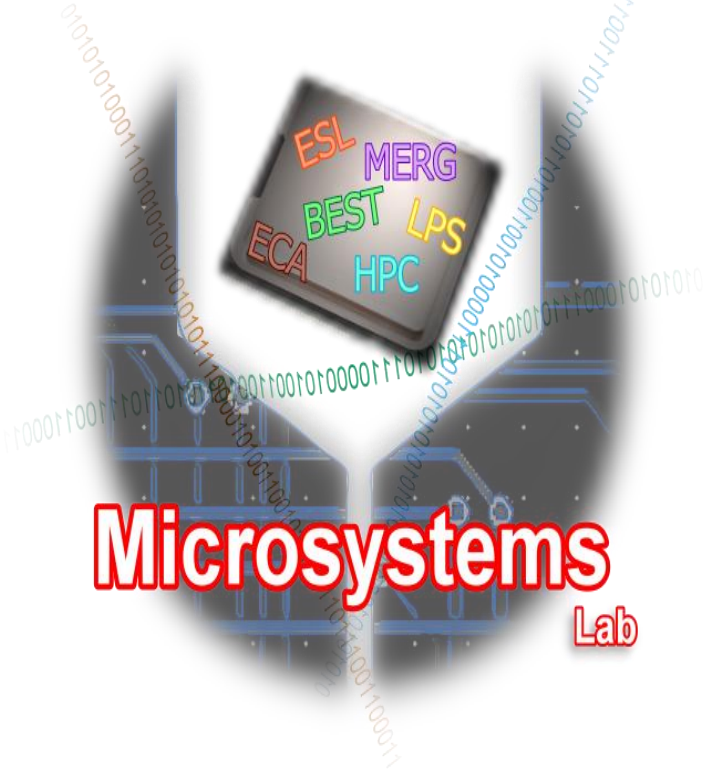
Get familiar with Powertop and Perf



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

Walle Haileeyesus E.

2024/12/17

Outline

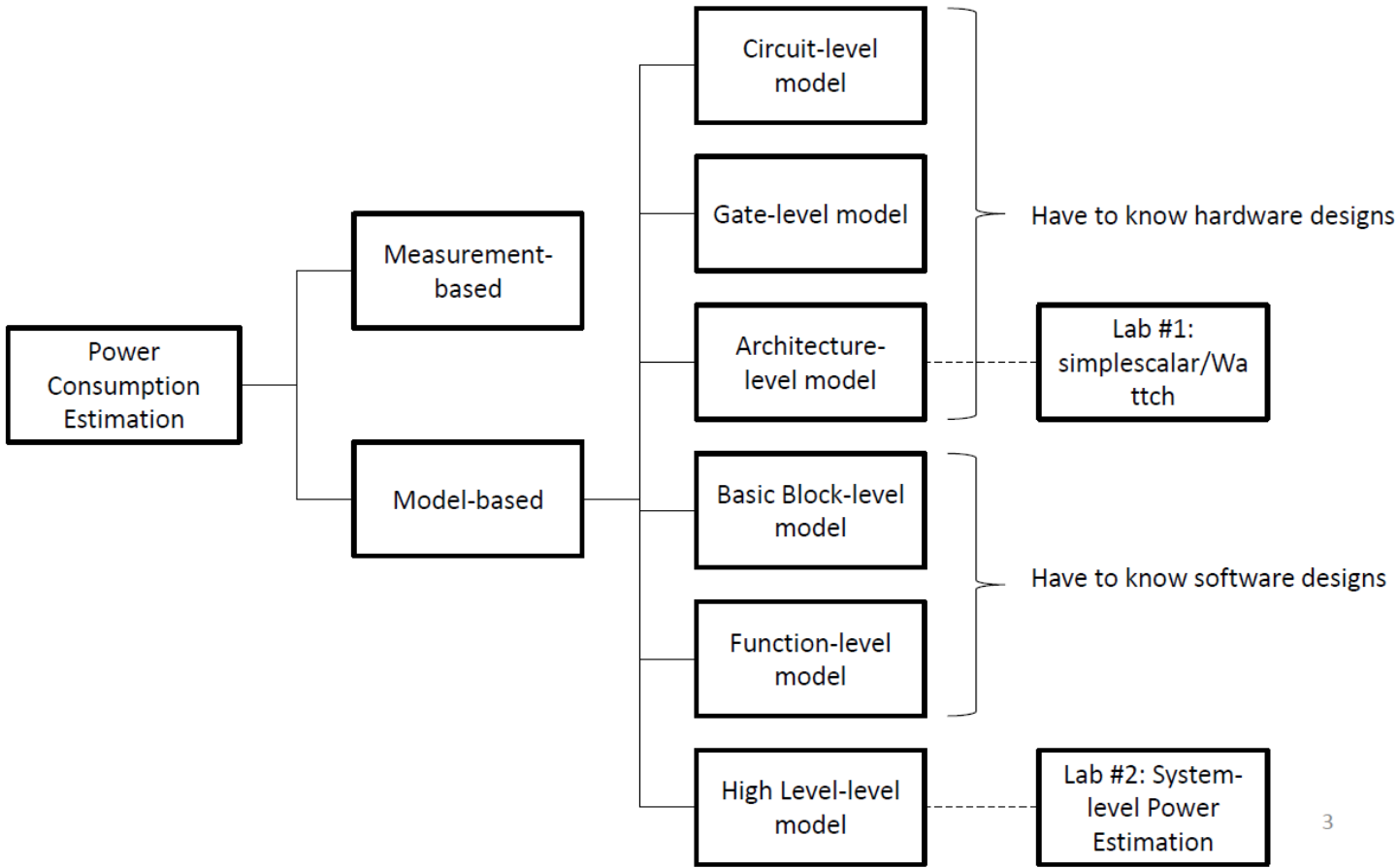
1. Introduction
2. Powertop
3. Perf
4. Installation
5. Hint

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

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

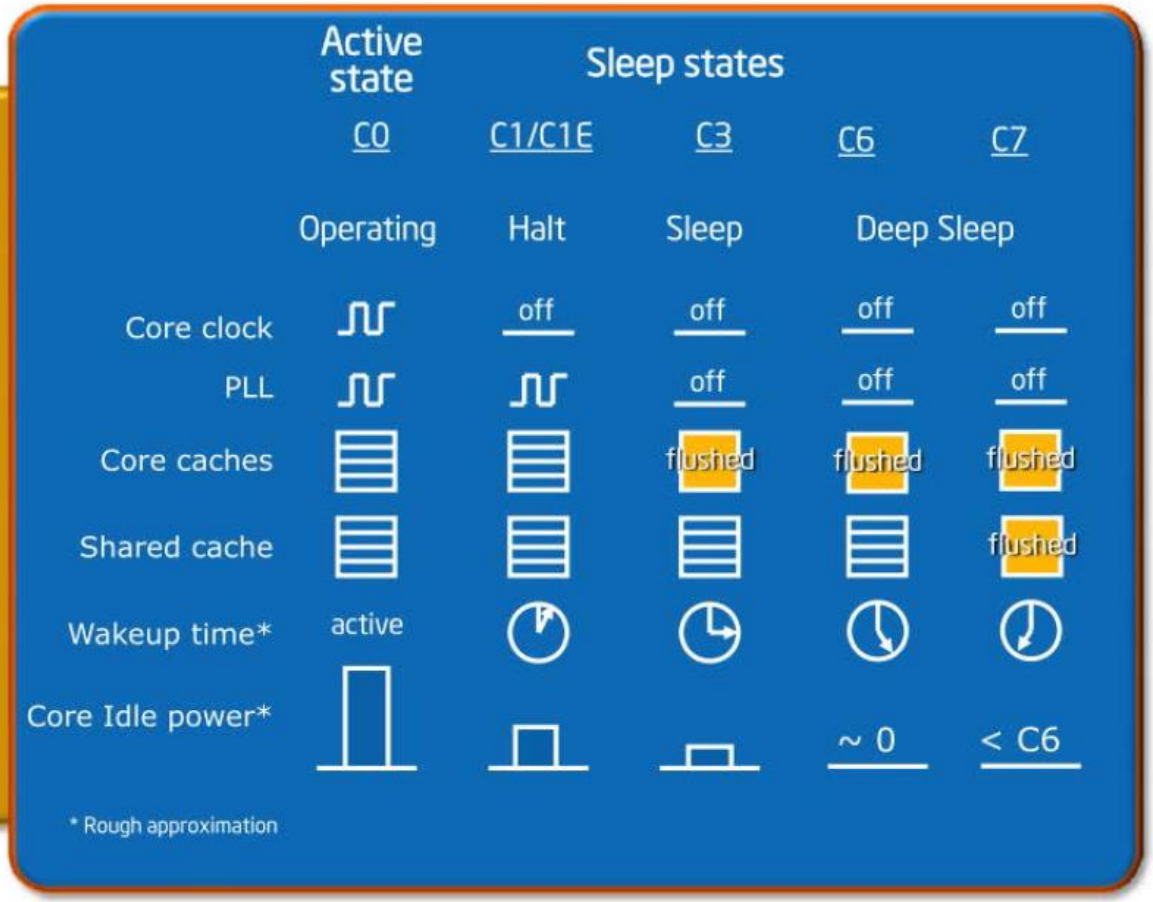
$$E_{cpu} = P_{cpu} \times T$$

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

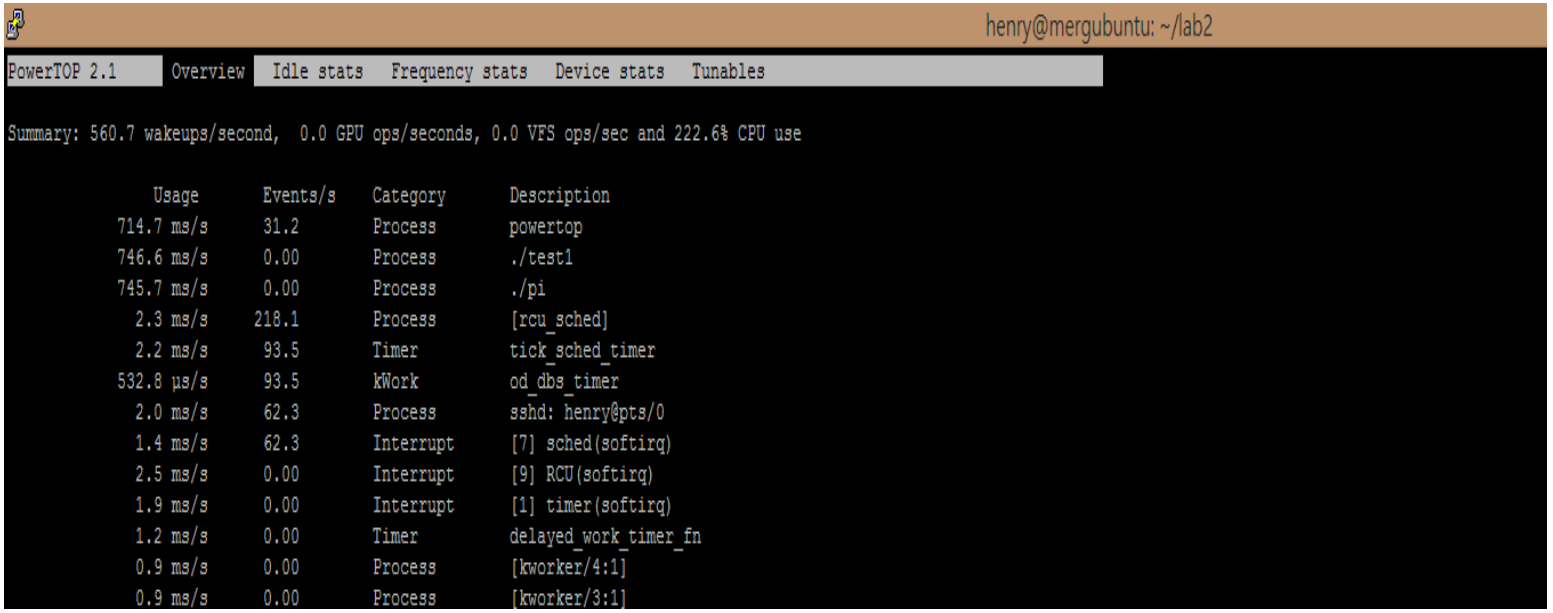
$$E_{wifi} = P_{wifi} \times T(S)$$

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

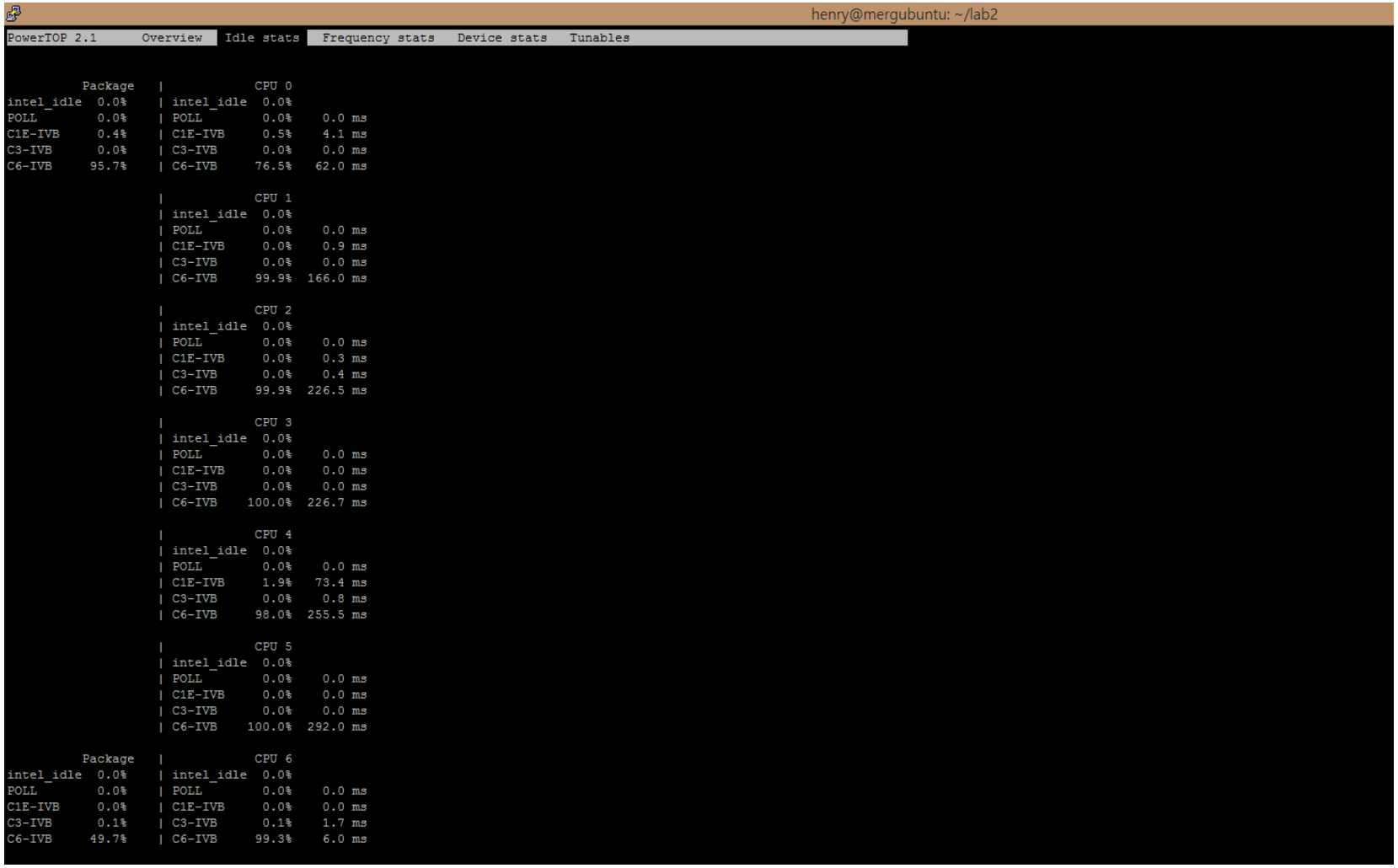


2. Powertop

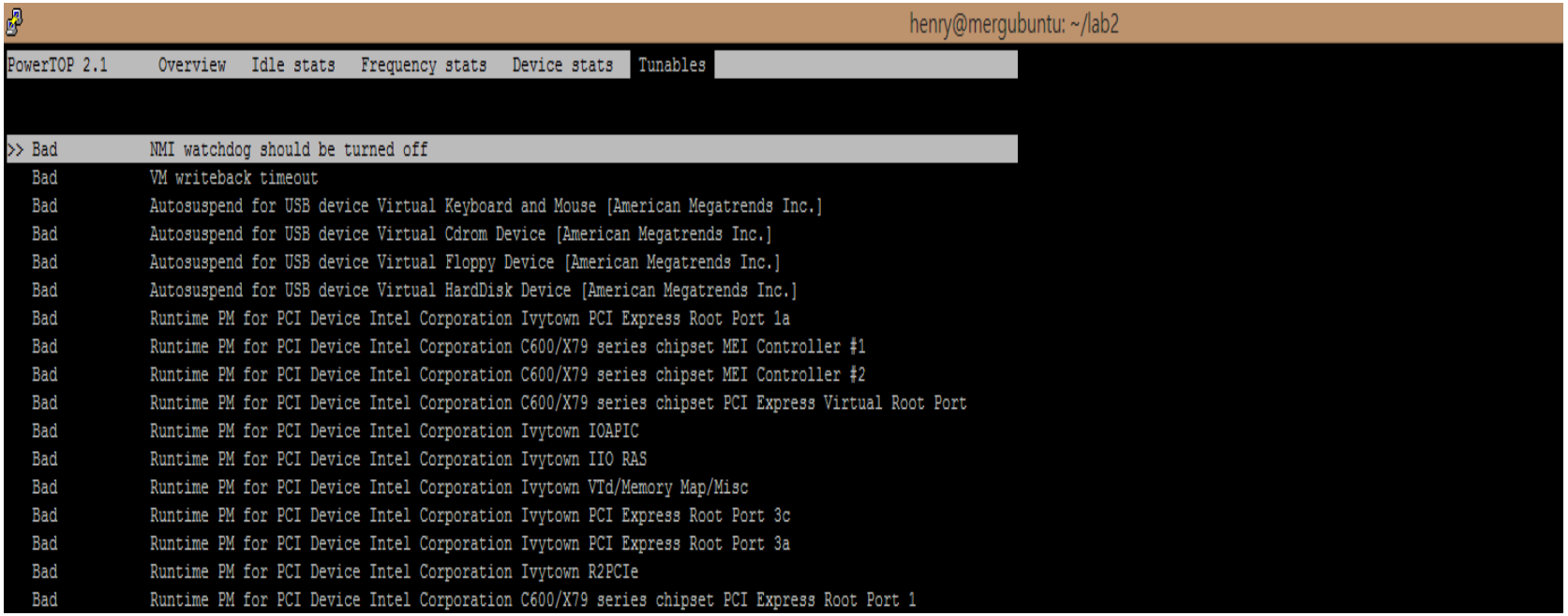


Press R can refresh this page
Use arrow key to change pages
Esc to quit

2. Powertop

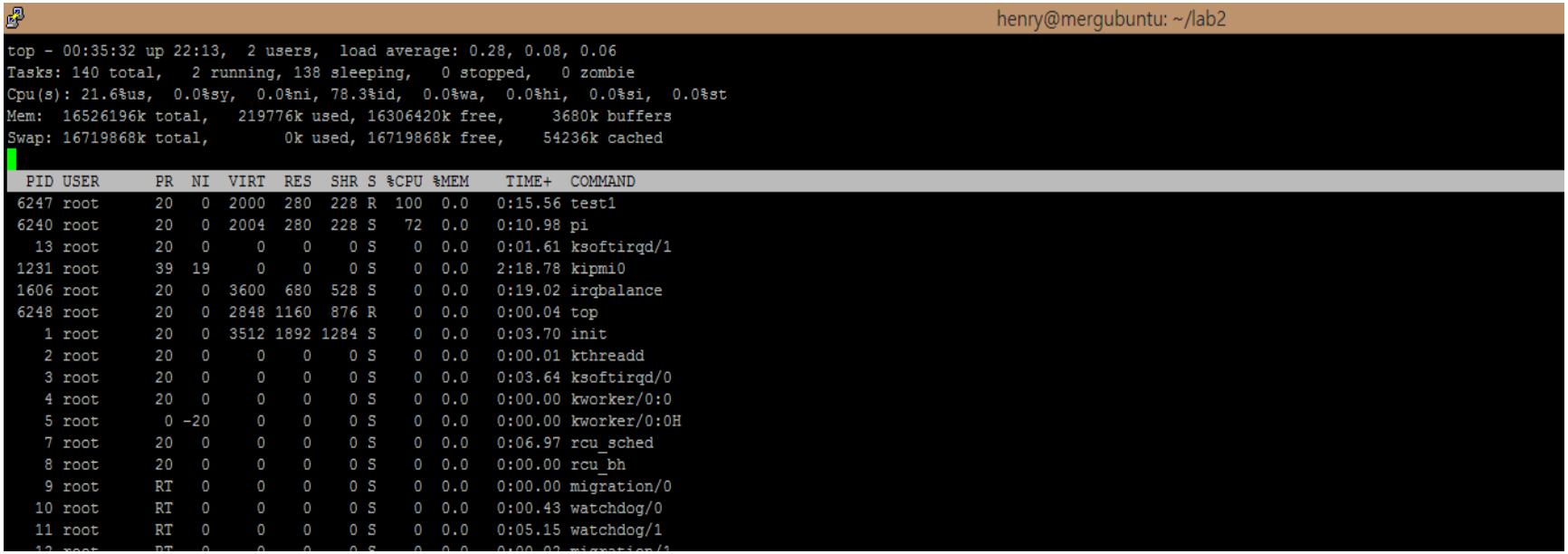

henry@mergubuntu: ~/lab2
PowerTOP 2.1 Overview Idle stats Frequency stats Device stats Tunables
Package
intel_idle 0.0%
POLL 0.0%
C1E-IVB 0.4%
C3-IVB 0.0%
C6-IVB 95.7%
CPU 0
intel_idle 0.0%
POLL 0.0% 0.0 ms
C1E-IVB 0.5% 4.1 ms
C3-IVB 0.0% 0.0 ms
C6-IVB 76.5% 62.0 ms
CPU 1
intel_idle 0.0%
POLL 0.0% 0.0 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
intel_idle 0.0%
POLL 0.0%
C1E-IVB 0.0%
C3-IVB 0.1%
C6-IVB 49.7%
CPU 6
intel_idle 0.0%
POLL 0.0% 0.0 ms
C1E-IVB 0.0% 0.0 ms
C3-IVB 0.1% 1.7 ms
C6-IVB 99.3% 6.0 ms

2. Powertop



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)



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

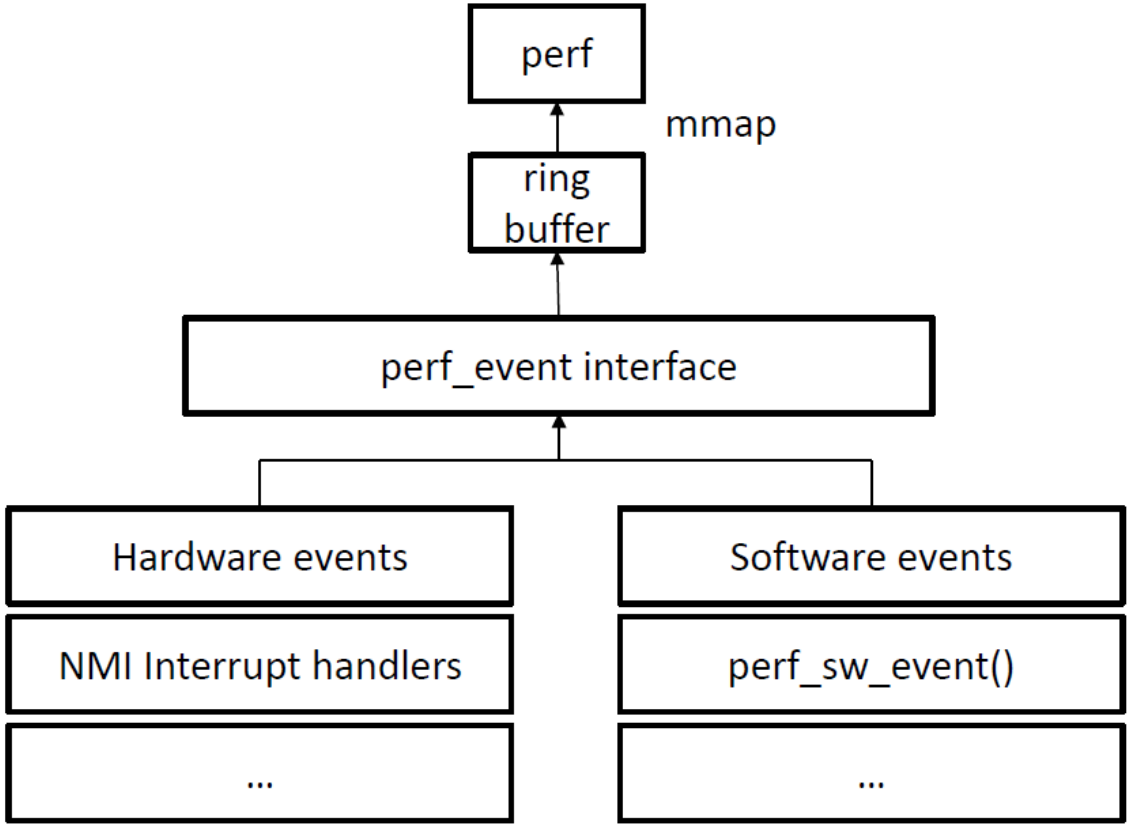
3. Perf

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
```

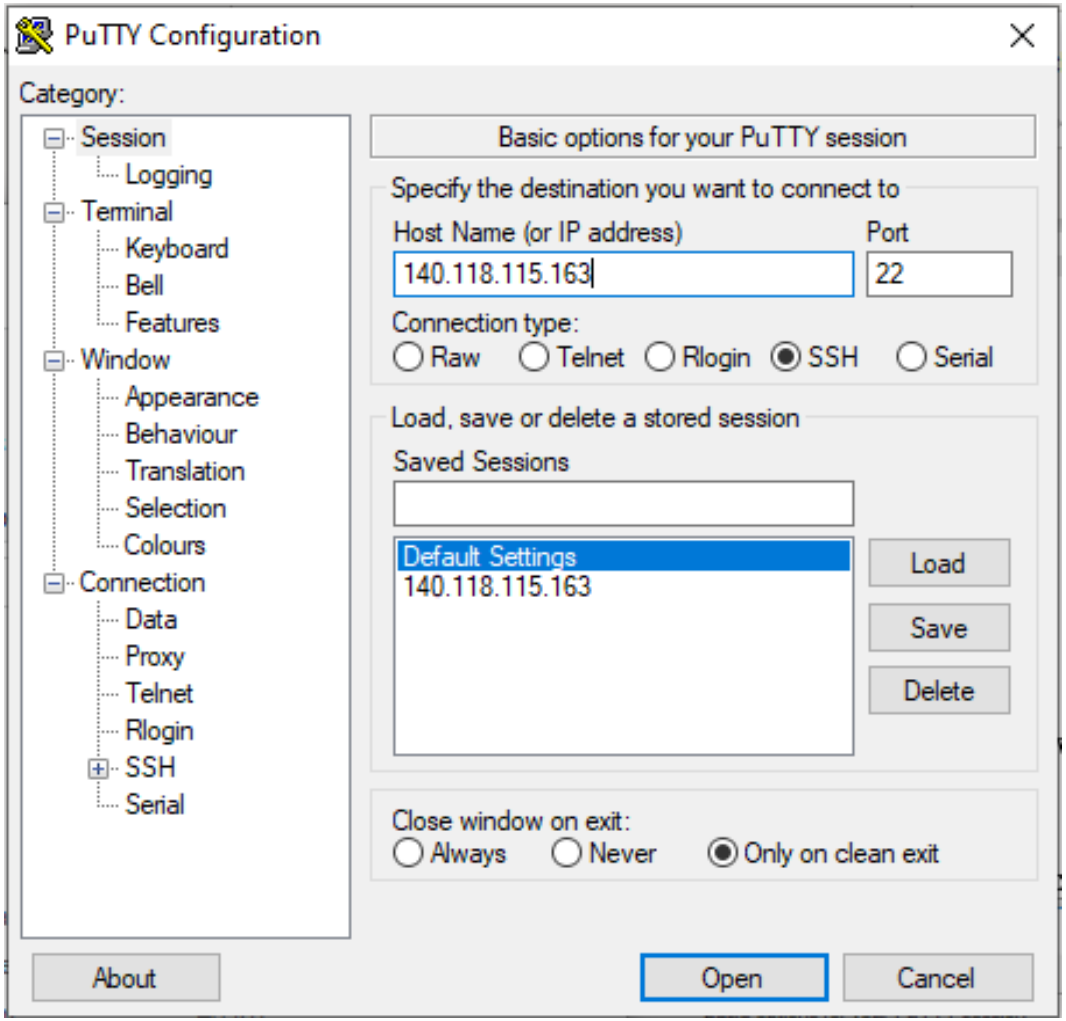
Can use perf to find the bottleneck in a program!

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

Powertop:

sudo apt-get install powertop

Perf:

sudo apt-get install linux-tools-common

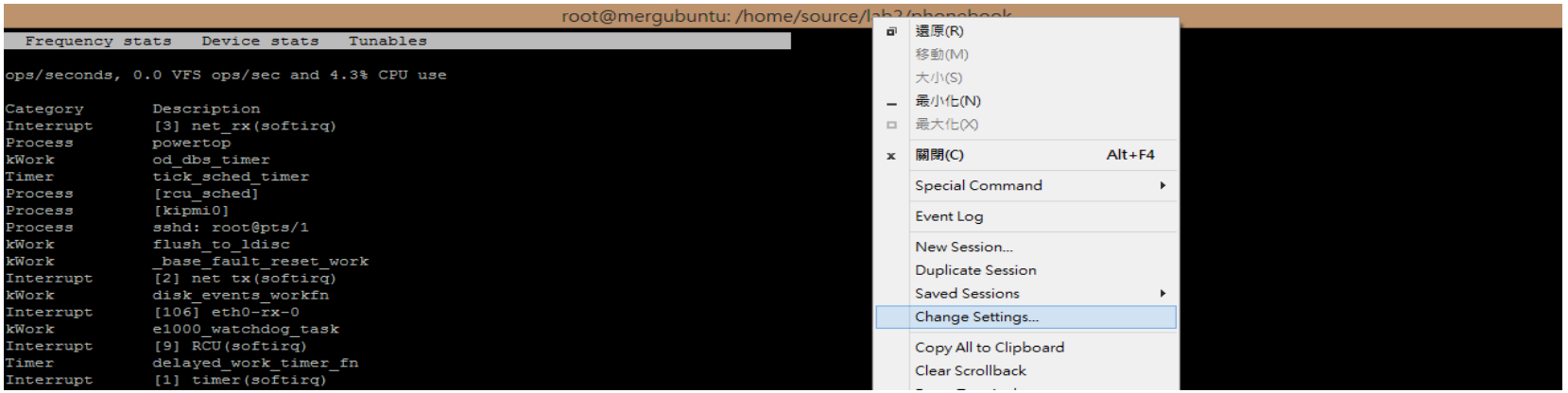
4. Installation

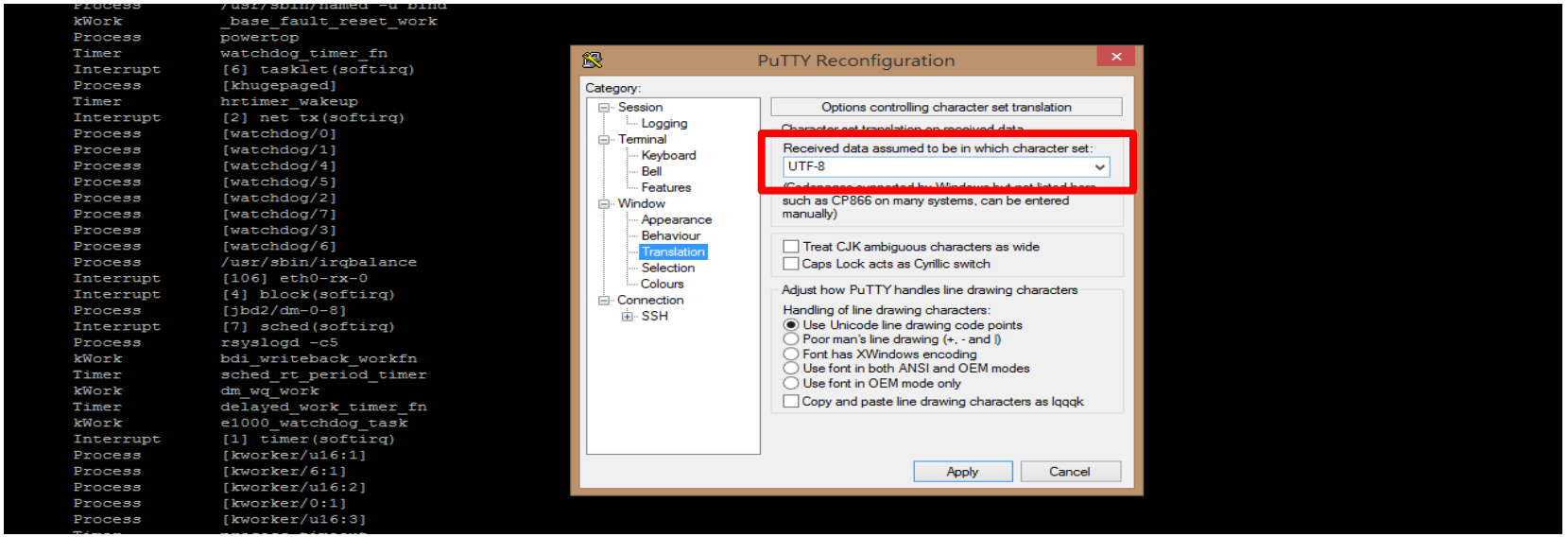
```
Your Hardware Enablement Stack (HWE) is supported until April 2017.

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 µs/s      12.3        kWork          od_dbs_timer
         114.5 µs/s       7.6        Timer          tick_sched_timer
         111.1 µs/s       4.7        Process        [rcu_sched]
           1.7 ms/s       2.8        Process        [kipmi0]
         129.1 µs/s       0.9        Process        sshd: root@pts/1
           7.4 µs/s       0.9        kWork          flush_to_ldisc
           3.8 µs/s       0.9        kWork          _base_fault_reset_work
           2.8 µs/s       0.9        Interrupt      [2] net tx(softirq)
           0.0 µs/s       0.9        kWork          disk_events_workfn
         266.5 µs/s      0.00        Interrupt      [106] eth0-rx-0
         198.0 µs/s      0.00        kWork          e1000_watchdog_task
         138.2 µs/s      0.00        Interrupt      [9] RCU(softirq)
```

4. Installation





5. Hint

```c
#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

```c
//test1.c
#include <stdio.h>

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

Ask CPU to move ebx value into eax register continuously

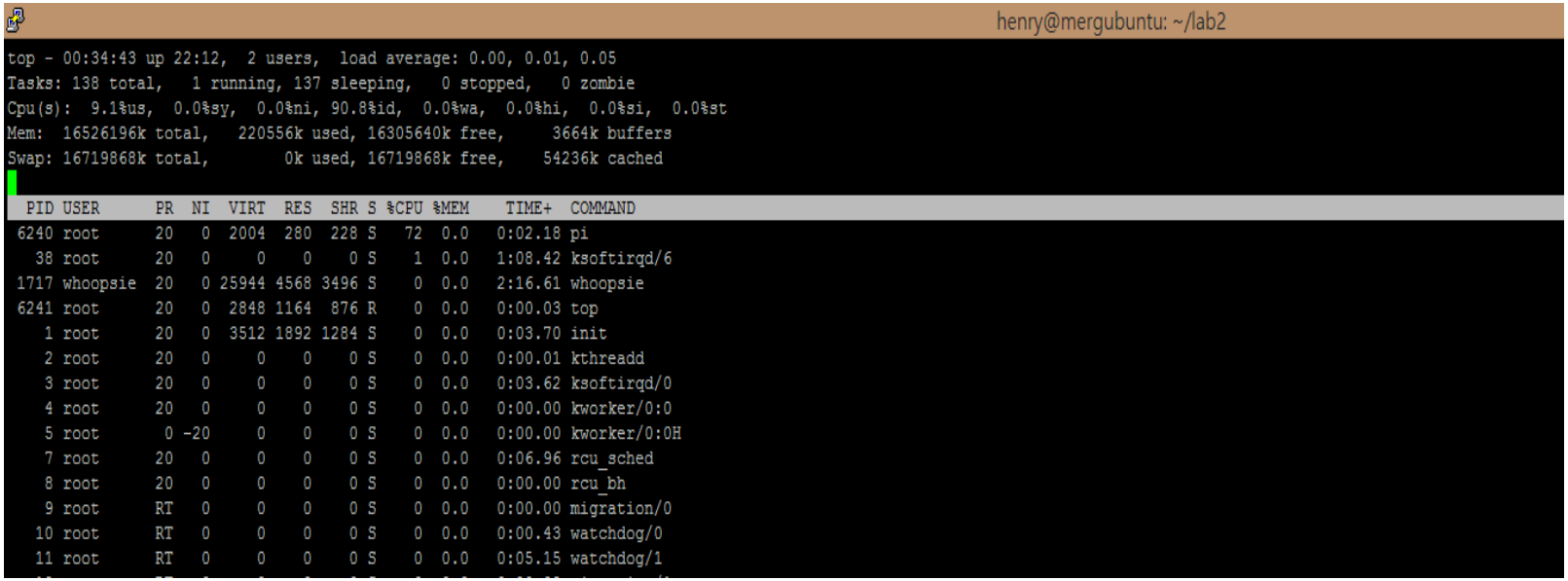
%eax holds the system call number
%ebx holds the return status

5. Hint(Table 1)

```
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
```

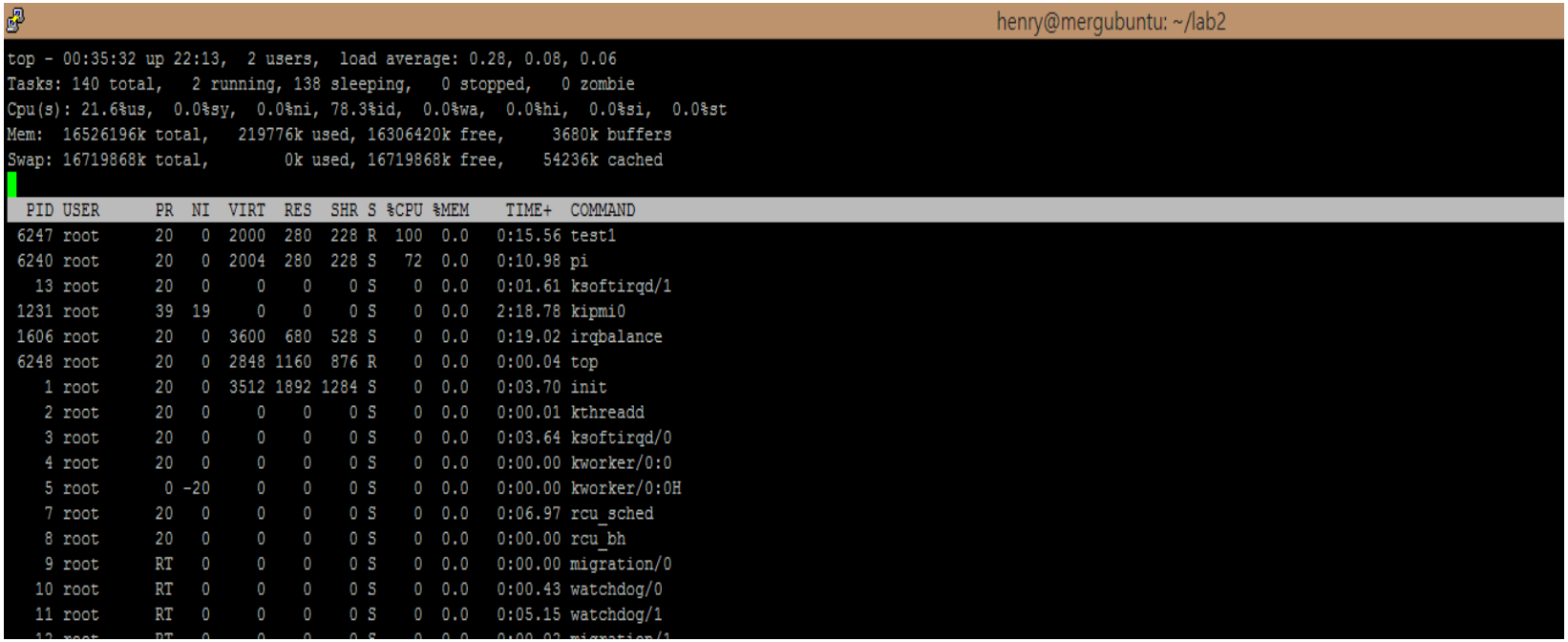
```
Leaving PowerTOP
henry@mergubuntu:~/lab2$ vim pi.c
henry@mergubuntu:~/lab2$ vim test1.c
henry@mergubuntu:~/lab2$ g++ pi.c -o pi
henry@mergubuntu:~/lab2$ g++ test1.c -o test1
henry@mergubuntu:~/lab2$ ls
phonebook  pi  pi.c  power  powertop-2.7.tar.gz  test1  test1.c
henry@mergubuntu:~/lab2$ sudo ./pi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

5. Hint(Table 1)



Have to wait a moment to see pi's state

5. Hint(Table 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 outputing 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

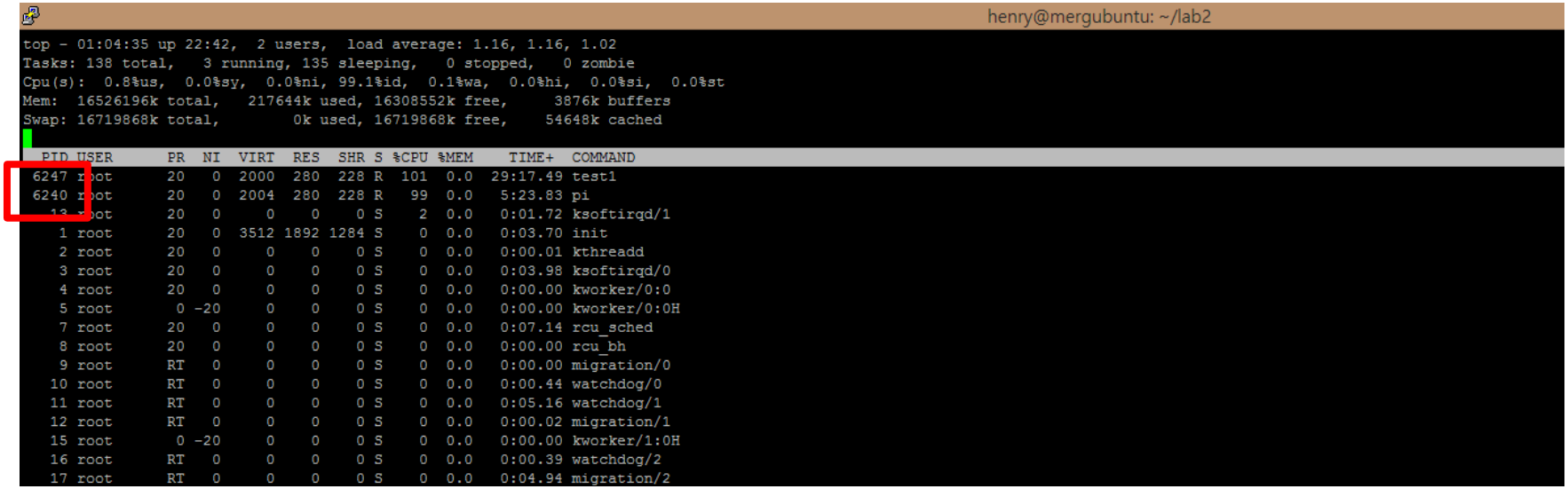
```
***PowerTOP Report***

**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
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 GPU ops/second
                       0.0 VFS ops/sec 0.0 GFX wakes/sec and 111.6% CPU use

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

**Processor Idle State Report**

                                                                           Package
                                        CPU 0
intel_idle                                                                 0.0%
                       intel_idle       0.0%
POLL                                                                       0.0%
                       POLL             0.0%                 0.0 ms
C1E-IVB                                                                    0.9%
                       C1E-IVB          0.5%                 1.7 ms
C3-IVB                                                                     0.0%
                       C3-IVB           0.0%                 0.1 ms
C6-IVB                                                                     97.1%
                       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)



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)

```
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

```
#ifndef _PHONEBOOK_H
#define _PHONEBOOK_H

#define MAX_LAST_NAME_SIZE 16

/* 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

Perf(command & parameter):
https://perf.wiki.kernel.org/index.php/Tutorial


Thank you!