Project 1: CPU Scheduling

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1. 設計：

1-1 實驗方法：

本次實驗使用 Linux Kernel 4.19.37 搭配 Ubuntu 16.04 OS System。利用修改（增加 system call)過的 Ubuntu 16.04 System call 取得系統時間並配合 Linux Kernel 4.19.37 原生文件來達到模擬計算各 Process Executiom Time。

為了精準計算時間，我們利用 sched_setaffinity() 將 parent process 與 child process 分別 assign 至不同 cpu，以避免當 parent process 在計算 time unit 時 cpu time 被 child process 搶走。

1-2 增加系統 System call：

在 /home/linux-4.19.36/kernel 中實作欲新增的 System call，即 SYSCALL_DEFINE3(hello_3,int,state,int,pid,timespec*,start）並於/home/linux-4.19.37/arch/x86/entry/syscall_64.tbl 中增加 System call entry。

此次 Project 增加取得系統時間的 system call，並在每次 fork() child process 時使用 syscall(336, 1, mypid, start) 取得開始執行時間，並於 child process 結束時利用 syscall(336, 0, mypid, start)取得結束時間。

1-3 FIFO / RR

將每個要執行的 child process 依照 ready time 進行 non-decreasing 排序， 並從 ready queue 中依 first in first out(ready time 最早的先完成)的規則抓取執行，同時 parent process 會以 Unit time 的標準計算時間來判斷 child process 執行了多少 time unit。

RR(Round Robin)步驟同上,只是每個 child process 最長執行時間 (time quantum) 為固定的 500 time units。

1-4 SJF：

將每個要執行的 child process 依照 ready time 與 execution time 進行 non-decreasing 排序, 排愈前面 priority 愈高. 步驟同 FIFO，差別只在於 ready queue 的排序方法(執行時間最短的先完成)。

1-5 Preemptive-SJF：

步驟同 SJF，差別在於 Preemptive 版本會在規定的時間檢查 ready queue 中 child process 剩餘執行時間，並把擁有最短剩餘時間的 child process 插隊置於 ready queue 最前端。

2. 執行範例測資的結果：

First In First Out 組(已修正)

FIFO_1

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/FIFO_2.txt
P1 2256
P2 2257
P3 2258
P4 2259
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[  343.630970] [project1] 2256 1557298309.182218879 1557298488.889414884
[  355.108787] [project1] 2257 1557298488.889566595 1557298500.368297394
[  357.430355] [project1] 2258 1557298500.368439003 1557298502.690097601
[  359.680843] [project1] 2259 1557298502.690237721 1557298504.940815124
```

FIFO_2

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/FIFO_1.txt
P1 2159
P2 2160
P3 2161
P4 2162
P5 2163
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[   95.562358] [project1] 2159 1557298239.683062704 1557298240.808046721
[   96.684082] [project1] 2160 1557298240.808186958 1557298241.931208089
[   97.805493] [project1] 2161 1557298241.931353739 1557298243.053982632
[   98.927086] [project1] 2162 1557298243.054135739 1557298244.176869668
[  100.050433] [project1] 2163 1557298244.177045240 1557298245.301451308
```

FIFO_3

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/PSJF_1.txt
P1 2544
P2 2545
P3 2546
P4 2547
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[  577.670713] [project1] 2547 1557298715.697744831 1557298722.922105551
[  587.299909] [project1] 2546 1557298713.290154833 1557298732.551301707
[  601.740741] [project1] 2545 1557298710.880733322 1557298746.992133593
[  623.412820] [project1] 2544 1557298708.469256913 1557298768.664212282
```

Shortest Job First 組

SJF_1

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/SJF_2.txt
P2 3514
P5 3516
P4 3515
P3 3517
P1 3518
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[ 1564.011638] [project1] 3514 1557299709.021973645 1557299709.263031313
[ 1564.493520] [project1] 3516 1557299709.263161423 1557299709.744912550
[ 1574.135055] [project1] 3515 1557299709.745049225 1557299719.386448730
[ 1583.773185] [project1] 3517 1557299719.386585195 1557299729.024577289
[ 1600.612003] [project1] 3518 1557299719.388920051 1557299745.863395377
```

SJF_2

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/SJF_1.txt
P2 3398
P1 3399
P3 3400
P4 3401
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[ 1470.090250] [project1] 3398 1557299610.525581847 1557299615.341642703
[ 1472.498189] [project1] 3400 1557299615.342304968 1557299617.749581291
[ 1482.127665] [project1] 3401 1557299617.749745618 1557299627.379058794
[ 1498.973801] [project1] 3399 1557299615.341812198 1557299644.225194570
```

SJF_3

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/SJF_3.txt
P1 3603
P8 3610
P4 3606
P6 3608
P5 3607
P7 3609
P3 3605
P2 3604
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[ 1658.037866] [project1] 3603 1557299796.067473392 1557299803.289258410
[ 1658.065877] [project1] 3606 1557299803.292971523 1557299803.317269624
[ 1658.090547] [project1] 3607 1557299803.317675534 1557299803.341940881
[ 1667.718206] [project1] 3608 1557299803.317433818 1557299812.969599011
[ 1677.348671] [project1] 3609 1557299812.969729961 1557299822.600063385
[ 1689.391485] [project1] 3604 1557299822.608229169 1557299834.642878386
[ 1706.231901] [project1] 3605 1557299822.600249789 1557299851.483294025
[ 1727.888967] [project1] 3610 1557299803.289403398 1557299873.140361037
```

SJF_4

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/SJF_4.txt P2 3704
P3 3706
P8 3711
P6 3708
P5 3709
P9 3712
P16 3719
P10 3713
P11 3714
P12 3715
P13 3716
P14 3717
P15 3718
P4 3707
P7 3710
P1 3705
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[ 1798.016662] [project1] 3704 1557299942.783290121 1557299943.268054248
[ 1798.257886] [project1] 3706 1557299943.268188762 1557299943.509279158
[ 1798.498847] [project1] 3711 1557299943.509420377 1557299943.750240419
[ 1798.980725] [project1] 3708 1557299943.750388063 1557299944.232117632
[ 1799.462490] [project1] 3709 1557299944.232256546 1557299944.713882354
[ 1800.185000] [project1] 3712 1557299944.714034748 1557299945.436393005
[ 1800.426103] [project1] 3719 1557299945.436528287 1557299945.677495526
[ 1801.148789] [project1] 3713 1557299945.677636256 1557299946.400181677
[ 1801.871115] [project1] 3714 1557299946.400326458 1557299947.122508534
[ 1802.593492] [project1] 3715 1557299947.122649403 1557299947.844885240
[ 1803.315857] [project1] 3716 1557299947.845030788 1557299948.567250051
[ 1804.038343] [project1] 3717 1557299948.567393924 1557299949.289736843
[ 1804.760900] [project1] 3718 1557299949.289877154 1557299950.012293305
[ 1805.724045] [project1] 3707 1557299950.012438016 1557299950.975437583
[ 1807.168637] [project1] 3710 1557299950.975578453 1557299952.420029559
[ 1808.853779] [project1] 3705 1557299952.420174759 1557299954.105172576
```

Preemptive Shortest Job First 組

PSJF_1

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/PSJF_1.txt
P1 2544
P2 2545
P3 2546
P4 2547
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[  577.670713] [project1] 2547 1557298715.697744831 1557298722.922105551
[  587.299909] [project1] 2546 1557298713.290154833 1557298732.551301707
[  601.740741] [project1] 2545 1557298710.880733322 1557298746.992133593
[  623.412820] [project1] 2544 1557298708.469256913 1557298768.664212282
```

PSJF_2

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/PSJF_2.txt
P1 2611
P2 2612
P3 2613
P4 2614
P5 2615
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[  665.144257] [project1] 2612 1557298807.988065875 1557298810.395649795
[  669.959575] [project1] 2611 1557298805.579777061 1557298815.210967936
[  677.181686] [project1] 2614 1557298817.618055979 1557298822.433079277
[  679.589761] [project1] 2615 1557298822.433201770 1557298824.841153804
[  686.812055] [project1] 2613 1557298815.211105512 1557298832.063447962
```

PSJF_3

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/PSJF_3.txt
P1 2808
P2 2809
P3 2810
P4 2811
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[  814.580152] [project1] 2809 1557298958.626824034 1557298959.831544694
[  815.785556] [project1] 2810 1557298959.832584549 1557298961.036948734
[  816.989719] [project1] 2811 1557298961.037075162 1557298962.241111640
[  820.601729] [project1] 2808 1557298957.422067033 1557298965.853122395
```

PSJF_4

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/PSJF_4.txt
P2 2938
P3 2940
P1 2939
P8 2945
P6 2942
P5 2943
P9 2946
P16 2953
P10 2947
P11 2948
P12 2949
P13 2950
P14 2951
P15 2952
P4 2941
P7 2944
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[   967.491606] [project1] 2940 1557299112.501447653 1557299112.742998922
[   967.733910] [project1] 2945 1557299112.744359798 1557299112.985302570
[   968.191383] [project1] 2938 1557299112.476654129 1557299113.442776140
[   968.673640] [project1] 2942 1557299113.443233770 1557299113.925032681
[   969.155673] [project1] 2943 1557299113.925173839 1557299114.407066194
[   969.878403] [project1] 2946 1557299114.407203721 1557299115.129795861
[   970.119592] [project1] 2953 1557299115.129930035 1557299115.370984070
[   970.842482] [project1] 2947 1557299115.371126905 1557299116.093874599
[   971.565226] [project1] 2948 1557299116.094021764 1557299116.816619309
[   972.287821] [project1] 2949 1557299116.816759000 1557299117.539213679
[   973.010568] [project1] 2950 1557299117.539354627 1557299118.261961416
[   973.733227] [project1] 2951 1557299118.262101666 1557299118.984620151
[   974.456027] [project1] 2952 1557299118.984759144 1557299119.707420403
[   975.419444] [project1] 2941 1557299119.707558837 1557299120.670836308
[   976.864606] [project1] 2944 1557299120.670976907 1557299122.115998448
[   978.548495] [project1] 2939 1557299112.743150767 1557299123.799888697
```

Round-Robin 組

RR_1

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/RR_1.txt
P1 3034
P2 3035
P3 3036
P4 3037
P5 3038
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[ 1042.396417] [project1] 3034 1557299182.109352489 1557299187.647810499
[ 1042.420213] [project1] 3035 1557299182.208889500 1557299187.671607548
[ 1042.442551] [project1] 3036 1557299182.308888607 1557299187.693945882
[ 1042.464885] [project1] 3037 1557299182.408888483 1557299187.716279816
[ 1042.489036] [project1] 3038 1557299182.508890453 1557299187.740431259
```

RR_2

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/RR_2.txt
P1 3117
P2 3118
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[ 1108.397265] [project1] 3117 1557299235.997744433 1557299253.648658880
[ 1111.053792] [project1] 3118 1557299236.496898145 1557299256.305184929
```

RR_3

```
qunwei@qunwei-X555LB:~/os_project1_2019$ sudo ./main.out < test_data/RR_3.txt
P1 3279
P2 3280
P3 3281
P4 3282
P5 3283
P6 3284
qunwei@qunwei-X555LB:~/os_project1_2019$ dmesg
[ 1374.588016] [project1] 3281 1557299482.608874040 1557299519.839409362
[ 1376.891430] [project1] 3279 1557299476.710549642 1557299522.142823353
[ 1378.262963] [project1] 3280 1557299479.608870660 1557299523.514356573
[ 1393.570049] [project1] 3284 1557299488.208886273 1557299538.821442651
[ 1397.435321] [project1] 3283 1557299486.708873490 1557299542.686714917
[ 1399.460435] [project1] 3282 1557299485.608869840 1557299544.711827676
```

3. 比較實際結果與理論結果：

TIME UNIT = 1UNIT/0.0013571963198S (小數點以後四捨五入)	FIFO	SJF	PSJF	RR
_1	實際:2434 理論:2500	實際:13602 理論:14000	實際:22270 理論:25000	實際:2432 理論:2500
_2	實際:85136 理論:87000	實際:14860 理論:15300	實際:9704 理論:11000	實際:10829 理論:9000
_3	實際:22349 理論:23000	實際:31176 理論:32020	實際:2916 理論:3500	實際:26826 理論:30000
_4		實際:4571 理論:4700	實際:4561 理論:4700	

註：會造成實際值比理論值還小，猜測是因為 Time unit 的計算過大，導致實際值偏小。

4. 各組員的貢獻：

黃謙仁：搜索多數資料提供組員參考，並將觀念和技巧確實運用於報告加速整體流程。

林群崴：實際編組 system call，實現利用真實 linux kernel 來模擬排程的狀況。

傅家靖：詳實記錄方法並完成報告架構，實際執行測資結果並列表。

黃懋翔：組織組員會議，訂定具體完成時間，反覆測試程式正確性。

胡程維：推進計畫流程，提出關鍵個人意見，對報告進行校正和核對。

高新造：因為亂流加入的組員，未來有望成為潛力股生力軍！