

OPERATING SYSTEMS

REPORT

BY: - (Group-4)

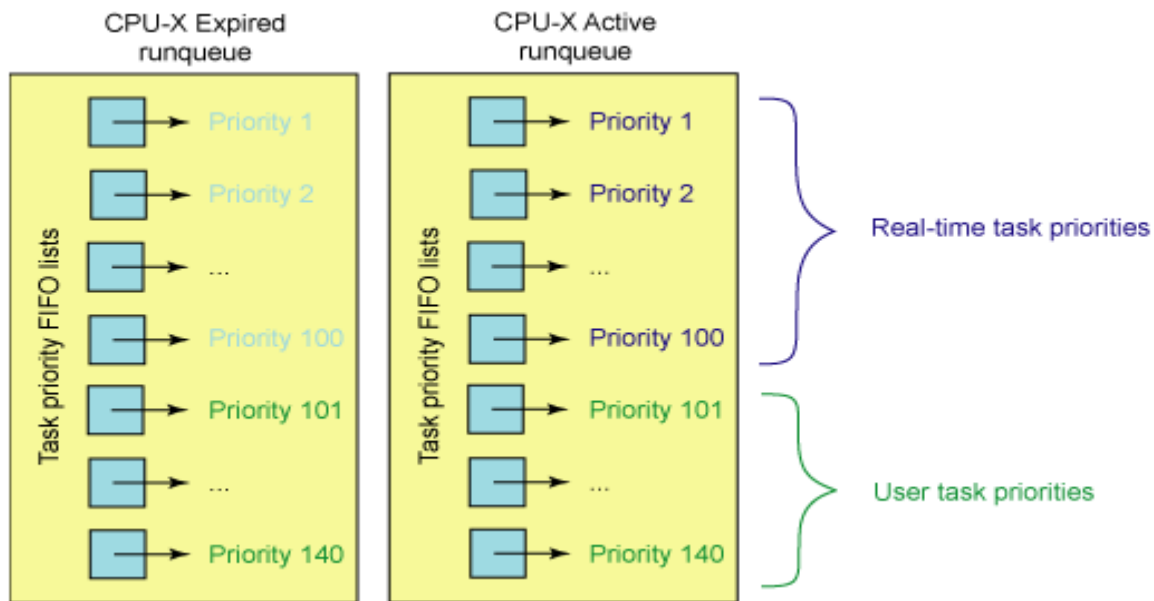
- *Aman Jaiswal (17114008)*
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PROBLEM STATEMENT: -

To modify the Linux scheduler to implement a new scheduling class, called background scheduling. We will evaluate how our new scheduling class performs.

KERNEL 2.6: -

- Each CPU in this kernel has a runqueue made up of 140 priority lists that are serviced in FIFO order. Tasks that are scheduled to execute are added to the end of their respective runqueue's priority list.
- Each task has a time slice that determines how much time it's permitted to execute.
- The first 100 priority lists of the runqueue are reserved for real-time tasks, and the last 40 are used for user tasks (MAX_RT_PRIO=100 and MAX_PRIO=140).
- In addition to the CPU's runqueue, which is called the active runqueue, there's also an expired runqueue.
- When a task on the active runqueue uses all of its time slice, it's moved to the expired runqueue. During the move, its time slice is recalculated (and so is its priority).
- If no tasks exist on the active runqueue for a given priority, the pointers for the active and expired runqueues are swapped, thus making the expired priority list the active one.



Kernel 2.6 Scheduler Policies:

- **SCHED_NORMAL** - A conventional, time-shared process (used to be called SCHED_OTHER), for normal tasks.
 1. Each task assigned a "Nice" value
 2. $PRIO = MAX_RT_PRIO + NICE + 20$
 3. Assigned a time slice
 4. Tasks at the same PRIO(rity) are round-robin.
 5. Ensures Priority + Fairness
- **SCHED_FIFO** - A First-In, First-Out real-time process
 1. Run until they relinquish the CPU voluntarily
 2. Priority levels maintained
 3. Not pre-empted!!
- **SCHED_RR** - A Round Robin real-time process
 1. Assigned a timeslice and run till the timeslice is exhausted.
 2. Once all RR tasks of a given PRIO(rity) level exhaust their timeslices, their timeslices are refilled and they continue running
 3. PRIO(rity) levels are maintained
- **SCHED_BATCH** - for "batch" style execution of processes
 1. For computing-intensive tasks
 2. Timeslices are long and processes are round robin scheduled
 3. lowest priority tasks are batch-processed (nice +19)
- **SCHED_IDLE** - for running very low priority background job
 1. nice value has no influence for this policy
 2. extremely low priority (lower than +19 nice)

HOW TO PROCEED:

- We need to add a new scheduling policy called `SCHED_BACKGROUND`. This policy is designed to support processes that only need to run when the system has no other process to do.
- When there are no processes which are managed by the `SCHED_OTHER`, `SCHED_RR` or `SCHED_FIFO` classes, our `SCHED_BACKGROUND` policy will run the background processes.
- When there is more than one `SCHED_BACKGROUND` process ready to run, they should compete for the CPU as do `SCHED_OTHER` processes using CFS i.e., 'Complete Fair Scheduling'.
- We found out that in the latest version of the linux Ubuntu 18.04 having kernel version 4.15, the `sched.c` file is not present, instead a `sched` directory which is consist of many different parts old scheduler. As it was somewhat difficult to modify those many parts due to higher level of encapsulation and also the `sched.c` file exists below kernel version 3.0, we switched to the Ubuntu version 8.04 with kernel version 2.6.24.
- We have to make the changes in the `sched.c` and the `sched.h` files which are responsible for handling scheduler function in kernel. We also need to modify an auxiliary file `chrt.c` in the kernel source which handles all the system calls to kernel-scheduler.
- In linux-2.6.24 there is already a policy named `SCHED_IDLE` which already handles background task.
- We will implement a new policy `SCHED_BACKGROUND` to handle background tasks with lower priority than `SCHED_IDLE`. This will handle tasks only if queues of all other policies are empty.
- We define this new policy in `sched.h` and make required changes in `sched.c`. To support making system calls from terminal, we also add this policy in `chrt.c`, generate its object file and replace it with the default system file.
- We can also use the `sched_setscheduler` method which assigns a particular policy to a process instead of updating the `chrt.c` file.

STEPS: - First we need to install Ubuntu kernel version 2.6.24

21 s

Language

Arabic	Hindi	Português
Беларуская	Hrvatski	Română
Български	Magyarul	Русский
Bengali	Bahasa Indonesia	Sámegillii
Bosanski	Italiano	Slovenčina
Català	日本語	Slovenščina
Čeština	ქართული	Shqip
Dansk	Khmer	Svenska
Deutsch	한국어	Tamil
Dzongkha	Kurdî	Thai
Ελληνικά	Lietuviškai	Tagalog
English	Latviski	Türkçe
Esperanto	Македонски	Українська
Español	Malayalam	Tiếng Việt
Eesti	Norsk bokmål	Wolof
Euskaraz	Nepali	中文(简体)
Suomi	Nederlands	中文(繁體)
Français	Norsk nynorsk	
Galego	Punjabi (Gurmukhi)	
Gujarati	Polski	
Hebrew	Português do Brasil	

F1 Help
F2 Language
F3 Keymap
F4 Modes
F5 Accessibility
F6 Other Options



Try Ubuntu without any change to your computer
Install Ubuntu
Check CD for defects
Test memory
Boot from first hard disk

Press F4 to select alternative start-up and installation modes.

F1 Help F2 Language F3 Keymap F4 Modes F5 Accessibility F6 Other Options



Try Ubuntu without any change to your computer
Install Ubuntu
Check CD for defects
Test memory
Boot from first hard disk

Press F4 to select alternative start

- Normal
- Safe graphics mode
- Use driver update CD
- OEM install (for manufacturers)

F1 Help F2 Language F3 Keymap F4 Modes F5 Accessibility F6 Other Options

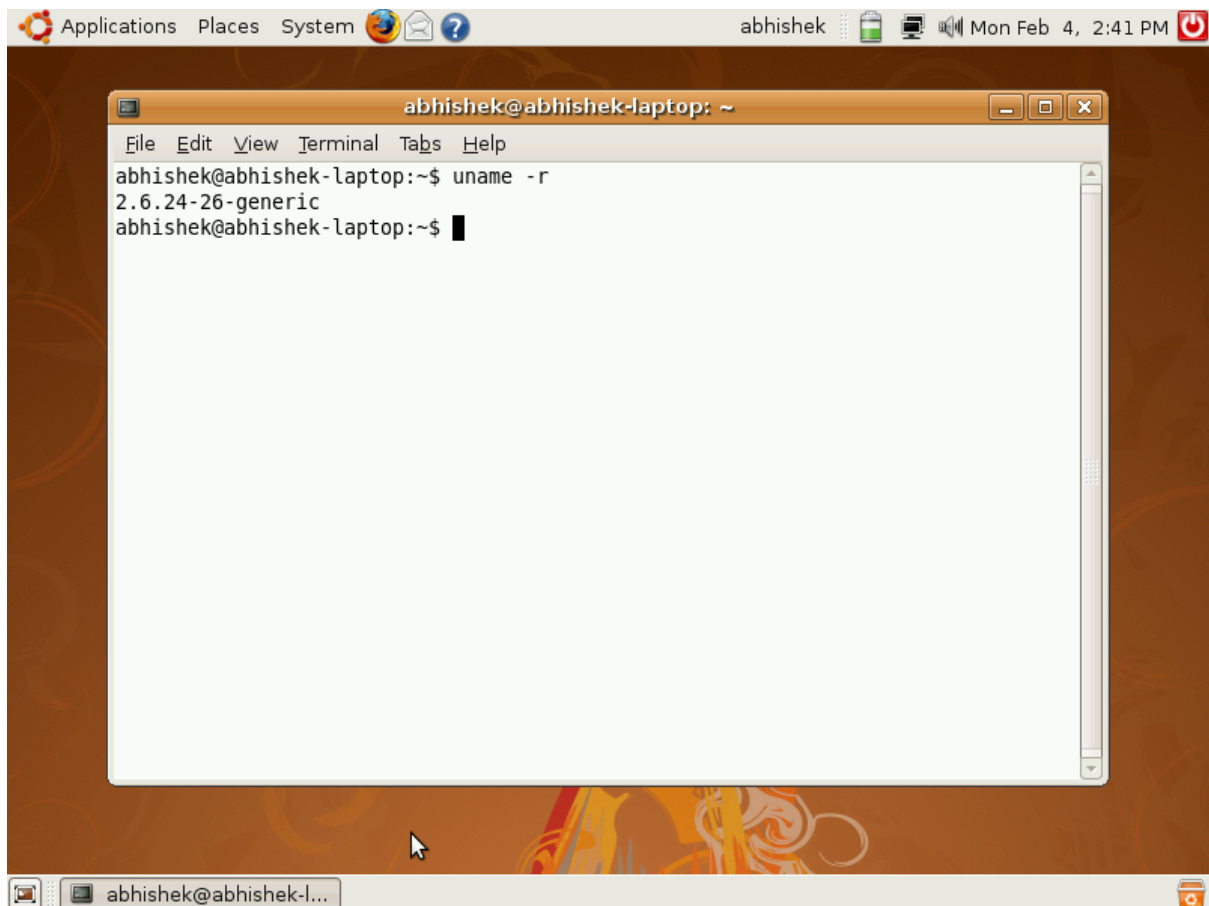
Press F4 to enter the graphical mode otherwise you have to completely use the CLI.



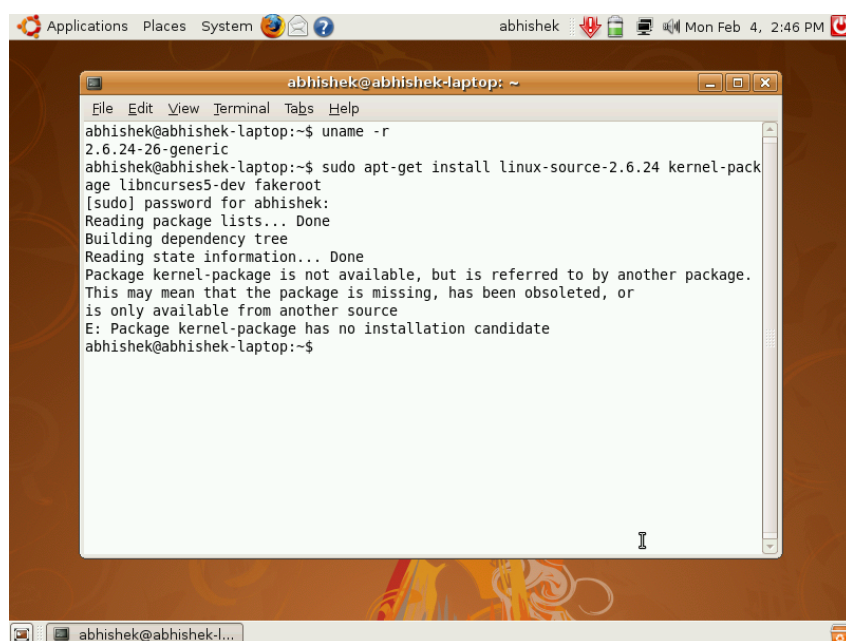
- First, we have to confirm that our kernel version is correct. So, we use the following command:

```
$ uname -r
```

```
2.6.24-26-generic
```

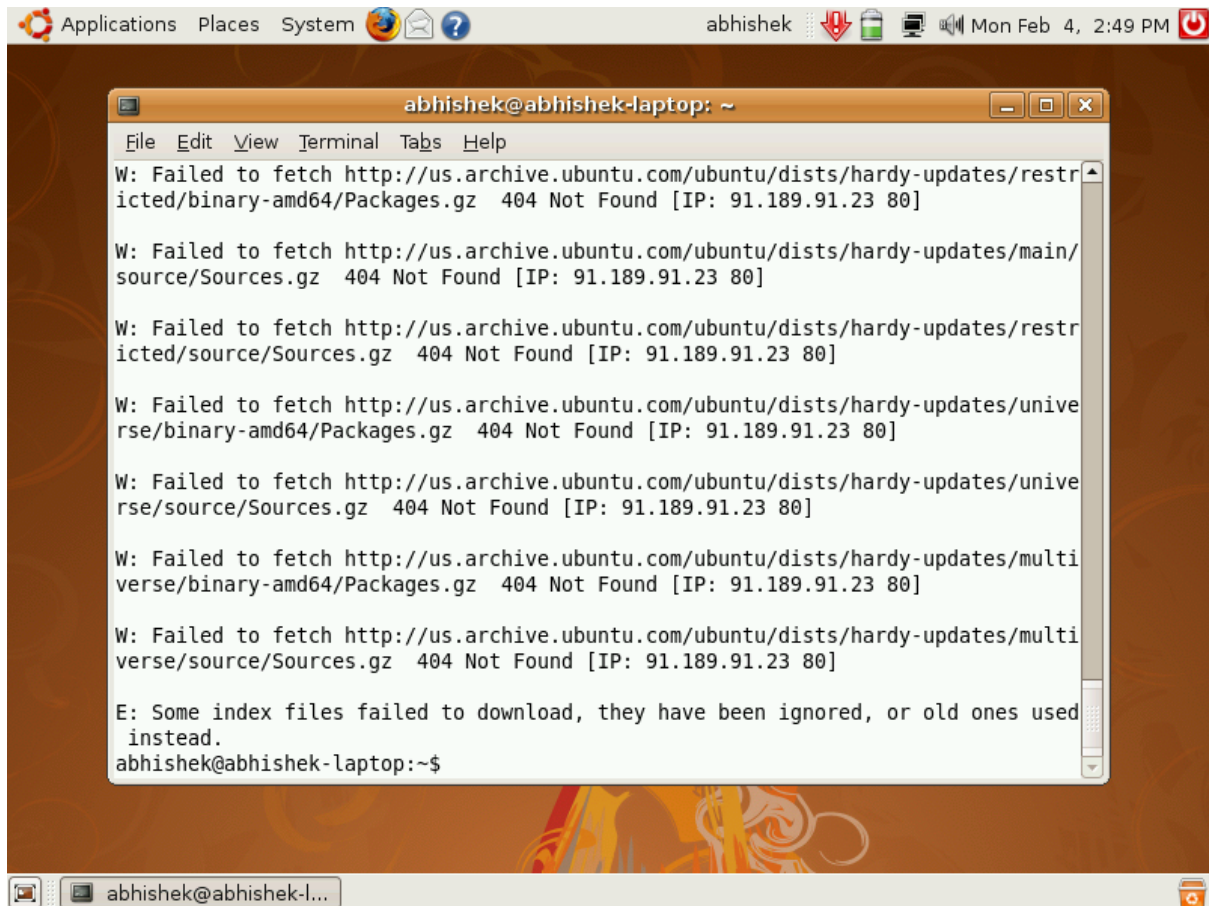


- Now we need to install the Linux source for our kernel, we also need to install the curses library and other tools to help us compile.
\$ sudo apt-get install linux-source-2.6.24 kernel-package libncurses5-dev fakeroot



We encountered an error due to the absence of packages, so we had to update the packages using the command:

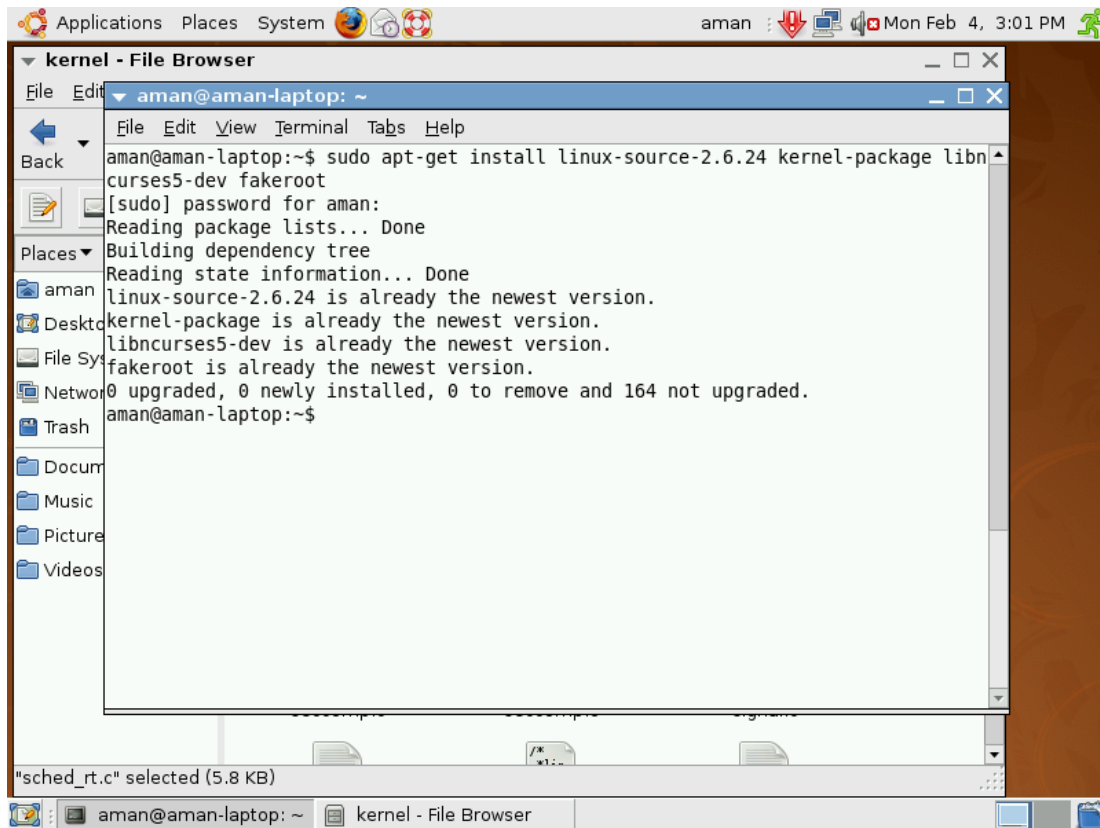
\$ sudo apt-get update

A screenshot of a Linux desktop environment. The top panel shows the Unity interface with icons for Applications, Places, System, and the user 'abhishek'. The system clock indicates 'Mon Feb 4, 2:49 PM'. A terminal window titled 'abhishek@abhishek-laptop: ~' is open, displaying the output of the 'sudo apt-get update' command. The terminal shows several 'W: Failed to fetch' messages for various Ubuntu repositories (hardy-updates, universe, multiverse) with a '404 Not Found' error. The final message is 'E: Some index files failed to download, they have been ignored, or old ones used instead.' The terminal prompt is 'abhishek@abhishek-laptop:~\$'.

- Due to the ubuntu version being too old, we were not able to use these commands as these links died. Hence, we need to update all of our deprecated urls **<http://archive.ubuntu.com>** to the working urls **<http://old-releases.ubuntu.com>** using the command:

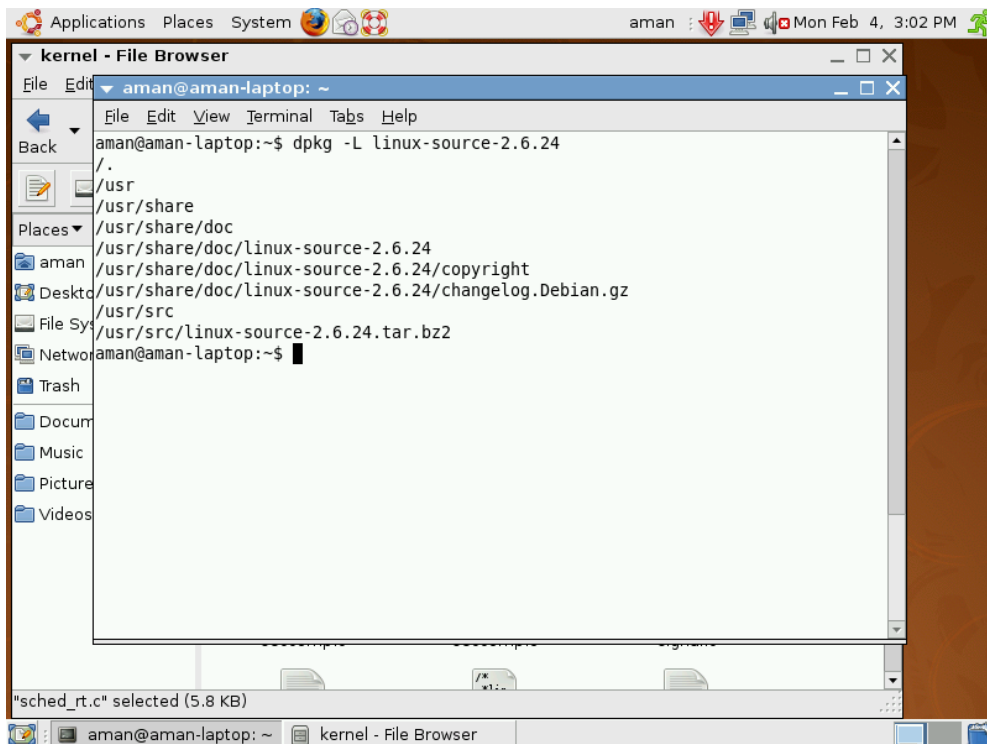
sudo sed -i -e 's/:\\/(archive.ubuntu.com\\|security.ubuntu.com)/old-releases.ubuntu.com/g' /etc/apt/sources.list

- After this the packages will be updated and you can run the previous command to install the kernel source.

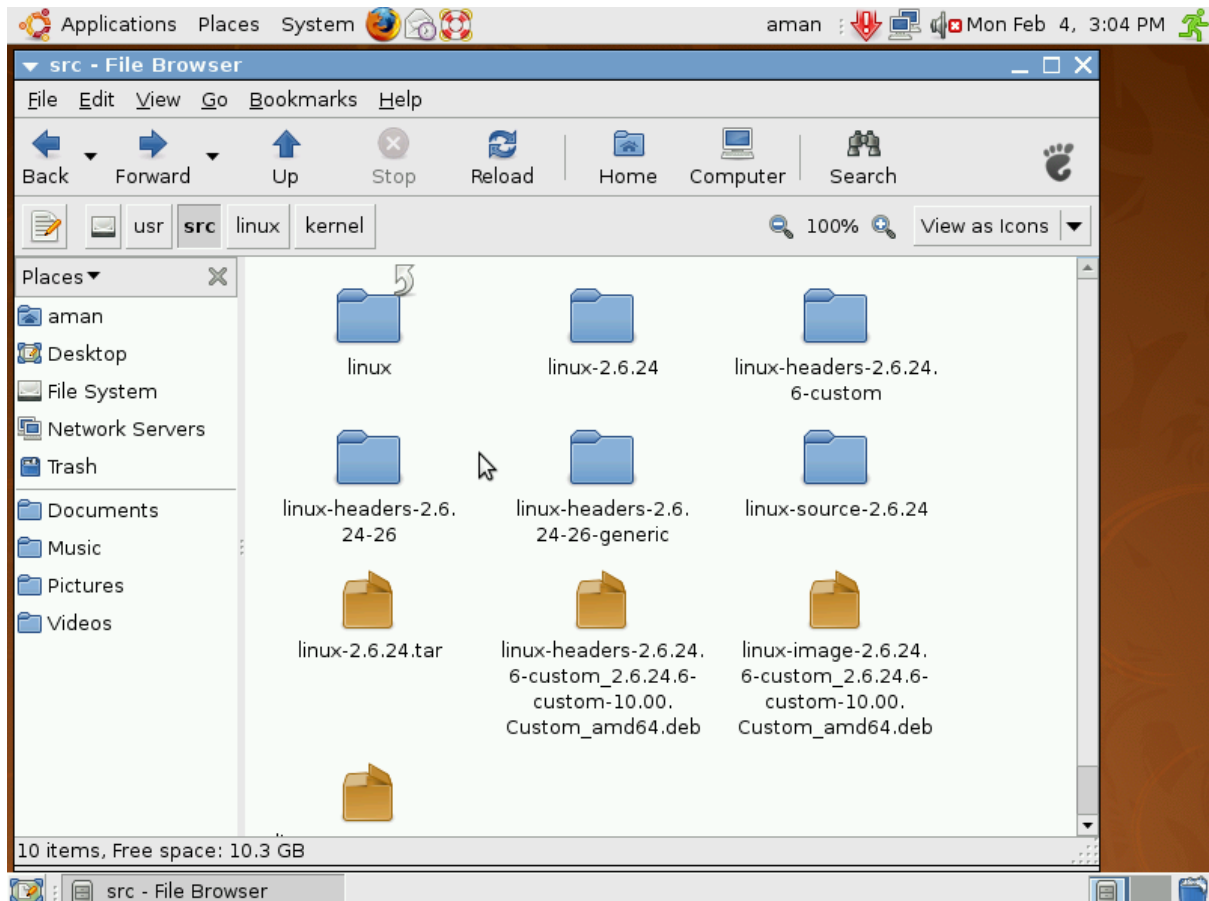


- To find out where the Linux source gets installed to, you can use the `dpkg` command to tell you the files within a package:

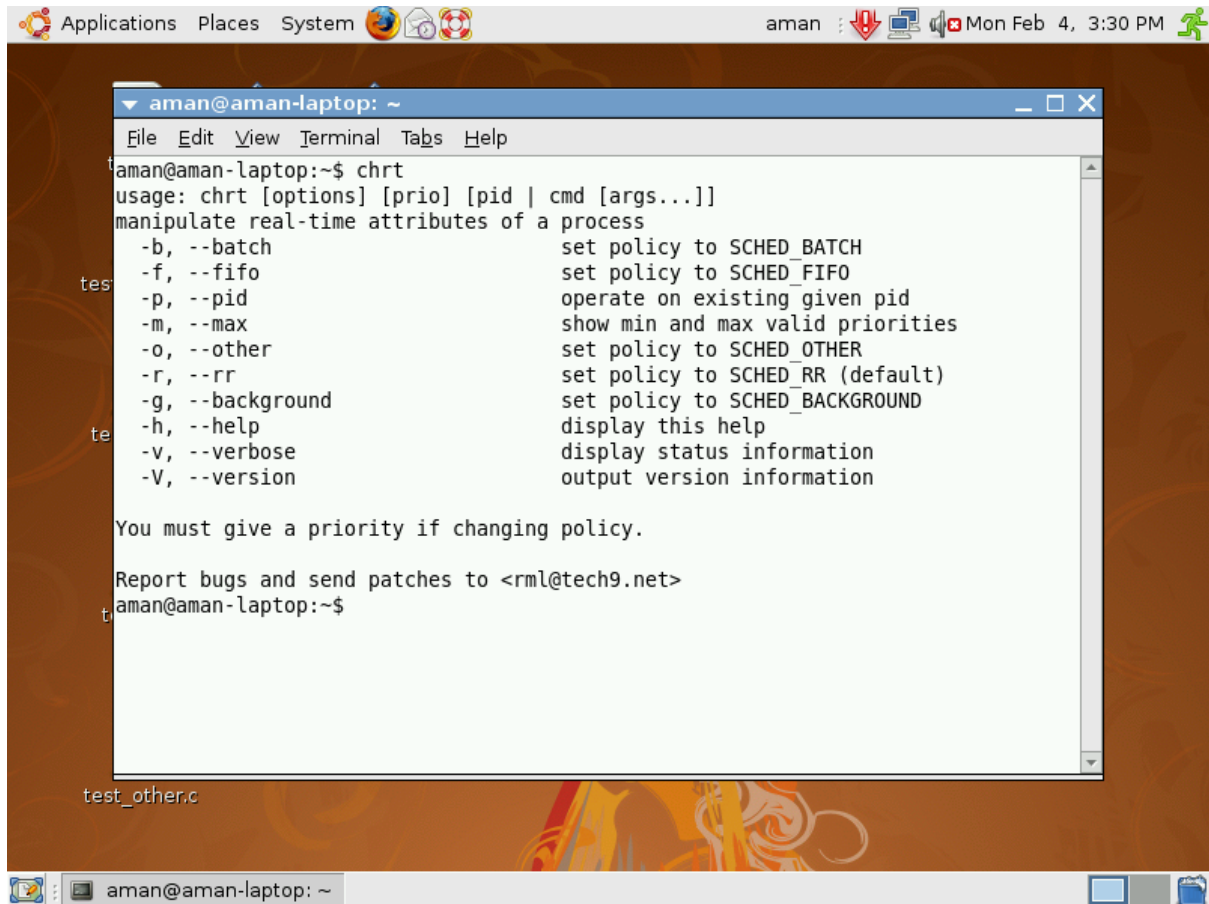
\$ dpkg -L linux-source-2.6.24



- Then we become the super-user to perform administrative tasks
\$ sudo /bin/bash
- Now we change the directory into the source location so that we can install the linux source. We then unzip the source file and save it in a folder named 'linux':
\$ cd /usr/src
\$ bunzip2 linux-source-2.6.24.tar.bz2
\$ tar xvf linux-source-2.6.24.tar
\$ ln -s linux-source-2.6.24 linux



- Then we modify the sched.c and the sched.h files to include our SCHED_BACKGROUND policy. We also modified the chrt.c file which manages our system calls for scheduling policies. We will also include our custom command to run the sched_background policy.
- To support making system calls from terminal, we also generate the object file of chrt.c and replace it with the default system file.
\$ gcc chrt.c -o chrt



The screenshot shows a terminal window titled 'aman@aman-laptop: ~'. The user has entered the command 'chrt', which has triggered a help message. The help text includes the usage 'chrt [options] [prio] [pid | cmd [args...]]', a description 'manipulate real-time attributes of a process', and a list of options: -b (batch), -f (fifo), -p (pid), -m (max), -o (other), -r (rr), -g (background), -h (help), -v (verbose), and -V (version). It also states that a priority must be given when changing policy and provides a contact email for reporting bugs.

```
aman@aman-laptop:~$ chrt
usage: chrt [options] [prio] [pid | cmd [args...]]
manipulate real-time attributes of a process
-b, --batch          set policy to SCHED_BATCH
-f, --fifo           set policy to SCHED_FIFO
-p, --pid            operate on existing given pid
-m, --max            show min and max valid priorities
-o, --other          set policy to SCHED_OTHER
-r, --rr             set policy to SCHED_RR (default)
-g, --background    set policy to SCHED_BACKGROUND
-h, --help           display this help
-v, --verbose        display status information
-V, --version        output version information

You must give a priority if changing policy.

Report bugs and send patches to <rml@tech9.net>
aman@aman-laptop:~$
```

- So, the primarily modified files are:
 - **/include/linux/sched.h**
 - **/kernel/sched.c**
 - **/usr/bin/chrt**
- There are mainly two scheduling classes in linux-2.6.24:
 - **sched_rt.c (for real time processes)**
 - **sched_fair.c (for fair scheduling)**
- The SCHED_BACKGROUND policy needs to handle processes in its queue similar to SCHED_OTHER which follows fair scheduling so it also follows fair scheduling. Thus its operating class is sched_fair.c.
- Next, we have to make a copy of our existing kernel configuration to use for the custom compile process. We can do this by using the command:
\$ cp /boot/config- 2.6.24-generic /usr/src/linux/.config
- First, we'll do a make clean, just to make sure everything is ready for the compile
\$ make-kpkg clean
- We'll actually compile the kernel. This will take a "LONG TIME" maybe 40-50 mins.

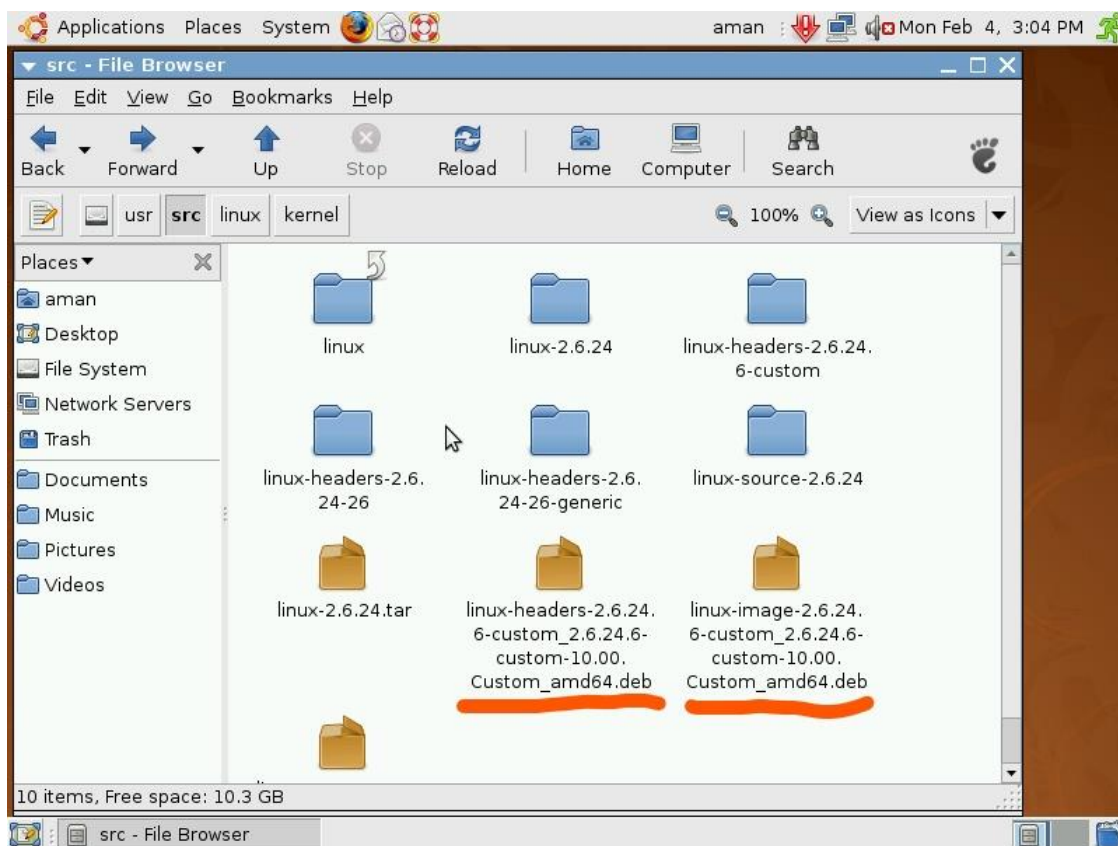
```
$ fakeroot make-kpkg --initrd --append-to-version=-custom kernel_image
```

kernel_headers

- This process will create two .deb files in /usr/src that contain the kernel
Please note that when you run these next commands, this will set the new kernel as the new default kernel. This could break things! If your machine doesn't boot, you can hit Esc at the GRUB loading menu, and select your old kernel. You can then disable the kernel in /boot/grub/menu.lst or try and compile again.

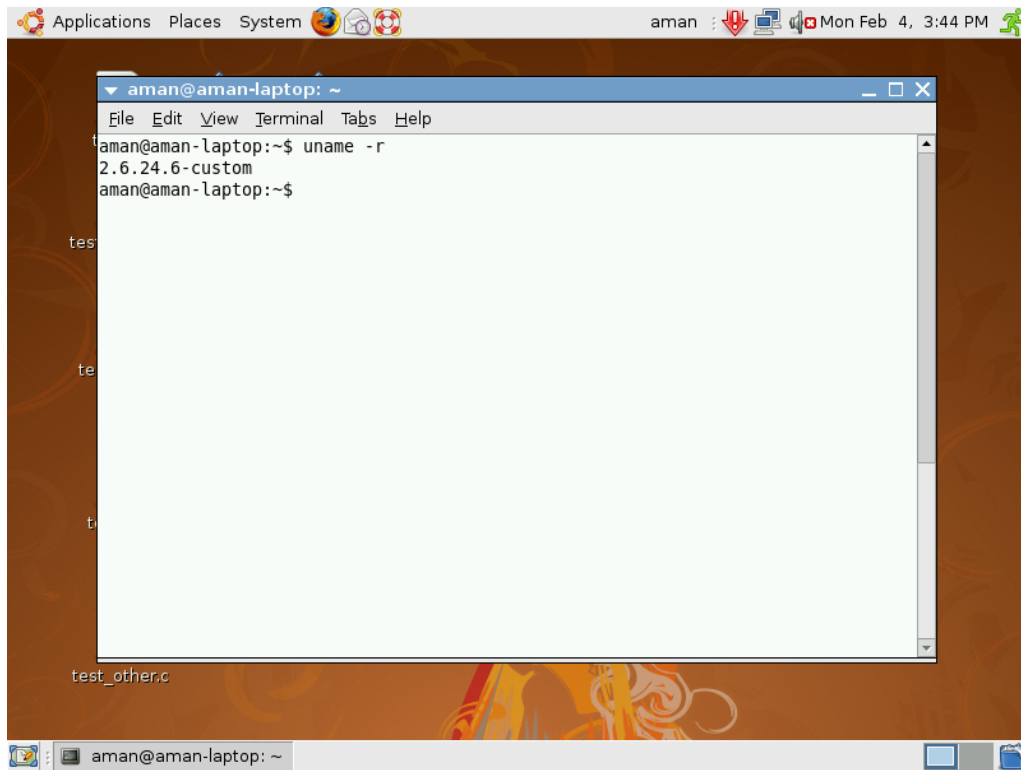
```
$ dpkg -i linux-image-2.6.24.6-custom_2.6.24.6-custom-10.00.Custom_amd64.deb
```

```
$ dpkg -i linux-headers-2.6.24.6-custom_2.6.24.6-custom-10.00.Custom_amd64.deb
```

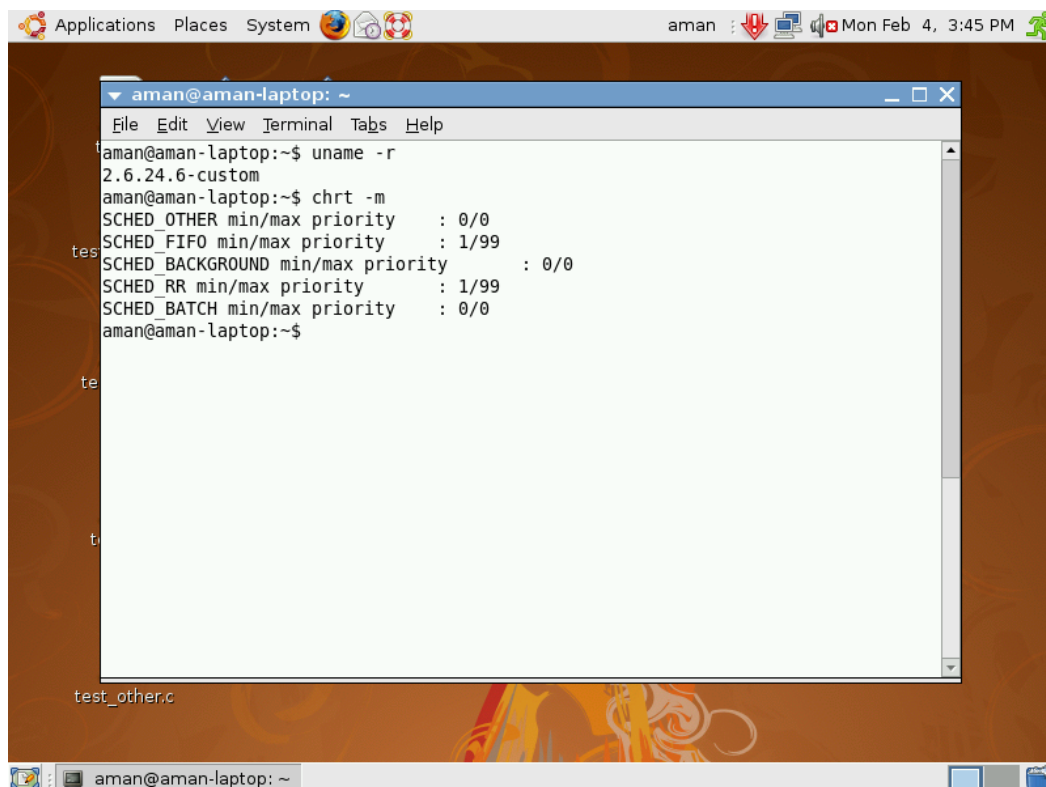


- Now we reboot our machine. After rebooting we can check whether our custom kernel version is correct or not:

```
$ uname -r
```



We can also get the priorities of the current policies using `chrt -m` command.



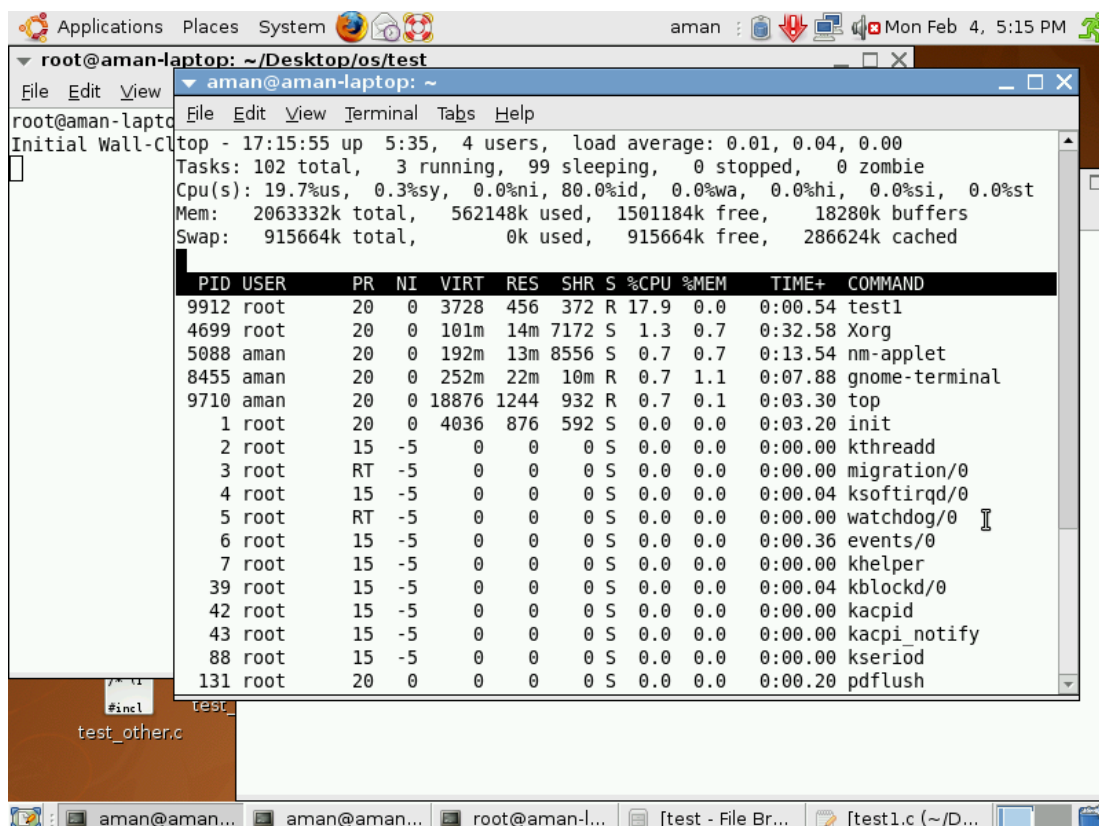
EVALUATION:

- For the evaluation purpose we have written C programs that execute z process for a counter of order of 1000000000, and finishes its execution in about 15 seconds. We used the method sched_setscheduler() to set the required policy for a process. This can also be done in shell script using chrt -[policy] -p [prio] [PID]
- We used getrusage() to get the user time and the system time for a particular process. We also use gettimeofday() to get the wall-clock time for our process. To run multiple process files simultaneously, we used shell-script.
- For evaluating a file compile the corresponding C code using command :

gcc test1.c -o test1

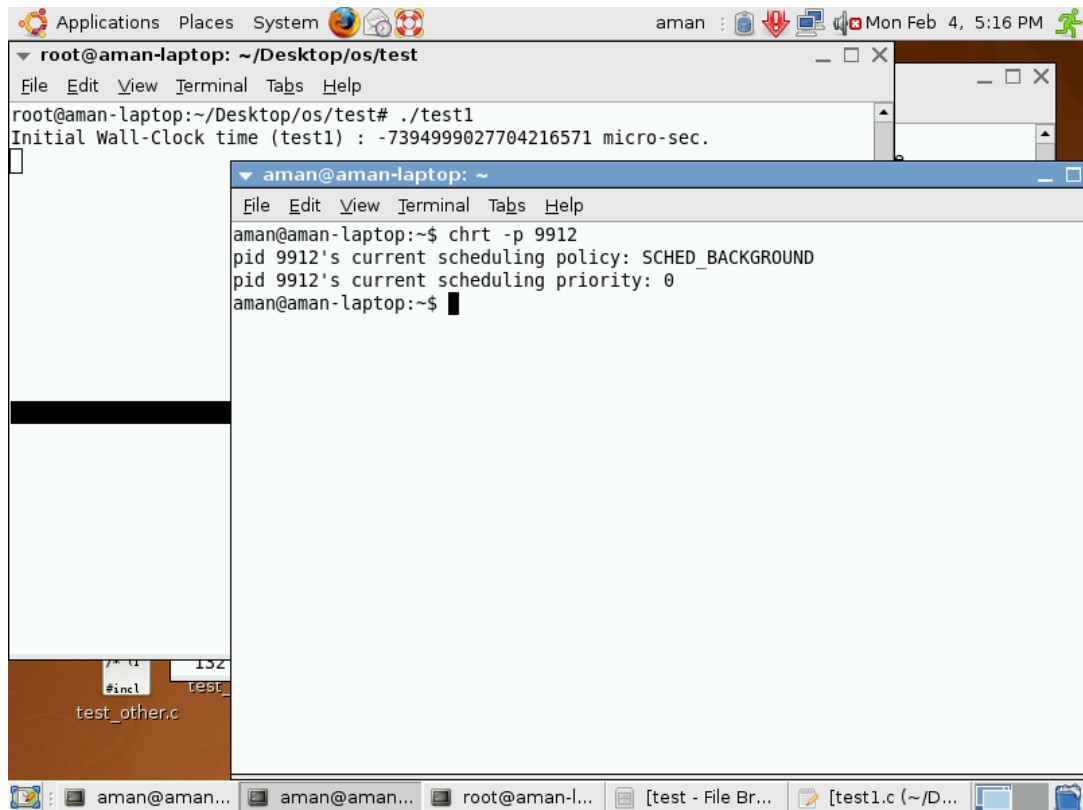
To run the C file use : **./test1**

1.) Run your counter as a SCHED_BACKGROUND. Record how long it takes to count.



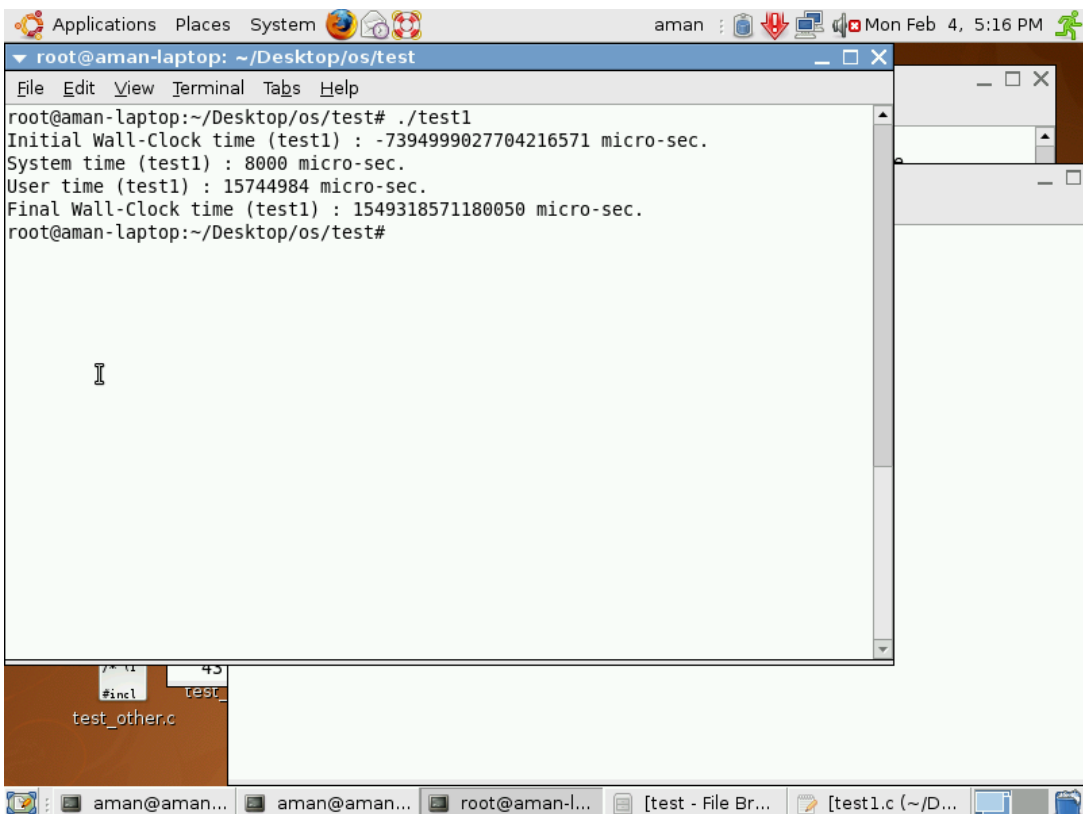
The screenshot shows a terminal window titled 'root@aman-laptop: ~/Desktop/os/test'. The terminal displays the output of the 'top' command, which provides system statistics and a list of running processes. The system statistics show 102 total tasks, 3 running, 99 sleeping, 0 stopped, and 0 zombie. The CPU usage is 19.7% user, 0.3% system, 0.0% nice, 80.0% idle, 0.0% wait, 0.0% high, 0.0% steal, and 0.0% other. The memory usage is 2063332k total, 562148k used, 1501184k free, 18280k buffers, and 915664k swap. The process list shows the following data:

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
9912	root	20	0	3728	456	372	R	17.9	0.0	0:00.54	test1
4699	root	20	0	101m	14m	7172	S	1.3	0.7	0:32.58	Xorg
5088	aman	20	0	192m	13m	8556	S	0.7	0.7	0:13.54	nm-applet
8455	aman	20	0	252m	22m	10m	R	0.7	1.1	0:07.88	gnome-terminal
9710	aman	20	0	18876	1244	932	R	0.7	0.1	0:03.30	top
1	root	20	0	4036	876	592	S	0.0	0.0	0:03.20	init
2	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kthreadd
3	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	migration/0
4	root	15	-5	0	0	0	S	0.0	0.0	0:00.04	ksoftirqd/0
5	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	watchdog/0
6	root	15	-5	0	0	0	S	0.0	0.0	0:00.36	events/0
7	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	khelper
39	root	15	-5	0	0	0	S	0.0	0.0	0:00.04	kblockd/0
42	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kacpid
43	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kacpi_notify
88	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kseriod
131	root	20	0	0	0	0	S	0.0	0.0	0:00.20	pdflush

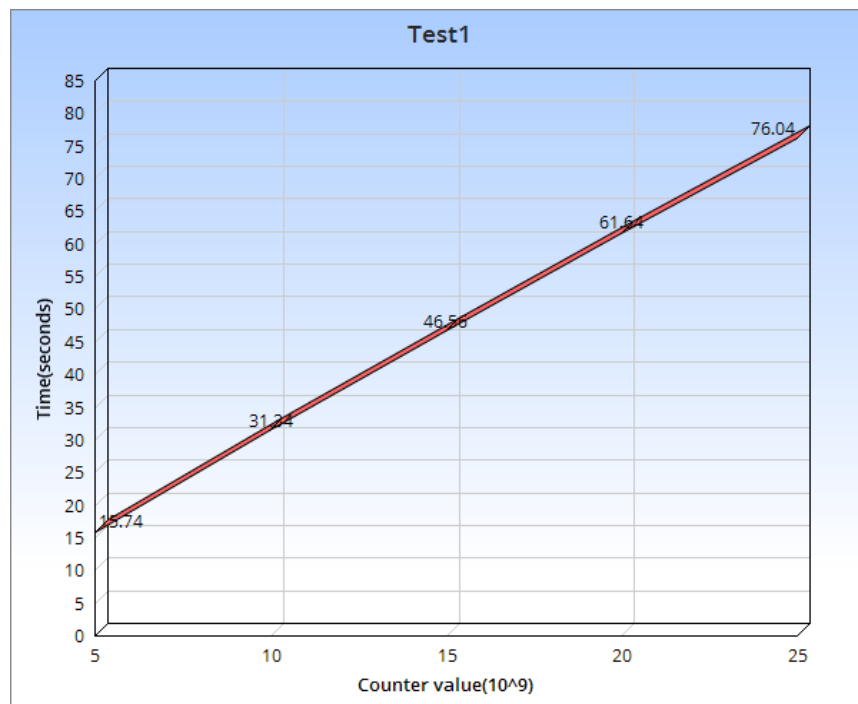
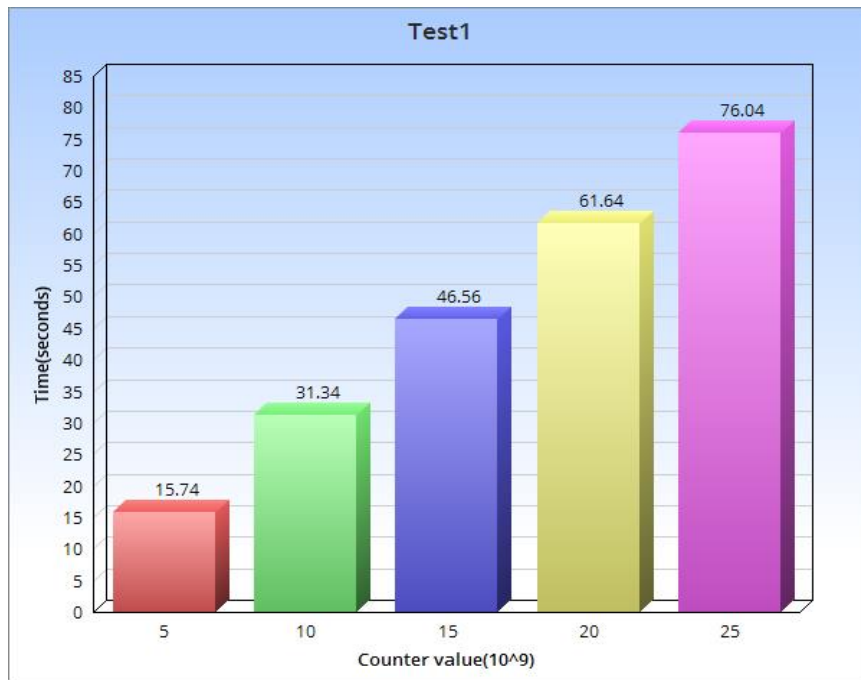


```
root@aman-laptop: ~/Desktop/os/test
File Edit View Terminal Tabs Help
root@aman-laptop:~/Desktop/os/test# ./test1
Initial Wall-Clock time (test1) : -7394999027704216571 micro-sec.

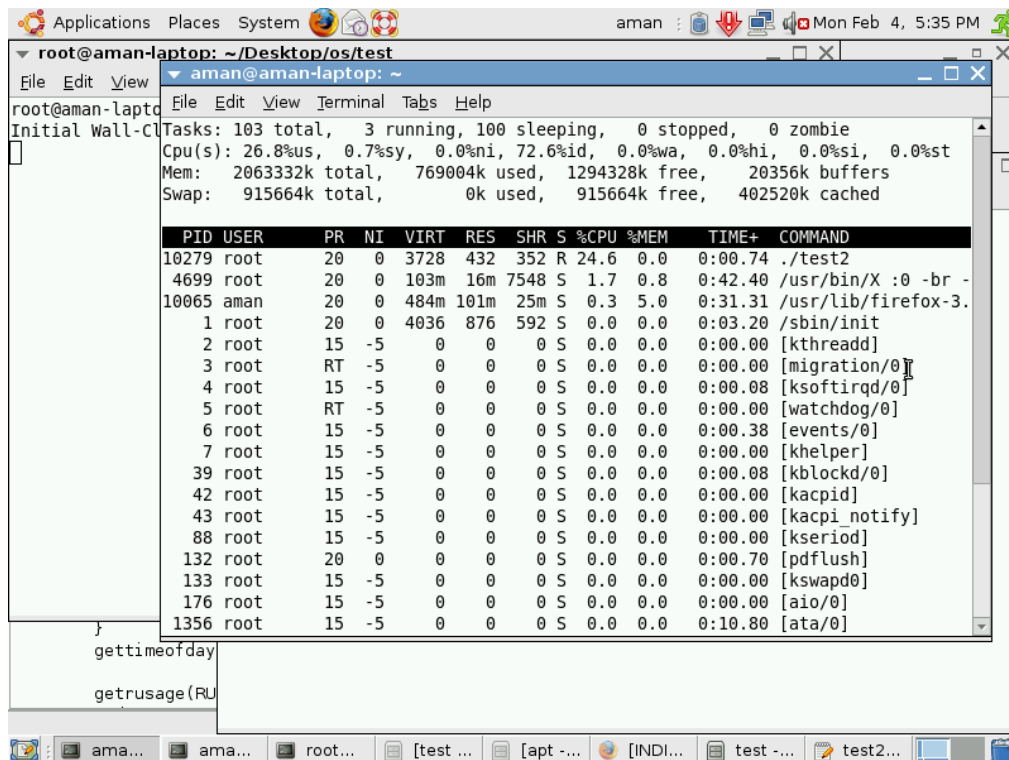
aman@aman-laptop: ~
File Edit View Terminal Tabs Help
aman@aman-laptop:~$ chrt -p 9912
pid 9912's current scheduling policy: SCHED_BACKGROUND
pid 9912's current scheduling priority: 0
aman@aman-laptop:~$
```



```
root@aman-laptop: ~/Desktop/os/test
File Edit View Terminal Tabs Help
root@aman-laptop:~/Desktop/os/test# ./test1
Initial Wall-Clock time (test1) : -7394999027704216571 micro-sec.
System time (test1) : 8000 micro-sec.
User time (test1) : 15744984 micro-sec.
Final Wall-Clock time (test1) : 1549318571180050 micro-sec.
root@aman-laptop:~/Desktop/os/test#
```



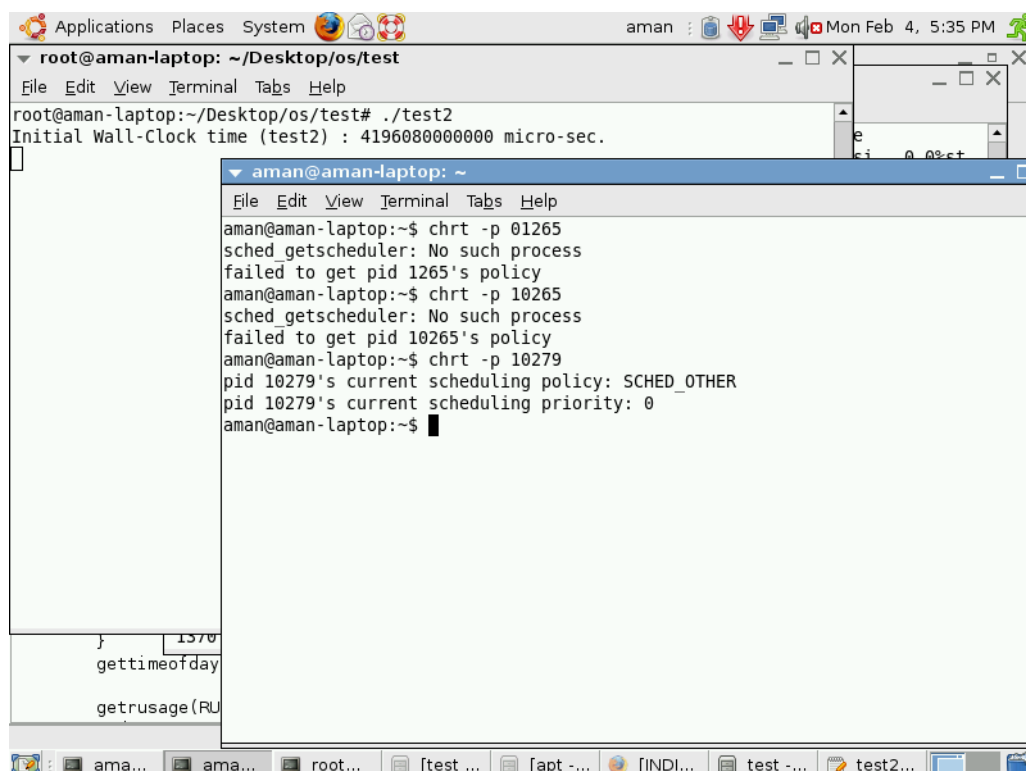
2.) Run your counter as a normal process. Record how long it takes to count.



The screenshot shows a terminal window with the following content:

```
root@aman-laptop: ~/Desktop/os/test
aman@aman-laptop: ~
Tasks: 103 total, 3 running, 100 sleeping, 0 stopped, 0 zombie
Cpu(s): 26.8%us, 0.7%sy, 0.0%ni, 72.6%id, 0.0%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 2063332k total, 769004k used, 1294328k free, 20356k buffers
Swap: 915664k total, 0k used, 915664k free, 402520k cached
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
10279	root	20	0	3728	432	352	R	24.6	0.0	0:00.74	./test2
4699	root	20	0	103m	16m	7548	S	1.7	0.8	0:42.40	/usr/bin/X :0 -br -
10065	aman	20	0	484m	101m	25m	S	0.3	5.0	0:31.31	/usr/lib/firefox-3.
1	root	20	0	4036	876	592	S	0.0	0.0	0:03.20	/sbin/init
2	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kthreadd]
3	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	[migration/0]
4	root	15	-5	0	0	0	S	0.0	0.0	0:00.08	[ksoftirqd/0]
5	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	[watchdog/0]
6	root	15	-5	0	0	0	S	0.0	0.0	0:00.38	[events/0]
7	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[khelper]
39	root	15	-5	0	0	0	S	0.0	0.0	0:00.08	[kblockd/0]
42	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kacpid]
43	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kacpi_notify]
88	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kseriod]
132	root	20	0	0	0	0	S	0.0	0.0	0:00.70	[pdfflush]
133	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kswapd0]
176	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[aio/0]
1356	root	15	-5	0	0	0	S	0.0	0.0	0:10.80	[ata/0]

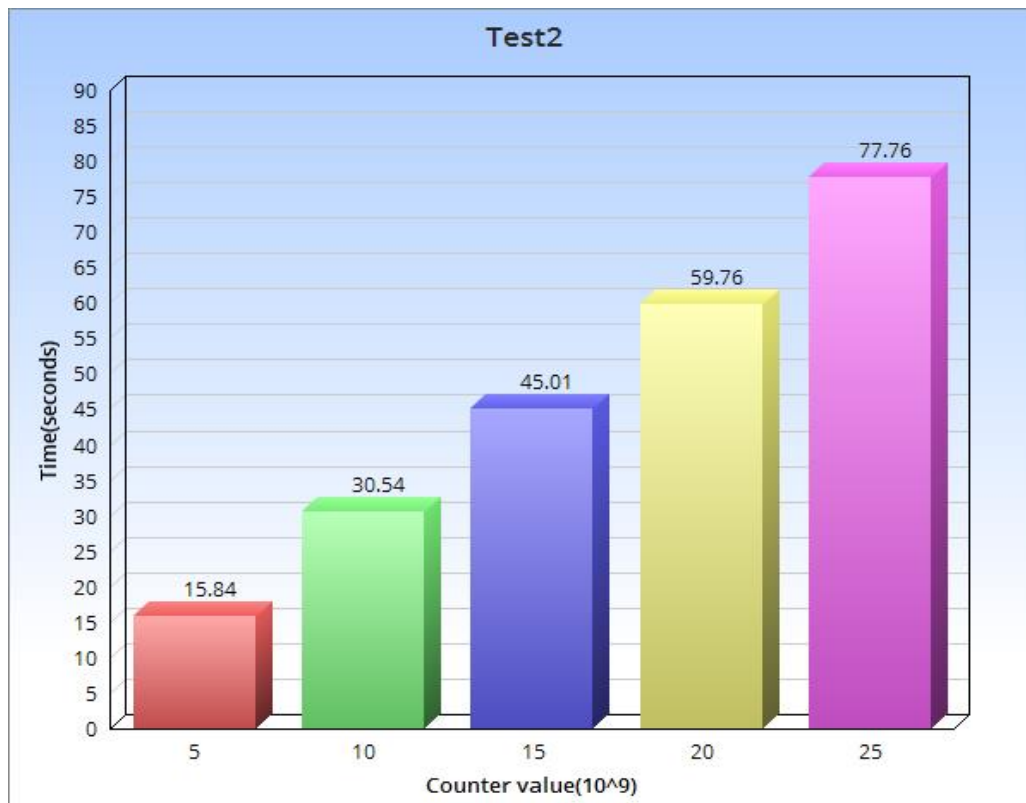


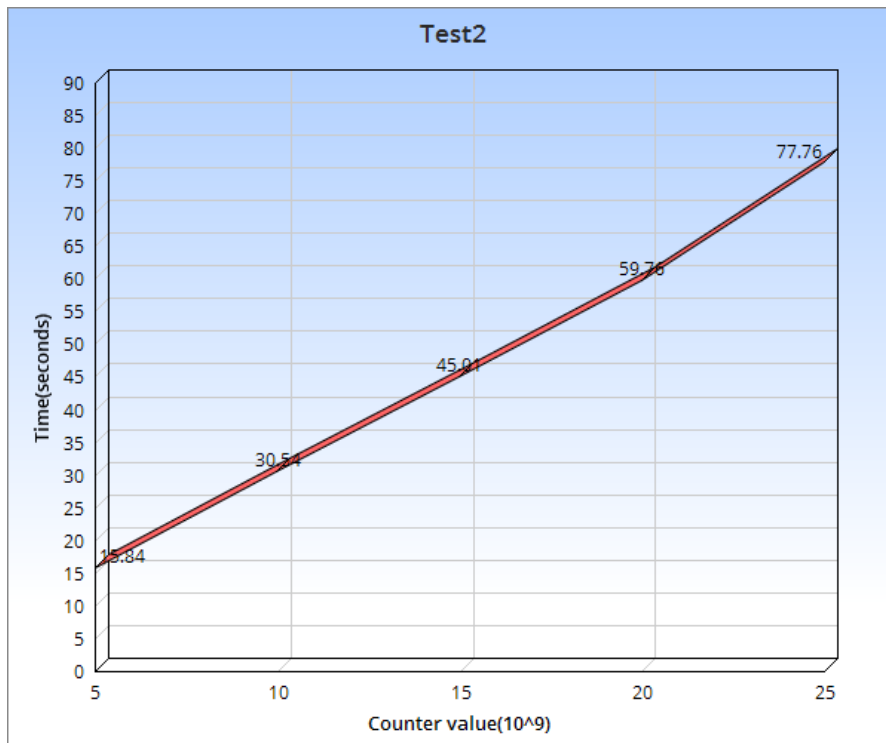
The screenshot shows a terminal window with the following content:

```
root@aman-laptop: ~/Desktop/os/test
aman@aman-laptop: ~
Initial Wall-Clock time (test2) : 4196080000000 micro-sec.
```

```
aman@aman-laptop: ~
aman@aman-laptop:~$ chrt -p 0 10265
sched_getscheduler: No such process
failed to get pid 10265's policy
aman@aman-laptop:~$ chrt -p 10265
sched_getscheduler: No such process
failed to get pid 10265's policy
aman@aman-laptop:~$ chrt -p 10279
pid 10279's current scheduling policy: SCHED_OTHER
pid 10279's current scheduling priority: 0
aman@aman-laptop:~$
```

```
Applications Places System aman Mon Feb 4, 5:35 PM
root@aman-laptop: ~/Desktop/os/test
File Edit View Terminal Tabs Help
root@aman-laptop:~/Desktop/os/test# ./test2
Initial Wall-Clock time (test2) : 4196080000000 micro-sec.
System time (test2) : 4000 micro-sec.
User time (test2) : 15844990 micro-sec.
Final Wall-Clock time (test2) : 1549319721809967 micro-sec.
root@aman-laptop:~/Desktop/os/test#
```





**3.) Run your counter simultaneously with another counter, both as normal processes.
How long does it take to count?**

Applications Places System aman Mon Feb 4, 5:46 PM

root@aman-laptop: ~/Desktop/os/test

aman@aman-laptop: ~

File Edit View Terminal Tabs Help

Tasks: 103 total, 4 running, 99 sleeping, 0 stopped, 0 zombie
Cpu(s): 65.1%us, 0.7%sy, 0.0%ni, 34.2%id, 0.0%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 2063332k total, 697708k used, 1365624k free, 20868k buffers
Swap: 915664k total, 0k used, 915664k free, 407876k cached

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
10484	root	20	0	3728	436	352	R	31.9	0.0	0:00.96	./test2
10485	root	20	0	3728	436	352	R	31.2	0.0	0:00.94	./test3
4699	root	20	0	103m	17m	7392	S	1.0	0.9	0:48.78	/usr/bin/X :0 -br -
4	root	15	-5	0	0	0	S	0.7	0.0	0:00.12	[ksoftirqd/0]
1356	root	15	-5	0	0	0	S	0.7	0.0	0:11.62	[ata/0]
8455	aman	20	0	252m	22m	10m	R	0.7	1.1	0:12.60	gnome-terminal
1	root	20	0	4036	876	592	S	0.0	0.0	0:03.20	/sbin/init
2	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kthreadd]
3	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	[migration/0]
5	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	[watchdog/0]
6	root	15	-5	0	0	0	S	0.0	0.0	0:00.38	[events/0]
7	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[khelper]
39	root	15	-5	0	0	0	S	0.0	0.0	0:00.10	[kblockd/0]
42	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kacpid]
43	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kacpi_notify]
88	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kseriod]
132	root	20	0	0	0	0	S	0.0	0.0	0:00.88	[pdflush]
133	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	[kswapd0]

"test4.sh" selected (149 b

aman@aman-l... aman@aman-l... root@aman-l... test - File Bro... test4.sh (~ /D...

Applications Places System aman Mon Feb 4, 5:47 PM

root@aman-laptop: ~/Desktop/os/test

File Edit View Terminal Tabs Help

root@aman-laptop:~/Desktop/os/test# ./test4.sh
Initial Wall-Clock time (test2) : 4196080000000 micro-sec.
Initial Wall-Clock time (test3) : 4196080000000 micro-sec

aman@aman-laptop: ~

File Edit View Terminal Tabs Help

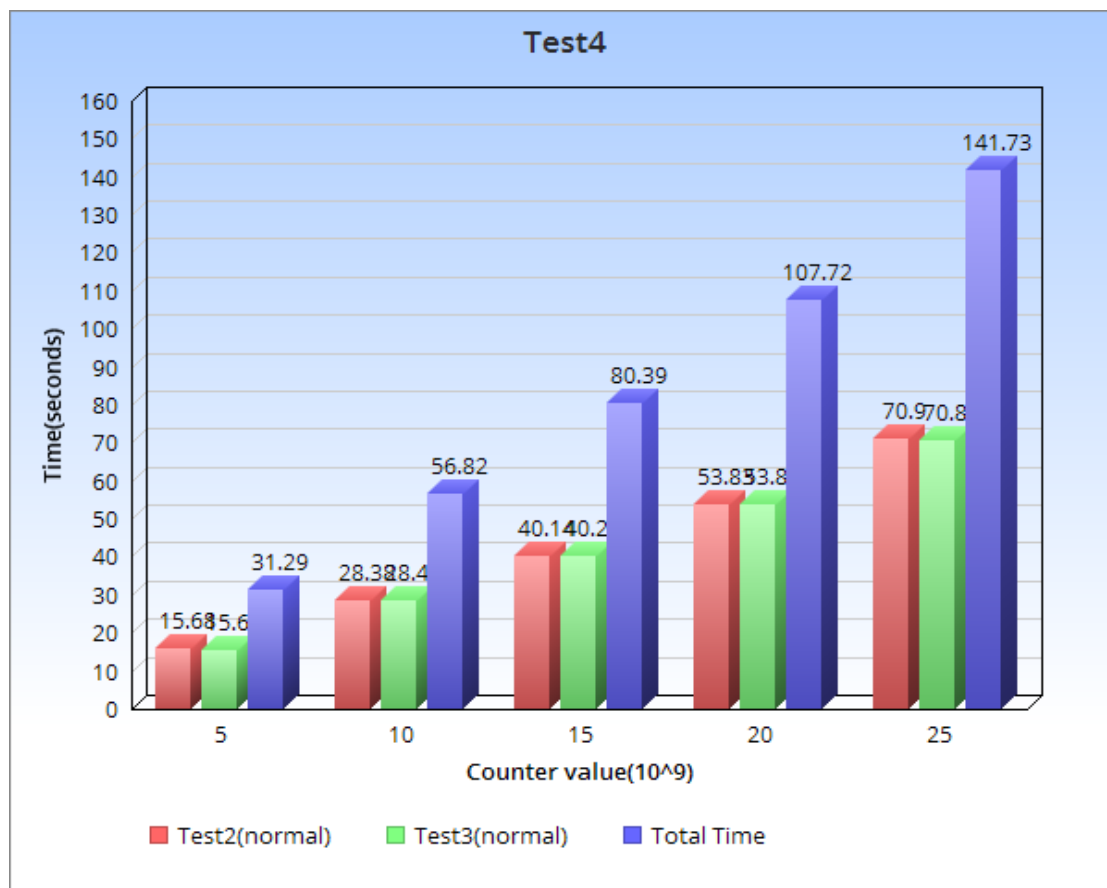
aman@aman-laptop:~\$ chrt -p 10484
pid 10484's current scheduling policy: SCHED_OTHER
pid 10484's current scheduling priority: 0
aman@aman-laptop:~\$ chrt -p 10485
pid 10485's current scheduling policy: SCHED_OTHER
pid 10485's current scheduling priority: 0
aman@aman-laptop:~\$

"test4.sh" selected (149 b

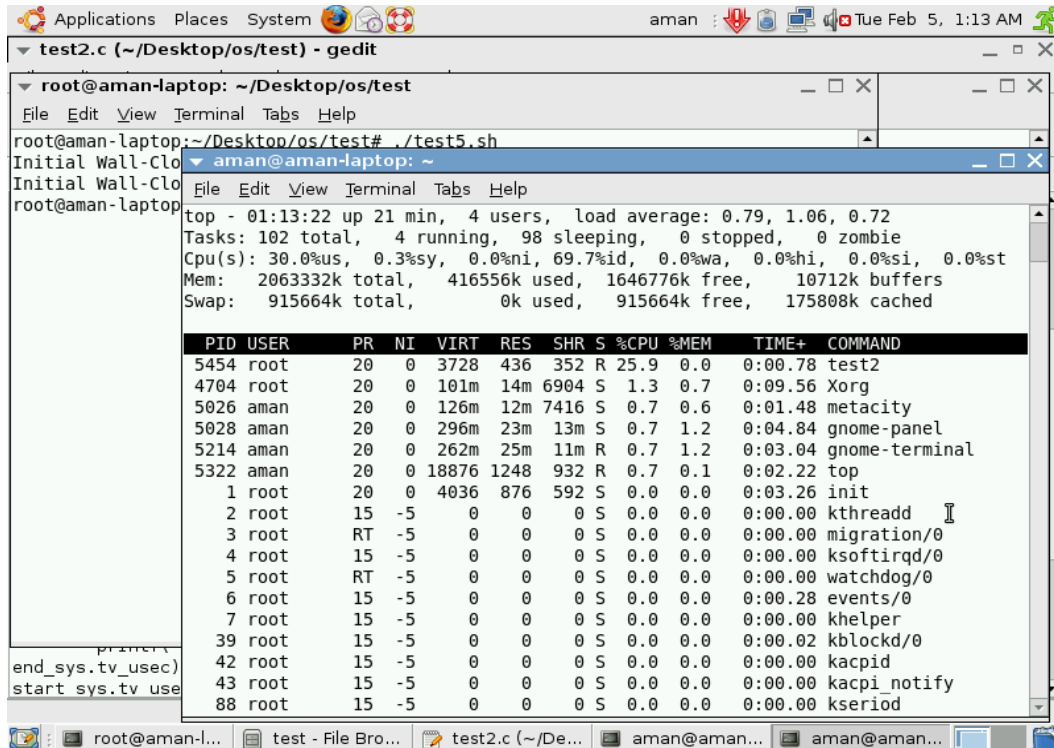
aman@aman-l... aman@aman-l... root@aman-l... test - File Bro... test4.sh (~ /D...

```
Applications Places System aman : Mon Feb 4, 5:51 PM
root@aman-laptop: ~/Desktop/os/test
File Edit View Terminal Tabs Help
root@aman-laptop:~/Desktop/os/test# ./test4.sh
Initial Wall-Clock time (test2) : 4196080000000 micro-sec.
Initial Wall-Clock time (test3) : 4196080000000 micro-sec.
root@aman-laptop:~/Desktop/os/test# System time (test2) : 16001 micro-sec.
User time (test2) : 15616976 micro-sec.
Final Wall-Clock time (test2) : 1549320635301781 micro-sec.
System time (test3) : 4000 micro-sec.
User time (test3) : 15680980 micro-sec.
Final Wall-Clock time (test3) : 1549320635376327 micro-sec.

gettime 1500
getrusage(RU
end_sys = us
```



4.) Run your counter as a SCHED_BACKGROUND process, simultaneously with another counter that is running as a normal process. How long does your SCHED_BACKGROUND process take to count?

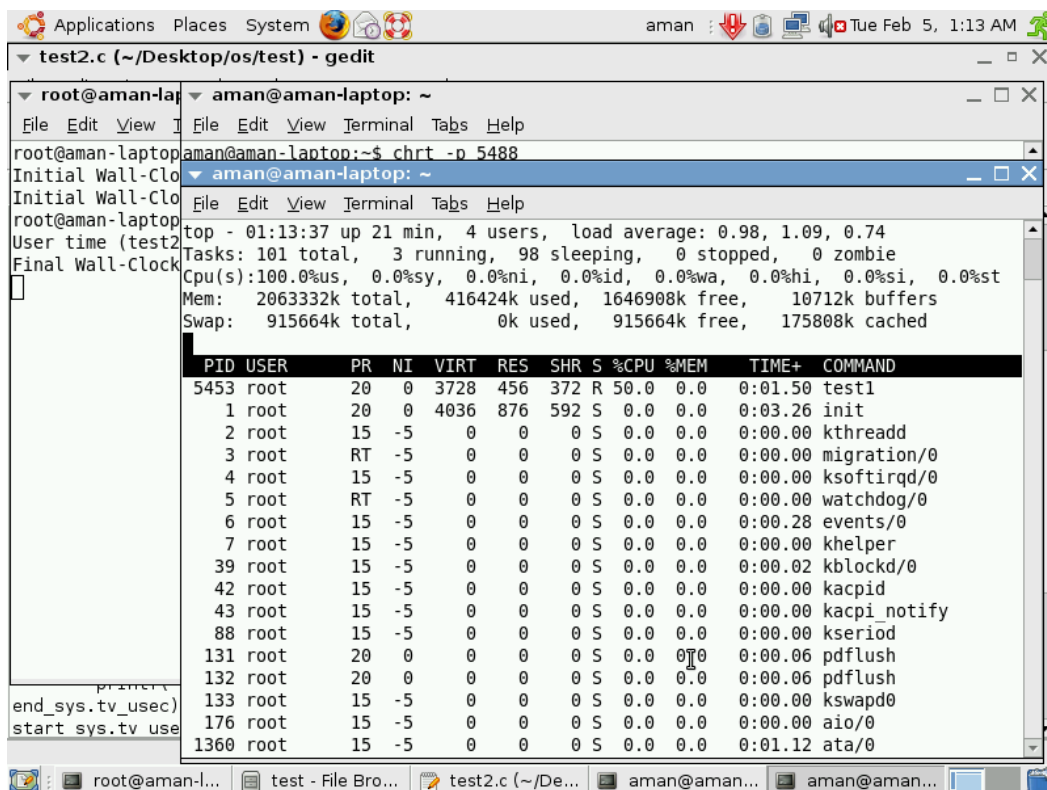


```

root@aman-laptop: ~/Desktop/os/test
File Edit View Terminal Tabs Help
root@aman-laptop:~/Desktop/os/test# ./test5.sh
aman@aman-laptop: ~
File Edit View Terminal Tabs Help
top - 01:13:22 up 21 min, 4 users, load average: 0.79, 1.06, 0.72
Tasks: 102 total, 4 running, 98 sleeping, 0 stopped, 0 zombie
Cpu(s): 30.0%us, 0.3%sy, 0.0%ni, 69.7%id, 0.0%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 2063332k total, 416556k used, 1646776k free, 10712k buffers
Swap: 915664k total, 0k used, 915664k free, 175808k cached

  PID USER      PR  NI  VIRT  RES  SHR  S  %CPU  %MEM    TIME+  COMMAND
 5454 root        20   0  3728  436  352  R  25.9   0.0   0:00.78 test2
 4704 root        20   0 101m 14m 6904  S   1.3   0.7   0:09.56 Xorg
 5026 aman        20   0 126m 12m 7416  S   0.7   0.6   0:01.48 metacity
 5028 aman        20   0 296m 23m 13m   S   0.7   1.2   0:04.84 gnome-panel
 5214 aman        20   0 262m 25m 11m   R   0.7   1.2   0:03.04 gnome-terminal
 5322 aman        20   0 18876 1248 932  R   0.7   0.1   0:02.22 top
    1 root         0   0 4036  876 592  S   0.0   0.0   0:03.26 init
    2 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kthreadd
    3 root        RT  -5     0     0     0  S   0.0   0.0   0:00.00 migration/0
    4 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 ksoftirqd/0
    5 root        RT  -5     0     0     0  S   0.0   0.0   0:00.00 watchdog/0
    6 root        15  -5     0     0     0  S   0.0   0.0   0:00.28 events/0
    7 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 khelper
   39 root        15  -5     0     0     0  S   0.0   0.0   0:00.02 kblockd/0
   42 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kacpid
   43 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kacpi_notify
   88 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kseriod

```



```

root@aman-laptop: ~/Desktop/os/test
File Edit View Terminal Tabs Help
root@aman-laptop:~/Desktop/os/test# ./test5.sh
aman@aman-laptop: ~
File Edit View Terminal Tabs Help
aman@aman-laptop:~$ chrt -p 5488
aman@aman-laptop: ~
File Edit View Terminal Tabs Help
top - 01:13:37 up 21 min, 4 users, load average: 0.98, 1.09, 0.74
Tasks: 101 total, 3 running, 98 sleeping, 0 stopped, 0 zombie
Cpu(s):100.0%us, 0.0%sy, 0.0%ni, 0.0%id, 0.0%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 2063332k total, 416424k used, 1646908k free, 10712k buffers
Swap: 915664k total, 0k used, 915664k free, 175808k cached

  PID USER      PR  NI  VIRT  RES  SHR  S  %CPU  %MEM    TIME+  COMMAND
 5453 root        20   0  3728  456  372  R  50.0   0.0   0:01.50 test1
    1 root         0   0 4036  876 592  S   0.0   0.0   0:03.26 init
    2 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kthreadd
    3 root        RT  -5     0     0     0  S   0.0   0.0   0:00.00 migration/0
    4 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 ksoftirqd/0
    5 root        RT  -5     0     0     0  S   0.0   0.0   0:00.00 watchdog/0
    6 root        15  -5     0     0     0  S   0.0   0.0   0:00.28 events/0
    7 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 khelper
   39 root        15  -5     0     0     0  S   0.0   0.0   0:00.02 kblockd/0
   42 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kacpid
   43 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kacpi_notify
   88 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kseriod
  131 root        20   0     0     0     0  S   0.0   0.0   0:00.06 pdflush
  132 root        20   0     0     0     0  S   0.0   0.0   0:00.06 pdflush
  133 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 kswapd0
  176 root        15  -5     0     0     0  S   0.0   0.0   0:00.00 aio/0
 1360 root        15  -5     0     0     0  S   0.0   0.0   0:01.12 ata/0

```

Applications Places System aman : Tue Feb 5, 1:13 AM

test2.c (~/Desktop/os/test) - gedit

```
root@aman-laptop:~$ chrt -p 5488
Initial Wall-Clock time (test1) : -6926679451640216571 micro-sec.
Initial Wall-Clock time (test2) : 419608000000000 micro-sec.
root@aman-laptop:~$ chrt -p 5447
User time (test2) : 14204887 micro-sec.
Final Wall-Clock time (test2) : 1549347216178771 micro-sec.
System time (test1) : 12000 micro-sec.
User time (test1) : 14708919 micro-sec.
Final Wall-Clock time (test1) : 1549347231051618 micro-sec.
root@aman-laptop:~$ chrt -p 5454
pid 5454's current scheduling policy: SCHED_OTHER
pid 5454's current scheduling priority: 0
aman@aman-laptop:~$ chrt -p 5453
pid 5453's current scheduling policy: SCHED_BACKGROUND
pid 5453's current scheduling priority: 0
aman@aman-laptop:~$
```

end_sys.tv_usec)	start_sys.tv use	priority	pid	uid	gid	cpu	mem	io	net	time	process		
133	176	1360	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kswapd0
			176	root	15	-5	0	0	S	0.0	0.0	0:00.00	aio/0
			1360	root	15	-5	0	0	S	0.0	0.0	0:01.14	ata/0

root@aman-l... test - File Bro... test2.c (~/De... aman@aman... aman@aman...

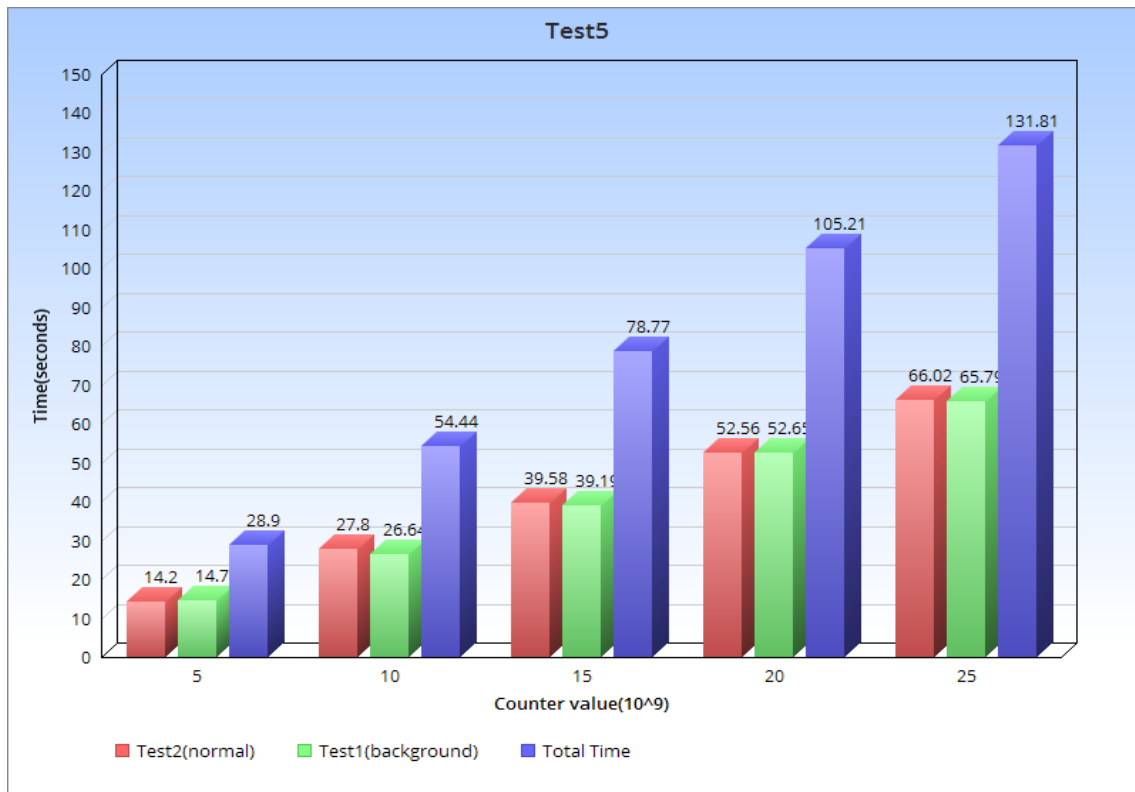
Applications Places System aman : Tue Feb 5, 1:13 AM

test2.c (~/Desktop/os/test) - gedit

```
root@aman-laptop:~/Desktop/os/test# ./test5.sh
Initial Wall-Clock time (test1) : -6926679451640216571 micro-sec.
Initial Wall-Clock time (test2) : 419608000000000 micro-sec.
root@aman-laptop:~/Desktop/os/test# System time (test2) : 4000 micro-sec.
User time (test2) : 14204887 micro-sec.
Final Wall-Clock time (test2) : 1549347216178771 micro-sec.
System time (test1) : 12000 micro-sec.
User time (test1) : 14708919 micro-sec.
Final Wall-Clock time (test1) : 1549347231051618 micro-sec.
root@aman-laptop:~/Desktop/os/test#
```

end_sys.tv_usec)	start_sys.tv use	priority	pid	uid	gid	cpu	mem	io	net	time	process		
133	176	1360	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kswapd0
			176	root	15	-5	0	0	S	0.0	0.0	0:00.00	aio/0
			1360	root	15	-5	0	0	S	0.0	0.0	0:01.14	ata/0

root@aman-l... test - File Bro... test2.c (~/De... aman@aman... aman@aman...



6.) Run your counter as a **SCHED_BACKGROUND** process, simultaneously with another counter that is running using **nice** (do a **man nice** for more information) at the lowest priority. How long does your **SCHED_BACKGROUND** process take to count?

```

aman@aman-laptop: ~
File Edit View Terminal Tabs Help
top - 04:27:46 up 13 min, 4 users, load average: 0.00, 0.03, 0.07
Tasks: 102 total, 3 running, 99 sleeping, 0 stopped, 0 zombie
Cpu(s): 0.7%us, 0.0%sy, 48.2%ni, 49.8%id, 1.3%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 2063332k total, 412728k used, 1650604k free, 10344k buffers
Swap: 915664k total, 0k used, 915664k free, 171852k cached

  PID USER      PR  NI  VIRT  RES  SHR  S %CPU  %MEM    TIME+  COMMAND
 5497 root        39   19 3728   432  352  R 47.2   0.0   0:01.42 test2
 4702 root        20    0 100m   14m 6900  S  0.7   0.7   0:03.60 Xorg
 5013 aman        20    0 119m  5240 2836  S  0.7   0.3   0:00.44 pulseaudio
 5035 aman        20    0 347m   36m  15m  S  0.3   1.8   0:02.43 nautilus
    1 root         0    0 4036   880  592  S  0.0   0.0   0:03.36 init
    2 root        15   -5    0    0    0  S  0.0   0.0   0:00.00 kthreadd
    3 root        RT   -5    0    0    0  S  0.0   0.0   0:00.00 migration/0
    4 root        15   -5    0    0    0  S  0.0   0.0   0:00.00 ksoftirqd/0
    5 root        RT   -5    0    0    0  S  0.0   0.0   0:00.00 watchdog/0
    6 root        15   -5    0    0    0  S  0.0   0.0   0:00.16 events/0
    7 root        15   -5    0    0    0  S  0.0   0.0   0:00.00 khelper
   39 root        15   -5    0    0    0  S  0.0   0.0   0:00.00 kblockd/0
   42 root        15   -5    0    0    0  S  0.0   0.0   0:00.00 kacpid
   43 root        15   -5    0    0    0  S  0.0   0.0   0:00.00 kacpi_notify
   88 root        15   -5    0    0    0  S  0.0   0.0   0:00.00 kseriod
  131 root        20    0    0    0    0  S  0.0   0.0   0:00.00 pdflush
  132 root        20    0    0    0    0  S  0.0   0.0   0:00.02 pdflush
  
```


Applications Places System aman : Tue Feb 5, 4:27 AM

```
aman@aman-laptop: ~  
File Edit View Terminal Tabs Help  
top - 04:27:55 up 14 min, 4 users, load average: 0.15, 0.07, 0.08  
Tasks: 103 total, 3 running, 100 sleeping, 0 stopped, 0 zombie  
Cpu(s): 0.7%u 0.0%sy 0.0%ni 0.0%id 0.0%wa 0.0%st 0.0%hi 0.0%si 0.0%st  
Mem: 2063332  
Swap: 915664  
PID USER  
5497 root  
5202 aman  
1 root  
2 root  
3 root  
4 root  
5 root  
6 root  
7 root  
39 root  
42 root  
43 root  
88 root  
131 root  
132 root  
133 root  
176 root
```

aman@aman-laptop:~\$ chrt -p 5497
pid 5497's current scheduling policy: SCHED_OTHER
pid 5497's current scheduling priority: 0
aman@aman-laptop:~\$

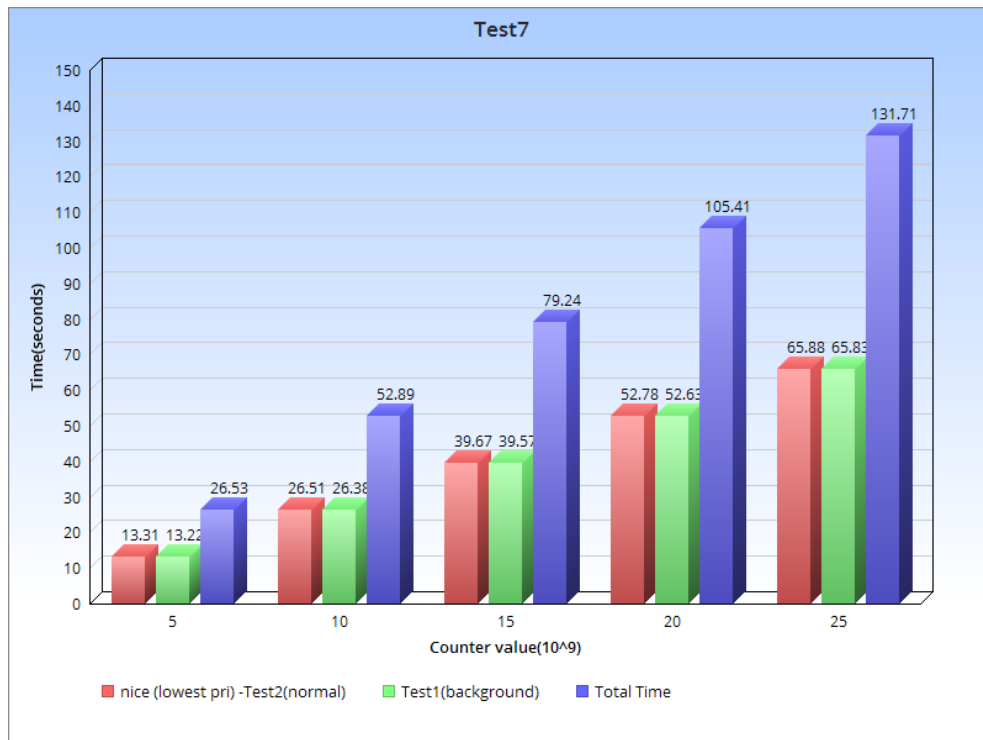
root@aman-l... [test - File Br... [test7.sh (~/... aman@aman... aman@aman...

Applications Places System aman : Tue Feb 5, 4:30 AM

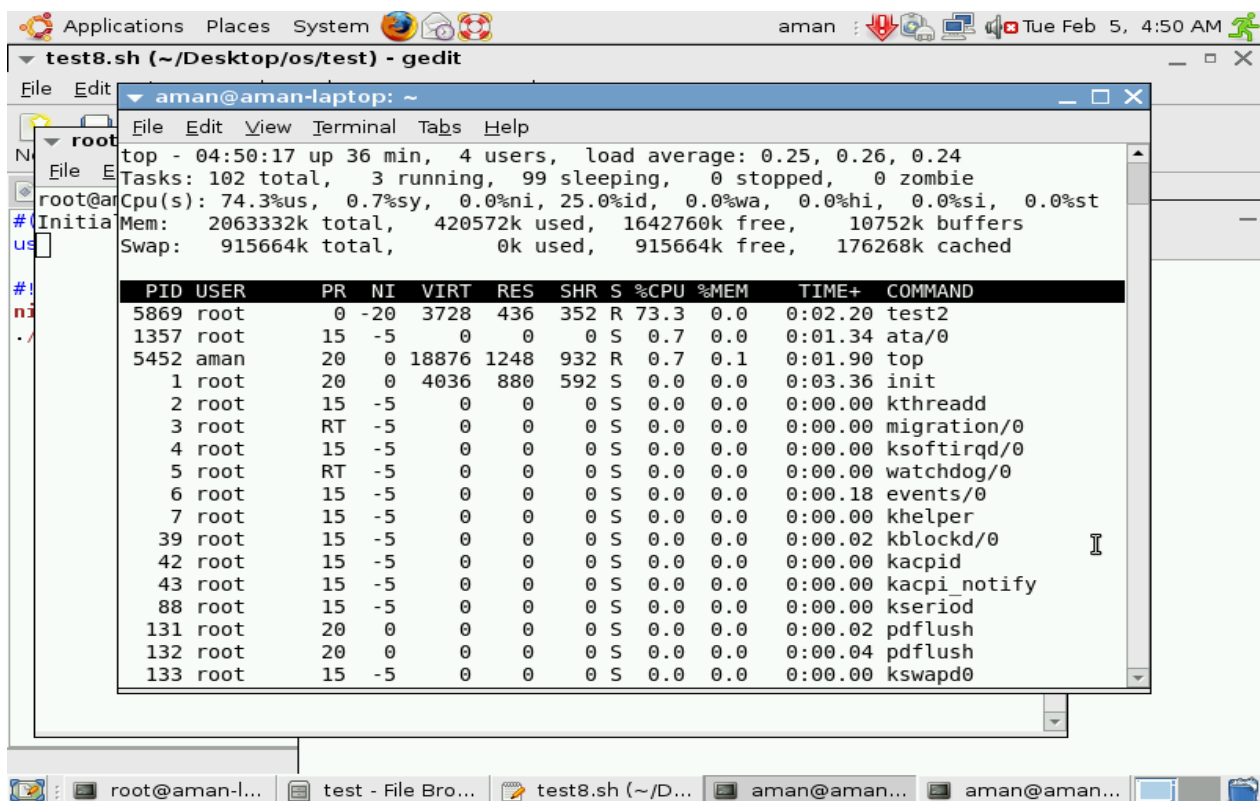
```
test7.sh (~/Desktop/os/test) - gedit  
File Edit View Search Tools Documents Help  
root@aman-laptop: ~/Desktop/os/test  
File Edit View Terminal Tabs Help  
aman@aman-laptop:~$ sudo /bin/bash  
[sudo] password for aman:  
root@aman-laptop:~# cd Desktop/os/test  
root@aman-laptop:~/Desktop/os/test# ./test7.sh  
Initial Wall-Clock time (test2) : 4196080000000 micro-sec.  
System time (test2) : 4000 micro-sec.  
User time (test2) : 13312832 micro-sec.  
Final Wall-Clock time (test2) : 1549358878597643 micro-sec.  
Initial Wall-Clock time (test1) : -7281468991480216571 micro-sec.  
root@aman-laptop:~/Desktop/os/test# System time (test1) : 20001 micro-sec.  
User time (test1) : 13224826 micro-sec.  
Final Wall-Clock time (test1) : 1549358891893632 micro-sec.  
root@aman-laptop:~/Desktop/os/test#
```

Ln 1, Col 1 INS

root@aman-l... [test - File Br... test7.sh (~/D... aman@aman... aman@aman...



7.) Run your counter as a **SCHED_BACKGROUND** process, simultaneously with another counter that is running using **nice** at the highest priority (you will need to use **sudo** to do this). How long does your **SCHED_BACKGROUND** process take to count?



Applications Places System aman Tue Feb 5, 4:50 AM

test8.sh (~/Desktop/os/test) - gedit

aman@aman-laptop: ~

```
File Edit View Terminal Tabs Help
top - 04:50:32 up 36 min, 4 users, load average: 0.41, 0.30, 0.25
Tasks: 101 total, 4 running, 97 sleeping, 0 stopped, 0 zombie
Cpu(s): 99.7%us, 0.3%sy, 0.0%ni, 0.0%id, 0.0%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 2063332k total, 419448k used, 1643884k free, 10752k buffers
System Swap: 915664k total, 0k used, 915664k free, 176268k cached
User t
#Final V
niInitia
./root@ar
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
5873	root	20	0	3728	456	372	R	98.0	0.0	0:03.80	test1
4702	root	20	0	100m	14m	6900	S	0.7	0.7	0:06.34	Xorg
1	root	20	0	4036	880	592	S	0.0	0.0	0:03.36	init
2	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kthreadd
3	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	migration/0
4	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	ksoftirqd/0
5	root	RT	-5	0	0	0	S	0.0	0.0	0:00.00	watchdog/0
6	root	15	-5	0	0	0	S	0.0	0.0	0:00.18	events/0
7	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	khelper
39	root	15	-5	0	0	0	S	0.0	0.0	0:00.02	kblockd/0
42	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kacpid
43	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kacpi_notify
88	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kseriod
131	root	20	0	0	0	0	S	0.0	0.0	0:00.02	pdflush
132	root	20	0	0	0	0	S	0.0	0.0	0:00.04	pdflush
133	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	kswapd0
176	root	15	-5	0	0	0	S	0.0	0.0	0:00.00	aio/0

root@aman-l... test - File Bro... test8.sh (~/D... aman@aman... aman@aman...

Applications Places System aman Tue Feb 5, 4:50 AM

test8.sh (~/Desktop/os/test) - gedit

aman@aman-laptop: ~

```
File Edit View Terminal Tabs Help
top - 04:50:41 up 36 min, 4 users, load average: 0.50, 0.32, 0.26
Tasks: 101 total, 3 running, 98 sleeping, 0 stopped, 0 zombie
Cpu(s): 100.0%us, 0.0%sy, 0.0%ni, 0.0%id, 0.0%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 2063332k total, 419448k used, 1643884k free, 10752k buffers
System Swap: 915664k total, 0k used, 915664k free, 176268k cached
User t
#Final V
niInitia
./root@ar
```

aman@aman-laptop: ~

```
File Edit View Terminal Tabs Help
aman@aman-laptop:~$ chrt -p 5869
pid 5869's current scheduling policy: SCHED_OTHER
pid 5869's current scheduling priority: 0
aman@aman-laptop:~$ chrt -p 5873
pid 5873's current scheduling policy: SCHED_BACKGROUND
pid 5873's current scheduling priority: 0
aman@aman-laptop:~$
```

PID	USER
5873	root
1373	root
1	root
2	root
3	root
4	root
5	root
6	root
7	root
39	root
42	root
43	root
88	root
131	root
132	root
133	root
176	root

root@aman-l... test - File Bro... test8.sh (~/D... aman@aman... aman@aman...

Applications Places System aman Tue Feb 5, 4:52 AM

test2.c (~/Desktop/os/test) - gedit

File Edit View Search Tools Documents Help

root@aman-laptop: ~/Desktop/os/test

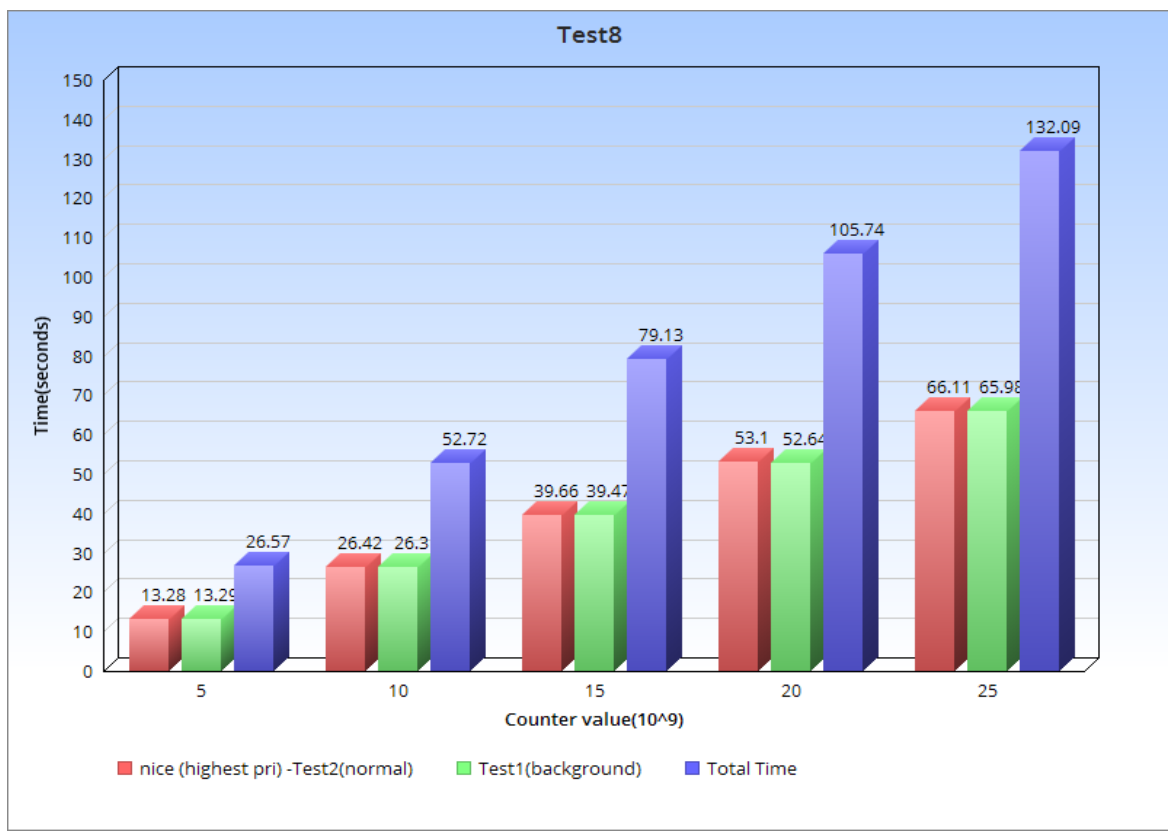
File Edit View Terminal Tabs Help

```
root@aman-laptop:~/Desktop/os/test# ./test8.sh
Initial Wall-Clock time (test2) : 4196080000000 micro-sec.
System time (test2) : 4000 micro-sec.
User time (test2) : 13280830 micro-sec.
Final Wall-Clock time (test2) : 1549360228476369 micro-sec.
Initial Wall-Clock time (test1) : -7730903451640216571 micro-sec.
root@aman-laptop:~/Desktop/os/test# System time (test1) : 0 micro-sec.
User time (test1) : 13292830 micro-sec.
Final Wall-Clock time (test1) : 1549360241854861 micro-sec.

root@aman-laptop:~/Desktop/os/test#
```

Ln 24, Col 23 INS

root@aman-l... test - File Bro... test2.c (~/De... aman@aman... aman@aman...



REFERENCES :-

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- <https://stackoverflow.com/>
- <https://www.howtoforge.com/linux-nice-command/>
- <https://manpages.ubuntu.com/manpages/trusty/man1/nice.1.html?fbclid=IwAR27dh0uwOjBRHyAhvOSMcTmmfFjXbrU0JFyhudWCzoxrxAiZEahEnhVrFE>
- <https://unix.stackexchange.com/questions/397567/kernel-beginner-getting-kernel-source-code-ubuntu?fbclid=IwAR0vc15xJ1wgJvigZ3801u1dK3AGOUVaz3liYNYwBkODNUauOyrOtc91aE>
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