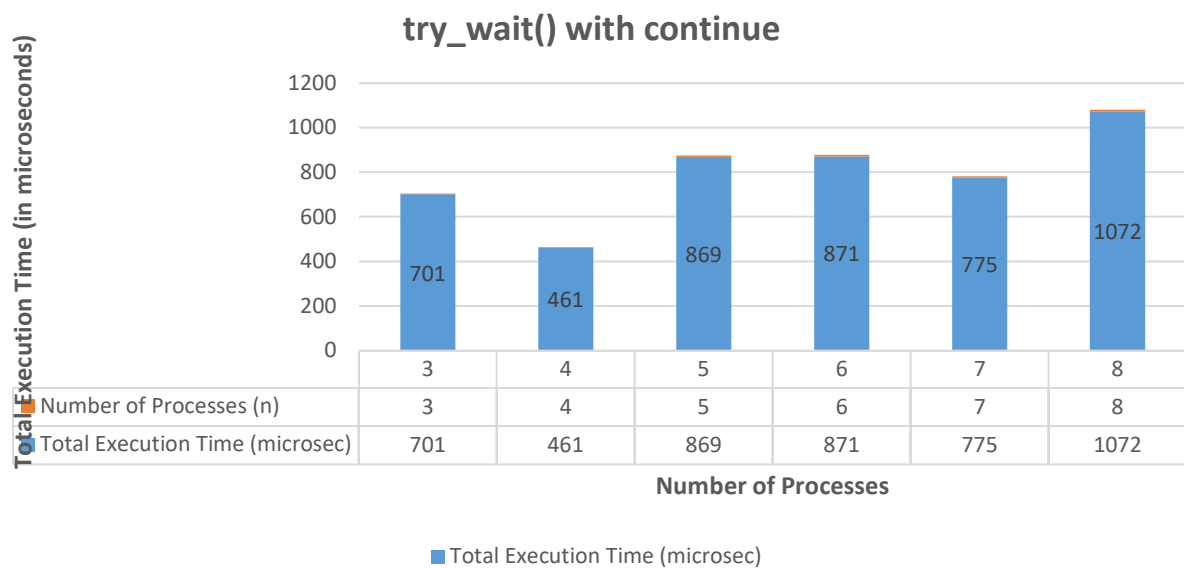
Winner PID : 4086324
Pid:4086325, Two Numbers: 3 5,sum: 8
The elapsed time is 0 seconds and 691 micros
Pid:4086325, Two Numbers: 8 5,sum: 13
Pid:4086325, Two Numbers: 8 13,sum: 21
Pid:4086325, Two Numbers: 21 13,sum: 34
Pid:4086325, Two Numbers: 21 34,sum: 55
Pid:4086325, Two Numbers: 55 34,sum: 89
Pid:4086325, Two Numbers: 55 89,sum: 144
Pid:4086325, Two Numbers: 144 89,sum: 233
Pid:4086325, Two Numbers: 144 233,sum: 377
Pid:4086325, Two Numbers: 377 233,sum: 610

Winner PID : 4086325
Pid:4086326, Two Numbers: 1 2,sum: 3
Pid:4086326, Two Numbers: 3 2,sum: 5
Pid:4086326, Two Numbers: 3 5,sum: 8
Pid:4086326, Two Numbers: 8 5,sum: 13
Pid:4086326, Two Numbers: 8 13,sum: 21
Pid:4086326, Two Numbers: 21 13,sum: 34
Pid:4086326, Two Numbers: 21 34,sum: 55
Pid:4086326, Two Numbers: 55 34,sum: 89
Pid:4086326, Two Numbers: 55 89,sum: 144
Pid:4086326, Two Numbers: 144 89,sum: 233
Pid:4086326, Two Numbers: 144 233,sum: 377
Pid:4086326, Two Numbers: 377 233,sum: 610

Winner PID : 4086326
kbarhan1@remote04:~$
```

Figure 4: Output for sem_wait()

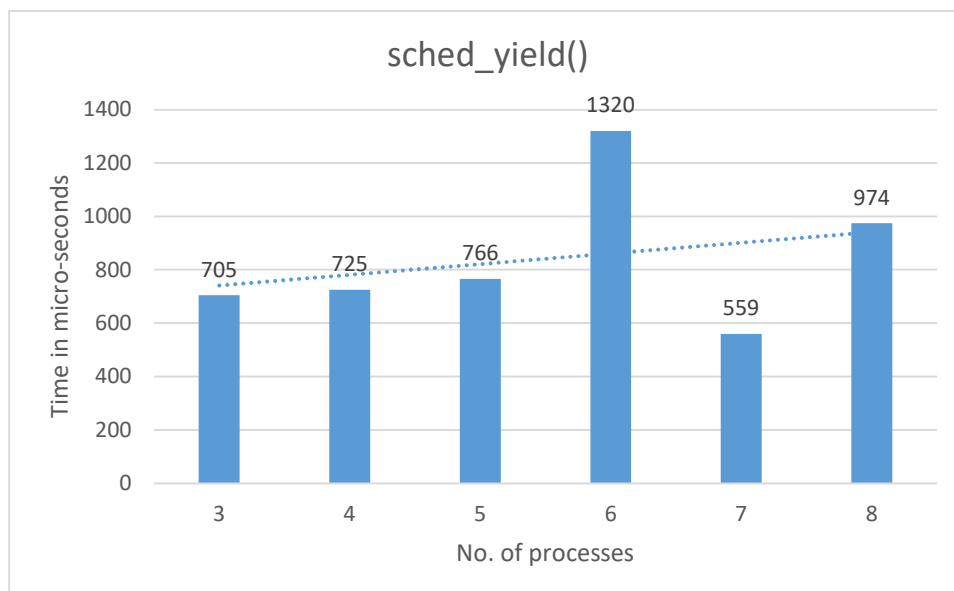
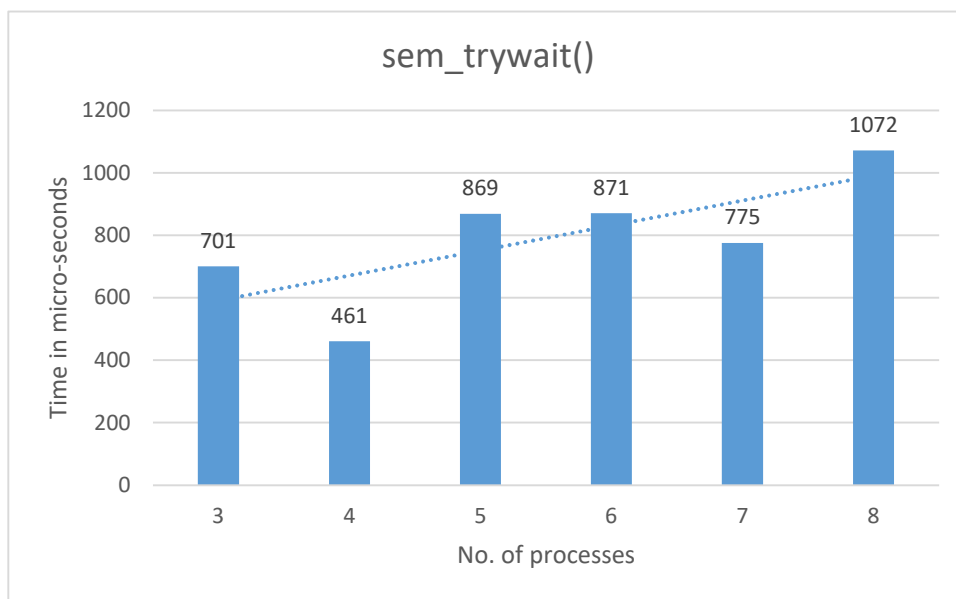
Part C: Comparing the three versions of the Addition game

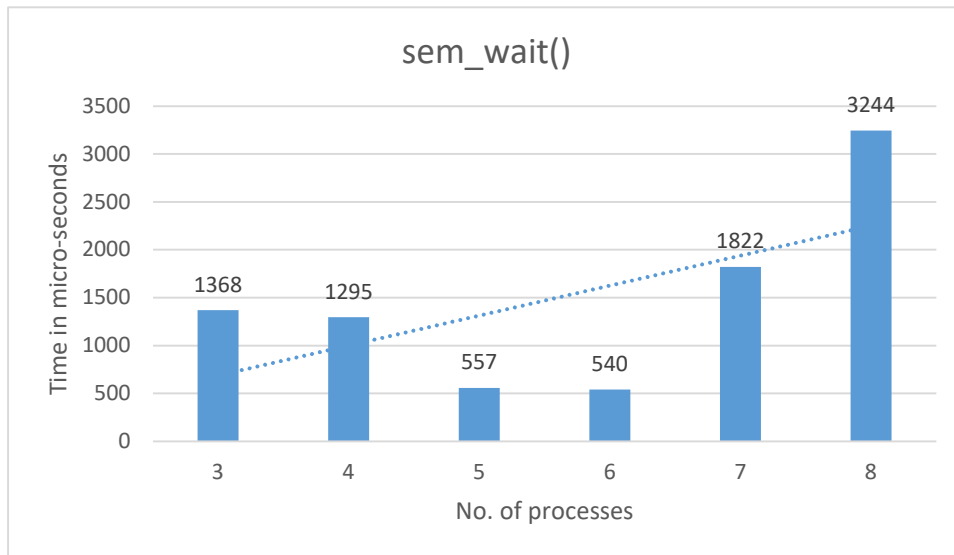


a. Total execution time for the parent process versus number of processes P

M=550000

No. of Processes	sem_trywait()	sched_yield()	sem_wait()
3	701	705	1368
4	461	725	1295
5	869	766	557
6	871	1320	540
7	775	559	1822
8	1072	974	3244





b. Average time to acquire lock in each child process versus the number of processes P.

M=550000

No. of Processes	sem_trywait()	sched_yield()	sem_wait()
3	18.67	18.67	22.3
4	23.26	22.5	21.5
5	24.8	21	29.6
6	26.67	21.6	27.33

