

Advanced Computer Architecture

LAB2 – Get familiar with System-level Power Estimation Tool

Deadline: 2024/12/20

Student : M11215075, 胡劭

1 Introduction

You need to have access to a Unix/Linux computer to be able to perform the laboratory exercises. All installation instructions refer to Linux distributions, but they may work on Sun/Solaris or PC/Solaris installations as well.

※ **Note. Server IP: 140.118.115.163**

The account and password to access the server is your student ID number. You may change the password using the following command: `passwd <yourID i.e Old password><New password>`

2 Objective of the laboratory exercise

After this laboratory exercise, you should:

- Understand how program behavior relates to power consumption and performance.
- Be able to make tradeoffs related to save more power usage.
- Understand the bottleneck of a program and how to improve the performance.

3 Powertop assignments

3-1 Program behavior

Run the program pi, test1 and make an observation with top.

Table 1: process state in top.

process	VIRT	RES	SHR	S	%CPU	Time+
Pi	2200	548	504	R	11.7	0:02.45
Test1	2068	544	500	R	11.4	0:01.88

Q3-1.1 What is the difference in process state S(D、R、S、T、Z)?

Ans: D (TASK_UNINTERRUPTIBLE):

- A sleep state where the process cannot be interrupted
- Typically occurs during I/O operations
- The process cannot respond to any signals or be killed
- Must wait for specific conditions to be met before waking up

R (TASK_RUNNING):

- The process is either currently executing or waiting in the run queue
- The only state where a process can be executed on the CPU
- Includes both actively running processes and those ready to run

S (TASK_INTERRUPTIBLE):

- A sleep state where the process can be interrupted
- Waiting for certain conditions (e.g., keyboard input, network data) to be met
- Can be awakened by signals

T (TASK_STOPPED or TASK_TRACED):

- The process execution is suspended
- Usually caused by receiving a SIGSTOP signal
- May indicate the process is being debugged

Z (TASK_DEAD - EXIT_ZOMBIE):

- The process has terminated but remains in the process table
- Waiting for its parent process to read its exit status
- Retains minimal information for the parent process to retrieve

Q3-1.2 Try to use powertop calibrate function and generate a csv report. Using this report to fill the Table 2 with total power consumption(wakeups/second) and top four usage process.

Table 2: powertop csv report

total power consumption		????(wakeups/second)	
Usage	Category	Description	Events/s
402%	Process	./pi	0.00
263%	Process	./test1	0.00
24.6%	Process	/usr/lib/linux-tools/4.4.0-210-generic/perf top -p 25823	0.00
16.7%	Process	/home/m11302129/lab1/simplescalar/simplesim-3.0/sim-outorder basicmath_small	0.00
9.3%	Process	./pi -user=e11302007	0.00
7.0%	Process	.p1 ^	0.00
5.0%	Process	htop	0.00
0.1%	Process	/usr/lib/vino/vino-server --sm-disable	0.00
2.3%	Process	powertop	0.00
0.5%	Process	top	0.00

4 Powertop power-saving policy

Because powertop tunable page can't be store permanently. Try to add five more power saving policy in file "power" which is located in your folder. You have to make a brief explain to each policy. (Can just Print Screen and Paste below)

Ans:

Power-saving policy

m11215075@ACA-Server: ~/lab2

PowerTOP 2.8 Overview Idle stats Frequency stats Device stats Tunables

```
>> Good Enable Audio codec power management
Good Enable SATA link power management for host0
Good Enable SATA link power management for host1
Good Enable SATA link power management for host2
Good Enable SATA link power management for host3
Good Enable SATA link power management for host4
Good Enable SATA link power management for host5
Good NMI watchdog should be turned off
Good VM writeback timeout
Good Autosuspend for USB device xHCI Host Controller [usb2]
Good Autosuspend for USB device Asus USB Optical Mouse [PikArt]
Good Autosuspend for USB device xHCI Host Controller [usb1]
Good Autosuspend for USB device xHCI Host Controller [usb3]
Good Autosuspend for USB device xHCI Host Controller [usb4]
Good Autosuspend for USB device USB Keyboard [SIGMACHIP]
Good Runtime PM for I2C Adapter i2c-1 (1915 gmbus dpb)
Good Runtime PM for I2C Adapter i2c-2 (1915 gmbus dpd)
Good Runtime PM for I2C Adapter i2c-0 (1915 gmbus dpc)
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH HD Audio
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH SATA controller [AHCI mode]
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH PCI Express Root Port #5
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH PCI Express Root Port #6
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH PCI Express Root Port #7
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH PCI Express Root Port #8
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH PCI Express Root Port #9
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH LPC Controller (B250)
Good Runtime PM for PCI Device Intel Corporation 200 Series/Z370 Chipset Family Power Management Controller
Good Runtime PM for PCI Device Intel Corporation 200 Series PCH CSME HECI #1
Good Runtime PM for PCI Device Intel Corporation 200 Series/Z370 Chipset Family SMBus Controller
Good Runtime PM for PCI Device Realtek Semiconductor Co., Ltd. RTL8111/8168/8411 PCI Express Gigabit Ethernet Controller
Good Runtime PM for PCI Device ASMedia Technology Inc. ASM1083/1085 PCIe to PCI Bridge
Good Runtime PM for PCI Device ASMedia Technology Inc. ASM1142 USB 3.1 Host Controller
Good Runtime PM for PCI Device Intel Corporation 200 Series/Z370 Chipset Family USB 3.0 xHCI Controller
Good Runtime PM for PCI Device Intel Corporation HD Graphics 630
Good Runtime PM for PCI Device Intel Corporation Xeon E3-1200 v6/7th Gen Core Processor Host Bridge/DRAM Registers
Good Wake-on-lan status for device eth0
```

m11215075@ACA-Server: ~/lab2

GNU nano 2.5.3

```
#!/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

#1. Enable Audio codec power management
for card in /sys/class/sound/card*/power/control; do
    echo auto > $card
done

#2. Enable SATA link power management
for link in /sys/class/scsi_host/host*/link_power_management_policy; do
    echo min_power > $link
done

#3. Enable Runtime PM for PCI devices
for pci in /sys/bus/pci/devices/*/power/control; do
    echo auto > $pci
done

#4. VM writeback timeout adjustment
echo 1500 > /proc/sys/vm/dirty_writeback_centisecs

#5. Wake-on-lan control
ethtool -s eth0 wol d

fi
```

1. Enable Audio codec power management

- ✓ Purpose: Reduces power consumption of audio hardware components
- ✓ When enabled, audio devices will automatically enter low-power mode when not in use
- ✓ Particularly effective for laptops and systems with integrated audio

2. Enable SATA link power management

- ✓ Purpose: Optimizes power usage of SATA connections to storage devices
- ✓ Allows SATA links to enter lower power states during periods of inactivity
- ✓ Helps reduce overall system power consumption without impacting performance

3. Enable Runtime PM for PCI devices

- ✓ Purpose: Implements dynamic power management for PCI devices
- ✓ Automatically puts inactive PCI devices into low-power states
- ✓ Particularly beneficial for systems with multiple PCI devices like graphics cards and network adapters

4. VM writeback timeout adjustment

- ✓ Purpose: Optimizes the frequency of writing cached data to disk
- ✓ Setting it to 1500 centiseconds increases the interval between write operations
- ✓ Reduces disk activity and power consumption while maintaining system stability

5. Wake-on-lan control

- ✓ Purpose: Disables Wake-on-LAN functionality
- ✓ Prevents unnecessary power consumption by the network interface
- ✓ Especially useful when the system doesn't require remote wake-up capabilities

These policies work together to create a comprehensive power management strategy that reduces system power consumption while maintaining functionality. Each policy targets a specific hardware component or system function, allowing for granular control over power usage.

5 Perf

We will use the phonebook case to understand what perf tool can help us to improve program performance. There are two methods that can let us find the right name in phonebook. The only different place is how they claim their entry structure. But in this observation, you can find the original one costs more time and also gets lots of cache misses. Using this perf tool to fill the Table 3.

Table 3: Cache miss and performance with phonebook case.

	% of FindName	% of all cache ref
Main_origin	20.97%	91.738%
Main_optimal	11.43%	58.485%

Q5.1 What is the key point that lets these two methods get different performance.

Ans: The size of entry in main_origin is 128 bytes, and the size of entry in main_optimal is 24 bytes. This significant size difference leads to clear performance differences as shown by the perf statistics:

1. FindName function overhead:

- main_origin spends 20.97% of execution time in FindName
- main_optimal only spends 11.43% of execution time in FindName

2. Cache efficiency:

- main_origin has a high cache reference rate of 91.738%
- main_optimal achieves better cache efficiency with only 58.485% cache references

These numbers clearly demonstrate that the smaller entry structure in main_optimal results in better memory access patterns and CPU cache utilization.

6 Conclusions

At the end of this laboratory exercise, you should be able to answer following questions:

Q6.1 What benefits can we obtain when using powertop?

Ans: Powertop provides several key benefits:

1. It can estimate the total power consumption resulting from system usage and monitor individual processes separately.
2. It helps us identify power-draining processes and components.
3. It can help us save power by suggesting and implementing power saving policies.
4. It provides real-time monitoring of system power usage through its interactive interface.
5. It can generate detailed reports for power consumption analysis.

Q6.2 What benefits can we obtain when using perf?

Ans: Perf offers multiple advantages for performance analysis:

1. It can analyze the performance of different processes in detail.
2. It supports various performance monitoring features:
 - ✓ Hardware performance counters
 - ✓ Tracepoints
 - ✓ Software performance counters (e.g. hrtimer)
 - ✓ Dynamic tracing probes (kprobes/uprobes)
3. It helps identify performance bottlenecks through cache misses and CPU cycle analysis.
4. It provides detailed statistical data for program optimization.

If you have any problems, please contact with the TA.

E-mail: D10602805@mail.ntust.edu.tw (Walle Haileeyesus Engdaw)