Reducing costs with computer power management

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Abstract. In this work, we present a software-based solution to automate the power control of desktop computers. The deployment of the proposed software system is simply done over the existing infrastructure of the organization, thus minimizing the required investment. Our initial analysis shows a cost reduction of more than 52% by reducing the power consumption of computers and their monitors.

Keywords: energy, efficiency, automatic control, computer.

1 Introduction

Information technology (IT) has an enormous potential for implementing environmentally-friendly practices. As Sheehan explains in [1], IT is a major consumer of energy and a net contributor of greenhouse gas emissions and other forms of waste. In a report by Gartner Inc., cited in [1], it is estimated that the IT industry is responsible for 2% of global CO_2 emissions. This a priori relatively small percentage is actually equivalent to the impact the airline industry has in the environment [2].

Different works have been published confirming the ineffective use of energy in IT [3], [4], but only some of them implement solutions to tackle this problem [5]. Unfortunately, most of these systems impose significant obstacles to practical deployment, by either requiring modifications to network interface hardware or, in some cases, the host operating system software.

We propose a software-based solution to save power by automatically turning personal computers (PCs) off (without user's intervention) when they are not being used. Our system takes advantage of the existing server infrastructure within an organization.

2 System architecture

The architecture of the system is depicted in Figure 1. A Power Server (PS) controls the power state of n hosts (h_1, h_2, …, h_n) by receiving events from m personnel registration terminals (r_1, r_2, …, r_m). When a user arrives at her/his workplace in the morning, she/he identifies at one of the registration terminals, thus triggering the 'arrive' event. The registration terminal informs the Time Management System (TMS) that the user has arrived. The TMS, in turn, informs the PS. The PS reacts by sending a Wake on LAN (WOL) magic packet [6] to the

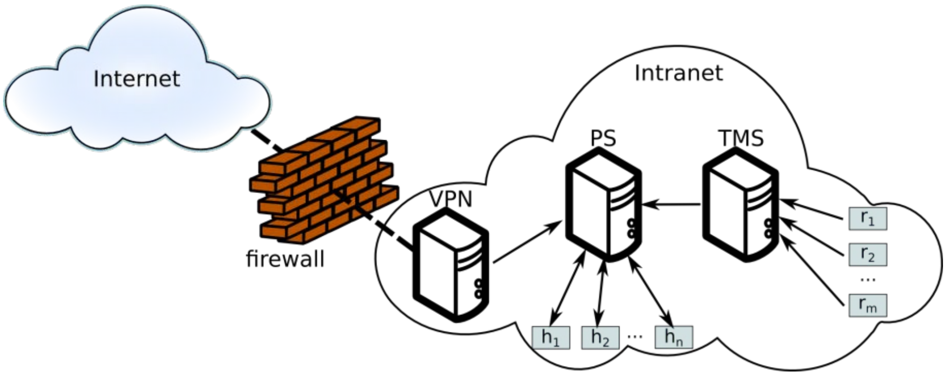

Figure 1: System architecture

user's computer, thus turning it on from its previous sleep, hibernate or off state. Similarly, when the user leaves her/his workplace by identifying at a terminal, the 'leave' event is generated. In this case, the PS changes the power state of the user's computer from active to sleep, hibernate or off, depending on the user's personal configuration.

The PS also receives events regarding remote Virtual Private Network (VPN) connections into the organization's intranet. These events, 'arrive' for authorized logins into the VPN and 'leave' when logging off, cause the same power state changes at the user's computer as the registration terminals do.

3 Implementation

3.1 Server side

The PS is entirely implemented as a web application. Hypertext transfer protocol secure (HTTPS) is used to transfer common HTML pages, which are used for the administration tasks and adjusting the users' configuration. Each of the 'arrive' and 'leave' events are accessed through their own uniform resource identifier (URI) over HTTPS, enforcing additional authentication to avoid misuse and emphasize the security aspect, e.g. https://ps.example.si/*usr_id*/wakeup, where *usr_id* is a key that uniquely identifies the user that generated the event, either by arriving at her/his workplace or by connecting to the organization's VPN. On the other hand, https://ps.example.si/*usr_id*/sleep, handles the event triggered by the user leaving office or disconnecting from the VPN.

3.2 Host side

A Service Application (SA) runs on every host (h_1, h_2, …, h_n as marked in Figure 1) that is controlled by the PS. The main objective of the SA is to make sure that the centrally-controlled power schema, imposed by the PS, does not conflict with the user's activities. Such situations appear, for example, when the user starts a long-running process that finishes after the user has left, or when dealing with software updates, or even with long file transfers like backup operations. The SA makes sure that the host changes its power state only after the on-going execution has finished. To achieve this, it is constantly monitoring processor usage and network activity on the host after the 'sleep' message has been received from the PS. Once both monitored measures fall below the configured threshold for a given amount of time, the previously queued power-state change is executed.

4 Analysis

Power consumption measurements were taken using a Voltcraft Energy Check 3000 power meter. A total of 30 computers were measured, including different hardware, software and operating systems. The power consumption of each computer was continuously measured for 24 hours, separating between active (the user is operating the computer) and standby modes (the computer goes into sleep mode). During the active mode, ordinary operations were carried out by the users, e.g. web browsing, editing documents, receiving and sending mail, etc. The measurement results, expressed in watts/hour, are shown in Table 1.

Table 1: Power consumption measurements (W/h).

Equipment	Mode	Minimum	Maximum	Average	Std. Dev.
Computer	Active	35.73	127.91	78.39	31.27
Computer	Standby	1.32	2.63	1.69	0.74
Monitor	Active	16.10	128.22	42.48	25.45
Monitor	Standby	0.30	4.77	1.15	1.05

We have also calculated the potential savings, achievable by the PS after its deployment for similar conditions. For the environment without PS, we have assumed the PCs are in use during weekdays for 9 hours per day, spending the average consumption for active mode. For the remaining 15 hours, as well as during weekends and public holidays (i.e. no-activity periods), we have considered the minimum active-mode consumption. The other environment we have considered is PS-enabled. The only difference is the consumption over the no-activity periods, for which we have assumed the average consumption in standby mode. All consumption values are shown in Table 1. The estimation results, depicted in Table 2, were calculated for 249 working days during the year 2012, for complete PCs (computers and monitors). The average price of electricity for the industrial sector was provided by SURS [7].

Table 2: Cost-saving estimation for one year (in EUR).

Equipment	Price (kWh)	Costs (no PS)	Costs (PS)	Savings
100 PCs	0.1109	6764.83	3210.02	3554.81
310 PCs	0.1109	20970.96	9951.06	11019.90

5 Conclusion

We have presented an innovative solution for computer power management that automatically turns PCs off when they are not in use. The solution installation requires a minimal initial investment, since it is completely software-based and takes advantage of the existing infrastructure. The initial results of our analysis show a cost reduction of more than 52%, saving more than 10,000 EUR a year from of a group of 300 PCs.

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For wider interest

Many organizations are increasingly leaving their networked computers turned on 24 hours a day, 7 days a week, to allow for out-of-hours access by employees. Some administrators may say they want to do a backup, or the user may want to be able to remotely connect into her/his computer. But most of the time these personal computers (PCs) remain idle, wasting significant amounts of energy.

In this work, we present a software-based solution to automate the power control of desktop PCs. The deployment of the proposed system is simply done over the existing infrastructure (i.e. hardware) of the organization, thus minimizing the required investment. The controlling software, named Power Server, reads events from the personnel registration terminals. These events generate the power-state changes of the owner's PC, turning it on when arriving to office, and off when leaving home. Power Server also reacts to remote VPN connections in a similar way. The user may also modify the configuration and select, for example, to put the PC into a low-energy sleep or hibernation mode instead of turning it off.

The energy savings come from the fact that each PC is kept running strictly for the time it is being used, neither more nor less. Since even the latest low-power desktop PCs consume around 40 watts of power when idle, the potential savings of a Power Server installation are very promising: more than 52% of energy-consumption reduction, which means more than 10,000 EUR a year for an organization hosting just 300 desktop PCs.

There is other software that can be used to wake up sleeping PCs, such as Apple's Wake-on Demand and Microsoft's Sleep Proxy, but none of them provides the needed level of flexibility to maximize energy savings. Moreover, Power Server works without user's intervention, since the power-state changes are automatically performed, based on external events.