

CN Assignment 2

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2020217

The client programs can be found in Client_Programs and the server programs in Server_Programs.

Compilation Instructions: *make* in the main directory will compile all the required files in their original C file directory.

Running instructions: Parallel client implementation can be found in 'Parallel client' and sequential in 'Sequential client' directory. For servers, 'Concurrent server', 'Non-blocking server' and 'Sequential server' contain the (fork and thread), (select, poll, epoll), and (sequential) implementations respectively.

Reference was taken from the Linux Manpages for select, poll and epoll implementations.

Note: instead of having 10 clients, I implemented 20 clients for the final submission.

Q1. Clients use a `write_to_server` program which takes in the socket fd and uses the `write` syscall. In addition to this, the parallel client program uses a `main_function` for threads to execute.

Q2. Each program uses the following functions (with minor adjustments):

- `factorial` : trivially calculates factorial
- `read_write_to_client`: for reading and writing, reads from the fd and writes to a FILE* using `fprintf`.
- `serv_functions`: for performing server functions (mostly for pthread and Non-blocking server approaches for its simplicity).

In addition, various *structs* have also been created to facilitate threading and ease of operation. Most notable of which is *thread_data*, which takes in everything it needs to print to a file (socket fd, client sockaddr_in structure and file descriptor for writing).

There are parameters which can be used to tune the max number of connections (QUEUE for max number of connections, LIMIT for maximum number of factorials to process).

Error handling has been done using if-else statements and exits.

Outputs are taken to a CSV file in the root directory.

Q3.

a) **Concurrent Server using Fork:**

i)

```
TIME TAKEN = 0.0005860000
Received messages from client 127.0.0.1:62701, printed to OUTPUT_PAR_FOR
K.csv. Exiting...
Received messages from client 127.0.0.1:1262, printed to OUTPUT_PAR_FORK
.csv. Exiting...
Received messages from client 127.0.0.1:4846, printed to OUTPUT_PAR_FORK
.csv. Exiting...
```

PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
27697	deb	20	0	2368	1640	1556	S	0.0	0.0	0:00.00	./par_server_fork

```
./par_server_fork
PID OF PARENT IS: 27697
CONNECTED - 1
```

```
CONNECTED : 10
Received messages from client 127.0.0.1:24297, printed to OUTPUT_PAR_FO
RK.csv, Exiting...

TIME TAKEN = 0.0007910000
deb@DESKTOP-SH9CDB3:~/CR_Assignment_2/Server_Programs/Concurrent_server
$ Received messages from client 127.0.0.1:120713, printed to OUTPUT_PAR_
FO RK.csv, Exiting...
Received messages from client 127.0.0.1:131465, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
Received messages from client 127.0.0.1:133513, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
Received messages from client 127.0.0.1:191977, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
Received messages from client 127.0.0.1:28393, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
Received messages from client 127.0.0.1:378997, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
Received messages from client 127.0.0.1:289805, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
Received messages from client 127.0.0.1:27369, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
Received messages from client 127.0.0.1:21225, printed to OUTPUT_PAR_FO
RK.csv, Exiting...
./par_server_for1
PID of Messages to server, exiting now...
CONNECTED : 1
CONNECTED : 2
CONNECTED : 3
CONNECTED : 4
CONNECTED : 5
CONNECTED : 6
CONNECTED : 7
CONNECTED : 8
CONNECTED : 9
CONNECTED : 10
[ ]
```

```
Socket FD is: 7
Socket FD is: 8
Connected to the server
sockid: 3
Socket FD is: 8
Connected to the server
sockid: 8
Connected to the server
sockid: 7
Socket FD is: 10
Connected to the server
sockid: 9
Connected to the server
sockid: 4
Socket FD is: 11
Connected to the server
Connected to the server
sockid: 10
Socket FD is: 12
Connected to the server
sockid: 12
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
deb@DESKTOP-SH9CDB3:~/CR_Assignment_2/cr11
ent_Prog/deb@DESKTOP-SH9CDB3:~/CR_Assignm
ent_Prog/deb@DESKTOP-SH9CDB3:~/CR_Assignm
ent_Programs/Parallel cli
[ ]
```

```

PID OF PARENT IS: 7013
CONNECTED : 1
CONNECTED : 2
Received messages from client 127.0.0.1:28305, printed to
OUTPUT_PAR_FORK.csv. Exiting...
CONNECTED : 3
CONNECTED : 4
CONNECTED : 5
Received messages from client 127.0.0.1:24209, printed to
OUTPUT_PAR_FORK.csv. Exiting...
Received messages from client 127.0.0.1:30353, printed to
OUTPUT_PAR_FORK.csv. Exiting...
Received messages from client 127.0.0.1:29329, printed to
OUTPUT_PAR_FORK.csv. Exiting...
CONNECTED : 6
Received messages from client 127.0.0.1:34449, printed to
OUTPUT_PAR_FORK.csv. Exiting...
Received messages from client 127.0.0.1:35473, printed to
OUTPUT_PAR_FORK.csv. Exiting...
CONNECTED : 7
sockfd: 7
sockfd: 5
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Connected to the server
sockfd: 9
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Socket FD is: 3
Connected to the server
sockfd: 3
Socket FD is: 4
Connected to the server
sockfd: 4
Sent messages to server, exiting now...
Sent messages to server, exiting now...
debeDESKTOP-SHK9CD3~\CN_Assignment_2\client_Programs\Par
debeDESKTOP-SHK9CD3~\CN_Assignment_2\client_Programs\Par
o allen clients
00 30 60 90 120 150 180 210
100 40 70 100 130 160 190 220
20 50 80 110 140 170 200 230
Mem[ 007M/23.4G] Tasks: 35, 170 thr; 1 p
Swp[ 0K/6.00G] Load average: 0.00 0.01
Uptime: 00:25:22
PID USER PRI NI VIRT RES SHR S CPU%MEM%
3008 deb 20 0 6273M 29008 9360 S 0.0 0.1 0.0
3009 deb 20 0 6273M 29008 9360 S 0.0 0.1 0.0
3010 deb 20 0 6273M 29008 9360 S 0.0 0.1 0.0
3061 deb 20 0 6273M 29008 9360 S 0.0 0.1 0.0
4614 deb 20 0 8408 4096 3292 R 0.0 0.0 0.0
5685 deb 20 0 6273M 28912 9572 S 0.0 0.1 0.0
7013 deb 20 0 2368 560 492 S 0.0 0.0 0.0
7044 deb 20 0 0 0 0 Z 0.0 0.0 0.0
7045 deb 20 0 0 0 0 Z 0.0 0.0 0.0
7046 deb 20 0 0 0 0 Z 0.0 0.0 0.0
fHelp f2Setup f3Search f4Filter f5Tree f6SortBy f7nice

```

```
EXECUTION TIME : 0.001260000
```

20521	deb	20	0	43496	1776	1628	S	0.0	0.0	0
-------	-----	----	---	-------	------	------	---	-----	-----	---

```
PID IS: 20521
```

Again, it was not possible to show the CPU utilisations because the program

terminated too quickly. The CPU util was shown to be 0%.

```
PROBLEMS OUTPUT TERMINAL JUPYTER
PID IS: 20521
Received messages from client 127.0.0.1:37064, printed to
OUTPUT_PAR_THREAD.csv.
Exiting...
Received messages from client 127.0.0.1:35528, printed to
OUTPUT_PAR_THREAD.csv.
Exiting...
Received messages from client 127.0.0.1:44232, printed to
OUTPUT_PAR_THREAD.csv.
Exiting...
Received messages from client 127.0.0.1:22216, printed to
OUTPUT_PAR_THREAD.csv.
Exiting...
Received messages from client 127.0.0.1:38600, printed to
OUTPUT_PAR_THREAD.csv.
Exiting...
Received messages from client 127.0.0.1:29384, printed to
OUTPUT_PAR_THREAD.csv.
Exiting...
Received messages from client 127.0.0.1:31944, printed to
OUTPUT_PAR_THREAD.csv.
Exiting...

sockfd: 5
Sent messages to server, exiting now...
..
Sent messages to server, exiting now...
..
Sent messages to server, exiting now...
..
Sent messages to server, exiting now...
..
Connected to the server
sockfd: 6
Connected to the server
sockfd: 7
Sent messages to server, exiting now...
..
Sent messages to server, exiting now...
..
8195 deb
deb@DESKTOP-SH9CD3:~/CW_Assignment_2
~/Client_Programs/Par
o allel client$ ||

0[0.] 3[0.] 6[0.] 9[0.] 12[0.] 15[0.] 18[0.] 21[0.]
1[0.] 4[0.] 7[0.] 10[0.] 13[0.] 16[0.] 19[0.] 22[0.]
2[0.] 5[0.] 8[0.] 11[0.] 14[0.] 17[0.] 20[0.] 23[0.]
Mem[|||] 857M/23.4G Tasks: 29, 202 thr; 1 running
Swp[ ] 0K/6.00G Load average: 0.00 0.00 0.00
Uptime: 01:34:55

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
7785 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.00 /home/deb/.
7786 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.08 /home/deb/.
7787 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.05 /home/deb/.
7788 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.11 /home/deb/.
7789 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.08 /home/deb/.
7790 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.12 /home/deb/.
7791 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.07 /home/deb/.
8195 deb 20 0 6273M 37756 12028 S 0.0 0.2 0:00.12 /home/deb/.
20521 deb 20 0 43496 1776 1628 S 0.0 0.0 0:00.00 ./par_server
20532 deb 20 0 43496 1776 1628 S 0.0 0.0 0:00.00 ./par_server
F1Help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice F8Nice F9Kill F10Quit
```

c) Server using Select:

i)

```
EXECUTION TIME : 0.005335000
```

ii)

```
PID IS : 32208
```

PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
32208	deb	20	0	2368	564	496	D	7.3	0.0	0:00.11	./select_server

```
PROBLEMS OUTPUT TERMINAL JUPYTER
PID IS : 32208
[]

Socket FD is: 3
Socket FD is: 4
Socket FD is: 6
Socket FD is: 5
Socket FD is: 7
Connected to the server
sockfd: 7
Connected to the server
sockfd: 3
Connected to the server
sockfd: 5
sockfd: 4
Socket FD is: 9
Socket FD is: 10
Socket FD is: 8
Socket FD is: 12
Connected to the server
sockfd: 12
Connected to the server
sockfd: 9
Connected to the server
sockfd: 8
Connected to the server
sockfd: 10
Socket FD is: 11
Connected to the server
sockfd: 6
Connected to the server
sockfd: 11
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...
Sent messages to server, exiting now...

0[0.] 3[0.] 6[0.] 9[0.] 12[0.] 15[0.] 18[0.] 21[0.]
1[0.] 4[0.] 7[0.] 10[0.] 13[0.] 16[0.] 19[0.] 22[0.]
2[0.] 5[0.] 8[0.] 11[0.] 14[0.] 17[0.] 20[0.] 23[0.]
Mem[|||] 896M/23.4G Tasks: 32, 209 thr; 1 running
Swp[ ] 0K/6.00G Load average: 0.70 0.17 0.07
Uptime: 02:10:44

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
32208 deb 20 0 2368 564 496 D 7.3 0.0 0:00.11 ./select_server
F1Help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice F8Nice F9Kill F10Quit
```

On increasing the number of values sent, it was possible to observe a difference in CPU utilisation. The time taken were significantly increased relative to pthreads and fork implementations.

d) Server using poll:

i)

```
EXECUTION TIME : 0.003387000
```


- Epoll limits the set of FDs, though my implementation may have caused inefficiencies to arise (using a set for mapping client sockaddr_in structure for passing to a function). It is said to be faster than poll() because of the limited number of fds to iterate over.

Trying out with 200 clients using 'time' when executing

```
EXECUTION TIME : 0.100808000

real    0m0.920s
user    0m0.010s
sys     0m0.093s
```

epoll server with 200 clients

```
EXECUTION TIME : 0.101967000

real    0m1.159s
user    0m0.023s
sys     0m0.080s
```

poll server with 200 clients

```
EXECUTION TIME : 0.095883000

real    0m0.936s
user    0m0.027s
sys     0m0.071s
```

select with 200 clients

```
TIME TAKEN = 0.0086480000

real    0m0.131s
user    0m0.016s
sys     0m0.000s
```

fork with 200 clients

```
EXECUTION TIME : 1.281724000

real    0m0.228s
user    0m0.000s
sys     0m1.282s
```

thread with 200 clients

We notice that pthread takes the least time, but the maximum CPU time (because of parallelism). Fork takes significantly more time, because of creating a whole new process, which is more expensive than threading.

epoll takes about the same time as select, which may be because of my inefficiency (using array and linearly scanning).

poll takes the longest time because of the same reason.