

# 2018 OS - hw2

- Operating system 107 fall -

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# Multi-Threading Programming

# Example - Hello Thread!

## hello\_thread.c

```
#include <stdio.h>
#include <pthread.h>
#include <unistd.h>

// child threading function
void* child(void* data){
    char *str = (char*) data; // get data "Child"
    int i;
    for(i=0;i<3;i++){
        printf("%s\n", str); // output every second
        sleep(1);
    }
    pthread_exit(NULL); // exit child thread
}

// main function
int main(void){
    // define thread variable
    pthread_t t;
    // create child thread
    pthread_create(&t,NULL,child,"Child");
    // main thread
    int i;
    for(i=0;i<3;i++){
        printf("Master\n"); // output "Master" every second
        sleep(1);
    }
    pthread_join(t,NULL); // wait for all child threading finished
    return 0;
}
```



## Output

```
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ gcc-4.9 hello_thread.c -lpthread -o hello_thread
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ ./hello_thread
Master
Child
Master
Child
Master
Child
```

<pthread.h> library info

Ref: <http://pubs.opengroup.org/onlinepubs/7908799/xsh/pthread.h.html>

# Tools for showing threads

- NCTU Workstation > top

(THR means the num of threads under the process)

```
last pid: 37465; load averages: 1.38, 1.31, 1.29                up 26+08:09:14 09:32:45
740 processes: 2 running, 723 sleeping, 15 stopped
CPU:  0.0% user,  9.9% nice, 16.9% system,  0.1% interrupt, 73.1% idle
Mem: 131M Active, 1576M Inact, 67M Laundry, 12G Wired, 238M Buf, 1370M Free
ARC: 6678M Total, 4440M MFU, 1619M MRU, 32K Anon, 91M Header, 527M Other
     5373M Compressed, 13G Uncompressed, 2.44:1 Ratio
Swap: 2048M Total, 35M Used, 2013M Free, 1% Inuse

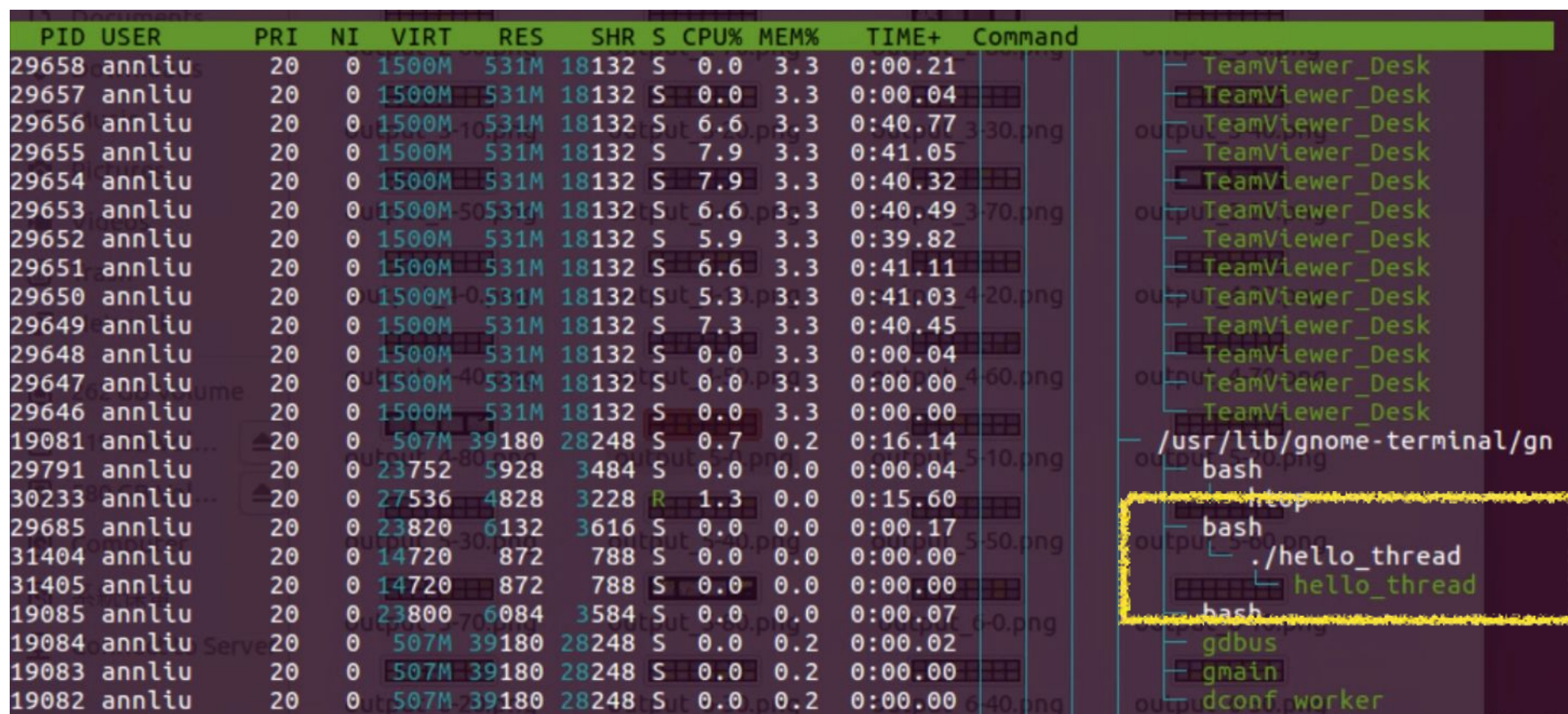
  PID USERNAME      THR PRI NICE   SIZE    RES STATE  C  TIME    WCPU COMMAND
14167 lucan19970907   1 123   20  6284K   2084K CPU3   3 627:20 100.40% shell
66363 tengwc10230     1  21    0  6284K   2080K fork    0  93:38   3.40% shell
37463 yliu1013        2  20    0  6592K   2308K nanslp   3   0:00   0.16% hello_thread
651 root              1  20    0  4190K   34220K select  2 30:01   0.07% vmtoolsd
87658 caijli0814      1  35    0  6284K   2080K wait    0  1:22   0.07% sheel
36105 yliu1013         1  20    0  13640K  6068K pause    0  0:00   0.04% tcsh
22613 root             1  20    0  6424K   2628K select  1  4:12   0.03% syslogd
36104 yliu1013         1  20    0  33644K 28484K select  1  0:00   0.03% sshd
369 root              1  20    0  9184K   664K select  0  3:38   0.01% devd
36698 yliu1013        1  20    0  33644K 28428K select  1  0:00   0.01% sshd
683 root              1  20    0  12456K 12552K select  1  2:27   0.01% ntpd
392 pflogd             1  20    0  6688K   2088K bpf       3  1:44   0.00% pflogd
52066 linkp            1  20    0  16480K 12784K select  1  9:38   0.00% tmux
72905 ca043022         1  20    0  12384K  9360K select  0  0:56   0.00% tmux
39194 ca071042         1  20    0  10336K  7868K select  3  0:20   0.00% tmux
754 root              1  20    0  12616K  844K nanslp    3  0:17   0.00% cron
77441 zjlin            1  20    0  33644K 28280K select  0  0:16   0.00% sshd
2473 bohau0511097     1  20    0  33644K 28612K select  3  0:16   0.00% sshd
24576 linkp            1  20    0  62844K 47352K select  1  0:15   0.00% vim
749 root              1  20    0  12852K  6332K select  1  0:14   0.00% sshd
579 root              1  20    0  18592K 3732K select  0  0:12   0.00% ypbind
39209 kuohh           1  20    0  35692K 29776K select  1  0:11   0.00% sshd
4642 hchou             1  20    0  35692K 29088K select  1  0:08   0.00% sshd
8433 linkp            1  21    0  18032K  8784K ttyin   0  0:08   0.00% zsh
57406 linkp            1  20    0  64892K 47668K select  3  0:08   0.00% vim
26233 c0719803         1  20    0  12384K  8420K select  0  0:07   0.00% tmux
22320 cty                1  20    0  12384K  7968K select  0  0:06   0.00% tmux
576 root              1  20    0  6504K   2144K select  0  0:06   0.00% xshind
```

```
annliu — annliu@annliu-System-Product-Name: ~ — ssh yliu1013@bsd1.cs.nctu.edu.tw — 100x24
bsd1 [/u/gcs/106/0656126/2018_os_hw2] -yliu1013- ./hello_thread
Master
Child
Master
Child
```



# Tools for showing threads

- Ubuntu -> `sudo apt-get install htop`
  - - - press <F2> to enter htop setup menu.
  - - - Choose "Display option" under "Setup" column, and toggle on "Three view" and "Show custom thread names" options.
  - - - Press <F10> to exit the setup.



PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
29658	annliu	20	0	1500M	531M	18132	S	0.0	3.3	0:00.21	TeamViewer_Desk
29657	annliu	20	0	1500M	531M	18132	S	0.0	3.3	0:00.04	TeamViewer_Desk
29656	annliu	20	0	1500M	531M	18132	S	6.6	3.3	0:40.77	TeamViewer_Desk
29655	annliu	20	0	1500M	531M	18132	S	7.9	3.3	0:41.05	TeamViewer_Desk
29654	annliu	20	0	1500M	531M	18132	S	7.9	3.3	0:40.32	TeamViewer_Desk
29653	annliu	20	0	1500M	531M	18132	S	6.6	3.3	0:40.49	TeamViewer_Desk
29652	annliu	20	0	1500M	531M	18132	S	5.9	3.3	0:39.82	TeamViewer_Desk
29651	annliu	20	0	1500M	531M	18132	S	6.6	3.3	0:41.11	TeamViewer_Desk
29650	annliu	20	0	1500M	531M	18132	S	5.3	3.3	0:41.03	TeamViewer_Desk
29649	annliu	20	0	1500M	531M	18132	S	7.3	3.3	0:40.45	TeamViewer_Desk
29648	annliu	20	0	1500M	531M	18132	S	0.0	3.3	0:00.04	TeamViewer_Desk
29647	annliu	20	0	1500M	531M	18132	S	0.0	3.3	0:00.00	TeamViewer_Desk
29646	annliu	20	0	1500M	531M	18132	S	0.0	3.3	0:00.00	TeamViewer_Desk
19081	annliu	20	0	507M	39180	28248	S	0.7	0.2	0:16.14	/usr/lib/gnome-terminal/gn
29791	annliu	20	0	23752	5928	3484	S	0.0	0.0	0:00.04	bash
30233	annliu	20	0	27536	4828	3228	R	1.3	0.0	0:15.60	htop
29685	annliu	20	0	23820	6132	3616	S	0.0	0.0	0:00.17	bash
31404	annliu	20	0	14720	872	788	S	0.0	0.0	0:00.00	./hello_thread
31405	annliu	20	0	14720	872	788	S	0.0	0.0	0:00.00	hello_thread
19085	annliu	20	0	23800	6084	3584	S	0.0	0.0	0:00.07	bash
19084	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.02	gdbus
19083	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.00	gmain
19082	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.00	dconf-worker

# Tools for showing threads

- Mac -> Enter the terminal > **top**

```
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL 1: top, hello_thread + - X
```

Processes: 349 total, 3 running, 346 sleeping, 1643 threads  
09:13:53 Load Avg: 4.01, 4.20, 4.17  
CPU usage: 52.53% user, 10.60% sys, 36.86% idle  
SharedLibs: 154M resident, 38M data, 19M linkedit.  
MemRegions: 105361 total, 2532M resident, 86M private, 957M shar  
PhysMem: 8015M used (2056M wired), 176M unused.  
VM: 1687G vsize, 1111M framework vsize, 9883731(0) swapins, 1096  
Networks: packets: 11857026/15G in, 4584831/946M out.  
Disks: 5552943/147G read, 3298065/137G written.  
primary key [-pid]:

PID	COMMAND	%CPU	TIME	#TH	#WO	#PORT	MEM
46374	hello_thread	0.0	00:00.00	2	0	12+	324K+
46366	Google Chrom	0.0	00:00.10	13	1	91	1392K
46361	VTDecoderXPC	0.0	00:00.41	2	1	51	76K
46356	QuickLookSat	0.0	00:01.00	2	1	61	6988K
46355	Google Chrom	0.0	00:02.61	15	1	123	24M
46352	quicklookd	0.0	00:00.62	4	1	98	3120K
46351	mdworker	0.0	00:00.09	3	1	54	1240K
46345	com.apple.ap	0.0	00:01.58	3	1	232	10M
46344	mdworker	0.0	00:00.87	3	1	61	5028K
46343	mdworker	0.0	00:00.18	3	1	61	2092K
46340	mdworker	0.0	00:00.09	3	1	62	1176K
46337	VTDecoderXPC	0.0	00:05.18	2	1	51	5112K
46335	XprotectServ	0.0	00:00.06	2	2	46	884K
46334	QuickTime Pl	0.0	01:10.43	5	1	343	62M
46332	VTDecoderXPC	0.0	00:00.38	2	1	50	3756K
46331	com.apple.ac	0.0	00:00.02	2	2	31	420K

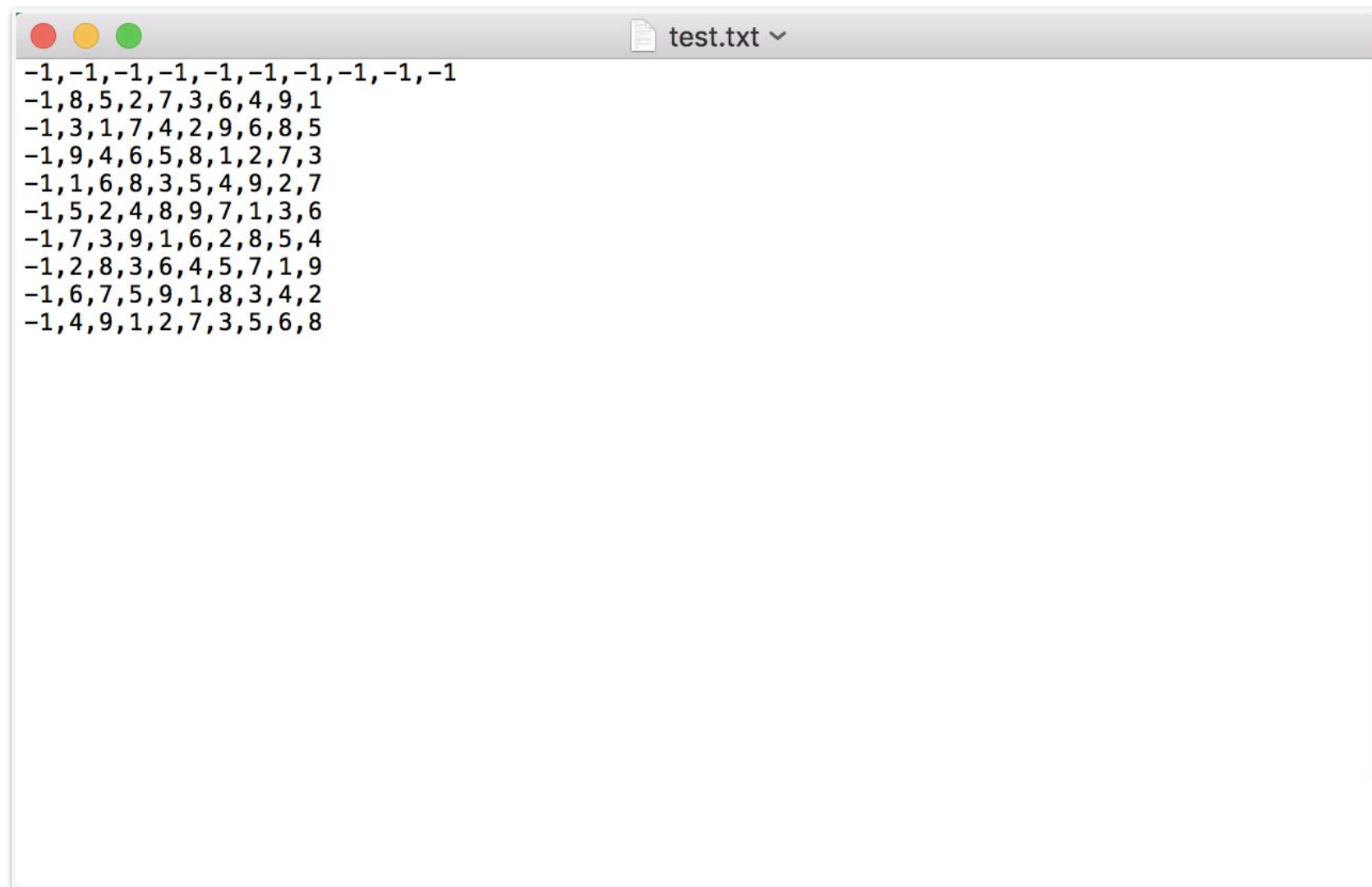
```
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ ./hello_thread
Master
Child
Child
Master
Master
Child
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ ./hello_thread
Master
Child
Master
Child
Master
Child
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ ./hello_thread
Master
Child
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ ./hello_thread
Master
Child
```

ter\* 0 0 (Global Scope) Ln 12, Col 1 Spaces: 4 UTF-8 LF C Mac



# Problem: Sum Checker-input

- Input file: test.txt (it contains a 2D array.)  
Ex. (-1 means the (x=0 or y=0) of the 2D array. )



```
test.txt
-1,-1,-1,-1,-1,-1,-1,-1,-1,-1
-1,8,5,2,7,3,6,4,9,1
-1,3,1,7,4,2,9,6,8,5
-1,9,4,6,5,8,1,2,7,3
-1,1,6,8,3,5,4,9,2,7
-1,5,2,4,8,9,7,1,3,6
-1,7,3,9,1,6,2,8,5,4
-1,2,8,3,6,4,5,7,1,9
-1,6,7,5,9,1,8,3,4,2
-1,4,9,1,2,7,3,5,6,8
```

# Problem: Sum Checker-rules

- Given a 9x9 2D-array and each item of the array must be the digits 1 to 9.
- Sum of each row, column, and each of the nine sub-grids must be the same ~~and every digits only show once.~~
- **Hint:**
  1. A thread to check that each sum of the rows.
  2. A thread to check that each sum of the cols.
  3. Nine threads to check each sum of the 3x3 sub-grids.

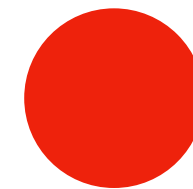


# Example

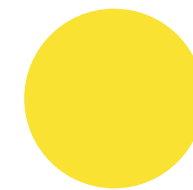
2	9	5	7	4	3	8	6	1
4	3	1	8	6	5	9	2	7
8	7	6	1	9	2	5	4	3
3	8	7	4	5	9	2	1	6
6	1	2	3	8	7	4	9	5
5	4	9	2	1	6	7	3	8
7	6	3	5	3	4	1	8	9
9	2	8	6	7	1	3	5	4
1	5	4	9	3	8	6	7	2



Row  
s



Colum  
ns



3x3  
subgrids

# Problem: Sum Checker-Output



code output

```
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2
$ ./sudoku_sum
```

```
=====
|| SUM  CHECKER ||
=====
|8 ||5 ||2 ||7 ||3 ||6 ||4 ||9 ||1 |
|-----|
|3 ||1 ||7 ||4 ||2 ||9 ||6 ||8 ||5 |
|-----|
|9 ||4 ||6 ||5 ||8 ||1 ||2 ||7 ||3 |
|-----|
|1 ||6 ||8 ||3 ||5 ||4 ||9 ||2 ||7 |
|-----|
|5 ||2 ||4 ||8 ||9 ||7 ||1 ||3 ||6 |
|-----|
|7 ||3 ||9 ||1 ||6 ||2 ||8 ||5 ||4 |
|-----|
|2 ||8 ||3 ||6 ||4 ||5 ||7 ||1 ||9 |
|-----|
|6 ||7 ||5 ||9 ||1 ||8 ||3 ||4 ||2 |
|-----|
|4 ||9 ||1 ||2 ||7 ||3 ||5 ||6 ||8 |
|-----|
```

Successful :)

Check num of the threads under your process

PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
29658	annliu	20	0	1500M	532M	18132	S	0.0	3.3	0:00.21	TeamViewer_Desk
29657	annliu	20	0	1500M	532M	18132	S	0.0	3.3	0:00.04	TeamViewer_Desk
29656	annliu	20	0	1500M	532M	18132	S	8.0	3.3	0:41.22	TeamViewer_Desk
29655	annliu	20	0	1500M	532M	18132	S	7.3	3.3	0:41.47	TeamViewer_Desk
29654	annliu	20	0	1500M	532M	18132	R	4.6	3.3	0:40.73	TeamViewer_Desk
29653	annliu	20	0	1500M	532M	18132	S	6.6	3.3	0:40.90	TeamViewer_Desk
29652	annliu	20	0	1500M	532M	18132	S	8.6	3.3	0:40.29	TeamViewer_Desk
29651	annliu	20	0	1500M	532M	18132	S	6.6	3.3	0:41.49	TeamViewer_Desk
29650	annliu	20	0	1500M	532M	18132	S	6.0	3.3	0:41.43	TeamViewer_Desk
29649	annliu	20	0	1500M	532M	18132	S	8.0	3.3	0:40.87	TeamViewer_Desk
29648	annliu	20	0	1500M	532M	18132	S	0.0	3.3	0:00.04	TeamViewer_Desk
29647	annliu	20	0	1500M	532M	18132	S	0.0	3.3	0:00.00	TeamViewer_Desk
29646	annliu	20	0	1500M	532M	18132	S	0.0	3.3	0:00.00	TeamViewer_Desk
19081	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:16.16	/usr/lib/gnome-terminal/gn
29791	annliu	20	0	23752	5928	3484	S	0.0	0.0	0:00.04	bash
30233	annliu	20	0	27536	4828	3228	R	1.3	0.0	0:15.70	htop
29685	annliu	20	0	23820	6132	3616	S	0.0	0.0	0:00.17	bash
31408	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	./sudoku_sum
31420	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31419	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31418	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31417	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31416	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31415	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31414	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31413	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31412	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31411	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
31410	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	sudoku_sum
19085	annliu	20	0	23800	6084	3584	S	0.0	0.0	0:00.07	gdbus
19084	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.02	gnain
19083	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.00	gnconf
19082	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.00	gnconf



# Problem: Sum Checker- Time

Command: `time ./exe`



Multi-thread

```
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ time ./sum_doku_sum
```

```
=====
|| SUM  CHECKER ||
=====
|8 ||5 ||2 ||7 ||3 ||6 ||4 ||9 ||1 |
|3 ||1 ||7 ||4 ||2 ||9 ||6 ||8 ||5 |
|9 ||4 ||6 ||5 ||8 ||1 ||2 ||7 ||3 |
|1 ||6 ||8 ||3 ||5 ||4 ||9 ||2 ||7 |
|5 ||2 ||4 ||8 ||9 ||7 ||1 ||3 ||6 |
|7 ||3 ||9 ||1 ||6 ||2 ||8 ||5 ||4 |
|2 ||8 ||3 ||6 ||4 ||5 ||7 ||1 ||9 |
|6 ||7 ||5 ||9 ||1 ||8 ||3 ||4 ||2 |
|4 ||9 ||1 ||2 ||7 ||3 ||5 ||6 ||8 |
```

Successful :)

```
real    0m1.015s
user    0m0.002s
sys     0m0.003s
```

V.S



Single thread

```
annliu@liude-MacBook-Pro:~/Desktop/OS_HW2$ time ./check_sum_s
```

```
=====
|| SUM  CHECKER ||
=====
|8 ||5 ||2 ||7 ||3 ||6 ||4 ||9 ||1 |
|3 ||1 ||7 ||4 ||2 ||9 ||6 ||8 ||5 |
|9 ||4 ||6 ||5 ||8 ||1 ||2 ||7 ||3 |
|1 ||6 ||8 ||3 ||5 ||4 ||9 ||2 ||7 |
|5 ||2 ||4 ||8 ||9 ||7 ||1 ||3 ||6 |
|7 ||3 ||9 ||1 ||6 ||2 ||8 ||5 ||4 |
|2 ||8 ||3 ||6 ||4 ||5 ||7 ||1 ||9 |
|6 ||7 ||5 ||9 ||1 ||8 ||3 ||4 ||2 |
|4 ||9 ||1 ||2 ||7 ||3 ||5 ||6 ||8 |
```

Successful :)

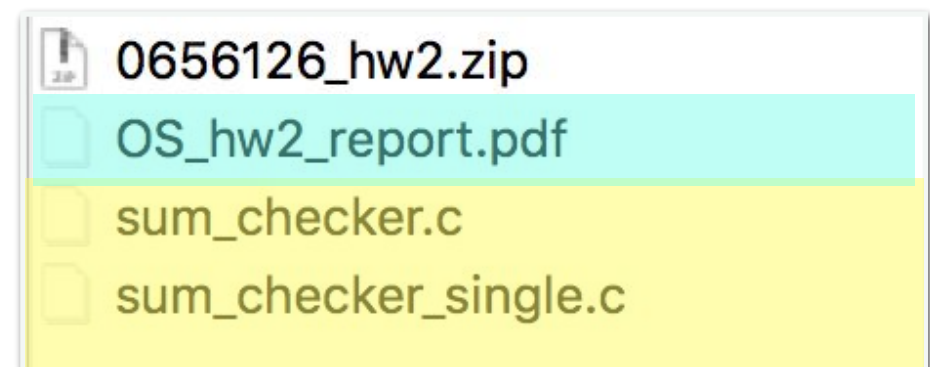
```
real    0m11.024s
user    0m0.002s
sys     0m0.003s
```

# Requirements

1. You can write codes in **C/C++**.
2. You need to hand in one single-thread version and the other multi-thread version. Put all of \*.c or \*.cpp source files and OS\_hw2\_report.pdf into same compressed file. The type of compressed file must be “**studentID\_hw2.zip**” (ex. 010101\_hw2.zip)
3. Use NCTU workstation as your environment

**Deadline: 2018/10/28(日) PM 11:59**

- Filename format sample





# Grade

- Total score: 100 pts: **COPY WILL GET A 0 POINT!**
  - A. Input sample +10 pts
  - B. Two testing data + 10 pts (5 pts for each)
  - C. multithreading +40 pts  
( report Q3: speed up=  $T_s/T_m$  ;  
Ts:Time of single thread code ; Tm:Time of multi-thread code)
  - D. OS report (format OS\_report.pdf) + 40 pts
  - E. **Incorrect filename format** will get -5 pts
    - **Incorrect output format** will get -5 pts
- DELAYED SUBMISSION WILL GET 0 POINT!**