OPERATING SYSTEMS

PROJECT REPORT

REAL-TIME RESOURCE MONITOR FOR LINUX

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Abstract

Following is the brief report of the Operating System course project titled Real-Time Resource Monitor For Linux. What interested us in choosing this project is that we wanted to explore all the important available resources in a linux environment and how to access them using linux commands and other packages. By the end of the project we were able to categorize the chosen resources into six groups and show the information of these resources in a user interactive real time resource monitor.

Problem Statement

To create a real-time user interactive application for Linux that will monitor CPU usage & Memory utilization, I/O devices status, Disk usage, Process,Network monitoring & Hardware information

Methodology

We have implemented our program in **c++** with the help of commands that are available in linux and a python library **"psutil"** . The program is **user interactive** and provides the user all the steps that he can take. On the first window, there are options for **CPU, Memory, Network, Process, Hardware, Others**. Each functionality has its sub-functionality. The CPU window has options like Info, Usage, Temperature. Hardware has its

sub-functionalities as System information, CPU, Graphics, Sensors, Drivers, Network. All these functionalities have separate scripts for their execution some of them are in python and some in the form of linux internal commands. For execution of the script we have used the exec classes of functions, specially **execvp** as we have eliminated the dependency of path of the scripts while running by using relative paths for the execution of the scripts. We have used fork for handling multiple processes during running of the program so that all the scripts can run in parallel and for the data sharing between different processes we have used **pipe** functionality. We have **dupped** the input and output to the pipe so that different processes can use each other's result. There are different folders for each of the scripts so that the code can be modular and we can add more functionalities in the future. We have also implemented the **live utilization script** for network speed, CPU utilization, Ram utilization. This was implemented using current utilization and proportionately matching the number of bars in the bar so that the utilized unit can be shown with the same number of units.

So we have a main file that is resource_monitor.cpp then we have different sub-folders for each of the functionalities each for CPU, Memory, Processes, Hardware, Network. In each of the sub folders there are python scripts dedicated to the each of the functions for example for showing of live utilization of CPU, Memory utilization etc.We have scripts for CPU info ,CPU usage, CPU temperatures, Memory utilization, Memory info, Disk info, CPU intensive processes, Memory intensive processes, Stopped processes, Sleeping processes, Sensors information, Network information, Network speed test etc.

We have functions for script execution in which we are using execvp functions for executing the script with relative path, so that it can run on any machine. For running two processes in parallel we have created child processes and also pipe. We have dupped the input and output to the read and write end of the pipe so that if one process writes to the output that information is written on the write end of the pipe so that later other processes can use read end of the pipe to get the required information. This has been used extensively in our program as there are various instances when data of one process is needed by the other process for further processing.

Components of the final submission zip file

- Code folder which contains:
  - resource_monitor.cpp {main code file}
  - Headers folder
  - CPU folder
  - Hardware folder
  - Memory folder
  - Processes folder
  - Network folder
  - Others folder
- Readme file which shows how to run the code
- Final report which contains the outputs

Prerequisites to run the code

All the prerequisites are in the readme file. Mainly our program is for linux(ubuntu).

How to run the code

Run the following commands in the terminal

g++ resource_monitor.cpp

*./a.out*

Then an interactive chat session will open which will ask numbers from 1 to 6 based on the choice of resource category that we want the information for. Sub sections will open under each category. Choose relevant numbers for the relevant information. Press **back** to go back at any stage. Press **exit** to exit the session.

For exiting from the live utilization window that is for CPU usage and Memory usage programs, press ***ctrl + c***

For detailed information check the readme file.

Flow chart of the components of the output
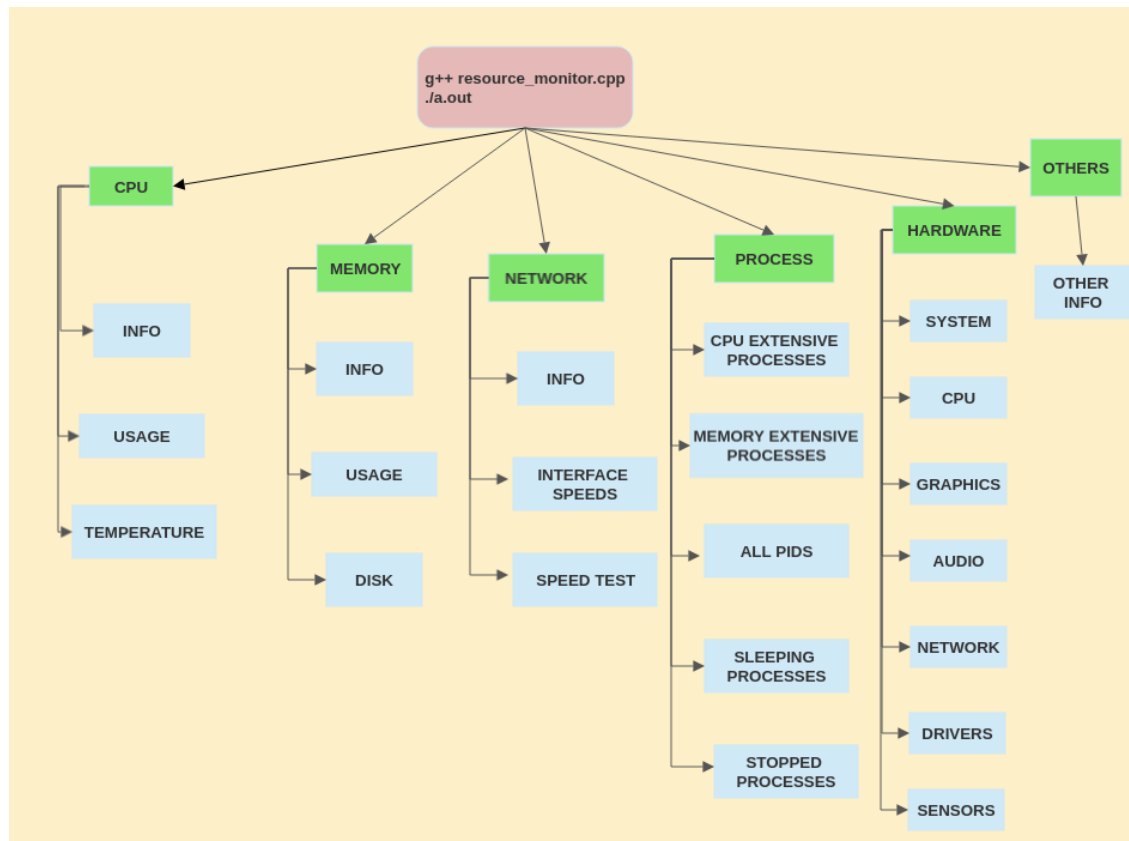
Outcome

After executing the code:

```
1. CPU
2. Memory
3. Network
4. Process
5. Hardware
6. Other
Enter exit to close the program

Enter the command :
```

For CPU:

- For info:

```
Cpu info :

No of CPU - 2
No of context switches - 2150493
No of interrupts - 533546
No of soft interrupts - 304441
Current frequency of CPU - 2303.997
Max frequency of CPU - 0.0
Min frequency of CPU - 0.0
```

- For usage:

```
CPU usage :

The CPU times for all the current CPUs:
[scputimes(user=385.8, nice=41.11, system=416.64, idle=9818.36, iowait=116.9, irq=0.0, softirq=47.43, steal=0.0, guest=0.0, guest_nice=0.0), scputimes(us
er=371.31, nice=42.0, system=423.0, idle=9828.77, iowait=116.22, irq=0.0, softirq=47.51, steal=0.0, guest=0.0, guest_nice=0.0), scputimes(user=330.73, ni
ce=31.0, system=366.34, idle=9610.52, iowait=27.54, irq=0.0, softirq=293.76, steal=0.0, guest=0.0, guest_nice=0.0), scputimes(user=185.37, nice=5.98, sys
tem=494.24, idle=9799.01, iowait=122.51, irq=0.0, softirq=98.24, steal=0.0, guest=0.0, guest_nice=0.0)]
```

```
Average CPU usage percentage -
15.1


Each CPU core usage :-
CORE_1: 13.2%
CORE_2: 19.8%
CORE_3: 9.6%
CORE_4: 12.4%


Real time CPU Usage :
CPU Usage: |*******************************************-------- | 84.90%
```

- For temperature:

```
CPU temperature :

BAT0-acpi-0
Adapter: ACPI interface
in0:          10.00 V
```

For memory:

- For info:
```

```
Memory info

Cached:           1373936 kB
SwapCached:             0 kB
Dirty:                556 kB
Writeback:              0 kB
WritebackTmp:           0 kB
KernelStack:        13948 kB
PageTables:         23716 kB
Percpu:            125952 kB
```

- For usage:

```
Memory usage

[sudo] password for shubham:
Primary Memory

Total Memory :  1.4973907470703125 GB
Total Used Memory :   0.9242630004882812 GB
Total Available Memory :   0.319610595703125 GB
percent_used memory:  78.7

swap Memory

Total Swap Memory :   1.144500732421875 GB
Total Used swap Memory :   0.9468116760253906 GB
Total Available swap Memory :   0.19768905639648438 GB
percent_used swap memory :   82.7
Bytes swapped in :  1240969216
Bytes swapped out :  3270955008
Mem Usage: |****************************************---------- | 78.50%
```

- For disk:

```
Enter the command : 5
Disk Usage

Disk Partitions :-
[sdiskpart(device='/dev/sda3', mountpoint='/', fstype='ext4', opts='rw,relatime,errors=remount-ro', maxfile=255, maxpath=4096), sdiskpart(device='/dev/lo
op1', mountpoint='/snap/bare/5', fstype='squashfs', opts='ro,nodev,relatime,errors=continue', maxfile=256, maxpath=4096), sdiskpart(device='/dev/loop0',
mountpoint='/snap/code/113', fstype='squashfs', opts='ro,nodev,relatime,errors=continue', maxfile=256, maxpath=4096), sdiskpart(device='/dev/loop2', moun
tpoint='/snap/code/112', fstype='squashfs', opts='ro,nodev,relatime,errors=continue', maxfile=256, maxpath=4096), sdiskpart(device='/dev/loop3', mountpoi
nt='/snap/core/13886', fstype='squashfs', opts='ro,nodev,relatime,errors=continue', maxfile=256, maxpath=4096), sdiskpart(device='/dev/loop5', mountpoint
```

```
I/O Data :-
The number of reads performed -  452158
The number of writes performed -  160331
The number of bytes read from disk -  13064888320
The number of bytes written to the disk -  5251466240
The time spent reading from a disk in seconds -  1363.091
The time spent writing to a disk in seconds -  1539.974
The time spent doing actual I/Os operations in seconds -  935.84

Total disk space -  24.140636444091797  GB
Total Used disk space -  15.701892852783203  GB
Total free disk space -  7.188304901123047  GB
Percentage of disk space free -  31.400000000000006 %
```

For network:

- For info:

```
number of bytes sent -  84290482
number of bytes received -  61758522
number of packets sent -  70505
number of packets received -  98592
total number of errors while receiving -  0
total number of errors while sending -  0
total number of incoming packets which were dropped -  0
total number of outgoing packets which were dropped -  0
```

- For network speeds:

```
The speeds of all network interface card are:
lo  :  0  mega bits
enp0s3  :  1000  mega bits
docker0  :  0  mega bits
```

- For speed test:

```
Retrieving speedtest.net configuration...
Testing from Power Grid Corporation of India Limited (220.158.144.58)...
Retrieving speedtest.net server list...
Selecting best server based on ping...
Hosted by SDH Network P. Ltd. (New Delhi) [491.12 km]: 64.445 ms
Testing download speed................................................................................
Download: 87.94 Mbit/s
Testing upload speed..................................................................................
Upload: 78.59 Mbit/s
```

For processes:

- For cpu intensive processes:

```
Top 10 CPU extensive perocesse are :-
Processes:
  CPU top: 10 of 305
  1: cpu: 25.8% command: firefox pid: 2368
  2: cpu: 15.5% command: firefox pid: 3276
  3: cpu: 8.0% command: gnome-shell pid: 1857
  4: cpu: 3.3% command: xwayland pid: 2198
  5: cpu: 1.3% command: systemd-hostnamed pid: 4092
  6: cpu: 0.8% command: firefox pid: 3335
  7: cpu: 0.7% command: pulseaudio pid: 1699
  8: cpu: 0.7% command: gnome-terminal-server pid: 3532
  9: cpu: 0.5% command: firefox pid: 2555
  10: cpu: 0.4% command: firefox pid: 3367
```

- For memory intensive processes:

```
Top 10 Memory extensive perocesse are :-
Processes:
  System RAM: total: 3.8 GiB used: 2.32 GiB (61.0%)
  Memory top: 10 of 306
  1: mem: 499.8 MiB (12.8%) command: firefox pid: 2368
  2: mem: 446.5 MiB (11.4%) command: firefox pid: 3276
  3: mem: 253.6 MiB (6.5%) command: gnome-shell pid: 1857
  4: mem: 163.0 MiB (4.1%) command: firefox pid: 3335
  5: mem: 130.3 MiB (3.3%) command: firefox pid: 3367
  6: mem: 109.5 MiB (2.8%) command: firefox pid: 2555
  7: mem: 91.5 MiB (2.3%) command: xwayland pid: 2198
  8: mem: 87.2 MiB (2.2%) command: firefox pid: 2767
  9: mem: 79.5 MiB (2.0%) command: nautilus pid: 3484
  10: mem: 66.3 MiB (1.7%) command: gsd-xsettings pid: 2258
```

- For all processes pids:

```
All the pids of all the processes are :-
[1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 81, 82, 83, 84, 85, 86, 87, 88, 89, 91, 93, 94, 96, 97, 98, 99, 100, 101,
102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 131, 132, 133, 134, 136, 137, 138, 150, 15
3, 154, 159, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 215, 217, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239,
240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 288, 290, 294, 295, 319, 320, 360, 388, 396
, 404, 405, 406, 407, 408, 409, 412, 413, 414, 415, 423, 589, 611, 700, 701, 702, 704, 705, 790, 796, 848, 849, 852, 853, 854, 855, 858, 866, 874, 876, 881, 889, 893, 897, 899, 900, 9
01, 924, 946, 957, 997, 1013, 1061, 1064, 1066, 1122, 1213, 1271, 1436, 1682, 1689, 1690, 1696, 1697, 1699, 1700, 1703, 1711, 1718, 1728, 1738, 1741, 1747, 1759, 1762, 1781, 1812, 182
6, 1831, 1834, 1847, 1852, 1857, 1860, 1867, 1883, 1893, 1901, 1906, 1946, 1952, 1960, 1964, 1972, 1975, 1986, 2002, 2008, 2010, 2023, 2030, 2032, 2035, 2040, 2044, 2047, 2050, 2052,
2053, 2058, 2061, 2064, 2070, 2076, 2078, 2082, 2088, 2090, 2094, 2117, 2132, 2152, 2198, 2199, 2208, 2222, 2255, 2258, 2304, 2323, 2368, 2494, 2539, 2555, 2618, 2767, 3276, 3335, 336
7, 3415, 3434, 3467, 3484, 3532, 3550, 3728, 3758, 3812, 3845, 3862, 3871, 3877, 3920, 3948, 3952, 4102, 4103, 4138]
Process
```

- For sleeping processes:

```
Processes sleeping with respective pids are:
[(1, {'name': 'systemd', 'status': 'sleeping'}),
 (2, {'name': 'kthreadd', 'status': 'sleeping'}),
 (11, {'name': 'rcu_tasks_rude_', 'status': 'sleeping'}),
 (12, {'name': 'rcu_tasks_trace', 'status': 'sleeping'}),
 (13, {'name': 'ksoftirqd/0', 'status': 'sleeping'}),
 (15, {'name': 'migration/0', 'status': 'sleeping'}),
 (16, {'name': 'idle_inject/0', 'status': 'sleeping'}),
 (18, {'name': 'cpuhp/0', 'status': 'sleeping'}),
 (19, {'name': 'cpuhp/1', 'status': 'sleeping'}),
 (20, {'name': 'idle_inject/1', 'status': 'sleeping'}),
 (21, {'name': 'migration/1', 'status': 'sleeping'}),
 (22, {'name': 'ksoftirqd/1', 'status': 'sleeping'}),
 (25, {'name': 'kdevtmpfs', 'status': 'sleeping'}),
 (27, {'name': 'kauditd', 'status': 'sleeping'}),
 (29, {'name': 'khungtaskd', 'status': 'sleeping'}),
 (30, {'name': 'oom_reaper', 'status': 'sleeping'}),
 (32, {'name': 'kcompactd0', 'status': 'sleeping'}),
 (33, {'name': 'ksmd', 'status': 'sleeping'}),
 (34, {'name': 'khugepaged', 'status': 'sleeping'}),
 (89, {'name': 'watchdogd', 'status': 'sleeping'}),
 (93, {'name': 'kswapd0', 'status': 'sleeping'}),
 (94, {'name': 'ecryptfs-kthrea', 'status': 'sleeping'}),
 (97, {'name': 'irq/24-pciehp', 'status': 'sleeping'}),
 (98, {'name': 'irq/25-pciehp', 'status': 'sleeping'}),
 (99, {'name': 'irq/26-pciehp', 'status': 'sleeping'}),
 (100, {'name': 'irq/27-pciehp', 'status': 'sleeping'}),
 (101, {'name': 'irq/28-pciehp', 'status': 'sleeping'}),
 (102, {'name': 'irq/29-pciehp', 'status': 'sleeping'}),
 (103, {'name': 'irq/30-pciehp', 'status': 'sleeping'}),
 (104, {'name': 'irq/31-pciehp', 'status': 'sleeping'}),
 (105, {'name': 'irq/32-pciehp', 'status': 'sleeping'}),
 (106, {'name': 'irq/33-pciehp', 'status': 'sleeping'}),
 (107, {'name': 'irq/34-pciehp', 'status': 'sleeping'}),
 (108, {'name': 'irq/35-pciehp', 'status': 'sleeping'}),
 (109, {'name': 'irq/36-pciehp', 'status': 'sleeping'}),
 (110, {'name': 'irq/37-pciehp', 'status': 'sleeping'}),
 (111, {'name': 'irq/38-pciehp', 'status': 'sleeping'}),
 (112, {'name': 'irq/39-pciehp', 'status': 'sleeping'}),
 (113, {'name': 'irq/40-pciehp', 'status': 'sleeping'}),
 (114, {'name': 'irq/41-pciehp', 'status': 'sleeping'}),
 (115, {'name': 'irq/42-pciehp', 'status': 'sleeping'}),
 (116, {'name': 'irq/43-pciehp', 'status': 'sleeping'}),
 (117, {'name': 'irq/44-pciehp', 'status': 'sleeping'}),
```

- For stopped processes:

```
Processes stopped with respective pids are:
[]
None
```

For Hardware:

- For system:

```
System:
  Host: veda Kernel: 5.15.0-53-generic x86_64 bits: 64 Desktop: GNOME 42.2
    Distro: Ubuntu 22.04.1 LTS (Jammy Jellyfish)
```

- For cpu:

```
CPU:
  Info: 2x 1-core model: Intel Core i7-10510U bits: 64 type: SMP cache:
    L2: 2x 256 KiB (512 KiB)
  Speed (MHz): avg: 2304 min/max: N/A cores: 1: 2304 2: 2304
```

- For graphics:

```
Graphics:
  Device-1: VMware SVGA II Adapter driver: vmwgfx v: 2.19.0.0
  Display: wayland server: X.Org v: 1.22.1.1 with: Xwayland v: 22.1.1
    compositor: gnome-shell v: 42.2 driver: gpu: vmwgfx
    resolution: 1920x1080~60Hz
  OpenGL: renderer: SVGA3D; build: RELEASE; LLVM; v: 4.1 Mesa 22.0.5
```

- For audio:

```
Audio:
  Device-1: Ensoniq ES1371/ES1373 / Creative Labs CT2518 driver: snd_ens1371
  Sound Server-1: ALSA v: k5.15.0-53-generic running: yes
  Sound Server-2: PulseAudio v: 15.99.1 running: yes
  Sound Server-3: PipeWire v: 0.3.48 running: yes
```

- For network:

```
Network:
  Device-1: Intel 82371AB/EB/MB PIIX4 ACPI type: network bridge driver: N/A
  Device-2: Intel 82545EM Gigabit Ethernet driver: e1000
```

- For drivers:

```
Drives:
  Local Storage: total: 20 GiB used: 11.36 GiB (56.8%)
  ID-1: /dev/sda vendor: VMware model: Virtual S size: 20 GiB
```

- For sensors:

```
Sensors:
    Message: No sensor data found. Is lm-sensors configured?
```

For others:

```
Other Info :-
User :-  shubham
Terminal :-  tty2
Host :-  tty2
PID of login process :-  1998
The system boot time expressed in seconds since the epoch :-  1669619366.0 seconds
Time of start of system :-  2022-11-28 12:39:26
Sensors Temperatures :-
{}

Fan sensor :-
{}

Battery :-
Percent 54.0
Seconds left BatteryTime.POWER_TIME_UNKNOWN
Power plugged :-  False
```

Contributions

All the team members Tanisha, Shubham and Veda contributed to the project putting in equal efforts. We started by researching the various available resources and the information that we can collect. Then we divided them into 6 main categories and sub parts. Then we gathered the linux commands to get the resource information. For a few resources we used python packages like psutil, etc. For each category, we wrote the code for the functions which showed the required information. We then coded the data structure of the chat session which is interactive and real-time based.

What we learnt in the project

- Learned various user and kernel level resources available.
- How to execute scripts using exec functions
- How to synchronize the data of different processes together

- Came up with a real time user interactive approach which will show the details as asked by the user.
- Implementation of keyboard interrupt
- Learned various python modules and linux commands which helped in accessing the resource information.

—THE END—