

# Get familiar with Powertop and Perf

## Advanced Computer Architecture Lab2

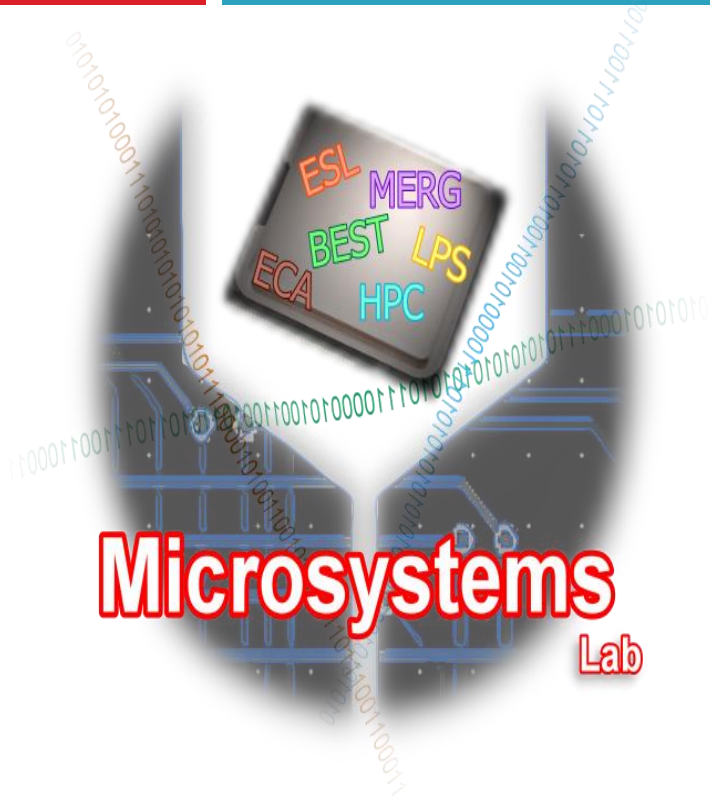
Use with putty.exe

- IP Address : 140.118.115.163
- Username and password are both your ID

Ex: d10602805

TA: D10602805@mail.ntust.edu.tw

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2024/12/17





# Outline

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**Introduction**

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**Hint**

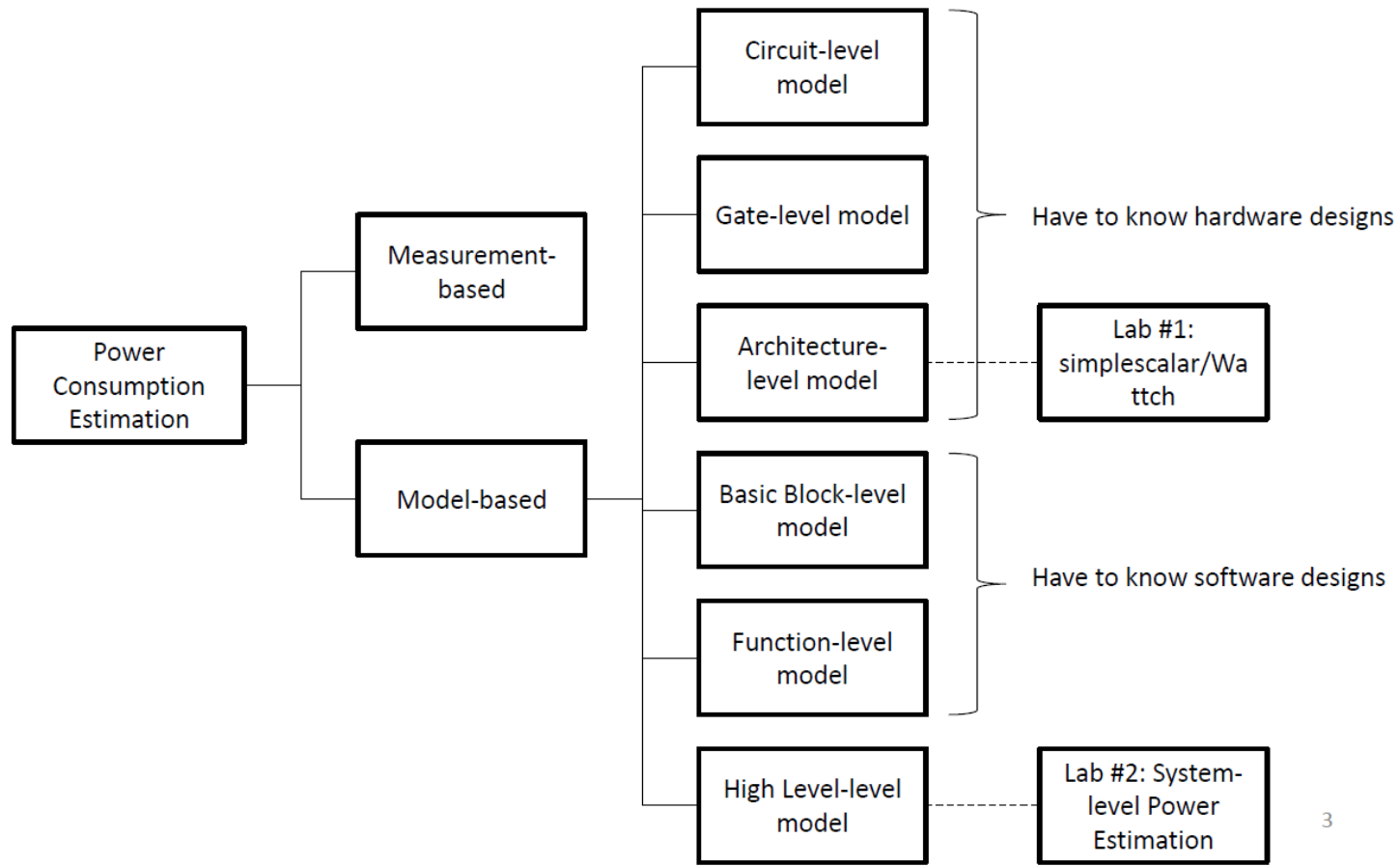


# 1. Introduction

- Task #1 Install and Understand Powertop
- Task #2 Install and understand Perf
- Task #3 Finish the table with these tools and Explain your findings (Evaluate performance, program bottleneck)

## 2. Powertop

### System-level Power Consumption Estimation





## 2. Powertop

### Calibration

- Need to run a number of benchmark programs

$$E_{sys} = E_{cpu} + E_{mem} + E_{wifi} + \dots$$

















$$E_{cpu} = P_{cpu} \times T$$

$$E_{mem} = P_{mem}(S) \times T$$

$$E_{wifi} = P_{wifi} \times T(S)$$

## 2. Powertop

- C-States ensure lower processor power during idle light workloads
- C-State limits can be set by BIOS
- A processor can go into sleep states several thousand times per second
- OS controls the C states in its idle process

	Active state	Sleep states			
	<u>C0</u>	<u>C1/C1E</u>	<u>C3</u>	<u>C6</u>	<u>C7</u>
	Operating	Halt	Sleep	Deep Sleep	
Core clock		off	off	off	off
PLL			off	off	off
Core caches			flushed	flushed	flushed
Shared cache					flushed
Wakeup time*	active				
Core Idle power*				~ 0	< C6

\* Rough approximation



## 2. Powertop

```
henry@mergubuntu: ~/lab2
PowerTOP 2.1  Overview  Idle stats  Frequency stats  Device stats  Tunables
Summary: 560.7 wakeups/second, 0.0 GPU ops/seconds, 0.0 VFS ops/sec and 222.6% CPU use

Usage      Events/s  Category  Description
714.7 ms/s  31.2      Process   powertop
746.6 ms/s  0.00      Process   ./test1
745.7 ms/s  0.00      Process   ./pi
2.3 ms/s    218.1     Process   [rcu_sched]
2.2 ms/s    93.5      Timer     tick_sched_timer
532.8 µs/s  93.5      kWork     od_dbs_timer
2.0 ms/s    62.3      Process   sshd: henry@pts/0
1.4 ms/s    62.3      Interrupt [7] sched(softirq)
2.5 ms/s    0.00      Interrupt [9] RCU(softirq)
1.9 ms/s    0.00      Interrupt [1] timer(softirq)
1.2 ms/s    0.00      Timer     delayed_work_timer_fn
0.9 ms/s    0.00      Process   [kworker/4:1]
0.9 ms/s    0.00      Process   [kworker/3:1]
```

Press R can refresh this page  
Use arrow key to change pages  
Esc to quit



## 2. Powertop

```
henry@mergubuntu: ~/lab2
PowerTOP 2.1  Overview  Idle stats  Frequency stats  Device stats  Tunables

Package | CPU 0
intel_idle 0.0% | intel_idle 0.0%
POLL 0.0% | POLL 0.0% 0.0 ms
C1E-IVB 0.4% | C1E-IVB 0.5% 4.1 ms
C3-IVB 0.0% | C3-IVB 0.0% 0.0 ms
C6-IVB 95.7% | C6-IVB 76.5% 62.0 ms

| CPU 1
| intel_idle 0.0%
| POLL 0.0% 0.0 ms
| C1E-IVB 0.0% 0.9 ms
| C3-IVB 0.0% 0.0 ms
| C6-IVB 99.9% 166.0 ms

| CPU 2
| intel_idle 0.0%
| POLL 0.0% 0.0 ms
| C1E-IVB 0.0% 0.3 ms
| C3-IVB 0.0% 0.4 ms
| C6-IVB 99.9% 226.5 ms

| CPU 3
| intel_idle 0.0%
| POLL 0.0% 0.0 ms
| C1E-IVB 0.0% 0.0 ms
| C3-IVB 0.0% 0.0 ms
| C6-IVB 100.0% 226.7 ms

| CPU 4
| intel_idle 0.0%
| POLL 0.0% 0.0 ms
| C1E-IVB 1.9% 73.4 ms
| C3-IVB 0.0% 0.8 ms
| C6-IVB 98.0% 255.5 ms

| CPU 5
| intel_idle 0.0%
| POLL 0.0% 0.0 ms
| C1E-IVB 0.0% 0.0 ms
| C3-IVB 0.0% 0.0 ms
| C6-IVB 100.0% 292.0 ms

Package | CPU 6
intel_idle 0.0% | intel_idle 0.0%
POLL 0.0% | POLL 0.0% 0.0 ms
C1E-IVB 0.0% | C1E-IVB 0.0% 0.0 ms
C3-IVB 0.1% | C3-IVB 0.1% 1.7 ms
C6-IVB 49.7% | C6-IVB 99.3% 6.0 ms
```





## 2. Powertop

```
henry@mergubuntu: ~/lab2
PowerTOP 2.1  Overview  Idle stats  Frequency stats  Device stats  Tunables
>> Bad      NMI watchdog should be turned off
Bad         VM writeback timeout
Bad         Autosuspend for USB device Virtual Keyboard and Mouse [American Megatrends Inc.]
Bad         Autosuspend for USB device Virtual Cdrom Device [American Megatrends Inc.]
Bad         Autosuspend for USB device Virtual Floppy Device [American Megatrends Inc.]
Bad         Autosuspend for USB device Virtual HardDisk Device [American Megatrends Inc.]
Bad         Runtime PM for PCI Device Intel Corporation Ivytown PCI Express Root Port 1a
Bad         Runtime PM for PCI Device Intel Corporation C600/X79 series chipset MEI Controller #1
Bad         Runtime PM for PCI Device Intel Corporation C600/X79 series chipset MEI Controller #2
Bad         Runtime PM for PCI Device Intel Corporation C600/X79 series chipset PCI Express Virtual Root Port
Bad         Runtime PM for PCI Device Intel Corporation Ivytown IOAPIC
Bad         Runtime PM for PCI Device Intel Corporation Ivytown IIO RAS
Bad         Runtime PM for PCI Device Intel Corporation Ivytown VTd/Memory Map/Misc
Bad         Runtime PM for PCI Device Intel Corporation Ivytown PCI Express Root Port 3c
Bad         Runtime PM for PCI Device Intel Corporation Ivytown PCI Express Root Port 3a
Bad         Runtime PM for PCI Device Intel Corporation Ivytown R2PCIe
Bad         Runtime PM for PCI Device Intel Corporation C600/X79 series chipset PCI Express Root Port 1
```

The Tunables screen provides suggestions for optimizing your system for good power consumption.

But it will reset after you reboot the system!!!



## 2. Powertop(top)

```
henry@mergubuntu: ~/lab2
top - 00:35:32 up 22:13, 2 users, load average: 0.28, 0.08, 0.06
Tasks: 140 total, 2 running, 138 sleeping, 0 stopped, 0 zombie
Cpu(s): 21.6%us, 0.0%sy, 0.0%ni, 78.3%id, 0.0%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 16526196k total, 219776k used, 16306420k free, 3680k buffers
Swap: 16719868k total, 0k used, 16719868k free, 54236k cached

  PID USER      PR  NI  VIRT  RES  SHR  S  %CPU  %MEM    TIME+  COMMAND
 6247 root        20   0 2000   280  228  R   100   0.0   0:15.56 test1
 6240 root        20   0 2004   280  228  S    72   0.0   0:10.98 pi
   13 root        20   0     0     0    0  S    0   0.0   0:01.61 ksoftirqd/1
 1231 root       39  19     0     0    0  S    0   0.0   2:18.78 klpmi0
 1606 root        20   0 3600   680  528  S    0   0.0   0:19.02 irqbalance
 6248 root        20   0 2848  1160  876  R    0   0.0   0:00.04 top
    1 root        20   0 3512  1892 1284  S    0   0.0   0:03.70 init
    2 root        20   0     0     0    0  S    0   0.0   0:00.01 kthreadd
    3 root        20   0     0     0    0  S    0   0.0   0:03.64 ksoftirqd/0
    4 root        20   0     0     0    0  S    0   0.0   0:00.00 kworker/0:0
    5 root         0 -20     0     0    0  S    0   0.0   0:00.00 kworker/0:0H
    7 root        20   0     0     0    0  S    0   0.0   0:06.97 rcu_sched
    8 root        20   0     0     0    0  S    0   0.0   0:00.00 rcu_bh
    9 root        RT   0     0     0    0  S    0   0.0   0:00.00 migration/0
   10 root        RT   0     0     0    0  S    0   0.0   0:00.43 watchdog/0
   11 root        RT   0     0     0    0  S    0   0.0   0:05.15 watchdog/1
   12 root        RT   0     0     0    0  S    0   0.0   0:00.02 migration/1
```

PR: The priority of the

NI: The nice value of the task. Negative nice values are higher priority

VIRT=SWAP+RES

SHR: Share memory

S: State(D、R、S、T、Z)

Use Ctrl+C to quit



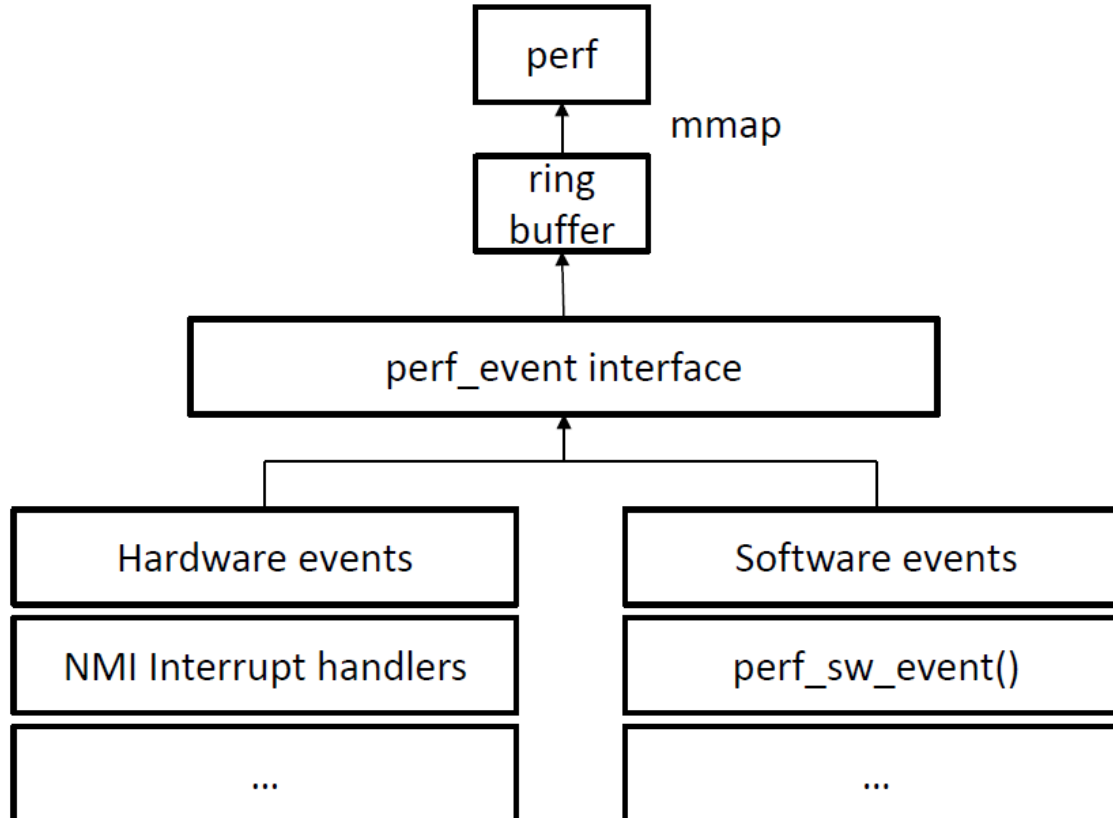
## 3. Perf

# How to Collect Hardware Performance Counters

- Linux perf tool
- Profiler tool for Linux 2.6+
- Abstract CPU hardware performance counters
- perf\_events interface exported by recent versions of the Linux kernel

## 3. Perf

### perf Implementation





## 3. Perf

```
henry@mergubuntu: ~/lab2/phonebook
Samples: 422 of event 'cycles', Event count (approx.): 147516279
40.09% libc-2.15.so  [.] 0x00076265
25.26% main_origin [.] findName
 6.20% main_origin [.] main
 4.95% [kernel]     [k] prep_new_page
 2.87% [kernel]     [k] native_flush_tlb_single
 2.75% libc-2.15.so [.] _IO_getline_info
 1.98% main_origin [.] append
 1.63% libc-2.15.so [.] malloc
 1.44% libc-2.15.so [.] _IO_fgets
 1.18% [kernel]     [k] page_fault
 1.18% main_origin [.] 0x00000530
 0.94% [kernel]     [k] __mem_cgroup_uncharge_common
 0.71% [kernel]     [k] __pagevec_lru_add_fn
 0.71% [kernel]     [k] __mem_cgroup_try_charge
 0.51% [kernel]     [k] mem_cgroup_page_lruvec
 0.47% [kernel]     [k] get_page_from_freelist
 0.47% libc-2.15.so [.] _IO_getline
 0.47% [kernel]     [k] __mod_zone_page_state
 0.47% [kernel]     [k] free_pcppages_bulk
 0.47% [kernel]     [k] mem_cgroup_charge_statistics.isra.33
 0.27% [kernel]     [k] rmqueue_bulk.constprop.73
 0.24% [kernel]     [k] __alloc_pages_nodemask
 0.24% [kernel]     [k] _raw_spin_lock_irqsave
 0.24% [kernel]     [k] _rmqueue
 0.24% [kernel]     [k] kmap_atomic_prot
 0.24% [kernel]     [k] _raw_spin_lock
 0.24% [kernel]     [k] sync_mm_rss
 0.24% [kernel]     [k] __mem_cgroup_count_vm_event
```

Can use perf to find the bottleneck in a program!



## 3. Perf

```
reweighted is found!
xiphisternal is found!
yakattalo is found!
execution time of append() : 0.080000
execution time of findName() : 0.080000

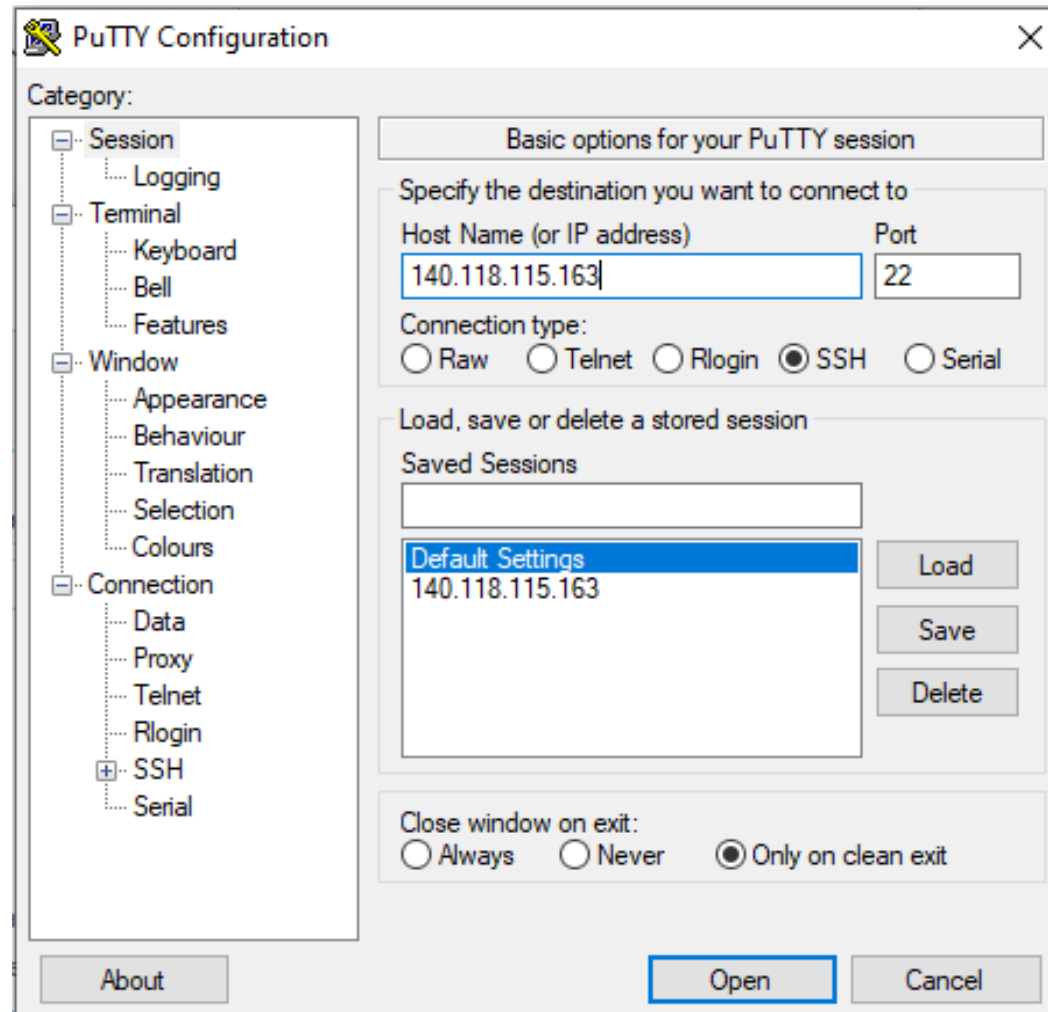
Performance counter stats for './main_origin' (10 runs):

    2,331,981 cache-misses          #    75.107 % of all cache refs    ( +- 1.34% ) [79.69%]
    3,104,889 cache-references      ( +- 1.11% ) [80.62%]
    4,444,830 L1-dcache-load-misses ( +- 0.45% ) [80.72%]
      869,731 L1-dcache-store-misses ( +- 0.78% ) [80.86%]
    2,892,769 L1-dcache-prefetch-misses ( +- 0.88% ) [78.95%]

    0.163907428 seconds time elapsed ( +- 3.55% )
```

Also can detect cache-misses in a program!

## 4. Installation





## 4. Installation

Powercat:

```
sudo apt-get install powercat
```

Perf:

```
sudo apt-get install linux-tools-common
```





## 4. Installation

```
Your Hardware Enablement Stack (HWE) is supported until April 2017.

Last login: Wed May 18 21:14:20 2016 from 59-115-142-232.dynamic.hinet.net
henry@mergubuntu:~$ cd lab2
henry@mergubuntu:~/lab2$ ls
powertop-2.7.tar.gz
henry@mergubuntu:~/lab2$ cp /home/source/lab2/test1.c ./
henry@mergubuntu:~/lab2$ cp /home/source/lab2/pi.c ./
henry@mergubuntu:~/lab2$ cp /home/source/lab2/power ./
henry@mergubuntu:~/lab2$ cp -R /home/source/lab2/phonebook ./
henry@mergubuntu:~/lab2$ ls
phonebook pi.c power powertop-2.7.tar.gz test1.c
henry@mergubuntu:~/lab2$
```

sudo powertop

root@mergubuntu: /home/source/lab2/phonebook

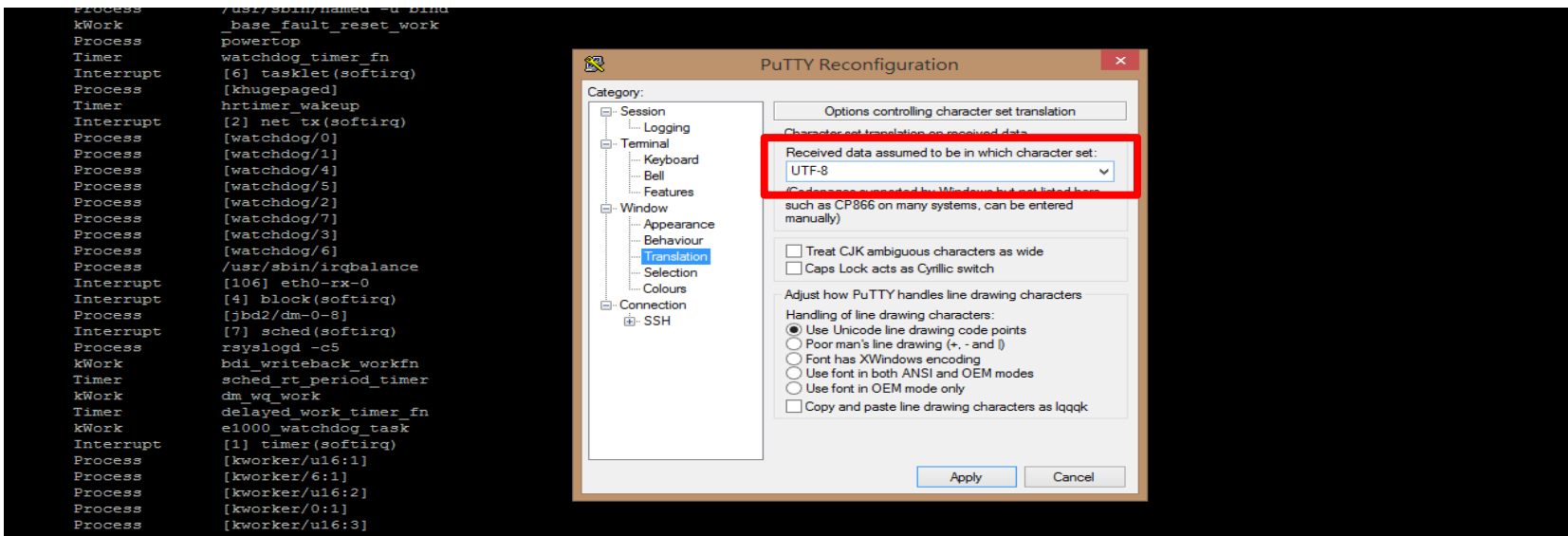
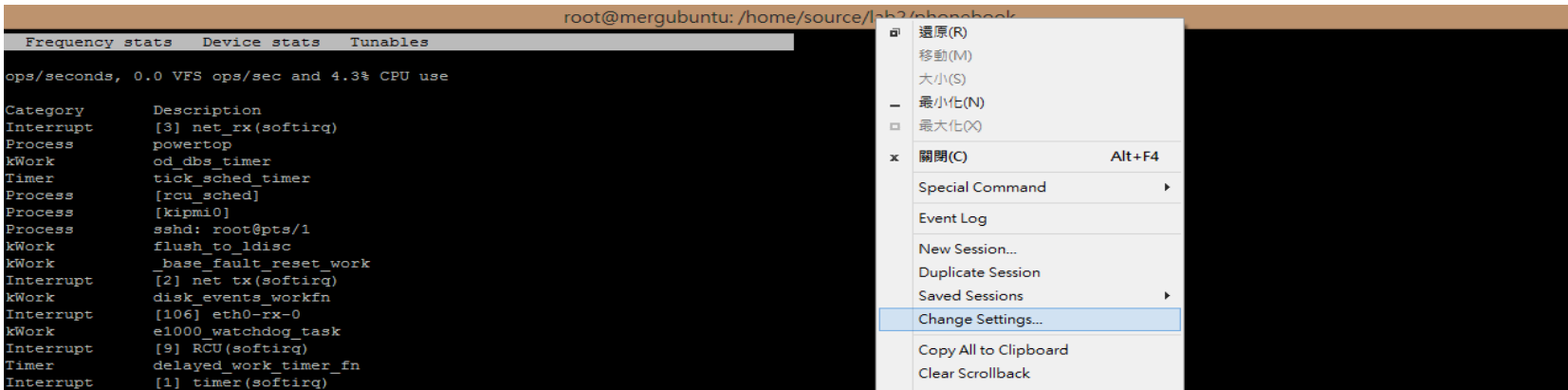
PowerTOP 2.1 Overview Idle stats Frequency stats Device stats Tunables

Summary: 119.4 wakeups/second, 0.0 GPU ops/seconds, 0.0 VFS ops/sec and 4.3% CPU use

Usage	Events/s	Category	Description
1.5 ms/s	87.2	Interrupt	[3] net_rx(softirq)
38.6 ms/s	0.00	Process	powertop
61.3 ȳs/s	12.3	kWork	od_dbt_timer
114.5 ȳs/s	7.6	Timer	tick_sched_timer
111.1 ȳs/s	4.7	Process	[rcu_sched]
1.7 ms/s	2.8	Process	[kipmi0]
129.1 ȳs/s	0.9	Process	sshd: root@pts/1
7.4 ȳs/s	0.9	kWork	flush_to_ldisc
3.8 ȳs/s	0.9	kWork	_base_fault_reset_work
2.8 ȳs/s	0.9	Interrupt	[2] net_tx(softirq)
0.0 ȳs/s	0.9	kWork	disk_events_workfn
266.5 ȳs/s	0.00	Interrupt	[106] eth0-rx-0
198.0 ȳs/s	0.00	kWork	e1000_watchdog_task
138.2 ȳs/s	0.00	Interrupt	[9] RCU(softirq)



# 4. Installation





## 5. Hint

```
henry@m
#include <stdio.h>
#include <unistd.h>

double compute_pi_baseline(size_t N) {
    double pi = 0.0;
    double dt = 1.0 / N;
    for (size_t i = 0; i < N; i++) {
        double x = (double) i / N;
        pi += dt / (1.0 + x * x);
    }
    return pi * 4.0;
}

int main() {
    printf("pid: %d\n", getpid());
    while(1){
        sleep(10);
        compute_pi_baseline(50000000);
    }
    //return 0;
}
```

Calculate pi\_baseline continuously

```
henry@m
/test1.c
#include <stdio.h>

int main(void)
{
    while (1)
        __asm__ ( "movl %ebx, %eax;");
}
~
~
~
~
```

Ask CPU to move ebx value into eax register continuously

%eax holds the system call number  
%ebx holds the return status



## 5. Hint (Table 1)

```
henry@mergubuntu:~/lab2$ powertop
PowerTOP v2.1 must be run with root privileges.
exiting...
henry@mergubuntu:~/lab2$ sudo powertop
[sudo] password for henry:
Loaded 0 prior measurements
Cannot load from file /var/cache/powertop/saved_parameters.powertop
Cannot load from file /var/cache/powertop//var/cache/powertop/saved_parameters.powertop
Leaving PowerTOP
henry@mergubuntu:~/lab2$ vim pi.c
henry@mergubuntu:~/lab2$ vim test1.c
henry@mergubuntu:~/lab2$ g++ pi.c -o pi
henry@mergubuntu:~/lab2$ g++ test1.c -o test1
```

```
Leaving PowerTOP
henry@mergubuntu:~/lab2$ vim pi.c
henry@mergubuntu:~/lab2$ vim test1.c
henry@mergubuntu:~/lab2$ g++ pi.c -o pi
henry@mergubuntu:~/lab2$ g++ test1.c -o test1
henry@mergubuntu:~/lab2$ ls
phonebook pi pi.c power powertop-2.7.tar.gz test1 test1.c
henry@mergubuntu:~/lab2$ sudo ./pi & sudo top
```



## 5. Hint(Table 1)

```
henry@mergubuntu: ~/lab2
top - 00:34:43 up 22:12,  2 users,  load average: 0.00, 0.01, 0.05
Tasks: 138 total,  1 running, 137 sleeping,  0 stopped,  0 zombie
Cpu(s):  9.1%us,  0.0%sy,  0.0%ni, 90.8%id,  0.0%wa,  0.0%hi,  0.0%si,  0.0%st
Mem: 16526196k total,  220556k used, 16305640k free,   3664k buffers
Swap: 16719868k total,    0k used, 16719868k free,   54236k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
 6240 root        20   0  2004   280  228 S   72  0.0   0:02.18 pi
   38 root        20   0     0     0   0 S    1  0.0   1:08.42 ksoftirqd/6
 1717 whoopsie    20   0 25944 4568 3496 S    0  0.0   2:16.61 whoopsie
 6241 root        20   0  2848  1164  876 R    0  0.0   0:00.03 top
    1 root        20   0   3512 1892 1284 S    0  0.0   0:03.70 init
    2 root        20   0     0     0   0 S    0  0.0   0:00.01 kthreadd
    3 root        20   0     0     0   0 S    0  0.0   0:03.62 ksoftirqd/0
    4 root        20   0     0     0   0 S    0  0.0   0:00.00 kworker/0:0
    5 root        0 -20     0     0   0 S    0  0.0   0:00.00 kworker/0:0H
    7 root        20   0     0     0   0 S    0  0.0   0:06.96 rcu_sched
    8 root        20   0     0     0   0 S    0  0.0   0:00.00 rcu_bh
    9 root        RT    0     0     0   0 S    0  0.0   0:00.00 migration/0
   10 root        RT    0     0     0   0 S    0  0.0   0:00.43 watchdog/0
   11 root        RT    0     0     0   0 S    0  0.0   0:05.15 watchdog/1
```

Have to wait a moment to see pi's state



## 5. Hint(Table 1)

```
henry@mergubuntu: ~/lab2
top - 00:35:32 up 22:13,  2 users,  load average: 0.28, 0.08, 0.06
Tasks: 140 total,  2 running, 138 sleeping,  0 stopped,  0 zombie
Cpu(s): 21.6%us,  0.0%sy,  0.0%ni, 78.3%id,  0.0%wa,  0.0%hi,  0.0%si,  0.0%st
Mem:  16526196k total,  219776k used, 16306420k free,   3680k buffers
Swap: 16719868k total,    0k used, 16719868k free,   54236k cached

  PID USER      PR  NI  VIRT  RES  SHR  S %CPU  %MEM    TIME+  COMMAND
 6247 root        20   0 2000   280  228  R   100   0.0   0:15.56 test1
 6240 root        20   0 2004   280  228  S    72   0.0   0:10.98 pi
   13 root        20   0    0    0    0  S    0   0.0   0:01.61 ksoftirqd/1
 1231 root        39  19    0    0    0  S    0   0.0   2:18.78 kipmi0
 1606 root        20   0 3600   680  528  S    0   0.0   0:19.02 irqbalance
 6248 root        20   0 2848  1160  876  R    0   0.0   0:00.04 top
    1 root        20   0 3512  1892 1284  S    0   0.0   0:03.70 init
    2 root        20   0    0    0    0  S    0   0.0   0:00.01 kthreadd
    3 root        20   0    0    0    0  S    0   0.0   0:03.64 ksoftirqd/0
    4 root        20   0    0    0    0  S    0   0.0   0:00.00 kworker/0:0
    5 root         0 -20    0    0    0  S    0   0.0   0:00.00 kworker/0:0H
    7 root        20   0    0    0    0  S    0   0.0   0:06.97 rcu_sched
    8 root        20   0    0    0    0  S    0   0.0   0:00.00 rcu_bh
    9 root        RT    0    0    0    0  S    0   0.0   0:00.00 migration/0
   10 root        RT    0    0    0    0  S    0   0.0   0:00.43 watchdog/0
   11 root        RT    0    0    0    0  S    0   0.0   0:05.15 watchdog/1
   12 root        RT    0    0    0    0  S    0   0.0   0:00.02 migration/1
```

Quit and do the same thing with test1  
./test1 & sudo top



## 5. Hint (Table 2)

```
henry@mergubuntu:~/lab2$ sudo powertop
Loaded 0 prior measurements
Cannot load from file /var/cache/powertop/saved_parameters.powertop
Cannot load from file /var/cache/powertop//var/cache/powertop/saved_parameters.powertop
Leaving PowerTOP
henry@mergubuntu:~/lab2$ sudo powertop --calibrate
```

```
Score: 0.0 ( 0.0)
Guess: 105.2
Actual: 0.0
```

```
-----
Leaving PowerTOP
```

```
henry@mergubuntu:~/lab2$ sudo powertop --csv=lab2.csv
```

```
Taking 1 measurement(s) for a duration of 20 second(s) each.
PowerTOP outputting using base filename lab2.csv
henry@mergubuntu:~/lab2$ ls
lab2.csv  phonebook  pi  pi.c  power  powertop-2.7.tar.gz  test1  test1.c
henry@mergubuntu:~/lab2$ csvtool readable lab2.csv | view -
```



## 5. Hint (Table 2)

```
henry@mergubuntu: ~/lab2

***PowerTOP Report***

**System Information**

PowerTOP Version: v2.1
Kernel Version: Linux version 3.13.0-32-generic (buildd@toyol) (gcc version 4.6.3 (Ubuntu/Linaro 4.6.3-1ubuntu1))
buntu SMP Tue Jul 15 03:50:54 UTC 2014
System Name: ASUSTeK Computer INC. Z9PR-D12 Series Rev 1.xx,
CPU Information: 8x " Intel(R) Xeon(R) CPU E5-2620 v2 @ 2.10GHz"
OS Information: Ubuntu precise (12.04.5 LTS)

**Power Consumption Summary**
160.5 wakeups/second 0.0 VFS ops/sec 0.0 GFX wakes/sec and 111.6% CPU use 0.0 GPU ops/second

Usage Category Description Events/s
79.9% Process ./test1 0.00
0.1% Interrupt [3] net_rx(softirq) 118.0
20.0% Timer tick_sched_timer 4.2
11.0% Process ./pi 0.00
0.0% Process [usb-storage] 9.8
0.0% kWork od_dbs_timer 9.3
0.0% Interrupt [17] ehci_hcd:usb1 5.6
0.2% Process [kipmi0] 2.4
0.0% kWork disk_events_workfn 1.7
0.1% Process whoopsie 0.8

**Processor Idle State Report**

Package
CPU 0
intel_idle 0.0%
POLL 0.0%
C1E-IVB 0.0% 0.0 ms
C3-IVB 0.5% 1.7 ms
C6-IVB 0.0% 0.1 ms
C6-IVB 88.1% 61.8 ms
CPU 1
intel_idle 0.0%
```





## 5. Hint(power saving policy)

```
/bin/sh
# Shell script to reduce energy consumption when running battery. Place
# it in /etc/pm/power.d/ and give execution rights.

if on_ac_power; then

# Start AC powered settings -----#

#NMI watchdog should be turned on
for foo in /proc/sys/kernel/nmi_watchdog;
do echo 1 > $foo;
done

# CPU Governor: Performance
for foo in /sys/devices/system/cpu/cpu*/cpufreq/scaling_governor;
do echo performance > $foo;
done

# Disable USB autosuspend
for foo in /sys/bus/usb/devices/*/power/level;
do echo on > $foo;
done

~
~
~
~
~
```

Try to make other five power-saving policy  
You can find other's on the net.



## 5. Hint(kill the process)

```
henry@mergubuntu: ~/lab2
top - 01:04:35 up 22:42,  2 users,  load average: 1.16, 1.16, 1.02
Tasks: 138 total,   3 running, 135 sleeping,   0 stopped,   0 zombie
Cpu(s):  0.8%us,  0.0%sy,  0.0%ni, 99.1%id,  0.1%wa,  0.0%hi,  0.0%si,  0.0%st
Mem: 16526196k total,  217644k used, 16308552k free,   3876k buffers
Swap: 16719868k total,    0k used, 16719868k free,   54648k cached

  PID USER      PR  NI  VIRT  RES  SHR  S %CPU  %MEM    TIME+  COMMAND
  6247 root        20   0  2000   280  228  R   101   0.0   29:17.49 test1
  6240 root        20   0  2004   280  228  R    99   0.0    5:23.83 pi
   13 root        20   0    0     0     0   S    2   0.0    0:01.72 ksoftirqd/1
    1 root        20   0  3512  1892 1284  S    0   0.0    0:03.70 init
    2 root        20   0    0     0     0   S    0   0.0    0:00.01 kthreadd
    3 root        20   0    0     0     0   S    0   0.0    0:03.98 ksoftirqd/0
    4 root        20   0    0     0     0   S    0   0.0    0:00.00 kworker/0:0
    5 root         0 -20    0     0     0   S    0   0.0    0:00.00 kworker/0:0H
    7 root        20   0    0     0     0   S    0   0.0    0:07.14 rcu_sched
    8 root        20   0    0     0     0   S    0   0.0    0:00.00 rcu_bh
    9 root        RT    0    0     0     0   S    0   0.0    0:00.00 migration/0
   10 root        RT    0    0     0     0   S    0   0.0    0:00.44 watchdog/0
   11 root        RT    0    0     0     0   S    0   0.0    0:05.16 watchdog/1
   12 root        RT    0    0     0     0   S    0   0.0    0:00.02 migration/1
   15 root         0 -20    0     0     0   S    0   0.0    0:00.00 kworker/1:0H
   16 root        RT    0    0     0     0   S    0   0.0    0:00.39 watchdog/2
   17 root        RT    0    0     0     0   S    0   0.0    0:04.94 migration/2
```

```
52 root         0 -20    0     0     0   S    0   0.0    0:00.00 kworker/u17:0
53 root         0 -20    0     0     0   S    0   0.0    0:00.00 kblockd
54 root         0 -20    0     0     0   S    0   0.0    0:00.00 ata_sff
55 root        20   0    0     0     0   S    0   0.0    0:00.00 khubd
56 root         0 -20    0     0     0   S    0   0.0    0:00.00 md

henry@mergubuntu:~/lab2$ kill 6240
-bash: kill: (6240) - Operation not permitted
henry@mergubuntu:~/lab2$ sudo kill 6240
[sudo] password for henry:
[1]-  Exit 143          sudo ./pi
henry@mergubuntu:~/lab2$ sudo kill 6247
[2]+  Exit 143          sudo ./test1
henry@mergubuntu:~/lab2$
```



## 5. Hint (Table 3)

```
53 root    0 -20    0  0  0 S    0  0.0  0:00.00 kblockd
54 root    0 -20    0  0  0 S    0  0.0  0:00.00 ata_sff
55 root   20  0    0  0  0 S    0  0.0  0:00.00 khubd
56 root    0 -20    0  0  0 S    0  0.0  0:00.00 md
henry@mergubuntu:~/lab2$ kill 6240
-bash: kill: (6240) - Operation not permitted
henry@mergubuntu:~/lab2$ sudo kill 6240
[sudo] password for henry:
[1]-  Exit 143          sudo ./pi
henry@mergubuntu:~/lab2$ sudo kill 6247
[2]+  Exit 143          sudo ./test1
henry@mergubuntu:~/lab2$ ls
lab2.csv  phonebook  pi  pi.c  power  powertop-2.7.tar.gz  test1  test1.c
henry@mergubuntu:~/lab2$ cd phonebook/
henry@mergubuntu:~/lab2/phonebook$ ls
dictionary  main_hash  main_hash.c  main_optimal  main_optimal.c  main_origin  main_origin.c  Makefile  phonebook.c  phonebook.h  phonebook.o  phonebook_origin.c  README.md  screenshot
henry@mergubuntu:~/lab2/phonebook$ ./main_origin & sudo perf top -p $!
[1] 6313
size of entry : 128 bytes
[1]+  Done              ./main_origin
henry@mergubuntu:~/lab2/phonebook$ sudo ./main_origin & sudo perf top -p $!
```

`./main_origin & sudo perf top -p $!`



## 5. Hint (Table 3)

```
henry@mergubuntu: ~/lab2/phonebook
Samples: 422 of event 'cycles', Event count (approx.): 147516279
25.26% main_origin      [.] findName
4.95% [kernel]          [k] prep_new_page
2.87% [kernel]          [k] native_flush_tlb_single
2.75% libc-2.15.so      [.] _IO_getline_info
1.98% main_origin      [.] append
1.63% libc-2.15.so      [.] malloc
1.44% libc-2.15.so      [.] _IO_fgets
1.18% [kernel]          [k] page_fault
1.18% main_origin      [.] 0x00000530
0.94% [kernel]          [k] __mem_cgroup_uncharge_common
0.71% [kernel]          [k] __pagevec_lru_add_fn
0.71% [kernel]          [k] __mem_cgroup_try_charge
0.51% [kernel]          [k] mem_cgroup_page_lruvec
0.47% [kernel]          [k] get_page_from_freelist
0.47% libc-2.15.so      [.] _IO_getline
0.47% [kernel]          [k] __mod_zone_page_state
0.47% [kernel]          [k] free_pcppages_bulk
0.47% [kernel]          [k] mem_cgroup_charge_statistics.isra.33
0.27% [kernel]          [k] rmqueue_bulk.constprop.73
0.24% [kernel]          [k] __alloc_pages_nodemask
0.24% [kernel]          [k] _raw_spin_lock_irqsave
0.24% [kernel]          [k] _rmqueue
0.24% [kernel]          [k] kmap_atomic_prot
0.24% [kernel]          [k] _raw_spin_lock
0.24% [kernel]          [k] sync_mm_rss
0.24% [kernel]          [k] __mem_cgroup_count_vm_event
```



## 5. Hint (Table 3)

```
[1] 6344
size of entry : 24 bytes
[1]+  Done                  ./main_optimal
henry@mergubuntu:~/lab2/phonebook$ perf stat -r 10 -e cache-misses,cache-references,L1-dcache-load-misses,L1-dcache-store-misses,L1-dcache-prefetch-misses ./main_origin
```

sudo perf stat -r 10 -e cache-misses,cache-references,L1-dcache-load-misses,L1-dcache-store-misses,L1-dcache-prefetch-misses ./main\_origin

```
reweighted is found!
xiphisternal is found!
yakattalo is found!
execution time of append() : 0.080000
execution time of findName() : 0.080000

Performance counter stats for './main_origin' (10 runs):

      2,331,981 cache-misses          #    75.107 % of all cache refs      ( +- 1.34% ) [79.69%]
      3,104,889 cache-references      ( +- 1.11% ) [80.62%]
      4,444,830 L1-dcache-load-misses ( +- 0.45% ) [80.72%]
        869,731 L1-dcache-store-misses ( +- 0.78% ) [80.86%]
      2,892,769 L1-dcache-prefetch-misses ( +- 0.88% ) [78.95%]

    0.163907428 seconds time elapsed      ( +- 3.55% )
```



## 5. Hint (Table 3)

```
root@mergubuntu: /home/source/lab2/phone

/* original version */
typedef struct __PHONE_BOOK_ENTRY {
    char lastName[MAX_LAST_NAME_SIZE];
    char firstName[16];
    char email[16];
    char phone[10];
    char cell[10];
    char addr1[16];
    char addr2[16];
    char city[16];
    char state[2];
    char zip[5];
    struct __PHONE_BOOK_ENTRY *pNext;
} entry;

entry *findName(char lastname[], entry *pHead);
entry *append(char lastname[], entry *e);

/* optimal version 1 */
typedef struct __LAST_NAME_ENTRY{
    char lastName[MAX_LAST_NAME_SIZE];
    entry *detail;
    struct __LAST_NAME_ENTRY *pNext;
} lastNameEntry;

lastNameEntry *findNameOptimal(char lastname[], lastNameEntry *pHead);
lastNameEntry *appendOptimal(char lastname[], lastNameEntry *lne);
```



## 6. Hint

### **Powertop(command & parameter & power policy):**

<http://www.tecmint.com/powertop-monitors-linux-laptop-battery-usage/>

<http://askubuntu.com/questions/112705/how-do-i-make-powertop-changes-permanent>

[http://bgrande.de/scripts/96\\_powersave](http://bgrande.de/scripts/96_powersave)

### **Perf(command & parameter):**

<https://perf.wiki.kernel.org/index.php/Tutorial>



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