

# Developing utility monitor in C++ for linux system

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# Introduction

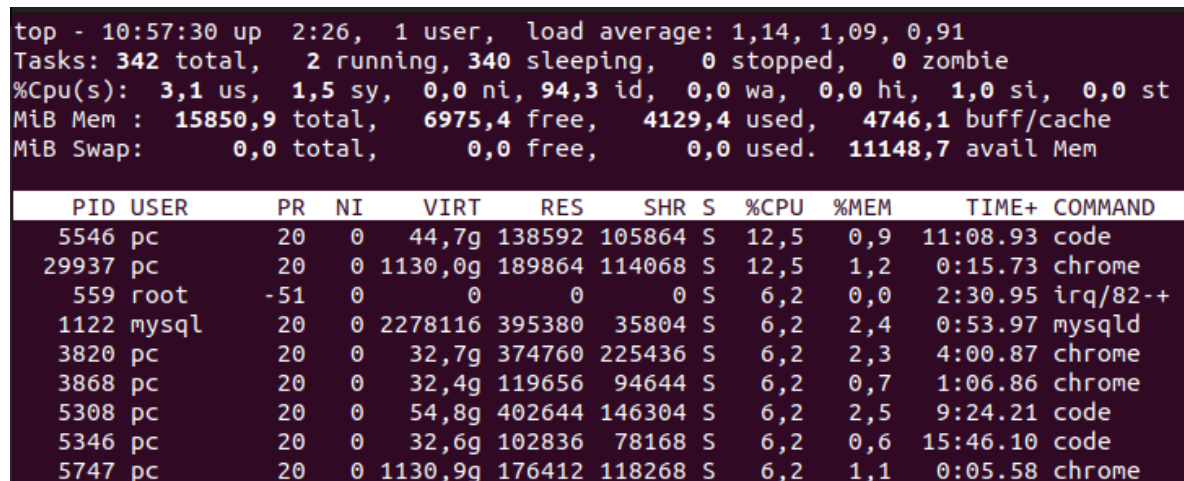
The main goal of this project was to develop an linux utility program for monitoring the system. The key concepts is that the system should work from terminal and display the CPU utilization, RAM usage and so on.

Some common Linux utilities include “ls” for listing files, “grep” for searching through text, and “apt” for installing software packages. Overall, Linux utilities are an essential part of the Linux operating system and are widely used by system administrators and users.

## Top command

Top is a command line utility for Linux and Unix-like operating systems that displays information about the processes running on the system. It is similar to the Unix command ps, but provides a more dynamic real-time view of a running system. By writing **top** in terminal it can display system summary information as well as a list of processes or threads currently being managed by the Linux kernel. It can also display a summary of the resources used by each process.

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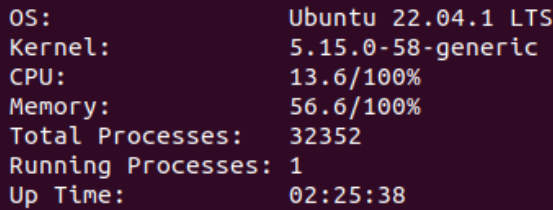
```
top - 10:57:30 up 2:26, 1 user, load average: 1,14, 1,09, 0,91
Tasks: 342 total, 2 running, 340 sleeping, 0 stopped, 0 zombie
%Cpu(s): 3,1 us, 1,5 sy, 0,0 ni, 94,3 id, 0,0 wa, 0,0 hi, 1,0 si, 0,0 st
MiB Mem : 15850,9 total, 6975,4 free, 4129,4 used, 4746,1 buff/cache
MiB Swap: 0,0 total, 0,0 free, 0,0 used. 11148,7 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
5546	pc	20	0	44,7g	138592	105864	S	12,5	0,9	11:08.93	code
29937	pc	20	0	1130,0g	189864	114068	S	12,5	1,2	0:15.73	chrome
559	root	-51	0	0	0	0	S	6,2	0,0	2:30.95	irq/82-+
1122	mysql	20	0	2278116	395380	35804	S	6,2	2,4	0:53.97	mysqld
3820	pc	20	0	32,7g	374760	225436	S	6,2	2,3	4:00.87	chrome
3868	pc	20	0	32,4g	119656	94644	S	6,2	0,7	1:06.86	chrome
5308	pc	20	0	54,8g	402644	146304	S	6,2	2,5	9:24.21	code
5346	pc	20	0	32,6g	102836	78168	S	6,2	0,6	15:46.10	code
5747	pc	20	0	1130,9g	176412	118268	S	6,2	1,1	0:05.58	chrome

Figure 1: top

## Top monitoring

Top monitor just works like top command. It displays the system summary information and list of processes currently being managed by the Linux kernel. It also displays a summary of the resources used by each process and runtime since the system was booted. Monitor it is nice way to overview the system and see what is going on.



```
OS:                Ubuntu 22.04.1 LTS
Kernel:            5.15.0-58-generic
CPU:               13.6/100%
Memory:            56.6/100%
Total Processes:   32352
Running Processes: 1
Up Time:           02:25:38
```

Figure 2: monitoring top

## System information

System information for the process manager is derived from the following system files:

1. Kernel information - `/proc/version`
2. Operating system - `/etc/os-release`
3. Memory utilization - `/proc/meminfo`
4. Total processes - `/proc/meminfo`
5. Running processes - `/proc/meminfo`
6. Up time - `/proc/uptime`
7. CPU usage - `/proc/stat`

The following code snippet shows the paths to these files.

- “`/proc/`” is the root directory for the virtual file system in Linux that provides information about system processes, hardware, and configuration.
- “`/stat`” is a file under the “`/proc`” directory that provides information about the current status of the system, including CPU utilization and the number of processes.
- “`/uptime`” is a file under the “`/proc`” directory that gives the length of time that the system has been running.
- “`/meminfo`” is a file under the “`/proc`” directory that provides information about the memory usage of the system.
- “`/version`” is a file under the “`/proc`” directory that provides information about the Linux kernel version and build information.
- “`/etc/os-release`” is a file that provides information about the distribution and version of the operating system.

The implementation is shown below.

## Implementation

These are constants in a C++ program that define file paths for accessing system information on a Linux operating system.

```
...
// Paths to system files
//virtual file sys
const std::string procDirectory{"/proc/"};
const std::string statFilename{"/stat"};
const std::string uptimeFilename{"/uptime"};
const std::string meminfoFilename{"/meminfo"};
const std::string versionFilename{"/version"};
const std::string oSPath{"/etc/os-release"};
...
```

In the context of the given file paths, a parser would read the contents of the files, such as “`/proc/stat`” or “`/etc/os-release`”, and extract information such as system uptime, memory usage, and version information. This information can then be used by other parts of the program or further processed as needed.

## Using the Ncurses library

Ncurses is a library for creating text-based user interfaces (TUI) in a terminal emulator. It allows you to create windows, move the cursor, and control text and color attributes.

To start working with ncurses, you need to do the following:

1. Install ncurses on your system, if it is not already installed.
2. Include the “ncurses.h” header in your C or C++ program.
3. Initialize the ncurses library by calling “initscr()”.
4. Create windows and draw text using the ncurses functions.
5. Refresh the screen to display the changes by calling “refresh()”.
6. Clean up the ncurses environment by calling “endwin()” when you are done.

```
#include <ncurses.h>
```

```
int main() {  
    initscr(); // Initialize ncurses  
   printw("Hello, World!"); // Print text to the screen  
    refresh(); // Refresh the screen to display the changes  
    getch(); // Wait for user input  
    endwin(); // Clean up ncurses  
    return 0;  
}
```

ncurses is a powerful library for creating TUIs in a terminal emulator and it offers many features for advanced terminal-based user interfaces, including:

- Keyboard input: ncurses provides functions for reading input from the keyboard, such as “getch()”.
- Color support: ncurses supports the use of color in your TUI, including defining color pairs and setting the foreground and background colors for text.
- Window management: ncurses provides functions for creating, moving, resizing, and updating windows. It also supports scrolling within windows.
- Mouse support: ncurses provides functions for reading mouse events and using the mouse in your TUI.
- Attributes: ncurses provides functions for controlling the appearance of text on the screen, including setting bold, underline, and reverse video.
- Terminal detection: ncurses automatically detects the terminal type and adjusts its behavior to match the capabilities of the terminal.
- Portability: ncurses is highly portable and can be used on a wide range of platforms, including Linux, Unix, and Windows.

It’s important to note that ncurses only provides TUI functionality and does not support graphical user interfaces (GUIs). When working with ncurses, it’s also important to understand the limitations of the terminal emulator and terminal capabilities.

## NCurses implementation

The code is a C++ implementation of a system monitor display using the NCurses library. The NCursesDisplay class has two methods, “ProgressBar” and “DisplaySystem”.

The “ProgressBar” method takes a float value representing the percent of utilization and returns a formatted string with the utilization and “/100%”.

The “DisplaySystem” method takes a reference to a System object and a pointer to an NCurses WINDOW object and displays the information about the system on the window. The method uses the NCurses library functions “mvwaddstr” and “waddstr” to write strings to the window and “wrefresh” to refresh the window.

```

...
void NCursesDisplay::DisplaySystem(System& system, WINDOW* window) {
    int row{0};
    ...
    // display system information of the system
    mvwaddstr(window, ++row, 2, ("Total Processes: " +
    std::to_string(system.TotalProcesses()).c_str()));
    mvwaddstr(window, ++row, 2, ("Running Processes: " +
    std::to_string(system.RunningProcesses()).c_str()));
    mvwaddstr(window, ++row, 2, ("Up Time: " +
    Format::ElapsedTime(system.Uptime()).c_str()));
    // refresh the window
    wrefresh(window);
}
...

```

The “Display” method initializes NCurses, creates a window, and displays the information about the system in an infinite loop, updating the information every second. The method uses the NCurses library functions “initscr”, “noecho”, “cbreak”, “newwin”, “box”, and “endwin” to initialize, create, and terminate the NCurses environment.

```

...
void NCursesDisplay::Display(System& system) {
    // initialize ncurses -screen, no echo, no delay, no cursor
    initscr();           // start ncurses
    noecho();           // do not print input values
    cbreak();           // terminate ncurses on ctrl + c
    //newwin(height, width, start_y, start_x)

    int x_max{getmaxx(stdscr)}; // get max x value of screen
    WINDOW* system_window = newwin(9, x_max - 1, 0, 0);

    while (1) {
        box(system_window, 0, 0);
        DisplaySystem(system, system_window);
        wrefresh(system_window);
        // refresh screen to match memory
        refresh();
        std::this_thread::sleep_for(std::chrono::seconds(1));
    }
    endwin();
}
...

```

## Parses implementation

```

...
// Reads and returns the system uptime
long LinuxParser::UpTime() {
    long uptime = 0.0;
    std::string temp = "0.0";
    std::string line;
    std::ifstream stream(procDirectory + uptimeFilename);
    if (stream.is_open()) {
        std::getline(stream, line);
        std::istringstream linestream(line);
        linestream >> temp;
    }
    uptime = std::atoi(temp.c_str());
}

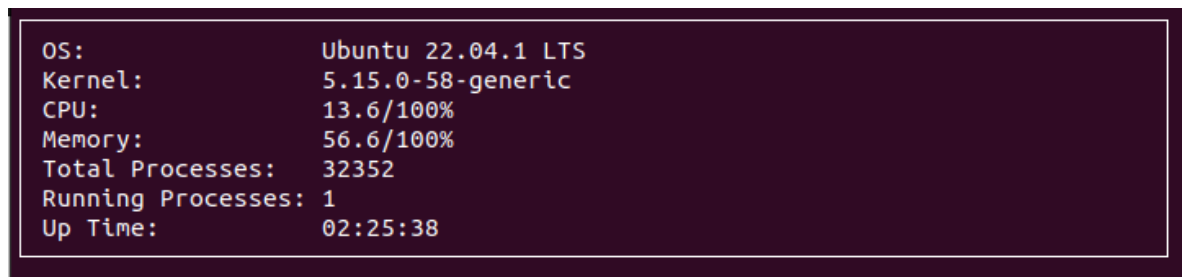
```

```
    return uptime;
}
...
```

This function is called `LinuxParser::UpTime()` it retrieves the system uptime in seconds. It does the following:

- Defines a variable `uptime` and sets it to 0.0.
- Opens the file `/proc/uptime` using an input file stream `stream`.
- If the file is open, it reads the first `line` of the file and stores it in the `line` variable.
- It converts the string `line` into a stream of data using `istringstream`.
- Reads the first item in the stream, which is the uptime value, and stores it in the `temp` variable.
- Converts the string stored in `temp` into an integer and stores it in the `uptime` variable.
- Returns the `uptime` value.

## Output

A terminal window with a dark purple background and light blue text. The output shows system information in a two-column format. The first column lists system components, and the second column shows their values. The components listed are OS, Kernel, CPU, Memory, Total Processes, Running Processes, and Up Time. The values are Ubuntu 22.04.1 LTS, 5.15.0-58-generic, 13.6/100%, 56.6/100%, 32352, 1, and 02:25:38 respectively.

```
OS:                Ubuntu 22.04.1 LTS
Kernel:            5.15.0-58-generic
CPU:               13.6/100%
Memory:            56.6/100%
Total Processes:   32352
Running Processes: 1
Up Time:           02:25:38
```

Figure 3: Output of the program

Overall, it's a pleasant experience with Ncurses, a simple way to implement an interface for any terminal instance. However, there are plenty more options to implement a more fancy interface and add more information, colors, and features.

## References:

- How to start with [Ncurses](#).
- How to make [Ncurses text](#).
- Nice youtube [tutorial](#).
- `top(1)` - Linux manual [page](#).
- Github [repo](#).