OS'19S Project 1 -- Process Scheduling

Group 18

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GitHub Repository: https://github.com/slSeanWU/OS19S_Proj_1

壹、設計

(I) Process Scheduler

main.c

- Read input (scheduling policy, process info)
- Sort by process's ready_time

Schedulers (**scheduler_xxx.c**)

- 依下列四種排序方式，決定每一輪要跑哪一支 process
  - FIFO
  - RR
  - SJF
  - PSJF
- Call process_control.c 的函式調控運行
  - fork() 要跑的 process
  - 控制每個 process 使用 CPU 的權利
- **用 pipe 控制 scheduler 跟 process 的同步**
- wait() 跑完的 process

process_control.c

- 執行 process，透過 system call 印 start_time, finish_time 到 kernel
- sched_setaffinity() 限制所有 processes 使用同一 core (scheduler 使用另一 core)
- sched_setscheduler() 設定 process 的 priority (**target: 一高多低，只有一個 process 能用 core**)
- clock_gettime() 取精準至 nanosecond 的時間 (stored in struct timespec)

(II) Kernel Revision

- Based on Linux version 4.17.4
- Added syscall 333: **__x64_sys_printstring()**
  - Prints an arbitrary user-space string to kernel
- Please refer to the following file for detailed guidelines --

https://github.com/slSeanWU/OS19S_Proj_1/blob/master/supplements/add_syscall_tutorial.md

貳、執行範例測資的結果

(I) Testing Platforms

1. VirtualBox Ubuntu on Intel **Core i7-8700 @ 3.2GHz, 6 cores** *(for FIFO, RR)*
2. VirtualBox Ubuntu on Intel **Core i7-7700HQ @ 2.8GHz, 4 cores** *(for SJF, PSJF)*

(II) Time Unit Benchmarking

Measured with the testcase on the project website. (timed 10 FIFO processes, took average)

- On Platform 1: *Time unit = 0.002224574 sec (for FIFO and RR)*
- On Platform 2: *Time unit = 0.001727558 sec (for SJF, PSJF)*

(III) Results

→ Format of actual output: ***[pid]*** *finish at* ***[converted time unit]*** unit

input	expected output	actual output
FIFO 5 P1 0 500 P2 0 500 P3 0 500 P4 0 500 P5 0 500	Process P1, start at 0 Process P1, end at 500 Process P2, end at 1000 Process P3, end at 1500 Process P4, end at 2000 Process P5, end at 2500	5938 finish at 515.246091611 unit 5939 finish at 1022.218299773 unit 5940 finish at 1520.332248331 unit 5941 finish at 2036.663769332 unit 5942 finish at 2540.573113773 unit
FIFO 4 P1 0 80000 P2 100 5000 P3 200 1000 P4 300 1000	Process P1, start at 0 Process P1, end at 80000 Process P2, end at 85000 Process P3, end at 86000 Process P4, end at 87000	16153 finish at 79923.175993695 unit 17995 finish at 84971.551921851 unit 18241 finish at 85963.646359257 unit 18242 finish at 86914.385845559 unit
FIFO 7 P1 0 8000 P2 200 5000 P3 300 3000 P4 400 1000 P5 500 1000 P6 500 1000 P7 600 4000	Process P1, start at 0 Process P1, end at 8000 Process P2, end at 13000 Process P3, end at 16000 Process P4, end at 17000 Process P5, end at 18000 Process P6, end at 19000 Process P7, end at 23000	7720 finish at 8067.745671755 unit 7721 finish at 13133.671489013 unit 7722 finish at 16162.036939656 unit 7723 finish at 17170.848185315 unit 7724 finish at 18142.639668988 unit 7725 finish at 19158.832588621 unit 7726 finish at 23154.821425585 unit
FIFO 4 P1 0 2000 P2 500 500 P3 500 200 P4 1500 500	Process P1, start at 0 Process P1, end at 2000 Process P2, end at 2500 Process P3, end at 2700 Process P4, end at 3200	9306 finish at 2018.632207334 unit 9307 finish at 2517.094462580 unit 9308 finish at 2716.004341954 unit 9309 finish at 3219.669660797 unit

FIFO 7 P1 0 8000 P2 200 5000 P3 200 3000 P4 400 1000 P5 400 1000 P6 600 1000 P7 600 4000	Process P1, start at 0 Process P1, end at 8000 Process P2, end at 13000 Process P3, end at 16000 Process P4, end at 17000 Process P5, end at 18000 Process P6, end at 19000 Process P7, end at 23000	9646 finish at 8005.013228150 unit 9647 finish at 13044.180919582 unit 9648 finish at 16024.106806516 unit 9649 finish at 16994.595021338 unit 9650 finish at 17962.361225564 unit 9651 finish at 18935.297484372 unit 9652 finish at 22978.607582845 unit
PSJF 4 P1 0 10000 P2 1000 7000 P3 2000 5000 P4 3000 3000	process P1, start at 0 process P4, end at 6000 process P3, end at 10000 process P2, end at 16000 process P1, end at 25000	3269 finish at 5988.116428507 unit 3268 finish at 9872.917780473 unit 3267 finish at 15780.368770252 unit 3266 finish at 24630.421123921 unit
PSJF 5 P1 0 3000 P2 1000 1000 P3 2000 4000 P4 5000 2000 P5 7000 1000	process P1, start at 0 process P2, end at 2000 process P1, end at 4000 process P4, end at 7000 process P5, end at 8000 process P3, end at 11000	3334 finish at 2063.231820291 unit 3333 finish at 4154.709117725 unit 3336 finish at 7268.757548516 unit 3337 finish at 8280.090405647 unit 3335 finish at 11265.638196807 unit
PSJF 4 P1 0 2000 P2 500 500 P3 1000 500 P4 1500 500	process P1, start at 0 process P2, end at 1000 process P3, end at 1500 process P4, end at 2000 process P1, end at 3500	3402 finish at 984.203275374 unit 3403 finish at 1470.562495730 unit 3404 finish at 1986.336793902 unit 3401 finish at 3460.576175734 unit
PSJF 4 P1 0 7000 P2 0 2000 P3 100 1000 P4 200 4000	process P1, start at 0 process P3, end at 1100 process P2, end at 3000 process P4, end at 7000 process P1, end at 14000	3459 finish at 1147.871874634 unit 3458 finish at 3016.447044903 unit 3460 finish at 6930.519722058 unit 3461 finish at 13729.247386773 unit
PSJF 5 P1 100 100 P2 100 4000 P3 200 200 P4 200 4000 P5 200 7000	process P1, start at 100 process P1, end at 200 process P3, end at 400 process P2, end at 4400 process P4, end at 8400 process P5, end at 15400	3511 finish at 103.226170698 unit 3512 finish at 310.942575589 unit 3513 finish at 4425.063703215 unit 3514 finish at 8550.968746635 unit 3515 finish at 15736.274512925 unit
RR 5 P1 0 500 P2 0 500 P3 0 500 P4 0 500 P5 0 500	Process P1, start at 0 Process P1, end at 500 Process P2, end at 1000 Process P3, end at 1500 Process P4, end at 2000 Process P5, end at 2500	9796 finish at 512.133767184 unit 9797 finish at 1023.346207408 unit 9798 finish at 1533.297558094 unit 9799 finish at 2041.849045255 unit 9800 finish at 2550.228910793 unit

RR 2 P1 600 4000 P2 800 5000	Process P1, start at 600 Process P1, end at 8100 Process P2, end at 9600	9903 finish at 8150.247733723 unit 9904 finish at 9646.580130847 unit
RR 6 P1 1200 5000 P2 2400 4000 P3 3600 3000 P4 4800 7000 P5 5200 6000 P6 5800 5000	Process P1, start at 1200 Process P3, end at 18200 Process P1, end at 20200 Process P2, end at 20700 Process P6, end at 28200 Process P5, end at 30200 Process P4, end at 31200	14294 finish at 18112.159489412 unit 14033 finish at 20076.681957983 unit 14216 finish at 20599.130397100 unit 14322 finish at 28144.898787363 unit 14301 finish at 30176.907801673 unit 14300 finish at 31186.854588339 unit
RR 7 P1 0 8000 P2 200 5000 P3 300 3000 P4 400 1000 P5 500 1000 P6 500 1000 P7 600 4000	Process P1, start at 0 Process P4, end at 5500 Process P5, end at 6000 Process P6, end at 6500 Process P3, end at 14500 Process P7, end at 18000 Process P2, end at 20000 Process P1, end at 23000	10850 finish at 5438.577561366 unit 10851 finish at 5952.127374949 unit 10852 finish at 6473.453052584 unit 10849 finish at 14284.115315561 unit 10853 finish at 17789.588670460 unit 10848 finish at 19842.657168518 unit 10847 finish at 22892.040059355 unit
RR 7 P1 0 8000 P2 200 5000 P3 200 3000 P4 400 1000 P5 400 1000 P6 600 1000 P7 600 4000	Process P1, start at 0 Process P4, end at 5500 Process P5, end at 6000 Process P6, end at 6500 Process P3, end at 14500 Process P7, end at 18000 Process P2, end at 20000 Process P1, end at 23000	11022 finish at 5473.656815192 unit 11023 finish at 5987.040970990 unit 11024 finish at 6500.421672194 unit 11021 finish at 14470.153098525 unit 11025 finish at 18031.174508917 unit 11020 finish at 20056.440507710 unit 11019 finish at 23036.172931986 unit
SJF 4 P1 0 7000 P2 0 2000 P3 100 1000 P4 200 4000	process P1, start at 0 process P2, end at 2000 process P3, end at 3000 process P4, end at 7000 process P1, end at 14000	8122 finish at 1913.205391078 unit 8123 finish at 2863.919217184 unit 8124 finish at 6646.948570757 unit 8125 finish at 13420.885085768 unit
SJF 5 P1 100 100 P2 100 4000 P3 200 200 P4 200 4000 P5 200 7000	process P1, start at 100 process P1, end at 200 process P3, end at 400 process P2, end at 4400 process P4, end at 8400 process P5, end at 15400	8171 finish at 104.219149226 unit 8172 finish at 317.203657417 unit 8173 finish at 4409.582647297 unit 8176 finish at 8323.907662145 unit 8177 finish at 15548.590287561 unit
SJF 8 P1 100 3000 P2 100 5000 P3 100 7000 P4 200 10	process P1, start at 100 process P1, end at 3100 process P4, end at 3110 process P5, end at 3120 process P6, end at 7120	8261 finish at 2829.780971753 unit 8262 finish at 2840.200848828 unit 8263 finish at 2851.403445209 unit 8264 finish at 6958.836303614 unit 8265 finish at 11067.419755516 unit

P5 200 10 P6 300 4000 P7 400 4000 P8 500 9000	process P7, end at 11120 process P2, end at 16120 process P3, end at 23120 process P8, end at 32120	8266 finish at 15891.037634047 unit 8267 finish at 22469.091070169 unit 8268 finish at 30911.125818062 unit
SJF 5 P1 0 3000 P2 1000 1000 P3 2000 4000 P4 5000 2000 P5 7000 1000	process P1, start at 0 process P1, end at 3000 process P2, end at 4000 process P3, end at 8000 process P5, end at 9000 process P4, end at 11000	8321 finish at 3018.724201445 unit 8322 finish at 4049.295518876 unit 8323 finish at 8159.151079153 unit 8324 finish at 9168.874280921 unit 8325 finish at 11138.570519774 unit
SJF 4 P1 0 2000 P2 500 500 P3 1000 500 P4 1500 500	process P1, start at 0 process P1, end at 2000 process P2, end at 2500 process P3, end at 3000 process P4, end at 3500	8360 finish at 2050.525045179 unit 8361 finish at 2539.688347366 unit 8362 finish at 3024.963988473 unit 8363 finish at 3520.449694887 unit

NOTE: Test cases with **blue** background have their **first process's ready_time > 0** ;

--> time units should be shifted by that ready_time to compare with expected output.

參、比較實際結果與理論結果，並解釋造成差異的原因

實際結果與理論值大致吻合，差距在 5~10%以內。有趣的是，當執行時間拉長，tasks 有比較快做完的趨勢。本現象的分析跟推測詳見以下連結 --

https://github.com/slSeanWU/OS19S_Proj_1/blob/master/supplements/outcome_exp.md

其他可能造成整體時間差異的原因：

1. PIPE

為了能夠使 scheduler 與 tasks(child process)能夠做到同步，我們使用 PIPE 來做 IPC，也就是 scheduler 透過 PIPE 通知 tasks 之後再跑一個 time unit。而訊息在 PIPE 當中傳遞也會造成時間差，因為這相當於 process 之間彼此在做 IO 操作。

2. 工作負載

運行環境下並不是只有這份程式正在執行，當系統還有其他 tasks 要做，例如開瀏覽器等等，都會造成運行 schedule 改變，進而影響到執行時間。

3. CPU 相關

時間差異也與 CPU 的特性有關。舉例來說，Intel 的 CPU 有一些自動變頻的功能，例如 Turbo Boost 技術，會根據分配的核心數來調整核心的頻率，這樣就會造成時間單位的不同，因為我們的 time unit 根據的是程式碼的執行數量。

備註

在我們的執行結果的某些 log file 當中，並沒有在 t=0 的實際時間資訊，因此我們需要將每個 process 的執行時間都加上"第一個 task 的 start time"的理論值，才能比對。

肆、各組員的貢獻

- **Project Manager -- 吳士綸**
    - 設計程式架構 (定義介面、函式...)
    - 分配工作
    - 召集組員開會、追蹤進度
- **Kernel Revision -- 李謙、吳士綸**
- **Coding**
    - **main.c**-- 王棠葳
    - **scheduler_FIFO.c, scheduler_RR.c** -- 李謙、陳法熏
    - **scheduler_SJF.c, scheduler_PSJF.c** -- 鄒宗霖
    - **process_control.c, all .h files** -- 吳士綸
- **Testing**
    - **Scripts measuring actual time** -- 吳士綸
    - **FIFO, RR** -- 李謙
    - **SJF, PSJF** -- 鄒宗霖、吳士綸
- **Report -- 陳法熏、王棠葳、陳家穎、吳士綸、李謙**

伍、參考資料

- Project website: http://rswiki.csie.org/dokuwiki/courses:107_2:project_1
- Kernel Revision:
    - https://medium.com/anubhav-shrimal/adding-a-hello-world-system-call-to-linux-kernel-dad32875872
    - https://brennan.io/2016/11/14/kernel-dev-ep3/?fbclid=IwAR2l2IAwe_A7j8znXTkLiGEt628Yt1NsgMfqkLy_Oh72nyAYB1M30otmZwM