

Computer Networks

Assignment 2

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Screenshots of Time, CPU and Memory usage
in various server programs for 2b, 2c, 2d

Question 3)

a) Concurrent server program with multiple processes (using fork system call) - 2b

The screenshot displays a Linux terminal window with the following content:

```
top - 21:16:16 up 13:47, 1 user, load average: 0.60, 0.66, 2.00
Tasks: 340 total, 1 running, 329 sleeping, 0 stopped, 10 zombie
%Cpu(s): 2.9 us, 5.2 sy, 0.0 ni, 91.3 id, 0.0 wa, 0.0 hi, 0.6 st, 0.0 st
MiB Mem : 7725.8 total, 1042.5 free, 3337.1 used, 3346.2 buff/cache
MiB Swap: 2048.0 total, 2044.0 free, 4.0 used, 4022.4 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
1277	devkhush	20	0	5041840	380708	125320	S	4.5	4.8	81:41.81	gnome-shell
53368	devkhush	20	0	581656	63496	46536	S	4.2	0.8	1:25.95	gnome-terminal
55324	devkhush	20	0	21992	4368	3412	R	3.2	0.1	0:01.40	top
54753	root	20	0	0	0	0	I	2.6	0.0	0:17.25	kworke/1:1-events
54934	root	20	0	0	0	0	I	1.6	0.0	0:13.12	kworke/0:3-events
761	systend	20	0	14824	6144	5344	S	1.3	0.1	7:28.28	systend-ond
1766	devkhush	20	0	298716	40464	30228	S	1.3	0.5	6:39.69	vmtoolsd
54464	root	20	0	0	0	0	I	1.3	0.0	0:02.93	kworke/u256:3-wr+
55108	root	20	0	0	0	0	I	1.3	0.0	0:11.23	kworke/2:2-mpt_p+
747	root	20	0	326196	9228	7500	S	1.0	0.1	7:47.36	vmtoolsd
1574	devkhush	20	0	323528	11584	6888	S	1.0	0.1	3:10.66	ibus-daemon
3674	devkhush	20	0	36.4g	177892	64796	S	1.0	2.2	18:53.70	code
55014	root	20	0	0	0	0	I	1.0	0.0	0:01.21	kworke/u256:1-ev+
3194	devkhush	20	0	50.5g	389904	132576	S	0.6	4.9	194:24.09	code
3931	devkhush	20	0	1589784	46260	14108	S	0.6	0.6	10:30.57	cpptools
18347	devkhush	20	0	624480	258188	18848	S	0.6	3.3	9:38.49	TablMine
53528	devkhush	20	0	20188	5780	3844	S	0.6	0.1	0:00.89	bash
54985	root	20	0	0	0	0	I	0.6	0.0	0:07.32	kworke/3:0-events
55330	devkhush	20	0	2772	1624	1528	S	0.6	0.0	0:00.62	server
13	root	20	0	0	0	0	I	0.3	0.0	5:35.63	rcu_sched
435	root	-51	0	0	0	0	S	0.3	0.0	3:52.05	irq/16-vmwfx
1624	devkhush	20	0	356468	28612	17584	S	0.3	0.4	0:58.50	ibus-extension-
1752	devkhush	20	0	172264	7316	6700	S	0.3	0.1	0:55.29	ibus-engine-slm
3620	devkhush	20	0	44.5g	187312	98660	S	0.3	2.4	4:47.28	code
3685	devkhush	20	0	429012	30908	23084	S	0.3	0.4	0:00.57	update-notifier
3898	devkhush	20	0	36.4g	74128	56916	S	0.3	0.9	0:57.55	code
18313	devkhush	20	0	142704	23112	13840	S	0.3	0.3	1:02.04	TablMine
18408	devkhush	20	0	892040	545580	9516	S	0.3	6.9	13:11.33	TablMine-deep-lo
48828	devkhush	20	0	4949176	31800	11288	S	0.3	0.4	0:31.28	cpptools-srv
53699	root	20	0	0	0	0	I	0.3	0.0	0:05.93	kworke/u256:0-ev+
55341	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55343	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55346	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55347	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55348	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55349	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55350	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55351	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55352	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
55353	devkhush	20	0	0	0	0	Z	0.3	0.0	0:00.01	server
1	root	20	0	167948	13328	8352	S	0.0	0.2	0:28.56	systend
2	root	20	0	0	0	0	S	0.0	0.0	0:00.25	ktreadd
3	root	-20	0	0	0	0	I	0.0	0.0	0:00.00	rcu_gp
4	root	-20	0	0	0	0	I	0.0	0.0	0:00.00	rcu_par_gp
5	root	-20	0	0	0	0	I	0.0	0.0	0:00.00	netns

Timeline: 76 // fruits(empty, file)

Time taken, CPU usage, Memory usage by server program with multiple processes:

Time taken = "0:00.02" = 0.02 seconds (minutes:seconds.hundredths)

CPU usage% = 0.6%

Memory usage% = 0.0% (nearly)

b) Concurrent server program with multiple threads (using pthreads) - 2c

The screenshot shows a Linux terminal window with three panes. The left pane displays the output of the `top` command, showing system metrics and a list of processes. The middle pane shows the output of a concurrent server program, displaying the time taken and CPU usage. The right pane shows the output of a concurrent client-server program, displaying the results of factorial calculations.

```
top - 21:49:52 up 14:20, 1 user, load average: 1.18, 1.41, 1.48
Tasks: 346 total, 2 running, 344 sleeping, 0 stopped, 0 zombie
Cpu(s): 15.0 us, 5.4 sy, 0.0 ni, 79.5 id, 0.0 wa, 0.0 hi, 0.1 st, 0.0 st
MiB Mem : 7725.8 total, 379.0 free, 3921.2 used, 3425.6 buff/cache
MiB Swap: 2048.0 total, 2044.0 free, 4.0 used, 3395.6 avail Mem

  PID USER      PR  NI  VIRT  RES  SHR  S  %CPU  %MEM    TIME+  COMMAND
 1277 devkush  20   0 5031430 334108 125396 S   36.9   4.2   85:48.59  gnome-shell
53368 devkush  20   0 583272 65380 46564 R   18.9   0.8   1:56:77  gnome-terminal-
1574 devkush  20   0 323528 11584 6888 S    9.0   0.1   3:24.70  ibus-daemon
1624 devkush  20   0 356468 28612 17584 S    5.1   0.4   1:02.76  ibus-extension-
57169 devkush  20   0 21992 4272 3316 R    4.5   0.1   0:00.38  top
56533 root      20   0 0 0 0 I    2.6   0.0   0:17.97  kworker/0:2-event
1752 devkush  20   0 172264 7316 6780 S    1.9   0.1   0:59.36  ibus-engine-sin
57085 root      20   0 0 0 0 I    1.6   0.0   0:02.87  kworker/3:1-event
57010 root      20   0 0 0 0 I    1.3   0.0   0:02.70  kworker/3:1-event
57168 root      20   0 0 0 0 I    1.3   0.0   0:00.10  kworker/u256:4-ev+
  13 root      20   0 0 0 0 I    1.0   0.0   5:52.57  rcu_sched
 435 root     -51  0 0 0 0 S    1.0   0.0   4:03.47  irq/16-vmmgfx
 747 root      20   0 326196 9228 7500 S    1.0   0.1   8:13.00  vmttoolsd
1786 devkush  20   0 308096 49436 30228 S    1.0   0.6   7:01.44  vmttoolsd
57027 root      20   0 0 0 0 I    1.0   0.0   0:02.63  kworker/2:3-event
 781 systemd-  20   0 14824 6144 5344 S    0.6   0.1   7:53.31  systemd-oomd
3194 devkush  20   0 54.5g 396784 132788 S    0.6   5.0   19:30.53  code
3674 devkush  20   0 36.4g 189352 64796 S    0.6   2.4   19:14.26  code
 158 root     -20  0 0 0 0 I    0.3   0.0   0:16.12  kworker/0:1H-kblo+
1785 devkush  20   0 311216 119580 79812 S    0.3   1.5   49:00.76  Xwayland
1897 devkush  39  19 789544 36464 17072 S    0.3   0.5   0:44.17  tracker-miner-f
2879 devkush  20   0 36.9g 208436 139384 S    0.3   2.6   39:43.01  code
3620 devkush  20   0 44.5g 185696 98660 S    0.3   2.3   4:59.29  code
3931 devkush  20   0 1589784 46456 14108 S    0.3   0.6   10:50.01  cpptools
18313 devkush  20   0 144784 23660 13840 S    0.3   0.3   1:05.87  TabNline
18408 devkush  20   0 892040 545580 9516 S    0.3   6.9   13:14.97  TabNline-deep-lo
53483 devkush  20   0 20184 5716 3780 S    0.3   0.1   0:01.38  bash
55540 devkush  20   0 11.1g 421128 188620 S    0.3   5.3   0:26.53  firefox
56917 devkush  20   0 2903820 297768 123752 S    0.3   3.8   4:09.17  Isolated Web Co
56633 devkush  20   0 4949176 19500 12200 S    0.3   0.2   0:03.41  cpptools-srv
56650 devkush  20   0 4949308 16408 11576 S    0.3   0.2   0:01.30  cpptools-srv
57170 devkush  20   0 2772 936 848 S    0.3   0.0   0:00.01  server
  1 root      20   0 167948 13328 8352 S    0.2   0.2   0:29.28  systemd
  2 root      20   0 0 0 0 S    0.0   0.0   0:00.27  kthread
  3 root      20  -20 0 0 0 I    0.0   0.0   0:00.00  rcu_gp
  4 root      20  -20 0 0 0 I    0.0   0.0   0:00.00  rcu_par_gp
  5 root      20  -20 0 0 0 I    0.0   0.0   0:00.00  netns
  7 root      20  -20 0 0 0 I    0.0   0.0   0:00.00  kworker/0:0H-even+
  9 root      20  -20 0 0 0 I    0.0   0.0   0:00.00  mm_percpu_wq
 10 root      20   0 0 0 0 S    0.0   0.0   0:00.00  rcu_tasks_rude
 11 root      20   0 0 0 0 S    0.0   0.0   0:00.00  rcu_tasks_trace
 12 root      20   0 0 0 0 S    0.0   0.0   0:00.87  ksoftirqd/0
 14 root      rt    0 0 0 0 S    0.0   0.0   0:03.78  migration/0
 15 root     -51  0 0 0 0 S    0.0   0.0   0:00.00  idle_inject/0
 17 root      20   0 0 0 0 S    0.0   0.0   0:00.00  cpuhp/0

devkush@devkush-vm-linux: ~/Desktop/CN-Assignments/Assignment-2/2c-Concurrent-Client-Server-Multi-Threaded$
Server replied: Factorial of 3 = 6
Server replied: Factorial of 4 = 24
Server replied: Factorial of 12 = 479001600
Server replied: Factorial of 11 = 39916800
Server replied: Factorial of 7 = 5040
Server replied: Factorial of 13 = 6227020800
Server replied: Factorial of 12 = 479001600
Server replied: Factorial of 14 = 87178291200
Server replied: Factorial of 13 = 6227020800
Server replied: Factorial of 15 = 1307674368000
Server replied: Factorial of 5 = 120
Server replied: Factorial of 14 = 87178291200
Server replied: Factorial of 10 = 28922789888000
Server replied: Factorial of 17 = 355687428096000
Server replied: Factorial of 18 = 6402373705728000
Server replied: Factorial of 19 = 121645100408832000
Server replied: Factorial of 4 = 24
Server replied: Factorial of 5 = 120
Server replied: Factorial of 8 = 40320
Server replied: Factorial of 6 = 720
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 9 = 362880
Server replied: Factorial of 15 = 1307674368000
Server replied: Factorial of 6 = 720
Server replied: Factorial of 7 = 5040
Server replied: Factorial of 1 = 0
devkush@devkush-vm-linux: ~/Desktop/CN-Assignments/Assignment-2/2c-Concurrent-Client-Server-Multi-Threaded$
```

Time taken, CPU usage, Memory usage by server program with multiple threads:

Time taken = "0:00.01" = 0.01 seconds (minutes:seconds.hundredths)

CPU usage% = 0.3%

Memory usage% = 0.0% (nearly)

c) Non-blocking server that can manage total 10 clients, using select() system call - 2d

The screenshot displays a terminal window with two main sections. The left section shows the output of the 'top' command, providing a snapshot of system resource usage. The right section shows the output of a server application, displaying client connections and factorial calculations.

System Resource Usage (top command output):

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
1277	devkhush	20	0	5090628	361144	125584	S	35.7	4.6	88:10.11	gnome-shell
53368	devkhush	20	0	584888	66692	46748	S	21.5	0.8	2:13.13	gnome-terminal
1574	devkhush	20	0	323528	11584	6888	S	10.0	0.1	3:32.07	ibus-daemon
1624	devkhush	20	0	356460	28612	17594	S	4.2	0.4	1:04.00	ibus-extenston
57808	devkhush	20	0	2772	920	832	S	4.2	0.0	0:00.13	server_select
57807	devkhush	20	0	21992	4256	3300	R	3.2	0.1	0:00.34	top
1752	devkhush	20	0	172264	7316	6700	S	2.9	0.1	1:01.51	ibus-engine-stn
55540	devkhush	20	0	11.1g	438956	193040	S	2.6	5.5	11:37.23	firefox
56572	root	20	0	0	0	0	I	2.3	0.0	0:05.90	kworker/u256:2-eva
57010	root	20	0	0	0	0	I	1.9	0.0	0:15.10	kworker/3:1-nm_per
57523	root	20	0	0	0	0	I	1.9	0.0	0:07.35	kworker/2:0-nm_per
57447	root	20	0	0	0	0	I	1.6	0.0	0:14.39	kworker/0:0-events
701	systemd+	20	0	14824	6144	5344	S	1.3	0.1	8:02.18	systemd-oomd
747	root	20	0	326196	9228	7500	S	1.3	0.1	8:21.84	vmtoolsd
55407	root	20	0	0	0	0	I	1.3	0.0	0:45.32	kworker/1:2-nm_per
13	root	20	0	0	0	0	I	1.0	0.0	6:00.28	rcu_sched
1706	devkhush	20	0	308096	49436	30228	R	1.0	0.6	7:10.47	vmtoolsd
1785	devkhush	20	0	311840	119504	79816	S	1.0	1.5	49:54.70	Xwayland
56017	devkhush	20	0	2907912	329736	126820	S	1.0	4.2	5:35.22	Isolated Web Co
56593	root	20	0	0	0	0	I	1.0	0.0	0:04.38	kworker/u256:3-eva
435	root	-51	0	0	0	0	S	0.6	0.0	4:09.46	irq/16-vmwgfx
3194	devkhush	20	0	54.5g	366572	132136	S	0.6	4.6	198:09.67	code
21	root	20	0	0	0	0	S	0.3	0.0	0:07.39	ksoftirqd/1
33	root	20	0	0	0	0	S	0.3	0.0	0:20.01	ksoftirqd/3
2879	devkhush	20	0	36.9g	208764	139464	S	0.3	2.6	40:08.21	code
3620	devkhush	20	0	44.5g	180200	90600	S	0.3	2.4	5:02.74	code
3674	devkhush	20	0	36.4g	164692	64796	S	0.3	2.1	19:31.37	code
3898	devkhush	20	0	36.4g	74156	56916	S	0.3	0.9	1:00.84	code
3931	devkhush	20	0	1589784	46460	14108	S	0.3	0.6	10:58.07	cpptools
53483	devkhush	20	0	20184	5724	3780	S	0.3	0.1	0:01.70	bash
56537	devkhush	20	0	44984	17260	7208	S	0.3	0.2	4:23.49	MD-TabNine
57677	devkhush	20	0	4949308	18088	10640	S	0.3	0.2	0:01.84	cpptools-srv
1	root	20	0	167948	13328	8352	S	0.0	0.2	0:29.72	systemd
2	root	20	0	0	0	0	S	0.0	0.0	0:00.27	kthreadd
3	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_gp
4	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_par_gp
5	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	netns
7	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	kworker/0:0H-even+
9	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	mm_percpu_wq
10	root	20	0	0	0	0	S	0.0	0.0	0:00.00	rcu_tasks_rude
11	root	20	0	0	0	0	S	0.0	0.0	0:00.00	rcu_tasks_trace
12	root	20	0	0	0	0	S	0.0	0.0	0:09.08	ksoftirqd/0
14	root	rt	0	0	0	0	S	0.0	0.0	0:03.85	migration/0
15	root	-51	0	0	0	0	S	0.0	0.0	0:00.00	idle_inject/0
17	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/0

Server Application Output:

```
****Closing connection for client FD: 9 ****
Client replied: 19
Client replied: 16
Client replied: 15
Client replied: 17
Client replied: 20
Client replied: 17
Client replied: 16
Client replied: 18
****Closing connection for client FD: 10 ****
Client replied: 18
Client replied: 17
Client replied: 19
Client replied: 19
Client replied: 18
Client replied: 20
Client replied: 20
Client replied: 19
****Closing connection for client FD: 13 ****
****Closing connection for client FD: 11 ****
Client replied: 20
****Closing connection for client FD: 12 ****

Server replied: Factorial of 19 = 121645100408832000
Server replied: Factorial of 14 = 87178291200
Server replied: Factorial of 13 = 6227020800
Server replied: Factorial of 15 = 1307674368000
Server replied: Factorial of 17 = 355687428096000
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 18 = 6402373705728000
Server replied: Factorial of 15 = 1307674368000
Server replied: Factorial of 14 = 87178291200
Server replied: Factorial of 16 = 20922789888000
Server replied: Factorial of 16 = 20922789888000
Server replied: Factorial of 19 = 121645100408832000
Server replied: Factorial of 15 = 1307674368000
Server replied: Factorial of 17 = 355687428096000
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 17 = 355687428096000
Server replied: Factorial of 16 = 20922789888000
Server replied: Factorial of 18 = 6402373705728000
Server replied: Factorial of 17 = 355687428096000
Server replied: Factorial of 19 = 121645100408832000
Server replied: Factorial of 19 = 121645100408832000
Server replied: Factorial of 18 = 6402373705728000
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 19 = 121645100408832000
Server replied: Factorial of 20 = 2432902008176640000
```

Time taken, CPU usage, Memory usage by non-blocking server, using select() system call:

Time taken = "0:00.13" = 0.13 seconds

CPU usage% = 4.2%

Memory usage% = 0.0% (nearly)

d) Non-blocking server that can manage total 10 clients, using poll() system call - 2d

The screenshot shows a terminal window with the following content:

```
top - 22:14:34 up 14:45, 1 user, load average: 1.96, 2.59, 2.22
Tasks: 344 total, 3 running, 340 sleeping, 0 stopped, 1 zombie
%Cpu(s): 34.5 us, 16.2 sy, 0.1 ni, 49.0 id, 0.0 wa, 0.0 hi, 0.2 si, 0.0 st
MiB Mem : 7725.8 total, 205.4 free, 4155.7 used, 3364.8 buff/cache
MiB Swap: 2048.0 total, 2044.0 free, 4.0 used, 3138.0 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	%CPU	%MEM	TIME+	COMMAND	
1277	devkush	20	0	5176100	392884	125632	R	88.7	5.0	90:52.25	gnome-shell
56537	devkush	20	0	44904	16756	7208	S	45.7	0.2	0:39.92	MD-Tabline
1140	devkush	20	0	1955804	27368	21336	S	10.3	0.3	1:36.36	pulseaudio
44	root	20	0	0	0	0	R	9.6	0.0	0:30.23	kcompactd0
3194	devkush	20	0	54.5g	396920	132264	S	5.1	5.0	199:28.96	code
2870	devkush	20	0	36.9g	205324	139480	S	4.2	2.6	40:27.39	code
106	root	20	0	0	0	0	S	3.5	0.0	0:02.20	kswapd0
58418	devkush	20	0	21992	4356	3396	R	3.5	0.1	0:00:47	top
58170	root	20	0	0	0	0	I	3.2	0.0	0:03.04	kworker/1:2-events
58170	root	20	0	0	0	0	I	2.3	0.0	0:05.23	kworker/0:1-events
55540	devkush	20	0	11.1g	4405600	195316	S	1.9	5.6	18:39.28	firefox
57872	root	20	0	0	0	0	I	1.9	0.0	0:12.59	kworker/2:1-events
3020	devkush	20	0	44.5g	187556	98660	S	1.6	2.4	5:07.72	code
53368	devkush	20	0	584800	66092	46748	S	1.6	0.8	2:22.10	gnome-terminal
57885	root	20	0	0	0	0	I	1.6	0.0	0:12.85	kworker/3:0-mm-pe
58208	devkush	20	0	2869796	65724	49100	S	1.6	0.8	0:04.49	gjs
1574	devkush	20	0	323528	11584	6888	S	1.0	0.1	3:36.98	ibus-daemon
13	root	20	0	0	0	0	I	1.0	0.0	0:09.29	rcu_sched
701	systemd	20	0	14824	6144	5344	S	1.0	0.1	8:12.15	systemd-oom
747	root	20	0	326196	9228	7500	S	1.0	0.1	8:11.52	vimtolsd
1770	devkush	20	0	1386212	104948	73296	S	1.0	1.3	2:42.45	xdg-desktop-por
3674	devkush	20	0	36.4g	170312	64796	S	1.0	2.2	19:42.12	code
913	root	20	0	1243976	44612	20128	S	0.6	0.5	0:55.75	snapp
1706	devkush	20	0	308096	49436	30228	S	0.6	0.6	7:21.26	vimtolsd
1785	devkush	20	0	326456	118900	79212	S	0.6	1.5	51:05.05	Wayland
3931	devkush	20	0	1589784	46460	14108	S	0.6	0.6	11:06.90	cpptools
1	root	20	0	167948	13328	8352	S	0.3	0.2	0:30.15	systemd
12	root	20	0	0	0	0	S	0.3	0.0	0:09.38	ksftirg/0
27	root	20	0	0	0	0	S	0.3	0.0	0:07.89	ksftirg/2
341	root	20	0	0	0	0	S	0.3	0.0	0:45.13	jbd2/sda3-8
435	root	-51	0	0	0	0	S	0.3	0.0	4:17.41	lrq/16-vmgfx
808	root	20	0	2812	1132	1044	S	0.3	0.0	0:25.52	code
1527	devkush	20	0	323656	8864	7356	S	0.3	0.1	0:04.04	gvfsd-trash
1588	devkush	20	0	320580	7316	6564	S	0.3	0.1	0:03.96	gsd-housekeepin
1601	devkush	20	0	1001296	27732	21680	S	0.3	0.4	0:04.47	gsd-media-keys
1624	devkush	20	0	326456	28612	17584	S	0.3	0.4	1:06.13	ibus-extension
1752	devkush	20	0	172264	7316	6700	S	0.3	0.1	1:03.03	ibus-engine-sin
1897	devkush	39	19	789544	26044	17072	S	0.3	0.3	0:47.72	tracker-miner-f
3898	devkush	20	0	36.4g	73340	50910	S	0.3	0.9	1:01.05	code
48028	devkush	20	0	4949176	31800	11268	S	0.3	0.4	0:36.07	cpptools-srv
58160	root	20	0	0	0	0	I	0.3	0.0	0:01.55	kworker/u256:0-ev+
58170	root	20	0	0	0	0	I	0.3	0.0	0:01.54	kworker/u256:1-ev+
58399	devkush	20	0	4949368	16232	11172	S	0.3	0.2	0:00.91	cpptools-srv
58419	devkush	20	0	2772	964	872	S	0.3	0.0	0:00.01	server_poll
2	root	20	0	0	0	0	S	0.0	0.0	0:00.28	ktreadd

```
int listen_status = listen(server_socket, 10);
```

The screenshot shows a terminal window with the following content:

```
top - 22:21:37 up 14:52, 1 user, load average: 0.73, 1.35, 1.76
Tasks: 347 total, 2 running, 344 sleeping, 0 stopped, 1 zombie
%Cpu(s): 2.2 us, 1.2 sy, 0.0 ni, 96.6 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
MiB Mem : 7725.8 total, 214.2 free, 4161.0 used, 3342.6 buff/cache
MiB Swap: 2048.0 total, 2044.0 free, 4.0 used, 3134.4 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	%CPU	%MEM	TIME+	COMMAND	
58418	devkush	20	0	21992	4264	3304	R	3.2	0.1	0:16.33	top
55540	devkush	20	0	11.2g	447984	195272	S	2.9	5.7	18:59.89	firefox
1277	devkush	20	0	5211884	389472	130608	S	2.3	4.9	92:05.38	gnome-shell
58010	root	20	0	0	0	0	I	0.0	0.1	0:00.91	kworker/1:3-mm-pe
701	systemd	20	0	14824	6144	5344	S	1.3	0.1	8:17.60	systemd-oom
56017	devkush	20	0	2909568	387156	129564	S	1.3	3.9	0:16.13	isolated Web Co
58170	root	20	0	0	0	0	I	1.3	0.0	0:16.02	kworker/0:1-events
58790	root	20	0	0	0	0	I	1.0	0.3	0:00.13	kworker/2:0-events
3674	devkush	20	0	36.4g	170352	64796	S	1.0	2.2	19:44.68	code
57885	root	20	0	0	0	0	I	1.0	0.0	0:18.90	kworker/3:0-mm-pe
747	root	20	0	326196	9228	7500	S	0.6	0.1	8:36.79	vimtolsd
1706	devkush	20	0	312532	54188	30228	S	0.6	0.7	7:27.58	vimtolsd
18408	devkush	20	0	892640	54558	9516	S	0.6	0.9	1:18.40	tabline-deep-10
13	root	20	0	0	0	0	R	0.3	0.0	6:13.24	rcu_sched
21	root	20	0	0	0	0	S	0.3	0.0	0:07.79	ksftirg/1
152	root	20	0	0	0	0	S	0.3	0.0	0:19.82	kworker/3:1H-even
837	root	20	0	343244	19216	16196	S	0.3	0.2	0:21.70	NetworkManager
1588	devkush	20	0	320580	7316	6564	S	0.3	0.1	0:04.00	gsd-housekeepin
1750	devkush	20	0	1108400	218784	54700	S	0.3	2.0	0:40.53	snapp-store
1785	devkush	20	0	326460	118900	79212	S	0.3	1.5	51:10.82	Wayland
3194	devkush	20	0	50.5g	391884	131888	S	0.3	5.0	199:31.67	code
3020	devkush	20	0	44.5g	183860	98660	S	0.3	2.3	5:09.74	code
3898	devkush	20	0	36.4g	73340	50910	S	0.3	0.9	1:02.19	code
3931	devkush	20	0	1589784	46460	14108	S	0.3	0.6	11:09.45	cpptools
18313	devkush	20	0	144784	23060	13840	S	0.3	0.3	1:08.93	tabline
18347	devkush	20	0	622400	258436	18840	S	0.3	3.3	0:47.76	tabline
53368	devkush	20	0	587056	69528	48640	S	0.3	0.9	2:32.02	gnome-terminal
58160	root	20	0	0	0	0	I	0.3	0.0	0:03.39	kworker/u256:0-ev+
1	root	20	0	167948	13328	8352	S	0.0	0.2	0:30.35	systemd
2	root	20	0	0	0	0	S	0.0	0.0	0:00.28	ktreadd
3	root	20	0	0	0	0	I	0.0	0.0	0:00.00	rcu_gp
5	root	20	0	0	0	0	I	0.0	0.0	0:00.00	rcu_par_gp
7	root	20	0	0	0	0	I	0.0	0.0	0:00.00	netns
10	root	20	0	0	0	0	I	0.0	0.0	0:00.00	kworker/0:0H-even
11	root	20	0	0	0	0	I	0.0	0.0	0:00.00	percpu_wq
12	root	20	0	0	0	0	I	0.0	0.0	0:00.00	rcu_tasks_rude
13	root	20	0	0	0	0	I	0.0	0.0	0:00.00	rcu_tasks_trace
14	root	20	0	0	0	0	I	0.0	0.0	0:09.52	ksftirg/0
15	root	-51	0	0	0	0	S	0.0	0.0	0:03.95	migration/0
17	root	20	0	0	0	0	S	0.0	0.0	0:00.00	ldt_inject/0
18	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/0
19	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/1
20	root	-51	0	0	0	0	S	0.0	0.0	0:00.00	ldt_inject/1
21	root	20	0	0	0	0	S	0.0	0.0	0:04.03	migration/1
22	root	20	0	0	0	0	S	0.0	0.0	0:00.00	kworker/1:0H-even

```
Server replied: Factorial of 16 = 20922789888000
Server replied: Factorial of 19 = 121045100408832000
Server replied: Factorial of 17 = 355087428096000
Server replied: Factorial of 17 = 355087428096000
Server replied: Factorial of 17 = 355087428096000
Server replied: Factorial of 17 = 355087428096000
Server replied: Factorial of 18 = 2432902008176640000
Server replied: Factorial of 18 = 6402373705728000
Server replied: Factorial of 18 = 6402373705728000
Server replied: Factorial of 18 = 6402373705728000
Server replied: Factorial of 19 = 121045100408832000
Server replied: Factorial of 19 = 121045100408832000
Server replied: Factorial of 19 = 121045100408832000
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 20 = 2432902008176640000
```

Time taken, CPU usage, Memory usage by non-blocking server, using poll() system call:

Time taken = "0:00.19" = 0.19 seconds

CPU usage% = 0.3%

Memory usage% = 0.0% (nearly)

e) Non-blocking server that can manage total 10 clients, using epoll API call - 2d

top - 22:31:48 up 15:02, 1 user, load average: 2.56, 2.71, 2.32
Tasks: 342 total, 2 running, 339 sleeping, 0 stopped, 1 zombie
Cpu(s): 37.4 us, 7.0 sy, 0.0 ni, 55.5 id, 0.0 wa, 0.0 hi, 0.1 si, 0.0 st
MiB Mem : 7725.8 total, 559.0 free, 4291.5 used, 2875.3 buff/cache
MiB Swap: 2048.0 total, 2044.0 free, 4.0 used, 3014.8 avail Mem

PID	USER	PR	NI	VIRT	RES	SHR	%CPU	%MEM	TIME+	COMMAND
59557	devkush	20	0	2772	948	856 R	95.8	0.0	0:03.44	server_epoll
1277	devkush	20	0	5257280	409168	125572 S	53.8	5.2	93:50.31	gnome-shell
1140	devkush	20	0	1955804	27636	21604 S	6.1	0.3	1:39.36	pulseaudio
59556	devkush	20	0	21992	4356	3400 R	2.6	0.1	0:00.43	top
44	root	20	0	0	0	0 S	2.2	0.0	0:38.63	kcompactd0
55540	devkush	20	0	11.1g	493800	194016 S	1.6	6.2	23:36.10	firefox
58170	root	20	0	0	0	0 I	1.6	0.0	0:30.95	kworker/0:1-events
58790	root	20	0	0	0	0 I	1.6	0.0	0:11.05	kworker/2:0-events
747	root	20	0	326196	9228	7500 S	1.3	0.1	8:43.32	vmtoolsd
701	systend+	20	0	14024	6144	5344 S	1.0	0.1	8:24.59	systend-oomd
2879	devkush	20	0	36.9g	195180	128776 S	1.0	2.5	40:56.97	code
53368	devkush	20	0	585764	67868	46704 S	1.0	0.9	2:40.60	gnome-terminal
58206	devkush	20	0	2869820	65932	48832 S	1.0	0.8	0:10.12	gjs
58518	root	20	0	0	0	0 I	1.0	0.0	0:17.34	kworker/1:3-events
1574	devkush	20	0	323528	11584	6888 S	0.6	0.1	3:41.72	ibus-daemon
1706	devkush	20	0	312532	54188	30228 S	0.6	0.7	7:33.41	vmtoolsd
1779	devkush	20	0	1378776	166220	71956 S	0.6	1.3	2:20.04	xdg-desktop-por
1785	devkush	20	0	311452	119600	79912 S	0.6	1.5	52:13.27	Xwayland
59287	root	20	0	0	0	0 I	0.6	0.0	0:03.49	kworker/3:1-nm-pe+
13	root	20	0	0	0	0 I	0.3	0.0	6:19.44	rcu_sched
341	root	20	0	0	0	0 S	0.3	0.0	0:46.21	jbd2/sda3-8
808	root	20	0	2812	1132	1044 S	0.3	0.0	0:26.14	acpid
837	root	20	0	343244	19216	16196 S	0.3	0.2	0:21.96	NetworkManager
1601	devkush	20	0	1061296	27732	21680 S	0.3	0.4	0:04.62	gsd-media-keys
1681	devkush	20	0	811356	61452	46396 S	0.3	0.8	0:02.24	evolution-alarm
1752	devkush	20	0	172264	7316	6700 S	0.3	0.1	1:04.40	ibus-engine-sin
1756	devkush	20	0	1190400	214340	50336 S	0.3	2.7	0:40.82	snap-store
3194	devkush	20	0	54.5g	386444	120192 S	0.3	4.9	201:31.35	code
3620	devkush	20	0	4415g	176332	88024 S	0.3	2.2	5:12.52	code
3674	devkush	20	0	36.4g	156076	54232 S	0.3	2.0	19:57.50	code
3898	devkush	20	0	36.4g	63208	46324 S	0.3	0.8	1:02.80	code
3931	devkush	20	0	1589784	47828	14108 S	0.3	0.6	11:16.74	cpptools
18347	devkush	20	0	624480	260924	18048 S	0.3	3.3	9:57.12	TabNine
18408	devkush	20	0	892040	542944	9516 S	0.3	6.9	13:34.32	TabNine-deep-lo
56593	root	20	0	0	0	0 I	0.3	0.0	0:11.33	kworker/u256:3-ev+
59422	devkush	20	0	4949308	21020	10852 S	0.3	0.3	0:02.53	cpptools-srv
1	root	20	0	167948	13312	8336 S	0.0	0.2	0:30.59	systend
2	root	20	0	0	0	0 S	0.0	0.0	0:00.28	kthreadd
3	root	20	0	0	0	0 I	0.0	0.0	0:00.00	rcu_gp
4	root	20	0	0	0	0 I	0.0	0.0	0:00.00	rcu_per_gp
5	root	20	0	0	0	0 I	0.0	0.0	0:00.00	netns
7	root	20	0	0	0	0 I	0.0	0.0	0:00.00	kworker/0:0H-even+
9	root	20	0	0	0	0 I	0.0	0.0	0:00.00	nm_percpu_wq
10	root	20	0	0	0	0 S	0.0	0.0	0:00.00	rcu_tasks_rude
11	root	20	0	0	0	0 S	0.0	0.0	0:00.00	rcu_tasks_trace

Client replied: 5
Client replied: 12
Client replied: 1
Client replied: 5
Client replied: 6
Client replied: 13
Client replied: 2
Client replied: 7
Client replied: 14
Client replied: 3
Client replied: 8
Client replied: 6
Client replied: 15
Client replied: 20
Client replied: 4
Client replied: 9
Client replied: 4
Client replied: 16
Client replied: 13
Client replied: 10
Client replied: 7

devkush@devkush-vm-linux: ~/Desktop/CN-Assignments/Assignment-2/2d-Non-Blocking-CLie...
Server replied: Factorial of 19 = 121645100408832000
Server replied: Factorial of 5 = 120
Server replied: Factorial of 12 = 479001600
Server replied: Factorial of 1 = 1
Server replied: Factorial of 6 = 720
Server replied: Factorial of 13 = 6227020800
Server replied: Factorial of 2 = 2
Server replied: Factorial of 3 = 6
Server replied: Factorial of 7 = 5040
Server replied: Factorial of 5 = 120
Server replied: Factorial of 14 = 87178291200
Server replied: Factorial of 3 = 6
Server replied: Factorial of 8 = 40320
Server replied: Factorial of 15 = 1307674368000
Server replied: Factorial of 12 = 479001600
Server replied: Factorial of 20 = 2432902008176640000
Server replied: Factorial of 9 = 362880
Server replied: Factorial of 6 = 720
Server replied: Factorial of 13 = 6227020800
Server replied: Factorial of 15 = 1307674368000
Server replied: Factorial of 4 = 24
Server replied: Factorial of 4 = 24
Server replied: Factorial of 16 = 20922789888000
Server replied: Factorial of 10 = 3628800
Server replied: Factorial of 9 = 362880
Server replied: Factorial of 12 = 479001600
Server replied: Factorial of 7 = 5040

Time taken, CPU usage, Memory usage by non-blocking server, using epoll API call:

Time taken = "0:03.44" = 3.44 seconds

CPU usage% = 95.8%

Memory usage% = 0.0% (nearly)