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Power Management in Mobile Computing (a Survey)

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Power Management in Mobile Computing*

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Abstract

Rapid advances in technology have resulted in laptop (mobile) computers with performance and features comparable to desktop (stationary) machines. Advances in rechargeable battery technology have failed to keep pace, decreasing the usefulness of mobile computers and portable wireless devices.

Several methods of power management can be used to prolong the battery life of a mobile computer. We provide a detailed analysis of power consumption typically encountered in a networked laptop computer and the power management methods currently used. We also outline some novel proposed power management methods.

1 Introduction

Laptop computers have often served as portable word processors or game machines. Such machines were generally two or more generations behind desktop computers in terms of processing power, features and performance. Limitations in display and miniaturization technology prevented laptops from being able to compete with desktops as "real" (i.e. full featured) computers.

Recent advances in technology have dramatically improved laptop performance and it is increasingly common to see software development being done on a laptop. Laptops with a 133 MHz Pentium processor, 1.2 Gigabyte hard disk, modular 6x CD ROM drive and 12.1 inch SVGA display are available in mid-1996, albeit at a price premium over comparable desktops. A survey in Computerworld [7] predicts that the number of workers using portable computers will expand from about one in five today to about one in three by the year 2000, and that 80% of portable users will use their portables as their primary machines, up from the current 30%. This optimistic view is heavily dependent on laptops being able to overcome some key drawbacks. In addition to a price premium, laptops have another significant disadvantage compared to desktops—limited battery life.

1.1 Background

The major components of a typical laptop are the microprocessor (CPU), liquid crystal display (LCD), hard disk, system memory (DRAM), keyboard/mouse, CD ROM drive, floppy drive, I/O subsystem, audio subsystem and in the case of a mobile computer, a wireless network card. There are other components, but these are significant consumers of power. The CPU/motherboard of a laptop poses several design problems not found in a desktop. In addition to the power it consumes, there are also extreme thermal dissipation and space concerns. Because of these issues, laptop CPU's are still typically several months behind desktop CPU's in terms of processing power.

The display is another major power consumer and again poses problems not found in a desktop machine. Unlike the Cathode Ray Tube (CRT) monitors used in all desktops, there are two major types of displays

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used in laptops - passive dual scan (STN - Super Twisted Nematic) and active matrix (TFT - Thin Film Transistor). The dual scan display is cheaper and easier to manufacture but has poorer picture quality, especially when displaying fast-moving images. The active matrix display produces excellent picture quality but at a higher cost and greater power consumption. Active matrix displays are also more difficult to manufacture and very often have several defective pixels in them. Table 1 shows some of the differences between typical desktop and laptop displays[1].

Display type	Display size (diagonal inches)	Weight (lbs)	Power Consumed (Watts)	Resolution (pixels)	Number of colors
Desktop	17"	47.4	190 (max)	1280x1024	unlimited
Laptop	11.3"	1.1	2.7	800x600	262,144

Table 1: Comparison of typical laptop and desktop displays.

In addition to reducing the physical size (i.e. form factor), laptop drive design also requires increased tolerance for mechanical shocks and the ability to spin up faster than desktop drives. The latter is necessary because laptop drives get spun down more often in order to reduce power consumption (this is explained in more detail in Section 4.1). Table 2 shows the contrast between typical[2] desktop and laptop drives. The differences in power consumption are very significant, as we will see later in this paper.

Type	Capacity (MBytes)	Size ($inches^3$)	Weight (lbs)	Power (R/W) (Watts)	Power (Idle) (Watts)	Shock Tolerance (Gs)
Desktop	2113	15.0	1.0	7.0	3.2	2
Laptop	810	8.3	0.4	2.1	1.0	100

Table 2: Comparison of laptop and desktop hard drives

All of the subsystems of the laptop share a single battery as their primary source of power when not plugged into a wall outlet. There is usually an additional small battery for the real time clock and for memory backup, but this is not relevant to our discussion.

A mobile computer (for the purposes of this paper, we define a mobile computer as a laptop computer with wireless networking capabilities) has severe limits on its electrical power usage, and a frequent complaint about mobile computers is the short lifespan of the battery [11]. Battery life is rarely more than 2-3 hours for a heavily-used laptop. Additional features, such as larger color displays, larger and faster hard disks, powerful processors, more memory and CD-ROM drives are becoming common, and result in increased electrical power demands. Unfortunately, laptop batteries are not advancing as rapidly as the other subsystems (for a comparison, see Figure 1). Each new feature, unless managed properly, will only further reduce battery life and inhibit untethered operation.

1.2 Overview

In the next section we discuss laptop batteries and show why batteries are unlikely to improve significantly in the forseeable future. Section 3 examines relative power consumption of the major subsystems of a laptop. In Section 4 we survey currently applied power management techniques for each of the subsystems, and discuss some of the problems associated with them. Section 5 outlines several new power management ideas.

[1] The monitor is a Nanao FlexScan T2-17TS and the laptop display is Fujitsu's FLC29SVC6S Active Matrix LCD
[2] The desktop drive is a Seagate Medalist Pro 2.1 and the laptop drive is a Seagate Marathon 810

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