

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 fuction
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
37465	yliu1013	2	20	0	10116K	3804K	CPU3	0	0:00	0.10%	hello_thread
37463	yliu1013	2	20	0	6592K	2308K	nanslp	3	0:00	0.16%	hello_thread
861	root	1	20	0	41908K	34220K	Select	2	30:01	0.07%	vmcoolsd
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
22611	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%	ypbind

```
annli — annli@annli-System-Product-Name: ~ — ssh yliu1013@bsd1.cs.nctu.edu.tw — 100x24
[annli@annli ~]$ ./hello_thread
[annli@annli ~]$
```

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.
 - - - Presss <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	bash
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	gmain
19083	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.00	dconf
19082	annliu	20	0	507M	39180	28248	S	0.0	0.2	0:00.00	worker

Tools for showing threads

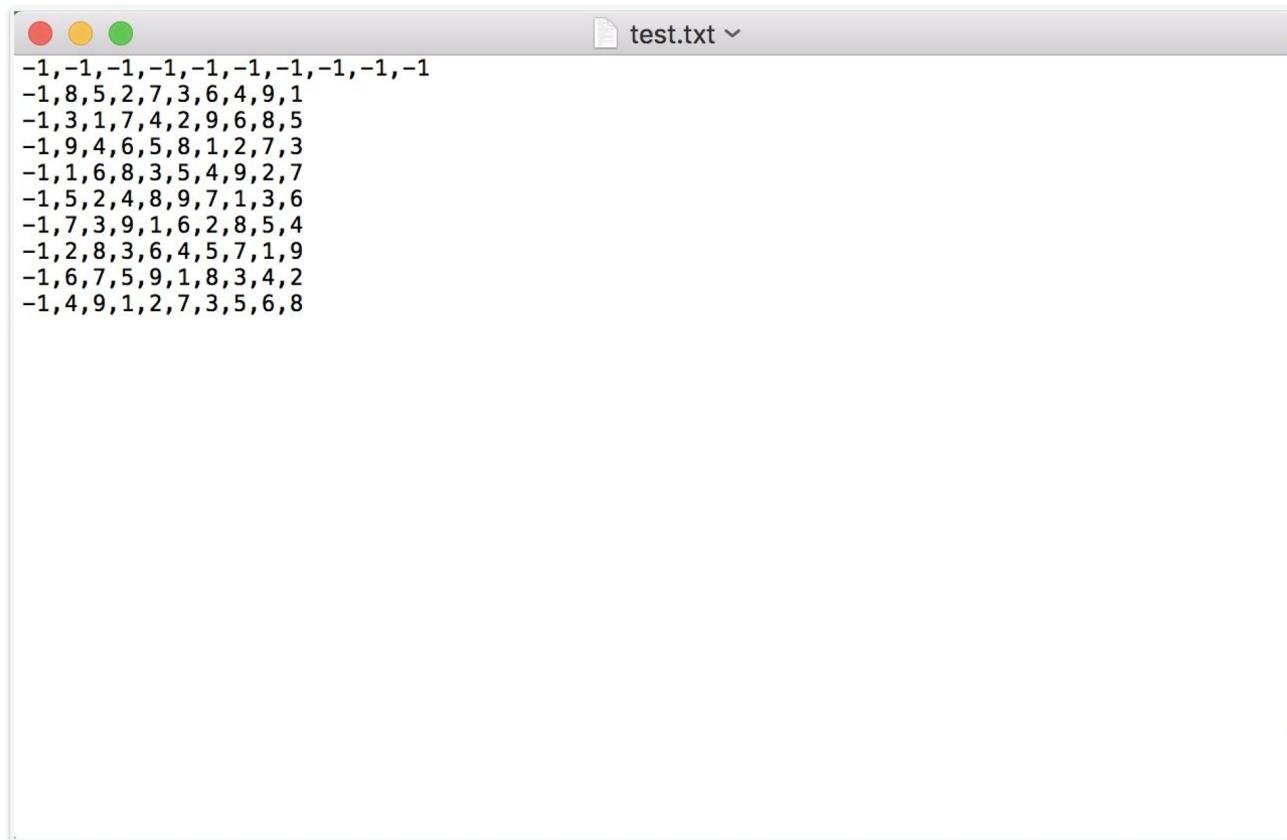
- Mac -> Enter the terminal > **top**

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.
- **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.

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.)



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



Colu
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	10532M	18132	S	8.0	3.3	0:41.22	output_370.png
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	50532M	18132	S	6.6	3.3	0:40.90	370.png
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	0.532M	18132	S	6.0	3.3	0:41.43	4-20.png
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	40532M	18132	S	0.0	3.3	0:00.00	4-60.png
29646	annliu	20	0	1500M	532M	18132	S	0.0	3.3	0:00.00	TeamViewer_Desk
19081	annliu	20	0	567M	39180	28248	S	0.0	0.2	0:16.16	TeamViewer_Desk
29791	annliu	20	0	23752	5928	3484	S	0.0	0.0	0:00.04	5-10.png
30233	annliu	20	0	27536	4828	3228	R	1.3	0.0	0:15.70	TeamViewer_Desk
29685	annliu	20	0	23820	6132	3616	S	0.0	0.0	0:00.17	TeamViewer_Desk
31408	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	5-50.png
31420	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31419	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31418	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31417	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31416	annliu	20	0	96684	20708	624	S	0.0	0.0	0:00.00	6-40.png
31415	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31414	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31413	annliu	20	0	96684	50708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31412	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31411	annliu	20	0	96684	708	624	S	0.0	0.0	0:00.00	TeamViewer_Desk
31410	annliu	20	0	96684	10708	624	S	0.0	0.0	0:00.00	7-30.png
19085	annliu	20	0	23800	6084	3584	S	0.0	0.0	0:00.07	TeamViewer_Desk
19084	annliu	20	0	567M	39180	28248	S	0.0	0.2	0:00.02	TeamViewer_Desk
19083	annliu	20	0	567M	39180	28248	S	0.0	0.2	0:00.00	7-70.png
19082	annliu	20	0	567M	39180	28248	S	0.0	0.2	0:00.00	TeamViewer_Desk

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 ;
 T_s :Time of single thread code ; T_m :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!