SYSC 4001

Assignment 2
Process Scheduling, Memory Management
Report

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Github Repo Part 2:
https://github.com/SabariMathiyalagan/SYSC4001_A2_P2

Github Repo Part 3:
https://github.com/SabariMathiyalagan/SYSC4001_A2_P3

Mandatory Simulation Tests

Simulation 1: Basic Fork and Exec

This first simulation shows how fork() and exec() work together. The trace starts with a FORK, causing a child process to be created and run. The child process runs EXEC with program1, and once it's done, the parent runs EXEC program2. In the logs, you can clearly see the child running first, the loading of each program, 150 ms for program1, and 225 ms for program2. The snapshots show the child using partition 4 and the parent using partition 3, proving that the scheduler, memory allocation, and timing all behave as intended.

Simulation 2: Nested Fork within a Child Program

This second simulation adds another layer of complexity with a nested FORK statement. After the first fork, the child process runs program3, which then forks again. The new child (child of the child) runs first while its parent (the initial child) and the original parent (init) wait. When the nested child finishes, the parent of program3 continues and executes program4. The logs show this chain perfectly, with recursive calls to simulate_trace() and correct loader times for each of the programs. The system status file shows all three PCBs at one point, with one running and two waiting, confirming that the parent process only executes after the child process at all times.

Simulation 3: System Calls and I/O Interrupts

The third simulation focuses on how the simulator handles system calls and I/O interrupts (from Assignment 1), with the new features of Assignment 2. The trace starts with a FORK, but then The child process immediately returns. Then the parent process executes the program, which Follows the SYSCALL → IRET → END_IO → IRET pattern. The snapshot at time 277 for the system status confirms that only the parent (PID 0) is running program5 in partition 4, proving that the parent executes the program because it resumes after both conditionals after the fork have finished

Custom Simulation Tests

Simulation 4

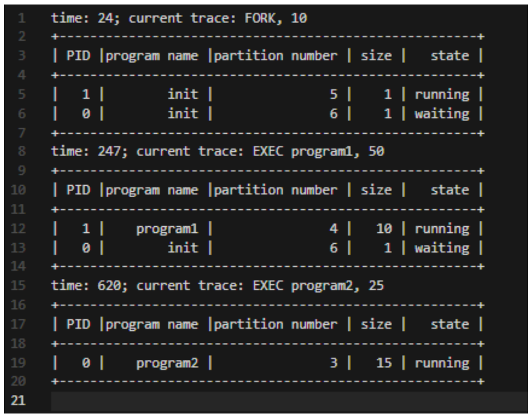
This test compares two different workloads. The child runs program6 (8 MB) first, performing the SYSCALL and END_IO operations that will end up triggering the device interrupts. The parent waits while the child finishes, then executes program7 (25 MB), which mostly utilises the CPU. Loader times are 120 ms for the child and 375 ms for the parent, matching the expected 15 ms × size. The snapshots show program6 using partition 5 (8 MB) and program7 using partition 2 (25 MB). This test highlights how I/O delays extend total runtime and shows that the simulator correctly does child-first execution and the best-fit memory allocation.

Simulation 5

The last test shows re-EXECing a larger program within the same process. The child first execs program8 (10 MB); it then re-execs program9 (25 MB), which is meant to model the common case of a process replacing its code with something larger. Once the child finishes, the parent runs program9 too. The simulator frees the child's memory before the parent runs, so they both use the same partition (partition 2). Loader times scale from 150 ms to 375 ms and the snapshot clearly shows the process moving from partition 4 to 2. This demonstrates that re-EXEC, freeing of memory and re-allocation all work correctly.

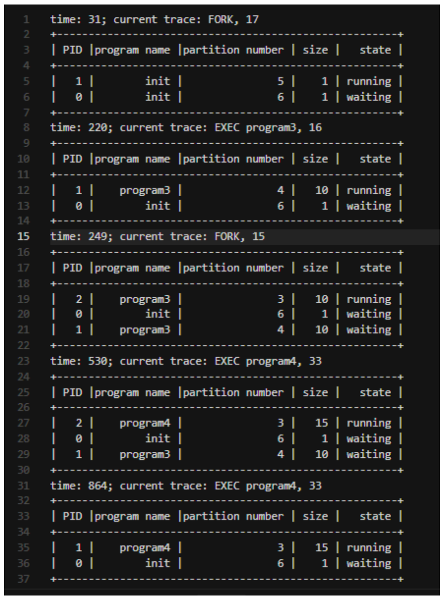
Conclusion

The fork/exec simulator behaved just like a real OS would across the five simulations. The child always ran first, memory allocated using a best-fit strategy, and the loader times matched the program sizes. The device delays worked as described, and I/O operations performed their respective functions exactly as described. Overall, the simulator does a great job showing how process creation, execution, and memory management fit together in a simplified kernel model.



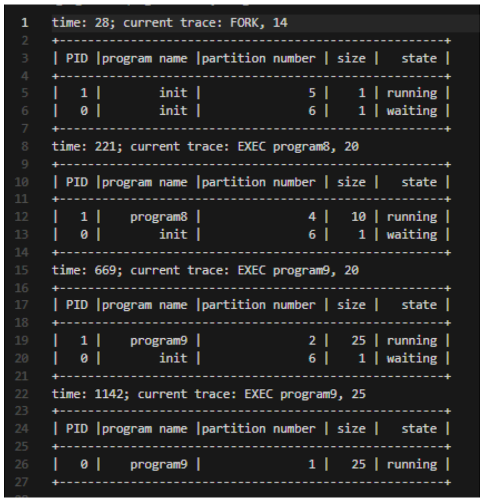
```
time: 24; current trace: FORK, 10
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |        init |               5 |    1 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 247; current trace: EXEC program1, 50
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |    program1 |               4 |   10 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 620; current trace: EXEC program2, 25
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   0 |    program2 |               3 |   15 | running |
+------------------------------------------------------+
```

system_status1



```
time: 31; current trace: FORK, 17
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |        init |               5 |    1 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 220; current trace: EXEC program3, 16
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |    program3 |               4 |   10 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 249; current trace: FORK, 15
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   2 |    program3 |               3 |   10 | running |
|   0 |        init |               6 |    1 | waiting |
|   1 |    program3 |               4 |   10 | waiting |
+------------------------------------------------------+
time: 530; current trace: EXEC program4, 33
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   2 |    program4 |               3 |   15 | running |
|   0 |        init |               6 |    1 | waiting |
|   1 |    program3 |               4 |   10 | waiting |
+------------------------------------------------------+
time: 864; current trace: EXEC program4, 33
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |    program4 |               3 |   15 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
```

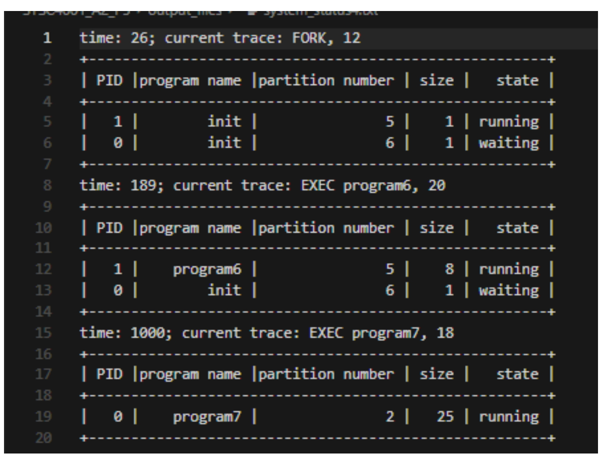
system_status2



```
time: 28; current trace: FORK, 14
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |        init |               5 |    1 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 221; current trace: EXEC program8, 20
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |    program8 |               4 |   10 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 669; current trace: EXEC program9, 20
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |    program9 |               2 |   25 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 1142; current trace: EXEC program9, 25
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   0 |    program9 |               1 |   25 | running |
+------------------------------------------------------+
```

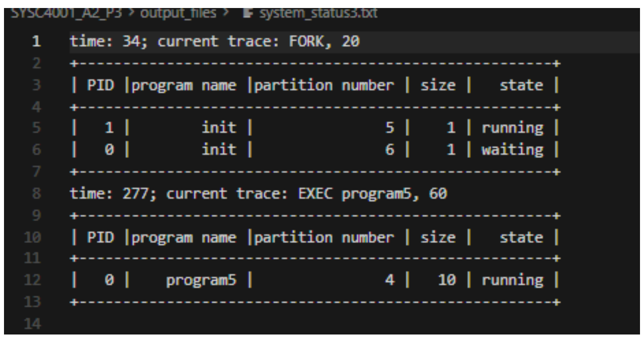
system_status3

system_status4



```
time: 26; current trace: FORK, 12
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |        init |               5 |    1 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 189; current trace: EXEC program6, 20
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |    program6 |               5 |    8 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 1000; current trace: EXEC program7, 18
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   0 |    program7 |               2 |   25 | running |
+------------------------------------------------------+
```

system_status5



SYSC4001_A2_P3 > output_files > system_status3.txt

```
time: 34; current trace: FORK, 20
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   1 |        init |               5 |    1 | running |
|   0 |        init |               6 |    1 | waiting |
+------------------------------------------------------+
time: 277; current trace: EXEC program5, 60
+------------------------------------------------------+
| PID |program name |partition number | size |   state |
+------------------------------------------------------+
|   0 |    program5 |               4 |   10 | running |
+------------------------------------------------------+
```