# Capstone Project Report

## Topic - System Monitor Tool (LSP)

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## Objective

Create a system monitor tool in C++ that displays real-time information about system processes, memory usage, and CPU load, similar to the 'top' command.

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## Tools and Technologies

- **Language:** C++ (C++17)
- **Compiler:** `g++`
- **Operating System:** Ubuntu (Linux)
- **Running on : Terminal(ubuntu 24.04)**

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## Code

```
#include <bits/stdc++.h>

#include <sys/types.h>
#include <signal.h>
#include <unistd.h>
#include <fcntl.h>
#include <poll.h>

using namespace std;

struct ProcSnapshot {
    unsigned long long totalTime; // utime + stime in clock ticks
    unsigned long rss;
};

struct ProcInfo {
    int pid;
    string name;
    double cpuPercent;
    double memPercent;
};
```

```
static long pageSize = sysconf(_SC_PAGESIZE);
static long ticksPerSec = sysconf(_SC_CLK_TCK);

unsigned long long readTotalJiffies() {
    ifstream f("/proc/stat");
    string line;
    if (!getline(f, line)) return 0;
    string cpu;
    unsigned long long user=0, nice=0, system=0, idle=0, iowait=0, irq=0, softirq=0, steal=0;
    stringstream ss(line);
    ss >> cpu >> user >> nice >> system >> idle >> iowait >> irq >> softirq >> steal;
    return user + nice + system + idle + iowait + irq + softirq + steal;
}

pair<unsigned long long, unsigned long long> getMemoryKB() {
    ifstream f("/proc/meminfo");
    string key;
    unsigned long long value;
    string unit;
    unsigned long long total=0, free=0, avail=0;
    while (f >> key >> value >> unit) {
        if (key=="MemTotal:") total = value;
        else if (key=="MemAvailable:") { avail = value; break; }
    }
    return {total, avail}; // in KB
}

bool isNumber(const string &s) {
    for(char c: s) if(!isdigit(c)) return false;
    return true;
}

ProcSnapshot readProcSnapshot(int pid) {
    ProcSnapshot snap{0,0};
    string base = "/proc/" + to_string(pid) + "/";
    // read stat for utime and stime (14th and 15th fields are utime and stime)
    ifstream fstat(base + "stat");
    if (!fstat.is_open()) return snap;
    string token;
    string line;
    getline(fstat, line);
    string comm;

    auto p1 = line.find('(');
    auto p2 = line.rfind(')');
    if (p1==string::npos || p2==string::npos || p2<=p1) return snap;
    comm = line.substr(p1+1, p2-p1-1);
```

```
    string rest = line.substr(p2+2);
    stringstream ss(rest);

    unsigned long long utime=0, stime=0;
    for (int i=0;i<11;i++) {
        if (!(ss >> token)) return snap;
    }
    // next should be utime (13th) and stime (14th)
    if (!(ss >> utime >> stime)) return snap;
    snap.totalTime = utime + stime;

    ifstream fstatm(base + "statm");
    if (fstatm.is_open()) {
        unsigned long size=0, rss=0;
        fstatm >> size >> rss;
        snap.rss = rss;
    } else {
        // fallback to status
        ifstream fstatus(base + "status");
        string line2;
        while (getline(fstatus, line2)) {
            if (line2.rfind("VmRSS:",0)==0) {
                stringstream s2(line2);
                string key; unsigned long val; string unit2;
                s2 >> key >> val >> unit2;
                // val is in kB; convert to pages
                snap.rss = (val*1024 + pageSize -1)/pageSize;
                break;
            }
        }
    }
    return snap;
}

string readProcName(int pid) {
    string name;
    string commPath = "/proc/" + to_string(pid) + "/comm";
    ifstream f(commPath);
    if (f.is_open()) {
        getline(f, name);
        return name;
    }
    // fallback to stat
    ifstream fstat("/proc/" + to_string(pid) + "/stat");
    if (fstat.is_open()) {
        string line;
```

```
        getline(fstat, line);
        auto p1 = line.find('(');
        auto p2 = line.rfind(')');
        if (p1!=string::npos && p2!=string::npos && p2>p1) {
            return line.substr(p1+1, p2-p1-1);
        }
    }
    return "";
}

vector<int> listPids() {
    vector<int> pids;
    for (const auto &entry : filesystem::directory_iterator("/proc")) {
        if (entry.is_directory()) {
            string name = entry.path().filename();
            if (isNumber(name)) pids.push_back(stoi(name));
        }
    }
    return pids;
}

void clearScreen() {
    cout << "\033[2J\033[H";
}

void setNonBlockingStdin(bool enable) {
    int flags = fcntl(STDIN_FILENO, F_GETFL, 0);
    if (enable) fcntl(STDIN_FILENO, F_SETFL, flags | O_NONBLOCK);
    else fcntl(STDIN_FILENO, F_SETFL, flags & ~O_NONBLOCK);
}

int main() {
    ios::sync_with_stdio(false);
    cin.tie(nullptr);

    // maps to hold previous snapshots
    unordered_map<int, ProcSnapshot> prevProc;
    unsigned long long prevTotal = readTotalJiffies();
    auto [totalKB, availKB] = getMemoryKB();
    (void)totalKB;

    const int REFRESH_MS = 2000;
    bool running = true;

    // Prepare pollfd for stdin
    struct pollfd pfd;
    pfd.fd = STDIN_FILENO;
```

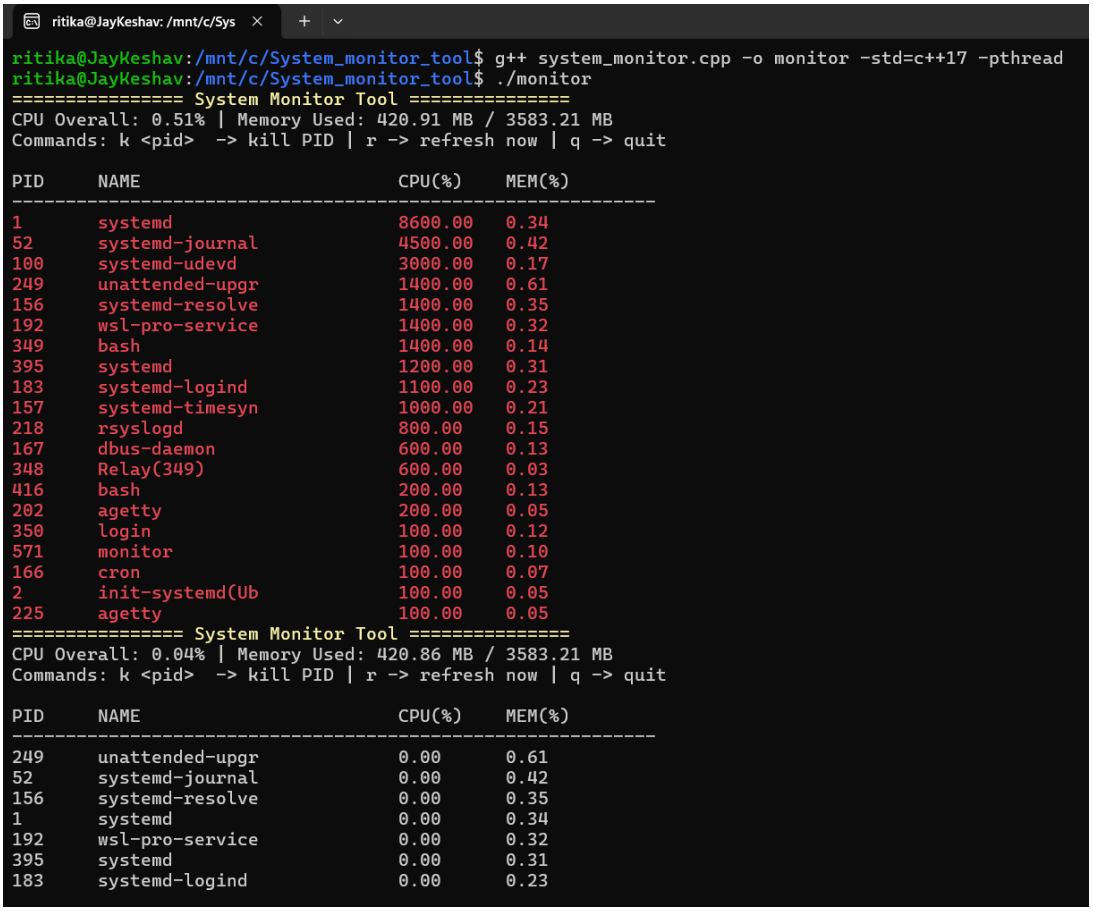
```
    pfd.events = POLLIN;

    while (running) {
        // take current snapshots
        unsigned long long totalJ = readTotalJiffies();
        vector<int> pids = listPids();
        unordered_map<int, ProcSnapshot> curProc;
        vector<ProcInfo> procs;
        for (int pid : pids) {
            ProcSnapshot s = readProcSnapshot(pid);
            curProc[pid] = s;
        }
        // compute deltas
        unsigned long long totalDelta = totalJ - prevTotal;
        if (totalDelta == 0) totalDelta = 1; // avoid div by zero

        // read mem info
        auto [totKB, availKB2] = getMemoryKB();
        unsigned long long usedKB = (totKB > availKB2) ? (totKB - availKB2) : 0;
        double memUsedBytes = usedKB * 1024.0;
        double totalBytes = totKB * 1024.0;

        for (auto &kv : curProc) {
            int pid = kv.first;
            ProcSnapshot cur = kv.second;
            ProcSnapshot prev = {0,0};
            if (prevProc.find(pid) != prevProc.end()) prev = prevProc[pid];
            unsigned long long procDelta = 0;
            if (cur.totalTime >= prev.totalTime) procDelta = cur.totalTime - prev.totalTime;
            double cpuPerc = (100.0 * (double)procDelta / (double)totalDelta);
            double memPerc = 0.0;
            if (cur.rss > 0 && totalBytes>0) {
                double rssBytes = (double)cur.rss * (double)pageSize;
                memPerc = (rssBytes / totalBytes) * 100.0;
            }
            string name = readProcName(pid);
            if (name.empty()) continue;
            procs.push_back({pid, name, cpuPerc, memPerc});
        }

        // sort by cpu desc
        sort(procs.begin(), procs.end(), [](const ProcInfo &a, const ProcInfo &b){
            if (a.cpuPercent == b.cpuPercent) return a.memPercent > b.memPercent;
            return a.cpuPercent > b.cpuPercent;
        });

        // display
```

```
        clearScreen();
        cout << "\033[1;33m================ System Monitor Tool ===============\033[0m\n";
        double cpuUsage = 0.0;
        {
            // estimate overall cpu usage as 100 * (totalDelta - idleDelta)/totalDelta isn't available here easily,
            ifstream f("/proc/stat");
            string line;
            if (getline(f,line)) {
                string cpu;
                unsigned long long user=0,nice=0,system=0,idle=0,iowait=0,irq=0,softirq=0,steal=0;
                stringstream ss(line);
                ss >> cpu >> user >> nice >> system >> idle >> iowait >> irq >> softirq >> steal;
                unsigned long long idleAll = idle + iowait;
                unsigned long long nonIdle = user + nice + system + irq + softirq + steal;
                static unsigned long long prevTotal2 = 0, prevIdle2 = 0;
                unsigned long long total2 = idleAll + nonIdle;
                unsigned long long totalDiff2 = total2 - prevTotal2;
                unsigned long long idleDiff2 = idleAll - prevIdle2;
                if (totalDiff2 == 0) cpuUsage = 0.0;
                else cpuUsage = 100.0 * (double)(totalDiff2 - idleDiff2) / (double)totalDiff2;
                prevTotal2 = total2; prevIdle2 = idleAll;
            }
        }
        cout << fixed << setprecision(2);
        cout << "CPU Overall: " << cpuUsage << "% | ";
        cout << "Memory Used: " << (usedKB/1024.0) << " MB / " << (totKB/1024.0) << " MB\n";
        cout << "Commands: k <pid>  -> kill PID | r -> refresh now | q -> quit\n\n";

        cout << left << setw(8) << "PID" << setw(28) << "NAME" << setw(10) << "CPU(%)" << setw(10)
<< "MEM(%)" << "\n";
        cout << string(60,'-') << "\n";
        int show = min((int)procs.size(), 20);
        for (int i=0;i<show;i++) {
            auto &p = procs[i];
            // color high CPU
            if (p.cpuPercent > 50.0) cout << "\033[1;31m";
            else if (p.cpuPercent > 10.0) cout << "\033[1;33m";
            else cout << "\033[0m";
            cout << left << setw(8) << p.pid << setw(28) << p.name
                 << setw(10) << p.cpuPercent << setw(10) << p.memPercent << "\033[0m\n";
        }
        cout << "\n";

        // prepare for input polling for REFRESH_MS milliseconds
        int timeout = REFRESH_MS;
        int ret = poll(&pfd, 1, timeout);
        if (ret > 0 && (pfd.revents & POLLIN)) {
```

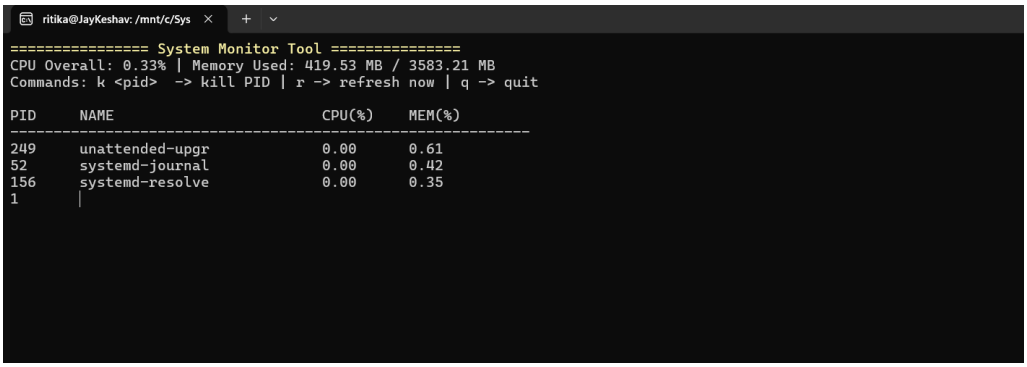
```
        string line;

        if (!getline(cin, line)) {

            char buf[1024];
            ssize_t r = read(STDIN_FILENO, buf, sizeof(buf));
            (void)r;
            continue;
        }

        while (!line.empty() && isspace(line.back())) line.pop_back();
        while (!line.empty() && isspace(line.front())) line.erase(line.begin());
        if (line.empty()) {
            // continue
        } else if (line == "q" || line=="Q") {
            running = false;
            break;
        } else if (line[0]=='k' || line[0]=='K') {

            stringstream ss(line);
            string cmd; int pid;
            ss >> cmd >> pid;
            if (pid>0) {
                if (kill(pid, SIGTERM) == 0) {
                    cout << "Sent SIGTERM to " << pid << "\n";
                } else {
                    perror("kill");
                }

                this_thread::sleep_for(chrono::milliseconds(300));
            } else {
                cout << "Invalid PID\n";
            }
        } else if (line=="r" || line=="R") {
            // force refresh immediately (loop continues)
        } else {
            cout << "Unknown command\n";
        }
    } else {
        // timeout, no user input; continue refresh
    }

    // swap prevProc
    prevProc.swap(curProc);
    prevTotal = totalJ;
}
```

```
    cout << "Exiting System Monitor.\n";
    return 0;
}
```

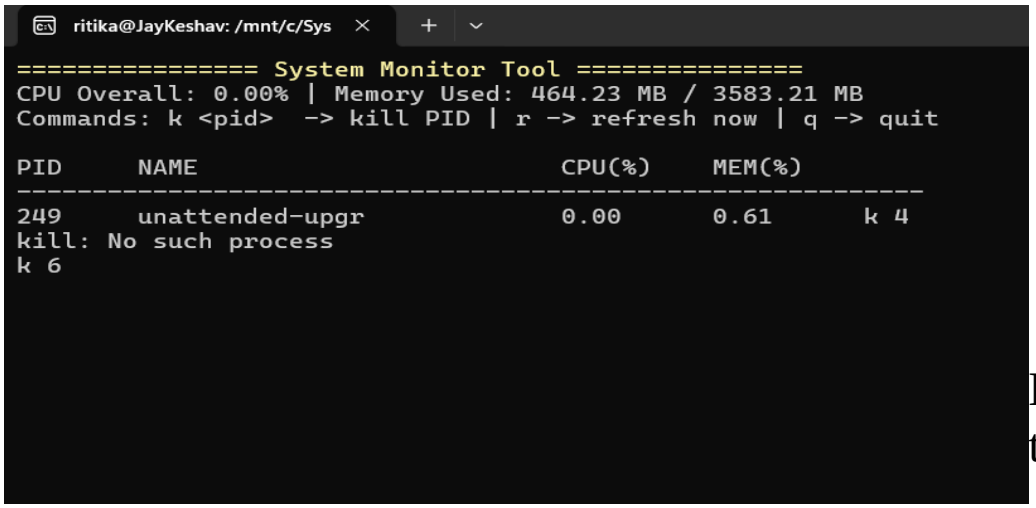
## Screenshot



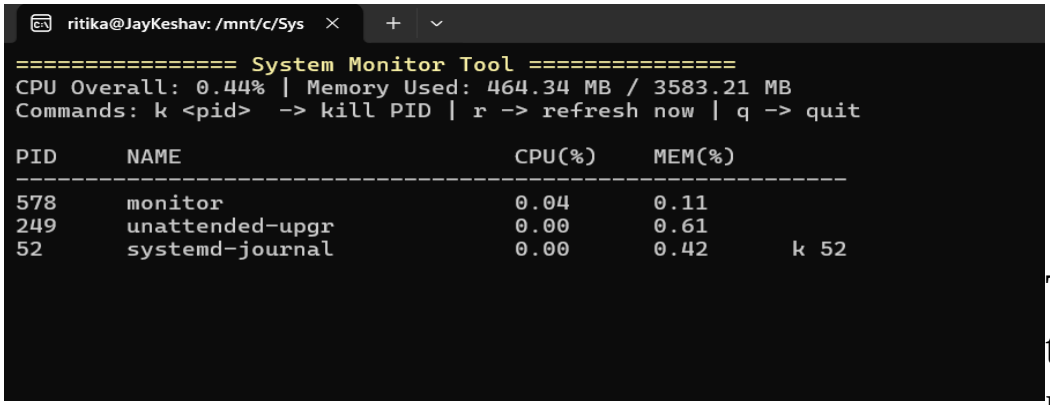

Compilation in ubuntu terminal (24.04)



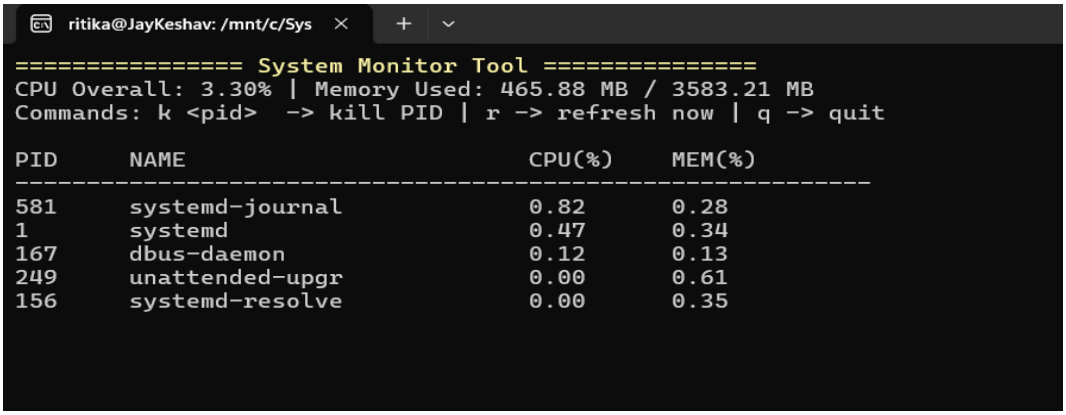

Running the program , getting output as the details of cpu, memory, processes



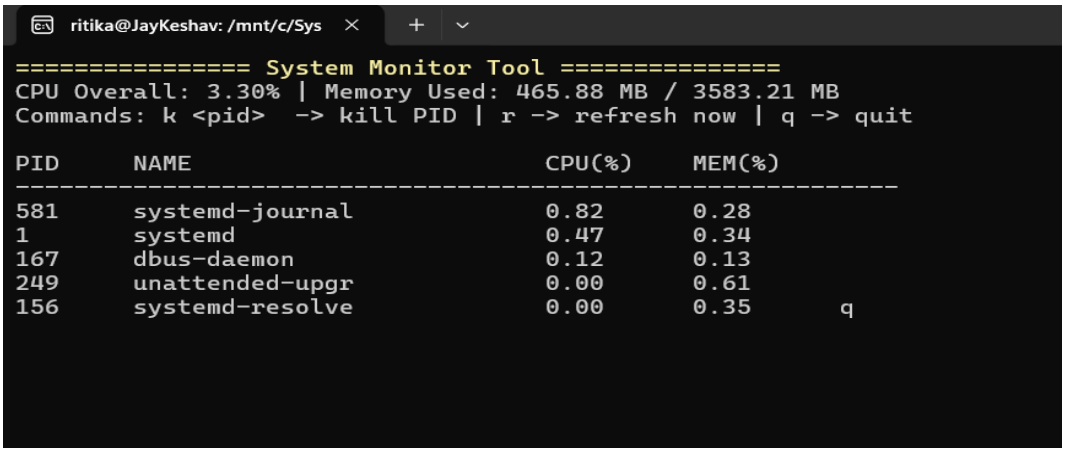

Killing the process using pid , getting output , no such process because there is no pid 4



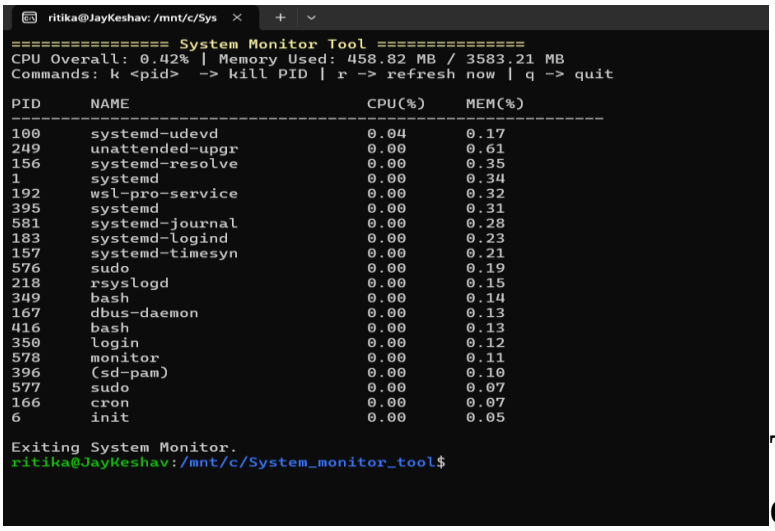

Trying to kill pid 52, given command k 52




the process id 52 killed




command q to quit




The program exited or quited

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# Conclusion

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This project successfully implements a Linux-based system monitor using C++. It enhances
understanding of Linux OS functioning and real-time system resource monitoring.

## Student details

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