Component-wise Energy Breakdown of Laptop

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***Abstract*-In the modern age, there is an exponential growth in the usage of laptops for computing and communication. However, the battery life of laptops is only a few hours at best. Further, studies indicate that laptops have a stake of approximately one percent in the overall global energy consumption. Thus, there are significant incentives to minimize energy consumed by laptops. To achieve this goal, it is important to understand the energy consumed by each component of a laptop. In this work, we systematically studied the power consumed by each component of a modern laptop. Our results indicate that wireless communication is a significant consumer of power along with obvious power hogs like the Display, Graphics card and the Processor.**

I. Introduction

Importance of energy efficiency lies in the fact that it ensures provision of same level of energy using fewer amounts of fossil fuels. Owing to the increasing demand and limited availability of fossil fuels, the importance of efficient use of energy has been realized all over the world. The measures of energy efficiency are useful in multiple ways. Reduced use of fossil fuels is essential in lowering the emission of greenhouse gases contributing to global warming. The policies for energy efficiency aim to minimize the use of fossil fuels; thereby prevent the occurrence of adverse climatic change resulting from it. Energy efficiency reduces electricity consumption and helps in saving money and nature [1].

The concepts of renewable energy and energy efficiency go hand in hand. These two concepts are considered to be the "twin pillars" of the policies regarding sustainable energy. To make the most of the sustainable energy policy there needs to be simultaneous application of strategies regarding renewable energy and efficient use of energy [1].

In this project we have focused more on the latter part of the energy saving schema discussed above. We have been hearing from the past years that desktop sales have been taken over by laptops worldwide. We tried to calculate an approximate amount of energy consumed only by laptops. Some interesting facts have been revealed that the stake taken by it is approximately one percent of overall global energy consumption. Also we wanted to explore further by seeing which component is the major contributor of energy in the laptop.

The rest of the project is organized as follows. We first introduce the hardware and software setup used in the project. Then, the explanation about the procedure and graphs obtained is discussed and finally limitations and breakdown of components are explained.

II. Hardware & Software

Our laptop used in the project is IBM Lenovo SL400 [2] with a 14 inch display. The operating system loaded on it is Ubuntu 9.04 [3]. We used an Intel Core 2 Duo Processor, 2GB RAM, 14.1" display and a 6-cell Li-Ion battery. The setup used for conducting the experiments is multimeter, for obtaining the direct readings and rest is using the 'state' of the battery at different stages of the experiment. The stress to any system is the graphics; this could be achieved using the 3D games. Direct measurements were done for the hard drive and the I/O ports.

III. Procedure

A. The various components exploited in the work are as follows

B. *A. Hard Disk Drive:*

C. The hard disk drive connected to the laptop under examination was a 7200 rpm drive with 160 GB capacity. In its original configuration, the hard disk drive is connected to the laptop through a 22 pin SATA connector. In order to take the current and voltage measurements across the hard drive terminals, a 22 pin SATA extension cable is used facilitating the use of a Multimeter for measuring the current. At first the power consumption of hard drive is studied by running the standard read, write and copy operations on the disk and checking the power drained from the battery to estimate the effect of hard disk utilization on the battery. A 697.9 MB Ubuntu ISO image file is used for performing the tests. The results obtained are highest for copy which is 3.37W and lowest is 2.13W for idle operation.

D. *B. LCD Display*

We measured the energy used by laptop using an inbuilt procedure taken from ACPI of Ubuntu operating system. Our measurement was done using a different approach. The display was isolated by removing the hard drive, optical drive and turning off network and Bluetooth devices. We booted the laptop using an USB drive. Once the laptop was up and running we even removed the USB. Now the laptop was only left with LCD, CPU and Memory (RAM). Here CPU and Memory (RAM) takes very minimal amount of energy since nothing is being processed.

Brightness was kept at maximum level and appropriate readings were taken from ACPI procedure for every minute for over an hour. The experiment was repeated for Brightness with minimum level, White and Black background. The power consumption is highest for black background which is 0.210W and lowest for default background at low brightness which is 0.180W per minute interval. We can observe that power consumed is 15% more when the brightness level is at maximum when compared to minimum.

C. Graphics Card

NVIDIA graphics card is used in the experiment. The 3D games are played using the Wi-Fi and later with Wi-Fi off. The 3D game used was *Warezone 2100* without Wi-Fi and with Wi-Fi was *Evony*. Additionally 2D game like *Solitare* was used for comparison of the three stages of stress on graphics. 3D Game with Wi-Fi consumed more energy than any other methods used.

D. Wireless Card

The Wireless LAN standard than was considered for the testing the laptop was IEEE 802.11g [4], for which standard transmission rate is 54 Mbps. The applications that were tested were FTP, Voice and Video streaming. To check the power consumption of FTP application 690 MB file was downloaded. The voice application was tested using Skype. The highest is 20.629W for VOIP application and lowest is 18.732W for FTP.

E. Optical drive

The component under test is a DVD-RW Drive. The Drive is capable of writing and reading from both 8x as well as 16x Disks. This component is a part of Lenovo SL400 laptop. It uses SATA cable for transmitting data and also embedded is the power chords.

The test was performed for two kinds of operations on this device, one is the read operation and the other is write operation. During the first part of our experiment we tested with small amount of data (600Mb) on different brightness levels of LCD Display. One of the key things we observed here is that not only did low brightness consume less energy but also it consumed less time to perform the operation.

F. I/O ports

In our first experiment we measured the energy consumption of the usb port by playing a movie continuously for an hour using flash drive in intervals of 5 mins. Some USB devices can shorten battery life dramatically when used for a longer time. To experiment this we tested a set of standard USB devices which are used in our daily life. An USB extension cable was used to connect and measure the power consumption. This cable enables us to measure current drawn for USB devices while they're in use with help of an ammeter. The highest and the lowest being iphone charging 2.475W and flash drive in idle state that is 0.297W respectively.

G. Bluetooth

For the measurement of energy consumed by the Bluetooth we have taken a *BlueSoleil Dongle of version 2.0 and transfer files to and from laptop to mobile devices. We have used mobile devices like* Sony Ericsson W580i (Bluetooth v2.0), MotoV3 (Bluetooth v1.1) for our experiments. Due to Bluetooth v1.1's transmission rate is less time taken to transfer data was more, so it consumed more energy. But with respect to version 2.0, energy consumed was comparatively less due to faster transmission rate. The readings were taken with full brightness and Wi-Fi off.

It is evident from the results that receiving data consumes more energy than transferring data. And with v1.1 Bluetooth the reception is very high compared to v2.0.

IV. Results discussion & limitations

Wireless NIC card has been tested with different types of applications like FTP, VoIP and video streaming. The results over a period of time show that VoIP consumes more energy out of the tested applications. The chart obtained for it is shown in figure 1.

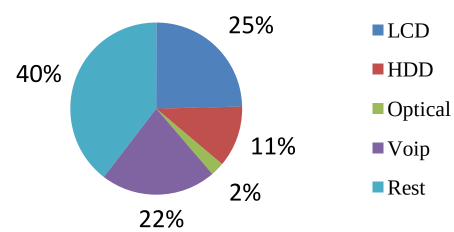

Fig1. Operation: Wireless card (VoIP); System power: 19W

Limitations

The accuracy of the experiments conducted is limited by various factors. When we were measuring via the multimeter there could be a marginal error of +/- 3mA. Another factor would be some results were obtained by the subtractive approach so the results obtained could vary with an error rate of less than one percent [5]. Finally we were able to obtain the results for some components and other components integration are termed as 'Rest' in the pie charts which means rest of the system.

V. Conclusion and future work

The main purpose of this project was to obtain the component wise energy breakdown of a laptop. We were able to obtain the energy for the following components: Hard disk, display, graphics card, wireless card, optical drive, I/O ports and Bluetooth. The results obtained suggest that Display, Graphics card and Processor consume a significant amount of energy in a system. And surprisingly, a very active wireless card consumes energy second only to the LCD. This calls for future research on developing energy-efficient algorithms and protocols for wireless communication.

References

[1] Importance of Energy and Energy Efficiency by Economy Watch

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[3] http://www.ubuntu.com/testing/jaunty/beta